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An Interesting Problem in Acoustics

In this number we publish an article by Dr. McLachlan on "Sound Waves of Finite Amplitude," in which he discusses a most interesting problem. The ordinary theory of the propagation of a sound wave assumes that the variations of pressure and volume are linearly related, which is only strictly true if the amplitude is infinitely small. With very loud sounds the amplitude will be so large that there will be an appreciable departure from this assumed linearity. A sinusoidal movement of a piston will not produce a sinusoidal variation of pressure. At first sight one might expect that any effects of this distortion would be minimised as the sound waves of a loud speaker moved away from the diaphragm, but according to Dr. McLachlan, if the sound wave travels down a horn or tube the distortion of the wave increases with the distance from the diaphragm.

The reason given for this is that the crest of the wave *i.e.*, the high pressure pulse, travels faster than the trough or low pressure pulse. If this be so, there will obviously be an increasing distortion of the wave, causing the original sinusoidal form to approximate to a saw tooth form. Dr. McLachlan assumes that the wave front gets progressively steeper and steeper until the wave front is vertical "when a discontinuity is presumed to occur." As a crude analogy he mentions the breaking of waves on the sea shore.

This result of the mathematical analysis is so startling that one cannot but wonder if something has been overlooked. So far as we know there is, as yet, no experimental confirmation of the phenomenon. There is one assumption made in the paper which cannot possibly hold up to the breaking point of the wave. It is stated that "the variation in velocity may be regarded in another way by considering the temperature difference between a crest and a trough due to compression and rarefaction under adiabatic conditions," and "it is clear that the temperature at a crest exceeds that at a point of zero pressure, which in turn exceeds that at a trough. Thus a crest travels faster than a point of zero pressure in the ratio $\sqrt{T_c/T_0}$, whilst a trough travels more slowly in the ratio $\sqrt{T_t/T_0}$, where T_c, T_0 and T_t are the respective absolute temperatures." These assumptions would appear to become untenable, however, as the wave-front approaches the vertical, because of the large temperature differences between contiguous points. It is doubtful whether the adiabatic condition can then be assumed. In the limit, when the wave-front became vertical, the same point would be simultaneously the hottest and the coldest in the wave. Is it not possible that the distortion reaches some limit at which stability is maintained by a transfer of heat from the closely contiguous regions of high and low pressure? We trust Dr. McLachlan will continue his researches into this problem, although we fear that its complexity will be largely increased by the consideration of heat transfer. G. W. O. H.

Sound Waves of Finite Amplitude*

By N. W. McLachlan

1. Distortion due to Curvature of Pressure/Volume Relationship for Air

A LINEAR response from a system having a curved characteristic can be obtained only if the working arc of the curve is sufficiently small. In the language of the mathematician, the amplitude must be infinitesimal, so that the tangent to the curve is used at the operating point. Fig. 1 illustrates the well-known adiabatic pressure/volume relationship for a gas. Here $pv^{\gamma} =$ const. where p is pressure, v is volume and γ is the ratio of the specific heat at constant pressure to that at constant volume. If M is the operating point on the adiabatic curve during the transmission of sound waves, MN represents the normal atmospheric pressure p_0. To avoid distortion in working at the point M, a finite portion of the curve cannot be used. This means that the variation in pressure above and below M must be infinitesimal in extent. The classical theory of sound is based upon this hypothesis.

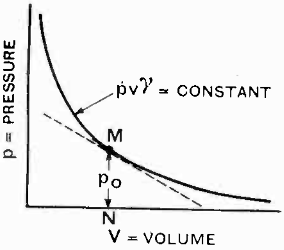

Fig. 1.—*Adiabatic curve for air, pv^{γ} = const., $\gamma = 1.4$.*

Since an infinitesimal pressure is below the lower threshold of audibility, it appears that the wave form of any audible sound differs from that in an ideal medium where pressure and volume are linearly related. The relationship in question is illustrated in Fig. 2, the equation being $p = a - bV$. A medium having a characteristic defined by this formula is impracticable, and must be regarded as being purely hypothetical. Despite the fact that all audible sounds are distorted due to the normal medium, the degree of distortion of most of them is of little consequence. When, however, a power of thirty watts is radiated from a horn type of loud speaker, it is appropriate to make calculations to ascertain whether the distortion is likely to be serious or not. Some idea of the matter can be gleaned from simple numerical data. A pressure of 5 dynes per square centimetre in the ear canal is perceived as quite a loud sound. In radiating 30 watts from a loud speaker having a small throat, the pressure in the throat chamber may reach 100,000 dynes per square centimetre or 0.1 of an atmosphere. This can hardly be regarded as "infinitesimal," and a finite part of the pressure/volume curve is involved.

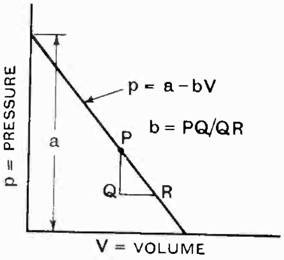

Fig. 2.—*Pressure/volume relationship for gaseous medium in which plane sound waves of finite amplitude would be propagated without distortion.*

Although the distortion arises from the p/v curve being non-linear, it cannot be computed from this curve alone, owing to the fact that sound is propagated outwards from the throat chamber of the horn as waves. In Fig. 3 suppose ON represents the volume of air at atmospheric pressure MN in the throat chamber when the diaphragm is at rest. If the entrance to the throat is closed by a plug and the diaphragm vibrates to and fro about its mean position, the volume changes from OP to OQ. Taking the volumes on each side of MN to be equal, we get $PN = NQ$. The rise in pressure RS on the backward swing will exceed the fall in pressure MT on the forward swing. Thus if the diaphragm executes a simple harmonic motion, the pressure on the plug will consist of a fundamental sine wave and a retinue of harmonics. In practice, however, the

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

horn throat is not closed, and the creation of distortion is somewhat different. Suppose for simplicity that the horn is replaced by an extremely long tube of equal diameter to the throat and diaphragm. The air particles in contact with the diaphragm execute a simple harmonic motion, and although there is now no throat chamber with a closed throat, it is evident that since a finite portion of the pressure/volume curve is used, there must be distortion of the sound pressure wave form. In fact the throat pressure consists of a fundamental frequency and harmonics, although the latter are relatively small. To understand how distortion arises, we must trace the history of the wave as it passes down the tube. We find that although the relationship between particle displacement and time is sinusoidal at the diaphragm, it steadily departs from this form as the distance increases. In other words distortion due to non-linearity of the medium increases with increase in the distance from the diaphragm. This is illustrated by the curves in Figs. 4 and 5. That in Fig. 4 shows the approximate shape of the pressure curve near the diaphragm, whilst Fig. 5 gives the shape of the curve some distance down the tube after cumulative distortion has occurred.

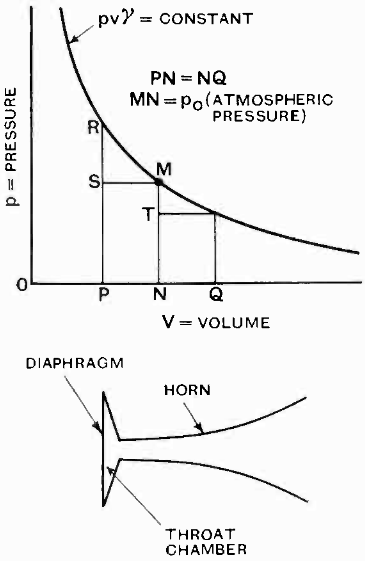

Fig. 3.

2. Variable Velocity of Propagation : How Distortion Arises

Whatever form the gas law may take, *e.g.* $pv = \text{const.}$, $pv^\gamma = \text{const.}$, the velocity of propagation of small disturbances is given by the formula $c' = \sqrt{\dfrac{dp}{d\rho}}$, where p is the pressure and ρ the corresponding density of the gas. During the transmission of sound waves, the adiabatic condition obtains, so the law $pv^\gamma = \text{const.}$, *i.e.*, $p/\rho^\gamma = \text{const.}$, must be used in analytical work. From the latter formula we have

$$p/\rho^\gamma = p_0/\rho_0{}^\gamma \text{ or } p = p_0\,(\rho/\rho_0)^\gamma\,, \quad .. \quad (1)$$

where p_0 and ρ_0 are the normal pressure and density, respectively. By differentiating (1) we get

$$\frac{dp}{d\rho} = \frac{\gamma p_0}{\rho_0}(\rho/\rho_0)^{\gamma-1} = c^2\,(\rho/\rho_0)^{\gamma-1},$$

$$\text{or} \quad c' = \sqrt{\frac{dp}{d\rho}} = c(\rho/\rho_0)^{\frac{1}{2}(\gamma-1)}, \quad .. \quad (2)$$

where $c^2 = \gamma p_0/\rho_0$.

For infinitesimal amplitudes $\rho = \rho_0$, so the formula for the velocity of propagation takes the well known form

$$c' = c = \sqrt{\frac{\gamma p_0}{\rho_0}}. \quad .. \quad .. \quad .. \quad (3)$$

If we assume that formula (2) is applicable to finite pressure amplitudes which are not unduly large, it is possible to explain how the wave form gradually alters with increase in the distance from the diaphragm at the near end of the tube considered in § 1.

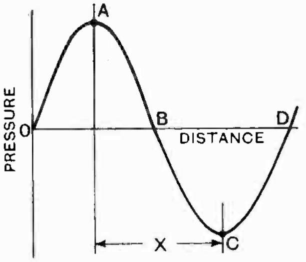

Fig. 4.—*Diagram showing shape of sound wave near the diaphragm at beginning of very long uniform tube.*

The proportionate increase (or decrease) in density during wave transmission is given by $\mathbf{s} = (\rho - \rho_0)/\rho_0$, and is termed the condensation. This relationship can also be written $\rho = \rho_0(1 + \mathbf{s})$, which if inserted in (2) gives the velocity at the crest of a wave as

$$c' = c(1 + \mathbf{s})^{\frac{1}{2}(\gamma-1)} \doteqdot c\{1 + \tfrac{1}{2}(\gamma - 1)\mathbf{s}\} \quad (4)$$

provided $\mathbf{s} << 1$.

At a trough $\mathbf{s}$ is negative since $\rho < \rho_0$, so the velocity there is

$$c' \doteqdot c\{1 - \tfrac{1}{2}(\gamma - 1)\mathbf{s}\} \quad .. \quad .. \quad (5)$$

At a point of zero pressure between a crest and a trough $\mathbf{s}$ is zero, so the velocity of propagation is $c' = c$. Thus due to variation in density there is a progressive reduction in velocity from a crest to the succeeding trough.

The variation in velocity may be regarded in another way, by considering the temperature difference between a crest and a trough due to compression and rarefaction under adiabatic conditions. From above we have $p/p_0 = \left(\frac{v_0}{v}\right)^{\gamma}$, also $pv = RT$ and $p_0 v_0 = RT_0$, where T and T_0 are the absolute temperatures corresponding to pressures p and p_0. From the two latter relationships, we obtain

$$\frac{v_0}{v} = \frac{p}{p_0} \cdot \frac{T_0}{T} \quad .. \quad .. \quad (6)$$

Substituting above for v_0/v, we find that

$$\left(\frac{p}{p_0}\right)^{\gamma}\left(\frac{T_0}{T}\right)^{\gamma} = \frac{p}{p_0},$$

$$\text{or} \quad \frac{T}{T_0} = \left(\frac{p}{p_0}\right)^{\frac{\gamma-1}{\gamma}} \quad .. \quad .. \quad (7)$$

Using (1), expression (7) can be written

$$\sqrt{\frac{T}{T_0}} = \left(\frac{\rho}{\rho_0}\right)^{\frac{1}{2}(\gamma-1)} \quad .. \quad .. \quad (8)$$

so that from (2) it follows that the velocity of propagation can be expressed in the form

$$c' = c\sqrt{\frac{T}{T_0}} \quad .. \quad .. \quad .. \quad (9)$$

From (7) and (8) it is clear that the temperature at a crest exceeds that at a point of zero pressure, which in turn exceeds that at a trough. Thus a crest travels faster than a point of zero pressure in the ratio $\sqrt{\frac{T_c}{T_0}}$, whilst a trough travels more slowly in the ratio $\sqrt{\frac{T_t}{T_0}}$, where T_c and T_t are the respective absolute temperatures.

In addition to the variation in velocity due to change in temperature, there is also the velocity of the air particles to be taken into account, since it is not negligible when the pressure amplitude is finite. The particle velocity is in the direction of propagation at the crest of a wave, but in the opposite direction at the trough. Hence if the particle velocity at the crest is u, the total velocity of propagation of the crest in space is $c\{1 + \frac{1}{2}(\gamma - 1)\mathbf{s}\} + u$. In like manner we find the total velocity of the trough is $c\{1 - \frac{1}{2}(\gamma - 1)\mathbf{s}\} - u$. The velocity of the crest exceeds that of the trough by an amount which is equal to the difference between these two quantities, namely $c\mathbf{s}(\gamma - 1) + 2u$. Consequently if the initial waveform is that of Fig. 4, as it travels along the tube mentioned in § 1, the wave gradually assumes the shape illustrated in Fig. 5. The slope at YY' steadily gets steeper and steeper until the line is vertical, when a discontinuity is presumed to occur. The effect in question can be illustrated in a crude way by comparison with the breaking of waves on the sea shore. The conditions are, of course, rather different owing to friction between the water and the beach, also to the rising gradient of the latter. Beyond the point of discontinuity the mathematical analysis, by aid of which the shape of the wave can be calculated nearer the diaphragm, ceases to have any physical significance. The only method of investigation would then be an empirical one.

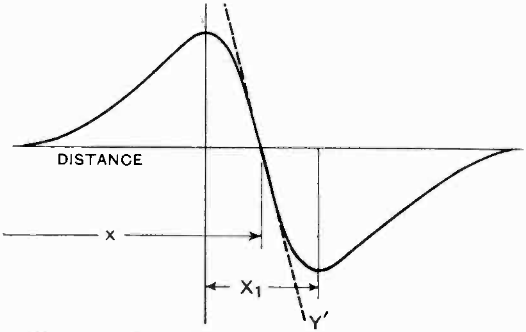

Fig. 5.—*Diagram illustrating distortion of a sound wave of finite amplitude as it travels along a long frictionless tube.*

In Fig. 5 the second harmonic of the fundamental frequency is more prominent than the higher harmonics, and this is readily seen by aid of a graph of the form illustrated in Fig. 6 where arbitrary amplitudes are chosen. The formula for the sound pressure at a distance x from the diaphragm is, to a second approximation,

$$p = a \sin \theta - bx \sin 2\theta \quad .. \quad .. \quad (10)$$

In this formula a and b are constants, $\theta = (\omega t - kx)$, $k = \omega/c$, $\omega = 2\pi$ frequency, and it holds provided $2kx >> 1$. It is seen from the second term in (10) that the amplitude of the second harmonic, namely, bx increases with increase in the distance from the diaphragm. This suggests that the formula must be restricted so far as x is concerned. It cannot be used beyond the point of discontinuity, but owing to the approximate nature of the analysis its use is limited to even smaller values of x than this. A discussion on the limitations of the formula is outside our present purpose, but has been given elsewhere.[1] We see, therefore, that as the sound passes down the tube, power is drawn from the fundamental, and harmonics are created. The total power is the same at any value of x, although this is not shown by (10), owing to the differential equation having been solved by a method of approximation.

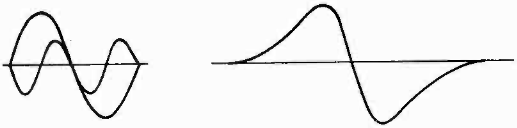
(a) (b)

Fig. 6.—*(a) Diagram showing the fundamental and second harmonic sound waves in opposition. (b) Resultant of the curves in (a).*

3. Numerical Example illustrating Distortion in a Long Uniform Tube

To give some idea of the magnitude of the distortion in plane wave propagation, we shall take the case of a very long frictionless tube 2.5 cm. radius devoid of reflection at the far end. We shall calculate the level of the second harmonic 600 cm. from a diaphragm at the transmitting end, supplying 26 watts of acoustical power at a frequency of 200 ∼. Assuming absence of transmission loss down the tube, the required formula for the ratio of the power P_2 in the second harmonic to that in the fundamental P_1 is,[2]

$$\phi_t = P_2/P_1 = 5.14 \times 10^{-12} P_1 x^2 n^2 / A_0 \quad .. \quad (11)$$

where x is the distance from the diaphragm in cm., n is the frequency, A_0 the cross-sectional area of the tube in square cm., and the power is expressed in watts. Using formula (11) and the above data, we find that $\phi_t = 0.1$. Thus the level of the second harmonic is 10 log 0.1 = − 10 decibels relative to that of the fundamental, and this would be detected aurally. For high-class reproduction the level of the second harmonic should be at least 30 db. below that of the fundamental.

From formula (11) we see that with a constant power input to a tube of given diameter, the relative power in the second harmonic at a specified distance from the diaphragm, increases as the square of the frequency. This can be explained in the following way. The higher the frequency the shorter the wavelength and the smaller the distance X from crest to trough in Fig. 4 (near the diaphragm). Thus the time taken for X to contract to X_1 of Fig. 5, as the wave travels down the tube, will decrease with rise in frequency. Thus when the ratio $\phi = P_2/P_1$ has attained a certain value, a short wave will not have travelled so far from the diaphragm as a long one. Hence when the short and long waves have travelled over equal distances, the value of ϕ will be greater in the former than in the latter case. We also infer from formula (11) that the degree of distortion at a given distance down the tube can be reduced by increasing the cross-sectional area A_0. The reduction in distortion is due to the smaller sound pressure necessitated at the diaphragm for a given input power to the tube.

4. Exponential Horn

Since the cross-sectional area of an expanding horn increases with increase in distance from the throat, the sound pressure decreases as the wave passes down the horn towards the mouth. Hence at a given distance x from the throat, the distortion for a given input power is less than that in a uniform tube whose cross-section is equal to that at the throat. The degree of distortion for a given input power depends upon the type

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[1] McLachlan and Meyers, *Proc. Phys. Soc.*, 47, 644, 1935; *Elektrische Nachrichten-Technik*, 12, 259, 1935.

[2] The formula was deduced from Lamb, *Dynamical Theory of Sound*, p. 183 (1925).

of horn, its length and throat area. Formulae for exponential[3] and conical[4] horns have been obtained, and these can be used for calculating the distortion. These formulae are the outcome of solving somewhat complicated differential equations. An analysis of the differential equation, for a horn of any cross-section, throws light upon the physical processes involved in the transmission of sound waves of finite amplitude. In an expanding horn there are several causes of distortion: (1) non-linearity of the medium, (2) variation in area of the cross-section as the wave travels outwards from the throat, (3) a combination of (1) and (2), this being represented by a hybrid term in the differential equation. The first and most important cause of distortion has already been explained in connection with the propagation of plane waves in a tube, so we pass on to the second. Referring to Fig. 7, which represents a longitudinal section of a conical horn, the air particles at abscissa x execute a finite amplitude ξ_0 on each side of their mean position. Obviously the volumes swept out on either side of this position are unequal and non-linear distortion ensues. This effect is represented by terms in the differential equation. The influence of attenuation of pressure as the wave expands down the horn, is, however, large enough to swamp the varying area effect. If, however, the medium were linear, the distortion due to varying area would still be present.

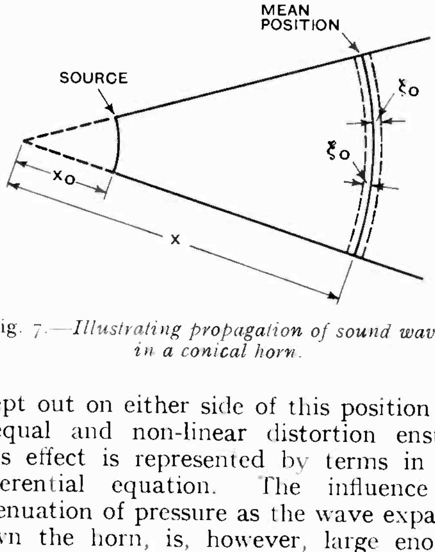

Fig. 7.—*Illustrating propagation of sound waves in a conical horn.*

To illustrate the influence of expansion in reducing distortion in waves of finite amplitude, we can calculate the ratio $\phi_h = P_2/P_1$ for an exponential horn with zero transmission loss using the numerical data given above for a tube. The throat of the horn is to be equal in area to that of the tube, and a lower cut-off frequency of 50∼ will be taken. Then from reference (3) we have,

$$\phi_h = P_2/P_1 = 1.48 \times 10^{-4}(P_1/A_0)(n/n_c)^2 \quad (12)$$

provided $k >> \frac{1}{2}\beta$, $e^{-\frac{1}{2}\beta x} << 1$, where β is the flaring index in the formula Area $= A_0 e^{\beta x}$, A_0 being the throat area, and n_c is the cut-off frequency, Now $\beta = 4\pi n_c/c = 0.018$, and $k = 2\pi n/c = 0.037$, so $k >> \frac{1}{2}\beta$. Also $x = 600$ cm., $\frac{1}{2}\beta x = 5.4$ which makes $e^{\frac{1}{2}\beta x} << 1$, so that both of the conditions for validity of the formula are satisfied. Formula (12) gives the ultimate value of ϕ_h. As the wave expands from the throat outwards, the level of the second harmonic steadily increases with reference to that of the fundamental. A point is reached, however, beyond which its growth is arrested due to the rapid rate of expansion of area causing a large drop in sound pressure, *i.e.*, by virtue of approach to the condition of infinitesimal amplitude. Formula (12) applies to distances from the throat at which this condition is substantially fulfilled, but it does not apply to values of x where the harmonic is growing appreciably, *i.e.*, near the throat.

From the above data we find that $\phi_h = 3.14 \times 10^{-3}$, so the level of the second harmonic is 10 log $3.14 \times 10^{-3} = -25$ decibels relative to that of the fundamental. It is, therefore, 15 decibels below the level of the harmonic in the tube, so this represents the reduction in distortion resulting from expansion of the wave. Formula (12) indicates that the lower the cut-off frequency, the greater is the distortion under given conditions. This is due to the fact that a low cut-off frequency necessitates a small value of β, the flaring index of the horn. Thus in the formula $A = A_0 e^{\beta x}$, if β is small, the horn flares but slowly at first and there is a relatively long tube like portion from the throat outwards. The major part of the distortion occurs here, since the wave cannot expand appreciably. The distortion can, however, be mitigated by

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[3] Goldstein and McLachlan, *Wireless Engineer*, 11, 427, 1934; *Journal Acous. Soc. Amer.*, 6, 275, 1935.

[4] McLachlan and Meyers, *loc. cit.*

making the throat of ample radius thereby reducing the sound pressure-amplitude. If the level of the second harmonics is to be not less than 30 decibels below that of the fundamental, formula (12) gives for the throat area

$$A_0 \geqslant 0.148 P_1 (n/n_c)^2 \text{ sq. cm.} \quad .. \quad (13)$$

where P_1 is expressed in watts.

5. Conical Horn (Spherical Wave Propagation)

Finally we turn to spherical waves of finite amplitude which are exemplified in the case of a conical horn or in a siren. To illustrate the degree of distortion in spherical wave propagation, suppose we take the case of a simple source of sound close to the ground, the power radiated being 9 kilowatts at 500 ∼. Since the source is near the ground, we may take the solid angle into which it discharges as 2π. For zero transmission loss, the formula for $\phi_s = P_2/P_1$ is given in reference (1). It is

$$\phi_s = P_2/P_1 = 4.95 \times 10^{-12} \frac{n^2 x_0^2}{A_0} \left[\log_e \frac{x}{x_0} \right]^2 \quad .. \quad .. \quad (14)$$

where x is the distance from the apex of the cone, and x_0 is the distance of the source therefrom as shown in Fig. 7. In the present case the cone is a hemisphere, although the source is not. We shall assume for simplicity, however, that the source is equivalent to a pulsating hemisphere 30 cm. radius, the power radiated therefrom being 9 kilowatts. Taking $x = 600$ metres and remembering that the superficial area of the hemisphere is $A_0 = 2\pi x_0^2 = 2\pi \times 30^2$, we obtain $\phi_s = 0.1$, so the level of the second harmonic is 10 decibels below that of the fundamental.

In formula (14), it appears that owing to the factor $\left[\log_e \frac{x}{x_0} \right]^2$ the ratio $\phi_s = P_2/P_1$, increases indefinitely with the distance from the source. This, however, is due to the differential equation being solved approximately, since an exact solution is out of the question. The difficulty can be removed by restricting all calculations using formulae given herein so that $\phi = P_2/P_1 \ngtr 0.1$ and $\xi_2/\xi_1 \ngtr 0.25$, where ξ_1 and ξ_2 are the particle amplitudes corresponding to the fundamental and the second harmonic. respectively. The method of calculating ξ_1 and ξ_2 is beyond our present purpose, but it is given in the references already cited.

