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A Journal of Radio Research & Progress

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THE

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The Tilt of Radio Waves and Their Penetration into the Earth

An alternating current transmission line has four characteristic properties upon which the transmission along it of electromagnetic waves depends; they are its resistance, inductance, capacitance and leakance. If we know the values of these four magnitudes per unit length of the line it is a simple matter to calculate the relation between the current and voltage at any point both as regards magnitude and phase by means of formulæ which are often referred to as telephone transmission formulæ. Many years ago the writer showed that these formulæ could also be employed to calculate the penetration of electromagnetic waves into the conductors carrying the current. This transmission of energy takes place laterally into the wires, and the formulæ show that at high frequencies the "waves" are rapidly attenuated, so that the current density falls off as the centre of the wire is approached—a phenomenon well known under the name of skin-effect.*

When the electromagnetic wave is radiated by a transmitting aerial, the earth levies toll on it as it passes over its surface, abstracting energy from it just as the conductors of the transmission line levy toll on the energy transmitted by their aid. Here again the telephone transmission formulae can be applied and even if they did not yield anything which had not already been found by other methods, their application to the problem would have the educative value of enabling one to look at the problem from a new point of view. The method may, however, prove of considerable value, especially simplifying the calculation of the effect of the variation with depth of conductivity and permittivity of the soil.

Generally speaking, the depth to which the currents penetrate is small compared with the wavelength so that little error is made by assuming that they flow horizontally. This assumption is fundamental to the method which we are about to employ, for if the currents flow horizontally, nothing would be materially changed if we inserted in the earth thin vertical sheets of infinitely conducting material, so long as these sheets were normal to the direction of current flow, as they would be if they were vertical cylinders with the transmitting station on their axis.

These cylinders may be imagined to extend as far down into the soil as we have any interest in it. It is very important to realise that we assume that any vertical component of the earth currents is so small

* The application of telephone transmission formulæ to skin effect problems. *Journn. Inst. of Elec. Eng.*, 54, p. 473, 1916.

compared with the horizontal component that the presence of these cylinders would not materially increase the conductivity of the soil so far as it is concerned in the propagation of the wireless waves over its surface.

Two such neighbouring cylinders being of infinitely conducting material act as perfect screens and the only way in which an electromagnetic wave can penetrate into the annular space between them is by being propagated vertically downwards. We can regard the two cylinders as the two conductors of a vertical transmission line extending down into the earth; the surface of the earth is the sending end and the applied voltage is the horizontal component of the electric field. The currents flowing up and down the cylindrical conductors may look at first sight to be contrary to what we have said as to the earth currents being practically horizontal, but if one considers several adjacent "transmission lines," it will be seen that the vertical currents are fictions introduced for the purpose of calculation and all cancel out.

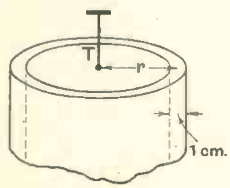


Fig. 1.

We shall consider the "line" made up of two cylinders 1 cm apart at a distance r from the transmitter (Fig. 1). The inductance of such a line per cm of length, *i.e.*, 1 cm vertically in the present case, can be calculated as follows: If 1 ampere were assumed to flow down one cylinder and return along the other, the magnetic field H in the space between them would be given by the formula

$$H \times 2\pi r = \frac{4\pi}{10} \quad \therefore H = \frac{1}{5r}.$$

This is equal to the flux per unit length for a current of 1 ampere, hence $L = 2 \cdot 10^{-9}/r$ henry. The leakance G per unit length $= A/\rho l = 2\pi r/\rho$ ohm^{-1}. For the capacitance per unit length we have

$$C = \frac{A\kappa}{4\pi d} = \frac{2\pi r\kappa}{4\pi} = \frac{r\kappa}{2}\ e.s.\ \text{units}$$

$$= \frac{r\kappa}{2 \times 9 \times 10^{11}}\ \text{farad.}$$

As our conductors are assumed to consist of infinitely conducting material, the resistance of the line is zero, and as we assume the line to extend indefinitely into the earth, we are only concerned with the simple formulae applicable to infinitely long lines. In our present case the wave is so rapidly attenuated that the line need only be a few metres in length in order to be treated as infinitely long.

For the impedance at the sending end of such a line we have the well-known formula

$$Z = \frac{V_1}{I_1} = \sqrt{\frac{R + j\omega L}{G + j\omega C}} = \sqrt{\frac{j\omega L}{G + j\omega C}}$$

In many actual cases the leakance is so great compared with the capacity term that the latter can be neglected. We shall make this simplifying assumption to begin with and shall consider the effect of the capacity term later. We, therefore, have

$$\frac{V_1}{I_1} = \sqrt{\frac{j\omega L}{G}} = \sqrt{j}\sqrt{\frac{\omega L}{G}} = \sqrt{\frac{\omega L}{G}}\ \underline{|45^\circ}$$

substituting the above given values for L and G we have

$$\frac{V_1}{I_1} = \frac{1}{r}\sqrt{\frac{2f\rho}{10^9}}\ \underline{|45^\circ}$$

Now V_1 is the voltage per radial cm, that is to say, it is the horizontal component E_h of the electric field expressed in volts per cm.

The sending end current I_1 is related to the magnetic field at the sending end, that is, at the earth's surface, as we have already seen, by the equation $H = I_1/5r$

so that $\dfrac{V_1}{I_1} = \dfrac{E_h}{5rH}$

and $\dfrac{E_h}{H} = 5\sqrt{\dfrac{2f\rho}{10^9}}\ \underline{|45^\circ}$ if E_h is in volts/cm

or $\dfrac{E_h}{H} = \dfrac{1}{60}\sqrt{\dfrac{2f\rho}{10^9}}\ \underline{|45^\circ}$ if E_h is in *e.s.* units.

Now in an electromagnetic wave in space $H = E$, but some doubt may be felt whether E in this case is the resultant electric field or the vertical component. In all practical cases the tilt is small and there is little difference between the magnitudes of the vertical component and the resultant electric field. It greatly simplifies the problem to assume that H is equal to and in phase with the vertical component E_v and we shall make this assumption throughout. If E_v is in volts per cm., then $E_v = 300\ H$ and we have

$$\frac{E_h}{E_v} = \frac{1}{60}\sqrt{\frac{2f\rho}{10^9}}\ \underline{|45^\circ}$$

ρ is here the specific resistance in ohms per cm cube. If one prefers to use the conductivity in e.s. units, the formula must be written

$$\frac{E_h}{E_v} = \frac{1}{60}\sqrt{\frac{2f \cdot 9 \times 10^{11}}{10^9\ \sigma}}\ \underline{|45^\circ} = \sqrt{\frac{f}{2\sigma}}\ \underline{|45^\circ}$$

(One can always replace ρ by $9 \times 10^{11}/\sigma$). The horizontal field has thus a lead of 45° ahead of the vertical field. The rotating vector representing the resultant field will have an elliptical locus, as shown in Fig. 2, which also shows the component fields and the resultant every 45° during a cycle.

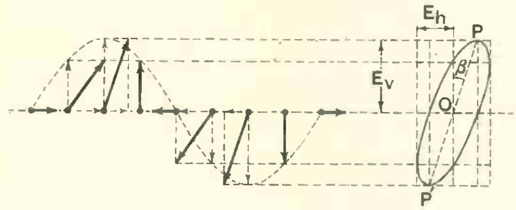


Fig. 2.

At certain moments the field is purely vertical and at others purely horizontal, but on the whole the resultant field has a forward slope. When Eh is small compared with E_v it can be shown that the resultant vector has its maximum value approximately when E_v has its maximum value and therefore when Eh has $1/\sqrt{2}$ of its maximum value; in other words, PP' in Fig. 2 is approximately the major axis of the ellipse. If then the tilt of the field is determined experimentally by means of a sloping aerial, the angle β so measured will be such

that $\tan\beta = \dfrac{E_h}{\sqrt{2}\,E_v} = \tfrac{1}{2}\sqrt{\dfrac{f}{\sigma}}$

If, however, the tilt is determined by making separate measurements of the vertical and horizontal fields, it must be remembered

that $\tan\beta = \dfrac{1}{\sqrt{2}} \cdot \dfrac{E_h}{E_v}$.

The Effect of Permittivity

Having thus considered this simple case, we now turn to the more complicated case in which the effect of the permittivity of the soil cannot be neglected.

If we put

$$\frac{V_1}{I_1} = Z = \sqrt{\frac{j\omega L}{G + j\omega C}} = a + jb$$

we find by squaring each side that

$$2a^2 = \frac{L}{C} n \frac{\sqrt{1 + n^2} + n}{1 + n^2} \quad .. \quad (1a)$$

and
$$2b^2 = \frac{L}{C} n \frac{\sqrt{1 + n^2} - n}{1 + n^2} \quad .. \quad (1b)$$

where $n = \dfrac{\omega C}{G} = \dfrac{f\kappa}{2\sigma}$, as can be shown by substituting the values already found for C and G.

If α is the angle of lag of I_1 behind V_1, $\tan\alpha = b/a$ and

$$\tan^2\alpha = \frac{b^2}{a^2} = \frac{\sqrt{1 + n^2} - n}{\sqrt{1 + n^2} + n} = \frac{1 - \dfrac{n}{\sqrt{1 + n^2}}}{1 + \dfrac{n}{\sqrt{1 + n^2}}}$$

but $\tan^2\alpha = \dfrac{1 - \cos 2\alpha}{1 + \cos 2\alpha}$

$$\therefore \quad \cos 2\alpha = \frac{n}{\sqrt{1 + n^2}}, \ \tan 2\alpha = 1/n,$$

$$\text{and } \sin 2\alpha = \frac{1}{\sqrt{1 + n^2}} \quad .. \quad (2)$$

For the magnitude of the impedance we have

$$\left[\frac{V_1}{I_1}\right] = \sqrt{a^2 + b^2} = \sqrt{\frac{L}{C}\frac{n}{\sqrt{1 + n^2}}}$$

$$= \sqrt{\frac{3600}{r^2\kappa}\frac{n}{\sqrt{1 + n^2}}}$$

$$\therefore \left[\frac{E_h}{E_v}\right] = \frac{r}{60}\left[\frac{V_1}{I_1}\right] = \sqrt{\frac{n}{\kappa\sqrt{1 + n^2}}}$$

Hence if the vertical component of the electric field is $E_v \sin \omega t$, the horizontal component will be $E_h \sin(\omega t + \alpha)$

$$\text{where } \frac{E_h}{E_v} = \sqrt{\frac{n}{\kappa\sqrt{1 + n^2}}} = \gamma, \text{ say} \quad .. \quad (3)$$

and $\tan 2\alpha = 1/n$

To find the tilt of the major axis of the ellipse we must first find the value of ωt for which the resultant electric field E is a maximum. Now

$$e^2 = E_v^2 \sin^2\omega t + E_h^2 \sin^2(\omega t + \alpha)$$
$$= (E_v^2 + E_h^2\cos^2\alpha)\sin^2\omega t$$
$$+ E_h^2\sin^2\alpha\cos^2\omega t + \frac{E_h^2}{2}\sin 2\alpha \sin 2\omega t$$

For e to be a maximum, the differential of this with respect to ωt must be zero, hence, putting $E_h/E_v = \gamma$ we have

$$\{1 + \gamma^2(\cos^2 \alpha - \sin^2\alpha)\} \sin 2\omega t + \gamma^2 \sin 2\alpha \cos 2\omega t = 0$$

$$\text{and } \tan 2\omega t = - \frac{\gamma^2 \sin 2\alpha}{1 + \gamma^2 \cos 2\alpha} \quad .. \quad (4)$$

Let this value of ωt be designated $\omega t'$. This gives the phase for both maxima and minima, *i.e.*, for both major and minor axes of the ellipse. In our case $\tan 2\omega t'$ is always a very small quantity; for example, if $\alpha = 15°$ and $\gamma = 0.1$, $\tan 2\omega t' = - 0.005$. To a very close degree of approximation we can therefore put

$$\cot\text{an}\, \omega t' = - \frac{\tan 2\omega t'}{2}$$

where t' is the time at which the resultant electric field reaches its maximum value.

If β is the angle between the vertical and the major axes (see Fig. 2) we have

$$\tan \beta = \gamma \frac{\sin (\omega t' + \alpha)}{\sin \omega t'}$$

$$= \gamma(\cos \alpha + \sin \alpha \cot\text{an}\, \omega t')$$

$$= \gamma \left(\cos \alpha - \sin \alpha \frac{\tan 2\omega t'}{2}\right)$$

Therefore, substituting for $\tan 2\omega t'$ from (4) we have

$$\tan \beta = \gamma\left(\cos \alpha + \frac{\gamma^2 \sin 2\alpha}{1 + \gamma \cos 2\alpha} \sin \alpha\right)$$

$$= \frac{\gamma(1 + \gamma^2)}{1 + \gamma^2 \cos 2\alpha} \cos \alpha \quad .. \quad (5)$$

Now we have seen in (2) and (3) that

$$\gamma = \sqrt{\frac{n}{\kappa \sqrt{1 + n^2}}} \text{ and } \cos 2\alpha = \frac{n}{\sqrt{1 + n^2}}$$

$$\therefore \cos \alpha = \sqrt{\frac{1 + \cos 2\alpha}{2}} = \sqrt{\frac{1 + n/\sqrt{1+n^2}}{2}}$$

If we put $N = \dfrac{n}{\kappa \sqrt{1 + n^2}}$ then $\gamma = \sqrt{N}$

and (5) may be written

$$\tan \beta = \frac{\sqrt{N}(1 + N)}{1 + \kappa N^2} \sqrt{\frac{1 + \kappa N}{2}}$$

$$= \frac{1}{\sqrt{2}} \frac{(1 + N) \sqrt{N + \kappa N^2}}{1 + \kappa N^2} \quad .. \quad (6a)$$

Except for wavelengths of less than about 20 metres and then only for very dry soil, the table shows that N is so small that $(1 + N)/(1 + \kappa N^2)$ is approximately unity,

$$\text{and } \tan \beta = \sqrt{\frac{N}{2}} (1 + \kappa N) \quad .. \quad .. \quad (6b)$$

The only approximations made in establishing this formula are (1) the assumption that the depth of penetration is small compared with the wavelength, so that the currents in the earth may be assumed to flow horizontally, (2) the assumption that $H = E_v$ and (3) that $\cot\text{an}\, \omega t' = - 0.5 \tan 2\omega' t$. The error introduced owing to the last assumption is only about 1 per cent. in an extreme case and is usually much less, that due to the second assumption is certainly very small in most cases, so that we need only concern ourselves with the correctness of our basic assumption that the earth currents are practically horizontal.

As a matter of fact, we shall see later that approximations (1) and (2) combine to give a rigorously correct result whatever the depth of penetration.

The density of the horizontal earth current at any depth x is proportional to the potential difference V of our fictitious transmission line at that depth, *i.e.*, at a distance x from the sending end.

Now from the ordinary telephone transmission formulae, we know that

$$V = V_1 e^{-\alpha x} = V_1 e^{-px} e^{-jqx}$$

$$\text{where } \alpha = p + jq = \sqrt{j\omega L(G + j\omega C)}$$

p is the attenuation constant, and e^{-px} is the ratio of the R.M.S. voltage at the point x to that at the sending end. Solving the equation we find that

$$2p^2 = \omega L \sqrt{\omega^2 C^2 + G^2} - \omega^2 LC$$

$$= \omega LG (\sqrt{1 + n^2} - n)$$

$$\therefore \quad p^2 = \frac{4\pi^2}{9 \times 10^{20}} f\sigma(\sqrt{1 + n^2} - n) \quad .. \quad (7)$$

If d be the value of x at which the earth currents have fallen to 0.1 of their value at the earth's surface, $e^{-pd} = 0.1$ and $d = 2.3/p$. We shall refer to this as the depth of penetration.

We wish to find an expression for the

ratio of this depth of penetration to the wavelength λ; we have

$$\frac{d}{\lambda} = \frac{d\,.\,f}{3 \times 10^{10}} = \frac{2.3f}{p \times 3 \times 10^{10}}$$

$$= \frac{2.3}{3 \times 10^{10}} \cdot \frac{3 \times 10^{10}}{2\pi}$$

$$\frac{f}{\sqrt{f\sigma(\sqrt{1 + n^2} - n)}} \quad \ldots \text{ from (7)}$$

$$= \frac{1.15}{\pi} \quad \frac{1}{\sqrt{\frac{\sigma}{f}\sqrt{1 + n^2} - \frac{n\sigma}{f}}}$$

$$= \frac{1.15 \times \sqrt{2}}{\pi} \cdot \frac{1}{\sqrt{\frac{1}{N} - \kappa}}$$

f	λ metres	κ	σ e.s. units $\times 10^8$	$n = f\kappa/2\sigma$	$N = \frac{n}{\kappa\sqrt{1+n^2}}$	tan β	β	λ/d
10^6	300	5	1	0.025	0.005	0.051	2° 55′	27.1
		80	1	0.4	0.0046	0.056	3° 14′	22.8
		20	4	0.025	0.00125	0.025	1° 27′	54.1
		40	10	0.02	0.0005	0.016	0° 55′	86
10^7	30	5	1	0.25	0.0485	0.18	10° 12′	7.65
		80	1	4.0	0.0121	0.11	6° 17′	3.18
		20	4	0.25	0.0121	0.088	5° 1′	15.3
		40	10	0.2	0.0049	0.054	3° 6′	24.8
3×10^7	10	5	0.5	1.5	0.167	0.4	21° 48′	1.94
		5	1	0.75	0.12	0.323	17° 54′	3.54
		80	1	12	0.0124	0.111	6° 20′	1.02
		20	4	0.75	0.03	0.157	8° 55′	7.1
		40	10	0.6	0.013	0.1	5° 43′	11.9

or $$\frac{\lambda}{d} = 1.94\sqrt{\frac{1}{N} - \kappa} \quad \ldots \ldots \ldots (8)$$

where $N = \frac{n}{\kappa\sqrt{1 + n^2}}$ and $n = f\kappa/2\sigma$.

Having calculated N it is thus a very simple matter to calculate the tilt angle β and this ratio of the wavelength to the depth of penetration. The depth d which we have taken is that at which the currents are 0.1 of the currents at the surface, corresponding to an energy dissipation only 1 per cent. of that at the surface. The greater part of the earth currents are therefore much nearer the surface. In the above table a few typical results are given.

When n is large compared with 1 as in the last line but one in the table, formula (8) is more conveniently written

$$\lambda/d = 1.37\,\frac{\sqrt{\kappa}}{n}.$$

A Surprising Result

On comparing the formulae established above for E_h/E_v and the phase-angle α with those obtained by a rigorous analysis of the problem based on Maxwell's electromagnetic equations* it is surprising to find that they are identically the same. It appears that the inaccuracies due to the two simplifying approximations which we made, viz. the assumption of horizontal earth currents and the equating of H and E_v in magnitude and phase, are mutually compensating. The only approximation in the final result for the angle of tilt is the assumption in determining the ellipse that cotan $\omega t' = -0.5 \tan 2\omega t'$, and the error due to this, as we have already stated, is usually much less than 1 per cent.

We stated at the beginning that the method may prove of considerable value in considering the effect of the variation of the properties of the soil with depth. The formulae to be employed will be similar to those used in the calculation of a telephone line which is made up of sections of different characteristics. The effect of a thin layer of dry soil upon a substratum of damp soil can be readily determined in this way.

G. W. O. H.

* See, for example, Bouthillon "La propagation des ondes électromagnetique à la surface de la terre," page 149.

A New High Efficiency Cathode-ray Tube*

Applications as a Projecting Oscillograph

By Manfred von Ardenne, Berlin

EVEN with the use of anode voltages of some thousands of volts the ordinary cathode-ray tube often gives insufficient spot brightness. An increase in brightness, to allow of the projection of fluorescent-screen pictures or curves, seems equally important for television purposes and for demonstration oscillographs for physical lectures. For general purposes, moreover, a large increase of brightness of fluorescent spot is desirable, to provide a reserve of light for facilitating the photographic recording of low-frequency oscillograms. Last but not least, an increased brightness is of advantage for obtaining the highest possible photographic recording speed, and thus extending the possibilities of the cathode-ray tube.

Obvious Methods of Increasing Brightness, and their Objections

The relations involved in gas-concentration of the cathode-ray make it undesirable —apart from practical and economic reasons —to employ higher anode voltages than from 3,000 to 4,000 volts. Moreover, the increase of the electron current leaving the cathode meets with considerable difficulties so long as the usual simple electrode system is adhered to. An increase of spot brightness, therefore, cannot be readily and satisfactorily obtained by raising the anode current and voltage, *i.e.*, by increasing the normal anode power. In the writer's new tube, without departing from the usual anode power of from ½ to 1 watt, the required increase of brightness—to the extent of ten times or thereabouts—is attained by a corresponding improvement in the *efficiency* of the tube.

The Efficiency of a Cathode-ray Tube and the Factors Tending to Reduce It.

The efficiency of a cathode-ray tube is given by the ratio of the total amount of light radiated on the viewing side of the screen to the steady anode power. It tends to be diminished by :

(1) Losses in the ray current,
(2) Loss of velocity in the electrons of the ray, and
(3) Losses in the transformation of the kinetic energy of the ray into luminous energy.

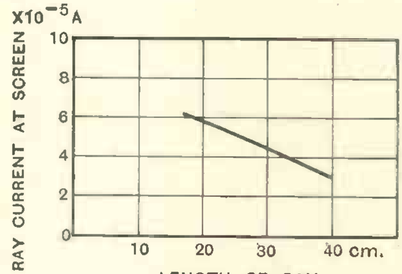


Fig. 1.—*Ray current at screen and its variation with the length of the ray.*

The results of an investigation into these three sources of loss are briefly summarised as follows :

(1) The effective ray current at the fluorescent screen can be measured, as is well known, by the use of a small Faraday cage device or by collector electrodes screened by glass. Measurements show that for gas-filled tubes of normal dimensions the ray current at the screen is only about 30 per cent. of the total anode current. This percentage is, as Fig. 1 shows, strictly dependent on the length of the electron path in the gas-filled space.

The decrease of the ray current with increased length of path is due to the sideways straying of the electrons out of the ray, pointed out in an earlier paper.† These "straying losses" increase with increasing anode voltages and decreasing gas-pressures ; the nature of the gas, moreover, has a considerable influence on them. But since the anode potential, the gas-pressure and the

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

† Von Ardenne, "Untersuchungen an Braunschen Röhren mit Gasfüllung," *Zeitschrift für Hochfrequenztechnik*, 1932, Vol. 39, No. 1, p. 22 : *Wireless Engineer*, Abstracts and References, 1932, p. 237.

nature of the gas may be considered as fixed, the only way to reduce the current losses in the ray is to decrease the length of the path. Now as the path-length diminishes, the deflection sensitivity—in general given in mm/V, where V is the deflecting potential—decreases in about the same proportion. At first sight it would appear that this decrease in sensitivity would always neutralise any advantages gained by shortening the tube. This, however, is not the case. For projection or photographic recording, where the image can be magnified or reduced as desired, the vital point is not the *absolute* length of the ray but its length compared with the diameter of the fluorescent spot. The deflection sensitivity referred to this spot-diameter, fortunately, does not decrease very seriously with the length of ray, since the spot-diameter simultaneously takes on smaller values. It is only when the length is so reduced that it is no longer large compared with the distance between the cathode and the deflecting system that a critical diminution of the relative sensitivity makes its appearance. The variation of the spot-diameter with length of ray may be regarded as an increased enlargement of the image of the cathode (and the space charge in front of it) as the length of ray increases; thus shorter tubes may be provided with screens of correspondingly smaller diameter without decreasing the "sharpness" of the image, under the conditions mentioned above. One other point: in addition to the limit set on the shortening of the ray by the relation to the cathode/deflecting system distance, the decrease of luminous output owing to saturation phenomena in the screen has to be reckoned with.

Increasing Efficiency in the New Tube by Shortening

In the new tube (Fig. 2) a successful compromise in the dimensions seems to have been attained. The current at the fluorescent screen is about 60 per cent. of the total anode current, compared * with the 30 per cent. mentioned under (1) for the usual tubes, so that by shortening the tube design so as to give a ray-path of 24 cm compared with the normal 40 cm or thereabouts, the efficiency has been about doubled.

(2) The loss of electron velocity. In the ordinary cathode-ray tube with insulated screen, the loss of electron velocity on the way from anode to screen is of the order of 100 to 150 volts. In the new tube this loss is avoided by the use of a conducting screen connected with the anode. For anode potentials of a few thousand volts this elimination of velocity-loss improves the efficiency only by some 5 per cent.

(3) Losses in the transformation into light. The efficiency of the fluorescent screen depends on the properties of the fluorescent material as well as on the optical arrangement of the screen. When the new tube is constructed for projection purposes a material is used whose spectral maximum is favourable to visual observation, and whose efficiency—especially for electron speeds of a few thousand volts—is quite high. It is the same material as is used in the writer's tubes of normal design. *The fact that in the new tube the screen efficiency*

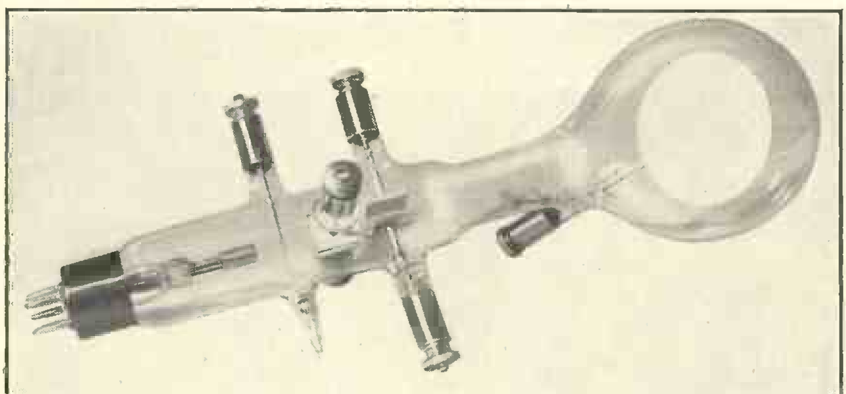


Fig. 2.—*The new short tube with increased efficiency.*

* Actual figures obtained with the new tube are: current at screen, about 0.6 × 10^{-4} mA for an anode potential of 1 500 v. At 3 000 v the effective power of the ray lies between 1/10 and 1/5 watt.

is three or four times as great as that of transparent screens deposited on the wall of the bulb is due to the new optical arrangement of the screen.

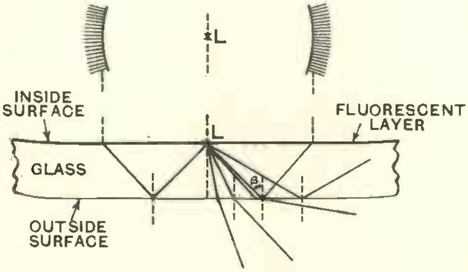


Fig. 3.—*The path of the light ray in the screen carrier; formation of halation in tubes with transparent screens.*

In tubes with transparent screens the following causes of loss occur:

(*a*) the luminous energy has to divide itself on the *two* sides of the fluorescent layer, which must therefore be kept thin.

(*b*) the side of the layer which is turned towards the electron ray, and which is therefore the more luminous, is turned away from the observer.

(*c*) the light emitted by the fluorescent spot L (*see* Fig. 3) is so broken up that the intensity of the light ray decreases to a marked extent. An important fraction is totally reflected at the glass/air surface of separation, and leads to the formation of halation.*

These sources of loss and interference can be avoided by the use of fluorescent screens designed for observation only on the side turned to the ray.† To make possible the image-formation of two-dimensional fluorescent figures, using lenses with high admission of light and little sharpness in the shadows, the screen must be fixed in a slanting position and the glass bulb must be specially shaped. The design shown in Fig. 2 makes it possible to use, for instance, projection lenses with very high light admission and focal lengths of the order of only 12 cm, without the glass bulb causing distortion or streaks in the image. Any such streaks would affect the picture very little in any case, owing to the large cross section of the light ray produced. The distortion which would otherwise be produced by the slanting position of the screen is avoided by setting the plates of one deflecting pair at an angle, as seen in Fig. 4. In this way a higher field strength between the deflecting plates is produced where the ray length is shorter, and a lower field strength where it is longer.

Naturally, the usual round-shaped fluorescent spot would be transformed into an oval by the slanting position of the screen. In order, therefore, to retain the more generally suitable circular spot, the new tube employs a cathode with an oval emission surface with its major axis oriented in the direction of the pair of slanting deflection plates. *In this way the new tube, in spite of its slanting screen, gives completely distortionless recording and makes it possible to obtain distortionless optical images.* The fluorescent material is deposited in a fairly

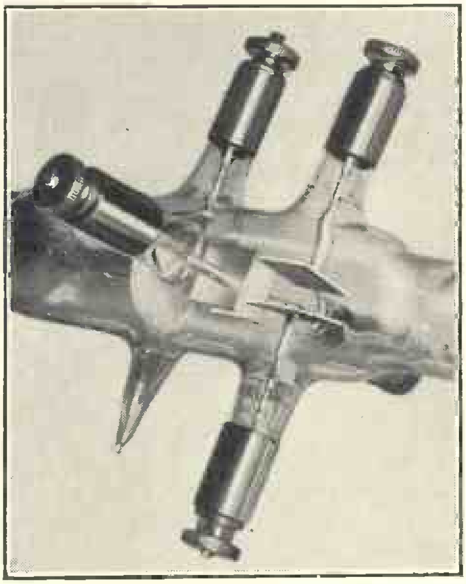


Fig. 4.—*Showing converging deflection plates to compensate for slanting screen.*

* *See* section "The Importance and Elimination of Halation at the Screen" in the book: M. von Ardenne: *Die Kathodenstrahlröhre und ihre Anwendung in der Schwachstromtechnik:* 1933, pub. by Julius Springer, Berlin.

† Screens for observation on the front side have been known for a long time (*cf.* Wehnelt and Donath: "Photographische Darstellung von Strom- und Spannungskurven mit der Braunschen Röhre": *Wied. Ann.*, Vol. 69, 1899, p. 861). They could not, however, hitherto be employed with low-voltage tubes on account of the sources of distortion only now eliminated by the new design of tube.

thick layer on a polished aluminium plate, by which, incidentally, part of the ray penetrating the layer is brought again into use; the thickness of the layer, however, is not so thick that the resulting halation is greater than the fluorescent spot itself. The luminous output is from three to four times as great as that given by the usual screen deposited on the container wall and viewed from the far side. The available spot brightness, with the new tube, is thus six to eight times the corresponding brightness given the ordinary long tubes with transparent screens.

Projection of the Image

The increase of spot brightness obtained in the new tube, by the methods described, is great enough to allow the screen image to be projected, by lenses with high light admission, to a large size. The arrangement of the tube in the projecting chamber is seen in Fig. 5. The distance of the tube from the lens system can be adjusted between suitable limits by a simple device, so as to give the sharpest image. In the apparatus represented in the diagram a two-lens system is used with an aperture ratio of f : 1; this is the same as the one which is employed, with shorter focus, in the writer's oscillogram-camera. The lens designed for the writer by H. Gramatzki, of the Astro-Gesellschaft, Berlin, possesses just the right definition for fluorescent-screen images. By abandoning unnecessarily high definition it was possible to obtain a lens which, in spite of its high light admission, is comfortably adjustable even at the short focal length of 12 cm necessary for projection. The system is spherically compensated, but not chromatically, since the screen material employed only emits over a comparatively small spectral range. If a specially clear image of the screen figure is required, chromatic distortion can be easily reduced by the introduction of a commercial yellow filter, or by using a screen which is limited to a greenish-yellow light. The wall of the tube between the screen and the lens can, as has already been mentioned, be made extraordinarily free from streaks in the design of tube shown. No noticeable decrease of image sharpness is produced by the interposition of the glass. With the perfectly flat form of screen and the use of spherically corrected lenses it is possible to get a sharp image right to the edges. With an anode potential of 3 000 volts, as the writer recently showed,* an image of any screen figure, of ample brightness for demonstration purposes, can be obtained covering an area of from a quarter to one square metre.

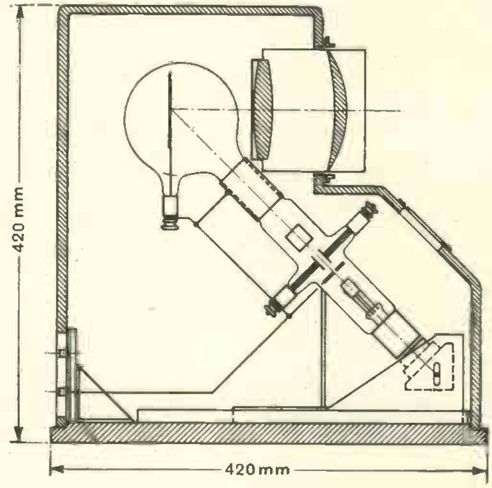


Fig. 5.—*The tube in its projection chamber.*

Photographic Recording

For the photographic recording of rapidly changing processes, the tube described above is provided with a special screen, particularly effective for photographic purposes, giving a blue light. With such a tube, recording speeds of over 5 km. per second are attainable.

* M. von Ardenne: Lecture: "Some Selected Themes from the Field of Television," 12th June, 1933, Heinrich-Hertz Institute.

Publication of Articles

It must often happen that those who are engaged on technical work have material available for the preparation of articles which they feel is not quite sufficiently comprehensive to form the subject of a paper for THE WIRELESS ENGINEER, and yet is matter which well merits publication.

In this connection we remind our readers that material of this kind would often provide useful contributions for our sister journal, *The Wireless World*. It should be noted that MS. for *The Wireless World* should be non-mathematical and, as far as possible, of a practical character.—EDITOR.

Civil Aviation Signal Services*

Considerations Affecting the Choice of Wavelengths

By N. F. S. Hecht, M.I.E.E., and H. L. Crowther, M.Sc.

The present paper has been prepared with the object of determining the scale of wavelengths which are particularly applicable to the signals organisation and technique of civil aviation services. The considerations which affect the final choice fall under three main headings, which are dealt with in detail in the paper. The study embraces practical considerations and technical requirements and peculiar limitations. These are exemplified and described in detail in an appendix which, being self-contained, avoids the encumbrance of the main paper by technical data and description, thus leaving the practical issues more accessible and clearly defined.

The main considerations are:

I. Reliability. II. Convenience. III. Special service requirements.

Part I.—Reliability

THE particular field of civil aviation is the rapid transport of passengers, mails and light goods. This service has to be performed with a maximum of safety and reliability and, as far as passengers are concerned, with a reasonable provision for convenience and comfort. To ensure reliability in air transport, it is necessary to provide a reliable signalling system and organisation whereby advantage will be taken of any meteorological conditions likely to expedite the service and whereby, as far as practicable, any conditions which are likely to interfere with this mode of transport may be overcome. The conditions here referred to are fog, gales or storms and bad visibility at night.