It is comforting to know that distortion due to non-linearity of the medium is of no practical importance in hornless loud speakers (so far constructed), owing to the relatively small value of the sound pressure at the diaphragm and to expansion into a large solid angle. Even at high audio-frequencies where the sound is propagated as a narrow beam, the distortion due to the medium is usually negligible compared with that due to other causes.

Book Review

Practical Radio Communication

By Arthur R. Nilson, U.S.N.R. (Retired), M.I.R.E., and J. L. Hornung, M.I.R.E. Pp. 754 xxxiii and 434 illustrations. McGraw Hill Publishing Company, Ltd., Aldwych House, Aldwych, London, W.C.2. Price 30s. net.

This is a highly authoritative work of outstanding merit and represents an important addition to serious radio literature. It is planned to meet the needs of those whose intention it is to become thoroughly qualified on the technical side of radio communication, whether they are already actively engaged or preparing to take up a responsible position.

As the authors point out, the book is divided into two sections, the first six chapters being devoted to a thorough treatment of fundamental principles, and the remaining nine chapters to modern practice.

It is noteworthy that the authors have broken away from the old notation of the direction of current flow. Throughout the volume the direction of flow is indicated as the direction in which the (negative) electrons travel, that is, from negative to positive in a circuit receiving electrical energy. This of course necessitates the reversal of Fleming's left and right hand rules in electromagnetism. The authors are to be congratulated on adopting entirely the strictly correct notation, which is really essential in the study of thermionics. There is a likelihood. however, that students who have become accustomed to the old notation may experience some confusion, especially as the authors apply the reversed rules without any reference to the older but more usual system.

The main part of the book deals with broadcast transmitters, studio acoustics, control room equipment, etc., commercial transmitters, receivers and aids to navigation. Short wave and ultra-short wave operation are also included. The last three chapters deal very fully with rectifier units, electrical machinery, meters and storage batteries.

The work is beyond criticism and may eventually rank as a standard textbook on the more practical side of radio communication. O. P.

A Portable Programme Meter*

By E. L. Payne, B.Eng., and J. G. Story

(Of the Engineering Staff, British Broadcasting Corporation)

THE desirability of introducing some means for controlling the general level of speech or music, in a broadcast chain or sound amplifying system is well known, and various methods for providing a visual indication of these variations of the controlled level are used by different organisations.

One such instrument which has given satisfactory results, and is due to C. H. Smith† has been used in the control rooms of the B.B.C. for some time.

This device, which is termed a "Programme Meter," gives a direct reading, over a certain range, of the logarithm of the audio-frequency voltage applied to its terminals. This indication was achieved by applying the programme voltages to the anodes of two pentode valves operating as push-pull rectifiers, and having a suitable D.C. potential applied to the outer screen grid only. The resultant rectification characteristic is practically logarithmic over the range used.

Although this instrument fulfils its functions when situated in a control room where bulk is comparatively unimportant, and adequate H.T. and L.T. supplies are available, it is unsuitable on these same grounds as a transportable instrument.

It was with the object of providing a more portable form of "Programme Meter," chiefly for outside broadcast use, that the instrument to be described was developed.

Although hardly any continuous controlling is carried out at the source of an outside broadcast it is desirable for the engineer to know at what voltage level programme is being supplied to the sending end of the line to headquarters. This is necessary, first, to prevent cross-talk occurring on adjacent lines and, secondly, in order to maintain the general level of programme at the sending end at a sufficiently high level to avoid, as far as possible, line noise and interference becoming troublesome.

Obviously any instrument designed to measure programme voltages at this point must cover a very wide range of levels since, in general, the programme voltages are uncontrolled after the initial setting at the commencement of the broadcast. Further, the desired sending level will vary considerably according to the loss and noise of the line.

In the instrument to be described the substantially linear relationship between the meter reading and the logarithm of the applied voltage has been retained. The desired result is attained, however, by the use of a different principle.

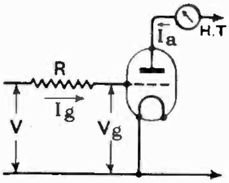

Fig. 1.

Considering the circuit arrangement given in Fig. 1, which shows a resistance R in series with the grid of a triode valve; then

$$V = I_g(R + R_g) \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where V is a direct voltage applied to the resistance R and the grid-cathode resistance of the valve, R_g, in series, and I_g is the grid current.

From (1) we get

$$\log_e V = \log_e I_g + \log_e(R + R_g) \quad \ldots \quad (2)$$

Now Colebrook‡ pointed out that, over quite an extensive range, the logarithm of the grid current bears a practically linear relationship to the grid voltage, shown as V_g in Fig. 1; or—

$$I_g = ae^{bV_g}$$

and hence,

$$\log_e I_g = \log_e a + bV_g \quad \ldots \quad \ldots \quad (3)$$

when I_g and V_g have the significance given

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

† *World Radio*, 26th February, 1932.

‡ *Experimental Wireless and Wireless Engineer*, November, 1925.

above, e is the base of the Naperian logarithms, and a and b are constants determined by the geometry and characteristics of the valves used.

Substituting this equivalent relationship for $\log_e I_g$ in equation (2) we have—

$$\log_e V = \log_e a + bV_g + \log_e(R + R_g) \quad .. \quad (4)$$

Equation (4) shows that, if $\log_e (R + R_g)$ is a constant, a linear relationship exists between $\log_e V$ and V_g.

By making R of the same order or greater than R_g it can be arranged in practice that, over a certain range, $\log_e(R + R_g)$ is and remains sufficiently constant for equation (4) to be rewritten—

$$\log_e V = K + bV_g \quad .. \quad .. \quad (5)$$

where K is a constant.

If, during the assumptions already enumerated, the anode current, I_a, bears a linear relationship to the grid voltage, then—

$$\log_e V = K' + kI_a \quad .. \quad .. \quad .. \quad (6)$$

where K' and k are new constants determined by the valve characteristics.

Recapitulating then, equation (6) holds if $\log_e(R + R_g)$ is constant over the range for which $I_g = ae^{bV_g}$ and if I_a is linear with respect to V_g.

These three conditions are easily capable of fulfilment, especially if R_g rapidly decreases with increasing V_g and R is greater than, or of a similar order to, R_g for minute values of grid current.

(*Below*) Fig. 2.

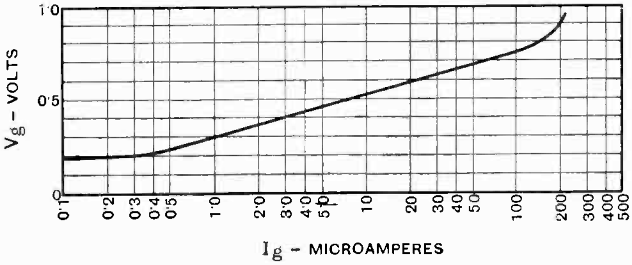


Fig. 2 shows the variation of I_g (plotted to a logarithmic base) with V_g for a modern indirectly heated valve. It will be seen that for values of grid current between 1 and 100 microamps equation (3) holds. Above 100 microamps, however, the approximate logarithmic relationship is not maintained and this equation no longer applies.

From equation (6)

$$\log_e V - \log_e V' = k(I_a - I_a')$$

or

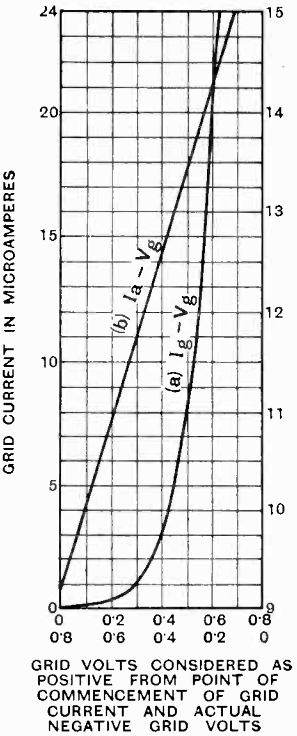
$$\log V/V' \propto \triangle I_a \quad .. \quad .. \quad (7)$$

where $\triangle I_a$ is the change in anode current for two applied voltages V and V'.

This equation indicates that the anode current change represents a linear voltage decibel scale which is the relationship desired.

To obtain the best results a valve having a high mutual conductance and a low grid-cathode resistance when grid current flows is desirable. Curve (*a*) Fig. 3 shows the grid volts-grid current characteristics of such a valve together with the corresponding anode current-grid volts characteristic, curve (*b*). The latter is included to show that I_a is proportional to v_g over the range where $\log_e i_g$ is also proportional to v_g.

(*Left*) Fig. 3.



Curves (2) to (5), Fig. 4, are calculated curves showing the logarithm of the applied voltage V plotted against the anode current I_a for various assigned values of series resistance R. Curve (1), Fig. 4, is obtained by taking the actual values shown in Fig. 3 and replotting as I_a against $\log v_g$, since, in this case, $R = 0$ and therefore $v_g = V$.

From the values of grid current and grid voltage given by curve (1), curves (2) to

(5) are readily obtained from the equation $V = (i_g R + v_g)$ for the various values of R and from the value of I_a corresponding to v_g.

It is seen that the larger R becomes, the more nearly does I_a become proportional to log V, as is to be expected.

It will also be noted that linearity ceases at the lower end of the curves. This is due, first, to the increase in value of R_g compared with R and, secondly, to a slight departure from the logarithmic relationship between grid current and grid volts which is plainly shown in Fig. 2. Preliminary bias may, however, be employed in order to ensure working over the linear portion of the curves.

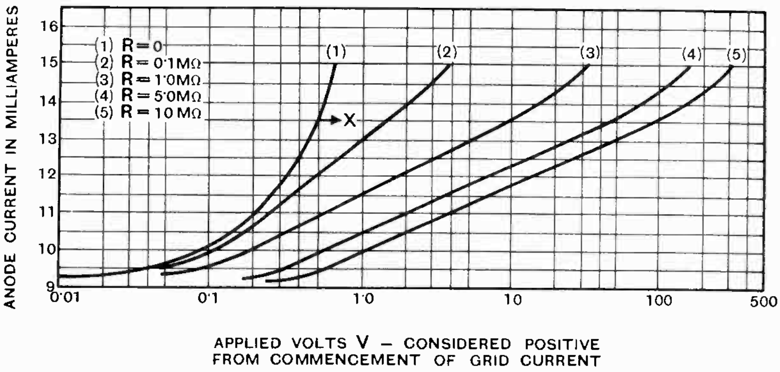


Fig. 4.

The upper limit to the linearity, marked "X" in Fig. 4, depends upon the range of the logarithmic relationship between grid current and grid volts and also upon the anode current-grid voltage characteristics of the particular valve used. The position of point "X" varies in different valves, even of the same type. It is always possible, however, to rely upon a certain amount of the curve being straight provided the value of R is sufficiently large.

A very useful feature of the device is that the change in anode current for two given applied voltages can be varied by simply increasing or decreasing the value of R; providing, of course, R is not made so small as to upset the linear conditions. In other words, the anode current meter may be calibrated in any convenient number of decibels per division, so long as the relation of equation (6) holds.

A complete circuit diagram of a programme meter embodying these principles is shown in Fig. 5.

The instrument is designed to work from a 250 volts high tension and a 6 volts low tension supply.

In order to provide a direct reading of the logarithm of the applied voltage, the standing feed to the anode of the last valve is balanced out so that only the change in anode current is indicated by the meter. This is accomplished in the programme meter by means of a Wheatstone bridge network, of which the valve forms one arm, whilst the meter is connected across the diagonal.

Balancing is carried out by adjustment of the potentiometer, P_3, until the meter indication is zero. The meter is such that reverse current is detectable. By splitting up the resistances r_1, r_2 and P_3 in the way shown, a very critical balance may be obtained. P_3 is made just large enough to allow for differences in resistance from valve to valve of the same type and manufacture.

Although it is not essential to use a special meter, actually a critically damped milliammeter giving a full scale reading for a current of 2 milliamps is employed. The reasons for either electrical or mechanical damping at some point in the circuit are discussed later.

The scale of the meter is divided into eight divisions, each division being equivalent to a change in applied voltage of four decibels—except that from 0 to 1 an infinite change of level is indicated.

A double diode rectifier is employed to supply the positive impulses to the logarithmic stage, the rectifier load being a non-inductive resistance R_1 virtually in series with the grid series resistance R. The circuit may be readily modified, however, to work in conjunction with a single wave rectifier.

It should be borne in mind that the rectifier is not linear for small applied voltages. It is therefore necessary, to ensure the accuracy of the instrument, to arrange that the alternating voltages which are applied to the rectifier, and which give D.C. pulses sufficient to deflect the meter over the working range of from 1 to 8 divisions, sweep well into the straight portion of the rectifier characteristic.

Indirectly heated valves, having 4 volt heaters, are employed throughout. As a 6 volts low tension supply is available, bias for the logarithmic valve, v_3, is conveniently obtained by normally connecting the negative end of the rectifier load resistance to the negative side of the filament voltage dropping resistance of 1.1 ohms for the valves v_2 and v_3. This connection is made through the calibrating key when in its normal operating position. In itself this would give a bias of a little under 2 volts to the grid of v_3.

Actually, however, there is always a small current flowing from the cathode to the anodes of the diode, even when no signal is applied, and this current sets up a voltage across the rectifier load resistance, R_1, in opposition to the bias. Thus the negative bias actually applied to the logarithmic valve is of the order of 1 volt. It is at round about this point that grid current just commences to flow.

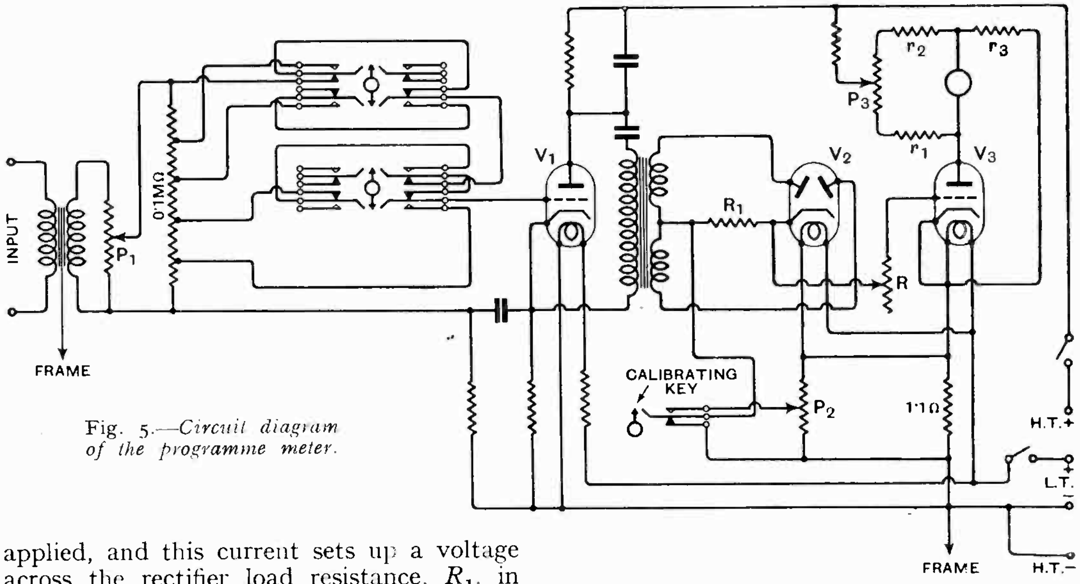


Fig. 5.—*Circuit diagram of the programme meter.*

In practice the point of commencement of grid current varies from valve to valve, and thus there is an optimum bias for every valve. It is not practical, however, to provide a variable bias for an instrument in production and a compromise has to be effected. Fortunately this does not seriously detract from the accuracy of the instrument.

Bias for the logarithmic valve obtained in this way has an additional advantage. It has been found that the correct performance of the instrument over a period of a few hours depends, to a very great extent, on the constancy of the bias to this valve. Advantage has been taken of the fact that, if the voltage across the heater of an indirectly heated valve be increased, the current increases to a less extent.

A supply voltage-heater current curve for two typical valves, the heaters of which are connected in parallel and one side joined directly, and the other through a 1.1 ohm resistance, to the supply is shown in Fig. 6.

It will be noticed that there is a small part of the curve, $X - Y$, where there is practically no increase in current for an increase in voltage. This kink in the curve seems to occur regularly in several types of valves of different manufacture, though its position varies according to the make of valve. The precise cause of this is not fully understood but the kink conveniently occurs at the normal supply voltage for the valves used ;—a piece of unusual good fortune. However, the curve is sufficiently flat about the working point, apart from this kink, to ensure an adequate constancy in performance of the instrument.

Across the bias resistance of 1.1 ohms is connected a high resistance potentiometer, P_2, the slider of which is pre-set to give a predetermined lesser amount of negative bias to the valve v_3 by operation of the calibrating key. The reason for this is as follows: When the negative bias applied to this valve is changed, the value of the grid voltage V_g is altered by an amount depending on the value of R plus R_1 in series and the grid current flowing. Furthermore, as the anode current is dependent upon the grid voltage, it will also change and can therefore be varied by adjustment of R.

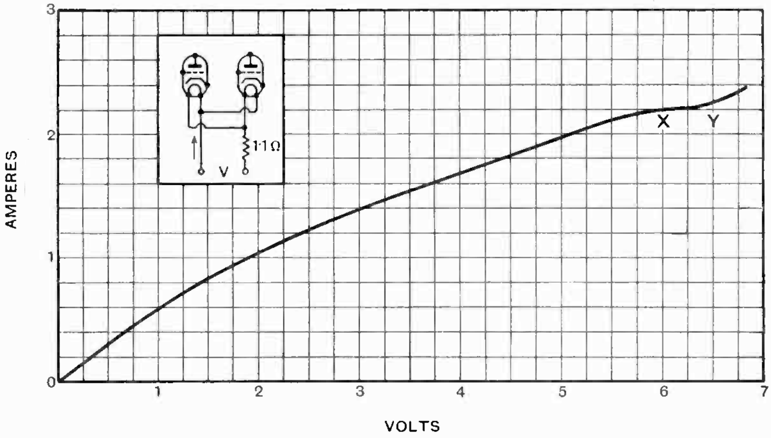


Fig. 6.

This gives a useful means of routine calibration. As has been shown before, the amount of the change in the anode current to the logarithmic stage for a given change in the applied voltage is, within certain limits, a function of R. The value of R is therefore adjusted in the test room so that a change in deflection of one division of the meter corresponds with the required change of level in decibels of the applied voltage—in this case, four decibels.

Assuming R to be correctly adjusted, a change of bias may then be introduced by operation of the calibrating key resulting in a deflection being obtained on the meter. This change of bias may be regulated by P_2 until a certain known deflection is obtained which only corresponds with the correct value of R.

For subsequent calibration, therefore, it is only necessary to re-obtain this deflection by operation of the calibrating key and making adjustments to R.

The potentiometer P_2 is pre-set and locked in position in the test room. Once set there is no need for readjustment unless either of the valves v_2 or v_3 fail. A replacement of the valve v_2 might cause a slight, though not negligible, change in the voltage set up across R_1 as mentioned before. As this voltage is in opposition to the bias, a consequent change in the operating conditions of the valve v_3 may be expected: hence the necessity of readjusting P_2 after a change of rectifier valve.

Whilst referring to routine calibration, it may not be out of place to mention again that the resistance of the valve v_3 varies with the actual value of the grid voltage. Thus, if R is varied appreciably during the calibration process, the bridge circuit will become unbalanced. If this occurs, it is necessary to rebalance and repeat the calibration.

It might appear that routine calibration is a lengthy process, but actually it is only a matter of ten or fifteen seconds.

It may happen in practice that it is inconvenient to make R sufficiently large compared with the grid-cathode resistance R_g. Slight departures in the linearity of the log $V - I_a$ characteristic due to this may sometimes be offset by a judicious choice of the effective resistance in the anode circuit, that is of r_1, r_2 and P_3. It must, however, be borne in mind that any change in anode voltage slightly shifts the point of grid current commencement. Hence the change of anode voltage over the working range must not be large, otherwise another error may be introduced.

The resistance in the anode circuit of the logarithmic stage is arranged to be as large as possible, in order to minimise the drain on the high tension supply, without appreciably altering the accuracy of the instrument.

Preceding the rectifier and coupled to it by means of a transformer is a single stage of amplification. The gain of this stage is continuously adjustable by means of a high resistance potentiometer, P_1, connected across the secondary of the input transformer. Adjustment of this forms a part of the initial setting up of the instrument in the test room, after which it is locked in position. Alteration to this setting is only necessary if the amplifying valve v_1 should fail.

To the slider of this potentiometer is connected a second potentiometer of 0.1 megohm. The grid of the amplifying valve is taken to one of a series of tappings on this latter potentiometer by means of keys. The tappings are arranged to give standard variations in the gain of the amplifier, the keys being engraved so as to indicate the levels, applied to the input terminals, relative to an arbitrary zero level.

The initial method of standardisation of the instrument is therefore as follows :—

The standing feed to the logarithmic stage is first balanced out by adjustment of the control P_3.

A sinusoidal voltage at any convenient frequency and of r.m.s. value corresponding with the desired input as specified by the setting of the level keys is applied to the input terminals. The potentiometer P_1 is adjusted such that a deflection of 7 divisions is obtained on the meter. The input voltage is then reduced to a quarter of its original value, that is attenuated by 12 decibels. It is required that the instrument shall indicate a voltage level change of 4 decibels per division, therefore, if it is properly aligned, a reading of 4 on the meter should result. If not, the resistance R is varied until a deflection of 4 is obtained.

This latter operation will change the overall sensitivity of the instrument and upset the balance of the bridge circuit. It is essential, therefore, for all these adjustments, that is of P_3, P_1 and R, to be repeated until deflections of 7 and 4 are obtained for a variation of input level of 12 decibels.

When the correct settings for these have been obtained the potentiometer P_1 is locked in position.

It is now necessary to provide for routine calibration, that is for calibration when neither tone source, attenuator nor other measuring devices are available, as in the case of programme origins such as outside broadcasts.

For this the alternating voltage is disconnected from the input terminals and, after it has been ascertained that the standing feed to the valve v_3 is balanced out, the calibrating key is depressed. This will give rise to a meter deflection dependent on the position of the slider of P_2, due to the effect of the change of bias voltage as previously described. The potentiometer, P_2, is manipulated until this deflection is 4 divisions and is then locked in position.

For subsequent routine calibration it is only necessary to re-obtain this meter reading by adjustment of the resistance R to the correct value.

The programme meter is then ready for use.

Tests made on the instruments so far designed show that the meter reading is correct to within plus or minus one decibel over a frequency range of 50 to 10,000 c/s, this accuracy being sufficient for the purpose for which the device was intended.

The programme meter is capable of measuring programme levels over a range of 44 decibels, and, when used as an A.C. voltmeter, will measure a voltage as low as 0.025 volt r.m.s. with a fair degree of accuracy.

Since the gain of the amplifier and the correct working of the logarithmic stage are, at least to some extent, related to the correct voltages of the supplies, it might be supposed that but a little variation in these would completely upset the performance of the instrument. Actually this is not the case. A variation of ±4 per cent. in the high tension and ± 5 per cent. in the low tension supply, *after* routine calibration has been carried out, gives rise to a maximum error in the meter reading of 1.7 and 2.5 decibels respectively. These errors occur at the lower end of the meter scale.

As, however, the instrument is likely to be in use for only two or three hours at a time, these comparatively large errors and variations in the supply voltages are not to be expected in practice.

Providing routine calibration is carried out under the actual conditions of operation, the supply voltages may differ from their correct value by as much as 5 per cent. without causing serious discrepancies. This is the state of affairs usually encountered in practice.

It has been mentioned that the milliammeter is critically damped.

Practical experience has shown that it is very tiring to control by a meter that responds to more than four variations of programme level per second. What is really required, then, is a meter which responds to changes in level occurring at frequencies up to 4 c/s but gives a steady mean reading for more rapid variations. Alternatively, a low pass filter having a cut-off frequency of 4 c/s together with a meter having a flat response up to any frequency higher than this could theoretically be used. A low pass filter of this nature may not be considered in practice on account of the bulk and cost.

Most direct current milliammeters on the market will respond to higher frequencies than 4 c/s and, furthermore, tend to overswing when a sudden impulse is applied to them.

The difficulty can be overcome by making the movement of the meter as light as possible and by applying electrical damping to the meter. This is effected in the programme meter described by shunting the meter with a low resistance, the meter actually being a 0 — 1 milliammeter shunted to read 0 — 2 milliamps for full scale deflection.