To cope with sudden and local changes of meteorological conditions, it is necessary to provide rapid and accurate communication between aerodrome or terminal stations, meteorological offices and aircraft in flight. By this means advice can be given to the pilot of an aircraft to change his course or his final destination should this be rendered necessary or advisable on account of a change of conditions which may have occurred since the aircraft left its aerodrome. This subject is conveniently discussed under two separate heads, *viz.*, A, Organisation and B, Technical requirements.

A. Organisation.—The organisation of the signal communications is established to meet the following requirements:

(i) *Point-to-point Service* between terminal stations and aerodromes. This provides the necessary interchange of information in respect of despatch of aircraft, number of passengers and detail of cargoes, state of landing grounds, local meteorological conditions, customs.

(ii) *Meteorological Service* over a large expanse of continental area. This ensures the rapid collection of data and its immediate dissemination over an appropriate area. For this purpose meteorological data is broadcast at specified or routine times, and must be disseminated over the whole of a particular air route or routes without delay and free from the possibility of confusion.

(iii) *Air to Ground and Ground to Air Communication.*—This enables fresh instructions to be issued to the pilot of the aircraft in view of altered meteorological conditions and provides useful information for the guidance of the pilot under these conditions. It also provides an S.O.S. service and is of assistance under difficult conditions of flight or emergency landing. It also provides, for the convenience of passengers, a link with the ground telegraph system.

(iv) *Direction Finding.*—This service enables an aircraft to obtain guidance and information under conditions of bad visibility and at night.

(v) *Beacon Services.*—This requirement will become of increasing importance in the future. It enables flying to take place under conditions of bad visibility and at night without appreciable danger provided it is supplemented by adequate ground assistance when effecting a final approach and landing at the terminal aerodrome.

Considering the above sub-paragraphs one by one, the following remarks will show more clearly the value of their various provisions.

(i) *Point-to-point.*—It may be suggested that this service can adequately be met by

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

making use of telegraphic land lines since aircraft are not directly concerned in its operation. It must be remembered, however, that in many cases of communication immediate connection is required between two or more points not on the same telegraphic system such as terminal points in different countries; land line telegraphy would necessitate a considerable use of long lines and trunk lines. As it would be impossible to claim priority, it is obvious that the service would be subject to serious and even dangerous delays. In special cases, no doubt, use can be made of local land lines, but it is of the utmost importance that a safe radio system be provided for a large part of the service.

(ii) *Meteorological Service.*—The collection of meteorological data is intended to enable the preparation of an estimate of approaching local conditions over a wide area. For this purpose it is necessary to obtain information of the meteorological conditions existing over an area very much greater than that covered by any particular air services. Reports have to be supplied from points many hundreds of miles apart and, as far as practicable, they must be received simultaneously at all stations concerned; this practically eliminates the possibility of using land lines and resort must be had to the broadcasting of data at specified times by specified stations, for the use of all other related meteorological stations. This service can only be satisfactorily provided by radio means.

(iii) *Air Communications.*—This point requires no expansion. On the assumption that the service is required it is obvious that no means of communication can be provided other than radio.

(iv) *Direction Finding.*—For this service the aircraft is required to transmit radio signals so that they may be received at a ground D.F. station and the direction of the aircraft be thus determined. For this purpose it is absolutely essential that the information received be entirely reliable and accurate; this at the present stage of knowledge involves the use of medium-long and long waves as will be discussed under "Technical Requirements."

(v) *Beacons.*—A beacon, to be universally useful, must give constant information to an aircraft in flight as to its line of flight and preferably as to its head. It must be available by night and by day and must therefore have the same degree of reliability as the D.F. system, referred to in sub-paragraph iv. The same or a similar band of wavelengths will therefore be required for the two services.

B. Technical Requirements.—The organisation detailed above can be set up provided careful and proper selection is made of the technical possibilities of radio as at present known. The considerations affecting this selection fall naturally under three subheadings:

i. Reliability of signal intensity.
ii. Reliability of D.F. accuracy.
iii. Freedom from interference.

(i) *Reliability of Signal Intensity.*

(*a*) *Meteorological.*—It has been shown above that meteorological and point-to-point services require the instantaneous dissemination and conveyance of information, in some cases to many points widely separated. This service has to be performed at all times of day and night. It is therefore important that the strength of signals be entirely reliable everywhere and at all times; the only way of obtaining this reliability in the present state of the art is to utilise such wavelengths as are least affected by meteorological and diurnal variations; there is no doubt whatever that, for this purpose, waves appreciably shorter than 700 metres fail to give the required degree of reliability; it is therefore essential that medium-long and long waves be chosen for the use of the meteorological services and for point-to-point communications.

(*b*) *Aircraft.*—There is also the question of providing satisfactory signal strength with certainty from and to aircraft. Wavelengths appreciably below 700 metres are attenuated overland to such a degree, especially in the skip area, say between 160 and 350 km., that a considerably greater power is required to produce the same signal strength than obtains in the case of long waves. This is quite apart from their unreliability in regard to long and short period fading. This question is discussed in Section II in relation to permissible weight and bulk.

It is therefore necessary to use medium-long or long waves for communications to and from aircraft.

(ii) *Reliability of D.F. Accuracy.*

The reliability of D.F. as far as its accuracy is concerned is entirely a question of wavelength utilised. The degree of reliability, in the present state of knowledge, is generally admitted to be unsatisfactory for wavelengths appreciably shorter than 700 metres. It may be that in the future satisfactory accuracy may be obtained on shorter wavelengths ; at present it is possible to obtain useful information on shorter waves provided an average can be taken of a number of readings, but this possibility is evidently not applicable to aircraft D.F. where D.F. readings must essentially be instantaneous and simultaneous.

The use of wavelengths above 700 metres for this service is therefore imperative.

(iii) *Freedom from Interference.*

This requirement is largely a matter of aircraft limitations. It is uneconomical and, to a great extent, impracticable to provide high grade receivers with complicated and delicate adjustments as these receivers are required to be operated by semi-skilled personnel and under conditions of great discomfort and general impediment all tending to reduce the efficiency of the wireless telegraphist. These limitations are dealt with in Section II. On this account it is a great assistance to the service to be free from interference, particularly from broadcasting and high power W/T stations. The choice of waveband should be such that excessive selectivity is not necessary for proper and efficient working of the service.

Part II.—Convenience

The considerations of convenience in dealing with aircraft radio installations are entirely a matter of practical limitations which are determined by the design of the aircraft. It would be uneconomical to carry bulky and heavy equipment and therefore the wireless apparatus must be reduced to its lowest possible weight and size. Since the power supply is derived directly or indirectly from the engine (and its weight has to be supported by absorbing power from the engine) this item is necessarily reduced to a strict minimum. With these limitations use must be made of such wavelengths as will provide a maximum signal strength over several hundred kilometres with a minimum consumption of power and with minimum weight and bulk. Preferably, also, the apparatus should be as simple as possible so that it may be made robust and less liable to damage by the effects of vibration and exposure.

It is shown in the appendix that signal intensity for a given power consumption is very markedly superior in the case of long waves compared with that obtained on the shorter waves of the medium band of wavelengths. It is clear that a claim for the use of wavelengths above 700 metres is well substantiated in respect of power to signal ratio and that, in general, aircraft transmitters should therefore work on such wavelengths.

The case of the receiver fitted to the aircraft is somewhat different. The limitation of sensitivity is not so marked as the limitation of power for the transmitter. Nevertheless there is a distinct limitation as to convenience of handling and operation. Reception in the air under vibration and uncomfortable conditions renders tuning more difficult on short waves, this difficulty being particularly marked on C.W. telegraphy. There is also a certain amount of limitation as regards the admissible complexity of the receiver both in respect of construction, and hence weight and size, and in respect of difficulty in handling. Further, the choice of wavelengths is very definitely affected by considerations of interference originating in the magneto or ignition system and the other electrical services (lighting and heating generators, etc.). Interference from these components takes the form of radiation of energy of short wavelength, roughly between 5 and 20 metres ; this radiation is always highly damped and therefore causes interference over a wide spectrum. The receiver is thus more seriously affected—for equal sensitivity—on the short wavelengths than on the longer ones. It is true that much of this interference can be avoided by suitable modes of screening of the interfering sources and bonding to the metal work of the aircraft, but this throws a heavy burden on the construction and maintenance of the aircraft and its components.

Interference is also caused, especially in the case of aircraft constructed wholly or partly of metal as is the present tendency, by variations of electrical contacts between adjoining metal members. This interference can be reduced or eliminated by careful bonding and by special design of joints, etc., but here again the difficulty and cost of upkeep to maintain satisfactory conditions are excessive. The interference caused by such contact variations is very much more serious on short waves than on long ones and becomes a maximum when the length of the interfering members is of the order of the wavelength of the signal being received.

In some aircraft and on certain routes it is not economical to carry a wireless operator and the duty of performing the necessary tuning operations falls on the pilot; conditions must therefore be made as convenient as possible and, especially in view of the transmitter requirements, use of medium-long waves is essential.

Part III.—Special Service Requirements

A. Geographical Considerations.—Whereas in ordinary wireless practice the geographical conditions over which a service has to be established are known in advance, this is not the case for aircraft purposes. Here communication has to be established over short and long distances and over all types of country from open sea to mountains; generally the distances that have to be considered range from 50 to 300 miles, but in some special cases greater ranges are required and these will be mentioned later.

There is a zone (between 100 and 300 miles from the ground station) where aircraft wireless communication is only reliable on wavelengths not appreciably shorter than 700 metres; this is more particularly the condition in the case of telephony which is an important feature in the communications in use with aircraft. Although *average* signal strength is frequently satisfactory below this wavelength, a reliable service cannot be obtained owing to the existence of short and long period fading and large variations by day and by night. Also, on the shorter wavelengths, considerable interference occurs at night from stations working many hundreds of miles away; on the ground of freedom from interference, wavelengths must be employed having a well-defined range by day and by night and this can only be obtained by the use of wavelengths not much shorter than 700 metres.

For special routes, mentioned below, this requirement cannot be fulfilled but the bulk of communications should be effected on medium-long waves.

Where aircraft have to fly long distances over desert and oceans, it is no longer practicable to use long wavelengths as the power limitation precludes this possibility. Even where the length of flight in tropical countries is not normally excessive from the point of view of long waves, it is found that owing to severe atmospheric disturbances it is impossible to operate a long wave service for periods of many hours or even days at a time. A service on short waves can, however, be provided satisfying the more urgent requirements. This is due to the fact that atmospherics are generally far less severe on short waves than on long waves. There is thus no alternative but to use short waves when outside the skip zone. By this means a useful service can be maintained subject only to repetitions and delays. Much can be done to improve this by providing a number of stations spread over a wide area and using diverse wavelengths; by taking advantage of favourable conditions in respect of wavelength and station distance as they occur, some degree of reliability can be obtained. For long range aircraft, therefore, it is essential to provide communication over a short-wave band. This, however, must be additional to the long wave provisions (D.F. facilities, beacons, etc.) when reliable communication is essential for use during the first and last part of the flight. The use of short waves in these aircraft is greatly facilitated by the fact that their size permits the carrying of a skilled wireless operator.

B. Direction Finding.—One of the most vital requirements of aviation is the provision of information when flying under conditions of bad visibility and at night. This information must enable a pilot to reach his aerodrome with certainty and for this purpose he must be provided with information as to his whereabouts to enable him to direct his aircraft accordingly. It is therefore necessary to provide him with a direction-finding system. This may be done by determining his direction from two or more points on the ground (ground D.F.) or by his determining his bearing from two or more points on the ground (aircraft D.F.

and radio beacons). It is essential that use be made of wavelengths not shorter than 700 metres. Below this wavelength atmospheric refraction produces large errors, especially at night, effectively preventing the accurate determination of direction of the transmitting station. On medium-long and on long waves, means are available for reducing night errors (which occur also on these waves) to practical limits but, so far, success has only been attained on wavelengths of the order of 700 metres and above. A D.F. system must therefore, at present, utilise medium-long and long waves; only by this means can navigation at night and in fog be rendered relatively safe.

Direction finding also takes another form, viz. :—Radio-route markers whereby a pilot is enabled to follow a definite route even under conditions of nil visibility; this system also requires the use of medium-long or long waves, at any rate for all distances in excess of 30 miles or so.

As previously discussed, a D.F. service on long waves requires that the waveband used shall be as free as possible from jamming and similar disturbances. The service should therefore have a reserved band of wavelengths. The use of high power stations, especially telephony or broadcasting stations, on wavelengths adjacent to those of this service should be avoided.

C. Telephony.—In many cases the signalling duties devolve on the pilot of the aircraft and by far the most satisfactory method of effecting the required communication is by means of telephony. It is practically impossible to maintain a satisfactory service on telephony, using short wavelengths, without excessively elaborate apparatus designed to overcome, as far as practicable, the effects of fading and short-period variations. Morse messages can be repeated a number of times to overcome the effect of fading, missing letters or words being filled in on a second transmission, but this is not the case for telephony where a sentence is practically unintelligible if an appreciable fraction of it is missed. Repetition, practically speaking, is no cure for fading in this latter case. Thus a satisfactory telephony service can only be provided by the use of medium-long and long waves and, in accordance with what has been said earlier, this service must be as free as possible from interference by broadcasting and high power telegraphy stations.

Conclusions

In view of the facts discussed in the foregoing sections, it is clear that the requirements of civil aviation in respect of wave band allocation are as follows :—

20–80 metres (sections in the band)	For long distance sea services, desert services and tropical services.
700–1,000 metres	For point-to-point and air to ground services and conversely.
1,000–1,200 metres	For D.F. and radio beacon services.
1,200–2,000 metres (A section in the band)	For meteorological services.

APPENDIX

Propagation in the Band 200–1000 Metres at Distances 0–250 Miles

It had been originally intended to obtain data relative to the propagation of waves radiated from an aircraft or received in flight throughout the band of wavelengths from 20 to 2,000 metres. In view of the short time available it was deemed impossible to carry out a sufficient number of long range flights, mostly in the winter months, to enable the whole waveband to be covered.

The data required being essentially in connection with modern types of commercial aircraft, it was necessary to obtain and equip such an aircraft with suitable and up-to-date apparatus. It was therefore found essential to limit the investigation to that strictly necessary for the purpose in view; that is, the waveband had to be limited to 200–1,000 m. The work was subdivided into three sections :

1. Field intensity obtained.
2. Comparison of field strengths required for radio telephony and radio telegraphy.
3. Field strength required for C.W. radio telegraphy.

In all three sections consideration was given to the two cases of communication, viz. : Air to ground and ground to air.

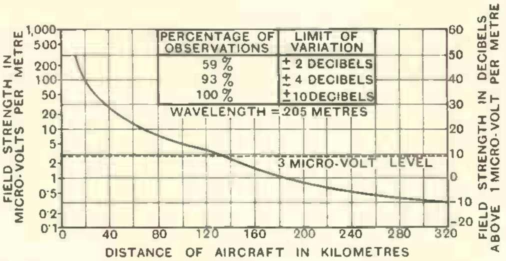
Part I.—Field Intensity

The aircraft was equipped with a master-oscillator transmitter giving good conditions of frequency steadiness and observations were made on the ground both with absolute field strength measuring equipment and with relative attenuation reception. The latter method was intended to supplement the absolute readings in order to increase the data and to provide a safer average.

The aircraft was fitted with a trailing aerial, the length of which was varied from 100 to 200 feet throughout the band of wavelengths of 200–1,000 m. The length in each case was appropriate to the characteristics of the transmitter. This was a matter of convenience as an aerial of constant length would have necessitated a special transmitter for each wavelength by reason of the large variation of radiation resistance with wavelength. The question of the effect on the results obtained of varying the length of aerial and its effective height is discussed at the end of this Appendix.

The power delivered to the transmitter was kept at the constant level of 85 watts and in each case the aerial current was recorded.

In the method employed in making the measurements the transmitter radiated practically continuously throughout the flight and values of field



CURVE 1.—*Input to aircraft transmitter* 200 *watts; length of aerial*, 100 *feet; effective height of aerial (calculated from photograph for each curve)*, 5.3 *metres; aerial current*, 2.15 *amp. Curves* 1–6 *and* 10 *show the average field strength during outward and return flights.*

strengths were taken as frequently as the convenience of the receiving apparatus would allow.

The return journey was always performed on the same day so that meteorological conditions did not alter considerably; there may have been some variations, however, due to the time of day but, judging by the consistency of the results over the band of wavelengths used, this factor cannot have been an important one. It must be stated, however, that the whole of the work was carried out during February and March 1932, and seasonal variations may affect the results to a considerable extent. It is generally admitted, however, that conditions on the shorter waves are definitely worse during the summer months than in winter, so that the comparison tends to be favourable to the shorter waves; this point must be borne in mind when discussing the results.

The wavelengths within the waveband which were selected, chiefly for reasons of freedom from interference, were 205, 243, 316, 443, 646, 797 metres. No longer wavelengths were used both on account of lack of time and by virtue of the fact that the results on 646 and 797 metres showed definitely that propagation was tending to what might be called "normal" as the wavelength increased so that established empirical formulae could be applied without serious error for calculation of field strength on wavelengths above 800 metres.

The total number of observations taken on each wavelength varied generally between 100 and 180, which is sufficient to enable a smooth curve to be drawn.

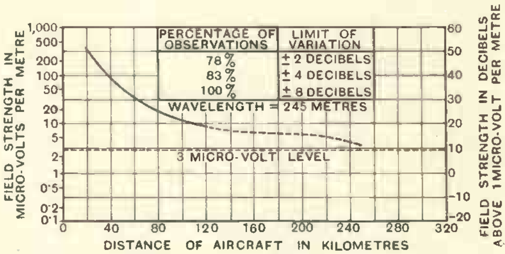
Curves were accordingly drawn through the points obtained. This was done separately for the "absolute" values and for the "relative" ones and the two curves superposed and averaged. The discrepancy between the two curves was very small indeed, the total attenuation between 12 and 200 miles differing by not more than 3 decibels in a total of 30 to 40 or more. On the longer waves indeed the curves when superposed could not be distinguished from each other.

To avoid unnecessary tabulation, the results are shown plotted in curves 1 to 6, these being the average curves as described above. On each curve a statement is included of the number of observations and their maximum and mean differences from the mean value. This gives a measure of the reliability of the readings as taken.

The curves of variation of field strengths with distance were analysed in an attempt to determine the attenuation factor α. It was found, in agreement with results obtained by Fassbender (see *Proc. I.R.E.*, August, 1931); that the value of α varies over a very wide range. There does not seem to be any virtue in giving values of α which cannot be applied in a general formula, and it was therefore decided that the curves of field strengths only would be shown. In all cases the values plotted were corrected to a level of 200 watts imput to the transmitter, the practical conditions obtaining in the tests being 85 watts input.

This value of 200 watts has been chosen as it represents approximately the maximum value acceptable at the present time for the power supply to an aircraft transmitter. As a general rule, smaller powers are used, but the basis of 200 watts can be reckoned as a commercially practicable maximum at the present day. It tends to favour the shorter wavelengths by raising the signal strength to a value approaching, but yet failing to reach, the essential minimum required for satisfactory working for telephony on the shorter wavelengths.

It was assumed that the propagation curves for ground to air working would be the same as for air to ground, but in order to establish this point



CURVE 2.—*Input to aircraft transmitter*, 200 *watts; length of aerial*, 150 *feet; effective height of aerial*, 6.3 *metres; aerial current*, 2.5 *amps. Average of* 36 *readings. The dotted lines shown after* 120 *km. is rather doubtful owing to serious interference from broadcasting stations.*

definitely a test was made on the wavelength of 205 metres receiving in the air from a ground transmitter (C.W.).

The conditions on the ground gave a metre-ampere value of 120 as against 11.6 for the aircraft tests on the same wavelength, thus showing an advantage of 20 decibels for the ground transmitter.

The aircraft was flown to a distance of 200 miles, readings being taken by means of an attenuator over the whole of this distance. An actual reading of field strength was also taken at a distance of 10 miles to fix the level of the received field strength curve and the result was plotted. This is given in curve 10.

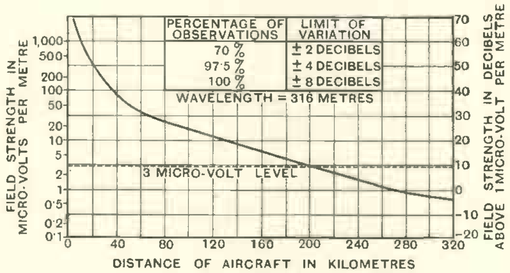
It will be seen by comparison with curve 1 that the agreement is satisfactory both as regards the shape of the curve and its actual level. At 200 miles the field strength on No. 1 curve is 10 decibels below 1 microvolt, whereas on No. 10 curve the level is 9.5 decibels above 1 microvolt, *i.e.*, a difference of 19.5 decibels, which is in very good agreement with the figure of 20 decibels quoted above for the ratio of metre-amperes.

It can be assumed, therefore, that the curves 1 to 6 can be used for ground to air propagation as well as for air to ground.

Discussion of Curves.

Inspection of the curves brings out three important facts having a bearing on the final choice of wavelengths.

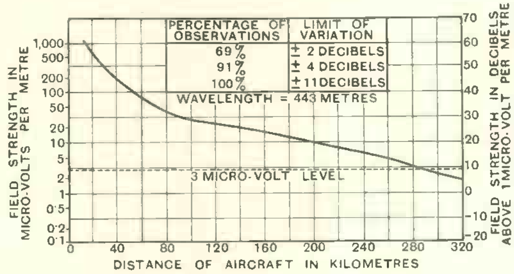
In the first place, it is noticeable that attenuation is roughly constant on medium-long waves and can be expressed roughly as 0.07 decibels per mile



CURVE 3.—*Input to aircraft transmitter,* 200 *watts ; length of aerial,* 150 *feet ; effective height of aerial,* 6.3 *metres ; aerial current,* 2.5 *amps. Average of* 115 *readings.*

on 800 metres (irrespective of reduction of strength due to spreading of the wavefront). The attenuation on the shorter waves, however, is very much greater in the first few miles than beyond the 12-mile point. This characteristic was further investigated and supplemented by a short series of ground-to-ground tests over the distance 0 to 12 miles ; the results were plotted and the curves produced were found to fit very satisfactorily with the air to ground measurements as regards their final slope at the 12-mile point.

It is clear from the curves that effective attenuation on the short waves is considerably less at distances in excess of 12 miles than at shorter distances ; in some cases the attenuation is even negative ; this is a clear indication of considerable reflection and/or refraction from various causes, including refraction from the higher atmosphere. No attempt will be made here to determine the effective height from which reflection takes place or what is the actual cause of the reduced attenuation, as this subject is outside the scope of this paper. This subject is discussed by Pedersen (see *Dan. Natur. Sam. A* NR15a). The fact remains, however, that on the shorter waves indirect propagation is the rule above 12 miles and consequently the field strength will depend almost entirely on the intensity of the indirect rays and



CURVE 4.—*Input to aircraft transmitter,* 200 *watts ; length of aerial,* 200 *feet ; effective height of aerial,* 9 *metres ; aerial current,* 2.5 *amps. Average of* 125 *readings.*

will therefore be liable to large fluctuations of a diurnal and seasonal character.

In the second place, it will be seen that the field intensity is considerably more on the longer waves at all distances from 12 to 200 miles, and that on the basis of a 200 watt supply the field strength is always amply sufficient to provide a satisfactory telephony service, whereas on the shorter waves the signal intensity is barely sufficient to maintain a C.W. telegraphy service up to a distance of 200 miles.

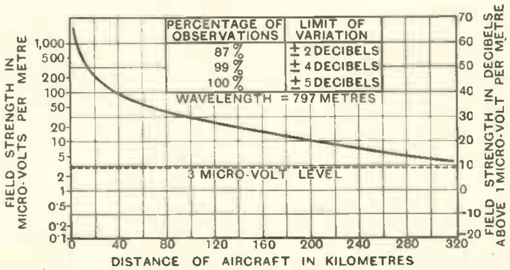
A further point of interest is that at various distances signals on wavelengths at the top of the medium waveband show a distinct tendency to reduced intensity as compared with those on the shorter waves of the band. It would appear that a wavelength of the order of 1,500 metres gives optimum signal strength for a given power input. This fact is due not to attenuation but to reduced radiation in view of the gradual reduction of the radiation resistance of the aerial with increase of wavelength. This reduced radiation resistance is itself occasioned by the fact that there is a practical limit of aerial length beyond which it would

CURVE 5.—*Input to aircraft transmitter,* 200 *watts ; length of aerial,* 200 *feet ; effective height of aerial,* 9 *metres ; aerial current,* 1.7 *amp. Average of* 35 *readings.*

be uneconomical and undesirable to go ; this may roughly be put at 250 to 300 feet. Such a limitation does not arise in so marked a degree on the shorter waves. Thus an average 250 foot aerial radiating on a wavelength of 2,500 metres has a radiation resistance of 0.125 ohms, whereas a 250 foot aerial radiating on 1,250 metres has a radiation resistance of about 0.5 ohm; this gives an advantage of 12 decibels in favour of the 1,250 metre wave which more than compensates for the loss due to attenuation, which at 200 miles is about 4 decibels over the type of country such as that flown over in the measurements here described. The variation of field strength with wavelength at a distance of 200 miles on a power input basis of 200 watts is given in curve 7. For the plotted values above 800 metres information was taken from Pedersen (see above) and are not the result of observation on these wavelengths; they are shown dotted as being of interest only.

Working on the preceding premises there has been worked out the power input required in the aircraft transmitter to produce equal field strength on all wavelengths between 200 and 1,000 metres at a range of 200 miles. This is shown in curve 8, which brings home more forcibly the fact that not only do the longer waves require far less power input than the shorter ones, but also that the power required on the shorter waves is prohibitive.

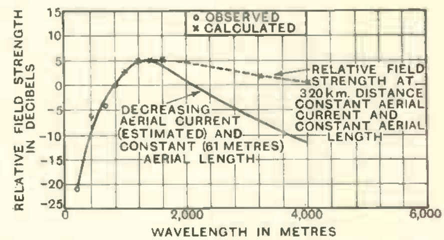
With regard to the question as to what is the economical length of aerial to use and what the effect would be if lengths were increased (*a*) on the longer waves, (*b*) on the shorter, the following considerations are relevant.



CURVE 6.—*Input to aircraft transmitter,* 200 *watts; length of aerial,* 200 *feet; effective height of aerial,* 9 *metres; aerial current,* 1.7 *amp. Average of* 187 *readings.*

(*a*) *Long Waves.*—To remove the disadvantage of waves over 2,000 metres as compared with those in the region of 1,000 metres, it would be necessary to increase the effective height of the aerial in the ratio of about 2 : 1. This improvement could be obtained in theory by either increasing the length of the aerial or increasing the trailing angle to the horizontal. The first method would necessitate an increase in length from 250 feet to about 500 feet and is therefore not practical. The second method would require use of a combination of aerial wire of finer gauge and a heavier streamline weight. Although an improvement would be possible in this direction, it would necessitate the use of steel wire; its dead loss resistance would be higher than that of copper and part of the advantage would be lost.

(*b*) *Short Waves.*—In the case of short waves a substantial increase of effective height by either of the means referred to is certainly possible, but it must be noted that such increase of effective height would be attended by a substantial increase not only of the radiation resistance as intended, but also of the total circuit resistance with corresponding decrease of aerial current. The gain would thus be partly nullified and the improvement of field



CURVE 7.—*Relative field strength for different wavelengths at* 320 *kilometres distance. The curve indicates the relative field strength at* 320 *kilometres* (200 *miles*) *with constant power input, below* 800 *metres the curve represents the results of tests* (*see curves* 1 *to* 6); *above* 800 *metres the curve is based on the assumption of ground propagation and that the aerial length is constant at* 61 *metres.*

strength which would be obtained would be too insignificant to raise the short wave field strengths to the required working level.

Part II.—Comparison of Telephony and Telegraphy Levels

Experiments were carried out to determine to what extent field strength of satisfactory level for telegraphy (C.W.) has to be increased to produce a satisfactory level for telephony.

The ratio of these two field strengths depends partly on the class of speech and to a greater extent on the depth of the modulation. The class of speech envisaged here is straightforward talk without code words and therefore requiring only average intelligibility. Depth of modulation varies widely with the type and make of transmitter, the pitch and strength of the operator's voice and microphone efficiency. There was taken as a basis the general conditions obtaining in the British broadcasting stations. It is generally accepted in commercial practice that telephony working requires a carrier about 18 decibels greater than is necessary for telegraphy. In order to obtain a rough check of this figure the following test was made.

A receiver was tuned in to the London Regional Station during a broadcast talk; the carrier was heterodyned by bringing the receiver just above the point of oscillation. The received signal was gradually attenuated by means of an output attenuator calibrated in decibels until the heterodyne note, which was artificially cut up into Morse signals, heard in the telephone was reduced to the lowest level where Morse signals were distinctly readable. The receiver was then brought to a point just below self-oscillation where the sensitivity was approximately equal to that obtaining for the oscillation adjustment. The attenuator was then gradually cut out until speech was clearly intelligible and the change of attenuation was noted. This test was repeated with half a dozen different observers and the average was taken. It was found that all observers agreed with each other to within 4 decibels, the ratio of telephony to telegraphy being about 20 decibels. It was observed that an operator of average skill required less change of attenuation when changing from telegraphy to telephony than was the case with a skilled operator. The latter could read Morse of such a low level of intensity that it was insufficient for an average observer, whereas for telephony the absolute level was the same for all.

This test was carried out under conditions of average requirements for reception on telephones. The conditions for commercial international public telephony are generally of a higher level but the ratio of telegraphy to telephony field strengths as here reported appears to be appropriate for a telephony service to and from aircraft.

This test enables us to convert the field strength values for ultimate telegraphy reception measured as described later to the field strengths required for telephony reception. The increase required is taken as 20 decibels as stated above. This ratio will obviously be roughly the same for all wavelengths under similar conditions.

Part III.—Field Strengths for Telegraphy.

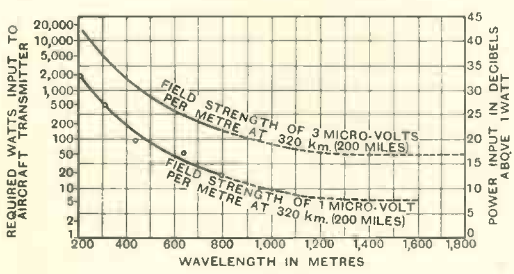
(*A*) Reception in aircraft.

(*B*) Reception on the ground.

These series of measurements were carried out separately for reasons of convenience. For this purpose the procedure was as follows :—

(*A*) A ground transmitter was supplied with a variable H.T. supply the value of which could be varied from 30 to 1,200 volts. The aerial current was read by means of a series of thermo-ammeters ranging from 40 milliamps to 2 amps.

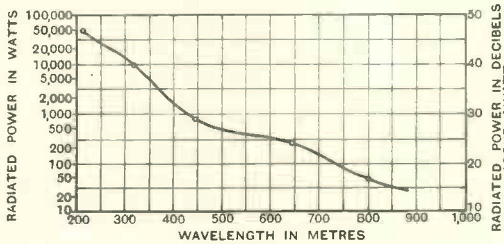
The aircraft was taken to a point at a distance of 12 miles from the ground transmitter and flew continuously over a short track immediately above



CURVE 8.—*The curves indicate the required power input to an aircraft transmitter to give a definitive field strength at a distance of 320 km. (200 miles). Points obtained from data given in curves 1 to 6. The dotted line is an extension of curve on the assumption that above 800 metres the field strength is due entirely to the ground propagation.*

a field strength measuring equipment. A preliminary test had been made to determine to what extent signal strength varied from ground level to the height at which the aircraft flew. This was done by means of an attenuator fitted to the output of the receiver. The aircraft signal was found to change by not more than 2 decibels from ground level to its normal height (2,000 feet); this reduction seemed to occur immediately on leaving the ground and remained constant throughout the changes in height.

Transmissions were then made for periods of 10 minutes on each adjustment. The aerial current was attenuated in steps of approximately 6 decibels



CURVE 9.—*Radiated power required to give a field strength of 30 micro-volts per metre at a distance of 320 km. (200 miles) for various wavelengths. The curve is based on the results given in the curves 1 to 6 and gives an indication of the radiated power required from a ground transmitter to give telephony communication to an aircraft at a distance of 320 km. (200 miles).*

until the lowest obtainable level was reached. During each transmission a characteristic signal and a test message in Morse were sent. The observer in the aircraft determined which transmission gave the lowest readable signal above set-noise while the observer on the ground determined the field strength of each group.

This was repeated over the range of wavelengths previously used in the field strength tests.

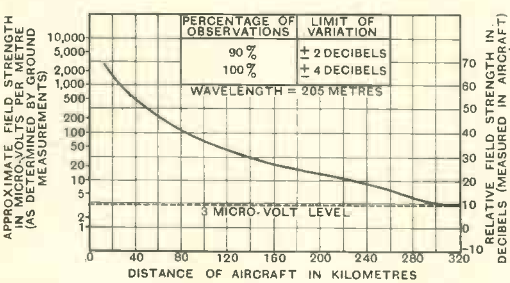
TABLE I.

Wave-length in Metres.	Reception in Aircraft. Min. *e* for *W/T* μ Volts/Metre.	Reception in Aircraft. Min. *e* for *R/T* μ Volts/Metre.	Reception on Ground. Min. *e* for *W/T* μ Volts/Metre.	Reception on Ground. Min. *e* for *R/T* μ Volts/Metre.	Dif. *db*
205	4.2	42	0.1	1.0	
320	3.1	31	0.39 0.37 0.37 0.31	3.9 3.7 3.7 3.1	
800	2.1	21	0.36	3.6	
Aver'ge	3.1	31	0.32	3.2	20
Column	(1)	(2)	(3)	(4)	

The results showed that no very great changes of field strengths occurred throughout the band of wavelengths. There is a tendency for the shorter waves to need stronger field strengths. This may be due to the fact that the internal noise level in aircraft is worse at the shorter wavelengths, partly on account of magneto and other interference. The values are given in Table I (columns 1 and 2). It is to be noted that the above tests were largely independent of receiver sensitivity as the final controlling factor in reading the weakest signal was the receiver noise level. Actually the receiver consisted of one stage of screen grid amplification, a detector and 3 L.F. amplifiers. The L.F. stages had a gain of about 70 decibels. It is true that with the addition of high grade H.F. filters a substantial improvement can be made in diminishing the receiver noise level but such filters when really effective impose extra weight and complication on the receiver and are mostly applicable for use on telegraphy. As the criterion here is telephony, it is assumed that selectivity will be of the highest degree obtainable by relatively simple tuned circuits. The figures given in Table I (column 2) can therefore be taken to be a fair indication of the values of field strengths required to receive telephony in aircraft. These values are obtained by adding 20 decibels to the figures obtained on C.W.

(*B*) For reception on the ground the same procedure was employed using in this instance a higher grade receiver and working down to noise level as before.

Here again the minimum readable signal was compared with the field strength reading. The results are given in column (3) of Table I and the corresponding telephony levels are shown in column (4).



CURVE 10.—*Relative field strength measured in aircraft from 0 to 320 km. Wavelength 250 metres ; height of vertical transmitting aerial, 27 metres, aerial current,* 8.6 *amps. Average of* 42 *readings.*

The appropriate value of necessary field strength to give just readable telephony signals on the ground is marked by a horizontal line on the curves 1–6. This shows the shortest wavelength on which satisfactory working is obtainable under conditions of 200 watts limiting permissible input to the transmitter.

Curve 9 shows the energy which would have to be radiated from a ground transmitter to provide satisfactory telephony communication with an aircraft at a distance of 200 miles on all wavelengths between 200 and 1,000 metres.

External Noise Background.

It was thought desirable to determine, in addition to radio characteristics, the effect of mechanical vibration and noise on the ears of an observer fitted with a good quality flying helmet.

For this purpose there was installed in the aircraft a telephonic intercommunication set without amplifier to which an output indicator was fitted.

An adjustment was made on the ground with the engines stopped giving the minimum intelligible strength in the telephones. A fresh adjustment was made in flight at cruising speed and the two were compared. This was repeated with a number of observers and the average taken. The results are shown in Table II. Allowance should be made for the noise picked up by the microphone so that the figures here given are slightly in excess of actual conditions when receiving telephony.

It is seen that quite apart from electrical and mechanical disturbances affecting the performance of the radio receiver there is a considerable amount of interference of a more direct kind tending to

TABLE II.

Observer.	Aircraft in Flight. Relative Voltage *db* above 1 Volt (Mean).	Aircraft on Ground (Engines off). Relative Voltage *db* above 1 Volt.	Dif.
No. 1	+9.5	−30.4	40
No. 2	+6.0	−29.1	35

Mean voltage across 2,000 ohm telephones required for intelligible speech in aircraft in flight and on the ground.

mask the signals heard. This is allowed for automatically in the curves 1 to 6 but it is mentioned separately as a matter of interest. It should be noted that the requirement of about 40 decibels increased strength in the telephones is partly set off by an 18 decibel increase of field strength to overcome set-noise level. The remaining 22 decibels are provided by an increase in the amplification of the receiver. A receiver with this amplification used on the ground would be excessively noisy.

Thus the total effective weakening of signals in aircraft is composed of two effects :—

(*a*) electrical and mechanical disturbances in the receiver, requiring greater field strength ;

(*b*) acoustic disturbances impinging in the ears of the observer directly through the helmet and indirectly through the cranial bones and requiring greater receiver output.

Provided the receiver amplification is suitably increased in the air, these two effects produce a signal intensity difference of 20 decibels between air and ground conditions (as shown in Table I).

Conclusions.

In view of the limitations of aircraft transmitter power and aircraft reception efficiency, it is clear that for a range up to 200 miles wavelengths appreciably below 700 metres are not satisfactory for the maintenance of telephony communication to and from aircraft with an adequate factor of reliability.

Acknowledgments : This paper is published by permission of the Air Ministry. The authors are particularly indebted to Mr. F. S. Barton, M.A., for valuable assistance, to Mr. N. Cox-Walker, Mr. R. T. Smith and Mr. N. Johnson-Ferguson for careful measurements in an aeroplane in flight under difficult experimental conditions, and generally to the Flying Staff of the Royal Aircraft Establishment for the keen interest which they took in flights made to obtain the data contained in the present paper.

A Multi-range Direct-reading Ohmmeter*

By M. G. Scroggie, B.Sc., A.M.I.E.E.

WHILE direct-reading instruments for current and voltage are obtainable in literally thousands of types, there are very few representatives of meters calibrated in ohms. One reason for this state of affairs is that a continuous indication of resistance is not commonly required, and consequently there would be no overwhelming desire to cover switchboards and panels with ohmmeters, even if they were available. Another reason is that, owing to the necessity for a battery or generator, an ohmmeter is always less simple than a voltmeter or ammeter need be. A battery does not last for ever, and so requires periodical attention; and a generator is costly and requires manual effort to obtain a reading.

Though the instrument to be described is not sufficiently revolutionary in character to overcome the need for a battery, the following list of advantages which apply to it may possibly be deemed to atone for failure to chieve the impossible.

(1) The indicating portion of the instrument is of a standard type, which has by itself a large field of usefulness.

(2) It is direct-reading.

(3) It covers a wide range of readings, particularly of low values where most other ohmmeters are inapplicable. Four or more decimal ranges may be combined.

(4) One scale serves all ranges.

(5) The scale shape is useful, the accuracy of reading being best in the middle and fairly constant over most of its range.

(6) The battery voltage—normally from a 2-volt cell—need not be accurate, and requires only one preliminary adjustment for compensation.

(7) It is impossible to damage the instrument by any value of connected resistance from zero to infinity. The soundness of a joint or switch contact can be tested by "tickling" it, without any fear of the pointer disappearing from view.

(8) It is possible to detect a change of resistance in some cases as small as 0.0001 ohm—another valuable feature for contact testing.

(9) The cost is not large.

The nucleus of the instrument is a standard "Unipivot" galvanometer as produced by the Cambridge Instrument Company, from whom the ohmmeter accessory may also be obtained.†

It is obvious that if an ammeter is supplied with current to give full-scale reading, the effect of shunting it with a resistance equal

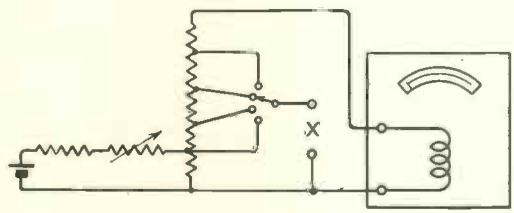


Fig. 1.

to its own resistance is to reduce the reading to half full-scale, assuming that the resistance of the supply circuit is sufficiently large to keep the total current sensibly constant. Thus, by fitting the instrument with a suitable scale it may be used to indicate directly unknown resistances of values around that of its own resistance.

This idea has been utilised for measuring low resistances.‡ It is clear that in order to make it more useful for general purposes it is necessary to have means for varying the shunt resistance without altering the full-scale reading. This is done by tapping the battery across a fixed portion of the shunt, and the unknown resistance across a portion which is determined by the range switch (Fig. 1).

In order to avoid error it is necessary for the battery current to be affected only to a small degree, say, not more than 1 per cent., by the connection of any resistance to the "*X*" terminals. Thus, if a 2-volt cell is used, the half-scale drop across the battery shunt should not greatly exceed 20 millivolts. As mid-scale reading is given by the more usual types of "unipivot" instrument with 1.2 millivolts, the difference allows plenty of added resistance for swamping tempera-

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

† Prov. Pat. No. 25594/32.

‡ L. H. Bainbridge-Bell, *Jour. Sci. Inst.*, April, 1929, Vol. 6, pp. 139–140.

ture errors, for ensuring rapid deflection of the pointer, and for the necessary range taps.

The battery shunt drop has been fixed at 24 millivolts at mid-scale, so that if the reading is arranged to be correct at this point there is a maximum error on the lowest range, due to battery current variation, at the extremes of the scale, of about 1 per cent. The error on the other ranges is quite negligible, as the "*X*" resistance does not appreciably affect the battery current.

The battery current is determined by the lowest range desired. In the present case the mid-scale resistance on the lowest range is 0.05 ohm, so this is also very closely the battery shunt resistance, and the two in parallel are required to drop 24 millivolts. The current is therefore 0.96 amp., and is determined by a fixed series resistance with a rheostat to compensate for varying battery voltages. This is done by setting the pointer to full-scale deflection with the "*X*" terminals open.

The question of range-switch contact naturally arises in connection with an instrument capable of very low readings. It will be noticed that the whole of the shunt circuit is independent of switching, and that as the switch is in series with the "*X*" terminals its resistance and that of the leads are allowed for in the preliminary short-circuit reading that is always desirable when such low resistances are being measured. The true value is, of course, the difference between the reading with the unknown in circuit and that with it shorted. This procedure is not usually necessary for the higher ranges.

The highest possible range is determined by the current sensitivity of the galvanometer. For the maximum internal resistance across the "*X*" terminals (equal, as before, to the mid-scale value of *X*) is obtained when the range-switch divides the total resistance of shunt plus meter into equal portions, and the available millivolt drop having already been settled, the maximum possible resistance is limited by the current required for deflection. The instrument described is normally fitted with a 10-ohm coil, and this is brought up to 200 by the swamp resistance and shunt. Divided in half this gives two resistances of 100 ohms each in parallel across the "*X*" terminals, i.e., 50 ohms, which is the value of *X* for mid-scale reading.

This being 1,000 times the lowest range, there is room for two more decimal ranges, given by appropriate tappings. The central values of the four ranges are therefore 0.05, 0.5, 5, and 50 ohms. With a 1,000-ohm galvanometer, which has ten times the current sensitivity, it is possible to provide a fifth range around 500 ohms. Satisfactory readings are given from one-fifth to five times the central values, and rough readings beyond these limits. Fig. 2 shows the complete instrument, and Fig. 3 the scale. It is possible to have this scale fitted along with the usual current, etc., markings, but as it obeys a simple law it is quite an easy matter to cut a piece of bristol-board to fit the recess of the meter, with a curved slot to render the pointer and parallax mirror visible, and to mark this with the resistance scale. It can then be laid on the glass when resistance readings are desired, without

Fig. 2.—*Standard "Unipivot" galvanometer with the ohmmeter coupled to it.*

opening up the instrument. Incidentally, this is a useful dodge for applying direct-reading scales to valve voltmeters and many other pieces of equipment that do not fit the printed scale.

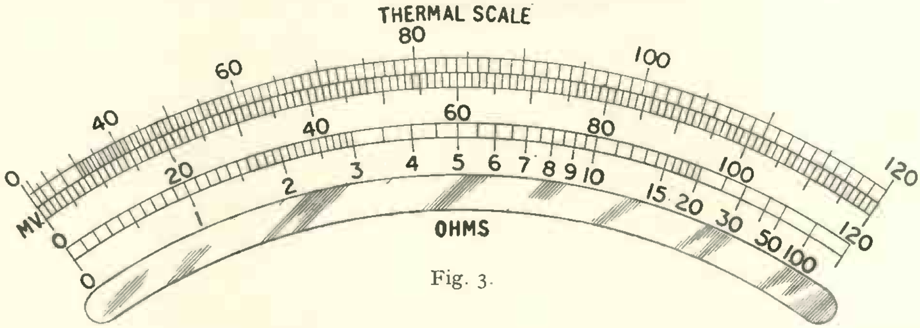

Fig. 3.

To relate the resistance scale to a linear scale, let the resistance scale reading for X ohms be S_x on the linear scale, and let X_m and S_m be the corresponding mid-scale readings. Then $S_x = \frac{2S_m}{1 + \frac{X_m}{X}}$

A variation of the method, to cover higher ranges of resistance, omits the battery shunt portion; so that all the current, except that shunted by X, passes through the coil of the instrument. The current taken is thus of the order of microamperes, but a higher voltage—an ordinary 100-volt "H.T." battery for example—is necessary. Fig 4 shows the circuit, which can be arranged to give central values of 500 and 5,000 ohms, giving an effective range of 100 to 25,000 ohms. It is possible to go ten or twenty times higher by this method, using a 1,000-ohm galvanometer.

The most useful application, however, and one which does not appear to be conveniently provided by any other appliance, is for low resistance readings, particularly those that are suspected of being variable. The *ordinary* type of Wheatstone bridge is remarkably inaccurate at low readings, and in any case entirely fails to allow tests to be made on fluctuating resistances. It would, in fact, be highly dangerous to the bridge galvanometer to attempt to measure the contact resistance of a bad joint or switch. Moreover, a direct-reading instrument saves much time in production testing, and acceptance limits can be marked, so that unskilled assistants can be entrusted with the work, or even replaced by automatic devices.

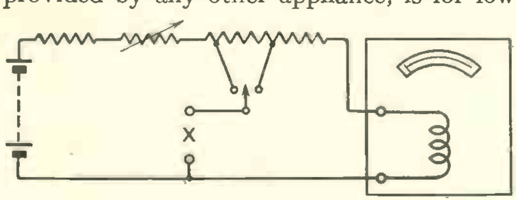

Fig. 4.

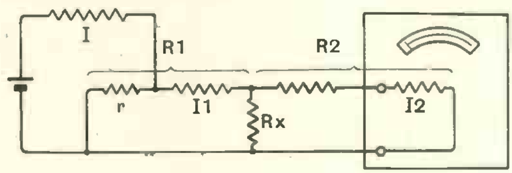

Fig. 5.

APPENDIX

Derivation of shunt values.

See Fig. 5. Battery current assumed constant. When R_x is not connected, galvanometer current

$I_2 = \frac{Ir}{R_1 + R_2}$ (full-scale current).

When R_x is connected, $I_1 = \frac{Ir}{R_1 + \frac{R_2 R_x}{R_2 + R_x}}$

$$I_2 = \frac{I_1 R_x}{R_2 + R_x}$$

$$= \frac{IrR_x}{(R_2 + R_x)R_1 + R_2 R_x} = \frac{IrR_x}{R_x(R_1 + R_2) + R_1 R_2}$$

Let ρ = ratio of galvanometer current with R_x connected, to full-scale current.

Then $\rho = \frac{1}{1 + \frac{R_1 R_2}{R_x(R_1 + R_2)}} = \frac{1}{1 + \frac{R_0}{R_x}}$

where $R_0 = R_1$ and R_2 in parallel. Hence rule for scale reading given in the text.

When $R_x = R_0$, $\rho = \frac{1}{2}$, as explained.

Note that this is independent of r, the battery shunt tapping.

Thus, when R_x is the resistance for half-scale reading, $R_x(R_1 + R_2) = R_1 R_2$, giving the required range tapping on $(R_1 + R_2)$.

Modifications in the New Impedance Measuring Set*

By A. T. Starr, M.A., B.Sc., A.M.I.R.E.

(Faraday House)

Introduction

IN *The Wireless Engineer* of June, 1932, I gave the theory of a new impedance measuring set, in which only resistances are used. Actual switching arrangements were not shown. Mr. James Steffensen described an arrangement in the September, 1932, number and gave also a table for the phase angle in place of the graph.

The arrangement of Mr. Steffensen includes the device (due to Professor Howe) for decreasing the effect of "turn-over," but an alteration has introduced the undesirable feature that the supply current is broken by each change of position of the voltmeter switch.

This present paper gives wiring diagrams of two sets (made by the Sifam Electrical Instrument Co., Ltd. and the author). The second set is for use when the measuring current is to remain fixed during the measurement, and contains an artifice which is an extension of a device used in the Tinsley potentiometer. Also a set is described for use at very high frequencies, when resistances are not reliable because of skin-effect and stray capacities.

The Simple Set.—Set A

The arrangement is shown in Fig. 1. The impedance to be measured is put between 1 and 2, the (Moullin) voltmeter between 5 and 6, and the source between 7 and 8. Key 1 is a simple change-over switch, and this is sufficient, if a reasonable oscillator is used, as "turn-over" will then be negligible. A suitable type is a Wearite anti-capacity switch. In the left position, the two key terminals on the left are shorted and the two on the right are open; and conversely for the right position. In the left position of the switch the voltmeter is across Z, in the right across R_1.

Key 2 behaves in a similar fashion. The left position is for R_1 and the right for R_2, when, also, R_1 is placed across Z.

Terminals 3 and 4 are for the insertion of a condenser of large value to determine the sign of ϕ. Normally they are shorted by a copper strip. In measurements of loudspeakers and pick-ups the sign of ϕ is usually positive, and these terminals remain shorted.

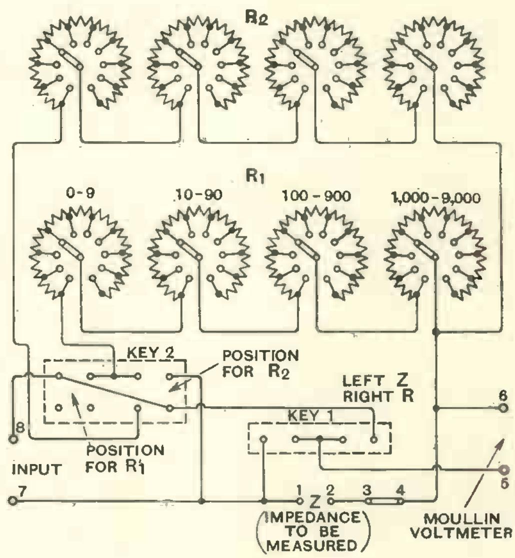

Fig. 1.

The maximum of R_1 is 9,999 ohms. R_2 need not have the last three thousand ohms, as it can never exceed 7,070 ohms, if R_1 is not to be greater than 9,999 ohms.

A More Elaborate Set.—Set B

This arrangement, shown in Fig. 2, allows the measuring current to be kept at a constant value during measurement. There is a special difficulty in a set of this kind, which is met also in the Tinsley potentiometer, viz., to keep the total impedance of the circuit constant and tap off the voltage across a variable portion, when more than

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

two dials are used. The way in which this difficulty is overcome in the Tinsley potentiometer is as follows. Let us assume for simplicity that there are three dials with ten positions each. (Actually the leading dial has twenty positions and the others have a hundred each). The arrangement is shown in Fig. 3. The units and hundreds are included in the main current circuit, but the tens are not. The tens dial has resistances 20, 40, . . . 200, and the total of 200 ohms is shunted across 200 ohms in the hundreds by the dials D_1 and D_2, which move together. In any position of the contacts and dials the resistance between A and B is 910 ohms, the resistance between D_1 and D_2 being 100 ohms, not 200. The variable voltage is tapped off between C and D and in the case shown is across 464 ohms. Only D_1 need be visible. If D_1 is to go up to 1,000, D_2 must go up to 1,200, in which case the total resistance is 1,110 ohms.

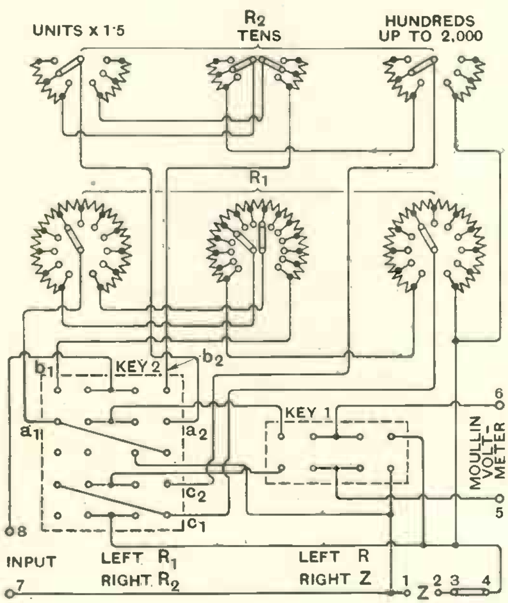

Fig. 2.

For the purpose of this set the method is modified. The tens and hundreds (the latter go up to 2,000) form the main current circuit. The tens have two contacts 30 ohms apart and units, which are multiplied by 1.5, are placed across these 30 ohms. Two-thirds of the total current pass through the unit

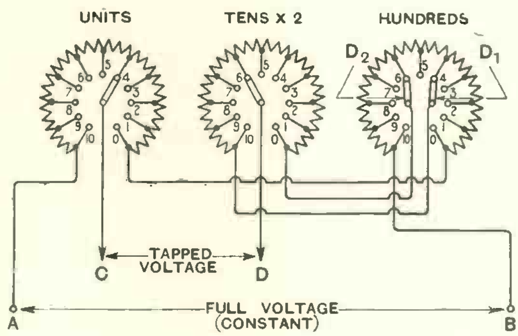

Fig. 3.

resistances, and, since the resistances are multiples of 1.5 ohms, the resulting drop is the same as if the total current had passed along so many ohms. The reading for R_1 is thus direct and exact. The position of key 2 is to the left for R_1. When key 2 is switched to the right (R_2 position), the resistance that is placed across Z is the resistance between a_1 and c_1. Let h = the hundreds, t = the tens, and u = the units of R_1, then this resistance is

$$100h + 10t + u[1.5 - u/20]$$
$$= 100\,h + 10\,t + u', \text{ say}$$

Values of u and u' are given at the foot of this page.

The error at most is 1.25 ohms, but it must be remembered that the error affects only the value of ϕ and not the value of Z. The greatest error is when Z is a pure resistance, when the effect is to increase the numerical value of ϕ. A low resistance of 15 ohms would be read as 15/30°, 25 ohms as 25/25°, but the error diminishes rapidly as the resistance increases; at 105 ohms the error is only about 4°. When Z has a phase angle, the error is considerably less. In any case, when the impedance to be measured is less than 1,000 ohms, two decades can be used and the error entirely avoided. When the

u	0	1	2	3	4	5	6	7	8	9	10
u'	0	1.45	2.8	4.05	5.2	6.25	7.2	8.05	8.8	9.45	10

impedance is greater than 1,000 ohms, the error is quite negligible.

If one were to use the values in the Tinsley potentiometer, the error would be much greater. For if the units were multiplied by 2 and placed across 20 ohms, the values of u and u' are the following. The formula for u' is $u' = 2u\,(1 - u/20)$.

u	0	1	2	3	4	5	6	7	8	9	10
u'	0	1.9	3.8	5.1	6.4	7.5	8.4	9.1	9.6	9.9	10

The general theory of this kind of device is simple and interesting. Let x of the ten-ohm resistances be shunted by 10 resistances, each of y ohms, in series. (See Fig. 4). The ratio of the total current that goes through the latter is $x/(x + y)$. If the reading is to be direct, the volt-drop of this part of the current across y ohms must be the same as the volt-drop of the total current across 1 ohm. This gives the condition $xy/(x + y) = 1$.

Then

$$u' = uy(10x + 10y - uy)/10(x + y)$$
$$= u(x - u/10)/(x - 1).$$

The error is $u' - u$, which has a maximum at $u = 5$ for all values of x, the maximum error being $5/2(x - 1)$. The Tinsley potentiometer uses $x = 2$, and our device $x = 3$. If we use $x = 4$, $y = 4/3$, and the maximum error is reduced to 5/6 ohm.

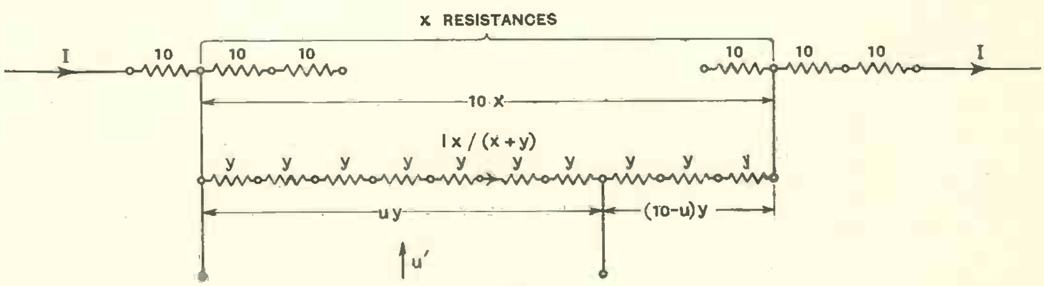

Fig. 4.

Capacities in Place of Resistances

Professor Trewman has pointed out that resistances are not reliable at very high frequencies. In that case capacities can be used. The procedure is exactly the same and if C_1 and C_2 are the capacities corresponding to R_1 and R_2, we have

$$Z = 1/\omega C_1 \quad .. \quad .. \quad .. \quad (1)$$

where $\omega = 2\pi x$ frequency of test,

and $1/\omega C_2$ = magnitude of $1/[(1/Z|\underline{\phi}) + j\omega C_1]$

= magnitude of $Z/[|\overline{\phi} + j]$

= magnitude of $Z/[\cos\phi + j(1 - \sin\phi)]$

$= Z/\sqrt{2 - 2\sin\phi}$.

Therefore $\sin\phi = 1 - \frac{1}{2}(\omega C_2 Z)^2$

$$= 1 - \tfrac{1}{2}(C_2^2/C_1^2) \quad .. \quad (2)$$

The vector diagram proof is simple, as in the case of the resistances.

There is an advantage here in that (2) gives the sign of ϕ, but on the other hand the frequency must be known to the accuracy required for the impedance. Another advantage is that this method is sensitive near $\phi = 0$.

Here the maximum value of C_2 is 2 C_1, which occurs at $\phi = -\pi/2$, *i.e.*, for a pure capacity. If Z is a nearly pure inductance, the shunting of C_1 causes parallel resonance and C_2 is very small. Small errors of capacity in such a case will introduce a large error in the estimate of resistance of the parallel circuit, but this will affect the estimate of the phase angle by a small amount only. This error, however, will produce an important error in the calculated a.c. resistance of the coil. Switch capacities must therefore be kept very low.

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.

Demodulation

To the Editor, The Wireless Engineer.

SIR,—An interesting point arises out of Mr. Callendar's "Note on Demodulation" in your September issue.

All deviations from the ideal rectifier circuit hitherto discussed indicate a reduction in demodulation effect from that to be expected from Butterworth's formulae.

The experimental values obtained by Mr. Callendar are in excess of Butterworth's figures, results attributed to overloading.

Is it not obvious that by the use of a unidirectional conductor whose rectification characteristic shows a slope decreasing with increased voltage, the mean rectified current may be made actually to decrease by the superposition of the interfering signal, and that for given values of A and B signal amplitudes, a characteristic may be chosen which will give a value of rectified current independent of B, and hence perfect obliteration of the unwanted signal? In short, validate Beatty's results by adjustment of the rectifier characteristic to make the rectified heterodyne envelope sinusoidal, or at least to have a mean value independent of its amplitude.

The amplitude distortion of the wanted signal could be compensated, after removal of all HF and supersonic components, by application of the audio and DC to a subsequent amplifier having a rising amplitude characteristic.

The system is particularly applicable to receivers with automatic control of detector input, and should be adjusted to give perfect demodulation with that value of interfering signal which is the largest obtained in practice through the preceding tuned circuits, the number and magnification of which could be greatly reduced.

Suitable rectifiers will not be hard to find. Examples are the carborundum crystal, the thermionic diode with neutralised space charge (*e.g.*, pentode) and Mr. Callendar's AB-cum-LG triode.

Handsworth, Birmingham, 20. G. FARREN CLARKE.

Decoupling Efficiency

To the Editor, The Wireless Engineer.

SIR,—An article and alignment chart on "Decoupling Efficiency" was published in your June issue of this year. In using this chart, however, it was found that such high efficiencies as it attributes to certain values of resistances and condensers were not obtainable in practice.

The reason is this:

Mr. Barclay states that the decoupling efficiency is given by the expression:

$$\frac{R}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}} \times 100\%$$

Take a common form of grid decoupling shown in Fig. 1 which consists of an L.F. amplifying valve, transformer coupled to the previous stage. The resistance R_1 serves to supply the valve with bias. The grid-cathode circuit is decoupled by means of C and R. It is the voltage E developed across R_1 which we wish to prevent as far as possible from being included in the grid-cathode circuit.

The undesired voltage which will be developed in the grid-cathode circuit is obviously:

$$\frac{E \times \frac{1}{\omega C}}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}}$$

The efficiency will thus be expressed by:

$$100 \left[1 - \frac{\frac{1}{\omega C}}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}} \right] \%$$

Taking a practical example, 10,000 ohms and 1 mf. at 50 cycles have, according to Mr. Barclay, a decoupling efficiency of just over 95 per cent. According to the above formula the efficiency is only about 70 per cent.—a much sadder state of affairs and one only too well borne out in practice.

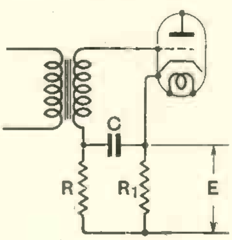

Fig. 1.

Mr. Barclay has assumed that, because 95 per cent. of the undesired voltage is developed across the resistance, there will only be about 5 per cent. remaining to intrude in the grid circuit. The voltages are, however, in quadrature and there will actually be about 30 per cent. intruding since $\sqrt{95^2 + 30^2} = 100$ approximately.

A use does however present itself for the chart. If it be called coupling instead of decoupling efficiency, it can be used for estimating quickly the coupling efficiency of a resistance capacity coupling at various frequencies.

Design Dept., Gramophone Co. R. I. KINROSS.

[This letter raises an important point. Mr. Barclay defined the "efficiency" as the relative proportion of the total L.F. current which is by-passed through the condenser, implying that, if the total current were 100 and he by-passed 70 per cent., only 30 would pass through the resistance. Unfortunately, as the letter points out, 70 per cent. would pass each way and the real efficiency of the device would be 30 and not 70 per cent. Neither Mr. Barclay nor Mr. Kinross mention the phase change which is produced: this will presumably be of some importance as the remanent voltage is almost in quadrature with the total voltage.—EDITOR.]

Abstracts and References

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PROPAGATION OF WAVES

IONOSPHERIC INVESTIGATIONS IN HIGH LATITUDES.—E. V. Appleton, R. Naismith and G. Builder. (*Nature*, 2nd Sept., 1933, Vol. 132, pp. 340–341.)

This note gives a preliminary account of the results of wireless observations made, in connection with the International Polar Year 1932–1933, at Tromsø (lat. 69° 39.8′ N.; long. 18° 56.9′ E.) in Norway, since the beginning of August 1932. The results found at Tromsø have emphasised the fact that an increase in ionisation is very frequently found to occur with a magnetic storm. In high latitudes the correlation is very much more marked than in S.E. England. The upper and lower [*F* and *E*] reflecting regions are found to exist at Tromsø as in England. For undisturbed conditions the daily maximum ionisation content for both upper and lower regions is less at Tromsø than in S.E. England, but the seasonal variation of normal ionisation is greater in high than in temperate latitudes. Disturbed conditions are very frequent, especially in the lower region, where the greatest ionisation densities occur during the night (usually from 20.00 h onwards). The magnetic records at Tromsø show just the same frequency of abnormality. During conditions of intense magnetic activity there is " a complete cessation of echoes on all of the available wavelengths (from 500 m to 20 m) normally in use for the observations." This absence of echoes is due to very high absorption connected with the production of ionisation at abnormally low levels. Violent fading and complex echoes accompany the onset of a magnetic disturbance.

The results as a whole " show that to account for wireless phenomena in high latitudes we must take into account both the normal influence of ultra-violet light and the abnormal influence of ionising charged particles." The latter produce electrification in and below the normal lower region. " The absorption which occurs during the day is probably due to ionisation caused by particles which are initially uncharged but acquire a charge in the early stages of their journey through the atmosphere." " The practical difficulty of maintaining communication over the polar cap can doubtless be traced to the frequent absence of reflection from the ionosphere which we have found to be so closely associated with conditions of magnetic activity."

THEORY OF THE TRANSMISSION OF WAVES IN AN IONISED GAS IN WHICH THERE IS A HORIZONTAL AS WELL AS A VERTICAL GRADIENT.—Eckersley. (*See* abstract under " Aerials and Aerial Systems.")

MEASUREMENTS OF ECHOES FROM THE IONOSPHERE AT THE SUMMER SOLSTICE [1933: Broadcast and Short Waves].—H. Mögel. (*Telefunken-Zeit.*, August, 1933, Vol. 14, No. 64, pp. 21–30.)

Records are given of a continuous run from 6 h on 21st June to 23 h on 22nd June, on a 56.7 m and a 227 m wave, and compared with other records of 7th and 8th June (56.7 m wave). A curve is also given of the upper and lower layer heights during May (56.6 m wave) where *E*-layer reflections only occurred during a few hours in the morning, whereas in the June records the *E*-layer reflections predominate by day, the *F* layer being only in evidence for comparatively short periods. Among the results which the writer picks out for comment is the behaviour of the *E* layer on the morning of the 21st June, because the violent fluctuations of concentration coincide with a perfectly calm magnetic condition: this seems to contradict the idea of aurora as a cause of such fluctuation and to support the penetrating radiation or the meteor shower hypothesis. Another thing emerging from the results is the great importance of *prolonged* recording of echoes: one day's results differ so greatly from another's, even in quiet magnetic conditions (" there must be some other factor besides solar radiation ").

Among the features of the solstice records are the multiple echoes at various heights up to 2 000 km, particularly at 1 800 km at about 2 h on 22nd June. It is noted that on this day there was no evidence of double refraction at the upper layer, whereas it was found regularly from March to mid-June.

In his short analysis of the broadcast wave results the writer mentions that at about 3 h on the 22nd June a sudden failure of *F*-layer reflections made way for reflections at heights of 750 and 660 km which appeared to have no connection with the lower layer.

CONTINUOUS MEASUREMENTS OF THE VIRTUAL HEIGHTS OF THE IONOSPHERE [on a Frequency of 4 100 kc/s].—T. R. Gilliland. (*Bur. of Stds. Journ. of Res.*, July, 1933, Vol. 11, No. 1, pp. 141–146.)

The system used is similar to that described in a preliminary note (1932 Abstracts, p. 334, r-h col.) except that the revolving mirror of the oscillograph and the chopper controlling the transmitter are now attached to the same shaft, the transmitting and receiving sets being in the same room, though the aerials are separate. The following conclusions are drawn :—" Of greatest interest perhaps is the reappearance of strong reflections at night from both *E* and *F* layers. Some of these reflections indicate sudden increases in ionisation, while others suggest that recombination in a lower part of the region exposes the upper part where ionisation is richer.

" Many of the changes observed are very sudden, and strong reflections from the *E* layer may appear at almost any hour. Various explanations have been offered in the past, including sunspots, meteor showers, and thunderstorms. Comparisons are also made between such results and changes in the earth's magnetic field. Although certain peculiarities, such as strong *E* reflections, are observed at magnetically disturbed times, quite similar phenomena are observed when no unusual magnetic changes are in evidence. Since the changes in the ionosphere are so frequent and so rapid, it is impossible, with the small amount of data at hand, to show definitely just how important each factor is.

" None of the explanations yet offered seems to explain satisfactorily the extremely high ionisation frequently observed at night. Although *E*-layer reflections appear at almost any time, they occur most frequently around the time of sunset or shortly after, on this frequency during the period of these observations."

SOUNDING THE IONOSPHERE.—L. C. Verman. (*Nature*, 26th Aug., 1933, Vol. 132, p. 323.)

A preliminary note on a system " for continuous recording, by cathode-ray oscillograph, of the equivalent heights at which radio signals are reflected by the ionosphere." Pulses of 100 microseconds' duration (*see* below) are produced by a generator using a cold-cathode neon discharge tube. The echo pulses are amplified and applied to the Wehnelt cylinder of the oscillograph and " the bright image of the linear time-base is thus interrupted by dark gaps which result from defocusing of the electron jet by the amplified echo e.m.fs." The width of the dark gap may be made to indicate the approximate intensity of the corresponding echo by the provision of a suitable time-constant in the l.f. amplifier.

PULSE GENERATOR USING COLD-CATHODE NEON DISCHARGE TUBE AND GIVING 100-MICROSECOND PULSES.—Verman. (*Paper No.* 10, *Math. and Physics Section, Indian Sci. Congress, Patna*, January, 1933.) Used in the layer-height measurements referred to in preceding abstract.