An alternative procedure is to smooth the circuit previous to the logarithmic stage. This is readily accomplished by connecting a condenser of about 2 microfarads capacity across the diode load resistance R_1.

It is not possible, however, to discuss the merits of these two alternative circuits in the present article.

Although the instrument so far described was designed as a programme meter for outside broadcast use, the principles involved may be, and indeed have been, employed in other connections.

It may be used in conjunction with a microphone and amplifier to measure the intensity of industrial and traffic noises. Its use for obtaining a direct reading of the frequency characteristics in decibels of other apparatus is obvious.

As the instrument is essentially a voltage operated device it is arranged that the minimum input impedance is not less than 5,500 ohms. Thus no appreciable diminution in level will result by connecting the programme meter at any point where the impedance, across which the voltage is to be measured, does not exceed 600 ohms.

In conclusion, the authors express their thanks to various members of the engineering staff for assistance given in the work described in this article.

The Industry

THE Dubilier " Radio Engineering Catalogue " (No. 835) is now available. This publication is especially intended for designers, technicians and manufacturers.

To cope with the growing demand for special batteries sutable for use in " midget " receivers, a series of miniature Drydex HT batteries with voltages between 18 and 75 are now being produced.

Small and inexpensive electric furnaces suitable for laboratory work are described in a catalogue issued by Wild-Barfield Electric Furnaces, Ltd., Elecfurn Works, North Road, Holloway, N.7.

To cope with developments in marine and geophysical apparatus, Burne-Jones & Co., Ltd., have moved into more modern premises at 309/317, Borough High Street, London, S.E.1.

An important catalogue of Electrical Standards for research and industry has just been produced by H. W. Sullivan, Ltd., and copies are available to readers of *The Wireless Engineer*.

The Detector Input Circuit*

By W. T. Cocking

THE practice of operating a diode detector at a large input is receiving considerable attention, for under such conditions the detector is almost perfectly linear and but little low-frequency amplification is necessary. Moreover, a large detector input is advantageous in assisting the design of a satisfactory and simple A.V.C. system. It is quite feasible to drive a large output stage directly from a diode detector with resistance capacity coupling, and in theory it is even possible to operate a loud speaker directly from the detector. Such a course, however, is practically uneconomical, for to obtain a given volume of sound from the loud speaker, the power dissipated in the valve preceding the detector must be four times that which is needed for the same volume with a conventional low-frequency output stage. This assumes a perfect detector and no losses in the coupling.

In practice no one wishes to go to this extreme. The desire to avoid amplification between the detector and the output stage is fairly common, however, and the attempt often leads to difficulties in the preceding stage. Let us consider first the arrangement of Fig. 1, in which a pentode or tetrode valve feeds a tuned circuit of dynamic resistance R_D through a transformer of ratio $1 - n_1$, and this in turn feeds a detector of input resistance R through a ratio of $1 - n_2$. The effective dynamic resistance of the tuned circuit becomes

$$\frac{R_D R/n_2^2}{R_D + R/n_2^2}$$

and the load on V_1 is

$$\frac{R_D R/n_1^2 n_2^2}{R_D + R/n_2^2}$$

and when this is small compared with the A.C. resistance of V_1, the voltage E applied to the detector becomes

$$E = \frac{egR_D R/n_1 n_2}{R_D + R/n_2^2}$$

where e is the voltage applied to the grid of V_1 and g is its mutual conductance. There is obviously no optimum value for n_1, the value of E increasing as n_1 decreases. We cannot normally employ a value of n_1 much smaller than unity without running into serious trouble through the self-capacity of the primary winding, so let us say $n_1 = 1$. Then

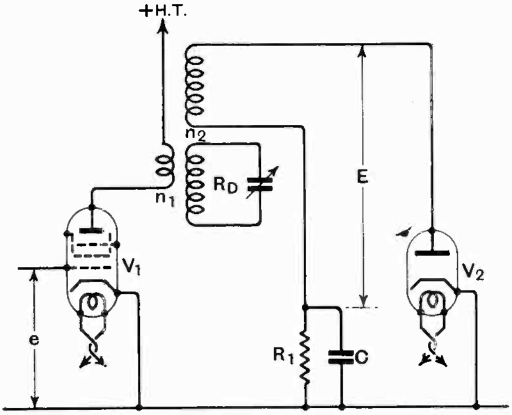


Fig. 1.

$$E = \frac{egRR_D}{n_2 R_D + R/n_2}$$

The denominator is a maximum when $n_2 R_D = R/n_2$, and we then have

$$E = \frac{egR^2/n_2^2}{2R/n_2} = \frac{egR}{2n_2}$$

$$= \frac{eg\sqrt{RR_D}}{2}$$

For a given value of operating voltage, the maximum value of e which can be handled by V_1 without distortion is a constant depending only on its static characteristics, for the load on the valve is assumed always to be low enough for this to be true. The voltage available for operating the detector, therefore, depends on the dynamic resistance of the tuned circuit and upon the input resistance of the detector. The voltage is

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

in fact directly proportional to the square root of either.

Now let us consider the case of a push-pull detector as shown in Fig. 2, and let the total input resistance across the tertiary winding become R'. Writing E' for the total detector input we find by a similar argument to before

$$E' = \frac{eg\sqrt{R'R_D}}{2}$$

If R_1 has the same value for both single and push-pull detectors, $R' = 2R$, so that

$$E' = \frac{eg\sqrt{RR_D}}{2} \times \sqrt{2}$$

$$E' = \sqrt{2}E$$

The use of the push-pull connection, therefore, enables us to obtain $\sqrt{2}$ times the total detector input owing to the higher total input resistance of the detector. For a given input, however, the output of a push-pull detector is one-half of that from a single diode, so that for the same input to V_1 in the two cases, and adjusting the value of n_2 suitably, we obtain $1/\sqrt{2}$ times the detector output with push-pull. There is, however, one alleviating circumstance. The by-pass condenser C of Fig. 1 need not be used with push-pull and we can then increase R_1 appreciably and so obtain a higher detector input resistance. C_1 is usually of the order of 100 $\mu\mu$F effective value, and in push-pull the stray capacities may total 10–20 $\mu\mu$F., so that R_1 can be increased from 5 to 10 times for the same degree of frequency distortion. Assume that it can be increased by 8 times, the input impedance of the detector is 16 times as great as that of a single diode, so that $R' = 16\,R$

so that $$E' = \frac{eg\sqrt{RR_D}}{2} \times 4$$

The total input voltage is four times that with a single valve, and the rectified output is consequently double. The use of push-pull is thus amply justified in this case. For equal outputs from the two detector systems, the H.F. input must be twice as great for the push-pull detector as for a single diode. If the load resistance R_1 for push-pull be made twice that for one detector, however, the input resistance is four times as large and as shown by the preceding equations the tuned circuit conditions are so changed that the gain of the preceding stage of amplification is doubled. Thus when the load resistance of the push-pull detector is twice that of a single diode, the ratio of detector L.F. output to H.F. valve carrier input is the same for both types of detector. As this condition can always be met in practice owing to the possibility of reducing the value of C or eliminating it altogether, we can conclude that push-pull detection offers considerable advantage over the single valve circuit where a large output is required.

The tetrode or pentode, however, is not necessarily the best valve to employ preceding the detector, for at large detector inputs an appreciable amount of power is needed. A neutralised triode, or a pair of triodes employed in the scheme described by Colebrook[1] is often more suitable, therefore.

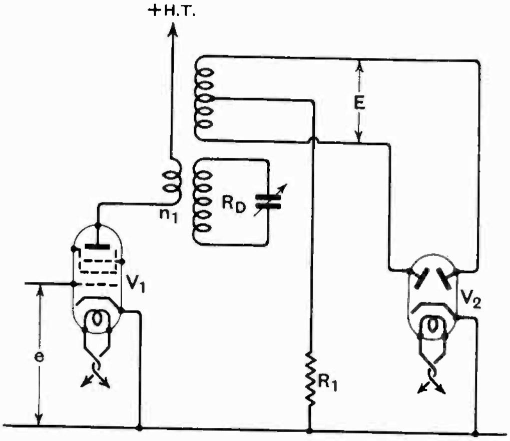

Fig. 2.

The essential circuit connections remain as in Figs. 1 and 2 save that V_1 is now a triode. Its internal resistance is important and its load cannot be neglected. As before the load on V_1 is

$$\frac{RR_D/n_1^2n_2^2}{R_D + R/n_2^2}$$

and $$E = \frac{e\mu RR_D/n_1n_2}{R_a(R_D + R/n_2^2) + RR_D/n_1^2n_2^2}$$

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[1] A Study of the Possibilities of Radio-Frequency Voltage Amplification with Screen-Grid and with Triode Valves, by F. M. Colebrook, *J.I.E.E.*, vol. 74, pp. 187–198.

There is no optimum value for n_1 and n_2, although if either be fixed from some other consideration an optimum for the other can be found. This has already been pointed out by Colebrook[2] and is clearly seen when it is remembered that the function of the tuned circuit is merely to couple the primary and tertiary circuits, and although it does this, it introduces a loss which is very appreciable if a circuit of high dynamic resistance is not used.

For maximum voltage amplification with a triode valve, it is well known that the load on the valve should equal its internal resistance, and this is also the condition for maximum power output if no regard be paid to distortion. For maximum power output at a given degree of distortion, the load must be higher. The conditions are similar to those existing in an output valve, for the detector is essentially a power-operated device, and it is well known that the load should be about twice to three times the valve resistance under normal conditions. The relation varies considerably with different valves, particularly with those capable of a large output. Considering small triodes of the ML4, MHL4, and MH4 type, however, the maximum output is obtained when the load is about twice the valve resistance. For present purposes, therefore, we can write

$$2R_a = \frac{RR_D/n_1^2n_2^2}{R_D + R/n_2^2}$$

and $$E = 0.6\, e\mu n_1 n_2$$

where $$n_1 = \sqrt{\frac{RR_D}{2R_a n_2^2(R_D + R/n_2^2)}}$$

If we take $n_2 = 1$

$$n_1 = \sqrt{\frac{RR_D}{2R_a(R + R_D)}}$$

and $$E = \frac{0.6\, e\mu\sqrt{RR_D}}{\sqrt{2R_a(R + R_D)}}$$

If $n_2 < 1$ the value of E is smaller and we cannot normally use a larger value than unity for n_2 on account of the self-capacity of the winding.

If we write $n_1 = 1$

$$E = 0.6\, e\mu n_2$$

$$n_2 = \sqrt{\frac{R(R_D - 2R_a)}{2R_aR_D}}$$

$$E = \frac{0.6\, e\mu\sqrt{R(R_D - 2R_a)}}{\sqrt{2R_aR_D}}$$

It is not possible to fulfil the conditions unless $R_D > 2R_a$, but if this relation is kept there is no difference in the value of E obtained in the two different ways. Thus for the greatest output we can make $n_1 = 1$ and choose the optimum value of n_2 or make $n_2 = 1$ and choose the best ratio of n_1. In general, however, it is more convenient to make $n_2 = 1$.

With a push-pull detector, the detector input resistance $R' = 2R$ for the same values of load resistance R_1, so that when $n_2 = 1$

$$E' = \frac{0.6\, e\mu\sqrt{R'R_D}}{\sqrt{2R_a(R' + R_D)}}$$
$$= \frac{0.6\, e\mu\sqrt{2RR_D}}{\sqrt{2R_a(2R + R_D)}}$$

The condition for equality of output from single and push-pull detectors is obtained when $E' = 2E$ or

$$\frac{R'}{R' + R_D} = \frac{4R}{R + R_D}$$

whence $$R' = \frac{4RR_D}{R_D - 3R}$$

to which there is no general solution involving R' and R only.

When $R_D = \infty$, $R' = 4R$ as in the case when V_1 is of infinite internal resistance, but with finite values of R_D the increase of input resistance for equality between the two systems must be greater. A common value for both R and R_D is 125,000 Ω, and for equality $R' = -1\ M\Omega$. In other words, the detector input resistance with push-pull must be negative, which is impossible. Equality, therefore, cannot be achieved and the push-pull circuit is inferior to the single valve. It can be seen that this must always be the case unless $R_D > 3R$, and with $R = 125{,}000\ \Omega$ this means that the dynamic resistance of the tuned circuit alone must be greater than 375,000 Ω. Normally, it is only in the intermediate frequency circuits

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[2] The Detector as a Radio-Frequency Load, by F. M. Colebrook, *The Wireless World*, Feb. 22nd, 1935.

of a superheterodyne that such a high dynamic resistance is possible, and it is not unduly difficult to obtain it at 110 kc/s and within the bounds of possibility at 465 kc/s.

Let us take, therefore, $R = 125{,}000\ \Omega$ and $R_D = 0.5\ M\Omega$. We then have $R' = 2\ M\Omega$. The load resistance R_1, therefore, must be $2\ M\Omega$ as compared with $0.25\ M\Omega$ for the single detector, and this represents about the greatest possible increase if distortion is to be avoided. There is then nothing to choose between the two systems and the push-pull system cannot be made to give a larger output than the single detector unless R' can still further be increased. It is clear, therefore, that while it may be advantageous to employ a push-pull diode detector when it is fed from a pentode or tetrode valve, it is usually inadvisable to do so when a triode is used. The formulæ clearly show the wisdom of using a tuned circuit of high dynamic resistance, whatever type of valve be used before the detector. One is often tempted to use a poor coil at this point, for it is usually heavily damped by the detector and so contributes little to selectivity. A poor coil, however, will seriously limit the maximum undistorted detector input which can be obtained. The input required is greater than is often realised and if the detector efficiency be 90 per cent. the maximum peak input V during 80 per cent. modulation for a given output v (peak) across the load resistance is for a single detector

$$V = \frac{1.8\ v}{0.8 \times 0.9} = 2.5\ v.$$

and with push-pull $V' = 5\ v$.

The R.M.S. carrier voltages involved are, of course, much less.

One of the commonest arrangements used in a superheterodyne is a pair of coupled circuits between a pentode I.F. valve and a diode detector, as shown in Fig. 3, and it is consequently important to determine the conditions for this form of coupling. Assuming that the two tuned circuits are identical so that we can write R_D for the dynamic resistance of either, and that $R_D << R_a$, we have

$$E = \frac{eg}{2} \times \sqrt{R_D} \times \sqrt{\frac{RR_D}{R + R_D}}$$

provided that the coupling between the circuits is optimum, that is

$$\omega^2 M^2 = \omega^4 L^4 (R_D + R)/RR_D{}^2$$

where L = primary = secondary inductance.

For the push-pull case, we have

$$E' = \frac{eg}{2} \times \sqrt{R_D} \times \sqrt{\frac{R'R_D}{R' + R_D}}$$

and equality between the two is reached when

$$E' = 2E$$

or
$$\frac{R'}{R' + R_D} = \frac{4R}{R + R_D}$$

therefore $R' = \dfrac{4RR_D}{R_D - 3R}$ which is the same result as in the case of a triode valve already investigated. The conclusion there reached regarding the relative advantages of push-pull and plain detectors thus apply here also.

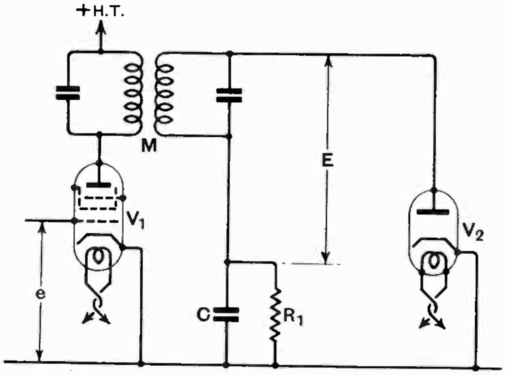

Fig. 3.

Comparing the single tuned and coupled tuned circuits as regards detector input with a pentode and writing E_1 for the former and E_2 for the latter, we find

$$\frac{E_1}{E_2} = \frac{\sqrt{R + R_D}}{\sqrt{R_D}} = \sqrt{1 + R/R_D}$$

Thus the single circuit coupling enables a larger detector input to be obtained and the disparity is greater with a high ratio of detector input resistance to dynamic resistance than with a low.

We can, therefore, draw the following conclusions which apply to cases where it is desired to obtain the largest possible detector output for a given input to the valve preceding the detector, that input being limited only by considerations of overloading.

For pentode and tetrode I.F. stages :

(1) A push-pull detector is better than a single one provided that the detector load resistance can be made more than twice as great as the value used for one detector, a single tuned circuit be used for the interstage coupling, the detector load be adjusted to the optimum by means of a suitable secondary winding, and this secondary is possible in practice.

(2) Where two tuned circuits coupled with optimum coupling are employed, a single detector is preferable to push-pull.

For a triode I.F. stage :

(3) With normal circuit values, a single detector is better than push-pull, but there are exceptional cases where the latter may give a slightly larger output.

It should be remarked, however, that even in the one case where push-pull detection is definitely superior to the single detector circumstances may not always permit it to be used. Owing to the higher input resistance of the detector a different ratio is needed in the feeding transformer and the analysis given in this article assumes that any ratio can be used. If the ratio with a single detector be n_2, then for equality between the two systems the ratio for push-pull $n_2' = 2n_2$. It will usually be difficult to make n'_2 greater than unity, on account of the self-capacity of the secondary which will begin to play an important part and will tend to turn the system into one embodying a pair of coupled tuned circuits. The argument only holds, therefore, for cases in which the secondary winding for a single detector has less than half the turns of the tuned coil, or $R/R_D < 0.25$. The dynamic resistance of the tuned circuit must be more than four times the detector input resistance (one valve) for push-pull to have any advantage, and this necessitates a very good coil and condenser.

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.

Frequency and Phase Distortion

To the Editor, The Wireless Engineer

SIR,—Referring to Mr. T. Tanasescu's letter in your September issue, commenting on my article, "Frequency and Phase Distortion," I should like to point out that, contrary to Mr. T. Tanasescu's contention, the method described in the article referred to, compensates also for frequency distortion due to the fact that self-induction and effective resistance are not constant in practice, but vary with frequency.

I beg to call Mr. T. Tanasescu's attention to page 377, where this is indeed fully demonstrated.

Bucharest. M. MARINESCO

Resonant Functions

To the Editor, The Wireless Engineer

SIR,—*The Wireless Engineer*, Vol. XII, Nr. 143, August, 1935, contains an article called "Resonant Functions," by W. Baggally. This article describes a kind of reactance transformation, which is a special branch of the well-known "frequency transformations," published by me in the following articles :

"Théorie et application pratique des demi-cellules à trois branches pour filtres électriques," Ericsson Technics, Nr. 5, 1934, appearing in print on the 9th October, 1934.

"Transformation fréquentielle des lignes artificielles correctrices d'affaiblissement," Ericsson Technics, Nr. 2, 1935, appeared in print on the 9th of April, 1935. Swedish Patent Nr. 83923. Convention date, 17th of November, 1933.

As the frequency transformations present many interesting possibilities and great practical values, which do not appear from Baggally's article, I should be very thankful if you would kindly attract attention to these articles in *The Wireless Engineer*.

L. M. Ericcson, TORBEN LAURENT,
Stockholm. Dr. of Technology.

Contrast Expansion

To the Editor, The Wireless Engineer.

SIR,—It will be acknowledged that the problem of practical contrast expansion is likely to engage the immediate attention of many wireless engineers. Exactly how near the ultimate form will approach the original one would not dare to prophesy except to hope that a critical musician may be satisfied with a perfect illusion.

Much is expected from the sound portion of ultra short wave television transmissions in that they make practically possible for the first time the emission of a full frequency band. Also an adjacent band is reserved for picture frequencies, but it is hardly likely that there will be enough material to occupy the latter for more than a few hours a day.

It has been pointed out that power would be saved if a programme were radiated at a constant percentage modulation and that the whole average level were automatically adjusted to this. Here now is a use for the idle transmitter, it can give the reciprocal of the arrangement which levels the first broadcast and leave it to reception designers to utilise part of the idle television receiver for a *level control* arranged, within certain limits, to give a very full contrast expansion ; further, a way would seem to be indicated towards a solution of the companion problem of tone control where as in the usual case the intensity level of the reproducer is not the same as the original.

This suggestion could hardly be made without regard to a number of attendant difficulties but it might appear that experimental transmission on these lines is warranted. GERALD SAYERS.

Ware, Herts.

International Electrotechnical Commission

WE have been asked by the Secretary of the Commission to draw the attention of our readers to the following notice. This we do very readily for it is a matter which cannot fail to interest all who are concerned with electromagnetic units and measurements. The statement deals with two different features of the Giorgi system. One is concerned with the magnitudes of the three fundamental units C, G and S, whilst the other is concerned with the introduction of a fourth fundamental unit. A centimetre and a gramme are no more fundamental than a metre and a kilogramme ; in fact, they are really less fundamental, because the latter are represented by the actual concrete standards maintained in France, and these are the real fundamental units and not something which they are, or were, supposed to represent. Giorgi showed 34 years ago that by taking the metre, kilogramme and second as the fundamental absolute units, the practical electric units are obtained directly without any 10^7, 10^8 or 10^9. His other suggestion is that a fourth fundamental unit should be adopted of an electrical nature, such as a quantity of electricity or a resistance. The confusion of having two systems of units, the electromagnetic and the electrostatic, in one of which resistance has the dimensions of a velocity, whereas in the other it has the dimensions of the reciprocal of a velocity, arises from the assumption that everything in nature, including electric and magnetic phenomena must be expressible in terms of L, M and T. To do this, some assumption has to be made, and different assumptions lead to different systems of units. Giorgi's system avoids these assumptions and the resulting confusion, but a paper read at the recent meeting of the British Association by Sir J. B. Henderson shows that there are those who would prefer to abolish the electrostatic system and regard the assumption on which the electromagnetic system is based as a recognised fact, *viz.*, that the magnetic induction or flux density in space is not merely caused by the magnetising force or ampere-turns per con, but that they are both one and the same thing, viewed perhaps from different standpoints.

Actions of the I.E.C. at the June, 1935, Meetings in The Hague and Brussels Concerning Electrical Units

Up to this time (June, 1935) science has employed the c.g.s. systems of physical units. Electrical units have been established in the c.g.s. system on the electrostatic and electro-magnetic schemes of Maxwell. There have been also published numerous papers employing electrical units departing in some measure from the classical c.g.s. systems.

The International Electrical Congresses including the International Electrotechnical Commission (I.E.C.) have adopted at various dates since 1881 certain so-called practical electrical units, ohm, volt, ampere, farad, coulomb, henry, joule, watt and weber ; these did not form an independent system, but were all based upon and defined from the c.g.s. electro-magnetic units, through numerical factors (10^9, 10^8, 10^{-1}, 10^9, 10^{-1}, 10^9, 10^7, 10^7, and 10^8 respectively).

As a result of the decisions taken at the I.E.C. meetings just past, all these practical units, without being in any way altered, become connected into a new coherent and absolute system based upon the proposals of Prof. Giorgi, first published in 1901. The system is known as the Giorgi-MKS (Metric, Kilogram-mass, Second) system. In this system the above-mentioned practical units are essential constituent elements in one to one relation, so that the conversion factors above-mentioned need no longer be learned and memorised by students.

The Giorgi system :—

(*a*) is essentially composed of units already in practical use,

(*b*) avoids the need for the complicated dimensional formulæ with fractional exponents,

(*c*) recognises the need for a fourth fundamental unit, to be selected from the existing practical electrical units,

(d) leaves the C.G.S. systems and all systems used by physicists undisturbed. All these systems may be explained simply in terms of the new system,

(*e*) it permits the use of either " rationalised " or " unrationalised " formulæ.

For the present, the I.E.C. has avoided a decision on the question of " rationalisation," thus leaving each author free to use the formulæ which he prefers.

In addition to the above-mentioned decision on the adoption of the Giorgi system, three derived units were pointed out by way of example. These were—

(*a*) the unit of electric gradient, the volt per metre,

(*b*) the unit of magnetic flux density, the weber per square metre,

(*c*) the unit of volume energy, the joule per cubic metre.

The I.E.C. meeting decided to endorse the I.E.C. Oslo convention of 1930 that the permeability of vacuum/u_0 be retained in magnetic formulæ as a physical quantity and not as a mere numeric. This is a fundamental part of the Giorgi System.

It was decided by the I.E.C. that the system be known as the " Giorgi System."

25 June, 1935.

A Trigger Peak Voltmeter Using "Hard" Valves*

By A. T. Starr, M.A., Ph.D., A.M.I.E.E.

Introduction

IT is clear that any arrangement, that triggers at a certain voltage and has a finite back-lash, can be used for the measurement of peak voltage. There are two well-known devices that trigger and have a satisfactory back-lash, viz., the neon lamp and the thyratron; they, therefore, form the basis of some recent peak voltmeters. The author experimented with a neon trigger peak voltmeter some years ago and decided that the characteristics were undesirably variable. The thyratron was considered, but it was a new valve, very expensive, and the types available (in 1932) unsuitable. Moreover, both the neon lamp and the thyratron possess an appreciable time lag, which render them useless for pulses of duration less than one-tenth of a millisecond.

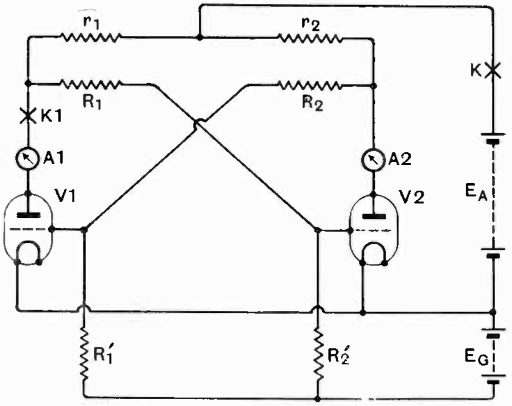

Fig. 1.

It is clear that a trigger device without an appreciable time lag is a very valuable tool, and there happens to be such a device which is not as well known as it should be. This paper describes this device and shows how a most satisfactory peak voltmeter can be made with its help. Incidentally it is so reliable and cheap as to render the thyratron peak voltmeter an unnecessary luxury, even though the thyratron is now cheaper than it was two years ago and there are more types available.

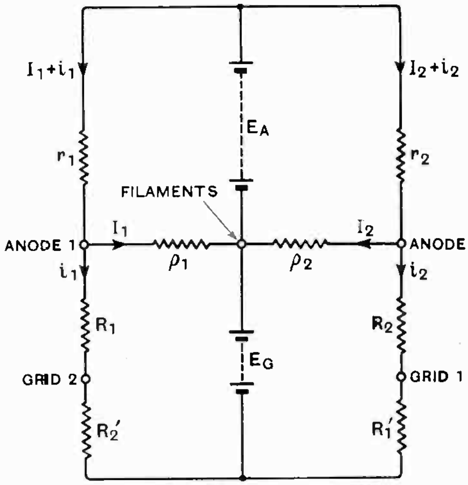

Fig. 2.

The Trigger Device

Fig. 1 shows the essential parts of the device, and it is seen that it is the dead-beat form of the multivibrator. V1 and V2 are "hard" triodes; in the first experimental form they were PM2's.

It will be shown that, if the resistances r_1, r_2, R_1, R_2, R_1' and R_2' and the batteries E_A and E_G have suitable values, there are two stable positions of the system. In one position V1 takes anode current and V2 takes none or very little, in the other V2 takes anode current and V1 none or very little.

Let the valves have anode-filament resistances ρ_1 and ρ_2, and suppose that neither has grid current; this latter condition can be obtained but it is not essential for the operation and the explanation is simplified

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

by this assumption. Fig. 2 represents the circuit. I_1 and I_2 are the anode currents and i_1 and i_2 the currents through R_1 and R_2', R_2 and R_1', respectively. The equations for the left-hand side of the circuit are

$$I_1(r_1 + \rho_1) + i_1 r_1 = E_A,$$

$$I_1 r_1 + i_1(r_1 + R_1 + R_2') = E_A + E_G,$$

and $$E_{G2} = - E_G + i_1 R_2',$$

where E_{G2} is the grid potential of valve 2. Eliminating i_1 from these equations we obtain

$$I_1(\rho_1 + r_1') = E_1 \qquad \ldots \quad \ldots \quad (1.1)$$

and $$E_{G2} = e_1 - r_1'' I_1, \qquad \ldots \quad \ldots \quad (2.1)$$

$$\left.\begin{aligned} &\text{where } r_1' = r_1(R_1 + R_2')/(r_1 + R_1' + R_2'), \\ &E_1 = E_A \frac{R_1 + R_2'}{r_1 + R_1 + R_2'} - E_G \frac{r_1}{r_1 + R_1 + R_2'}, \\ &e_1 = \frac{E_A R_2' - E_G(r_1 + R_1)}{r_1 + R_1 + R_2'}, \\ &\text{and } r_1'' = r_1 R_2'/(r_1 + R_1 + R_2') \end{aligned}\right\} \qquad \ldots \quad \ldots \quad (3.1)$$

We obtain similarly

$$I_2(\rho_2 + r_2') = E_2 \qquad \ldots \quad \ldots \quad (1.2)$$

and $$E_{G1} = e_2 - r_2'' I_2, \qquad \ldots \quad \ldots \quad (2.2)$$

where r_2', E_2, e_2 and r_2'' are obtained from equations (3.1) by replacing 1 by 2 and 2 by 1.

It follows from equation (1.1) that the current I_1 in V1 is that which flows when an anode voltage E_1 acts in series with a resistance r_1', the grid voltage being the actual voltage E_{G1}. The physical meanings of E_1 and r_1' are seen from their algebraic forms in equations (3.1); E_1 is the voltage between the anode and filament of V1 when ρ_1 is infinite, and r_1' is the parallel combination of r_1 and $R_1 + R_2'$. In fact, equation (1.1) expresses Thévénin's Theorem* for the circuit external to V1, E_1 and r_1' being the open-circuit E.M.F. and resistance.

e_1 is the grid bias of V2 when I_1 is zero and e_2 that of V1 when I_2 is zero.

In order to give some idea of the quantities involved, it may be said that in the practical arrangement E_A and E_G are nearly equal (about 60 volts), r_1 and r_2 are of the order of 6,000 to 10,000 ohms, and R_1, R_2, R_1' and R_2' of the order of a hundred thousand ohms. It follows from equations (3.1) and the unstated set (3.2), that r_1' and r_2' are nearly equal to r_1 and r_2 and are constant, E_1 and E_2 are constant and nearly equal to E_A, whilst r_1'' and r_2'' are nearly equal to $\frac{1}{2} r_1$ and $\frac{1}{2} r_2$ respectively. The voltages e_1 and e_2 are constant for a given arrangement and may be positive or negative. These approximations are not used in what follows.

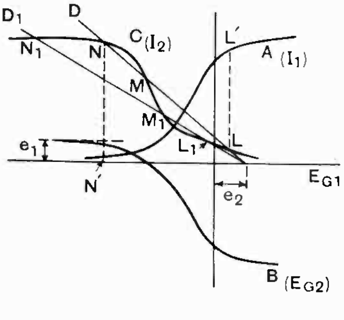

Fig. 3.

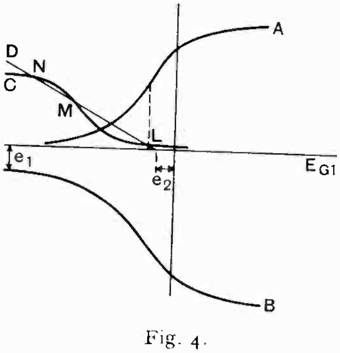

Fig. 4.

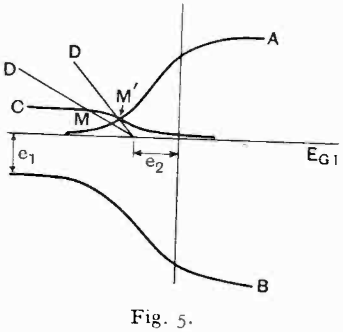

Fig. 5.

In Fig. 3, curve A represents the anode current, I_1, in V1, with E_{G1} as abscissa; by what has been said above the value of I_1 is that in the valve produced by a voltage E_1 acting in series with the resistance r_1' so that equation (1.1) is satisfied. Equation (2.1) shows how E_{G2} varies with I_1 and thus with E_{G1}; curve B represents E_{G2} *vs* E_{G1}, as calculated by this method, assuming that e_1 is positive. Curve B has the same shape as curve A, but is inverted. Curve C represents the anode current in V2 with an anode voltage E_2 acting in series with a resistance r_2'' (so that (1.2) is satisfied) and

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* See "Electric Circuits and Wave Filters," by the author, page 78.

for the grid-bias values of E_{G2} as given on the curve B. Finally the straight line D represents equation (2.2). The positions of equilibrium of the system are given by the intersections of curves C and D, since both represent the values of I_2 against E_{G1}. It is easy to see that the position given by the point M is unstable and those by points L and N are stable. At L, I_2 is small and I_1 (point L′) is large, whilst at N I_2 is large and I_1 is small. In the case shown V1 takes grid current in the former case, but this is not necessarily the case even when e_2 is positive. Thus if the resistance r_2'' were such that the line represented by (2.2) were the line D_1, the equilibrium position denoted by L_1 would be such that neither valve takes any appreciable grid current.

Fig. 4 shows a case of suitable arrangement when e_1 and e_2 are both negative. No grid current flows at any time. It is possible to have suitable arrangements with e_1 and e_2 positive or negative in any combination, and grid current may or may not flow at any stage according to the values of r_1'' and r_2''; but, as shown, no grid current will flow at any stage if both e_1 and e_2 are negative.

Fig. 5 explains an unexpected result that was discovered in the experimental work. The trigger effect is curiously sensitive to certain variations in E_A and E_G under some conditions. A symmetrical arrangement was used in which $r_1 = r_2$, etc. It was found that the trigger effect was unaffected by large variations in E_A and E_G, provided E_A was greater than E_G, but the action became blurred and both valves took nearly equal currents when E_G was greater than E_A. In the arrangement the valves were PM2's, and the resistances had the values $r_1 = r_2 = 6{,}000$ ohms, $R_1 = R_2 = R_1' = R_2' = 100{,}000$ ohms. Satisfactory triggering occurred for $E_A = 60$ volts and $E_G = 60$, $E_A = 62$ and $E_G = 59$, and $E_A = 72$ and $E_G = 60$: no triggering occurred for $E_A = 59$ and $E_G = 62$. (It may be mentioned, as a matter of interest, that there was no grid current in the first two successful arrangements, but there was in the third.) The explanation is that when e_1 and e_2 are negative and large enough the line D may lie under the curve C, as shown in Fig. 5, so that there is only one position of equilibrium given by M. When the system is symmetrical, the line is D′ and the point M′ so that $I_1 = I_2$.

The Trigger Effect

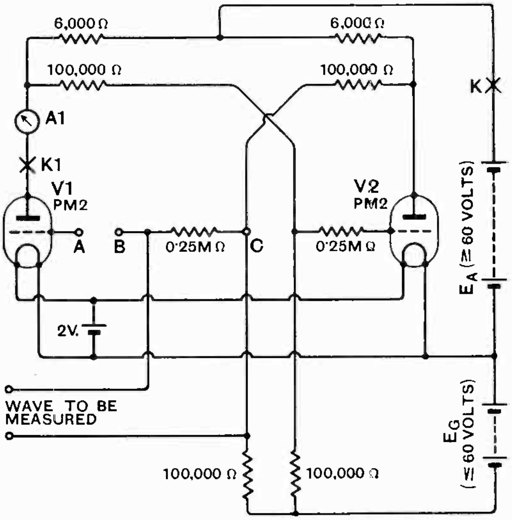
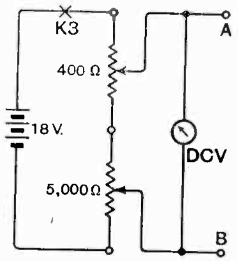


Fig. 6.

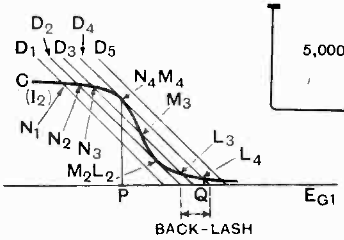
Fig. 6 shows a symmetrical form of the trigger peak voltmeter. K and K1 are make or break keys and A1 a milliammeter which measures the current through V1. Let us ignore the wave to be measured; a variable grid voltage can be inserted between A and B. Suppose that the arrangement is such that the curves for I_1 and I_2 are given by curves A and C in Fig. 4, I_2 being reproduced in Fig. 7. Varying the grid bias between the points A and B in Fig. 6 has the effect of moving the line D (which represents the curve I_2 *vs* E_{G1}) parallel to itself. Suppose that the bias applied is large and negative, then the line becomes D_1, and the position of equilibrium is represented by N_1 at which I_1 is small and I_2 has a normal value. As this bias is increased (algebraically) the line becomes D_2, and then there is a stable position of equilibrium represented by N_2 and a neutral position by L_2M_2. A further increase shifts the line to D_3, at which there are the stable positions L_3 and N_3 and the unstable position M_3. The position N_3 will be maintained unless a surge occurs which shifts D further to the right; but this will be described as we proceed. A further increase of bias shifts the line to D_4, at which there is the neutral position M_4N_4 and the stable position L_4. The slightest further increase shifts the line to D_5, at which there is only one position of equilibrium (stable, of course). Thus when the system is biased to the condition represented by the line D_4, the slightest increase causes a triggering, in which the current I_2 falls from the value PM_4 to the small value QL_4; the current I_1 jumps simultaneously from a small value (comparable with QL_4) to a high value (comparable with PM_4).

If the bias is now reduced, I_2 does not recover its large value until the line passes the position D_2. The horizontal distance between D_2 and D_4 on the axis of E_{G1} represents the finite back-lash.

Suppose the line is in the position D_3, having come from the triggered position D_5, I_1 will have its large value and the equilibrium position is indicated by L_3. For the purpose of triggering we want the position to be N_3, which can be reached in two ways. We can either decrease the bias between A and B to a sufficiently large value, or we can break the anode circuit of V1 by means of the key K1 and then remake the circuit. The first method is not generally desirable as it may require a large bias battery; the second method is quick and convenient, especially if the key is a depress-break release-make key, when a single push shifts the equilibrium position from L_3 to N_3.



(*Right*) Fig. 8.



(*Below*) Fig. 7.

Use of the Trigger Device as a Peak Voltmeter

Fig. 6 shows the device and Fig. 8 shows a simple arrangement for supplying the grid of V1 with a variable bias. The terminals, to which the wave to be measured is applied, are shorted, the bias between A and B is reduced to the algebraic minimum, and the system is triggered to the position N_3 by a push of K1. (The battery in Fig. 8 is not sufficient to shift the line to the left of D_2.) The bias is then increased until the system triggers and the moving-coil voltmeter, DCV, gives the value of the bias required, v_1 say. This is the zero measurement of the system, *i.e.*, the bias voltage required for triggering with zero applied wave. The bias is reduced to the minimum and the system switched back to position N_3 by means of K1. The wave terminals are unshorted and the wave applied. Then the bias is increased until triggering occurs. Let the bias voltage now be v_2. Then $v_1 - v_2$ is the peak of the wave. A check measurement of v_1 may be made.

Actually it is found that the trigger voltage is extraordinarily definite and keeps constant over considerable intervals of time.

Practical Design

In order to calculate suitable values of E_A, E_G, r_1, r_2, R_1, R_2, R_1' and R_2' for a given type of valve, it is accurate enough to assume that I_1 or I_2 is zero in a stable position, although in practice the robbing action may not be complete. We will find a symmetrical arrangement in which $r_1 = r_2$, $R_1 = R_2 = R$, and $R_1' = R_2' = R'$. Let $I_2 = 0$. Equations (2.2) and (3.2) give

$$E_{G1} = e_2 = \frac{E_A R' - E_G(r + R)}{r + R + R'}$$

Equations (1.1), (2.1) and (3.1) give

$$E_{G2} = \frac{E_A R' - (R + r + Rr/\rho_1)E_G}{r + R + R' + r(R + R')/\rho_1}$$

It was decided to use PM2's and a convenient battery of 150 volts enables us to take $E_A = E_G = 60$ volts. There is sufficient spare voltage to allow for the natural decrease with time. It is found that when $r = 6{,}000\ \Omega$ and $R = R' = 100{,}000\ \Omega$, $E_{G1} = -1.8$ volts. The anode current and voltage of V1 are 4 mA and 36 volts, so that ρ_1 is about $9{,}000\ \Omega$. These values give $E_{G2} = -12.8$ volts and then $I_2 = 0$.

The practical arrangement with these

valves, batteries and resistances gave $I_1 = 3.8$ in A and $I_2 = 0.05$ mA in one stable position and $I_1 = 0.05$ mA and $I_2 = 3.8$ mA in the other. The valve with the larger anode current had a grid current of 0.5μA, and the other had none. The latter ensures that there is no error by a drop along the 0.25 MΩ.

It is impossible to get the case when I_1 and I_2 are equal to the normal value, but it is easy to start with $I_1 = I_2 = 0$ by opening K. It is then a matter of chance which valve takes the current when K is closed. As a matter of interest it may be stated that in twenty trials, one valve took the current eleven times and the other nine times; it may be noted also that no effort was made to choose carefully balanced valves for this test, but the resistances were balanced fairly well (within $\frac{1}{10}$ per cent. about). Another test was made with ammeters of approximately equal resistance but unequal inductance. A1 has an inductance of 8μH and A2 280μH. Then V1 always took the current. It was calculated that the time constant of the circuit of V2 was only $\frac{1}{10}$ microsecond, and it seems that this was long enough to let the quicker circuit rob the slower.

It is difficult to estimate the time of action of the circuit, but it is thought (see Knoll and Freundlich, quoted later) that the main lag is due to the time of charge or discharge of the grid-capacities. This time is greatly diminished by placing capacities of about $0.25\,\mu$F across R_1 and R_2. A quantitative analysis of this action and of the time of build-up of the anode current is being made.

The 5,000 Ω in Fig. 8 is a coarse adjusting potentiometer and the 400 Ω a fine adjusting. K3 is a make or break key, so that the 18V battery need not give current when the set is not in use.

RMS (Substandard).	Peak Calculated.	$v_1 - v_2$
0	0	0
36.1	0.269	0.27
59.0	0.418	0.41
119.5	0.845	0.84
145.7	1.026	1.02
176.5	1.246	1.24
206.5	1.48	1.44
227.8	1.61	1.58

Test of the Peak Voltmeter

To test the peak voltmeter, the mains voltage was put across a potentiometer, the output measured by a substandard A.C. voltmeter and stepped down by a volt-box of 200 : 1 ratio, and the peak was then measured by the trigger device.

The errors, which occur in the last two measurements, may have been as much in the substandard instrument as in the peak voltmeter. In fact, later tests seemed to confirm the opinion that the peak voltmeter is as accurate as the moving-coil voltmeter DCV, which was accurate within about $\frac{1}{2}$ per cent. The difficulty in obtaining a very accurate test is to obtain a supply with a harmonic content of less than 1 per cent.; for the RMS voltmeter will ignore completely a third harmonic of 1 per cent., whilst the trigger peak voltmeter will be affected by it, if the third harmonic is not zero at the moment when the fundamental passes through its maximum.

A Modification of the Circuit

It can be shown that the trigger voltage is increased if r_2 is increased, and so an unbalanced arrangement was employed with $r_1 = 6{,}000\ \Omega$ and $r_2 = 18{,}000\ \Omega$. With $E_A = 62$V and $E_G = 59$V, the trigger voltage is about 10V. Furthermore, if the voltage drops to about 4V, the system triggers back to V2; there is thus a back-lash of 6V. This system has the advantage that we can determine the back-lash very much more easily than in the balanced case, so that we may know whether the negative part of the wave is likely to cause a back trigger effect in each cycle. Unless the back trigger occurs very early after the forward trigger it is of no importance. What will happen then is that, to begin with, V2 will have all the current and V1 none, but when the trigger voltage is reached both will have current at different parts of the cycle. The ammeter A1 will register, however. If the back trigger occurs too early, A1 will read only a small current, which may be mistaken for its residual value.

In practice, this should not catch us unawares. For if we suspect a large negative peak soon after the positive peak, we reverse the wave and measure the negative peak and know what to expect. Suppose, for instance, that the positive peak is 2V and the negative is 9V, we need a back-lash of 11V to avoid difficulties. As we have only 6V back-lash at our disposal, we apply only half of the wave voltage (by means of a high resistance potentiometer) and all difficulties are avoided.

We can increase the back-lash by making $E_A = 75$V and $E_G = 60$V, when $v_1 = 12.4$V and the back-lash is 8.1V.

The sensitivity of the voltmeter is limited, not in the least by the suddenness of the trigger effect, but by the fineness of the potentiometer and the sensitivity of the moving-coil voltmeter DCV. As we do not wish to vary the bias the full 12.4V, it is sufficient that DCV have a full scale deflection corresponding to about 7 volts. We achieve this by the use of a grid-bias system of the form shown in Fig. 9, in which 6 volts of the grid bias are outside the voltage measurement. This external voltage should not vary during the measurement, as these batteries give no current at all. A check test of v_1 will verify this in practical measurements.

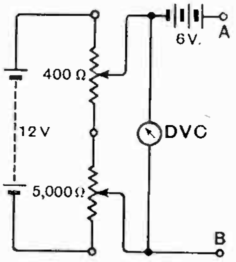


Fig. 9.

Advantages of the Trigger Peak Voltmeter

Cheapness and the extraordinarily clean character of the trigger effect are two of the most striking advantages. Furthermore, the absence of time lag in " hard " valves makes the arrangement suitable for the measurement of the peak values of high frequency waves. As the readings are taken on a D.C. voltmeter, the accuracy and sensitivity of the measurement are good. Although the instrument is not direct reading, in that the slide-back principle is employed, yet the wave to be measured need not be periodic as it must be for the rectifying peak voltmeter method. If the wave can be repeated at will, it may be transient and still be measured with great accuracy.

Comments on the Trigger Device

The author considers that the trigger device is so useful and at the same time so little known that some comments will not be out of place.

The earliest accounts of the device, which is sometimes called the " flip-flop," are by Eccles and Jordan, British Patent 149018 and *Radio Review*, vol. 1, No. 3. L. B. Turner has written on the device in a special form, which he calls the Kallirotron (see British Patents 139867 and 169845; *Radio Review*, Vol. 1, p. 317; and *Wireless*, p. 260).

A. H. Reeves has used the principle of the device to make a frequency halver and valve relays (British Patent 15895). If R_1 and R_2 are replaced by shunted diodes in series with inductances, the times of switching from one stable position to the other are different; in this way the valve relay can be made to make quickly and break slowly or make slowly and break quickly.

The circuit of Fig. 1 contains resistances only, so that the time of switching from one position to the other is very small. This enables us to produce square waves from distorted telegraph waves.

D. A. Ley has suggested that, if R_1 is replaced by a condenser, then a pulse applied to *AB* will cause the device to trigger from valve 2 to valve 1; but the device will trigger back to valve 2 of its own accord after a time depending on the values of the resistances and the condenser. In this way the time of a pulse can be magnified.

C. R. Dunham has made an extensive study of the possibilities of the device (British Patent 357532) as a distributor for very high-speed telegraphy.

Bedford and Puckle have found the device a great improvement over the thyratron as a trigger instrument for television scanning (" A velocity-modulation television system," *Journal I.E.E.*, vol. 75, No. 451, p. 68; and British Patent 399469).

Knoll and Freundlich have used the circuit as a trigger relay for use with the high-speed cathode-ray oscillograph (*Elektrotechnische Zeitschrift*, volume 28, July 14, 1932).

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Abstracts and References

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PROPAGATION OF WAVES

3749. INTERACTION OF RADIO WAVES. II [Résumé of Results of Special Luxembourg Tests for U.R.S.I., 1935].—B. van der Pol. (*Tijdschr. Nederlandsch Radiogenoot.*, September, 1935, Vol. 7, No. 3, pp. 93–97 : in English.)

For Part I *see* 2549 of August. Among the conclusions are the following :—the effect due to a long-wave station is of the same order for wanted long-wave and wanted medium-wave stations. The effect diminishes steadily with the distance between the unwanted station and the mid-point (or, in the case of very distant reception, the quarter-point) of the wave trajectory, and practically vanishes when this distance exceeds about 600 km. The cause of the interaction is definitely found to lie in non-linear properties of the ionosphere. The same changes which produce the variable absorption responsible for the effect may be expected to react on the propagation of the interfering wave itself, so that a sufficiently powerful station would be left with an excessive modulation percentage of the higher modulation frequencies (*cf.* 2168 of July and 3309 of October). " A further research along the above lines might enable one to locate more precisely the horizontal extension of the region of the ionosphere which is effective in ' reflecting ' a wave from a transmitter to a given receiving station."

3750. MEASUREMENTS OF THE ABSORPTION OF WIRELESS WAVES IN THE IONOSPHERE.—F. T. Farmer and J. A. Ratcliffe. (*Proc. Roy. Soc.*, Series A, 2nd Sept. 1935, Vol. 151, No. 873, pp. 370–383.)