THE LIMITING POLARISATION OF DOWNCOMING RADIO WAVES TRAVELLING OBLIQUELY TO THE EARTH'S MAGNETIC FIELD.—W. G. Baker and A. L. Green. (*Proc. Inst. Rad. Eng.*, August, 1933, Vol. 21, No. 8, pp. 1103–1131.)

This theoretical paper contains essentially the same material as that dealt with in July Abstracts, pp. 385–386 and 396. The effect of electronic collisions is more fully considered and, as a numerical example, the limiting shape of the polarisation ellipse as the electron density tends to zero for a collision frequency of 5×10^5 is worked out. Curves are also given for the attenuation factors of the ordinary and extraordinary rays for different angles between the direction of propagation and the earth's field. The effect of the presence of large numbers of heavy negative ions in the Kennelly-Heaviside layer is considered ; the limiting polarisation is found to be unaffected by this. In all the work the Lorentz polarisation term has been omitted and the writers conclude that the expression for the limiting polarisation is unaffected by its inclusion.

EFFECT OF THE SOLAR ECLIPSE ON THE IONOSPHERE.—S. K. Mitra, H. Rakshit, P. Syam, B. N. Ghose. (*Nature*, 16th Sept., 1933, Vol. 132, pp. 442–443.)

The writers' experiments during the annular eclipse of Aug. 21st, 1933, visible in Calcutta, showed that " the ultra-violet light is at least one of the agencies producing ionisation of the *E* layer, and that the corpuscular rays have little or no effect as an ion-producing agency." The experiments were carried out using Appleton's method of critical frequency measurement (1931 Abstracts, p. 202) and curves are given for the variation of the electron content of the *E* and *F* layers between 6 a.m. and 2 p.m. on Aug. 20th, 21st (eclipse) and 22nd.

" BLANKETING " EFFECT OF AURORA AND OF ELECTRIC CHARGES IN THE CLOUDS DUE TO INTENSE SUMMER HEAT.—Ogilvie. (*See* abstract under " Measurements and Standards.")

TRANSOCEANIC [Short-Wave] RADIO AND SOLAR ACTIVITY.—W. A. R. Brown : National Broadcasting Company. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 129–139.)

The results of a co-operative investigation of transatlantic and other services over several years. " Of the various relationships investigated, including solar, lunar, planetary, barometric, temperature, and magnetic, only the last showed any promise of day-by-day correlation. . . . Although it is convenient to speak of the effects of a magnetic disturbance, it should be recognised that transmission irregularities are probably due largely to abnormal ionisation conditions of the upper atmosphere, presumably caused by solar activity, and that these magnetic disturbances may be regarded as an indirect measure of such activity. . . . The magnetic index finally adopted was the daily sum of the hourly ranges of the horizontal component or, in some cases, the horizontal and vertical components together. These summation ranges are easily and quickly obtained directly from the magnetograms, and are vastly superior to magnetic character figures or daily ranges."

High-latitude circuits showed the closest correlation, low-latitude circuits being comparatively immune to the effects of magnetic disturbance. Among the results discussed, it is remarked that "recovery of signals after a magnetic storm does not follow a reversal of the three phases previously mentioned [advance in normal daily trend of transmission, at times resulting in night conditions existing during the day; increased fading; increased attenuation, causing premature fade-outs and occasionally the disappearance of signals for days]. Fading usually returned to normal values before the signal strength, indicating that the turbulence of the upper atmosphere disappears before the excessive ionisation. The extensive storms which extend over a period of a week or so appear to be composed of several individual disturbances closely following one another, and it is possible in some instances to trace the independent build-up and decay of the individual storms on successive recurrences. This suggests that these storms are due to separate 'active solar areas' rather than to intermittent emissions from one area." Although no day-by-day nor short-period correlation was found between either magnetic disturbances or transmission irregularities and the various indices of solar activity (such as sunspots, faculae and flocculi) the long-term correlation was apparent in the form of the progressive yearly shift to lower optimum frequencies since the last sunspot maximum.

The writer ends: "In the prediction of day-to-day transmission conditions, which is obviously very desirable, sufficient accuracy has been attained to warrant its inclusion as an operations function. Such forecasting is dependent upon the prediction of magnetic activity. We admit that this is merely intelligent guessing, based upon certain characteristics of magnetic activity together with the experience gained from observation of this phenomenon over the past five years. These characteristics are the 27-day recurrence of magnetic disturbances, the 26- and 28-day sequences of quiet periods, the cycle of build-up and decay displayed on successive storm recurrences, and the general confinement of disturbances to the period between the solstitial dates." *See* also 1933 Abstracts, p. 230, l-h column.

OZONE AND THE SUNSPOT CYCLE [Latest Observations Not Confirming a Correlation].—F. E. Fowle. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 110–111.)

"*Prima facie*, the new results [since 1928] do not confirm a dependence of the amount of ozone in our atmosphere upon solar conditions as roughly indicated by the sunspots. This situation may be worthy of further comments:

(1) The observations do not extend over a complete spot-cycle, which is now known to be double the time formerly allotted to it, some 22 instead of 11 years; there are differences in the polarities of the spots in the two halves of the longer period.

(2) There has been a tendency among some to suppose the amount of ozone to be due to the ultra-violet light of the sun; others would connect it with the auroral discharge. It might owe its origin to the bombardment of the Earth by particles of some kind. The first two causes we know to be closely connected with the sunspot cycle. . . ."

SOME RESULTS OF FURTHER STUDIES IN THE CORRELATION OF COSMIC PHENOMENA WITH RADIO INTENSITIES AS MEASURED AT THE PERKINS OBSERVATORY.—H. T. Stetson. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 127–129.)

Continuation of the work referred to in May Abstracts, p. 265, r-h col. Regarding lunar influence, "Josef Johnson has correlated the actual luni-tidal force at latitude 40° with the intensities of radio reception and finds evidence for points of inflection in the intensity-curve corresponding to critical values in the tidal force, which presumably suggests critical layer-heights for optimum reception." Evidence is brought to light of an apparent variation of field intensities not only with the lunar hour-angle but also with lunar declination. "The fact that the two curves representing north and south declinations are inverted in phase is highly suggestive of tidal phenomena in the Kennelly-Heaviside layer. The curve representing field intensities with the moon near the equator suggests semi-diurnal tides. . . . It is difficult to explain the large variations here found on any simple gravitational tides in the atmosphere. A theory involving resonance may, however, be sufficiently elastic to offer some basis for explanation. . . ."

FURTHER RESULTS IN THE STUDY OF APPARENT VARIATIONS OF THE VERTICAL WITH THE HOUR-ANGLE OF THE MOON [and the Variation in Time-Determinations at Greenwich and Washington with Lunar Hour-Angle and Declination].—H. T. Stetson: Loomis and Stetson. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 47–52.)

THE INFLUENCE OF THE MOON ON ELECTROMAGNETIC WAVES.—K. Stoye. (*Funktechnische Monatshefte*, April, 1933, No. 4, p. 152.)

NEW RANGE TESTS WITH MICRO-WAVES OF 60 CENTIMETRES.—Marconi. (Paragraph in *E.T.Z.*, 7th Sept., 1933, Vol. 54, No. 36, p. 876.)

With the transmitter 38 metres above sea level and the receiver 5 metres (on board the "Electra"), strong and regular [telephonic ?] signals were received over 150 km; weak Morse signals were obtainable at 258 km, with high mountains intervening.

PROPAGATION OF ELECTROMAGNETIC WAVES [over the Surface of a Conductive Earth: Revival and Amplification of Vaschy's Treatment (1925)].—J. B. Pomey. (*Rev. Gén. de l'Élec.*, 29th July, 1933, Vol. 34, No. 4, pp. 103–109.)

A large number of researches published since 1925 are concerned with the behaviour, in the neighbourhood of the ground, of electromagnetic waves received from a distant source, and the various writers appear to be ignorant of Vaschy's analysis of the subject. The present writer has encountered difficulties in reading the more recent papers, and has therefore thought it desirable to reproduce and amplify Vaschy's treatment: particular attention is given to the proof that when the dielectric constant is complex the vibration is elliptical. When the lower medium is a pure dielectric, without conductivity, the formulae obtained revert to the well-known Fresnel formulae.

RADIATION FROM ANTENNAE UNDER THE INFLUENCE OF THE EARTH'S PROPERTIES. E.–RADIATION INTO THE EARTH.—Strutt. (*See* under "Aerials and Aerial Systems.")

INVESTIGATIONS ON SPACE CHARGES IN ICE [and Their Effect on the Dielectric Constant].—G. Oplatka. (*Helvet. Phys. Acta*, Fasc. 3, Vol. 6, 1933, pp. 198–209.)

DISCUSSION OF SOME ASYMPTOTIC EXPANSIONS IN THE THEORY OF THE VERTICAL ELECTRIC DIPOLE.—F. H. Murray. (*Ann. der Physik*, 1933, Series 5, Vol. 17, No. 7, pp. 821–824.)

A further discussion of mathematical points in papers referred to in January and July Abstracts, pp. 40 (l-h col.) and 382 (r-h col.).

CALCULATION OF THE ELECTROMAGNETIC FIELD OF AN ALTERNATING CURRENT IN A SPACE WITH A PLANE BOUNDARY SURFACE.—V. Fock. (*Ann. der Physik*, 1933, Series 5, Vol. 17, No. 4, pp. 401–420.)

This paper is a re-publication of a Russian paper published in 1926, and makes available convenient mathematical methods of computing the integrals which occur in calculations of the fields produced by vertical or horizontal dipoles above the earth's surface. *Cf.* Sommerfeld, *Ann. der Physik*, 1909, Series 4, Vol. 28, p. 665; 1926, Series 4, Vol. 81, p. 1135; and papers referred to in Abstracts, 1931, p. 30 (van der Pol and Niessen); 1930, p. 388 (Thomas); also Murray (above).

THE REFLECTION OF PLANE WAVE PULSES FROM PLANE PARALLEL PLATES.—M. Muskat. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 319: abstract only.)

"A wave theory analysis has been developed for the reflection of wave pulses from plates. . . . The general theorem is proved that if the reflection coefficient for a harmonic wave system is exactly periodic in the frequency of the waves, the reflections from the plate due to an incident pulse will consist of a series of wave trains of exactly the same form as the incident pulse."

ON THE SCATTERING AND ABSORPTION OF [Plane] ELECTROMAGNETIC RADIATION BY A SMALL SPHERE [Theoretical Investigation and Application to Atomic Theory].—G. Beck and P. Wenzel. (*Zeitschr. f. Physik*, 1933, Vol. 84, No. 5/6, pp. 335–355.)

PHENOMENA OF DIFFRACTION AT SMALL SPHERES IN THE NEIGHBOURHOOD OF FOCI OF CONVERGENT SPHERICAL WAVES [Mathematical Investigation].—F. Möglich. (*Ann. der Physik*, 1933, Series 5, Vol. 17, No. 8, pp. 825–862.)

SOME EXPERIMENTS ON THE DIFFRACTION OF LIGHT BY SUPERSONIC WAVES.—Bär and Meyer. (*Helvet. Phys. Acta*, Fasc. 4, Vol. 6, 1933, pp. 242–244.)

LINE OSCILLATIONS—"TUNED POWER LINES" [101 km Telephone Line with Ground Return set into Resonance Oscillation at 940 Cycles/Second].—M. Marro. (*Elec. Engineering*, September, 1933, Vol. 52, No. 9, pp. 646–647.)

TRAVELLING WAVE VOLTAGES IN CABLES.—Brinton, Buller and Rudge. (*Elec. Engineering*, August, 1933, Vol. 52, No. 8, pp. 559–564.)

THE DAMPING OF SURGES ON H.T. LINES. II.—Flegler and Röhrig. (*Archiv f. Elektrot.*, 1st Sept., 1933, Vol. 27, No. 9, pp. 637–641.) For Part I *see* August Abstracts, p. 440, r-h column.

ON LINEAR SYSTEMS WITH FIRST-ORDER PARTIAL DERIVATIVES WITH TWO VARIABLES.—T. Carleman. (*Comptes Rendus*, 16th Aug., 1933, Vol. 197, No. 7, pp. 471–474.)

THE TRANSMISSION OF SEISMIC WAVES [Deductions from the Santiago Data].—F. Neumann. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 329–335.)

One of a large number of papers in the Seismology section extending from p. 251 to p. 336.

THE DISCONTINUOUS NATURE OF LOVE WAVES.—J. Coulomb. (*Comptes Rendus*, 21st Aug., 1933, Vol. 197, No. 8, pp. 525–528.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

DEVELOPMENT OF THE LIGHTNING DISCHARGE.—B. F. J. Schonland and H. Collens. (*Nature*, 9th Sept., 1933, Vol. 132, pp. 407–408.)

The writers have studied lightning flashes with a revolving lens camera (Abstracts, 1928, p. 638, l-h col., Boys; April, pp. 208–209, Halliday) and obtained evidence of the reality of effects hitherto considered to be probable: *viz.*, "that the first stage in the preliminaries to spark breakdown is the passage from cathode to anode of an electron avalanche . . . the real breakdown occurs after the passage of this avalanche and proceeds from anode to cathode as a thermally ionised tongue."

GASEOUS BREAKDOWN AT NORMAL PRESSURE [Application to Growth of Lightning Flash].—J. J. Sämmer. (*Zeitschr. f. Physik*, 1933, Vol. 83, No. 11/12, pp. 814–831.)

This theoretical paper shows "how the gas can be made to glow in filamentary form by the effect of electrons; how this glowing filament gradually develops towards the cathode; and why the discharge phenomenon is concentrated in a narrow canal."

THE RECORDING OF SURGES [Description of Two Simple Equipments for Measuring and Recording, as Substitutes for the Cathode-Ray Oscillograph].—Dodds and Fucks. (*See* under "Subsidiary Apparatus and Materials.")

THE BEHAVIOUR OF GLASS-ENCLOSED SINGLE SPARK-GAPS TO SURGES [and the Advantage of Radioactively Produced Ionisation].—K. Berger. (*Bull. Assoc. suisse des Élec.*, No. 2, Vol. 24, pp. 18–29.)

SOME POINTS CONCERNING LIGHTNING CONDUCTORS [including Calculation of Probable P.Ds between the Conductor Tip and Earth].—A. Monney. (*Bull. Assoc. suisse des Élec.*, No. 16, Vol. 24, 1933, pp. 363–367.)

METHODS OF MEASURING THE ELECTRICAL CONDUCTIVITY AND IONISATION OF THE AIR.—E. Salles. (*Rev. Gén. de l'Élec.*, 17th June, 1933, Vol. 33, No. 24, pp. 779–788.)

ELECTROMAGNETIC EFFECTS IN STELLAR ATMOSPHERES [Short Survey].—J. A. Anderson. (*Elec. Engineering*, September, 1933, Vol. 52, No. 9, pp. 621–623.)

PROGRESS-REPORT OF THE INTERNATIONAL POLAR YEAR OF 1932–33.—J. A. Fleming. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 146–154.)

ASSOCIATED PROBLEMS OF HYDROLOGY AND TERRESTRIAL ELECTRICITY.—O. H. Gish. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 37–40.)

THE PROBLEM OF VERTICAL EARTH CURRENTS [and Their Probable Non-Existence].—O. H. Gish. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 144–146.)

THE APPARENT EFFECT OF MAGNETIC ACTIVITY UPON THE SECULAR VARIATION OF THE EARTH'S MAGNETIC FIELD [Post-Perturbation Hypothesis *versus* Chapman's Hypothesis].—A. G. McNish. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 139–144.)

THE AURORAL SPECTRUM AND ITS INTERPRETATION.—L. Vegard. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 68–69.) *See* also July Abstracts, p. 389, l-h column.

NEW OBSERVATIONS ON THE SPECTRUM OF THE NIGHT SKY [and a Comparison with the Auroral Spectrum].—J. Dufay. (*Journ. de Phys. et le Rad.*, May, 1933, Vol. 4, No. 5, pp. 221–235.)

SPECTRA OF THE NIGHT SKY, THE ZODIACAL LIGHT, THE AURORA, AND THE COSMIC RADIATIONS OF THE SKY [Origins of Cosmic Radiations probably chiefly in the Earth's Atmosphere].—V. M. Slipher. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 125–127.)

COSMIC RAY OBSERVATIONS AND JANSKY'S "STATIC HISS" QUOTED AS EVIDENCE OF ABSOLUTE COSMIC MOTION IN ETHER-DRIFT THEORY.—D. C. Miller. (*Reviews of Mod. Physics*, July, 1933, Vol. 5, No. 3, p. 241 : in a long paper on the Ether-Drift Experiment.)

RELATIONS AMONG FLUCTUATIONS OF THE COSMIC-RAY IONISATION, OF THE TERRESTRIAL MAGNETIC FIELD, OF THE ATMOSPHERIC POTENTIAL GRADIENT AND OF THE ABSOLUTE HUMIDITY.—J. W. Broxon, G. T. Merideth and L. Strait. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, pp. 253–257.)

From the authors' summary :—Defining the cosmic-ray ionisation "character" as the product of the average for a particular day by the difference between the maximum and minimum ionisation values for that day, the writers found a considerable correspondence between the ionisation "character" curve and the curve representing the magnetic character of days during the period of the observations. Further similarities with the corresponding "character" curves for the atmospheric potential gradient and the absolute humidity were brought out. Certain important consequences are pointed out.

APPLICATION OF LIOUVILLE'S THEOREM TO ELECTRON ORBITS IN THE EARTH'S MAGNETIC FIELD [and Cosmic-Ray Intensities].—W. F. G. Swann : Lemaitre and Vallarta. (*Phys. Review*, 1st Aug., 1933, Series 2, Vol. 44, No. 3, pp. 224–227.)

This paper establishes the ultimate validity of the use of Liouville's theorem by Lemaitre and Vallarta (*see* Vallarta, October Abstracts, p. 562 l-h column.).

INFLUENCE OF THE EARTH'S MAGNETIC FIELD ON COSMIC RADIATION.—H. Zanstra. (*Naturwiss.*, 7th July, 1933, Vol. 21, No. 27, p. 516.)

Theoretical considerations on the lines of those given by Kulenkampff (April Abstracts, p. 209, l-h col.) lead to the conclusion that the curve of ionisation with height to be expected as a result of the action of the earth's magnetic field is more complicated than that found experimentally by Regener.

THE HARDEST COSMIC RAYS AND THE ELECTRIC CHARGE OF THE EARTH.—W. Kolhörster. (*Nature*, 9th Sept., 1933, Vol. 132, p. 407.)

The penetration of radiation to 700–800 m of water has been confirmed by coincidence experiments. This radiation "has the properties needed for a corpuscular penetrating cosmic radiation capable of maintaining the electric charge of the earth."

NEW HIGH-ALTITUDE STUDY OF COSMIC-RAY BANDS AND A NEW DETERMINATION OF THEIR TOTAL ENERGY CONTENT.—I. S. Bowen, R. A. Millikan and H. V. Neher. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, pp. 246–252.)

Experiments in aeroplanes have made it possible to plot "a complete cosmic-ray intensity curve extending from the lowest depths to the top of the atmosphere." Comparison of curves for latitude 34° and in the equatorial belt "permits of the separation of the magnetically deflectable particles from the primary non-deflectable cosmic rays." The intensity curve can be built up on the assumption of "three cosmic-ray bands of widely different penetrating power." "More than 90% of the ionisation of the atmosphere is due to the softest cosmic-ray band." "The energy falling on the earth [in the form of cosmic rays] is about half of the total radiant energy received from the stars" [*cf.* Korff, below].

DENSITY OF ENERGY IN THE UNIVERSE [Smaller than Cosmic-Ray Energies].—S. A. Korff. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, pp. 300–301.) *Cf.* Bowen, Millikan and Neher, above.

THE ATTENUATION OF COSMIC RAYS IN THEIR PASSAGE THROUGH DIFFERENT MATERIALS.—E. G. Steinke and H. Tielsch. (*Zeitschr. f. Physik*, 1933, Vol. 84, No. 7/8, pp. 425–429.)

PASSAGE OF SWIFT CORPUSCULAR [Cosmic] RADIATION THROUGH A FERRO-MAGNETIC SUBSTANCE [Theoretical Investigation].—C. F. von Weizsäcker. (*Ann. der Physik*, 1933, Series 5, Vol. 17, No. 8, pp. 869–896.)

THE DISINTEGRATION OF VARIOUS MATERIALS BY COSMIC RADIATION.—E. G. Steinke, A. Gastell and H. Nie. (*Naturwiss.*, 28th July, 1933, Vol. 21, No. 30, p. 560.) Continuation of experiments referred to in 1932 Abstracts, pp. 401 and 578.

COSMIC-RAY NUCLEAR DISINTEGRATIONS.—W. F. G. Swann and C. G. Montgomery. (*Phys. Review*, 1st July, 1933, Series 2, Vol. 44, No. 1, pp. 52–53: *Journ. Franklin Inst.*, Aug., 1933, Vol. 216, No. 2, pp. 249–252.)

SPACE DENSITY OF COSMIC-RAY PARTICLES.—W. F. G. Swann. (*Phys. Review*, 15th July, 1933, Series 2, Vol. 44, No. 2, p. 124: *Journ. Franklin Inst.*, Aug., 1933, Vol. 216, No. 2, pp. 272–274.)

ON THE NATURE OF THE PRIMARY COSMIC RADIATION.—W. F. G. Swann. (*Journ. Franklin Inst.*, Aug., 1933, Vol. 216, No. 2, pp. 252–254.) *See* September Abstracts, p. 499, l-h column.

CONCERNING THE PRODUCTION OF GROUPS OF SECONDARIES BY THE COSMIC RADIATION.—J. C. Street and T. H. Johnson. (*Journ. Franklin Inst.*, Aug., 1933, Vol. 216, No. 2, pp. 256–259.) *See* January Abstracts, p. 34, r-h column.

THE SECONDARY AND TERTIARY PARTICLES PRODUCED BY COSMIC RAYS.—J. H. Sawyer, Jr. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, pp. 241–245.)

THE STRAIGHT LINE LAW IN COSMIC RAY COINCIDENCES AND ITS EXPERIMENTAL VALIDITY.—W. Kolhörster and L. Tuwim. (*Zeitschr. f. Physik*, 1933, Vol. 84, No. 9/10, pp. 629–636.)

THE COSMIC RAY HODOSCOPE.—T. H. Johnson and E. C. Stevenson. (*Journ. Franklin Inst.*, Sept., 1933, Vol. 216, No. 3, pp. 329–337.)

The hodoscope described in this paper is "an instrument for observing and studying the detailed phenomena of the cosmic radiation by making visible the paths of the penetrating corpuscular rays through a continuous region of space." It consists of a two-dimensional array of a large number of small Geiger-Müller counters, each counter being connected through one stage of amplification to a neon glow lamp fixed on a panel in a position corresponding to the position of the counter in the array. Reference to a preliminary model of the instrument was made in July Abstracts, p. 388, r-h column.

PROPERTIES OF CIRCUITS

AMPLITUDE CHARACTERISTICS [Resonance Curves] OF COUPLED CIRCUITS HAVING DISTRIBUTED CONSTANTS [Bridge-Coupled Lecher Wire Pairs].—R. King. (*Proc. Inst. Rad. Eng.*, August, 1933, Vol. 21, No. 8, pp. 1142–1181.)

In a previous paper (Abstracts, 1932, p. 637) the writer derived the theoretical wavelength characteristics of such circuits and compared them with experimental results. In the present paper he obtains a general expression for the amplitude characteristics of the same type of circuit, and computes from it the resonance curves of a number of typical and important circuit arrangements, including the "double-hump" phenomenon (June, p. 327, r-h col.) which is shown to be merely a special case of the coupled-circuit theory here developed; these curves are shown to be in excellent agreement with those found experimentally. The experimental technique has already been discussed (1931, p. 221, r-h col.). A new precision method for measuring the wavelength of ultra-short waves is described, suggested by the theoretical results and by the method suggested by Hoag (April, p. 222, r-h col.) with which it is compared. For this new method *see* abstract under "Measurements and Standards." The ordinary "maximum deflection" and "minimum deflection" methods of measuring wavelengths are shown to be correct. Incidentally, the work leads to the emergence (p. 1160) of a method of measuring the input impedance of ultra-short-wave receivers: a further analysis and development of the method is reserved for a later paper, but it is here used to show that the screen-grid voltmeter employed as a resonance-indicator has a linear resonance-current/deflection characteristic and an input impedance, measured at 4.34 m wavelength, equal to that of a definite length of the parallel wires. "The significance of this result should not be under-estimated. Let it be emphasised that an experimental method has been devised by which impedances may be measured accurately at ultra-high frequencies. For if the impedance of the detector is known, small impedances connected in series with it may be measured."

A NEW THEOREM FOR ACTIVE NETWORKS.—A. T. Starr. (*Journ. I.E.E.*, September, 1933, Vol. 73, No. 441, pp. 303–308.)

Author's summary:—"A theorem is proved which states that any network with three accessible terminals can be replaced by a star or delta of certain e.m.fs and impedances. This is an extension of Kennelly's star-delta theorem and Thévenin's theorem. . . . The sensitivity of an impedance bridge, in which a 3-winding transformer is used, is also found by the help of the theorem. Finally, the theorem is used to find the errors in voltage measurement due to earth capacitances. An important result which emerges is that, in measurements of attenuation in balanced systems, an unbalance of capacitance that occurs *after* the attenuation pad causes an error in the measured voltage which is *not* attenuated by the pad. This is in contradiction to accepted theory, but agrees with practice." For Brainerd's paper on Thévenin's theorem *see* October Abstracts, p. 563, l-h column.

A METHOD FOR CALCULATING TRANSMISSION PROPERTIES OF ELECTRICAL NETWORKS CONSISTING OF A NUMBER OF SECTIONS [using Difference Equations].—A. Alford. (*Proc. Inst. Rad. Eng.*, August, 1933, Vol. 21, No. 8, pp. 1210–1220.)

Author's summary:—The solution of certain electrical networks can be made to depend on the solution of a much-studied mathematical problem in difference equations. This fact, while recognised for some time, has not received as much attention as it deserves. On the following pages we have worked out several relatively simple electrical networks by the method of difference equations. Our aim was not to obtain the solutions of the particular cases considered, but rather to illustrate the procedure involved.

THE QUADRIPOLE PROPERTIES OF THE TWO-WIRE TWO-VALVE REPEATER AND THEIR DEPENDENCE ON ITS INTERNAL CONSTRUCTION.—A. Byk. (*E.N.T.*, August, 1933, Vol. 10, No. 8, pp. 333–344.)

SIMPLIFICATION OF THE CALCULATION OF PARALLEL-CONNECTED A.C. RESISTANCES [*e.g.*, Equivalent Circuit of Piezoelectric Crystal].—F. Vilbig. (*T.F.T.*, May, 1933, Vol. 22, No. 5, pp. 117–119.)

MECHANICAL RELAXATION OSCILLATIONS [Application of Electrical Theory to Mechanical Systems: Experimental Confirmation].—N. L. Kajdanowsky and S. E. Chaikin. (*Journ. of Technical Physics*, Leningrad and Moscow, No. 1, Vol. 3, 1933, pp. 91–109: in Russian, with German summary.)

A NEW METHOD OF RADIOELECTRIC COUPLING: THE "DIFFUSION" COUPLING.—Cordebas. (*See* under "Reception.")

NON-LINEAR CHARACTERISTIC CURVE FAMILIES [and the Straight Working-Point Lines drawn through Them, where the Non-Linear Generator behaves as Linear: Application to Triode Amplifier Valves].—Feldtkeller and Jacobi. (*T.F.T.*, August, 1933, Vol. 22, No. 8, pp. 198–203.)

SUB-HARMONICS IN FORCED OSCILLATIONS IN DISSIPATIVE SYSTEMS.—Pedersen. (*See* under "Acoustics and Audio-frequencies.")

THE ACTION OF DAMPING REDUCTION [by Retroaction] IN BROADCAST RECEIVERS.—Kautter. (*See* under "Reception.")

TRANSMISSION

STUDY OF THE SYNCHRONISATION OF A SELF-EXCITED OSCILLATOR, AND OF ITS BEHAVIOUR IN THE NEIGHBOURHOOD OF SYNCHRONISATION.—H. Subra. (*L'Onde Élec.*, July, 1933, Vol. 12, No. 139, pp. 353–384.)

An investigation prompted by Abraham's Note (1932 Abstracts, pp. 579–580). The classic theory of beats is only applicable if the generators of the two currents oscillate freely and do not show any unilateral or bilateral coupling. In the other case, new phenomena appear, the more pronounced the nearer the two frequencies are to one another. The paper investigates these phenomena and explains them in the case of one oscillator acted on by a second, of frequency close to its own, on which it cannot react: for example, in autodyne, and usually in heterodyne, receivers.

The conclusions arrived at are summed up on pp. 380–381. A number of applications of these results include the following practical points:—(*a*) all methods of measurement (such as wavelength measurements) based on the beat-note principle are erroneous if the two sources of r.f. have any coupling whatever, however small; the utmost precautions must be taken, and the great utility is mentioned of the method of coupling the oscillation under measurement by means of two neutrodyned tetrodes: (*b*) absolute measurements of frequency by the multivibrator require similar precautions: (*c*) synchronisation of a local oscillator by locking-in with a fraction of the carrier wave from a distant station (de Bellescize, Jan. Abstracts, p. 38): (*d*) l.f. oscillators on the beat-note principle will be defective unless proper precautions are taken; the notes in the lower part of the scale will be of "relaxation" type and far from sinusoidal: (*e*) the possibilities of devising special autodyne receiver circuits in which the phasing of the grid potential is regulated; "one can, for example, use this method for the complete suppression of an unwanted wave": (*f*) the "double beat" method of frequency measurement is not as accurate as it is considered to be, being liable to an error measured by the distance *AB* in Fig. 21.

WHERE DOES A DECAYING OSCILLATING PROCESS END, AND A BUILDING-UP PROCESS BEGIN?—H. Barkhausen and G. Hässler. (*Hochf:tech. u. Elek:akus.*, August, 1933, Vol. 42, No. 2, pp. 41–42.)

An oscillographic investigation of the physically detectable "final" and "initial" amplitudes, respectively. Each is found to be identical with the unavoidable minimum disturbance due to shot effect and thermal agitation. *See* also next abstract.

THE PROOF OF THE SHOT EFFECT BY THE BUILDING-UP OF OSCILLATIONS IN A VALVE GENERATOR.—G. Hässler. (*Ibid.*, pp. 42–44.)

See preceding abstract. The oscillographic investigation of the initial amplitude is described, and the value is shown to agree quantitatively with the calculated disturbance due to small-shot effect. In this case the disturbance due to thermal agitation is negligible.

INVESTIGATION OF BARKHAUSEN-KURZ OSCILLATIONS.—H. Alfvén. (*Zeitschr. f. Physik*, 1933, Vol. 83, No. 3/4, pp. 222–233.)

The writer studies the mechanism of Barkhausen-Kurz oscillations by measuring the (positive or negative) resistance of the valve in its non-oscillating condition. Curves are given for the variation of the resistance with the voltages used. The minima are found to correspond to the oscillation regions of the valve and to have no connection with resonance oscillations.

A theory of Barkhausen-Kurz oscillations is worked out under simplified assumptions. The motion of the electrons is found to cause induced currents in the electrodes, which differ in phase from the voltage. Theoretical curves for the resistance, deduced on this theory, agree with those found experimentally.

THE DETERMINATION OF THE INTERELECTRODE TIMES OF TRANSIT OF ELECTRONS IN TRIODE VALVES WITH POSITIVE GRID POTENTIALS.—J. S. McPetrie. (*Phil. Mag.*, Sept., 1933, Series 7, Vol. 16, No. 106, pp. 544–553.)

This paper extends the theory of Scheibe (*Ann. der Physik*, 1924, Vol. 73, p. 54) to include cases of (1) positive potential on the anode and (2) finite velocity of emission of electrons from the filament.

ON THE GENERATION OF THE MEDIUM-WAVE OSCILLATION BY THE SPLIT-ANODE MAGNETRON.—K. Morita. (*Journ. I.E.E. Japan*, August, 1933, Vol. 53 [No. 8], No. 541: English summary p. 66, Japanese paper pp. 695–700.)

Investigation of the dynamic, as distinct from the electronic, method of oscillation production with the split-anode magnetron. Habann's explanation of the dynamic oscillation, as the result of negative resistance between the halves of the split anode due to the "curling" action of the magnetic field on the moving electrons, is confirmed.

With the circuit shown, the wavelength is chiefly determined by the values of C and L, so that short or medium waves can be produced at will. But if the impedance L/CR is made smaller than a given value, these oscillations are replaced by oscillations of a few metres' wavelength, although of dynamic nature.

A NOTE ON THE THEORY OF THE MAGNETRON OSCILLATOR [Correction to Okabe's Constant by allowing for Cardioid Path of Electron].—J. B. Hoag. (*Proc. Inst. Rad. Eng.*, August, 1933, Vol. 21, No. 8, pp. 1132–1133.)

By Okabe's theory, when the accelerating voltage and the field strength (H gauss) have been adjusted so that the anode current starts to decrease rapidly, $\lambda H = 10\,650$. His experimental value is 13 000, that of Mohler is 13 230. The writer, making use of Langmuir's proof that (owing to the space charge near the filament) the actual electron path is a cardioid whose length is 1.23 times that of the circle, arrives at the constant $10\,650 \times 1.23$, or 13 100, which is in much better agreement with the experimental values.

ULTRA-SHORT-WAVE GENERATOR USING MAGNETRON [with Anode split longitudinally into Four Segments: Modulation by Change of Magnetising Current].—(*Hochf:tech. u. Elek:akus.*, August, 1933, Vol. 42, No. 2, p. 75: U.S.A. Pat. No. 1 901 112, pub. 14th March, 1933, GEC and McArthur.)

Each pair of opposite anode segments is connected to an oscillatory circuit, the two circuits being coupled separately to a common aerial.

ULTRA-SHORT-WAVE MAGNETRON GENERATOR [with Anode split longitudinally into Four Segments: Opposite Pairs joined by a Curved Connector of Length chosen to give Standing Waves].—(*Hochf:tech. u. Elek:akus.*, August, 1933, Vol. 42, No. 2, p. 75; German Pat. No. 573 634, pub. 4th April, 1933, RCA.)

ON THE MODULATION OF AN ULTRA-SHORT WAVE BY A [Modulated] MEDIUM WAVE, AND ITS DETECTION.—H. Ataka. (*Journ. I.E.E. Japan*, July, 1933, Vol. 53 [No. 7], No. 540: English summary, pp. 54–55, Japanese paper, pp. 556–560.)

Among the results of the theoretical treatment, it is shown that if m is the modulation factor of the medium wave by the speech frequency, and n the modulation factor of the ultra-short wave by the medium wave, the amplitude of the e.m.f. of the speech frequencies in the receiver is greatly influenced by m and n: the maximum amplitude is given when $m = 1$ and $n = 0.5$. Experimental results, on a 4.05 m wave modulated by a 408 m wave, are discussed. The receiver illustrated gives greatly increased sensitivity when operated in an oscillating condition (super-regeneration without external quenching—*cf.* September Abstracts, p. 501, same author).