For references to apparatus used *see* Ratcliffe and White, Abstracts, 1933, pp. 495 and 559 (l.h. column), and Farmer, 2165 of July. Measurements are here described of the reflection coefficients of the two magneto-ionic components of ionospheric echoes, reflected at vertical incidence at different times of day, of pulses on wavelengths from 50 to 500 m. The writers interpret their results on the basis of the magneto-ionic theory and arrive at " the following description of the ionosphere as an absorbing medium. In the daytime considerable absorption occurs in a region in which the refractive index is nearly unity, and which is situated below the maximum of the E region (the D region of Appleton and Ratcliffe [1930 Abstracts, p. 561]).

" At night there is very little absorption except near the top of the wave trajectory, and the magnitude of this absorption is consistent with an electron collisional frequency of 1.5×10^3 per second in the F region. The ordinary wave is appreciably absorbed only when it is group-retarded. The absorption of the extraordinary wave reflected from the F region takes place in the E region and increases as the magneto-ionic wavelength, 214 m, is approached."

3751. DISPERSION IN AN ELECTRON-ION MIXTURE, UNDER THE INFLUENCE OF AN EXTERNAL MAGNETIC FIELD (CONTRIBUTION TO THE DISPERSION THEORY OF THE IONOSPHERE).—G. Goubau. (*Hochf:tech. u. Elek:akus.*, August, 1935, Vol. 46, No. 2, pp. 37–49.)

For previous work *see* 2921 of September. The present paper discusses the influence of ions on propagation phenomena ; § 1 contains an estimate of the ratio between the ions and electrons in E region. A " mixture ratio " k is defined, which is the quantity $\delta_e/\Sigma\delta_i$, where $\delta = 4\pi Ne^2/m$ [usual notation] and suffixes e and i denote electrons and ions respectively. k decreases with the frequency, so that the influence of the ions will be greatest in the propagation of long waves. Fig. 1 shows k as a function of $\delta (= \delta_e + \delta_i)$; the effect of the ions may be considerable in E region but will rapidly decrease with height. In § 2 the dispersion formula for a mixture of electrons and ions in an external magnetic field is derived from the equations of motion ; the effect of the magnetic field on the motion of the ions may be neglected and eqn. 20 gives the formula. This is discussed in § 3 under the assumption that all the ions have the same mass and collision frequency and are singly charged. The discussion applies only to reflection measurements for vertical incidence on the ionosphere in mean geographical latitudes. Various special cases are considered in § 3B ; a wave whose electric vector is parallel to the magnetic field is not affected by it. In

§ 3C the effect of collisions is neglected; the zeros and infinities of the refractive index are worked out and dispersion curves for constant values of *k* are drawn (examples in Figs. 3, 4, 5) and shortly discussed. § 3D contains a discussion of the effect of collisions; two critical collision frequencies are found, one for electrons and one for ions. The influence of collision frequency on the dispersion curve is discussed first for the case when electrons alone are present, by considering the behaviour in the complex plane of the quantity under the square root sign in the dispersion formula; this is then extended to the electron-ion mixture and a graphical determination of critical collision frequencies for mixtures is given in Fig. 8. These are always smaller than the value for an electron gas and depend on the frequency; there may under certain conditions be three critical collision frequencies.

Dispersion curves for various frequencies, collision frequencies and mixture ratios are given in Figs. 9–14. When $\nu < \nu_0$, the reflection points are found to be more clearly marked for a mixture than for an electron gas; the reflection points of the extraordinary wave are nearer to that of the ordinary wave and, in the region of propagation of a wave, its index of attenuation is smaller. Special points about the curves are also discussed in detail. The case $\nu > \nu_0$ is similarly considered. § 4 deals with the polarisation of the waves; this is given for reflected waves by eqn. 37 and is determined by the electrons alone. The influence of the ions on propagation is considered in § 5; (a) the reflection points are changed and partial and multiple reflections occur; (b) the absorption of the waves is smaller. § 6 indicates the possibilities for determining the ion content of the ionosphere by measuring the critical frequency or the polarisation; the difficulties and limitations of these determinations are shortly discussed.

3752. THE STRUCTURE OF THE IONOSPHERE [Ionisation in Space between E and F Regions estimated from Relative Group Retardation of Magneto-Ionic Components of Echo, one reflected from E and one from F Region: Probable Uniform Distribution of Inter-Region Ionisation, slightly below Maximum of E Region].—J. Hollingworth. (*Proc. Phys. Soc.*, 1st Sept. 1935, Vol. 47, Part 5, No. 262, pp. 843–851.)

Calculations based on the magneto-ionic dispersion formula and the usual formula for group velocity, assuming independent travel of the magneto-ionic components, are given which enable estimates to be made of the time-lag between the components under various ionisation conditions and thence, by comparison with experimental results (*see* Appleton and Builder, 1933 Abstracts, p. 262), of an approximate value of the intensity of ionisation in the space between E and F regions. This is found to be "fairly uniformly distributed over the space between" the regions, and "only a few per cent less in value" than that at the top of E region. It is pointed out that the value of the inter-region ionisation "is of the utmost importance in determining the path of long-distance transmissions."

3753. PERIODIC AND IRREGULAR PHENOMENA IN THE IONOSPHERE [Results of Tromsö Observations: Sunrise and Sunset Phenomena: Directional Variations: Effect of Magnetic Storms and Auroras].—K. W. Wagner and K. Franz. (*E.N.T.*, July, 1935, Vol. 12, No. 7, pp. 201–213.)

A short account of some typical results of the German Polar Year expedition to Tromsö, December 1932—October 1934. For a previous report and description of apparatus used *see* 1934 Abstracts, p. 259 (Wagner), and 367 of February (Stoffregen). Here, Fig. 1 shows the regular phenomena (for ionospheric sunrise and sunset) in F region for a frequency of 2 Mc/s. Behaviour at sunrise was very regular and the curve gives the time at which the sun is 7.5° below the horizon. The sunset phenomena were much more scattered and the ionospheric sunrise and sunset were found to be asymmetrically placed with respect to true noon. Sudden onset of ionisation during the early hours of the morning was frequently observed.

Fig. 2 shows the annual curve for the onset of variations in direction of various European broadcasting stations. These variations could not be explained as interference between a linearly polarised ground wave and an elliptically polarised space wave, as no ground wave was received at Tromsö. Fig. 3 shows typical records of disturbed conditions in the ionosphere, in particular a sudden inrush of corpuscular radiation. Fig. 4 demonstrates the relation between terrestrial magnetic activity, the reflecting power of the ionosphere and the onset of directional variations during 1933. Magnetic disturbances were found to be connected with sudden development of high evening values of ionisation in E region (Fig. 3). F region was very selective towards small differences in frequency. The phenomena can be satisfactorily explained by the effects of auroral corpuscular radiation (*see* Appleton, Builder and Naismith, 1933 Abstracts, p. 613). During magnetic storms, vertical-incidence echoes frequently vanished completely, but broadcast reception was rarely impossible. Ionisation produced by corpuscular radiation appeared to be very irregular.

3754. MULTI-FREQUENCY IONOSPHERE RECORDING AND ITS SIGNIFICANCE.—T. R. Gilliland. (*Proc. Inst. Rad. Eng.*, September, 1935, Vol. 23, No. 9, pp. 1076–1101.) *See* 2160 of July.

3755. REFLECTING HEIGHTS OF THE IONOSPHERE [Oct. 1934/April 1935: on Waves between 60 and 100 m].—Elias, de Bruine and Deurvorst (*Tijdschr. Nederlandsch Radiogenoot.*, September, 1935, Vol. 7, No. 3, pp. 85–92: in Dutch.) For 1932/1933 results *see* 1934 Abstracts, p. 29.

3756. SOME EXPERIMENTAL STUDIES ON ELECTRON DENSITY IN THE IONOSPHERE [by Pulse Method: Occasional Increase of E Layer Density during Night: Simultaneous E and F Echoes explicable by Partial Reflection Theory: etc.].—Maeda and Konomi. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 465: English summary p. 62.)

3757. On the Attenuation Equations of Short Waves travelling in the Ionosphere [by Geometrical Optics, assuming Electron Distribution as of Parabolic Form and Collision Frequency as Exponential Function of Height].—T. Nakai. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 463: English summary p. 62.)

Equations are derived for the attenuation making the wave return after refraction and for that permitting the wave to pass through (in the second case the electron distribution is assumed to be of the form of Chapman's equation). It is shown that both equations agree well with the results of field-strength measurements.

3758. The Refraction of a Wave Group [at Interface between Two Dispersive Media: Generalisation of Classical Theory of Group Velocity].—R. Stoneley. (*Proc. Camb. Phil. Soc.*, July, 1935, Vol. 31, Part 3, pp. 360–367.)

The change in direction of a wave front on refraction at an interface between two dispersive media will be determined by the ratio of the wave velocities, but the time of transit of a group of waves will depend on the group velocities. The wave front and the amplitude front of the refracted wave will differ in direction, so that the amplitude of a wave varies along the crest of the waves and the amplitude front is arranged *en échelon*. A theoretical prediction of the *échelon* wave pattern is here made and illustrated graphically by generalising the classical theory of group velocity to the case of two wave trains, both travelling before refraction in the same direction. The law of refraction of the amplitude front is established. Rayleigh's theory (*Scientific Papers*, Vol. 1, p. 540) is generalised and an expression found for the amplitude of the disturbance for large values of the time. The geophysical implications of the theory are shortly discussed.

3759. Theory of the Reflection of the Light from a Point Source by a Finitely Conducting Flat Mirror: with an Application to Radiotelegraphy.—B. van der Pol. (*Physica*, August, 1935, Vol. 2, No. 8, pp. 843–853: in English.)

The classic expressions of Sommerfeld and of Weyl have been the subject of many investigations by different writers, whose results, however, were not as a rule very clear physically, because the approximations or developments used were more mathematical than physical in character. The present paper shows that the problem, without any approximations whatever, is capable of being developed in a different way, leading to a solution in the form of a simple space integral (15 and 17) which admits of a direct physical interpretation.

3760. Diffraction of a Progressive Wave by a Screen in the Form of Half-Plane [Complete Solution by Extension of Carson's Method].—L. Cagniard. (*Journ. de Phys. et le Radium*, July, 1935, Vol. 6, No. 7, pp. 310–318.) "An important application of these formulae will be developed in a paper appearing very shortly."

3761. Propagation of [Material] Waves in Wave Mechanics: Example of Elastic Waves [Rigorous Treatment, extensible to Electromagnetic Waves].—L. Brillouin. (*Journ. de Phys. et le Radium*, May, 1935, Vol. 6, No. 5, pp. 185–193.)

3762. Zones of Silence [lying in Belts parallel to Magnetic Equator?].—R. Stranger. (*World-Radio*, 20th and 27th Sept. 1935, p. 18: p. 18.) *See* 3317 of October.

3763. Experimental Determination of the Influence of Geographical Location on the Received Strength of Short Waves [over Sea-Water, on Cornfields, Sands, Meadows, etc.].—Nakai, Kamoshita and Endo. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 464: English summary p. 62.)

3764. The Electrical Properties of Soil at Frequencies up to 100 Megacycles per Second: with a Note on the Resistivity of Ground in the United Kingdom.—R. L. Smith-Rose. (*Proc. Phys. Soc.*, 1st Sept. 1935, Vol. 47, Part 5, No. 262, pp. 923–931: Discussion p. 931.)

For previous work *see* Abstracts, 1933, p. 382, and 1934, p. 609. The measurements are here extended to 100 Mc/s; the conductivity is found to be of "the order of 10 e.s.u. at all frequencies up to 1 Mc/s, rising to twice this value at 100 Mc/s . . . the dielectric constant decreases from about 10^5 at a frequency of 50 c/s to about 15 at 100 Mc/s." *Cf.* also 16 and 17 of January.

3765. Five-Metre Signals do the Impossible [Ranges up to 900 Miles: chiefly during Middle of Day].—R. A. Hull. (*QST*, August, 1935, Vol. 19, No. 8, p. 17.) "It is very important, we think, to differentiate between this sort of five-metre DX and that made possible by atmospheric conditions in the lower atmosphere . . ."

3766. Ultra-Short-Wave Service between Blue Hill and Mount Washington [142.5 Miles].—McKenzie. (*See* 4097.)

3767. Cruft Laboratory's Mobile Laboratory for Ultra-Short-Wave Propagation Tests and Ionosphere Measurements.—H. Selvidge. (*QST*, July, 1935, Vol. 19, No. 7, pp. 25 and 80, 82.) *See* also 2554 of August.

3768. Ten-Metre Activity Increasing.—(*QST*, August, 1935, Vol. 19, No. 8, pp. 20–21 and 34.)

3769. On the Acoustics of the Atmosphere [and the Maximum-Range Formula allowing for Refraction].—L. Gutin. (*Physik. Zeitschr. der Sowietunion*, No. 1, Vol. 8, 1935, pp. 71–80: in German.)

As an example, the range of a 500-watt all-round sound source, giving 500 c/s and raised 10 m from the ground, is calculated from equation 10. The range is found to be 7.5 km, instead of the 1.5 km given by the geometrical method on an optical analogy.

3770. Effect of Temperature on the Absorption Spectrum of Atmospheric Ozone.—Barbier, Chalonge and Vassy. (*Journ. de Phys. et le Radium*, June, 1935, Vol. 6, No. 6, pp. 91–92s.)

3771. Light Absorption and Distribution of Atmospheric Ozone [Survey].—R. W. Ladenburg. (*Journ. Opt. Soc. Am.*, September, 1935, Vol. 25, No. 9, pp. 259–269.)

3772. Factors affecting Ultra-Violet Solar-Radiation Intensities.—W. W. Coblentz and R. Stair. (*Journ. of Res. of Nat. Bur. of Stds.*, August, 1935, Vol. 15, No. 2, pp. 123–150.)

3773. The Light of the Night Sky: Analysis of the Intensity Variations at Three Stations [Terling, Canberra, the Cape: Period 1923–34: Details of Periodic Variations and Slow Variation with Irregular Fluctuations].—Rayleigh and H. S. Jones. (*Proc. Roy. Soc.*, Series A, 1st Aug. 1935, Vol. 151, No. 872, pp. 22–55.)

3774. The Light of the Night Sky, from the Spectrographic Researches of Dufay and Cabannes (Aug. 1933–April 1935).—J. Cabannes. (*Helvetica Phys. Acta*, Fasc. 5, Vol. 8, 1935, pp. 405–420: in French.)

3775. The Lunar Tide in the Earth's Atmosphere [Present Knowledge summarised by Diagram: Connection with Lunar Semi-Diurnal Variation of Atmospheric Temperature].—S. Chapman. (*Proc. Roy. Soc.*, Series A, 1st Aug. 1935, Vol. 151, No. 872, pp. 105–117.)

3776. Electromagnetic Waves on a Wire, with Concentrated Source of Energy [Mathematical Investigation of Space and Surface Waves: Concentration of Energy in Cone filled with Surface Waves].—F. Noether. (*Physik. Zeitschr. der Sowietunion*, No. 1, Vol. 8, 1935, pp. 1–24: in German.)

A theoretical discussion is given of the electromagnetic field surrounding a wire of infinite length and finite conductivity; the source of energy is taken as the alternating magnetic field of a ring coil surrounding the wire. The work is a development of that by Kessenich (1934 Abstracts, pp. 30–31) and follows lines similar to those of Sommerfeld's treatment of the field due to a vertical dipole above a plane earth. The existence of space and surface waves is discussed and it is found that the main part of the energy is propagated in a cone-shaped region, filled with surface waves.

3777. On the Fundamental Optical Invariant, the Optical Tetrality Principle, and on the New Development of Gaussian Optics based on This Law.—M. Herzberger. (*Journ. Opt. Soc. Am.*, September, 1935, Vol. 25, No. 9, pp. 295–304.)

3778. On the Propagation of Light in Sea Water.—L. I. Katsaurov. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 5, 1935, pp. 169–173.)

An account of measurements of the volume intensity of the diffused light taken by means of a spectrophotometer lowered into the water of the Black Sea, showing an increase in the volume intensity with increased depth of submersion of the instrument.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

3779. Direction Finding of Atmospherics [and Its Use for Weather Forecasting: Canadian Observations with the British Radio Research Board C.R.D.F.].—J. T. Henderson. (*Canadian Journ. of Res.*, August, 1935, Vol. 13, No. 2, pp. 34–44.)

3780. Electrical and Atmospheric Phenomena at Cloud Heights in the Malabar District, Java [Long-Wave Aerial and Long Triatic about 6000 ft above Sea Level: 1923/1925 Results].—D. C. Noppen. (*Radio-Centrum*, 16th Aug. 1935, pp. 291–293.)

3781. Lightning Currents in Field and Laboratory [Current Values, the Diameter of the "Core" of the Lightning Stroke Channel, etc.].—P. L. Bellaschi. (*Elec. Engineering*, August, 1935, Vol. 54, No. 8, pp. 837–843.)

3782. Multiple Lightning Strokes [as a Cause of the Fusing of Wires apparently Capable of Carrying the Current].—P. L. Bellaschi. (*Science*, 16th Aug. 1935, Supp. pp. 6–7.)

3783. Discharge Processes in Gases before the Breakdown [Cloud-Chamber Photographs show Multi-Canal Pre-Discharges even with Uniform Field].—E. Flegler and H. Raether. (*Naturwiss.*, 23rd Aug. 1935, p. 591.)

3784. Field Strength and Surface Discharges from a [Plane] Dielectric to a Point Electrode [Calculation of Lines of Force in Ionised Region surrounding Electrode and Electron Avalanches from Dielectric].—J. Müller. (*Arch. f. Elektrot.*, 1st Aug. 1935, Vol. 29, No. 8, pp. 568–576.)

3785. Spark Discharges between Resistance Plates [Calculation of Voltages Required].—D. Müller-Hillebrand. (*Arch. f. Elektrot.*, 1st Aug. 1935, Vol. 29, No. 8, pp. 513–529.)

3786. Spark Lag of the Sphere Gap [measured by a Special Timing Instrument].—A. Tilles. (*Elec. Engineering*, August, 1935, Vol. 54, No. 8, pp. 868–876.)

3787. "Direct Measurement of Surge Currents": Discussion.—Foust and Henderson. (*Elec. Engineering*, September, 1935, Vol. 54, No. 9, pp. 989–992.) *See* 1771 of June.

3788. Composition of Air in the Stratosphere [Gases in Same Proportions as at Earth's Surface].—A. Lepape and G. Colange. (*Comptes Rendus*, 27th May, 1935, Vol. 200, No. 22, pp. 1871–1873.)

3789. Investigation of the Atmospheric Electricity Potential Gradient in the Arctic [Russian Polar Year Expedition: Vertical Current reduced on appearance of Auroras: etc.].—J. Scholz. (*E.T.Z.*, 29th Aug. 1935, Vol. 56, No. 35, p. 960: summary only.)

3790. "Physical and Dynamical Meteorology" [Book Review].—D. Brunt. (*Science*, 30th Aug. 1935, pp. 197–198.)

3791. "Through the Weather House" [Book Review].—R. A. Watson Watt. (*Wireless Engineer*, September, 1935, Vol. 12, No. 144, p. 495.)

3792. On the Electrical Nature of Snow Particles [Tend to be Negatively Charged when No Water Droplet is attached, Positively when Numerous Droplets are attached: etc.].—Nakaya and Terada. (*Jap. Journ. of Phys.*, July, 1935, Vol. 10, No. 2, Abstracts pp. 48–49.)

3793. Total Formation of Carriers of Slow Cathode Rays in Air [at Various Pressures: Different Velocity Groups].—L. Freund. (*Ann. der Physik*, Series 5, No. 8, Vol. 22, 1935, pp. 748–760.)

3794. The Radioactivity of the Earth's Crust and Its Influence on Cosmic-Ray Electroscope Observations made near Ground Level [All Terrestrial Radiation due to Gamma-Rays from Earth's Crust].—R. D. Evans and R. W. Raitt. (*Phys. Review*, 1st Aug. 1935, Series 2, Vol. 48, No. 3, pp. 171–176.)

3795. Variation of Small-Ion Production near the Earth's Surface [Existence of Diurnal Variation due to Diminution of Radium-Emanation Content].—A. G. McNish and G. R. Wait. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, pp. 785–786: abstract only.)

3796. The Distinction between Langevin Ions and Dust Particles in the Atmosphere, *and* Ionisation Balance of the Atmosphere near the Earth's Surface [Langevin Ion not predominant as Remover of Small Ions].—G. R. Wait. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 786: pp. 810–811: abstracts only.)

3797. The Intermediate Ion of the Atmosphere.—G. R. Wait. (*Phys. Review*, 15th Aug. 1935, Series 2, Vol. 48, No. 4, p. 383.)

No critical vapour pressure: mobility decreases in accordance with Blanc's Law: number undergoes diurnal variation: value of recombination coefficient: numerous during thunderstorms: mobility spectrum: errors in small-ion counts arising from non-differentiation between small and intermediate ions.

3798. The Annual and Diurnal Variations of Ions in Urban Communities [Two Finite Mobility Values].—A. P. Gagge. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 786: abstract only.)

3799. On the Cosmic Corpuscular Radiation in the Earth's Magnetic Field [Exact Definitions of Terrestrial Magnetic Quantities, etc.].—E. M. Bruins. (*Physica*, August, 1935, Vol. 2, No. 8, pp. 879–891: in German.)

3800. On the Influence of the Earth's Magnetic Field on the Corpuscles of the Cosmic Radiation in the Latitude of Florence.—Bernardini and Bocciarelli. (*La Ricerca Scient.*, 15/31 July, 1935, 6th Year, Vol. 2, No. 1/2, pp. 36–37.)

3801. The Ionisation in a Gas at Various Pressures under the Action of Photons and of Corpuscular Rays.—J. Clay. (*Physica*, August, 1935, Vol. 2, No. 8, pp. 811–816: in German.)

3802. A Rapid Method of Determining the Saturation Current, on Jaffé's Theory of Columnar Ionisation, *and* Ionisation Measurements in Air at High Pressures.—H. Zanstra: Clay and van Tijn. (*Physica*, August, 1935, Vol. 2, No. 8, pp. 817–824: 825–832: in German.)

3803. Results of the Dutch Cosmic Ray Expedition 1933. VII. Positive and Negative Primaries. North-South Asymmetry. Difference of Decrease in Lead at Different Latitudes.—J. Clay. (*Physica*, August, 1935, Vol. 2, No. 8, pp. 861–869: in English.)

3804. The Nature of Cosmic Rays.—J. Clay. (*Proc. Roy. Soc.*, Series A, 1st Aug. 1935, Vol. 151, No. 872, pp. 202–210.) *See* also 3344 of October.

3805. A Hypothesis on the Nature and Properties of the Corpuscular Cosmic Rays [on Entry into Atmosphere, 50 Electrons to 1 Proton], *and* Absorption and Secondary Effects of Cosmic Rays.—P. Auger: Auger and Rosenberg. (*Journ. de Phys. et le Radium*, May, 1935, Vol. 6, No. 5, pp. 226–228: 229–232.) *See* also 3353 of October.

3806. Progress of the Directional Survey of Cosmic-Ray Intensities and Its Application to the Analysis of the Primary Cosmic Radiation [Description of Automatic Multi-Directional Intensity Comparator: Anomalies in Latitude and Longitude Effects].—T. H. Johnson. (*Phys. Review*, 15th Aug. 1935, Series 2, Vol. 48, No. 4, pp. 287–299.)

3807. On the Longitude Effect of Cosmic Radiation [Comparison of Theory with Experiment: Good Agreement].—M. S. Vallarta. (*Phys. Review*, 1st May, 1935, Series 2, Vol. 47, No. 9, pp. 647–651.)

3808. Absorption of the Soft Component of Corpuscular Cosmic Radiation [Separation of Effects of Planetary Electrons and Nuclear Charges: Electronic Nature of Soft Component].—P. Auger, L. Leprince-Ringuet and P. Ehrenfest. (*Comptes Rendus*, 20th May, 1935, Vol. 200, No. 21, pp. 1747–1749.)

3809. A New Secondary Effect of Cosmic Radiation [Second Maximum in Absorption Curve].—M. Ackemann. (*Zeitschr. f. Physik*, No. 5/6, Vol. 94, 1935, pp. 303–316.) *See* 1934 Abstracts, p. 263 (Hummell, Ackemann).

3810. The Secondary and Tertiary Particles produced by Cosmic Rays.—J. H. Sawyer, Jr. (*Phys. Review*, 1st April, 1935, Series 2, Vol. 47, No. 7, pp. 515–521.)

3811. Shower-Producing Cosmic-Ray Primaries [Absorption Measurements].—J. H. Sawyer, Jr. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, p. 635.)

3812. Production of Induced Radioactivity by the Cosmic Radiation [Correction of Error].—J. E. I. Cairns. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, p. 631.) *See* 1353 of May.

3813. Electrical Deviation of Cosmic-Ray Particles [Coincidence Apparatus and Measurements].—E. Lenz. (*Ann. der Physik*, Series 5, No. 3, Vol. 23, 1935, pp. 207–239.)

3814. A Circuit for the Detection of Coincidences in Multiplying Counters.—Bernardini and Oppenheimer. (*La Ricerca Scient.*, 15/31 July, 1935, 6th Year, Vol. 2, No. 1/2, pp. 34–36.)

3815. An Improved Counting Circuit [using Pentode: Improved Discrimination between Total and Partial Coincidences, *e.g.* with Cosmic Rays].—H. P. Barasch. (*Proc. Phys. Soc.*, 1st Sept. 1935, Vol. 47, Part 5, No. 262, pp. 824–834.)

PROPERTIES OF CIRCUITS

3816. Symmetrical F-Filters.—E. Selach and M. Zimbalisty. (*E.N.T.*, August, 1935, Vol. 12, No. 8, pp. 243–250.)

The filters here described (fundamental circuit Fig. 1) are similar to the so-called "double filters" (*see* Matsumae & Matsumoto, 1934 Abstracts, pp. 435–436, and Laurent, *Ericsson Technics*, 1935, No. 5) but contain fewer elements. § 2.—The matrix system of the circuit in Fig. 1 is set up; the impedance and propagation constant are given by eqns. 4 and 5 resp. § 3.—Physically realisable F-circuits are found theoretically (Fig. 3, giving equivalent circuits: Fig. 4, reciprocal circuits to Fig. 3). § 4.—The F-filters are compared with other filters; Figs. 7, 8 show equivalent band-pass filters. The F-filters do not contain expensive transformers with fixed coupling and are less sensitive than bridge circuits to deviations of their elements from the theoretically correct values. § 5.—Symmetrical filters of Zobel's "derived m-type" are assumed to take the place of the elements in Figs. 3a, 4a, and the circuits of Figs. 9a–12a are obtained; their impedances are worked out (eqns. 18–22). The propagation constant is the same as that of Zobel's M-filter: the attenuation is found to be more favourable. § 6.—The general case of the symmetrical F-circuit is discussed, giving the circuit of Fig. 13 and its reciprocal in Fig. 14; the impedance is similar to that of Zobel's MM' type, the propagation constant to that of his type M. § 7.—Examples of composite filters with members of the F-type are given (Figs. 15–18).

3817. Dissipation in Phase-Compensating Networks [Its Three Effects and Its Correction].—A. T. Starr. (*Proc. Inst. Rad. Eng.*, September, 1935, Vol. 23, No. 9, pp. 1102–1115.)

"The third effect [image impedance variation] is most important as it causes highly inconvenient reflections. Two methods are described for avoiding this effect, one of the methods having the special advantage that it avoids the first effect [change of phase shift from ideal calculated value] at the same time."

3818. Relation between the Attenuation and the Phase Displacement in a Linear Transmission System.—R. Leroy. (*Ann. des P.T.T.*, August, 1935, Vol. 24, No. 8, pp. 733–740.)

3819. Application of a Theorem on the Development of Operators in Series to the Theory of Transient Phenomena on Homogeneous Conductors.—L. Kosten. (*E.N.T.*, August, 1935, Vol. 12, No. 8, pp. 231–236.)

See 2073 of June. Operational solution of differential equations under given initial conditions: general series giving voltages and current, when ohmic losses are present, in terms of loss-free voltages and current.

3820. Switch-On Phenomena in Iron-Cored Choke Coils with Eddy Currents [Theoretical Investigation of Rise of Current when Direct Voltage Impulse is applied to Coil].—G. Eckart. (*E.N.T.*, August, 1935, Vol. 12, No. 8, pp. 250–256.)

After preliminary remarks on phenomena known from previous work (Kneschke, 1930 Abstracts, pp. 39–40) the writer considers the cases of an iron sheet of given width but otherwise unlimited, and a core of circular cross section but infinite length. He integrates the appropriate differential equations first for the quasi-stationary state (§ 3) and then applies operational methods to obtain the solution for the sudden application of a direct voltage impulse (§§ 4, 5); the rise of current is shown graphically in Fig. 6 and its time derivative in Fig. 7.

3821. A Theorem in Electricity deduced from the Generalised Maxwell Reciprocity Theorem [and Its Application to Bridge Circuits with Ballistic Galvanometers, to Transients in Networks, etc.].—van den Meersche. (*Rev. Gén. de l'Élec.*, 24th Aug. 1935, Vol. 38, No. 8, pp. 259–263.)

3822. On the Building Up of Oscillations in an Auto-Oscillating System with Partial or Complete "Pulling-in" of the Frequency.—P. Riazin. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 5, 1935, pp. 38–52.)

A mathematical investigation, confirmed experimentally, of the operation of a valve oscillator to whose grid circuit an external e.m.f. is applied of a frequency differing from that of the oscillating circuit. A theory of the operation of the system, as proposed by van der Pol, is briefly outlined, and a method is suggested for solving the non-linear differential equations of the amplitudes. The processes of building up oscillations in the system are examined in detail both for the case of complete and partial "pulling-in." In the latter case the frequency of the system is brought nearer to the frequency of the applied e.m.f., and it shows that the resultant frequency is of a complex character and contains a whole range of frequencies. The main conclusion reached is that the operation of the system can be adequately represented only by the use of the non-linear theory. An account is also given of experiments in which two a.f. oscillators were used, and some of the oscillograms obtained are shown.

3823. The Balancing of Valve Circuits [Ultra-Micrometer Circuits using Ordinary Valves: Elimination of Effects of Valve and Battery Fluctuation].—J. J. Dowling and C. O'Ceallaigh. (*Phil. Mag.*, September, 1935, Series 7, Vol. 20, No. 133, pp. 532–542.)

For previous work *see* Soller, Abstracts, 1932, p. 654; Du Bridge & Hart Brown, 1934, p. 50; Turner, 1934, p. 164; Donzelet, Pierret and Divoux, 1934, p. 270. Du Bridge (*loc. cit.*) designed a circuit (here Fig. 1) to compensate for irregular emission effects on the assumption that, when emission changes in a valve, equal percentage changes occur in both anode current and space-charge grid current; this is not quite generally valid but may be made to hold by connecting resistances externally to the valve circuits (anode and grid). The present writers have adopted this as the principle of a method of "matched characteristic balance," which is here discussed on the basis of the valve characteristics. A practical circuit is given (Figs. 7, 8) employing directly heated valves, and numerical data for an ultra-micrometer circuit are given. The working schedule for balancing the circuit is described.

In another method, "emission effects and h.t. battery changes are separately compensated by independent adjustments of suitable external circuits." These "zero balance circuits" are discussed. The writers use ordinary valves, running under normal conditions, for all their circuits, and the conclusions are found to be "applicable to almost any valve circuit using space-charge tetrodes and to many with triodes or pentodes."

3824. The Natural Oscillations and Dampings of Coupled Oscillatory Circuits [Electrical and Mechanical Systems: Instructional Article].—K. W. Wagner. (*T.F.T.*, August, 1935, Vol. 24, No. 8, pp. 191–203.)

3825. A Mechanical Model of Coupled Electrical Circuits [giving Magnetic- or Electrostatic-Type Coupling alone, and Other Advantages].—E. L. Chaffee. (*Review Scient. Instr.*, August, 1935, Vol. 6, No. 8, pp. 231–238.)

3826. "Les Circuits Oscillants" [Book Review].—J. Mercier. (*Electronics*, August, 1935, p. 251.)

3827. An Investigation of an [Ultra-Short-Wave] Oscillator with Distributed Constants.—Maibaum and Osipov. (*See* 3841.)

3828. On the Periodic Time of the Flashes of a Neon Lamp [Reasons for Discrepancies between Observation and Theory: a New Formula].—T. Terada. (*Jap. Journ. of Phys.*, July, 1935, Vol. 10, No. 2, Abstracts p. 51.)

3829. Frequency and Phase Distortion [and the Use of L.F. Retroaction].—T. Tanasescu: Marinesco. (*Wireless Engineer*, September, 1935, Vol. 12, No. 144, p. 496.) Criticism of Marinesco's conclusions (3492 of October).

3830. Some Methods for making Resonant-Circuit Response and Impedance Calculations ["Short-Cut" Methods using "Q" and "W" as Fundamental Parameters].—H. T. Budenbom. (*Rad. Engineering*, August, 1935, Vol. 15, No. 8, pp. 7–13.) Q is $\omega L/R$ and W is $(1 - f_0^2/f^2)$. The methods avoid all use of "$a + jb$" calculations.

3831. A Frequency-Lock Multi-Vider [for Multiplying or Dividing High Radio Frequencies].—De Young. (*See* 3847.)

TRANSMISSION

3832. A Loop Transmitter [with Single Loop serving both as Generator and as Directional Radiator of Electromagnetic Waves: Possibilities of Construction of Compact, Powerful and Strongly Directional Portable Ultra-Short-Wave Transmitter].—R. King. (*Phil. Mag.*, September, 1935, Series 7, Vol. 20, No. 133, pp. 514–528.)

The essential part of the oscillating and radiating circuit is a square of brass tubing with a triode connected at each corner (Fig. 1: circuit diagram Fig. 2). Undamped oscillations are sustained whose frequency is determined by the dimensions of the square and any other impedances in series with it. The mathematical theory is discussed with special reference to a working model operating at a carrier frequency of 1.02×10^8 c/s. Fig. 3 shows the nearly sinusoidal current amplitude distribution along the conductors forming the square. The electromagnetic field of a square carrying a uniform current is worked out and shown diagrammatically in Fig. 7; it is that of a magnetic dipole. The radiation resistance is also found. Generalisations of the transmitter and its possible applications are shortly discussed. The loop may be adapted to either directional or non-directional transmission by placing it in a horizontal or vertical position respectively: its greatest physical dimension is in the plane of maximum radiation. It is suggested that the transmitter might have special advantages in aeroplane work of all kinds. Only working laboratory models have so far been constructed.

3833. A New Type Ultra-High-Frequency Transmitter.—R. King. (*QST*, September, 1935, Vol. 19, No. 9, pp. 30–31 and 41 [not 39 as given]). Practical details of the transmitter dealt with in 3832.

3834. Development of [Micro-Wave] Transmitters for Frequencies above 300 Megacycles [and the Rocky Point Propagation Tests].—N. E. Lindenblad. (*Proc. Inst. Rad. Eng.*, September, 1935, Vol. 23, No. 9, pp. 1013–1047.) The full paper, a summary of which was dealt with in 1934 Abstracts, p. 378. For the propagation tests *see* also Trevor and George, 2916 of September.

3835. On an Electron-Oscillation Circuit using Anode Balance [compensating for Potential Drop along Directly-Heated Cathode].—S. Ohtaka. (*Journ. I.E.E. Japan*, June, 1935, Vol. 55 [No. 6], No. 563, pp. 518–520: English summary p. 68.)

The "synchronising power loss" due to this potential drop and the consequent lack of uniformity of field "is remarkably reduced by connecting a suitably resonant circuit, including the total length of the anode as a part, to the valve. In addition to this anode resonant circuit, a Lecher-wire system shall be attached to the valve as load circuit. . . . The writer reports that he has obtained a constant saving of 24 to 27 w of grid input for a wide range of oscillation currents from several hundred milliamperes up to nearly 2 000 mA for valves of 100 w rated grid input."

3836. On the Characteristics and Applications of the "Modulation-Grid" Vacuum Tube for Ultra-Short Waves.—S. Nishimura. (*Journ. I.E.E. Japan*, June, 1935, Vol. 55 [No. 6], No. 563, pp. 515–518: English summary p. 68.)

This valve (due to Okabe and Hisida) requires a comparatively large modulating voltage, "though no power is consumed in it." Practically no frequency modulation is produced. The writer also finds the valve useful for super-regenerative reception of ultra-short waves, the quenching voltage being applied to the modulation grid.

3837. A New System of Modulating Electron Oscillation without Undue Frequency Modulation.—T. Hayasi. (*Journ. I.E.E. Japan*, June, 1935, Vol. 55, [No. 6], No. 563, pp. 511–515: English summary pp. 67–68.)

By suitable use of a tetrode. The inner grid is kept at a high positive potential with respect to the filament; the outer is kept negative and acts as the retarding electrode, turning back the electrons; the anode, acting as modulating electrode, varies the oscillation amplitude almost linearly when its voltage changes from 0 to + 30 v.

3838. Valve Emitter for Ultra-Short Waves [Multiple-Valve Arrangement, extending "Holborn" Circuit].—Telefunken. (German Pat. 602 764, pub. 18.9.1934: *Hochf:tech. u. Elek:akus.*, August, 1935, Vol. 46, No. 2, p. 69.)

3839. Magnetron Oscillators [including Diagram of Philips Type XDC 100 L/2 Transmitter: 70–200 cm Wave Range, 75–100 W Aerial Power].—Philips Company. (*Bull. Assoc. suisse des Élec.*, 30th Aug. 1935, pp. 515–517: in German.)

3840. Magnetrons for Decimetre Waves.—V. M. Bovsheverov and M. T. Grechowa. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 5, 1935, pp. 69–74.)

An experimental investigation of a split-anode magnetron with the oscillating circuit connected to the segments of the anode and mounted inside the magnetron bulb. The oscillating circuit is of a rectangular shape and is made of a wide metal ribbon, a type found experimentally to be most suitable for operation on wavelengths between 10 and 40 cm.

A number of such magnetrons of various dimensions were tested and their natural wavelengths determined. Curves based on these experiments are plotted and approximate equations deduced enabling the natural wavelength of a magnetron to be calculated.

The operation of the magnetron at the upper and lower bends of the cut-off characteristic was next investigated, and a number of curves are shown. One of the conclusions reached is that the operating wavelength is practically independent of the anode voltage and emission current, *i.e.* that the oscillations are not electronic.

3841. An Investigation of an [Ultra-Short-Wave] Oscillator with Distributed Constants.—B. K. Maibaum and N. V. Osipov. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 5, 1935, pp. 53–62.)

When the short-circuiting bridge is moved along the Lecher conductors of an ultra-short-wave oscillator, the system starts to oscillate for certain equidistant positions of the bridge. The intensity curve of oscillations for these positions passes through two maxima, and it has been suggested that two frequency ranges, lying close to each other, are generated in the system. The author proves in the present paper that this is not the case, and that in order to explain the appearance of a trough in the intensity curve the remaining sections of the Lecher conductors beyond the bridge should be taken into consideration. In fact, it is shown that when the bridge passes through an excitation region, a position is reached for which the Lecher system becomes equivalent to an open-circuited transmission line. This position is determined by the following formula:— $l_2 - l_1 = k \,.\, \lambda/4$, where l_2 is the total length of the conductor, l_1 is the length of the conductor from the input terminal to the bridge, λ is the wavelength, and k is 1, 3, 5, 7 . . . . Experiments confirming these conclusions are described.

3842. The Effect of Gas Pressure on Ultra-High-Frequency Oscillations.—A. V. Saveliev. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 5, 1935, pp. 63–68.)

An account of experiments carried out with valves filled with mercury vapour whose pressure was varied by changes in the ambient temperature. Two separate series of experiments were conducted: (a) in which the anode/grid capacity was utilised as a part of the oscillating circuit (the Lecher wires were connected one to the anode and the other to the grid—Barkhausen and Kurz, *Physik. Zeitschr.*, 1920); and (b) in which the capacity of the spiral grid was utilised (Lecher wires connected to the ends of the grid—Grechowa, *Zeitschr. f. Phys.*, Vol. 35, 1926). The pressure of the vapour was raised approximately between the limits of 1×10^{-8} to 1×10^{-3} mm Hg. The wavelengths used were of the order of 100 cm. The following two main conclusions are reached :—(1) The effect of the gas pressure on the oscillating system is similar to the effect of the operating constants of the valve, and (2) while for case (b) there is an optimum pressure for which the intensity of the oscillations increases several times, there is no such optimum for case (a).

3843. The Variation of Voltage-Distribution and of Electron Transit-Time with Current in the Planar Diode [with Application to Micro-Wave Oscillations].—Cockburn. (*See* 3894.)

3844. Optimum Design of [Single-Turn] Toroidal Inductances [for "High-Q" *LC* Circuits for Ultra-Short-Wave Transmitters : Characteristics also useful for Tuned R.F. Receivers, Image and Noise Suppression, etc.].—G. Reber. (*Proc. Inst. Rad. Eng.*, September, 1935, Vol. 23, No. 9, pp. 1056–1068.) For Kolster's use of these inductances, for frequency stability at ultra-high frequencies, *see* 988 of April.

3845. Some Possibilities for Low-Loss Coils [Toroidal Coils wound with Strip Conductor shaped to follow Surface of Revolution : Theoretical "Q" Values of 1000–10000 : Possibility of Multi-Layered Coils : Frequency Stabilisation, even for Broadcasting Stations].—F. E. Terman. (*Proc. Inst. Rad. Eng.*, September, 1935, Vol. 23, No. 9, pp. 1069–1075.)

3846. Resonant Lines for Frequency Control [for High-Precision Ultra-Short-Wave Transmitters and, with Short Waves, for Larger Power Output than is obtainable with Crystal Oscillators].—C. W. Hansell. (*Elec. Engineering*, August, 1935, Vol. 54, No. 8, pp. 852–857.)

See also 2968 of September. "The general principles of the design of concentric conductor lines, and means for compensating temperature changes, are discussed. Line-controlled oscillators may be used with frequency multipliers, or to control oscillators at lower frequencies."

3847. A Frequency-Lock Multi-Vider : an Interesting Circuit for Multiplying and Dividing High Radio Frequencies.—J. A. De Young. (*QST*, September, 1935, Vol. 19, No. 9, pp. 32–33.)

With the circuit described a crystal (or electron-coupled or magnetostriction) generator on 40 m gives harmonics down to 8 m or sub-harmonics up to 200 m. With two or more "frequency locks" in cascade the range could be extended.

3848. Studies on Very Slow Electrical Oscillations [2 c/s : the Relations between Grid, Inductance and Condenser Currents investigated Oscillographically].—W. Bindseil. (*Zeitschr. f. Unterr.*, No. 2, Vol. 68, 1935, pp. 78–80.)

3849. The Grid-Coupled Dynatron [Power Output of Tetrode Dynatron Oscillator increased 50% by Feeding Back some of Output to Inner Grid : Use as A.F. or R.F. Generator : etc.].—F. M. Gager. (*Proc. Inst. Rad. Eng.*, September, 1935, Vol. 23, No. 9, pp. 1048–1055.)

3850. Parasites and Instability in Radio Transmitters [Nature, Detection and Elimination].—G. W. Fyler. (*Proc. Inst. Rad. Eng.*, September, 1935, Vol. 23, No. 9, pp. 985–1012.)

3851. Plate Modulation of Pentodes [Linearity : Operating Conditions : Modulator Requirements].—G. Grammer. (*QST*, September, 1935, Vol. 19, No. 9, pp. 13–16 and 33.)

Modulation of plate and screen in proper proportion gives a characteristic as good as that of a plate-modulated triode, and has certain advantages over the latter.

3852. Further Controlled-Carrier 'Phone Systems : Suppressor-Grid and Class C Excitation Methods [Unmodulated Aerial Current One-Tenth of Modulated : Improved Reception : etc.].—(*QST*, July, 1935, Vol. 19, No. 7, pp. 37–38.)

3853. The Determination of the Data of a Valve Emitter.—Plisch. (*See* 3897.)

RECEPTION

3854. Determination of the Effectiveness of "Anti-Fading" Devices [Analytical and Graphical Methods].—P. Mandel. (*L'Onde Élec.*, August, 1935, Vol. 14, No. 164, pp. 531–539.)

The writer's mathematical treatment leads to the general equation 8, giving the relation between the input voltage e_1 and the output voltage e_2 of an amplifier of $(n-1)$ stages provided with automatic fading regulation. The coefficients $abc \ldots \alpha\beta \ldots$ depend on the method employed. As an example, the case is taken of a r.f. amplifier of 3 identical stages, with diode rectification of the regulating voltage, and no delay action (Fig. 4). For complicated circuits it is troublesome to calculate the various coefficients, and the graphical method is then conveniently used.

3855. The Glow-Discharge Indicator Tube with Three and Four Electrodes, as Optical Tuning Device for Broadcast Receivers.—W. Heinze and W. Pohle. (*E.T.Z.*, 15th Aug. 1935, Vol. 56, No. 33, pp. 917–920.)

Further development of the work dealt with in 1934 Abstracts, p. 322. The advantage of the third (ring) electrode, which can be used either as an auxiliary anode or as an auxiliary cathode (preferably, in general, the former—Fig. 1) is to give a more uniform and smoother action : it lies between the main ring anode and the tube base. When a fourth electrode is used, this lies about 16 mm above the anode and is led out through the top cap. It can be used to give "silent tuning" between stations, the a.f. part of the amplifier being put out of action except when the luminous column is high enough to make contact with this electrode. Two ways of doing this are described, the blocking being accomplished through the screen grid in the one case and through the control grid in the other. The limitations of both methods are discussed, and an improved method is given in which a dry-plate rectifier is paralleled with the discharge tube (Figs. 5 and 6). With this arrangement the action is satisfactory even with valves with high amplification factor.

3856. Resonance Indication by Cathode-Ray Tube [Tuning Device for Broadcast Receivers].—H. W. Parker. (U.S.A. Pat. 1 951 036: *Funktech. Monatshefte*, August, 1935, No. 8, p. 320.) *Cf.* "micromesh tunograph," *Wireless World*, 10th August, 1934, pp. 108–109.

3857. The RCA–6E5 Electron-Ray Tube as Tuning Indicator.—(*See* 4030.)

3858. Expanding-Volume Amplifiers [and a Relay Method avoiding the Defects of Variable-Amplification-Valve Methods].—T. S. E. Thomas. (*Wireless Engineer*, September, 1935, Vol. 12, No. 144, pp. 493–495.)

3859. Volume [or "Contrast"] Expansion—a New Agency for Realism.—(*Electronics*, August, 1935, p. 259.) *See* also 3004 of September.

3860. Tone Compensation.—M. G. Scroggie. (*Wireless World*, 30th Aug. 1935, Vol. 37, pp. 252–255.)

Tone compensation cannot be treated as a simple fitment to the modern receiver which will correct for variations in intensity at all frequencies in such proportions as to maintain correct relative loudness. This article discusses some of the difficulties which have to be taken into account.

3861. Detection at Large Inputs [Advantages: Special Emphasis on Detector feeding Push-Pull Output Stage directly: a New Circuit: Cathode-Heater Capacity Assymmetry: etc.].—W. F. Cope. (*Wireless Engineer*, August, 1935, Vol. 12, No. 143, pp. 437–438.)

3862. Effect of the Detector Load on Transformer Design [Analysis and Practical Conclusions].—F. M. Colebrook. (*Wireless Engineer*, August, 1935, Vol. 12, No. 143, pp. 415–420.) For a preliminary communication *see* 1046 of April.

3863. The Detector Load: Some Experiments in Optimum Amplifier/Detector Coupling.—W. F. Cope: Colebrook. (*Wireless Engineer*, September, 1935, Vol. 12, No. 144, pp. 478–480.) Experimental confirmation of the theoretical results in 3862.

3864. Retroaction Audion with Decreased Non-Linear Distortion.—W. Nestel. (*E.T.Z.*, 12th Sept. 1935, Vol. 56, No. 37, p. 1021.)

See also 3025 of September. "Thanks to its high amplification the audion circuit with retroaction is indispensable for cheap receivers. Its disadvantage is a high 'klirr' factor, which has a bad effect on the quality. A method of reducing this non-linear distortion is given." The method consists in shunting the grid/cathode path by a diode and inserting a condenser-shunted resistance (some 100 ohms) in the cathode circuit, so as to give the audion grid a small negative bias. The result is to diminish the 'klirr' factor to about a quarter. Moreover, the grid leak can be decreased (*e.g.* to 0.1 instead of 2 megohms) which considerably improves high-note reproduction and decreases the sensitivity to hum.

3865. Design for Higher Performance in the Super-Regenerative Receiver: Details and Characteristics of a New-Type Three-Tube U-H-F Circuit [Mobile Receiver for Police Communication].—G. W. Fyler. (*QST*, July, 1935, Vol. 19, No. 7, pp. 11–14.)

3866. The Optimum Decrement of Band-Pass Filters for the Reception of Telephony.—D. A. Bell. (*Wireless Engineer*, September, 1935, Vol. 12, No. 144, pp. 491–492.) Further development of the work dealt with in 1933 Abstracts, pp. 503–504.

3867. Permeability Tuning introduced in I.F. Transformers [for Trimming].—(*Electronics*, August, 1935, p. 260.)

3868. Iron-Core ["Polyiron"] I.F. Transformers [also for Other Frequencies].—A. Crossley. (*QST*, August, 1935, Vol. 19, No. 8, pp. 22–23 and 80, 82.)