"FIVE-AND-TEN" [Ultra-Short-Wave] OSCILLATOR-AMPLIFIER TRANSMITTERS.—D. A. Griffin. (*QST*, August, 1933, Vol. 17, No. 8, pp. 18–20 and 28.)

THE TOOL-BOX 56-Mc [Ultra-Short-Wave] TRANSCEIVER: A HAND-PORTABLE FIVE-METRE STATION WITH A NEW TYPE [G. W. Pickard] ANTENNA SYSTEM.—T. P. Leonard and C. F Hadlock. (*Ibid.*, pp. 23–25.)

DIFFERENT FORMS OF OSCILLATION OBTAINABLE WITH THERMIONIC VALVES.—F. Vecchiacchi. (*Alta Frequenza*, June, 1933, Vol. 2, No. 2, pp. 242–243.) Summary and diagrams of a Paris Congress paper.

ON SELF-EXCITED NON-LINEAR VALVE OSCILLATIONS [Relaxation Oscillations: Experimental and Theoretical Investigation].—H. Straub. (*Helvet. Phys. Acta*, Fasc. 5, Vol. 6, 1933, pp. 337–384.)

EFFECT OF CIRCUIT PARAMETERS ON THE CONSTANCY OF THE FREQUENCY OF A PLIODYNATRON.—W. C. Mears. (*Physics*, July 1933, Vol. 4, No. 7, pp. 241–245.)

THE INNER-GRID DYNATRON AND THE DUO-DYNATRON [Single Tetrode Beat-Frequency Oscillator].—T. Hayasi. (*Journ. I.E.E. Japan*, August, 1933, Vol. 53 [No. 8], No. 541: English summary, p. 65, Japanese paper, pp. 686–694.)

The writer points out that the inner grid of a tetrode possesses "a remarkable secondary electron emission phenomenon," and proposes that dynatrons should be classified as (*a*) anode dynatrons (Hull), (*b*) outer-grid dynatrons (Ito, 1931 Abstracts, p. 386), and (*c*) inner-grid dynatrons (here described). Under suitable voltage conditions and with appropriate circuits, the inner-grid dynatron gives two oscillations of different frequency in anode and inner-grid circuits simultaneously ("duo-dynatron oscillator"): experimental results are described, particular attention being given to the synchronising effect of the strong anode oscillation on the weaker inner-grid oscillation. Finally the arrangement is analysed mathematically.

GENERATION OF CURRENT WITH RECTANGULAR WAVE-FORM BY GLOW-DISCHARGE TUBES OR DYNATRONS [Two giving Relaxation Oscillations of Same Frequency (controlled through Grid) but of Opposed Phase: igniting and extinguishing Third Tube without Grid].—(*Hochf:tech. u. Elek:akus.*, August, 1933, Vol. 42, No. 2, p. 75: German Pat. No. 573 633, pub. 4th April, 1933, Telefunken.)

DETERMINATION OF GRID DRIVING POWER IN RADIO-FREQUENCY POWER AMPLIFIERS.—H. P. Thomas. (*Proc. Inst. Rad. Eng.*, August, 1933, Vol. 21, No. 8, pp. 1134–1141.)

The number of stages required in the amplifier chain and the size of the valve needed in each stage depend on the power necessary to excite the successive grid circuits. Very little information on this is available to the designer. Spitzer's experimental method (1929 Abstracts, p. 505, l-h col.) uses a 60-cycle frequency, which has certain inconveniences. The present paper describes an approximate method of measuring the power required to drive the grid circuit of a class C type amplifier when operating at radio frequencies. The only quantities which need to be known are the grid excitation voltage (r.m.s.) and the direct grid current, the driving power being given by

$$W = \sqrt{2} . E_g I_{dg}.$$

ELEMENTARY THEORY OF A SYSTEM OF MULTIPLE MODULATION OF A R.F. OSCILLATION [a Method of Obtaining Maximum Efficiency with Linear Modulation up to the Highest Modulation Percentage].—G. Fayard. (*L'Onde Élec.*, June, 1933, Vol. 12, No. 138, pp. 295–325.)

A theoretical examination of the conditions in the various stages of a power amplifier, as regards the efficiencies of each stage and the distortions introduced, leading to a description of the writer's method of "multiple modulation" in which several stages are modulated simultaneously.

MODULATION PRODUCTS IN A POWER LAW MODULATOR.—A. G. Tynan. (*Proc. Inst. Rad. Eng.*, August, 1933, Vol. 21, No. 8, pp. 1203–1209.)

Author's summary:—Expansion of the current as a function of the voltage in a multiple Fourier series [by Bennett's method—Sept. Abstracts, p. 519, l-h col.] is used to solve the problem of determining the amplitude of the various frequency components produced when a voltage is applied across a resistance, the current in which varies as a power of the voltage across it. Recurrence formulas are developed by which the higher order products can be computed from those of lower order. Certain of the integral coefficients in the Fourier series expansion are evaluated in the form of double summations. The method is applied to a specific case [valve amplifier working into a low plate-load resistance], and sample calculations are carried through in detail. While the method is not as well adapted to obtaining qualitative results as are the usual forms of analysis, it does appear to have some advantages when numerical results are required, or when the effects of the contributions of higher order products are to be studied.

A SIMPLIFIED METHOD OF MODULATOR DESIGN.—E. A. Laport. (*Electronics*, July, 1933, Vol. 6, No. 7, pp. 184–185.)

NOTE ON AN IMPULSE INDICATOR [for Monitoring Modulation of Wireless Transmitters and Sound Films: Length of Light Column in Neon Tube proportional to Current Flowing].—Y. Rocard. (*Bull. de la Soc. Franç. Radioélec.*, May/June, 1933, Vol. 7, No. 3, pp. 56–60.) *See* also pp. 61–65.

CLASS B AUDIO AMPLIFIER AS A MODULATOR FOR BROADCASTING STATIONS.—L. E. Barton. (*Rad. Engineering*, July, 1933, Vol. 13, No. 7, pp. 6–8.)

RECEPTION

THE RECEPTION OF DECIMETRE WAVES WITH THE RETARDING-FIELD AUDION.—H. E. Hollmann. (*Funktechnische Monatshefte*, July, 1933, No. 7, pp. 249–253.)

An account of Heinrich-Hertz Institute researches on demodulation by the retarding-field audion, following on the writer's presentation of his "ultra-dynamic oscillation excitation" theory of ultra-short-wave generation (Oct. Abstracts, pp. 563–564). One important result of these researches is referred to at the beginning of the next abstract. For decimetre wave reception it was found desirable, when signals were very weak, to increase the sensitivity by damping reduction. This could be done by simultaneous adjustment of filament heating and of operating voltages. It was found that the maximum sensitivity *did not occur just before the setting-in of oscillation*, but at much lower emission current values: investigation showed that the two processes, the rectification and the excitation of oscillation, do not simply superimpose themselves one on the other in the case of the retarding-field valve: the increase of control voltage resulting from the decrease of damping is paid for by a corresponding decrease in rectification. This discovery led to a separation of the two functions by the use of two valves, and finally (in the "Twin" receiver) of a double valve with two entirely separate electrode systems capacitively coupled inside the valve.

THE RETARDING-FIELD AUDION CONTROLLED WITHOUT POWER EXPENDITURE [and used for Waves other than Ultra-Short].—H. E. Hollmann. (*E.N.T.*, August, 1933, Vol. 10, No. 8, p. 353.)

The writer has shown (*see* above) that in the reception of ultra-short waves with the retarding-field circuit the rectifying effect of such a valve depends on its non-linear characteristic and is in no way a result of the Barkhausen "dance of the electrons" which occurs only with decimetre waves. Consequently the retarding-field audion should be applicable as a detector not only for decimetre waves but for any desired carrier frequency. There is however an important difference between such a detector and the ordinary, space-charge controlled triode, in that the simple, directly controlled retarding-field audion loads the control voltage very heavily indeed with its internal resistance of the order of 10^3 to 10^4 ohms. As a result, it is only serviceable with waves of a few metres or less, where the resonance resistance of the input circuit is something of the same order: for longer waves, such as those of the broadcasting band, the resonance circuit would be practically short circuited by the retarding-field valve.

The writer however has devised a circuit in which the control voltage from the input circuit coupled to the aerial is applied not only to the retarding-field electrode but simultaneously to the grid: the simplest way of doing this is by a small bridging condenser of a few hundred centimetres' capacity, a choking coil being introduced to prevent r.f. from reaching the output transformer. As a result of this connection the control voltage acts on the pure saturation resistance of the valve without the absorption of energy; the retarding-field audion, with simple tungsten valves, then surpasses in sensitivity the modern audion valves with grid rectification, while as regards its rectifying action it is as good as the normal anode-bend detector. Further researches will be published later.

Reception of Ultra-Short (3 Metre) Waves on a Tourmalin-Stabilised Receiver.—Heinrich-Hertz Institute. (*E.N.T.*, May, 1933, Vol. 10, No. 5, p. 232: paragraph only.)

On the Modulation of an Ultra-Short Wave by a [Modulated] Medium Wave, and its Detection.—Ataka. (*See* under "Transmission.")

The Theory of the Super-Regenerative Coupling.—G. Gorelik. (*Journ. of Technical Physics*, Leningrad and Moscow, No. 1, Vol. 3, 1933, pp. 110–130: in Russian.)

For a previous paper *see* 1932 Abstracts, p. 164. The writer derives the non-linear differential equation for a simple super-regenerative circuit and gives its approximate solution in the case of rapid modulation and very small average damping. In the absence of any external signal, either quasi-periodic oscillations (average damping negative) or an irregular rise and fall of oscillations (average damping positive) may occur. On the arrival of external sinusoidal signals, quasi-periodic oscillations occur, with combination tones between the signal frequency and the modulation frequency. Resonance occurs whenever one of these combination frequencies coincides with the natural frequency of the circuit. The writer calculates the energy of the quasi-periodic oscillations in the resonance zone: the calculation shows that the receiver is the more sensitive, the greater the amplitude of the modulating potential and the smaller its frequency.

A New Method of Radioelectric Coupling: the "Diffusion" Coupling [giving Great Selectivity to Pre-Selector Circuits, and Unidirectional Properties to a Receiving Frame: based on the "Depolarising" Effect of Flake Graphite].—R. Cordebas. (*Rev. Gén. de l'Élec.*, 9th Sept., 1933, Vol. 34, No. 10, pp. 305–312.)

An accidental discovery in the course of tests on the conductivity of graphite at radio frequencies. The graphite, in the form of 2 mm flakes, is contained in a 10 cm glass tube of 3 cm external diameter, with a central copper rod electrode extending nearly to the bottom. The tube is wholly or partly surrounded by a solenoidal or honey-comb winding. The "diffusion" coupling between the circuit connected to the electrode and that connected to the coil is due to a transfer of energy through the mediation of the graphite flakes. Special tests, here described, have convinced the writer that this is no ordinary capacity effect but a new phenomenon with very unusual attributes. "The radioelectric couplings through the dielectrics currently employed carry out their energy transfer by polarised wave; that is to say, by a wave in which the vectors of the electric and magnetic fields have fixed directions in the wave front. The distinction between capacitive and magnetic coupling relates only to the directions of the conductors with regard to those of the electric and magnetic vectors. Certain media, such as graphite flakes, 'diffuse' the electromagnetic wave. If one considers a wave front at a given instant, one finds always the electric and magnetic vectors, but their direction depends on the part of the front which is considered: the wave may be said to be 'depolarised.'"

Experiments are described in which the "diffussion coupling" was employed (1) in a pre-selector circuit to a superheterodyne receiver (which was carefully insulated). As arranged in Fig. 8 it gave remarkable selectivity, with a vertical aerial instead of the usual frame. An interesting point is that two positions of the tuning condenser, very close together, give high signal strength and complete extinction respectively. (2) As a pivot for a rotating frame aerial: used in this way the coupling eliminates the 180° error. "We believe that this apparatus could be extremely useful for aeroplanes, in which the mass of metal could be used as antenna, the aeroplane being able to take its bearings in flight without any aerial having to be erected." (3) In an equipment for a 30-seconds' test of the quality of graphite.

Alteration of Tuning when the Retroaction Coupling is Varied [Cases where the Leithäuser Circuit, with Capacitive Retroaction Coupling, Fails].—R. Schienemann. (*T.F.T.*, May, 1933, Vol. 22, No. 5, pp. 115–117.)

The Action of Damping Reduction [by Retroaction] in Broadcast Receivers.—W. Kautter. (*E.N.T.*, July, 1933, Vol. 10, No. 7, pp. 287–302.)

Author's summary:—"In a previous paper [August Abstracts, p. 447] it was shown how, with the usual retroactive coupling connections in receivers, the action of the back coupling can be replaced completely by a negative real conductance of calculable value. In the present paper it is explained what effects the damping reduction has on the selectivity, potential transformation (amplification), non-linear distortion factor [' klirrfaktor '] and such secondary phenomena in the circuits. With the help of these negative conductances many known properties of retroactively coupled circuits can be dealt with and explained in a greatly simplified manner."

THE H.F. SCREEN-GRID VALVE AS AN ANODE-BEND DETECTOR.—J. Kammerloher. (*E.N.T.*, August, 1933, Vol. 10, No. 8, pp. 345–352.)

The theoretical part starts off by assuming (1) that the positive envelope of the r.f. applied to the grid lies in the straight part of the static characteristic, and (2) that the negative bias of the control grid is made so high that the negative r.f. amplitudes are practically suppressed. It is seen that such an anode-bend detector, when supplied with modulated r.f., can also act simultaneously as a l.f. amplifier; in this case, however, if non-linear distortion is to be avoided, the dynamic characteristic also must be straight in the working zone; above all, the bend due to premature saturation must be kept out of action. This involves keeping the anode voltage always at least as high as the s.g. voltage, and this again limits the permissible anode-circuit resistance to the value given by formula 7. Examination of the frequency dependence of the circuit leads to formula 11 for the maximum permissible capacity across the anode-circuit resistance.

The second part describes an experimental investigation, largely with a cathode-ray oscillograph, to check the various theoretical results.

THE MODE OF ACTION OF DIODE DETECTION.—R. Urtel. (*Telefunken-Zeit.*, August, 1933, Vol. 14, No. 64, pp. 30–45.)

Theoretical analysis of a generator of l.f.-modulated r.f. potential loaded with a rectifying gap in series with an ohmic resistance R_a, the latter being shunted by a condenser C of such a size that practically the full terminal voltage of the generator is applied to the rectifying gap. The object is to find how the various components of the circuit affect the amplitude and the distortion (linear and non-linear) of the l.f. voltage obtained. All the implications of the results are not as yet quite clear, but it is seen that *the internal resistance R_g of the generator plays a specially important rôle.* As regards the R_aC circuit it is evident that while on the one hand the ratio R_a/R_g should be very great in order to give good rectification and small distortion, on the other hand R_a is limited by the necessity of keeping the phase angle small. This can be done to a certain extent only by making C small, so that an inadmissible r.f. voltage drop does not occur at C.

THE BEAT-NOTE–COMBINATIONAL-TONE CONTROVERSY.—H. Hazel and R. R. Ramsey. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 321: abstract only.)

" Experimental study of the conditions necessary for modulation shows that combinational tones or side-band frequencies are produced whenever a product term of the two parent frequencies is involved, regardless of whether linear or non-linear response characteristics are used."

SELECTED PROBLEMS FROM BROADCAST RECEIVER TECHNIQUE, WITH SPECIAL REFERENCE TO THE SUPERHETERODYNE RECEIVER.—A. Clausing. (*Funktechnische Monatshefte*, Aug., 1933, No. 8, pp. 297–303.)

STABILITY PROBLEMS OF TUNED R.F. AND SUPERHETERODYNE RECEIVERS.—S. W. Place. (*Rad. Engineering*, August, 1933, Vol. 13, No. 8, pp. 8 and 20.)

WHY THE DOUBLE HUMP? [in Band Pass Filters]. —G. W. O. Howe. (*Wireless World*, 4th August, 1933, Vol. 33, pp. 74–76.)

PROBLEMS OF ELECTRICAL INTERFERENCE.—A. Morris. (*Wireless World*, 18th August, 1933, Vol. 33, p. 144.)

A REVIEW OF DEVELOPMENTS IN [American] BROADCAST RECEIVERS OF 1933.—E. Messing and M. Cohen. (*Rad. Engineering*, August, 1933, Vol. 13, No. 8, pp. 6–7 and 20.)

THE TREND OF PROGRESS.—(*Wireless World*, 18th August, 1933, Vol. 33, pp. 121–128, 137–142, 145–146, 147–148.)

A series of articles dealing with the year's advances in the design of receivers and components as reflected by the Olympia Radio Show.

ITALIAN BROADCAST RECEIVERS: " RADIOMARELLI" 1932–33 RECEIVERS.—(*Alta Frequenza*, June, 1933, Vol. 2, No. 2, pp. 298–309.)

RECEPTION TESTS ON THE GERMAN " PEOPLE'S RECEIVER."—G. Leithauser. (*Funktechnische Monatshefte*, July, 1933, No. 7, pp. 253–254.)

THE WIRELESS WORLD MODERN BATTERY FOUR [with Iron-Cored Tuning Inductances and Class B Output].—W. T. Cocking. (*Wireless World*, 11th and 25th August, 1933, Vol. 33, pp. 86–90 and 153–154.)

AUTOMATIC FADING REGULATION WITHOUT REGULATING VALVE OR BATTERY [using Grid Bias of Output Valve (from P.D. due to Anode Current) as Bias for Previous Stages].—K. Franck. (*Funktechnische Monatshefte*, February, 1933, No. 2, p. 70.)

THE INFLUENCE OF FADING COMPENSATION ON CONTRAST IN MUSIC.—Th. Sturm. (*Funktechnische Monatshefte*, April, 1933, No. 4, pp. 139–143.)

DELAYED DIODE A.V.C.—W. T. Cocking. (*Wireless World*, 8th September, 1933, Vol. 33, pp. 208–210.)

DELAYED AMPLIFIED A.V.C.—W. T. Cocking. (*Wireless World*, 22nd September, 1933, Vol. 33, pp. 244–246.)

AERIALS AND AERIAL SYSTEMS

EXPERIMENTAL AND THEORETICAL STUDY OF THE POLAR DISTRIBUTION OF ENERGY IN A BEAM AT GREAT DISTANCE FROM THE SENDER [and Theory of the Transmission of Waves in an Ionised Gas in which there is a Horizontal as well as a Vertical Gradient].—T. L. Eckersley. (*Marconi Review*, July/August, 1933, No. 43, pp. 1–11.)

Discussing "the question of the difference between theoretical and observed values . . . as revealed by recent experiments made by the Marconi Company in conjunction with the British Post Office on the transmission from the Marconi Beam Station at Klipheuval, S. Africa." With regard to certain observations showing a lateral deviation of the beam towards the west, the writer says "It seems as if the beam were not only bent but also spread, some of the rays—for example the high-angle ones—being largely bent, and others—say the low-angle ones—being hardly bent at all. On examining the theory given in the next section, it appears that such an effect would follow on the assumption that the rays are bent both by a vertical and by a horizontal gradient of ionic density." At the end of the section in question he points out that the theoretical deviation is proportional to the square of the number of hops: the trace of the ray on the ground is then a parabola. The amount of deviation increases rapidly with the angle of elevation, so that the high-angle rays are more deviated than the low-angle ones and the beam is fanned out. "The deviations likely to be produced with known horizontal gradients in the layer can be calculated, and they are found to be of the right order. It seems therefore probable that the explanation offered of the results observed is substantially correct."

RADIATION FROM ANTENNAE UNDER THE INFLUENCE OF THE EARTH'S PROPERTIES. E.—RADIATION INTO THE EARTH [Theoretical Investigation].—M. J. O. Strutt. (*Ann. der Physik*, 1933, Series 5, Vol. 17, No. 4, pp. 376–384.)

This paper gives formulae for the Hertzian potentials and Poynting vectors of the field in the earth, at a great distance from the emitting aerial, produced by vertical and horizontal electric and magnetic dipoles above the earth's surface. For the previous papers *see* Abstracts, 1929, p. 329 (*see* also p. 623); 1930, p. 278; and 1932, pp. 27–28.

PHASE SYNCHRONISATION IN DIRECTIVE ANTENNA ARRAYS, WITH PARTICULAR APPLICATION TO THE RADIO RANGE BEACON [using the "Transmission Line" Antenna, Adcock Principle].—Kear. (*See* under "Directional Wireless.")

DISCUSSION OF SOME ASYMPTOTIC EXPANSIONS IN THE THEORY OF THE VERTICAL ELECTRIC DIPOLE.—Murray. (*See* under "Propagation of Waves.")

GENERAL FORMULA FOR THE MUTUAL RADIATION IMPEDANCE OF ANY STRAIGHT PARTS OF THE WIRES WITH STANDING SINUSOIDAL CURRENT DISTRIBUTION.—G. Hara. (*Journ. I.E.E. Japan*, July, 1933, Vol. 53 [No. 7], No. 540: English summary pp. 50–51, Japanese paper pp. 535–546.)

MUTUAL IMPEDANCE OF GROUNDED WIRES LYING ON OR ABOVE THE SURFACE OF THE EARTH.—R. M. Foster. (*Bell S. Tech. Journ.*, July, 1933, Vol. 12, No. 3, pp. 264–287.)

A preliminary report on the results of this theoretical paper was referred to in 1932 Abstracts, p. 641, l-h col. This full account of the work gives comprehensive curves and numerical tables of quantities occurring in the course of the calculations.

IS THE PROBLEM OF THE COMMUNAL AERIAL SOLVED?—F. Noack: Philips' Company. (*Funktechnische Monatshefte*, March, 1933, No. 3, pp. 100–101.)

"RECEPTRU" SCREENED LEAD-IN CABLE. (*Television*, September, 1933, Vol. 6, No. 67, p. 332.)

VALVES AND THERMIONICS

THE BEHAVIOUR OF AN ELECTRONIC VALVE WITH A FERROMAGNETIC ANODE IN A MAGNETIC FIELD.—H. A. Schwarzenbach. (*Ann. der Physik*, 1933, Series 5, Vol. 17, No. 4, pp. 385–400.)

The static characteristics of a triode with nickel anode, under the action of a magnetic field parallel to the axis of the electrodes, are given and their variation with time described. It is shown that there are changes in the magnetic field due to temperature variations in the anode.

VARIOUS PAPERS AND PATENTS ON MAGNETRON OSCILLATORS.—(*See* under "Transmission.")

SPACE-CHARGE PHENOMENA IN ELECTRONIC VALVES [and the Anomalies in the Static Characteristic of the Hull Magnetron].—H. A. Schwarzenbach. (*Helvet. Phys. Acta*, Fasc. 4, Vol. 6, 1933, pp. 252–254.)

TUBES TO FIT THE WAVELENGTH [Specially Small Triode and S.G. Valve for Micro-Waves: Max. Overall Dimension about 3/4 Inch].—B. J. Thompson. (*Electronics*, August, 1933, Vol. 6, No. 8, pp. 214–215 and cover.)

The valves here described are not contemplated for immediate manufacture: they are RCA Radiotron experimental models. Both have indirectly heated cathodes and a parallel-plane structure, the cathodes and anodes being shaped as flat-bottomed cups and the grids as flat discs. The inter-electrode spacing is of the order of 0.005 inch. "Considering the excellent performance of these tubes as oscillators and detectors, and the fair performance as r.f. amplifiers, it is to be expected that good superheterodyne receivers could be constructed at wavelengths approaching 50 cm."

300 KW TRANSMITTING VALVE FOR HILVERSUM.—Philips Company. (*Electronics*, July, 1933, Vol. 6, No. 7, p. 198.)

[German] HIGH-POWER TRANSMITTING VALVES. (*E.T.Z.*, 7th Sept., 1933, Vol. 54, No. 36, pp. 871–872.)

THE INNER-GRID DYNATRON AND THE DUO-DYNATRON.—Hayasi. (*See* under "Transmission.")

AUDIO SYSTEM WITH THE NEW 2B6 TUBE [for Class A Triode Output: Two Sets of Triode Elements in Series, with Common Heater but Electrically Separate Cathodes].—C. F. Stromeyer. (*Rad. Engineering*, August, 1933, Vol. 13, No. 8, pp. 11–12 and 20.)

"Since Class A triode output is conceded as the most desirable of known methods for perfect reception, it or its equivalent should be the goal of the development" in the search for large undistorted outputs. The 2B6 gives 4 watts with a total harmonic content of 5% or less. Two in push-pull easily give 10 watts, and the harmonics are considerably reduced by the push-pull cancellation: "the evens nearly disappear and the odds, contrary to the erroneous general push-pull conception, are considerably reduced."

MEASUREMENT OF THE INTERNAL RESISTANCE OF B-AMPLIFIER VALVES [by a Modified Wheatstone Bridge Method].—V. Babits and V. Szalontay. (*Zeitschr. f. Physik*, 1933, Vol. 84, No. 3/4, pp. 260–263.)

SCREEN-GRID, PENTODE AND EXPONENTIAL VALVES.—W. Heinze. (*Funktechnische Monatshefte*, Aug., 1933, No. 8, pp. 305–314.)

THE NEW VALVES [Mixing Hexode, Fading Hexode, and Binode] AND THEIR CONNECTIONS IN SUPERHETERODYNE RECEIVERS.—H. von der Bey. (*Die Sendung*, 15th September, 1933, Vol. 10, No. 38, pp. 828–829.)

THE WESTINGHOUSE INDUSTRIAL TUBE DRJ-571, AN INDIRECTLY HEATED MULTI-GRID VALVE GIVING CONSTANT CURRENT OUTPUT FOR PLATE POTENTIALS VARYING FROM 10 TO 400 VOLTS.—Haller. (*See* abstract under "Subsidiary Apparatus and Materials.")

RECTIFIERS AND OSCILLATORS WITH 220-VOLT VALVES, *and* TESTS ON HIGH-VOLTAGE RECTIFIER VALVES.—W. Diefenbach: H. Härtel. (*Funktechnische Monatshefte*, February, 1933, No. 2, pp. 73–75: 79–80.)

NEW TELEFUNKEN VALVES [and in particular the Bifilar Cathode].—F. Schröter. (*Telefunken-Zeit.*, August, 1933, Vol. 14, No. 64, pp. 19–21.)

FINE BUT STRONG LOW-CURRENT OXIDE-COATED CATHODES WITH TUNGSTEN (Molybdenum, Tantalum) CORE COATED WITH NICKEL (Platinum, Cobalt).—(*Rev. Gén. de l'Élec.*, 1st July, 1933, Vol. 33, No. 26, pp. 206–207 D: French Pat. No. 744 135, pub. 12th April, 1933, Thomson-Houston Company.)

THE TOTAL RADIATION FROM OXIDE CATHODES.—Clausing and Ludwig. (*Physica*, No. 6, Vol. 13, 1933, pp. 193–205: in German.)

EMISSION OF METALLIC IONS FROM OXIDE SURFACES. I.—IDENTIFICATION OF THE IONS BY MOBILITY MEASUREMENTS: II.—MECHANISM OF THE EMISSION.—L. Brata: C. F. Powell and L. Brata. (*Proc. Roy. Soc.*, 1st Aug., 1933, Vol. 141, No. A844, pp. 454–462: 463–472.)

ELECTRONIC PHENOMENA IN RADIOELECTRIC VALVES.—B. van der Pol. (*Alta Frequenza*, June, 1933, Vol. 2, No. 2, p. 241.) Summary of Paris Congress paper: diagrams pp. 240–242.

NOISE [Thermal and Shot Effect] AS A LIMITING FACTOR IN AMPLIFIER DESIGN.—Keall. (*See* under "Phototelegraphy and Television.")

PAPERS ON SHOT EFFECT AND THERMAL AGITATION, AND THE INITIAL AND FINAL AMPLITUDES OF A DAMPED OSCILLATORY PROCESS.—Barkhausen and Hässler: Hässler. (*See* abstracts under "Transmission.")

CONTACT POTENTIAL DIFFERENCES BETWEEN DIFFERENT FACES OF COPPER SINGLE CRYSTALS.—Farnsworth and Rose. (*See* under "Phototelegraphy and Television.")

DIRECTIONAL WIRELESS

PHASE SYNCHRONISATION IN DIRECTIVE ANTENNA ARRAYS, WITH PARTICULAR APPLICATION TO THE RADIO RANGE BEACON [using the "Transmission Line" Antenna, Adcock Principle].—F. G. Kear. (*Bur. of Stds. Journ. of Res.*, July, 1933, Vol. 11, No. 1, pp. 123–139.)

Author's summary:—"With the development of the TL antenna system [March Abstracts, p. 162] for use with the radio range beacon a new problem was encountered. It became necessary to provide a positive means of stabilising the space pattern. Slight detuning of the antennas would alter the course indications. The extent to which detuning affects the pattern is demonstrated in detail, and the limits to which the tuning must be maintained are shown to be very rigid. To overcome this difficulty two types of excitation systems have been developed, in which the stability of the space pattern is independent of the antenna tuning to a marked degree. Either a parallel connected pair of lines 90° in electrical length, or a series connection of lines 180° in length, is shown to possess this characteristic" [the parallel connection seems to be preferable as it operates over a wider range, requires less line length, and has a simpler exciting circuit: for use in the airway installations it has been adopted as standard].

"Experimental data on several types of lines show the system to be practical for use along the airways, and no sacrifice of the desirable features of the TL antenna is required. Tests of the system on actual airway range beacons show it to be satisfactory."

A RADIO COMPASS DEVELOPED IN H.M. SIGNAL SCHOOL.—Horton and Crampton. (*Journ. I.E.E.*, September, 1933, Vol. 73, No. 441, pp. 284–294.)

The full paper, a summary of which was dealt with in July Abstracts, p. 395, r-h column.

ERRORS IN DIRECTION-FINDING CALIBRATIONS IN STEEL SHIPS DUE TO THE SHAPE AND ORIENTATION OF THE AERIAL OF THE TRANSMITTING STATION.—J. F. Coales. (*Journ. I.E.E.*, September, 1933, Vol. 73, No. 441, pp. 280–283: Discussion pp. 292–294.)

The full paper, a summary of which was dealt with in July Abstracts, pp. 395–396.

S.F.R. TRANSMITTER FOR RADIO ALIGNMENT [" SADOD " System].—(*Bull. de la Soc. Franç. Radioélec.*, Nov./Dec., 1932, Vol. 6, No. 6, pp. 145–149.)

Development of the system dealt with in 1929 Abstracts, p. 332 (Aicardi).

FOG LANDING BY WIRELESS [Newark Air Port]. (*Wireless World*, 25th August, 1933, Vol. 33, pp. 151–152.)

ELIMINATION OF 180° ERROR IN A FRAME AERIAL BY THE USE OF THE " DIFFUSION COUPLING." —Cordebas. (*See* abstract under " Reception.")

ACOUSTICS AND AUDIO-FREQUENCIES

A NEW [Double-Heterodyne] METHOD OF FREQUENCY ANALYSIS AND ITS APPLICATION TO THE INVESTIGATION OF AEROPLANE NOISES.—F. Eisner. (*Hochf:tech. u. Elek: akus.*, August, 1933, Vol. 42, No. 2, pp. 53–64.)

In a previous paper (Eisner, Rehm and Schuchmann, January Abstracts, p. 46, l-h. col.) on the analysis of aircraft noises it was shown that the methods then available had not sufficiently good resolving power for a satisfactory investigation of such noises : a resolving power of a few cycles in a range from zero to about 5 000 c/s is really necessary. The present paper describes a new procedure which satisfies this requirement and which is suitable also for many other investigations.

The method by which the resolving power of the well-known Grützmacher exploring-note process is enormously improved is as follows :—Supposing that a mixed noise is to be analysed whose highest component has a frequency a c/s. A pure sinusoidal exploring note is superposed on the mixture, its frequency slowly increasing from a to $2a$. A note of x c/s in the spectrum under investigation combines with the exploring note of $a + x$ c/s to give a difference note of a c/s. The beat-note current produced by the superposition, after rectification with dry-plate rectifiers, flows through an electrical filter whose pass-band extends $\pm f_0$ c/s on either side of a c/s ; f_0 being so chosen that the filter can be made conveniently. On the far side of the filter a current is given only in the zone between $a - f_0$ and $a + f_0$, as the exploring note varies from $a + x - f_0$ to $a + x + f_0$; the maximum deflection of the indicating instrument is exactly at a c/s. This current beyond the filter has superposed on it the current from a generator of constant frequency $a - f_0$, with the consequent production of a second difference note whose frequency moves from 0 to $2f_0$ as the exploring note progresses to $2f_0$. The maximum of this second difference note lies at f_0 c/s. The current is taken to a very sharply tuned filter with a pass band only 5 c/s wide and a mean resonance frequency of $f_0 = 100$ c/s. Since such a filter, if carried out electrically, would involve very large coils and condensers, a mechanical resonance system is used consisting of a circular hard steel diaphragm, fixed only by its single lug, between two telephone magnet systems (*cf.* Gunn, Abstracts, 1932, pp. 357–358). The current passed by this second filter is taken to an oscillograph whose movements are recorded photographically.

The best way of utilising the very high resolving power obtained with such an equipment is discussed in section II 2. A direct procedure would mean that the source of the sound to be analysed would have to function constantly during the space of about one hour. This would be very inconvenient, and in many cases impossible : thus the " knocking " of a motor would cause damage if prolonged in this way. The solution in such cases lies in a complete separation of the recording and analysing processes, the sound mixture being recorded by sound-film technique over a short time and reproduced slowly for analysis. The errors likely to be introduced by this procedure are examined at length.

Other methods of obtaining a high resolving power are mentioned on p. 56, including the valve-filament-heating method of Theodorsen (1932, pp. 229–230) and of Diebitsch and Zuhrt (1932, p. 644), but the writer prefers the double-heterodyne method on account of the simplicity of the apparatus and the division of the necessary amplification between two different frequencies, which has advantages as regards screening and freedom from interference and tendency to howl. The paper ends with some examples of the use of his equipment.

SUB-HARMONICS IN FORCED OSCILLATIONS IN DISSIPATIVE SYSTEMS.—P. O. Pedersen. (*Ingeniørvidenskabelige Skrifter*, A Nr. 35, 1933, 86 pp : abridged report in *Ingeniøren*, Copenhagen, 28th January, 1933.)

This is the paper referred to in the correspondence on " Vibrations of a coil-driven paper cone " (Sept. Abstracts, p. 509). The writer sums up : " The calculations thus prove that while in systems with but one degree of freedom *only* second sub-harmonics can occur, in systems with two degrees of freedom a fourth sub-harmonic *may* occur under certain circumstances. This fourth sub-harmonic is not capable of arising ' on its own '—as previously mentioned, an already existing second sub-harmonic is necessary for its development. The fourth sub-harmonic which we found during the experiments with the loudspeaker must undoubtedly be explained as here outlined, since the loudspeaker diaphragm must be considered as a system with several degrees of freedom.