With adjustable coupling. Very promising results are also being obtained at broadcast frequencies. "Sufficient investigation has not been possible at this time on the use of iron at higher frequencies. Creditable results have been obtained up to 4000 kc/s, however, and it is reasonable to expect that, with proper iron core and coil design, good results will be possible at still higher frequencies."

3869. Crystal Coupling for High-Quality I.F. Circuits.—Bell Laboratories. (*Electronics*, August, 1935, pp. 256–257.)

3870. Superheterodyne Whistles [especially those due to Harmonics of the I.F., and the Necessary Remedies].—M. G. Scroggie. (*Wireless World*, 13th Sept. 1935, Vol. 37, pp. 302–304.)

3871. Novelties in Receiver Design at the 1935 Berlin Radio Exhibition.—J. Gross. (*Radio, B., F. für Alle*, September, 1935, pp. 149–156.)

3872. An All-Purpose Single-Signal Superhet with Turret-Type Automatic Coil Changing [Efficiency of Plug-In Coils with Convenience of Switching].—C. Fisher. (*QST*, Aug. and Sept. 1935, Vol. 19, Nos. 8 and 9, pp. 13–16: 17–20, 64, 66, 68.)

3873. An Audio Output Stage for the Regenerative Single-Signal Superhet [without Additional Socket].—Van Arsdale. (*QST*, September, 1935, Vol. 19, No. 9, p. 42.)

3874. Resistance Coupled Push-Pull Amplification.—W. T. Cocking. (*Wireless World*, 16th Aug. 1935, Vol. 37, pp. 164–165.)

Describing a feeder unit for coupling a conventional detector system to the "Push-Pull Quality Amplifier" dealt with in 1934 Abstracts, p. 445.

3875. Highly Sensitive Quality Receiver.—W. T. Cocking. (*Wireless World*, 20th Sept. 1935, Vol. 37, pp. 318–320.)

Describing a coupling unit for linking the receiver described in 3427 of October to the amplifier described in 1934 Abstracts, p. 445.

3876. Compact Battery Two [with Headphones: especially for Small Yachts].—(*Wireless World*, 30th Aug. 1935, pp. 242–244.)

3877. The Three-in-One Portable [with Headphones].—(*Wireless World*, 13th Sept. 1935, Vol. 37, pp. 292–295.)

3878. Radio Interference from High-Tension Transmission Lines.—S. A. Prentice, J. R. Callow and W. W. Miller. (*Journ. Inst. Engineers, Australia*, July, 1935, Vol. 7, No. 7, pp. 253–260.)

Authors' summary:—The problem . . . is being examined both in the field and in the laboratory. Results which have been so far obtained indicate that, with proper insulator design and careful erection and maintenance, the area over which objectionable interference is produced may be limited to within a few yards of the line. From laboratory experiments, information has been obtained which indicates certain alteration in insulator design which may be expected to lead to further suppression of interference.

3879. Note on the Tracing and Suppression of Radio Interference produced by Power Lines [Successful Treatment of H.T. Insulators with Coating of Special Beeswax Solution: etc.].—E. Boyer. (*Ann. des P.T.T.*, August, 1935, Vol. 24, No. 8, pp. 771–775.)

3880. Protection of Transpacific Receiving Station from Interference from Neighbouring High-Tension Line.—H. N. Kalb. (*Elec. World*, 2nd March, 1935, Vol. 105, pp. 482–483.

3881. The Present Position of the Technique for the Elimination of Broadcast Interference due to Telephone Systems.—F. Seelemann. (*T.F.T.*, June, 1935, Vol. 24, No. 6, pp. 146–152.)

3882. A Radio Interference Measuring Instrument [for Crest and R.M.S. Values of Field Strength: High Ratio of these Values, for Many Types of Interference, explains Discrepancies in Interference Investigations].—F. O. McMillan and H. G. Barnett. (*Elec. Engineering*, August, 1935, Vol. 54, No. 8, pp. 857–862.)

3883. "Handbuch der Funktechnik und ihrer Grenzgebiete": Industrial Interference, Its Measurement and Suppression.—(*Radio, B., F. für Alle*, Aug. and Sept. 1935, pp. 130–136 and 137–166.) For previous instalments *see* 3276 of September.

3884. Measuring Radio Interference.—David Dick. (*Electronics*, August, 1935, pp. 261–262.) Based on the papers dealt with in 1829 and 1833 of June.

3885. The Measuring Technique of Broadcast Interference Suppression, and Its Equipment.—H. Reppisch. (*T.F.T.*, August, 1935, Vol. 24, No. 8, pp. 203–208.)

3886. Approximate Method of Calculating the Minimum Value for Interference-Suppressing Condensers for D.C. Machines.—K. Heinrich. (*E.T.Z.*, 22nd Aug. 1935, Vol. 56, No. 34, pp. 943–944.)

3887. A Cathode-Ray Oscilloscope Equipment for Testing Receivers.—Berger. (*See* 3993.)

3888. Data of Broadcast Listeners over the World in the Years 1930 to 1935.—(*E.T.Z.*, 15th Aug. 1935, Vol. 56, No. 33, p. 930.)

3889. The Spanish Radio Market.—A. W. Cruse. (*Rad. Engineering*, August, 1935, Vol. 15, No. 8, pp. 16–17.)

AERIALS AND AERIAL SYSTEMS

3890. New Antenna System Developed ["V-Doublet Antenna System" as Completely Assembled Kit for All-Wave Receivers].—(*Gen. Elec. Review*, August, 1935, Vol. 38, No. 8, p. 395.)

3891. The "Double-Doublet" Kit [Interference Reducing Aerial].—(*Scient. American*, August, 1935, Vol. 153, No. 2, pp. 108–109.)

3892. Ultra-High-Frequency Antenna Terminations, using Concentric Lines.—W. C. Tinus. (*Electronics*, August, 1935, pp. 239–241.) Including the design and use of the "quarter-wave" transformer (*see* 3246 of September).

3893. Low-Capacity Air-Insulated Cable [with Conductor centred by Kinks at Intervals].—Geoffroy-Delore. (French Pat. 781 803, pub. 22.5.1935: *Rev. Gén. de l'Élec.*, 31st Aug. 1935, p. 72D.)

VALVES AND THERMIONICS

3894. The Variation of Voltage Distribution and of Electron Transit Time with Current in the Planar Diode [Theory applicable to Electron Oscillations].—R. Cockburn. (*Proc. Phys. Soc.*, 1st Sept. 1935, Vol. 47, Part 5, No. 262, pp. 810–817.)

The differential equation of motion of the electrons in a planar diode is solved to give the general solution for the voltage distribution and electron transit time. Increase of space charge is found to increase the transit time, which is however reduced by the effect of initial emission velocities. The application of the theory to electron oscillations is shortly discussed.

3895. Magnetrons for Micro-Waves between 10 and 40 cm [with Ribbon Oscillatory Circuit within Bulb].—Bovsheverov and Grechowa. (*See* 3840.)

3896. Investigations on Continuously Controllable Gaseous Discharges and Their Application to Amplifying Purposes.—H. Rothe and W. Kleen. (*Telefunken-Zeit.*, August, 1935, Vol. 16, No. 71, pp. 44–52.)

"It has been repeatedly suggested that continuously controllable gaseous discharges should be used for amplification in order to steepen the slope and thus increase the amplification in comparison with the high-vacuum valve." Methods of doing this are divided into two classes. In the first, a self-maintained or semi-self-maintained discharge (with or without a hot cathode) merely provides a plasma and thus acts like a hot cathode in a high-vacuum valve: the gas filling is necessary for the formation of the discharge, but has no importance in the actual amplifying system (*see*, for example, Runge, 1076 of April). In the second class, with which the present paper deals exclusively, the ordinary electrode system of hot cathode, control grid and anode, and perhaps auxiliary electrodes, is provided with a slight filling of gas, but the ionisation is kept so low that no semi-self-sustained discharge can occur.

The paper, after a preliminary discussion and literature references, gives a theoretical treatment of the static behaviour of un-self-sustained discharges, and then describes the experimental plotting of characteristics of valves with helium and argon fillings. Slopes of 20–30 mA/v were obtained with helium, but with suitable electrode systems these could be increased to about 60 mA/v. Argon did not give such good results. Bombardment phenomena, destroying the oxide cathodes, limit the anode voltage for a helium-filled triode to 40 v, but in a screen-grid valve (screen grid at 40 v) this can be raised to 70 v, or 100 v if a collector grid is added, without the cathode deterioration spoiling a life of 1 000 hours.

Investigation of the variation of amplification with frequency shows, however, that even at 10^4 to 10^5 c/s the dynamic characteristics of such valves begin to depart from the form of the static curves, and the writer concludes: "the use of gas-filled valves is therefore limited to l.f. amplification. For this purpose, however, there are the objections of anode-voltage limitation, the negative resistance of the grid/cathode space (leading to great circuit disadvantages) and the considerably higher level of background noise compared with high-vacuum valves; so that, in the present position, valves of this type have no practical importance."

3897. The Determination of the Data of a Valve Emitter (Conclusion).—H. H. Plisch. (*Hochf:tech. u. Elek:akus.*, August, 1935, Vol. 46, No. 2, pp. 55–62.)

For Part I *see* 3445 of October. The present part discusses (§12) the grid current and its influence; the most favourable value of grid current is found to be between 15 and 20% of the anode direct current. The efficiency when the applied voltage is too large (§12e) and too small (§13) is formulated; the load on the grid (§14), the limitation of the anode current by saturation (§15), the determination of the external resistances (§16), the load on the electrode leads (§17), measurements of efficiency (§18) and some numerical examples (§19), are also considered.

3898. Phototubes for Testing Power Tubes.—Westinghouse Company. (*Electronics*, August, 1935, p. 253.)

3899. The RCA - de Forest 803 High-Power Pentode [R.F. Output about 210 Watts].—(*QST*, August, 1935, Vol. 19, No. 8, pp. 30–31.) With graphite anode. "Plate voltage [2 000 v] and input power should be reduced at frequencies higher than 20 Mc/s."

3900. New High-Power Transmitting Pentode: the RK-28 [about 250 Watts R.F. Output].—(*QST*, July, 1935, Vol. 19, No. 7, pp. 28–29 and 47.)

3901. Amplifier and Oscillator Valves for High-Power Broadcasting Stations.—A. Gehrts and A. Semm. (*Naturwiss.*, 16th Aug. 1935, pp. 567–577.)

"The reliability and economy of broadcast transmitters, especially those of high power, have been considerably increased by the latest developments of water-cooled and of air-cooled valves. With the water-cooled type this is attained by the development of ever larger valve units; with the air-cooled type, by an increase of the maximum anode dissipation and above all by the introduction of thoriated tungsten cathodes instead of the ordinary tungsten. The development of the 300 kw water-cooled valve with large-surface cathode has, moreover, made possible an improved transmission quality (decrease of non-linear distortion) thanks to its straight-line characteristic. Another contribution to this improvement has been the construction of water-cooled valves with characteristics lying completely in the region of negative grid potentials."

3902. Measurements of Output and Distortion in Broadcast Receiving Valves [Simple Practical Method: Oscillographic Investigation: Combination Tones frequently more Distorting than Harmonics: etc.].—Graffunder, Kleen and Wehnert. (*Telefunken-Röhre*, No. 4, 1935, pp. 142–163.)

3903. Development of the Broadcast Receiving Valve [including a Quick-Heating Cathode and Pin-less Valves].—A. Mainka. (*Zeitschr. V.D.I.*, 17th Aug. 1935, Vol. 79, No. 33, pp. 999–1004.)

3904. Construction of a Top-Cap Shield for Metal Tubes [for Additional Stability in Certain Very Sensitive Receivers].—RCA. (*Rad. Engineering*, August, 1935, Vol. 15, No. 8, p. 19.)

3905. The New Valve Programme [at Berlin Radio Show: with Explanation of Type Symbols and Table of Old and New Nomenclature].—(*Radio, B., F. für Alle*, September, 1935, pp. 157–162.)

3906. The New [German] Valve Programme.—E. Schwandt. (*Funktech. Monatshefte*, August, 1935, No. 8, pp. 291–298.)

3907. Current Distribution [near Cathode and Grid of Triodes: Calculation and Experimental Confirmation: a Method of Testing the Uniformity of Emissive Power of a Cathode: etc.].—W. Rothe. (*Telefunken-Röhre*, No. 4, 1935, pp. 130–141.)

3908. Measurement of the Saturation Current of High-Emission Hot Cathodes [Direct Method using Condenser Discharge].—E. Patai and G. Frank. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 16, 1935, pp. 254–262.)

A short-time method avoiding damage to the valve and the errors due to heating of the cathode or anode by the emission current. If the anode potential is applied only just long enough to ensure that the emission reaches its saturation value, the problem resolves itself into the accurate and convenient measurement of the maximum value of a current pulse. The method adopted (Fig. 1) is to discharge a condenser C, of suitable size, through the test valve: the emission current passes through a non-inductive resistance R, and the voltage-drop produced is used to charge the measuring condenser c through the rectifying path of the cathode/control-grid gap of the electrometer valve B. The consequent change in the anode current of B is measured by a compensation method, the circuit being derived from the well-known modulation-measuring (" impulse-meter ") circuit.

The duration of the surge must be considerably greater than the time constant of the condenser c, and the grid/cathode insulation of the electrometer valve must be so good that the anode-current change can be carefully measured. A special " low grid current " tetrode (Vatea EM 430) developed by Patai was used: it has particularly uniform emission and very high insulation (Fig. 2). Specimen results are given for various types of cathode, and the final section deals with work in plotting Richardson-constant curves for tungsten and alkali-earth oxides over a wide temperature range.

3909. On the Design and Construction of Indirectly Heated Oxide Cathodes [for Thyratrons].—N. S. Ivanchenko, A. V. Jelehovsky, and E. M. Sinelnikov. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 5, 1935, pp. 101–108.)

The development was undertaken mainly with a view to establishing the fundamental principles of design of such cathodes, since there is very little information published on the subject. The cathode developed consists essentially of a nickel cylinder containing a tungsten heater and is surrounded by two further cylinders which prevent excessive loss of heat by radiation. The advantages of this type of cathode are stated in detail, and a method is indicated for calculating the required heating power for a predetermined strength of the emission current. A description is given of the apparatus used for measuring the emission coefficients of pure and oxide-coated nickel surfaces for various temperatures, and the results obtained are shown in a number of tables and curves. Several thyratrons using these cathodes were constructed for various currents varying from 0.5 to 10 amperes.

3910. Cathode-Ray Oscillography of Gas Adsorption Phenomena. I.—A Method for Measuring High-Velocity Approach to Certain Physical and Chemical Equilibria: II.—Durations of an Adsorbed State of Oxygen on Tungsten.—M. C. Johnson and F. A. Vick. (*Proc. Roy. Soc.*, Series A, 2nd Sept. 1935, Vol. 151, No. 873, pp. 296–307: 308–316.)

Part I: Oscillograms of the progress of gas reactions which modify the electron emission from a solid surface are obtained by connecting the plates of a cathode-ray oscillograph across a resistance carrying a thermionic current. A special time base using a pentode is described, with circuit diagram; " a theoretical and experimental analysis is made of the transient thermal and pressure instabilities which occur when gas is admitted to a high vacuum or the temperature of a solid suddenly raised." Illustrative oscillograms of the behaviour of oxygen at a tungsten surface are given. Part II. The average lengths of time between deposition and re-evaporation of oxygen on tungsten at given high temperatures are determined. There is a linear relation between the logarithm of these time intervals and reciprocal temperatures, from which the heat of evaporation is deducible. This is raised by ageing of the tungsten and lowered by contamination with certain added vapours.

3911. Thermionic Emission from Platinum in Atmospheres of Chlorine and Bromine.—S. Kalandyk. (*Acta Phys. Polonica*, Vol. 3, 1934, pp. 165–178: in German.) For previous work *see* Abstracts, 1930, p. 161, and 1931, p. 270.

3912. The Relation between the Electron Field Emission and the Work Function of Liquid Mercury [Variation of Field with Work Function more Pronounced than That Forecast by Fowler-Nordheim Theory].—L. R. Quarles. (*Phys. Review*, 1st Aug. 1935, Series 2, Vol. 48, No. 3, pp. 260–264.) A summary was referred to in 1899 of June.

3913. A New Material with Applications in Radioelectricity: Colloidal Graphite in Water [" Aquadag "].—P. Vincent. (*L'Onde Élec.*, August, 1935, Vol. 14, No. 164, pp. 547–550.) *Cf.* 3472 of October.

DIRECTIONAL WIRELESS

3914. Simultaneous Speech and Directional Signals from Pittsburg Radio Beacon.—(*Engineer*, 30th Aug. 1935, p. 219.)

" In bad weather a pilot can hold his machine on the beam by means of a dash-board indicator, whilst receiving aural instructions. . . ." The interlocking " a " and " i " signals are more easily distinguishable than the usual " a " and " n." The transmission " registers on a d.f. needle without the fluctuation which is inevitable with the standard beam signals."

3915. An Ultra-Short-Wave Loop Transmitter [and Its Advantages for Aircraft].—King. (*See* 3832 and 3833.)

3916. Sender Arrangement for Blind Landing of Aircraft [Rays reflected from Mirror on Ground give Path for Landing].—A. Leib. (German Pat. 608 440: *Hochf:tech. u. Elek:akus.*, July, 1935, Vol. 46, No. 1, p. 36.)

ACOUSTICS AND AUDIO-FREQUENCIES

3917. Iron-Cored Resonance Coils for Audio-Frequencies [Measurements of Logarithmic Decrement for Various Core Materials.]—K. Dannehl and P. Kotowski. (*E.N.T.*, July, 1935, Vol. 12, No. 7, pp. 200–204.)

Measurements are given of the minimum attainable logarithmic decrements for some small iron-cored coils. The circuit used is shown in Fig. 1 and the coils in Fig. 2; the results are shown in Fig. 3, which gives the "relative resistance" (*i.e.* the ratio of iron loss resistance to inductance of coil: H. Jordan, *E.N.T.*, Vol. 1, p. 7, 1924) as a function of frequency for various core materials. Fig. 4 shows the logarithmic decrement as a function of frequency; this could be made less than 0.05 throughout almost the whole range of audio-frequencies. The steepness of the separate hysteresis loops, and thus the inductance, decreases as pre-magnetisation increases (Fig. 5). The temperature coefficient of permeability was also measured (Fig. 6); the permeability decreases with the temperature. It is found that an air gap may be necessary, not only to decrease the damping and the effect of pre-magnetisation, but also the temperature coefficient of inductance.

3918. A New Filter Speaker [Loudspeaker with Mechanical Resonator giving Very Sharp "Peaking" at 1 000 c/s: for Telegraphy Reception.].—(*QST*, September, 1935, Vol. 19, No. 9, pp. 80 and 82.)

3919. A Common Defect in Cone Loudspeakers [Sub-harmonic Oscillation]. — G.W.O.H.: Schaffstein. (*Wireless Engineer*, September, 1935, Vol. 12, No. 144, pp. 469–470.) Discussion of §IV of Schaffstein's paper (3081 of September).

3920. Loudspeaker Baffles [Fundamental Principles].—N. W. McLachlan. (*Wireless World*, 13th Sept. 1935, Vol. 37, pp. 296–299.)

3921. Motional Impedance [and Its Effect on Loudspeaker Performance].—F. R. W. Strafford. (*Wireless World*, 6th Sept. 1935, Vol. 37, pp. 285–286.)

3922. The Permanent Magnet Industry.—(*Wireless World*, 16th Aug. 1935, Vol. 37, pp. 204–205: conclusion.) *See* 3480 of October.

3923. An Experimental Determination of the Frequencies of Free Circular Plates [of Various Diameters and Thicknesses: Determination of Velocity of Sound in Material available in Small Quantities].—A. B. Wood. (*Proc. Phys. Soc.*, 1st Sept. 1935, Vol. 47, Part 5, No. 262, pp. 794–799.)

3924. Crystal Microphone Design for Single-Direction Pick-Up [Brush UD-3 Unidirectional Type].—A. L. Williams and J. P. Arndt. (*Electronics*, August, 1935, pp. 242–243.)

3925. An Interference Light Relay [forming an Optical Microphone].—von Ohain. (*See* 3981.)

3926. Theory of the Propagation of Acoustic Oscillations in Granular Substances and Experimental Investigations on Carbon Powder [Influence of Mechanical Resonance of Carbon Powder on Microphone Behaviour].—G. Hara. (*E.N.T.*, July, 1935, Vol. 12, No. 7, pp. 191–200.)

The first, theoretical part of this paper contains an investigation of the propagation of sound in granular substances. §1A. A sound wave is assumed to enter the substance from a plane oscillating membrane (Fig. 1); the grains are supposed to be uniformly arranged spheres (Fig. 2) of diameter small compared to the acoustic wavelength. Fig. 3a shows the scheme by which the sound is propagated and Fig. 3b the electrical analogy, a low-pass filter. The velocity of propagation (eqn. 9) for frequencies lower than the cut-off is found; consideration of the elastic properties of the grains (Fig. 4) leads to eqn. 15 for the velocity of propagation, which depends on the size of the grains, the mechanical pressure, and the elasticity and density of the granular material. Closer packing of the grains (Fig. 5) gives eqn. 19 for the velocity of propagation. This is found to increase with the packing density, the pressure, and the square root of the grain radius, but to decrease with increasing frequency. Eqns. 20a and 21a give the mean values of the velocity over the whole granular column for loose and close packing respectively.

§1B contains a calculation of the acoustic impedance and attenuation, using the analogy of cable theory; §1C discusses the effect of the air enclosed on the mechanical impedance of the grains when the sound passes (1) through the grains and (2) through the air (eqns. 30, 31 resp.).

Part II describes experiments for the measurement of the acoustic impedance. §11A gives the experimental arrangement and method of measurement; a loudspeaker is used as the source of sound and an a.c. bridge measures the electrical impedance of the loudspeaker coil when different amounts of carbon powder are placed on the membrane, at various frequencies. Measurements with and without field excitation give the reaction of the membrane movement, referred to the coil impedance. The results are discussed and shown in diagrammatic form (§ 11B); Fig. 6 gives the coil impedance of the driving system with and without field excitation, as a function of frequency, Fig. 7a the circle diagram of the electrical reaction of the membrane motion, Fig. 7b the corresponding resonance curve, Fig. 8 the circle of Fig. 7a for different thicknesses of the carbon layer (numerical data Table 1), Fig. 9 the effective mechanical impedance and the resonance frequency of the membrane as a function of the layer thickness, Fig. 10 the same quantities for large grains. The acoustic impedance, the attenuation and the velocity of sound are calculated from the results. It is found that carbon microphones show marked effects of the mechanical resonance of the carbon powder; this explains Madia's results (468 of February).

Oscillograms of propagation of sound are given in §11C, Fig. 11; Fig. 12 shows the time of travel of an oscillation to different distances in the carbon powder, deduced from the oscillograms. A value for the velocity of sound is thus obtained which is in good agreement with theory and with the experimental value previously obtained. §11D finally discusses shortly the behaviour of the powder as a porous material: this was investigated with a Kundt's tube apparatus.

3927. ELEMENTARY RULES FOR THE CALCULATION OF THE LENS-AND-SLIT COMBINATIONS, ESPECIALLY FOR SOUND-ON-FILM AMPLITUDE RECORDING.—P. Hatschek. (*Funktech. Monatshefte*, August, 1935, No. 8, Supp. pp. 56–58.)

3928. THE SOUND FILM [Survey, chiefly the Klangfilm Sound-on-Film System].—von Lölhöffel. (*Telefunken-Zeit.*, August, 1935, Vol. 16, No. 71, pp. 5–16: to be continued.) The present instalment deals with the taking of the film.

3929. A SOUND-ON-FILM REPRODUCING UNIT FOR USE WITH A BROADCAST RECEIVER.—E. Nesper: Arndt. (*E.T.Z.*, 5th Sept. 1935, Vol. 56, No. 36, p. 996.)

The small barrier-layer cell is so placed that the light ray strikes the sensitive layer *edgeways*: this allows the optical arrangements to be simplified and cheapened. The cell is so comparatively efficient that no pre-amplification is required for ordinary use, though a single stage is actually provided for reproduction in very large rooms or in the open air.

3930. ELECTROGRAPHY, A NEW ELECTROSTATIC RECORDING PROCESS [applicable to Sound Recording].—Selényi. (*See* 3983.)

3931. HOME RECORDING OF GRAMOPHONE RECORDS AT THE BERLIN RADIO SHOW.—(*Radio, B., F. für Alle*, September, 1935, pp. 156–157.) Including the AEG "Magnetophone," using 6.5 mm film with iron coating; also "Alupliaphone" discs, kept soft until recorded and then dried out.