" It will also appear from the preceding that fourth sub-harmonics are comparatively rare phenomena, since their occurrence necessitates a small damping of the coupled systems as well as a rather exacting tuning of the one system for ½f and of the other for ¼f. As already mentioned, the phenomenon has been observed on several occasions in connection with loudspeakers, but even extremely small alterations, as for instance a very small increase of the sound absorption of the surroundings, or an increase of the humidity in the room (with a consequent increase of the damping of the diaphragm) may prevent the occurrence of the tone ¼f.

" Second sub-harmonics are, contrary to the fourth sub-harmonics, very easily developed and actually they occur quite frequently. It is therefore most important to pay attention to these sub-harmonics not only in technical acoustics but in physical and physiological acoustics as well. It may also be of importance to the designing engineer to pay attention to the possibilities of the occurrence of such sub-harmonics."

GENERATION OF HARMONICS IN HORN LOUDSPEAKERS: THE RESULTING POWER LIMITATION FOR THESE INSTRUMENTS.—Y. Rocard. (*Bull. de la Soc. Franç. Radioélec.*, March/April, 1933, Vol. 7, No. 2, pp. 28–39.)

THE BEAT-NOTE–COMBINATIONAL-TONE CONTROVERSY.—Hazel and Ramsey. (*See* under "Reception.")

MODULATION PRODUCTS IN A POWER LAW MODULATOR.—Tynan. (*See* under "Transmission.")

ON THE FAITHFUL REPRODUCTION OF SOUND [Equipment comprising Improved Ribbon Microphone, Special Amplifier with "Thyrite" Compensation, and Two Loudspeakers, M.C. and Ribbon Types].—P. Caporale and R. di Sabatino. (*Alta Frequenza*, June, 1933, Vol. 2, No. 2, pp. 186–196.) For Caporale's paper mentioning "Thyrite" compensation *see* Oct. Abstracts, p. 563, l-h column.

NATURAL VIBRATIONS OF A CONICAL SHELL [Application to Loudspeaker Theory].—M. J. O. Strutt. (*Ann. der Physik*, 1933, Series 5, Vol. 17, No. 7, pp. 729–735.)

Formulae are found giving the frequencies of the natural vibrations of a thin loudspeaker cone, under the assumption that there is no extension of the conical surface during the vibration. The cases of (1) a cone surrounded by an unstretchable baffle and (2) a free cone are considered; a mathematical method due to Rayleigh is employed.

MEASUREMENT OF THE [Frequency of] RADIAL OSCILLATIONS OF THIN ALUMINIUM CONICAL SURFACES.—A. T. van Urk and G. B. Hut. (*Ann. der Physik*, 1933, Series 5, Vol. 17, No. 8, pp. 915–920.)

The results of measurement of the frequency of radial oscillations of thin aluminium conical surfaces do not agree with the theoretical formula deduced by Strutt (*see* above abstract). The discrepancy between the results of theory and experiment does not decrease with the thickness of the aluminium.

VIBRATIONS IN SOLID RODS AND DISCS.—G. S. Field. (*Canadian Journ. of Res.*, June, 1933, Vol. 8, No. 6, pp. 563–574.)

Author's abstract:—I. A method is described for producing on the screen of a cathode-ray oscillograph a curve showing the oscillations occurring in a solid rod or disc as the result of impact. These curves are usually quite complex, as they represent combinations of several different modes of vibration. They may be analysed, however, so that for any specimen the various component frequencies may be determined. This has been done for a great number of rods and discs, and the experimental frequencies so obtained have been compared with those calculated from theory. A discussion of the results is given.

II. The solutions given by Love for the general equations of vibration applicable to transverse waves in cylindrical rods are examined, and it is shown that they do not apply to comparatively short rods. Other solutions of the same simple form are considered, and the conclusion is finally reached that a much more complex solution will be required to satisfy all the boundary conditions.

LOUDSPEAKER WITH LARGE-SURFACE MEMBRANE FIXED AT EDGES AND DRAWN OUT INTO OBLIQUE CONE: DRIVEN THROUGH A CONE-SHAPED LINK FIXED ECCENTRICALLY TO IT.—(*Hochf:tech. u. Elek:akus.*, July, 1933, Vol. 42, No. 1, p. 37: German Pat. No. 570 866, pub. 21st Feb., 1933, van Lier.)

LOUDSPEAKER PERFORMANCE AND DESIGN: DRIVING MECHANISMS [Balanced Armature and Inductor Dynamic Types: Hornless Moving-Coil and Blatthaller Speakers].—N. W. McLachlan. (*World-Radio*, 11th and 18th Aug., 1933, Vol. 17, Nos. 420 and 421, pp. 166, 168 and 201, 204: Parts 3 and 4 of a Series.)

THE ACOUSTICAL PROPERTIES OF PARABOLIC REFLECTORS [and a Comparison with Conical Horns].—K. Satô and M. Sasao. (*Sci. Abstracts, Sec. A*, June, 1933, Vol. 36, No. 426, p. 618.)

THE MEASUREMENT OF MECHANICAL IMPEDANCE TO L.F. ALTERNATING TORSIONAL MOTION: *and* THE RECORDING OF THE CHARACTERISTIC OF A MECHANICAL FILTER.—E. Paolini. (*Alta Frequenza*, June, 1933, Vol. 2, No. 2, pp. 197–211 and 212–223.)

The method of measurement described in the first paper is that dealt with in Oct. Abstracts, p. 570. The second paper describes tests on a mechanical filter developed on the lines there mentioned; a low-pass filter of this type is compared with the corresponding electrical filter.

SPECIAL PICK-UPS FOR THE LOW AMPLIFICATION PROVIDED BY THE GERMAN "PEOPLE'S RECEIVER."—(*Radio, B., F. für Alle*, August, 1933, p. 340.)

PRACTICAL EXPERIENCES WITH THE HOME-RECORDING OF GRAMOPHONE DISCS.—W. Daudt. (*Funktechnische Monatshefte*, May, 1933, No. 5, pp. 177–181.)

ANALYSIS OF SOUND RECORDING [on Gramophone Discs: Relations between Recording Technique, Playing Time, Loudness, etc.].—W. Hagemann. (*Funktechnische Monatshefte*, February, 1933, No. 2, pp. 49–53.)

THE "DRIVE-IN" MOVIE [Outdoor Automobile Sound-Film Theatre].—(*Electronics*, August, 1933, Vol. 6, No. 8, p. 209.)

BINAURAL RECEPTION.—Harvey Fletcher. (*Wireless World*, 1st September, 1933, Vol. 33, pp. 199–200.) *See* also September Abstracts, pp. 508–509.

ELECTRICAL MUSICAL INSTRUMENTS, THEIR METHODS OF ACTION AND FUNCTIONS.—W. Janovsky. (*E.T.Z.*, 13th and 27th July, 1933, Vol. 54, Nos. 28 and 30, pp. 675–678 and 727–730.)

Musical notes and their characters: definitions and effects of "mobile" and "fixed" formants

(Stumpf) and of the Trautwein "Hallformants" (tone formers). Mechanical-electrical generators, both rotating-disc and vibrating-string types: the production of oscillations with mobile formants by means of a rotating slotted disc and a fixed aperture of suitable outline, or by a fixed regular aperture and a rotating disc of suitable outline: the production of several notes with different mobile formants and different pitch, by a single slotted disc and several "coupling elements" (fixed apertures of different outline): methods of setting strings into vibrations: etc.

THE TRAUTONIUM.—W. Germann. (*Telefunken-Zeit.*, August, 1933, Vol. 14, No. 64, pp. 46–50.)

CARRIER IN CABLE [and the use of a New Type of Amplifier embodying the Principle of "Negative Feedback"].—A. B. Clark and B. W. Kendall: H. S. Black. (*Bell S. Tech. Journ.*, July, 1933, Vol. 12, No. 3, pp. 251–263.)

This paper is also given in the July issue of *Electrical Engineering*. Referring to a 7 650 miles' length of two-way telephone circuit whose total attenuation without amplifiers was about 12 000 db, representing a necessary energy amplification of 10^{1200}, the writers remark that "balancing this huge amplification against the correspondingly huge loss, to the required precision, one or two db, is a difficult problem. Fortunately, a new form of amplifier employing the principle of negative feedback has been invented by Mr. H. S. Black of the Bell Telephone Laboratories and may be described later in an Institute paper. By making use of this negative feedback principle, amplifiers were produced for this job giving an amplification of 50–60 db, and this amplification did not change more than 0.01 db with normal battery and tube variations."

FILTER-TYPE INTERSTAGE AMPLIFIER COUPLING.—W. G. Stone: Salisbury. (*Electronics*, July, 1933, Vol. 6, No. 7, p. 194.)

On a U.S. patent by W. W. Salisbury, according to which a low-pass filter (mid-series termination filter) is used as an inter-valve coupling. In a 3-stage amplifier with 1½ sections of filter in the plate circuit of each stage, with a cut-off of 20 c/s, the gain with old types of valves was 66 db, the maximum variation from 30 to 7 500 c/s being 1 db and up to 15 000 5 db.

AUDIO SYSTEM WITH THE NEW 2B6 TUBE.—Stromeyer. (*See* under "Valves and Thermionics.")

REQUIREMENTS OF AUDIO-FREQUENCY SYSTEMS [including Tolerable Harmonic Distortion with Single-Sided and Push-Pull Connections].—C. H. W. Nason. (*Rad. Engineering*, July, 1933, Vol. 13, No. 7, pp. 20–21.)

SELF-BIASING OUTPUT CIRCUIT USING FIELD COIL OF LOUD SPEAKER.—(*Rev. Gén. de l'Élec.*, 29th July, 1933, Vol. 34, No. 4, p. 29 D: French Pat. No. 744 362, pub. 19th April, 1933, Thomson-Houston Company.)

MATCH YOUR IMPEDANCES [and the Calculation of Audio-Transformer Ratios to Avoid Distortion].—D. E. Noble. (*QST*, July, 1933, Vol. 17, No. 7, pp. 34–36.)

DEVELOPMENTS IN THE APPLICATION OF ARTICULATION TESTING.—T. G. Castner and C. W. Carter, Jr. (*Bell S. Tech. Journ.*, July, 1933, Vol. 12, No. 2, pp. 347–370.)

A SYSTEM OF EFFECTIVE TRANSMISSION DATA FOR RATING TELEPHONE CIRCUITS.—F. W. McKown and J. W. Emling. (*Bell S. Tech. Journ.*, July, 1933, Vol. 12, No. 3, pp. 331–346.)

THE RESTORATION OF SUPPRESSED SPEECH FREQUENCIES BY MEANS OF A NON-LINEARLY DISTORTING SECTION [Dry-Plate Rectifier or Valve Circuit].—K. O. Schmidt. (*E.N.T.*, July, 1933, Vol. 10, No. 7, p. 316.) Author's long summary of the paper referred to in July Abstracts, p. 398, r-h col.

DELAYED SPEECH [including the Magnetic Tape-Recording Method].—C. N. Hickman. (*Bell Lab. Record*, June, 1933, Vol. 11, No. 10, pp. 308–310.)

MIXER CIRCUITS [for Combining Programme Elements on Several Channels].—(*Rad. Engineering*, July, 1933, Vol. 13, No. 7, pp. 14–15.)

MICROPHONE AND STUDIO TECHNIQUE.—(*World-Radio*, 4th August, 1933, Vol. 17, pp. 132–133: Part III of a series.)

RESISTANCE-STABILISED [Audio] OSCILLATORS [and Their Design Principles].—F. E. Terman. (*Electronics*, July, 1933, Vol. 6, No. 7, pp. 190–191.)

AUTOMATIC SYNCHRONISATION OF OSCILLATORS BY LISSAJOUS FIGURE AND PHOTOCELL DEVICE.—(*Hochf:tech. u. Elek:akus.*, August, 1933, Vol. 42, No. 2, pp. 75–76: German Pat. No. 575 176, pub. 12th April, 1933, Zeiss.)

The master tuning fork and the working fork combine optically (by a light or heat ray) to give Lissajous' figures whose shape determines the amount of light falling on a photocell: the amplified output of the latter corrects the working fork.

NOISE MEASUREMENT [a Survey].—E. E. Free. (*Review Scient. Instr.*, July, 1933, Vol. 4, No. 7, pp. 368–372.)

SUMMATION METHODS IN NOISE PROBLEMS.—B. G. Churcher, A. J. King and H. Davies. (*Nature*, 2nd Sept., 1933, Vol. 132, p. 350.)

A RECORDING NOISE-LEVEL METER: THE "PEGELSCHREIBER" AND ITS USE BY THE GERMAN P.O.—Ribbeck and Wiedemann. (Summary in *E.T.Z.*, 3rd Aug., 1933, Vol. 54, No. 31, p. 755.) *See* also Fenyö, under "Subsid. App."

THE OBJECTIVE MEASUREMENT OF SOUNDS.—F. Trendelenburg. (*Rev. Gén. de l'Élec.*, 8th July, 1933, Vol. 34, No. 1, p. 5 D: summary only.) *See* also 1932 abstracts, p. 99, r-h column.

"LEVELS" IN ELECTRO-ACOUSTICS [Suggestion of "Brigg" to replace TU, Decibel and Phon: Absolute and Relative Levels, etc.].—P. C. Vandeweile. (*Rev. Gén. de l'Élec.*, 22nd July, 1933, Vol. 34, No. 3, pp. 67–77.)

THE SCALE OF SOUND AMPLITUDES IN MUSIC.—K. W. Wagner. (*Alta Frequenza*, June, 1933, Vol. 2, No. 2, pp. 164–185.) The full paper, a summary of which was dealt with in April Abstracts, pp. 218–219.

MEASUREMENT OF THE REFLECTING POWER OF THE EARTH FOR SOUND WAVES AT NORMAL INCIDENCE.—F. Eisner and K. Krüger. (*Hochf:tech. u. Elek:akus.*, August, 1933, Vol. 42, No. 2, pp. 64–67.)

Tests carried out from the gondola of an airship, the transmitter and microphone being fixed on opposite sides of the gondola. The frequency used was 2 900 c/s. The reflecting power of water, thus found, being taken as unity, that for a thin layer of ice worked out at 1.07, that for meadows at 0.49, while the values for wooded country varied from 0.45 to 0.21. The variation of echo amplitude with the height above ground was also investigated. Further tests with improved apparatus are needed: other types of ground should be tried, and at other seasons: the effect of different frequencies also requires investigation.

PHOTOTELEGRAPHY AND TELEVISION

STATIC LIGHT/ AND CURRENT/VOLTAGE CHARACTERISTICS AS THE BASIS OF BRIGHTNESS MODULATION IN CATHODE-RAY TUBES [and the Electrical Behaviour of such Tubes compared with that of Gas-Filled Valves].—F. Hehlgans. (*Hochf:tech. u. Elek:akus.*, August, 1933, Vol. 42, No. 2, pp. 45–53.)

The c.r. tube used in this investigation was of the type developed by the AEG (Dobke, 1932 Abstracts, p. 653) and the questions to be decided were (1) does such a tube behave electrically like an amplifier valve with gas filling? and (2) is there a simple relation between the luminous output of the spot on the fluorescent screen and the electrical tube data, and if so which is the best electrode system and the best method of brightness modulation for that system?

Three electrode systems were investigated: the simple hot-cathode and anode (corresponding to a diode valve); the same with the addition of a Wehnelt cylinder (corresponding to a triode); and a tetrode system of cathode, auxiliary electrode in front of cathode (with constant positive bias and behaving as a space-charge grid in a tetrode valve), Wehnelt cylinder (with its function now changed) and anode.

As regards the first question, the writer finds experimentally (*a*) how the anode current varies with the anode voltage in a two-electrode tube (Fig. 3, for three different values of gas pressure): with the Wehnelt cylinder voltage in three- and four-electrode tubes (Figs. 5*d*–5*f*, where three different gas pressures are dealt with separately and the parameter for the curves I, II and III is the anode voltage; also 7*b*, where the anode voltage is 1 000 v and the parameter is the positive voltage applied to the auxiliary electrode): with the auxiliary electrode voltage (Fig. 8*b*, where the anode voltage is again 1 000 v and the parameter is the negative Wehnelt cylinder voltage); and (*b*) how the Wehnelt cylinder current varies with the anode voltage: with the Wehnelt cylinder voltage (Figs. 5*g*–5*i*, with anode voltage as parameter, for three different gas pressures): with the auxiliary electrode voltage (Fig. 8*d*, with negative Wehnelt cylinder voltage as parameter). Finally (*c*) the variation of the auxiliary electrode current with Wehnelt cylinder voltage and with auxiliary electrode voltage is examined (Figs. 7*c* and 8*c*, where the anode voltage is kept at 1 000 v and the parameters are the positive auxiliary electrode voltage and the negative Wehnelt cylinder voltage respectively.).

The writer points out that these various curves agree completely with those of the corresponding gas-filled amplifying valves, so that the well-known definitions of slope (mutual conductance), "durchgriff," etc., can be applied to such cathode-ray tubes (*cf.* Kleen, April Abstracts, p. 220, r-h col.). In this connection it is particularly to be remarked that the anode-current characteristics of the tubes correspond to those of the valves, since the screen-exciting electrons passing through the anode to the screen are carried back to the anode by a special gaseous discharge. Thus in cathode-ray tubes, as in valves, the *whole* emission current is measured in the anode circuit.

As regards the second question, a comparison of the electrical characteristics and the luminosity characteristics (in most of the diagrams the top curve-families are these light/voltage characteristics) shows that for the tubes in question there is no simple relation between the two, and that there can certainly be no talk of a simple proportionality between anode current and luminous flux. It follows therefore that for the technique of brightness modulation decisions as to the electrical modulation conditions can only be made by plotting the luminosity characteristics. A close examination of these characteristics shows that in certain ranges a distortionless brightness modulation can be obtained by controlling either the anode voltage, the auxiliary electrode voltage, or the Wehnelt cylinder voltage; the last method of modulation appears the most advantageous on account of the small electrical amplitudes required. Of the three types of tube examined (*i.e.*, with two, three and four electrodes) the four-electrode tube is the best, chiefly on account of the steepness of its characteristics. The best gas pressures lie between 0.001 and 0.01 mm Hg; in this region the characteristics are steep and the conditions are right for constancy of the necessary gaseous discharge in the space between anode and screen.

THE USE OF THE CATHODE-RAY OSCILLOGRAPH AT ULTRA-HIGH FREQUENCIES.—Hollmann. (*See* under "Subsidiary Apparatus and Materials.")

THE ICONOSCOPE.—Zworykin. (*Wireless World*, 1st September, 1933, Vol. 33, p. 197.)

THE PRESENT POSITION OF TELEFUNKEN TELEVISION BROADCASTING.—F. Schröter. (*Telefunken-Zeit.*, August, 1933, Vol. 14, No. 64, pp. 7–11.)

"In the past year television has made greater progress than ever before, thanks to the success of cathode-ray-tube and ultra-short-wave technique." The Telefunken cathode-ray-tube equipment of the 1932 Exhibition (90 lines, 25 frames/sec.) owed its advantages to the screening-out of interfering wall charges near the control electrodes, the use of a magnetic lens, and the employment of a new, very luminous zinc-cadmium-sulphide screen material. The 1933 Exhibition equipment, using strongly illuminated films, increased the number of lines to 180, retaining the 25 frames/sec. For the format employed this gave a picture of about 40 000 elements and a maximum frequency of 5×10^5 c/s. In this way it is estimated that over 90% of the valuable content of all ordinary films can be reproduced. Whether the 180 lines will be standardised is not yet certain; it depends on the demands of freedom from flicker. In cinematography the limiting frequency, where a flickering image turns into a steady one, increases with the logarithm of the light intensity: in film projectors giving up to 200 lux the number of frames per second must be increased by special methods to 48 or 72. On the cathode-ray screen only 60 lux are obtained at best: the relation cannot be applied directly to such a case, for various reasons, but experience shows that the critical framing frequency lies between 30 and 36. Therefore to avoid undue extension of the frequency band a compromise in the region 120 to 150 lines seems desirable. Apart from this limitation there is nothing to prevent the use (particularly with high-vacuum tubes) of more than 30 frames/sec. and 300 lines, giving 100 000 elements. This could be done on a 1-metre wave.

The article discusses the often suggested abolition of flicker by the use of persistence of fluorescence; not much success has been met with here. Experiments with a ZnS–Cu material gave an illusion of steadiness but showed the disadvantage not only of a brilliant green colour but also of producing zones of fogging due to insufficiently rapid extinction of highly lit points. After considering the comparative advantages of the high-vacuum and gas-filled tubes (concluding in favour of the former, with magnetic or electric focusing) the article ends with a discussion of the probable lines of development. The lowering of anode and deflecting potentials is considered one of the most important objects: mention is made of Scheller's method, later tried by Zworykin and others, of acceleration in stages, the deflecting process taking place in the slower stage: here again the high-vacuum tube would appear the more suitable. Cathode-ray scanning at the transmitter cannot as yet take the place of mechanical methods, but if the number of lines is going to exceed 180 some such change will have to occur.

A New Method of Beam-Scanning Transmission [based on the Ulbricht Sphere Principle used in Photometry].—R. Möller. (*Funktechnische Monatshefte*, June, 1933, No. 6, Supp. pp. 29–30.) *See* also *Wireless World*, 15th Sept., 1933, p. 234.

[Television] Progress at Radiolympia.—(*Television*, September, 1933, Vol. 6, No. 67, pp. 308–309.)

Television at the Berlin Exhibition.—(*Ibid.*, pp. 310–311.)

The New Continuously-Working Intermediate-Film Television Transmitter of the Fernseh A.G.—G. Schubert. (*Funktechnische Monatshefte*, Aug., 1933, No. 8, Supp. pp. 42–43.) *See* also *Wireless World*, 15th Sept., 1933, p. 234.

The Te-Ka-De Crystal Light Relay [replacing Kerr Cell].—F. von Okolicsanyi. (*Ibid.*, Supp. pp. 43–46.) *See* also *Wireless World*, 15th Sept., 1933, p. 234.

New American Light Sources for Television Receivers: the Weiller Hot-Cathode Crater Lamp, and a Mercury-Arc Tube with Very Short Arc whose Light is conducted to Scanning System through Quartz Rod.—(*Television*, June, 1933, Vol. 6, No. 64, p. 216.)

Combination of Mirror Drum and Nipkow Disc on Same Axle, to give the Detail provided by the Latter together with the Luminosity provided by the Former. —Lecuyer. (*Television*, June, 1933, Vol. 6, No. 64, pp. 217–218.)

A Contribution to the Development of Practicable Television Systems.—R. Thun. (*Funktechnische Monatshefte*, April, 1933, No. 4, Supp. pp. 21–26.)

Brightness Relations in Mirror-Wheel Reception: Correspondence.—Papst: Kirschstein. (*Ibid.*, pp. 26–28.)

Reflecting Values of Colours [Experimental Results].—F. Wood. (*Television*, July, 1933, Vol. 6, No. 65, p. 254.)

The Dependence of the Optical Threshold of the Eye on the Visual Angle, and its Relation to the Visibility of Weakly Lit Elements in Television Reception.—H. Peters. (*Funktechnische Monatshefte*, February, 1933, No. 2, pp. 2–3.)

Retinal Rivalry as a Neglected Factor in Stereoscopic Vision.—M. F. Washburn. (*Proc. Nat. Acad. Sci.*, August, 1933, Vol. 19, No. 8, pp. 773–777.)

Present Position of Technical Arrangements for Television Broadcasting.—O. Schriever. (*Funktechnische Monatshefte*, June, 1933, No. 6, Supp. pp. 31–35.)

Including an outline of the writer's new synchronising method in which the unmodulated aerial current is kept at a level of about ¼ the maximum amplitude: the picture modulations control this in the upward direction, while the line-changing and picture-changing impulses reduce it to zero.

Survey of the Development and Present Position of Television.—G. Kette. (*Funktechnische Monatshefte*, January, 1933, No. 1, pp. 31–44.)

NOISE AS A LIMITING FACTOR IN AMPLIFIER DESIGN [with Special Reference to Television: Empirical Formulae for Thermal and Shot Effects: Generalisation of Johnson and Nyquist's Formula: etc.].—O. E. Keall. (*Marconi Review*, July/August, 1933, No. 43, pp. 18–26.)

Based on experimental work to obtain data for the design of wide frequency spectrum amplifiers for television. The writer concludes: "In order to preserve a reasonable signal/noise ratio in a television transmission (it is suggested that 30 db should be aimed at in the present state of development) the following requirements should be met: (1) maximum light on screen, (2) photocells in reflectors, this arrangement also assisting to increase wanted to unwanted light ratio by virtue of the directional effect, and (3) amplifiers cutting off sharply at the maximum frequency. Should it be desired to include the 3rd harmonic of the maximum frequency, then there will be a decrease of 4.8 db in the signal/noise ratios shown in the Tables above [for a given source and for constant spot intensity respectively, with 50, 100 and 200 lines in each case]. The greatest limitation is the first named, and until improved lighting or improved photocell performance is available, any question of the inclusion of the 3rd harmonic is premature." Direct scanning, as in a film system, shows a great advantage over indirect: for a 200-line scan the signal/noise ratio for an easily maintained 10^{-7} A would be 52 db, as against 18 db for the 2×10^{-9} A (or thereabouts) given by indirect scanning. The paper is to be continued.

THE LOW FREQUENCIES IN THE TELEVISION IMAGE CURRENTS.—F. Kirschstein. (*Funktechnische Monatshefte*, April, 1933, No. 4, Supp. pp. 15–20.)

THE OCCURRENCE OF IMAGE ERRORS IN TELEVISION, PHOTOTELEGRAPHY, ETC.—R. Thun. (*Funktechnische Monatshefte*, February, 1933, No. 2, pp. 3–8.)

ELECTRICAL CHARACTERISTICS OF BARRIER-LAYER PHOTO-CELLS.—P. R. Gleason. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 315: abstract only.)

THE EQUIVALENT CIRCUIT OF A BLOCKING-LAYER PHOTO-CELL.—L. A. Wood. (*Review Scient. Instr.*, August, 1933, Vol. 4, No. 8, pp. 434–439.)

THE VARIATION IN SENSITIVITY OF THE PHOTRONIC CELL WITH X-RAY WAVELENGTHS.—P. R. Gleason. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 330: abstract only.)

MEASUREMENTS ON THE EFFECT OF LIGHT ON SPURIOUS CONTACT POTENTIALS AND "TRAPPED" ELECTRONS.—W. B. Nottingham. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 311.)

CONTACT POTENTIAL DIFFERENCES BETWEEN DIFFERENT FACES OF COPPER SINGLE CRYSTALS.—H. E. Farnsworth and B. A. Rose. (*Proc. Nat. Acad. Sci.*, August, 1933, Vol. 19, No. 8, pp. 777–780.)

The writers point out that their results suggest that any measurements of a contact p.d. on polycrystalline surfaces must yield only an averaged effective value. Since, however, in a photoelectric experiment with such a surface the long-wave limit would be determined by the faces having the smallest work function, it would appear that an agreement between the difference in photoelectric work function and the contact p.d. is not necessarily to be expected for two polycrystalline surfaces. Consequently the agreement observed by Glasoe (1932 Abstracts, p. 102) "may be only a coincidence. Thermionic experiments also should be influenced by the non-uniform work function of a polycrystalline surface."

THE PHOTOELECTRIC EFFECT IN A SILICON CARBIDE DETECTOR.—P. Specht. (*Physik. Zeitschr.*, 15th Aug., 1933, Vol. 34, No. 16, p. 640.)

ELECTRICAL AND OPTICAL BEHAVIOUR OF SEMICONDUCTORS. IX. MECHANISM AND ORIGIN OF CONDUCTIVITY IN THE DARK AND PHOTOELECTRIC CONDUCTIVITY OF CUPROUS OXIDE.—E. Engelhard. (*Ann. der Physik*, 1933, Series 5, Vol. 17, No. 5, pp. 501–542.)

CRYSTAL PHOTOELECTRIC EFFECT IN PHOTOELECTRICALLY CONDUCTING NaCl.—S. Pelz. (*Naturwiss.*, 7th July, 1933, Vol. 21, No. 27, p. 517.)

THE PHOTOELECTRIC PROPERTIES OF MAGNESIUM LAYERS.—G. Déjardin and R. Schwégler. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 316: abstract only.)

EFFECT OF TEMPERATURE ON THE ENERGY DISTRIBUTION OF PHOTOELECTRONS.—W. W. Roehr and L. A. Du Bridge. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 316: abstract only.)

"An extended experimental test has been carried out of the theory of energy distribution recently developed by Du Bridge (August Abstracts, p. 455, r-h col.). . . . The results obtained are in complete quantitative agreement with the theory."

INFLUENCE OF THE METAL SURFACE ON THE POSITION OF SELECTIVITY IN THE EXTERNAL PHOTOELECTRIC EFFECT, *and* THE SELECTIVE BEHAVIOUR OF ALLOYS IN THE EXTERNAL PHOTOELECTRIC EFFECT.—F. Hlučka. (*Zeitschr. f. Physik*, 1933, Vol. 84, No. 5/6, pp. 364–367 and 367–369.)

THE EXTERNAL PHOTOELECTRIC EFFECT IN ALKALI HALIDES.—R. Fleischmann. (*Zeitschr. f. Physik*, 1933, Vol. 84, No. 11/12, pp. 717–721.

On irradiation by ultraviolet light of wavelength less than 200 mμ, a new absorption region is found in alkali halides and can be demonstrated using the external photoelectric effect.

THE LONG-WAVE LIMIT OF SENSITIVITY OF THE CAESIUM-OXIDE PHOTOCELL [Contradiction of a Result of de Boer and Teves].—J. P. Widmer. (*Helvet. Phys. Acta*, Fasc. 4, Vol. 6, 1933, pp. 269–270.)

A PHOTOELECTRIC "VALVE" [Action explained as primarily a Photoelectric Phenomenon connected with Space Charges].—J. Kunz and J. T. Tykociner. (*Physics*, July, 1933, Vol. 4, No. 7, pp. 246–254.).

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THE INTERNAL PHOTOELECTRIC EFFECT OF GAMMA RAYS.—L. Meitner and Kan Chang Wang. (*Naturwiss.*, 11th Aug., 1933, Vol. 21, No. 32, p. 594.)

BEHAVIOUR OF ELECTRONS AND " HOLES " [Positive Electrons] IN [Illuminated] CUPROUS OXIDE. —A. Joffé, D. Nasledov and L. Nemenov. (*Nature*, 12th Aug., 1933, Vol. 132, pp. 239–240.)

PHOTOELECTRIC INVESTIGATION OF THE TEMPERATURE VARIATION OF THE ELECTRONIC WORK FUNCTION AT A NICKEL SURFACE COVERED WITH ATOMIC BARIUM [Preliminary Note].—R. Suhrmann and R. Deponte. (*Physik. Zeitschr.*, 15th Aug., 1933, Vol. 34, No. 16, pp. 630–631.)

PHOTOELECTRIC MEASUREMENT OF THE SHAPES OF SOLAR ABSORPTION LINES.—T. Dunham, Jr. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 329 : abstract only.)

PHOTOTELEGRAPHIC RECORDER WITH STYLUS TRACING A SINE WAVE OF AMPLITUDE DEPENDENT ON THE ABSORPTION OFFERED TO THE SCANNING LIGHT SPOT.—(*Rev. Gén. de l'Élec.*, 1st July, 1933, Vol. 33, No. 26, pp. 207–208 D : French Pat. No. 744 308, pub. 18th April, 1933, Brulin.)

ELECTRICAL CINEMATOGRAPHY [Images recorded on Gramophone Records].—P. Hémardinquer. (*Rev. Gén. de l'Élec.*, 24th June, 1933, Vol. 33, No. 25, p. 198 D : summary only.)

MEASUREMENTS AND STANDARDS

WAVELENGTH MEASUREMENT OF ULTRA-SHORT WAVES BY A NEW PRECISION METHOD USING A MOVABLE LECHER WIRE SYSTEM. —King. (*See* abstract under " Properties of Circuits.")

A small parallel-wire system of special design (two bridge-coupled pairs—Fig. 7) is arranged so that it can be moved relatively to the source of the frequency to be measured. If it is more convenient, the source may be moved instead, but the former method involves no practical difficulties since the wires need not be more than 150 or 200 cm in length. The coupling distance between the source and the wires must be maintained constant and must not be so short that close-coupling effects are observable. The preliminary adjustment of the Lecher system consists only in placing a bridge at some point near the end remote from the indicator such that a satisfactory deflection is obtained in this latter. The wire system is now moved, parallel to the source, a centimetre or two at a time, and the deflection D recorded. By plotting the position along the wires, measured from any convenient reference point, against the arc-cosine of the ratio $D/D_{max.}$, a straight line is obtained whose slope is $\lambda/2\pi$. No critical adjustments, such as that of the input admittance of the wire system, necessary in Hoag's method, are here required : the essential conditions that the secondary bridge-coupled pair should be detuned, and the primary pair adjusted to give a conveniently large deflection, involving no difficulty. A large number of points are easily plotted and a straight line drawn through them : with suitably constructed apparatus the method becomes both convenient and precise.

A 200-KILOCYCLE PIEZO-OSCILLATOR [for Standard-Frequency Transmissions].—E. G. Lapham. (*Bur. of Stds. Journ of Res.*, July, 1933, Vol. 11, No. 1, pp. 59–64.)

The transmissions are for 2 hours at a time, on a frequency of 5 Mc/s, and an accuracy at all times better than 1 c/s is required. A circular quartz plate, Curie- or zero-cut, of frequency 200 kc/s, is held by 3 screws bearing at the bottom of a V-shaped groove mid-way between the plane faces. It is connected between grid and filament ; the coupling to the first amplifier is considerably reduced by a voltage-dividing arrangement.

PIEZOELECTRIC CRYSTAL WITH LOW TEMPERATURE COEFFICIENT.—(*Hochf:tech. u. Elek:akus.*, July, 1933, Vol. 42, No. 1, p. 36 : German Pat. No. 571 236, pub. 18th March, 1933, Telefunken and Osnos.)

A crystal plate with parallel surfaces has the form of a polygon, two sides of which are cut parallel, or nearly parallel, to two electrical axes (which in the case of quartz enclose an angle of 120°). In the figure the polygon has only four sides, the other two sides being at right angles.

VIBRATION OF PIEZOELECTRIC OSCILLATING CRYSTAL [Theoretical Investigation].—I. Koga. (*Phil. Mag.*, Aug., 1933, Series 7, Vol. 16, No. 104, pp. 275–283.)

Mathematical expressions are found for the normal modes and frequency of thickness vibrations of quartz plates ; the X-cut plate is found to be the only one giving the longitudinal thickness vibration. " Plates cut parallel to the electrical axis vibrate always in the pure shear mode." *See* also Jan. Abstracts, p. 50.

PIEZOELECTRIC OSCILLATOR CIRCUIT WITH IMPROVED CONSTANCY OF FREQUENCY.—(*Rev. Gén. de l'Élec.*, 1st July, 1933, Vol. 33, No. 26, pp. 205–206 D : French Pat. No. 744 097, pub. 11th April, 1933, Thomson-Houston Company.)

MULTIVIBRATOR WITH CONDENSERS REPLACED BY PIEZOELECTRIC RESONATORS OF SAME NATURAL FREQUENCY AND OPPOSED TEMPERATURE COEFFICIENTS.—(*Hochf:tech. u. Elek:akus.*, August, 1933, Vol. 42, No. 2, p. 75 : German Pat. No. 572 972, pub. 25th March, 1933, Telefunken.) *See* also Oct. Abstracts, p. 576, l-h column.

DISCUSSION ON OVERTONES IN TOURMALIN-CRYSTAL VIBRATIONS. — Heinrich - Hertz Institute. (*E.N.T.*, May, 1933, Vol. 10, No. 5, pp. 229–230 and 233.)

In tourmalin crystals working at wavelengths of the order of 1 metre numerous inharmonic overtones are found. Various explanations are given : the absence of stationary conditions at these wavelengths, " ziehen " effects through the coupling of the different modes of vibration of the crystal, etc.

RESEARCHES ON THE SECONDARY CHARGES AND MECHANICAL ATTRACTIVE FORCES OF A QUARTZ CRYSTAL OSCILLATOR: THE PRACTICABILITY OF QUARTZ RELAYS.—Heinrich-Hertz Institute. (*E.N.T.*, May, 1933, Vol. 10, No. 5, p. 233: paragraph only.)

THE NATURAL FREQUENCIES OF ROCHELLE-SALT BAR OSCILLATORS: UNEXPECTED DEPARTURE FROM USUAL FORMULAE.—Heinrich-Hertz Institute. (*Ibid.*, p. 233: paragraph only.)

A METHOD OF DETERMINING THE MAGNETOSTRICTIVE CONSTANTS, AND SOME NOTES ON THE MOTIONAL IMPEDANCES OF MAGNETOSTRICTIVE RESONATORS.—K. Aoyagi. (*Journ. I.E.E. Japan*, August, 1933, Vol. 53, [No. 8], No. 541: English summary pp. 60–61, Japanese paper pp. 654–666.)

STUDY OF THE SYNCHRONISATION OF A SELF-EXCITED OSCILLATOR, AND OF ITS BEHAVIOUR IN THE NEIGHBOURHOOD OF SYNCHRONISATION.—Subra. (*See* under " Transmission.")

BEAT-NOTE METHODS OF MEASUREMENT AND THEIR LIABILITY TO ERROR [including the " Double-Beat " Method].—Subra. (*See* preceding reference.)

A NEW IMPEDANCE MEASURING DEVICE [by Beat Method, using Ratio Coil with Tapped Secondary and Multi-Point Selector Switch: Zero Beat observed by introducing a Third Signal].—A. W. Barber. (*Electronics*, July, 1933, Vol. 6, No. 7, pp. 194–195.)

QUARTZ CLOCKS AS TIME STANDARDS [Critical Discussion].—A. Scheibe. (*Naturwiss.*, 7th July, 1933, Vol. 21, No. 27, pp. 506–512.)

SCHULER'S COMPENSATING PENDULUM [Efficiency, and Accuracy compared with Wireless Time-Signals].—J. Weber. (*Naturwiss.*, 21st July, 1933, Vol. 21, No. 29, pp. 543–547.) *See* Abstracts, 1930, pp. 52 and 167; 1932, p. 235.

FURTHER RESULTS IN THE STUDY OF APPARENT VARIATIONS OF THE VERTICAL WITH THE HOUR-ANGLE OF THE MOON [and the Variation in Time-Determinations at Greenwich and Washington with Lunar Hour-Angle and Declination].—H. T. Stetson: Loomis and Stetson. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 47–52.)

THE APPLICATION OF RADIO TO ASTRONOMICAL LONGITUDE-DETERMINATIONS OF THE GEODETIC SURVEY OF CANADA.—N. J. Ogilvie. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 44–45.)

The writer mentions that perfect reception of time signals (Annapolis, 17 kc/s, Arlington and other stations on short waves) over an entire field-season is seldom, if ever, attained by the Survey. Radio reception in general is at its worst during the warm months of the year when field longitude-work is undertaken. " Unaccountable failures of time signals to 'come through' have puzzled observers throughout the world. Electric charges in the clouds resulting from intense summer heat no doubt are partly responsible for some of the poor reception. The aurora borealis has on two occasions been observed by officers of this Survey to produce a sudden blanketing effect which completely shut off the signals from Arlington. In northern Canada where the auroral displays are quite common in the late summer and early autumn these phenomena may cause considerable slowing down of progress in this line of work. On the other hand, intense displays of aurora borealis have been observed in the north to have no appreciable effect on incoming radio signals. On another occasion . . . it was found that the blanketing effect of the aurora borealis was much less marked on the long-wave Annapolis transmissions (17-kc) than on the short-wave broadcasts."

EMPIRICAL FORMULAE FOR THE CALCULATION OF AIR-CORED CHOKES.—J. Hak. (*Elektrot. u. Masch:bau*, 3rd Sept., 1933, Vol. 51, No. 36, pp. 477–481.)

THE CALCULATION OF AIR-CORED PROTECTING CHOKES.—R. Edler. (*Bull. Assoc. suisse des Élec.*, No. 7, Vol. 24, 1933, pp. 149–157.)

A QUASI-STATIONARY CALCULATION OF THE NATURAL WAVELENGTHS OF SINGLE-LAYER FLAT AND CYLINDRICAL COILS [with Experimental Confirmation].—H. Zuhrt. (*Archiv f. Elektrot.*, 1st Sept., 1933, Vol. 27, No. 9, pp. 613–636.)

THE CALCULATION OF MUTUAL INDUCTANCES [of Two Coaxial Coils] FROM THE FIELD DIAGRAM OF A WINDING.—K. Potthoff. (*Archiv f. Elektrot.*, 1st Sept., 1933, Vol. 27, No. 9, pp. 661–670.)

A WIDE-RANGE COUPLING METER FOR INDUCTIVE, CAPACITIVE AND REAL COUPLINGS.—A. Wirk: Siemens & Halske. (*T.F.T.*, June, 1933, Vol. 22, No. 6, pp. 144–146.)

RADIOELECTRIC MEASUREMENTS AT THE LABORATOIRE NATIONAL DE RADIOÉLECTRICITÉ.—(*Ann. des P.T.T.*, July and Aug., 1933, Vol. 22, Nos. 7 and 8, pp. 569–591 and 645–674: to be continued.)

METHOD OF MEASURING THE INPUT IMPEDANCE OF ULTRA-SHORT-WAVE DETECTORS, AND OTHER IMPEDANCES AT ULTRA-HIGH FREQUENCIES, BY A BRIDGE-COUPLED LECHER WIRE SYSTEM.—King. (*See* abstract under " Properties of Circuits.")

DIRECT-READING PHONIC CAPACITY METER [Oscillating Neon Tube Method].—M. Durepaire. (*Rev. Gén. de l'Élec.*, 15th July, 1933, Vol. 34, No. 2, pp. 39–43.)

The principle of this meter was dealt with in a *Comptes Rendus* Note (1932 Abstracts, p. 534). The present paper shows how the instrument is made to give measurements practically independent of the insulation resistance of the capacity, examines the accuracy obtainable, and describes the commercial instrument made by the firm Chauvin and Arnoux.

THE INDUSTRIAL MEASUREMENT OF CAPACITY AND HIGH RESISTANCE.—P. Regoliosi. (*L'Elettrotec.*, 5th August, 1933, Vol. 20, No. 22, pp. 510–514.)

THE CONVERGENCE OF SUCCESSIVE MEASUREMENTS IN BRIDGE METHODS.—K. Küpfmüller. (Summary in *Rev. Gén. de l'Élec.*, 8th July, 1933, Vol. 34, No. 1, p. 4 D.)

HIGH-FREQUENCY MEASUREMENTS.—A. Hund. (Short Book Review in *Proc. Inst. Rad. Eng.*, August, 1933, Vol. 21, No. 8, p. 1225.)

ERRORS IN VOLTAGE MEASUREMENTS DUE TO EARTH CAPACITANCES.—Starr. (*See* abstract under "Properties of Circuits.")

ERRONEOUS LOSS-ANGLE MEASUREMENTS DUE TO CAPACITY CHANGES [from Small Corona Effects, etc.] DURING THE PERIOD OF APPLICATION OF A. C. VOLTAGE.—L. Tschiassny. (*Archiv f. Elektrot.*, 1st Sept., 1933, Vol. 27, No. 9, pp. 675–680.)

ON THE USE OF THE VACUUM TUBE ELECTROMETER WITH EXTREMELY HIGH INPUT RESISTANCE [Difficulty introduced by Large Time Constant of Input Circuit].—R. E. Burroughs and J. E. Ferguson. (*Review Scient. Instr.*, July, 1933, Vol. 4, No. 7, p. 406.)

NEW GALVANOMETERS.—Moll: Moll and Burger. (*Journ. Scient. Instr.*, July, 1933, Vol. 10, No. 7, pp. 223–224.)

BRIDGE FOR MEASURING A BILLION OHMS WITH 1 VOLT IMPRESSED: USING THE GENERAL ELECTRIC FP-54 FOUR-ELECTRODE VALVE.—I. J. Saxl. (*Electronics*, June, 1933, Vol. 6, No. 6, p. 171.)

AN ELECTROSTATIC VOLTMETER FOR HIGH VOLTAGES [Simple and Nearly Linear].—G. S. Field. (*Canadian Journ. of Res.*, June, 1933, Vol. 8, No. 6, pp. 575–576.)

A BRAUN ELECTROMETER WITH FIBRE SUSPENSION.—A. Wehnelt and J. Johannesson. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 14, 1933, pp. 349–350.)

MEASUREMENT OF THE INTERNAL RESISTANCE OF B-AMPLIFIER VALVES [by a Modified Wheatstone Bridge Method].—V. Babits and V. Szalontay. (*Zeitschr. f. Physik*, 1933, Vol. 84, No. 3/4, pp. 260–263.)

SOME RECENT EARTH-RESISTIVITY MEASUREMENTS IN THE UNITED STATES.—R. H. Card. (*Trans. Am. Geophys. Union, 14th Annual Meeting*, April, 1933, pp. 111–115.)

EARTH-RESISTANCE METER WITH GREATLY INCREASED SENSITIVITY [using Moving-Coil Instrument and Synchronous Vibrating-Contact Rectifier].—P. M. Pflier. (*Sci. Abstracts, Sec. B*, May, 1933, Vol. 36, No. 425, p. 278.)

FIELD INSTRUMENTS [and Methods of Meeting their Special Requirements].—D. C. Gall. (*Journ. Scient. Instr.*, July, 1933, Vol. 10, No. 7, pp. 197–203.)

VALVE VOLTMETERS.—E. L. Payne. (*World-Radio*, 16th and 30th June, 1933, Vol. 16, Nos. 412 and 414, pp. 798 and 866–867.)

FUTURE PROGRESS IN ELECTRICAL MEASURING INSTRUMENTS.—C. V. Drysdale. (*Journ. I.E.E.*, May, 1933, Vol. 72, No. 437, pp. 365–384: Discussion, *ibid.*, September, pp. 317–318.)

CORRECTION OF FREQUENCY ERROR IN MOVING-IRON VOLTMETERS.—A. Campbell: Carter: Gall. (*Journ. Scient. Instr.*, April, 1933, Vol. 10, No. 4, pp. 121–123.) *See* May Abstracts, p. 280, l-h column.

CHECKING THE PERFORMANCE OF LOOP OSCILLOGRAPHS BY MEANS OF THE CATHODE-RAY OSCILLOGRAPH: UNEXPECTEDLY LARGE ERRORS FOUND EVEN AT LOW FREQUENCIES.—J. Lončar. (*E.T.Z.*, 1st June, 1933, Vol. 54, No. 22, p. 522–523.)

APPARATUS FOR THE COMPARISON OF THE ELECTROMOTIVE FORCES OF STANDARD CELLS.—P. Vigoureux: Brooks. (*Journ. Scient. Instr.*, June, 1933, Vol. 10, No. 6, pp. 182–183.)

METHODS OF MEASURING VOLTAGE, CURRENT AND POWER IN PULSATING CURRENT [using a Symmetrical Two-Valve Voltmeter Circuit where Plate Current is proportional to Square of Voltage].—A. Okitsu. (*Journ. I.E.E. Japan*, April, 1933, Vol. 53 [No. 4], No. 537: English summary p. 27, Japanese paper pp. 267–269.)

A VALVE WATTMETER.—E. Mallett. (*Journ. I.E.E.*, September, 1933, Vol. 73, No. 441, pp. 295–302.)

Author's summary:—"The paper describes a wattmeter depending for its action on the use of two thermionic valves and a d.c. measuring instrument. Three forms of instrument are described, the first suitable for measuring the powers used in ordinary power work, and the second and third for measuring the small powers used in communication work." *Cf.* Turner and McNamara, 1931 Abstracts, p. 105, r-h column.

AEF PROVISIONAL RESOLUTIONS ON THE NAMES AND DEFINITIONS OF VARIOUS TYPES OF ELECTRIC CURRENT AND VOLTAGE [including Different Types of Modulation and Transients].—(*E.T.Z.*, 10th Aug., 1933, Vol. 54, No. 32, pp. 784–785.)

SUBSIDIARY APPARATUS AND MATERIALS

THE USE OF THE CATHODE-RAY OSCILLOGRAPH AT ULTRA-HIGH FREQUENCIES.—H. E. Hollmann. (*Wireless Engineer*, Aug. and Sept., 1933, Vol. 10, Nos. 119 and 120, pp. 430–433 and 484–486.)

Cf. 1932 Abstracts, pp. 652–653. There is a final section on "gas concentration at very high recording speeds," where the effect of these high speeds in diminishing the action of gas concentration (since the short time in which a path-curve is passed over is not enough for a fresh building-up of a concentrating field) is discussed. The concept of the space charge as a kind of conical envelope, within which the ray rotates at very high speed, is outlined.

NEW CATHODE-RAY TUBE FOR MICRO-WAVES.—K. Kreielsheimer. (*Electronics*, July, 1933, Vol. 6, No. 7, p. 198.)

Summary of an article covering some of the ground of the Hollmann paper dealt with above.

NOTE ON THE CATHODE-RAY OSCILLOGRAPH.—W. Rogowski. (*Elektrot. u. Masch:bau*, 23rd April, 1933, Vol. 51, pp. 249–254.)

Including mention of the 500 v cold-cathode tube dealt with in May Abstracts, p. 283, l-h column, and of multiple-ray oscillographs depending on a diaphragm, with several holes, interposed between anode and cathode. Concentration methods are also discussed, including the use of an electromagnet and of three perforated diaphragms forming an electrostatic concentrating system.

THE USE OF THE A.C.-DRIVEN CATHODE-RAY TUBE AS SYNCHRONOSCOPE.—E. Brüche. (*Archiv f. Elektrot.*, 1st Aug., 1933, Vol. 27, No. 8, pp. 609–612.)

APERIODIC AMPLIFIER FOR COLD-CATHODE OSCILLOGRAPHS [Single-Stage Amplifier raising Deflection Sensitivity to that of Hot-Cathode Oscillograph, in Frequency Range 0–10^5 Cycles/Second].—H. Kroemer. (*Archiv f. Elektrot.*, 1st Sept., 1933, Vol. 27, No. 9, pp. 657–660.)

THE ELECTRON CURRENT DENSITY IN CATHODE-RAY DISCHARGE TUBES.—F. Malsch. (*Archiv f. Elektrot.*, 1st Sept., 1933, Vol. 27, No. 9, pp. 642–656.)

Author's summary :—(1) The electron current distribution in the ray-cone of a c.r. tube is investigated as to its dependence on voltage, current, tube dimensions and form and age of cathode. The connection between the gas pressure and these quantities is shown. (2) The current distribution in a ray with focusing-coil concentration is examined for 'long' and 'short' coils. The obtainable current densities are extraordinarily high ; for a total current of 1 mA and 40 kv exciting voltage they are about 20 mA/mm². (3) A number of tubes in common use in c.r. oscillography are compared as to their maximum recording speeds and thickness of trace. The tube with pre-concentrating coil is by far the most efficient.

A NEW [Low-Voltage] CATHODE-RAY OSCILLOGRAPH.—J. Dantscher : AEG. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 14, 1933, pp. 337–341.)

The new AEG cathode-ray tube working at low voltages (such as 300 v) has already been described by Dobke (1932 Abstracts, p. 653, l-h col.) : the present paper, after a historical summary, devotes itself to a description and analysis of the complete oscillograph with its gas-discharge-tube time-base circuit, which is suitable for frequencies from a few cycles per second up to 3 x 10^4 c/s.

DISCUSSION OF THE ACTION OF A WEHNELT CYLINDER USING POTENTIAL THEORY.—G. Wendt. (*Ann. der Physik*, 1933, Series 5, Vol. 17, No. 4, pp. 445–459.)

For purposes of mathematical discussion the Wehnelt cylinder in cathode-ray tubes may be treated as a circular hole in a plate or as a spherical cap. The potential distribution along the axis for such systems is calculated. The concentrating action of the cylinder on the electron beam is demonstrated.

SELF-FOCUSING ELECTRON STREAMS [e.g. in Cathode-Ray Tubes].—W. H. Bennett. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 322 : abstract only of theoretical investigation.)

FORMATION OF IMAGES BY SECONDARY ELECTRONS IN AN ELECTRON MICROSCOPE.—M. Knoll and G. Lubszynski. (*Physik. Zeitschr.*, 1st Sept., 1933, Vol. 34, No. 17, pp. 671–674.)

COMPULSORY COUPLING OF BEAM-LOCKING AND TIME-BASE IN THE CATHODE-RAY OSCILLOGRAPH.—Fucks and Kroemer. (*Archiv f. Elektrot.*, 1st Aug., 1933, Vol. 27, No. 8, pp. 606–608.)

Extension of the method dealt with in May Abstracts, p. 283, l-h col., to cases where the duration of the impulse is less than 10^{-4} sec. and the sudden charging of the time-base circuit capacity would require far too much power (over 1 kw for an impulse of 10^{-6} sec., if the voltage were 2 000 v and the capacity 50 cm).

A LINEAR TIMING AXIS FOR CATHODE-RAY OSCILLOGRAPHS [Condenser/Grid-Glow Tube Combination with Constant Current Supply from "Westinghouse Industrial Tube" (Indirectly Heated Multi-Grid Valve)].—C. E. Haller. (*Review Scient. Instr.*, July, 1933, Vol. 4, No. 7, pp. 385–386.)

The constant current is usually produced by a saturated rectifier of the tungsten-filament type, but the saturation point is extremely sensitive to filament potential in the desired operating range. The new DRJ-571 valve will maintain a constant current output for values of plate potential from ten to several hundred volts (Fig. 1). "In view of the low power consumption of this apparatus, it can be readily adapted to operate from the potential supply for the cathode-ray tube, thereby eliminating extra A batteries or a power pack." A truly linear axis is given, the amplitude of beam motion is simply controlled by one potentiometer, and the frequency by another.

CONTINUOUS-DRIVE RECORD PAPER HOLDER FOR OSCILLOGRAPHS.—C. F. Fischer. (*Gen. Elec. Review*, July, 1933, Vol. 36, No. 7, pp. 328–329.)

STUDY OF H.T. CIRCUIT BREAKERS, USING A CATHODE-RAY OSCILLOGRAPH WITH FILM WOUND ON ROTATING DRUM.—Van Sickle and Berkey. (Summary only in *Elec. Engineering*, June, 1933, Vol. 52, No. 6, pp. 412–413.)

ANALYSES OF RATES OF ROTATION OF RECORDING DRUMS.—A. Blake and H. E. McComb. (*Trans. Am. Geophys. Union*, 14th Annual Meeting, April, 1933, pp. 324–329.)

THE RECORDING OF SURGES [Description of Two Simple Equipments for Measuring and Recording, as Substitutes for the Cathode-Ray Oscillograph].—Dodds and Fucks. (*Archiv f. Elektrot.*, 1st Aug., 1933, Vol. 27, No. 8, pp. 597–605.)

The first equipment is based on the spark-gap/

glow-discharge-tube circuit of Rogowski and Beyerle; the second on the dynatron trip-relay circuit of Fucks (1932 Abstracts, p. 106). The second equipment can be made in two types, one registering only the amplitude, the other both the amplitude and the duration. Various methods of time extension (for use, in addition to amplification, in order to make the output from the trip circuit operate the mechanical recorder) are described.

A Fast and Economical Type of Photographic Oscillograph.—Draper and Luck. (*Review Scient. Instr.*, August, 1933, Vol. 4, No. 8, pp. 440–443.)

A New Method for Amplifying and Recording Small E.M.Fs [using a Photoelectric Cell]. —H. E. Morgan, L. T. De Vore and R. F. Baker. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 324: abstract only).

A High-Gain A.C.-D.C. Amplifier [Valve Amplification Factor made to approach Rated Value by using Pentode as Plate-Circuit Resistance].—E. R. Meissner. (*Electronics*, July, 1933, Vol. 6, No. 7, p. 195.)

Three-Stage Direct-Coupled Amplifier [Practically Independent of Fluctuations of Operating Voltages, and Distortionless between 0 and 10^4 Cycles/Second].—H. König. (*Helvet. Phys. Acta*, Fasc. 3, Vol. 6, 1933, pp. 218–228: summary in *Electronics*, July, 1933, Vol. 6, No. 7, p. 198.)

A fraction of the potential used for the grid, plate or filament of one valve is applied to the corresponding electrode of the preceding valve. The three stages give an overall amplification of 900.

A High Voltage Sensitivity Direct-Current Amplifier [based on Tetrode Negative Resistance in Plate Circuit of Amplifying Valve: Sensitivity controlled by Space-Charge Grid].—Macdonald and Campbell. (*Physics*, July, 1933, Vol. 4, No. 7, pp. 237–240.) *See* also April Abstracts, p. 228, Macdonald and Macpherson, whose explanation is here revised.

An Improved Balanced Circuit for Use with Electrometer Tubes.—Turner and Siegelin. (*Review Scient. Instr.*, August, 1933, Vol. 4, No. 8, pp. 429–433.)

The Ignition Process and Power to the Grid in Hot-Cathode Gas-Filled Relays [Thyratrons, etc.].—H. Klemperer and M. Steenbeck. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 14, 1933, pp. 341–349.)

A theoretical and experimental investigation leading to a comparison between mercury-vapour and rare-gas tubes as regards the necessary power to the grid, and to certain conclusions as to the factors controlling the amount of this power, particularly the design of the grid. The power is slightly greater in gas-filled than in mercury-vapour tubes, owing to the greater gas pressure employed in the former for the protection of the cathode. The size of the tube has little effect.

The Mode of Action of Gas-Discharge D.C. Converters.—H. Laub. (*E.T.Z.*, 20th July, 1933, Vol. 54, No. 29, pp. 693–695.)

A New Method of Starting an Arc [High Resistance "Starter Rods" of Carborundum, Galena, etc., for Controlled Rectifiers].—Slepian and Ludwig: Westinghouse Company. (*Elec. Engineering*, September, 1933, Vol. 52, No. 9, pp. 605–608.) *See* also "The Ignitron," October Abstracts, p. 577, l-h column.

The Extinction of Anode-Current Arc by Polarised Grid in Mercury Vapour Tubes [Contrary to Usual Belief: New Possibilities].—E. Kobel. (*Bull. Assoc. suisse des Élec.*, No. 3, Vol. 24, 1933, pp. 41–48.)

The Application of the FP-54 Pliotron to Atomic Disintegration Studies.—L. R. Hafstad. (*Phys. Review*, 1st August, 1933, Series 2, Vol. 44, No. 3, pp. 201–213.)

A Phanotron [Hot-Cathode Gas-Filled] Rectifier for Power and Lighting Service.—Currier and Whitney. (*Gen. Elec. Review*, July, 1933, Vol. 36, No. 7, pp. 312–314.)

The Use of Triode Vacuum Tube Rectifiers to Supply Constant Voltage.—L. A. Richards. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 324: abstract only).

"If triode power amplifier tubes are substituted for the usual half-wave rectifiers it has been found that a fairly steady d.c. output can be obtained by having changes in the a.c. line voltage automatically change the negative bias of the triode grids."

A Rectifier System for [Plate Voltage Supply of] Broadcast Speech-Input Equipment, using the New –83 [Mercury-Vapour Rectifier].—C. Bradner Brown. (*Rad. Engineering*, July, 1933, Vol. 13, No. 7, pp. 10–11.)

AEF Provisional Resolutions on Names and Definitions relating to Gas Discharges of Various Types.—(*E.T.Z.*, 24th Aug., 1933, Vol. 54, No. 34, pp. 831–834.)

The Contact Rectifier as Noise-Limiting Device for Telephone Receivers [in particular Opposed Selenium Rectifier Pairs mounted in Plug].—H. E. Kallmann. (*Funktechnische Monatschefte*, March, 1933, No. 3, pp. 109–111.)

Electrical and Optical Behaviour of Semi-conductors. IX. Mechanism and Origin of Conductivity in the Dark and Photo-electric Conductivity of Cuprous Oxide. —E. Engelhard. (*Ann. der Physik*, 1933, Series 5, Vol. 17, No. 5, pp. 501–542.)

The Stopping Layer of Rectifiers.—W. Jusé. (*Nature*, 12th Aug., 1933, Vol. 132, p. 242.)

"Rectification is dependent on the thickness of the contact layer between a semi-conductor and a metal within quite narrow limits . . . 10^{-5}–10^{-6} cm."

On Thermal and Voltaic E.M.Fs. of Cuprous Oxide.—G. Mönch and S. Stechhöfer. (*Zeitschr. f. Physik*, 1933, Vol. 84, No. 1/2, pp. 59–64.)

FUNDAMENTAL CHARACTERISTICS AND APPLICATIONS OF THE COPPER-OXIDE RECTIFIER.—Hamann and Harty. (*Gen. Elec. Review*, August, 1933, Vol. 36, No. 8, pp. 342–348.)

AN ELECTRON-TUBE TIME-DELAY RELAY.—Holloway. (*See* under "Miscellaneous.")

NEW PIN INSULATORS FREE FROM RADIO INTERFERENCE [Comparative Tests of Several Types] —H. H. Brown. (*Elec. Engineering*, September, 1933, Vol. 52, No. 9, pp. 608–613.)

CONDUCTIVITY AND LOSS ANGLE MEASUREMENTS ON PAPER CONDENSERS FOR 50-CYCLE SUPPLY WITH SUPERPOSED HIGH FREQUENCY [300-Metre Wave].—W. Fehr and W. Hubmann. (*E.T.Z.*, 24th Aug., 1933, Vol. 54, No. 34, pp. 819–822.)

KOLONIT, A NEW INSULATING MATERIAL FROM COAL.—(*E.T.Z.*, 24th Aug., 1933, Vol. 54, No. 34, p. 829.)

MYCALEX, AN INSULATING MATERIAL FOR HIGH VOLTAGE AND HIGH FREQUENCY [with Data].—A. von Nagy. (*E.T.Z.*, 20th July, 1933, Vol. 54, No. 29, p. 711.)

THE DIELECTRIC STRENGTH OF THIN LAYERS OF GLASS AND MICA.—A. P. Alexandrow and A. F. Joffe. (*Journal of Technical Physics*, Leningrad and Moscow, No. 1, Vol. 3, 1933, pp. 32–38: in Russian.)

The breakdown voltage for layers of from 10 to 0.7μ thickness is quite constant for glass and increases only very slightly for mica: this contradicts the hypothesis of ion "avalanches" and ionisation by collision. It appears that the conductivity of glass and of mica increases steeply near the breakdown point.

A VOLTAGE-MULTIPLYING CONNECTION FOR INFLUENCE ELECTRICAL MACHINES AND A MODEL GIVING 210 KV FOR INSULATOR TESTING, ETC.—P. Hochhäusler. (*E.T.Z.*, 20th July, 1933, Vol. 54, No. 29, pp. 704–705.)

THE ELECTRICAL STRENGTH OF INSULATING MATERIALS UNDER MECHANICAL STRAIN.—Akahira and Gemant. (*Archiv f. Elektrot.*, 1st Aug., 1933, Vol. 27, No. 8, pp. 577–585.)

A NEW METHOD OF ELIMINATING EDGE EFFECT IN ELECTRIC BREAKDOWN.—A. S. Norcross. (*Review Scient. Instr.*, August, 1933, Vol. 4, No. 8, pp. 444–446.)

CALCULATION OF THE DIELECTRIC CONSTANT OF A SALT FROM A SINGLE MEASUREMENT OF A MIXTURE OF AIR AND THE SALT.—D. A. G. Bruggeman. (*Naturwiss.*, 4th Aug., 1933, Vol. 21, No. 31, pp. 577–578.)

ANOMALOUS DISPERSION OF THE DIELECTRIC CONSTANT OF ROCHELLE SALT [Errera's Result Not a Molecular Property but a Piezoelectric Effect: Influence of Temperature on Natural Frequency].—G. Busch. (*Helvet. Phys. Acta*, Fasc. 5, Vol. 6, 1933, pp. 315–336.)

ELECTRICAL BREAKDOWN IN AIR AND TRANSFORMER OIL UNDER PRESSURE.—A. Walther and L. D. Inge. (*Journal of Technical Physics*, Leningrad and Moscow, No. 1, Vol. 3, 1933, pp. 45–53: in Russian.)

THE MOLECULAR ORIENTATION OF LIQUID AND VISCOUS INSULATORS AND ITS INFLUENCE ON THE ANOMALOUS PROPERTIES OF THESE DIELECTRICS AT HIGH FREQUENCIES.—V. Kostomaroff. (*Rev. Gén. de l'Élec.*, 26th Aug., 1933, Vol. 34, No. 8, pp. 243–250.)

THE ELECTRICAL CONDUCTIVITY OF THIN FILMS OF MINERAL OILS [due to Decomposition and the Probable Formation of Carbon Particles]. —van Arkel and Koopman. (*Physica*, No. 6, Vol. 13, 1933, pp. 189–192.)

ELMET METALS ["Rotung" and "Silvung"—Specially Prepared Tungsten with Copper and with Silver: for Contacts and Thermionic Valves].—(*Rev. Gén. de l'Élec.* 22nd July, 1933, Vol. 34, No. 3, pp. 89–90.)

A NEW RESISTANCE MATERIAL WITH VERY HIGH MELTING POINT: THE KANTHAL ALLOYS. (*E.T.Z.*, 24th Aug., 1933, Vol. 54, No. 34, p. 829.)

A RESISTOR FOR HIGH-VOLTAGE MEASUREMENTS [made from Thin-Film Carbon Resistances]. —G. W. Bowdler. (*Journ. I.E.E.*, July, 1933, Vol. 73, No. 439, pp. 65–68.)

A 100-megohm resistor made from the Siemens & Halske units described by Hartmann and Dossmann (1929 Abstracts, pp. 223 and 342, l-h columns).

ELECTRO-PLATING COPPER ON MANGANIN.—C. R. Cosens. (*Journ. Scient. Instr.*, Aug., 1933, Vol. 10, No. 8, pp. 256–258.)

THE INFLUENCE OF SURFACE CHARGES ON MEASUREMENTS OF THE CONDUCTIVITY OF POOR CONDUCTORS.—A. D. Goldhammer. (*Zeitschr. f. Physik.*, 1933, Vol. 84, No. 3/4, pp. 212–217.)

METALLIC ELECTRICAL RESISTANCE MATERIALS [including Megapyr, Isabellin and Kruppin]. —A. Schulze. (*Zeitschr. V.D.I.*, 5th Aug., 1933, Vol. 77, No. 31, pp. 856–858.)

NEW CONNECTING LEADS FOR BROADCAST RECEIVER EQUIPMENTS [including the Use of Soft-Rubber Plugs continuous with the Cable Coating].—AEG. (*E.T.Z.*, 24th Aug., 1933, Vol. 54, No. 34, Advert. p. 13.)

NEW MAGNETIC MATERIALS FOR PUPIN COILS (Materials of Very High Magnetic Stability; Isoperms).—Dahl, Pfaffenberger and Sprung. (*E.N.T.*, August, 1933, Vol. 10, No. 8, pp. 317–332.)

FURTHER REMARKS ON THE NON-EXISTENCE OF AN ANOMALY IN THE PERMEABILITY OF IRON IN THE WAVELENGTH RANGE 84–1 300 METRES.—G. R. Wait. (*Zeitschr. f. Physik*, 1933, Vol. 83, No. 11/12, pp. 786–788.) *See* 1929 Abstracts, p. 112.

THE STABILISATION OF POTENTIALS OF THE ORDER OF 1 000 VOLTS BY MEANS OF POSITIVE CORONA DISCHARGES: A PORTABLE APPARATUS FOR USE WITH ION TUBE COUNTERS, ETC. [using a Spark Coil as Supply Source].—G. Medicus. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 14, 1933, pp. 304–306.)

Further development of the work dealt with in 1932 Abstracts, p. 278, r-h col. Author's summary: —" If a discharge tube, of suitable length, of the type of a Geiger-Müller ion counter [thin stretched wire along the axis of an evacuated tube] is connected is series with a sufficiently high ohmic resistance ('stabiliser connection'), a potential can be tapped off across this discharge tube which is extraordinarily unaffected by variations, within wide limits, of the total working voltage. This stabilised potential can be varied over a wide range (about $10^3 - 10^4$ volts) by adjusting the pressure in the stabiliser tube. If dry air is used as the filling and the tube subjected to heat treatment the stabilised potential is practically independent of temperature [since the effect of temperature is due to the action of water vapour]. With this stabiliser, an induction coil and a spark gap, a simple portable equipment for the supply of Geiger-Müller ion counters, etc., can be constructed." The range of current values for a fixed stability of potential can be increased by increasing the length of the tube or by connecting several tubes in parallel. Thus for a current supply of 1 mA and a constancy within 1 o/oo a total length of 100 m would be needed (internal diameter 1.3 cm); but for the smaller currents used by such instruments as ion counters a total length of the order of one metre is enough.

AUTOMATIC VOLTAGE REGULATION BY A RECORDING VOLTMETER WITH PREDETERMINED LIMITS INSCRIBED IN A CONDUCTIVE INK.—P. Fehr. (*Bull. Assoc. suisse des Élec.*, No. 2, Vol. 24, pp. 29–32.)

A CURRENT TRANSFORMER FOR LOW RADIO FREQUENCIES [for Use in the Measurement of Currents of 10–500 A at 60 kc/s, in Conductors at Potentials 10 000 V above Earth].—L. B. Hilton. (*Rad. Engineering*, July, 1933, Vol. 13, No. 7, pp. 16–17.)

PUSH PULL OUTPUT TRANSFORMER [Construction of Transformers up to 6 Watts Power Rating].—(*Wireless World*, 8th September, 1933, Vol. 33, pp. 218–219.)

A METHOD FOR CALCULATING TRANSMISSION PROPERTIES OF ELECTRICAL NETWORKS CONSISTING OF A NUMBER OF SECTIONS.—Alford. (*See* under " Properties of Circuits.")

THE CONSTRUCTION AND BALANCING OF INTERMEDIATE-FREQUENCY BAND-PASS FILTERS.—Th. Sturm. (*Funktechnische Monatshefte*, January, 1933, No. 1, pp. 15–21.)

BALANCING DEVICE FOR ROTATING CONDENSERS, ETC., BY SEPARATELY SCREW-ADJUSTED SEGMENTS OF A SLOTTED STATOR PLATE.—(*Hochf:tech. u. Elek:akus.*, August, 1933, Vol. 42, No. 2, p. 76: German Pat. No. 572 944, pub. 25th March, 1933, von Kramolin.)

COST *versus* QUALITY IN RADIO SET COMPONENTS [I.R.E. Symposium].—(*Electronics*, August, 1933, Vol. 6, No. 8, pp. 210–213 and 215.)

S.F.R. CHAUVEAU AUTO-ALARM [Distress Signal] RECEIVER.—(*Bull. de la Soc. Franç. Radio-élec.*, March/April, 1933, Vol. 7, No. 2, pp. 48–51.)

THE FIELD OF APPLICATION OF THE "PEGELSCHREIBER" [Automatic Level Recorder] IN TELEPHONE ENGINEERING.—L. Fenyö. (*T.F.T.*, Nos. 1 and 2, Vol. 22, 1933, pp. 3–13 and 36–43: abridged version in *E.N.T.*, August, 1933, Vol. 10, No. 8, pp. 354–356.)

A GEOMETRICAL METHOD OF INTEGRATION AND AN APPARATUS FOR MEASURING THE AREAS OF CURVED SURFACES.—F. E. Myard. (*Génie Civil*, 2nd Sept., 1933, Vol. 103, No. 10, pp. 228–232.)

LOGARITHMIC PROTRACTOR.—H. J. Yearian. (*Review Scient. Instr.*, July, 1933, Vol. 4, No. 7, pp. 407–409.)

A MECHANICAL PROCESS FOR THE COMPARISON OF OBSERVATIONS BY THE METHOD OF LEAST SQUARES [using Commercial Rubber Bands or Small Spiral Springs].—B. Germansky. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 14, 1933, pp. 370–374.)

STATIONS, DESIGN AND OPERATION

THE LEAGUE OF NATIONS WIRELESS STATION.—G. F. van Dissel. (*L'Onde Élec.*, July, 1933, Vol. 12, No. 139, pp. 329–352.)

THE GERMAN BROADCASTING NETWORK. II. THE NEW LEIPZIG HIGH-POWER STATION AND THE COMMON-WAVE STATIONS AT FRANKFORT (Main) AND TRIER.—A. Semm. (*T.F.T.*, July, 1933, Vol. 22, No. 7, pp. 167–174.)

THE VIENNA [Bisamberg] HIGH-POWER BROADCASTING STATION.—W. Meyer. (*Telefunken-Zeit.*, August, 1933, Vol. 14, No. 64, pp. 12–19.) *See* also *E.T.Z.*, 13th July, 1933, Vol. 54, p. 684, and May Abstracts, p. 286, l-h column.

THE INSTALLATION AT WHAM [Rochester, N.Y.].—(*Rad. Engineering*, July, 1933, Vol. 13, No. 7, pp. 12–13 and 19.)

" FRANCE–ALGERIA " MULTIPLEX AND SECRET RADIOTELEPHONE SERVICE.—P. Borias. (*Bull. de la Soc. Franç. Radioélec.*, May/June, 1933, Vol. 7, No. 3, pp. 66–72.)

RECEPTION REPORTS ON " RADIO-LUXEMBURG."—(*Bull. de la Soc. Franç Radioélec.*, May/June, 1933, Vol. 7, No. 3, pp. 73–78.)

THE DEVELOPMENT OF BROADCASTING IN ITALY.—(*Alta Frequenza*, June, 1933, Vol. 2, No. 2, pp. 310–316.)

SIMULTANEOUS BROADCASTING [Land-Line Technique].—J. S. Lyall. (*Wireless World*, 4th August, 1933, Vol. 33, pp. 68–70.)

EXPERIMENTAL RESULTS ON A RADIO BROADCASTING SYSTEM USING DISTRIBUTION NETWORKS OF ELECTRIC SUPPLY.—I. Miura. (*Journ. I.E.E. Japan*, July, 1933, Vol. 53 [No. 7], No. 540: English summary, pp. 56–57, Japanese paper, pp. 561–570.)

With a carrier frequency of 60 kc/s only 30–40 watts output are required for covering (*i.e.*, yielding 5 mv or more) an area of about 20 km radius; with a carrier of 1 500 kc/s the attenuation is much higher. At the lower frequency, moreover, radiation and consequent interference with other services is negligible. Man-made static is only of the order of that found with ordinary mains-driven receivers.

THE FIRST BROADCAST "WITH REPLY" [Hugenberg's Speech to Cassel Meeting].—H. Kluth. (*Funktechnische Monatshefte*, March, 1933, No. 3, p. 112.)

THE "RADIO TRAINS" OF THE NATIONAL SOCIETY OF BELGIAN RAILWAYS [equipped for Broadcast Reception, Gramophone Programmes, and Public Address].—I. Katel. (*Génie Civil*, 2nd Sept., 1933, Vol. 103, No. 10, pp. 234–235.)

THE RADIOELECTRIC AND TELEGRAPHIC CONFERENCES AT MADRID, 1932, AND LUCERNE, 1933.—J. C. de Fabel. (*Génie Civil*, 19th Aug., 1933, Vol. 103, No. 8, pp. 185–187.)

THE EUROPEAN RADIOCOMMUNICATIONS CONFERENCE AT LUCERNE, 1933.—J. Reyval. (*Rev. Gén. de l'Élec.*, 26th Aug., 1933, Vol. 34, No. 8, pp. 253–262.)

AIRCRAFT RADIO [a Survey].—M. Okada. (*Electrotech. Laboratory, Tokyo*, Circular No. 90, 124 pp.: in Japanese.)

TRANSOCEANIC SHORT-WAVE SERVICES: THE PREDICTION OF DAY-TO-DAY TRANSMISSION CONDITIONS BY FORECASTING THE MAGNETIC ACTIVITY.—Brown: National Broadcasting Company. (*See* abstract under "Propagation of Waves.")

ADAPTATION OF THE BAUDOT APPARATUS TO LONG- AND SHORT-WAVE RADIOTELEGRAPHY.—C. Verdan. (*Ann. des P.T.T.*, August, 1933, Vol. 22, No. 8, pp. 675–699.)

NOTE ON AN IMPULSE INDICATOR [for Monitoring Modulation of Wireless Transmitters and Sound Films: Length of Light Column in Neon Tube proportional to Current Flowing].—Y. Rocard. (*Bull. de la Soc. Franç. Radioélec.*, May/June, 1933, Vol. 7, No. 3, pp. 56–60.) *See* also pp. 61–65.

GENERAL PHYSICAL ARTICLES

VARIATIONAL PRINCIPLES IN ELECTROMAGNETISM [Theoretical Paper].—H. Bateman. (*Phys. Review*, 15th March, 1933, Series 2, Vol. 43, No. 6, pp. 481–484.)

SYNTHESIS OF THE WORKS OF NEWTON, FRESNEL AND MAXWELL.—E. Sevin. (*Comptes Rendus*, 8th May, 1933, Vol. 196, No. 19, pp. 1379–1381.)

ON THE NEW RELATIONS IN ELECTROMAGNETISM AND THEIR INTERPRETATION.—F. Prunier. (*Rev. Gén. de l'Élec.*, 4th March, 1933, Vol. 33, No. 9, pp. 267–277.)

ON THE SUBJECT OF THE ELECTROMAGNETIC EQUATIONS.—F. Prunier. (*Comptes Rendus*, 3rd April, 1933, Vol. 196, No. 14, pp. 1007–1009.)

A NEW EXPRESSION FOR POYNTING'S RADIATION VECTOR.—F. Prunier. (*Comptes Rendus*, 10th July, 1933, Vol. 197, No. 2, pp. 131–132.)

The writer has already found (*see* preceding reference) expressions holding in the wave-front of electromagnetic waves; he here combines them and obtains expressions for the components of Poynting's vector as products of an energy density and the components of a velocity, which agree with the definition of a radiation vector as a measure of the flow of energy.

THE LAWS OF ACTION AT A DISTANCE IN ELECTRICITY.—H. Abraham. (*Comptes Rendus*, 10th April, 1933, Vol. 196, No. 15, pp. 1094–1095.)

THEORETICAL CONSIDERATIONS ON THE CONSTITUTION OF NEUTRONS, POSITIVE ELECTRONS AND PHOTONS: THE EXISTENCE OF NEGATIVE PROTONS.—J. J. Placinteanu. (*Comptes Rendus*, 28th Aug., 1933, Vol. 197, No. 9, pp. 549–552.)

REPLY TO THE REMARK OF F. EHRENHAFT ON MY PAPER "MEASUREMENTS OF CHARGES ON SELENIUM PARTICLES AT HIGH GAS PRESSURES" [and the Possible Existence of a Charge smaller than that of the Electron].—E. Wasser: Ehrenhaft. (*Physik. Zeitschr. der Sowietunion*, No. 5, Vol. 3, 1933, pp. 545–550: in German.) *See* also May Abstracts, p. 287, l-h column, Ehrenhaft.

THE POLARISATION OF THE FLUORESCENT LIGHT OF PURE MERCURY VAPOUR [and the Depolarising Effect of a Magnetic Field].—A. Kastler. (*Comptes Rendus*, 7th Aug., 1933, Vol. 197, No. 6, pp. 442–444.)

ELECTROSTATIC THEORY OF A [Langmuir] PLASMA.—D. Gábor. (*Zeitschr. f. Physik*, 1933, Vol. 84, No. 7/8, pp. 474–508.)

AN EFFECT OF SPACE-CHARGE IN PROBE ANALYSIS OF A PLASMA.—R. H. Sloane and K. G. Emeleus. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 322: abstract only.)

MISCELLANEOUS

ON THE RELATION BETWEEN THE CARSON INTEGRAL EQUATION AND THE SOLUTION BY FOURIER'S INTEGRAL IN THE SOLUTION OF TRANSIENT PHENOMENA.—H. Nukiyama. (*Journ. I.E.E. Japan*, August, 1933, Vol. 53 [No. 8], No. 541, pp. 639–642: in Japanese.)

ON LINEAR SYSTEMS WITH FIRST-ORDER PARTIAL DERIVATIVES WITH TWO VARIABLES.—T. Carleman. (*Comptes Rendus*, 16th Aug., 1933, Vol. 197, No. 7, pp. 471–474.)

THE DIELECTRIC CONSTANT [of Rocks containing Salt and Bitumen] AT VOLKENRODA.—H. Löwy. (*Physik. Zeitschr.*, 1st Sept., 1933, Vol. 34, No. 17, pp. 674–676.)

AN INSTALLATION FOR TELEPHONY ON INFRA-RED RAYS [over 20 Kilometres, or 30 at Night].—L. Fernandes. (Summary in *Rev. Gén. de l'Élec.*, 8th July, 1933, Vol. 34, No. 1, p. 8 D.)

ULTRA-SHORT [6 Metre] WAVES KILL PESTS IN STORED BEANS, PEAS, ETC.—(*Electronics*, July, 1933, Vol. 6, No. 7, p. 193.)

ULTRA-SHORT ELECTRIC WAVES: A NEW DEVELOPMENT IN DIATHERMY [Advantages over Diathermy: Success in Curing Furuncles, Pulmonary Abscesses, Tonsilitis, etc.].—E. Schliephake. (*Brit. Journ. Physical Medicine*, September, 1933, Vol. 8, No. 5, pp. 69–71.) For previous work *see* Abstracts, 1930, p. 587, and 1931, p. 458: both r-h columns.

ULTRA-SHORT WAVES [as used for producing Artificial Fever] BAKE CRUSTLESS BREAD.—(*Electronics*, June, 1933, Vol. 6, No. 6, p. 163.)

SOME RECENT DEVELOPMENTS IN ELECTROMAGNETIC INSPECTION AND TEST EQUIPMENTS [Detecting Presence of Iron in Asbestos, Coil Turn Counting, Electric Gauge, Flaw Detectors for Tubing, Testing of Packages for Metallic Inclusions, etc.].—B. M. Smith. (*Gen. Elec. Review*, August, 1933, Vol. 36, No. 8, pp. 368–370.)

MODERN METHODS OF PROTECTION AGAINST THEFT BY AUTOMATIC ALARM APPARATUS [Infra-Red-Ray, Vibration, and Capacity-Change Methods].—R. Dubois. (*Rev. Gén. de l'Élec.*, 24th June, 1933, Vol. 33, No. 25, pp. 831–836.)

THYRATRON CONTROL OF WELDING IN TUBE MANUFACTURE.—Lord and Livingston. (*Electronics*, July, 1933, Vol. 6, No. 7, pp. 186–187 and 206.)

AN ELECTRON-TUBE TIME-DELAY RELAY [particularly for Automatic Stopping of Mandrel-less Coil-Making Machines for Valve Filaments: using the WL-712 Argon Glow Tube].—G. C. Holloway. (*Electronics*, August, 1933, Vol. 6, No. 8, p. 220.)

ELECTRONICS IN RESISTOR MANUFACTURING [Testing, Sorting, Temperature Control, Viscosity Testing, etc.].—L. Podolsky. (*Electronics*, July, 1933, Vol. 6, No. 7, pp. 180–181.)

REMOVAL OF METALLIC DEPOSITS [on Walls of Discharge Tubes] BY HIGH-FREQUENCY CURRENTS.—J. K. Robertson and C. W. Clapp. (*Nature*, 23rd Sept., 1933, Vol. 132, pp. 479–480.)

VARIABLE SPEED MOTOR WITH VACUUM TUBES [400 HP Synchronous Motor with Speed controlled by 18 Thyratrons: Application to Electrically-Driven Ship Propellers].—Alexanderson. (*Electronics*, July, 1933, Vol. 6, No. 7, p. 192.)

PROGRESS OF VULCANISATION WATCHED BY MEANS OF OSCILLATOR GRID-CIRCUIT CONDENSER PLATES EMBEDDED IN RUBBER MASS.—(*Electronics*, July, 1933, Vol. 6, No. 7, p. 192.)

STROBOSCOPY APPLIED TO THE CALIBRATION OF ELECTRICITY METERS.—P. Maurer. (*Rev. Gén. de l'Élec.*, 22nd July, 1933, Vol. 34, No. 3, pp. 79–89.)

LIGHT SENSITIVE PROCESS CONTROL [Photoelectric Control of Concentration of Solutions].—J. V. Alfriend, Jr. (*Elec. Engineering*, September, 1933, Vol. 52, No. 9, pp. 601–604.)

PHOTOCELL APPLICATIONS:—SURGEON AND OPERATING THEATRE DOOR; MINE DOOR OPENED BY MINE LOCOMOTIVE; DRINKING FOUNTAIN; THEATRE ADMISSION CHECKING; COMPARING "AMOUNT OF INK" IN PRINTING BOOK FORMS FOR UNIFORMITY.—(*Electronics*, July, 1933, Vol. 6, No. 7, pp. 192 and 193.)

A PHOTOGRAPHIC RECORDING PHOTOELECTRIC DENSITOMETER.—L. T. De Vore. (*Phys. Review*, 15th Aug., 1933, Series 2, Vol. 44, No. 4, p. 329: abstract only.)

THE PROJECTION OF SOLID IMAGES IN SPACE BY THE "KATASCOPE."—Siemens Company. (*Die Sendung*, No. 15, Vol. 10, 1933, p. 315.)

ON ABSTRACTS JOURNALS.—G. B. Pegram. (*Review Scient. Instr.*, July, 1933, Vol. 4, No. 7, pp. 367–368.)

GLOSSARY OF PHYSICAL TERMINOLOGY [Announcement].—Le Roy D. Weld. (*Review Scient. Instr.*, July, 1933, Vol. 4, No. 7, pp. 419–420.)

RADIO INTERNATIONAL [a Five-Language Dictionary giving 900 of the Most Important and Commonly Used Radio Terms].—E. A. Pariser. (Book Review in *Proc. Inst. Rad. Eng.*, August, 1933, Vol. 21, No. 8, p. 1222.)

MEETING OF THE HEINRICH-HERTZ INSTITUTE, 1933.—(*E.N.T.*, May, 1933, Vol. 10, No. 5, pp. 229–236.)

CODE OF FAIR COMPETITION FOR THE RADIO MANUFACTURING INDUSTRY [submitted to the National Recovery Administration].—(*Rad. Engineering*, August, 1933, Vol. 13, No. 8, pp. 13–19.) *See* also *Electronics*, August, 1933, pp. 207, 208 and 230.

CARRIER IN CABLE [and the Use of a New Type of Amplifier embodying the Principle of "Negative Feedback."]—Clark and Kendall. (*See* under "Acoustics and Audio-frequencies.")

MUTUAL IMPEDANCE OF GROUNDED WIRES LYING ON OR ABOVE THE SURFACE OF THE EARTH.—Foster. (*See* under "Aerials and Aerial Systems.")

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.

CABINET SETS

Application date, 23rd September, 1931. *No.* 389831

In self-contained cabinet sets incorporating a loud speaker, microphonic interference is often caused by mechanical vibrations induced by the speaker, particularly upon the detector valve. In order to avoid this, the valves are mounted so that they are shielded by the chassis of the speaker from vibrating columns of air. To enlarge the area of acoustic shadow the speaker-chassis may be fitted with one or more screening plates.

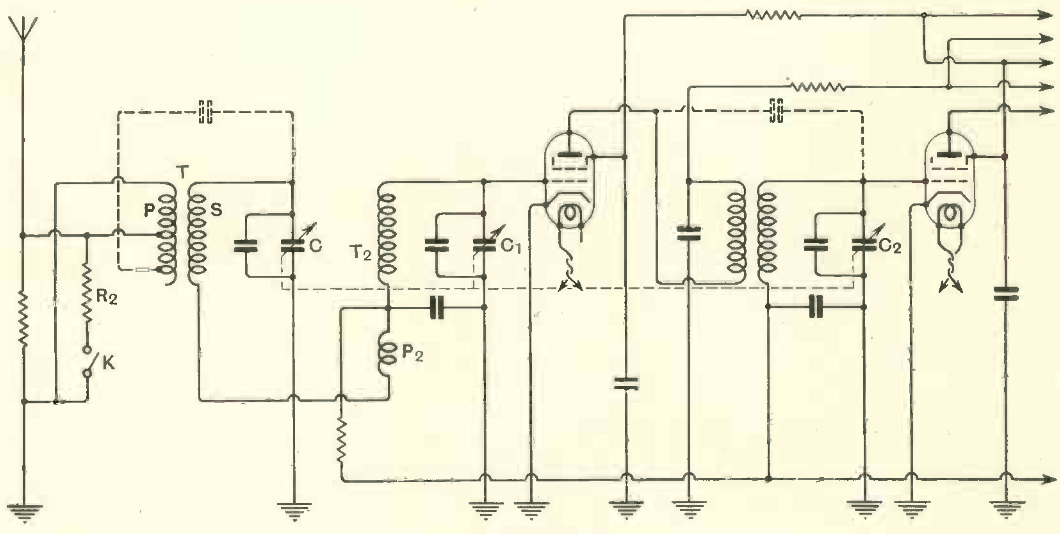
Patent issued to The Paragon Rubber Manufacturing Co., Ltd., and H. C. Atkins.

CONSTANT-SENSITIVITY COUPLINGS

Convention date (U.S.A.), 10th September, 1930. *No.* 389869

The figure shows the tuned input and first two H.F. stages of a receiver in which the coupling-circuits are designed to have a frequency-amplification response which maintains constant sensitivity and selectivity over the whole tuning range. The first input transformer *T* has a sufficiently high inductance to resonate with an aerial of average capacity at a frequency below the tuning range. The primary *P* is connected so that it has a dead-end portion. Its magnetic coupling with the secondary *S* is comparatively small, but it is supplemented by the inherent capacity coupling shown in dotted lines, so as to maintain a uniform transfer of energy at all frequencies. Each tuning condenser *C*, *C*1, *C*2 is fitted with a parallel capacity, pre-set to bring all the tuned circuits into resonance at a frequency slightly higher than the tuning range. The primary winding *P*2 of the second transformer *T*2 is designed to offset the apparent reduction of the secondary inductance *S* by its primary *P*, thereby facilitating the ganging of the tuning condensers. A switch *K* may be closed to connect a low impedance shunt *R*2 across the aerial for local-station reception.

Patent issued to Hazeltine Corporation.



No. 389869.

MULTIPLEX SIGNALLING

Application date, 3rd December, 1931. *No.* 389917

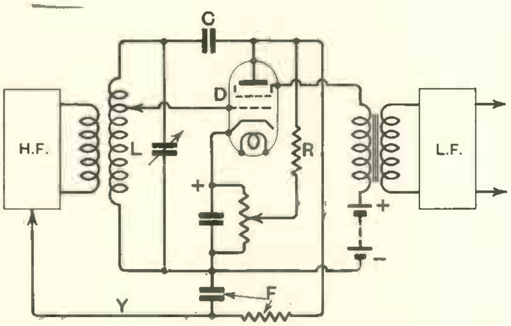
Relates to a method of producing from a common source a plurality of currents of substantially equal amplitude, but different frequencies, for multiplex carrier-wave signalling. The source is arranged to generate in the first place an electric current having a wave-form possessing only odd harmonics, the amplitudes of which are subsequently equalised. A rotating shutter is interposed between a source of light and a photo-sensitive cell included in the input circuit of a valve amplifier, the speed of rotation of the shutter being controlled by an electro-magnetic tuning-fork and phonic motor, so that the resulting pulsations of current have a square wave-form. A resistance-capacity coupling is provided between the first valve and a second amplifier, the impedance of the condenser being made large relatively to the resistance, so as to equalise the amplitudes of the various harmonics.

Patent issued to The General Electric Co., Ltd., and D. C. Espley.

AUTOMATIC VOLUME CONTROL

Convention date (U.S.A.), 14th October, 1931.
No. 389763

A single valve is used for detecting the received signals by anode rectification, and at the same time for rectifying the carrier-wave components in order to derive voltage for automatic volume control. The input coil *L* is connected across the anode and cathode of the detector valve *D*, the anode lead



No. 389763.

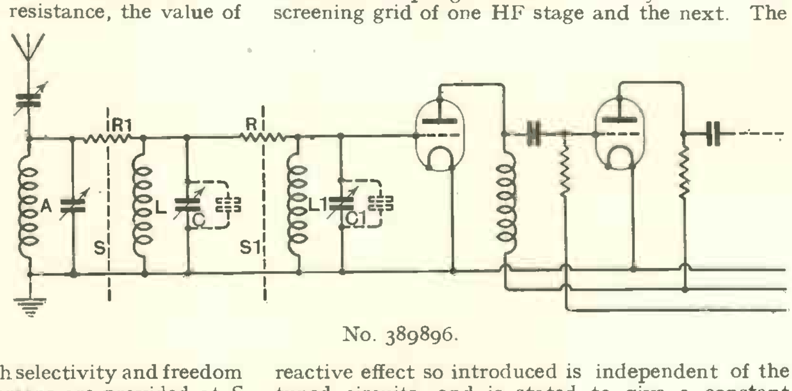
containing a condenser *C* of high impedance to signal frequencies but of low impedance to the carrier wave. The anode is not positively biased, but serves simply to rectify the carrier energy, the resulting potential drop across the output resistance *R* being transferred through a lead *Y* comprising filter elements *F* to the grids of the preceding H.F. valves for automatic volume control. A tapping from the input coil *L* also feeds signal energy to the control grid of the valve *D*, which then functions in combination with the positively-biased screening-grid as a triode detector, feeding the rectified signals to a low-frequency amplifier L.F.

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

COUPLING-CIRCUITS

Application date, 22nd October, 1931. No. 389896

A tuned circuit is coupled to a source of alternating E.M.F. mainly by a resistance, the value of which is of the same order as the impedance at resonance frequency of the tuned circuit, the value of the coupling-resistance being also chosen to give the coupled circuits a single-hump characteristic. As shown in the Figure, the tuned circuits *C*, *L* and *C*1, *L*1 are coupled by a resistance *R*, the former circuit being in turn coupled to the aerial circuit *A* through a resistance *R*1. The method is stated to give high selectivity and freedom from cross-modulation. Screens are provided at *S* and *S*1, and trimming condensers are fitted to the main tuning condensers *C*, *C*1, as shown in dotted lines. The reaction coupling between the aerial circuit *A* and the circuit *C*, *L* is kept sufficiently low to give a single-hump resonance curve.



No. 389896.

Patent issued to R. E. H. Carpenter and P. P. Eckersley.

CONSTANT-GAIN RECEIVERS

Application date, 25th May, 1932. No. 390021

In a set using tuned transformer or impedance coupling, the amplification-gain per valve-stage falls off with increasing wavelength; the same also applies to the input circuit feeding the first amplifier. To offset this tendency the aerial coupling circuit includes in the high-potential lead a choke circuit made permanently resonant (either by virtue of its distributed capacity or by means of a shunt condenser) to a frequency a little above the highest frequency which the set is designed to accept. In this way the response of the coupling-circuits is made more uniform over the whole tuning range.

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

LIGHT-SENSITIVE RELAYS

Convention date (Germany), 30th July, 1931.
No. 390041

It is known that a glow-discharge tube can be adjusted to a "threshold" condition such that an incident ray of light will start a heavy discharge which stops when the illumination ceases. According to the invention the sensitivity of such an arrangement is increased by placing two external electrodes near the outer surface of the tube. One of the external electrodes is fed with an out-of-phase component of the supply voltage, whilst the other is either earthed or suitably insulated.

Patent issued to Technik and Investment Akt.

SCREEN-GRID AMPLIFIERS

Convention date (Germany), 15th July, 1932.
No. 392045

To avoid the detuning effect of inductive reaction, particularly with ganged circuits, a capacity feed-back coupling is inserted directly between the screening grid of one HF stage and the next. The reactive effect so introduced is independent of the tuned circuits, and is stated to give a constant degree of coupling over a wide frequency band.

Patent issued to Ideal Werke Akt für drahtlose Telephonie.

POWDERED MAGNETIC CORES

Application date, 15th February, 1932. No. 390925

Relates to core fillings of high-permeability metal in finely-powdered form, the particles being electrically insulated from each other. Usually the core is suitably " diluted " with an admixture of Kaolin, talc, etc., so as to ensure a low " overall " permeability, but the filling reduces mechanical rigidity so that it becomes difficult to mould the core under high pressure. To overcome this defect the Kaolin filler is replaced by a non-magnetic or only slightly magnetic metal in powdered form, the grains being preferably insulated from each other either by shellac or by oxidation. A suitable metal is tungsten, or a chromium—aluminium alloy.

Patent issued to The General Electric Co., Ltd., C. G. Smith, and S. V. Williams.

MODULATING SYSTEMS

Convention date (Poland), 13th June, 1932. No. 390390

Consists of a " phase-shift " system designed to allow up to 100 per cent. modulation at high efficiency and with constant supply voltage. Second harmonics, in particular, are balanced out. A high-frequency source *S* feeds an unmodulated H.F. amplifier *A*, which drives a modulator *M*. Signal energy is supplied through a transformer *T* from the line *L*. The modulated currents are amplified in parallel at *A*1, *A*2 and are then combined with phase-shifted carrier waves from the amplifiers *A*3, *A*4. The suppressed carrier-wave is restored to the aerial by the amplifiers *A*5, *A*6. The result is that all the units, except *M*, are handling either unmodulated waves, or waves of constant amplitude, though in the aerial deeply modulated energy is present.

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

COLOUR TELEVISION

Convention date (U.S.A.), 4th October, 1930. No. 390158

Covers the adaptation to television of a known method of colour-cinematography in which a series of contiguous curved ridges, formed on the reverse side of a sensitized film, are used to control the projection of the image through different colour filters. The film to be televised is formed with longitudinal ridges on one side, and with an image consisting of a plurality of striations on the other side. The film is operated in conjunction with say three different photo-sensitive cells so that the image is split into three fundamental colour values, which are then scanned and thrown in rapid succession on to the corresponding photo-sensitive cell. Each cell controls a separate transmission channel, the various frequencies in each channel being re-combined at the receiving end to produce the effect of natural colour.

Patent issued to Electrical Research Products Inc.

Application date, 2nd November, 1931. No. 391781

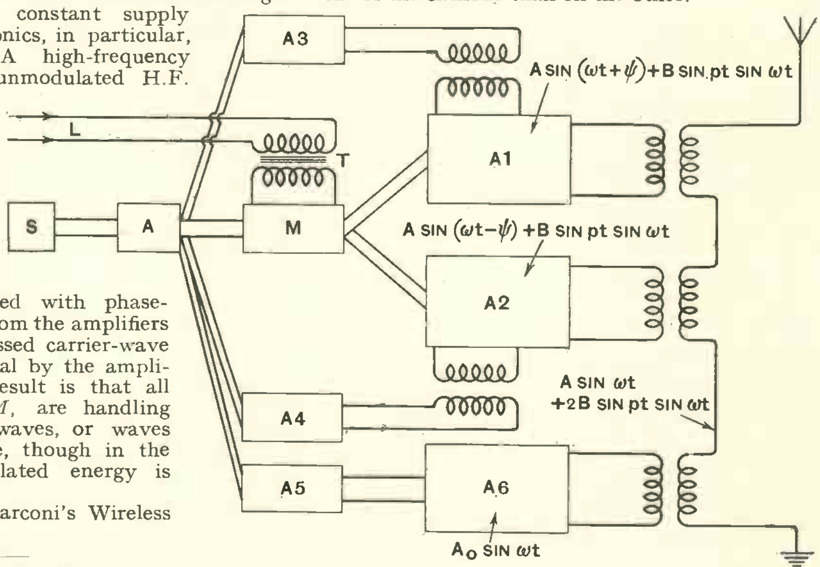
The ordinary scanning disc is backed by a second transparent disc which is divided into three sectors (coloured red, blue-violet, and green, respectively), and is rotated approximately 2¼ times faster than the first disc. The effect is to split up each of the usual scanning lines into parti-coloured strips on which the various colours are so interspersed as to give a tri-chromatic analysis of the original picture or scene.

Patent issued to T. Thorne Baker.

VARIABLE-MU VALVES

Convention date (Germany), 11th September, 1931. No. 391021

The required " tailing " of the characteristic curve is secured by using a grid of circular or elliptical section and making the mesh finer on one side of the cathode than on the other.



No. 390390.

Patent issued to Telefunken Ges für drahtlose Telegraphie.

Convention date (Germany), 7th August, 1931. No. 392391.

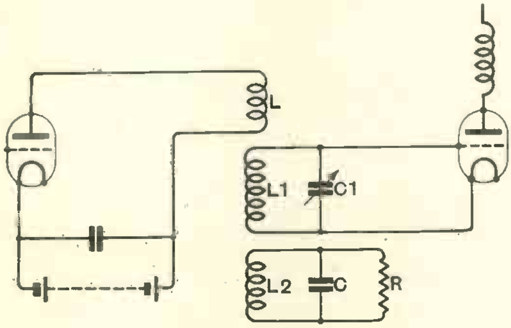
To produce a desired operating characteristic (*e.g.*, the variable-mu effect) the anode is formed with a series of axial apertures progressively increasing in size from one end to the other. Or it may be pierced with an irregular series of holes which may, for instance, be more closely grouped together at one end than at the other. This arrangement may be combined with the known method of using a non-uniform grid.

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

CONSTANT-COUPLING CIRCUITS

Application date, 16th February, 1932. No. 390926

The tendency of a high-frequency amplifier to go into self-oscillation depends among other things on the effective value of the anode inductance of each stage. In order to maintain this constant,



No. 390926.

particularly when using a reactance method of volume control, a compensating-circuit comprising an inductance $L2$ shunted by capacity C and resistance R is mechanically coupled to the intervalve coupling—coils L, $L1$. The coils are arranged so that as the coupling between L and $L1$ is increased, to augment the volume, the coupling between $L1$ and $L2$ is reduced, and *vice versa*.

Patent issued to J. E. Pollak.

MEASURING PERCENTAGE MODULATION

Application date, 19th September, 1932. No. 392053

The modulated wave is passed through two separate rectifying circuits, one having a time-constant which is large compared with the lowest modulation frequency used, whilst the time-constant of the other is small in comparison with the highest modulation frequency. The rectified output from the first circuit is accordingly proportional to the crest value of the carrier voltage, whilst the output from the second circuit follows the envelope of the modulated wave. The two outputs are then integrated and compared to indicate the percentage modulation.

Patent issued to F. B. Dehn.

TELEVISION SYSTEMS

Application date, 2nd February, 1932. No. 391924

Certain parts of the picture to be transmitted are scanned in finer detail than other parts, and the portions so scanned are systematically interchanged, so that all areas are finely scanned at least once in each complete cycle. This is stated to give clearer definition, without flicker, and without involving any increase in wave-band. The scanning disc is formed with three separate series of apertures, the size of the latter increasing or decreasing progressively.

Patent issued to J. L. Baird and Baird Television, Ltd.

THERMIONIC VALVES

Convention date (Holland), 24th March, 1931. No. 391938

During the "gettering" operation it is usual to run the heating-element of an AC valve at a temperature considerably higher than the normal, which tends to render the wire brittle and liable to subsequent fracture. The invention consists in providing two independent heaters, one of which is used for "gettering" alone, leaving the other available for normal working.

Patent issued to N. V. Philips Gloeilampenfabrieken.

CATHODE-RAY TUBES

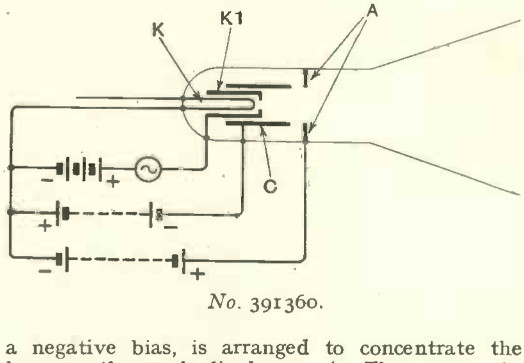
Application date, 19th November, 1931. No. 391887

The fluorescent screen of a cathode-ray tube, as used for television, should be smooth and of an even depth and texture, otherwise undesirable spots or blemishes are liable to spoil the definition of the received picture. To ensure this, a thin coating of silver is first deposited on the interior surface of the big end of the tube from a solution of silver nitrate. Pulverised fluorescent material, such as fine-screened Willemite, in suspension in water, is then poured in and allowed to remain until the powder has completely settled on the silver coating. The sharpness of the particles, caused by the grinding or pulverising, then causes the particles to adhere and interlock without the use of any other binding-material. The clear liquid must be drained off by a very slow tilting movement.

Patent issued to Electric and Musical Industries, Ltd.

Convention date (Germany), 29th August, 1931. No. 391360

In order to maintain a well-concentrated beam, even after comparatively long use of the tube, the cathode proper K is surrounded by a positively-biased electrode $K1$ with a central aperture in close proximity to the emitting surface. A further concentrating electrode or Wehnelt cylinder C, carrying



No. 391360.

a negative bias, is arranged to concentrate the beam on the anode diaphragm A. The aperture in the electrode $K1$ thus forms the effective origin of the beam.

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

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