3932. A NEW WAX FOR ELECTRICAL TRANSCRIPTIONS [Gramophone Recording: "Velvalac"].—(*Rad. Engineering*, August, 1935, Vol. 13, No. 8, p. 24.)

3933. THE IMPROVEMENT OF QUALITY IN THE ELECTRICAL REPRODUCTION OF GRAMOPHONE RECORDS: PART II.—Kalmeijer. (*Radio-Centrum*, 30th Aug. 1935, pp. 305–307.)

3934. A CLASS B AMPLIFIER FOR 800 WATTS SPEECH OUTPUT [in Tempelhofer Field Installation].—(*Funktech. Monatshefte*, August, 1935, No. 8, pp. 318–319.)

3935 GRID-COMPENSATED POWER AMPLIFIERS: THE OPTIMUM WORKING CONDITIONS.—W. Baggally. (*Wireless Engineer*, September, 1935, Vol. 12, No. 144, p. 496.) Further development of the work dealt with in 1933 Abstracts, pp. 217–218.

3936. LOST MILLIWATTS.—M. S. Graham. (*Wireless World*, 16th Aug. 1935, Vol. 37, pp. 193–194.)

It is shown that non-uniform amplifier characteristics are responsible for more than distortion; even if the departure from the ideal "straight-line" response curve is too small to be appreciable by ear, it will considerably reduce the average output otherwise obtainable.

3937. FREQUENCY AND PHASE DISTORTION [and the Use of L.F. Retroaction].—Tanasescu: Marinesco. (*See* 3829.)

3938. ON ACOUSTIC "ROUGHNESS" [due to Non-Linear Distortion].—G. von Békésy. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 16, 1935, pp. 276–282.)

Author's summary:—As a foundation for the investigation of the sensation of roughness produced by non-linear distortion, the roughness of beating and modulated notes is first examined, and it is shown that the strength of the roughness can be measured by comparison with a "standard" roughness. [Thus a 200 c/s note completely modulated at 50 c/s, and a 500 c/s note modulated at 90 c/s just deeply enough to produce a noticeable roughness, were compared, the former being weakened until its roughness was equal to that of the latter; this adjustment to equal roughness was not rendered difficult by the large difference in the two strengths. A "standard" roughness was produced by beating a 3000 c/s note with an equally strong 3050 c/s note, and comparison of this roughness with the two equalised roughnesses agreed, as a rule, within 3 db].

The roughness of musical sounds was then measured, for varying ratios of the frequencies of the fundamental notes, and the results compared with Helmholtz' calculation (Fig. 5). The roughness of a pure note was also measured. [A pure note of even 1 000 c/s appears less "smooth" than one of 3 000 c/s, and notes below 300 c/s show a distinct roughness—Fig. 6]. It is shown that the fatigue effects of rough notes are as a rule very slight (Fig. 7), and it is suggested that for this reason rough notes might well be used as standards of loudness, to avoid the discrepancies arising, with most observers, as a result of such effects.

3939. CHARACTERISTICS OF VIOLIN TONE [with Oscillograms: Effect of Varnish].—C. E. S. Phillips. (*Nature*, 7th Sept. 1935, Vol. 136, pp. 362–363: Note on Royal Institution discourse.)

3940. ON THE EFFECT OF SURROUNDING SOLID MATTER ON THE OSCILLATING AIR CURRENT [Influence of Materials on Wind Instruments].—K. V. Struve. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 5, 1935, pp. 88–100.)

The main object of this theoretical and experimental investigation was to find the absorption of sound energy due to the following factors:—(a) elasticity of material, (b) thickness of material, (c) quality of the inner surface, and (d) vibration of the instrument at the resonant frequency. The results of the investigation are as follows:—(a) Materials with elasticity of the order of

10^5 kg/cm^2 can be regarded as non-absorbent of sound energy. (b) The thickness of material within wide limits has no effect on the properties of the instrument. (c) The inner surface of the instrument should be made as smooth as possible. (d) A series of experiments were conducted with a trumpet but no vibration of the trumpet due to resonance was detected.

3941. REVERBERATION TIMES OF CONCERT HALLS AND ABSORPTION OF SOUND BY THE AUDIENCE.—E. Meyer and V. Jordan. (*E.N.T.*, July, 1935, Vol. 12, No. 7, pp. 213–220.)

A method of measurement of reverberation times and sound absorption has already been described (2006 of June) and curves of measured values of the absorption of sound in a small hall by different kinds of chairs (Fig. 2), and the additional absorption per person when they are occupied (Fig. 3), are here given. The apparatus used in a concert hall itself is shown schematically in Fig. 4. The sound is received through a microphone, amplified, and passed through a band filter in a bridge circuit (Fig. 5) to cut out a desired frequency range. The amplifier and the rectifier with logarithmic regulation (*loc. cit.*) then follow; the reading of the output milliammeter is recorded by phosphorescence on a rotating drum and the slope of the decay curve measured. Fig. 6 shows the frequency curves of the apparatus including the filter. The apparatus was tested by two methods in a small hall with satisfactory agreement (Fig. 7); Fig. 8 shows examples of records obtained during actual concerts. Fig. 9 shows records of the reverberation of a revolver shot in two empty concert halls; the same measured values are given by an impulse as when a continuous tone suddenly ceases.

Experiments in the Philharmonic Hall and the State Opera House, Berlin, are then described. Table 1 gives measurements of reverberation times; Fig. 10 shows them as a function of frequency, with the hall (a) full and (b) empty. Fig. 11 shows the additional absorption of sound per person when the hall is (a) full and (b) half empty. The additional absorption at low frequencies is very small and may even become negative. Fig. 12 gives reverberation-time curves for the State Opera House; the reverberation times are small compared with those of a concert hall. Fig. 13 shows curves for other buildings, measured from gramophone records taken there or from broadcasts from the building, as received in Berlin. It is found throughout that the reverberation time increases as the frequency decreases; the reverberation times of actual concert halls are never independent of frequency.

3942. DRAMATIC USE OF CONTROLLED SOUND [and the Hoboken "Sound Show" Demonstrations].—N. Urguhart. (*Electronics*, August, 1935, pp. 252–253.) *Cf.* 3484 of October.

3943. ON THE LIMITS OF THE ANALYSING SPEED FOR FREQUENCY MIXTURES, *and* ON A RECORDING FREQUENCY ANALYSER [2–8 Minutes per Record].—C. H. Walter: Walter and Freystedt. (*Wiss. Veröff. Siemens-Konzern*, No. 1, Vol. 14, 1935, pp. 56–62: 63–77.)

3944. A RECORDING, MEASURING AND CONTROL APPARATUS OF MANY USES FOR ELECTROACOUSTICAL PURPOSES.—H. J. von Braunmühl and W. Weber. (*E.N.T.*, August, 1935, Vol. 12, No. 8, pp. 223–231.)

Apparatus with logarithmic scales is desirable in electroacoustics and previous designs have been referred to in Abstracts, 1934, p. 212 (Ballantine); 1932, p. 352 (Stanton and Tweeddale); 2006 of June; and 1103 of April. The apparatus here described is said to be of simple construction, to be very reliable and easily transportable; it is an amplifying arrangement whose output is automatically adjusted to a constant value by the input potentiometer; the position of the latter measures the magnitude of the input voltage. Photographs are given in Fig 1, and Fig. 2 shows the scheme in principle, with its magnetic coupling, controlled potentiometer, and recording and amplifying arrangements. Its construction is described in §2; Fig. 3 gives a view of the potentiometer, which can easily be changed for another giving a different range. In §3 the measuring ranges and the rapidity of response of the apparatus are discussed; Fig. 4 shows records of audio-frequency impulses. The registration is aperiodic. The mode of control of the input voltage of an ordinary loudspeaker to radiate a constant amount of acoustic energy at all frequencies is also discussed. Examples of the measurements which can be made with the apparatus are given in §4: Fig. 5 shows loudspeaker frequency curves, measured with pure sinusoidal tones; Fig. 6 gives the frequency curve of a working condenser microphone, Fig. 7 records of reverberation time in a room with very little damping, Fig. 8 a record of speech vibrations, Fig. 9 one of the intensity of noise disturbances, and Figs. 10 and 11 records of the ratio between the highest and lowest values of sound intensity ["Durchmodulation"] throughout a speech in rooms with different degrees of damping, for different frequencies.

3945. A CORRECTION TO THE THEORY OF THE RAYLEIGH DISC AS APPLIED TO THE MEASUREMENT OF SOUND-INTENSITY IN WATER.—A. B. Wood. (*Proc. Phys. Soc.*, 1st Sept. 1935, Vol. 47, Part 5, No. 262, pp. 779–793.)

3946. AN ELECTROSTATIC AUDIO GENERATOR [Multi-Harmonic: with Shielded Segmented Disc rotating near Stationary Wave-Pattern Plate: for Various Applications].—E. B. Kurtz and M. J. Larsen. (*Elec. Engineering*, September, 1935, Vol. 54, No. 9, pp. 950–955.) *Cf.* 3098 of September.

3947. THE [Audio] TEST-FREQUENCY GENERATOR TMM 33 OF THE GERMAN POST OFFICE.—K. Gunther. (*T.F.T.*, June, 1935, Vol. 24, No. 6, pp. 142–146.) Driven by a synchronous motor, the machine gives 20 frequencies (150–4 800 c/s).

3948. NOISE MEASUREMENT: THE CASE OF ROTATING ELECTRICAL MACHINERY.—B. B. Ray. (*Electrician*, 23rd Aug. 1935, pp. 219–222.)

3949. ON THE QUANTITATIVE APPRECIATION OF THE LOUDNESS OF SOUND.—S. N. Rjevkin and A. V. Rabinovich. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 5, 1935, pp. 75–87.)

A critical survey is given of the methods used by various authors to establish a quantitative relationship between changes in the intensity of sound (in db) and the corresponding sensations of loudness. This is followed by an account of experiments which were carried out by the author with the same object in view. The main conclusions reached are as follows :—

1. Fatigue of the ear, when the original sound lasts for more than about one second, reduces the changes in the intensity of sound required to produce the same effect. This phenomenon was not taken into account by other authors. 2. Only comparatively small changes in loudness (2, 3 or 4 times) are judged with certainty by an average person. 3. When an increase in loudness is followed by an equal decrease, the original level of sound is not reached : there is a certain hysteresis of loudness.

4. For a frequency of 1000 c/s and changes between the levels of 35 and 100 db, the following relationship exists :—$\log G = 0.0218 L + K$, where L is the level of sound in db, G the loudness in certain units, and K a constant depending on these units. 5. The results obtained approximate those given by Laird, Taylor & Wille (Abstracts, 1932, p. 352), but show a divergence from the investigations of Fletcher & Munson (1934, p. 99).

3950. SUPERSONIC WAVES IN INDUSTRY.—(*Funktech. Monatshefte*, August, 1935, No. 8, pp. 289–290.)

3951. SOME EXPERIENCES IN THE CONSTRUCTION OF AN EQUIPMENT FOR THE GENERATION OF SUPERSONIC WAVES.—M. von Ardenne. (*Funktech. Monatshefte*, August, 1935, No. 8, pp. 285–288.)

3952. A NEW METHOD OF MEASURING THE ELASTIC CONSTANTS OF TRANSPARENT ISOTROPIC SOLIDS [by Supersonic Waves].—Hiedemann and Hoesch. (*Naturwiss.*, 16th Aug. 1935, pp. 577–578 : *Nature*, 31st Aug. 1935, Vol 136, p. 337.)

3953. A NEW PRECISION METHOD OF DETERMINING THE ELASTIC CONSTANTS OF ISOTROPIC TRANSPARENT SOLID BODIES [by Measurements of Supersonic Wave Grating].—E. Hiedemann. (*Zeitschr. f. Physik*, No. 3/4, Vol. 96, 1935, pp. 273–276.)

3954. MAKING STANDING SUPERSONIC WAVES VISIBLE IN TRANSPARENT SOLID BODIES. II. OPTICAL INVESTIGATIONS WITH A GLASS BLOCK.—E. Hiedemann and K. H. Hoesch. (*Zeitschr. f. Physik*, No. 3/4, Vol. 96, 1935, pp. 268–272.) *See* also 3544 of October and many other past abstracts. Direct measurement of constants of supersonic wave grating : measurements with polarised light show that observed grating distances depend on position of plane of polarisation of light incident on block : transverse oscillations.

3955. LOCATING WRECKS [by Supersonic Sounding]. —(*Wireless World*, 20th Sept. 1935, Vol. 37, pp. 326–327.)

3956. PIEZOELECTRIC QUARTZ CRYSTALS WITH FREQUENCIES DOWN TO 86.6 c/s.—Gruetzmacher. (*See* 4016.)

3957. ON THE ACOUSTICS OF THE ATMOSPHERE [and the Maximum-Range Formula allowing for Refraction].—Gutin. (*See* 3769.)

PHOTOTELEGRAPHY AND TELEVISION

3958. THE FACTORS INFLUENCING PICTURE QUALITY [and Their Estimation].—R. Thun. (*Funktech. Monatshefte*, August, 1935, No. 8, Supp. pp. 54–55.)

The first 3 curves show the variation of the percentage of pictures (of a number of different kinds) which can be viewed satisfactorily as the conditions are changed as regards number of lines (Fig. 1), brightness of illumination (Fig. 2), and contrast (Fig. 3 : based on Goldberg's results). In Fig. 1 there is a pronounced bend at about 60 lines and another at 240. Fig. 4 shows the variation of flicker as the number of brightness-changes per second is increased from 10 to 80, for values of illumination from 1.5 to 200 lux. This diagram is based on the results of Marbe and of Porter and Arndt, and on the writer's own tests ; the lower bend represents the point when the flicker quickly tires the eyes, the upper bend the point where there is still an appreciable flicker which, however, does not tire the eyes after prolonged watching. Fig. 5 represents the variation of the quality of motion-reproduction as the framing frequency is increased : it shows that at 50–60 per sec. all ordinary motions are reproduced naturally if the illumination time is equal to the framing time, as it is, for instance, in the iconoscope. Fig. 6 shows the quality of motion-reproduction as a function of the "framing-numbers ratio" (ratio of recording framing frequency to reproducing framing frequency). Reproduction is natural if this ratio is 1 : 1, but the "hump" is fairly broad. If the scenes change so rapidly that the picture content has to be taken in as a whole, and there is no time to examine details, a picture angle of 12–24° is suitable (curve "Film" of Fig. 7). If there is time (as in a stage play) to examine the scene bit by bit, the angle must be much greater (curve "Bühne" of Fig. 7). For television the former condition should apply. Fig. 8 is meant to show how the effectiveness of a picture varies with its size if the picture angle is kept constant. The improvement for the larger sizes is chiefly due to the fact that at the correspondingly longer distances the conditions for the eyes are better as regards the plastic effect.

3959. THE PHYSIOLOGICAL ASPECT OF CONTRAST DISTRIBUTION IN TELEVISION IMAGES.—P. Hatschek. (*Funktech. Monatshefte*, August, 1935, No. 8, Supp. pp. 58–59.)

Comparison of the television difficulty, that the contrast range of the image is much smaller (in many cases) than the contrast range of the subject, with the well-known problem in photography due to the different contrast ranges of negative and positive materials, leads to the following "pointer" for the television engineer :—the subjectively best results for the observer will be obtained if amplifier technique is so used that the image characteristic is not linear but has such a double curvature (Fig. 5) that its slope is steep at low and high illuminations and flatter at medium illuminations.

3960. An Experimental Determination of the Visual Thresholds at Low Values of Illumination.—Conner and Ganoung. (*Journ. Opt. Soc. Am.*, September, 1935, Vol. 25, No. 9, pp. 287–294.)

3961. Scanning-Aperture Distortion [Phase Distortion as well as Amplitude Distortion : Mathematical Analysis].—E. E. Wright. (*Journ. Television Soc.*, June, 1935, Series 2, Vol 2, Part 2, p. 32.)

3962. "Influence of a Screen surrounding a Telephone Circuit. . . ." : Errata.—Fargeas. (*Rev. Gén. de l'Élec.*, 10th Aug. 1935, Vol. 38, No. 6, p. 208.) *See* 3584 of October.

3963. Dissipation in Phase-Compensating Networks.—Starr. (*See* 3817.)

3964. The Status of Television in Europe.—A. W. Cruse. (*Elec. Engineering*, September, 1935, Vol. 54, No. 9, pp. 966–969.)

3965. High-Definition Television Service in England : Views on the Two Standards of Definition.—(*Journ. Television Soc.*, June, 1935, Series 2, Vol. 2, Part 2, pp. 34–43.)

Giving the views of von Ardenne, Gardiner, Lance, Traub and Wikkenhauser on the decision to have "interlaced" scanning transmissions as well as "straight."

3966. Time Bases and Interlaced Scanning : the First Published Details.—J. McPherson. (*Television*, September, 1935, Vol. 8, No. 91, pp. 505–506.)

3967. Reception of the B.B.C. 30-Line Television Transmissions in Madeira [and the Effects of Two Types of Atmospherics].—W. L. Wraight. (*Journ. Television Soc.*, June, 1935, Series 2, Vol. 2, Part 2, pp. 25–28.)

3968. Two-Way Television by the State Post Office.—G. Weiss. (*Funktech. Monatshefte*, August, 1935, No. 8, Supp. pp. 53–54.)

3969. The Ultra-Short-Wave Television Transmitter at Berlin.—R. Möller. (*Television*, September, 1935, Vol. 8, No. 91, p. 532–533.) Summary of the article referred to in 2332 of July.

3970. "Fernsehen und Bildfunk" [Television and Phototelegraphy. Fundamental Principles and Present Position : Book Review].—R. Thun. (*E.T.Z.*, 15th Aug. 1935, Vol. 56, No. 33, p. 931.)

3971. The Position of Television Development in France.—(*Funktech. Monatshefte*, August, 1935, No. 8, Supp. pp. 59–60.)

3972. Television Experiments [High-Definition Experimental Transmitter].—J. H. Reyner. (*Wireless World*, 20th Sept. 1935, 37, p. 331.)

3973. The Farnsworth Receiver.—Farnsworth. (*Television*, September, 1935, Vol. 8, No. 91, pp. 528 and 530.)

3974. A Simple Explanation of the Iconoscope.—Zworykin. (*Television*, September, 1935, Vol. 8, No. 91, pp. 507–509.)

3975. The Paraxial Equations of Electron Optics.—L. C. Martin. (*Journ. Television Soc.*, December, 1934, Vol. 1, Part 12, pp. 377–383.)

3976. Important Scophony Developments : First Details of the Scophony Double-Image Kerr Cell : the TeKaDe Mirror Screw.—(*Television*, September, 1935, Vol. 8, No. 9, pp. 502–503 and 504.)

3977. Kerr Cell Design for High Definition.—L. M. Myers. (*Journ. Television Soc.*, June, 1935, Series 2, Vol. 2, Part 2, pp. 29–31.) *See* 1977 of June and 3573 of October.

3978. The Electrical Kerr Effect in Nitro-Compounds [and the High Value in Orthonitroaniline].—C. Zakrzewski. (*Acta Phys. Polonica*, Vol. 3, 1934, pp. 291–295 : in German.)

3979. The Pockels Effect [and Its Application to the Crystal Light-Modulating Cell : Comparison with Kerr Cell : Mathematical Analysis of Harmonic Distortion].—E. E. Wright : Okolicsanyi. (*Journ. Television Soc.*, June, 1935, Series 2, Vol. 2, Part 2, p. 33.)

It is the relative phase retardation between ordinary and extraordinary rays that is proportional to the voltage in the Pockels effect and to the square of the voltage in the Kerr effect ; *not* the change of illumination, as assumed in papers on Okolicsanyi's work. The harmonic distortion due to the curvature of the characteristic is therefore not zero. For the papers quoted on the corresponding analysis of the Kerr cell *see* Abstracts, 1932, p. 288 (Narath) and 1933, p. 512 (Wright).

3980. Recent Developments in Light-Valves for Television [Zinc Sulphide Cells and the Question of Their Linear Response : the Colloid Cell and the Suitability of "Oildag"].—(*Rad. Engineering*, August, 1935, Vol. 15, No. 8, p. 21.)

3981. An Interference Light Relay for White Light [Pressure Variations transformed directly into Light Variations : Use as Optical Microphone and Electrical Apparatus for Light Control].—H. J. Pabst von Ohain. (*Ann. der Physik*, Series 5, No. 5, Vol. 23, 1935, pp. 431–441.)

Periodical variations of pressure have hitherto been converted into light variations (*e.g.* in sound-films) by using as an intermediate stage the variations of an electric current. This stage is cut out in the light relay here described (§ 2) which is, optically considered, an interferometer with absolutely symmetrical ray paths (Fig. 1). The incident beam of light *E* falls on the semi-transparent glass plate *II* and is divided at *e* into two half-beams of equal intensity. These join again at *a* and the issuing complete beam *A* is measured by a photocell. The interference band of zero order can easily be adjusted and the apparatus can therefore be used with white light. The plate *III* is the movable one which is subjected to the pressure variations; its zero position is chosen as the one which gives the mean brightness in the transition from the centre black spot to the first bright maximum in the interference band system. The variations of light intensity are proportional to the displacements of *III*; these however must not exceed a value of $\lambda/10$ (measurements in § 3). In the experiments described, frequency independence was attained throughout the range 10–10^4 c/s; the interferometer and photocell together were thus equivalent to a microphone free from selectivity in this range. The technical construction of the interferometer for this purpose is described (Fig. 2). In § 3 the theory is discussed and a series of measurements is shown in Fig. 4 (scheme of apparatus, Fig. 3) which shows the illumination of the field of view (measured by the photocell current) as a function of the path difference between the interfering beams. Fig. 5 gives a comparison of the characteristic curve of the light relay with that of a Kerr cell; the latter does not give such a high degree of linearity as the light relay, the output ratio of both being 10 : 1.

In § 4 the effect of varying the frequency is investigated; Fig. 6 shows a comparison of the frequency characteristic of the light relay (*J.L.*) with that of various microphones. § 5 describes the apparatus used in this investigation; Fig. 7 shows (a) the optical siren which gave sinusoidal voltage variations of constant amplitude and variable frequency, and (b) the transference of these to the light relay through a condenser telephone. The theoretical bases for the independence of frequency are discussed in § 6.

3982. POSSIBILITIES OF FURTHER DEVELOPMENT IN PICTURE TELEGRAPHY. PART 2.—F. Schröter. (*Telefunken-Zeit.*, August, 1935, Vol. 16, No. 71, pp. 17–36.)

For Part 1 *see* 2732 of August. The present part includes discussions of synchronising methods; "time modulation" (particularly the Alexanderson system) giving half-tone pictures in spite of short-wave fading; frequency modulation, for the same purpose; and the "harmonic canal" process suggested by Stahl and Lockemann (*see* Part 1, *loc. cit.*, and 1982 of June); the problem of increasing the speed of transmission (particularly the Thun variable-velocity principle to avoid waste of time over the blank spaces: the use of amplitude filters to eliminate the speed-reducing effect of echoes: the author's "detuning" method: cathode-ray method); and systems for simultaneous picture and telegraphy transmissions.

3983. ELECTROGRAPHY, A NEW ELECTROSTATIC RECORDING PROCESS AND ITS APPLICATIONS [to Picture Telegraphy, etc.]—P. Selényi. (*E.T.Z.*, 29th Aug. 1935, Vol. 56, No. 35, pp. 961–963.)

An oxide-coated platinum filament in open air emits an ion stream which passes through the aperture in a metal screen (some tenths of a millimetre distant) on to the insulating coating of a moving metal anode (*e.g.* a metal drum coated with ebonite). The perforated metal screen also acts as the control grid or Wehnelt cylinder. The anode potential is 500–1 000 v. The record is made visible by a fine powder sprayed over the insulating coating: if lycopodium powder is used, the line thickness can be as little as 0.03 mm. An interval of 5–10 minutes may elapse before the powder is sprayed on. Examples are given of picture and facsimile recording and of sound recording. In the latter, no amplification is needed for the microphone currents, since the ion-stream modulation requires only a few volts.

3984. AMPLIFICATION OF PHOTOCURRENTS BY THE EMISSION OF SECONDARY ELECTRONS [from a Third Electrode of Same Material as Cathode].—F. M. Penning and A. A. Kruithof. (*Physica*, August, 1935, Vol. 2, No. 8, pp. 793–804: in German.)

A "secondary-emission" photocell of the vacuum class, with a grid-type anode between the cathode and the third electrode, gives a current multiplication of about 7, and shows a practically constant dynamic response to light variations up to at least 20 kc/s. A gas-filled "secondary-emission" cell at very low gas pressures gives very large amplification (the effect is ascribed to the to-and-fro motion of the secondary electrons) which is, however, very sensitive to slight changes in working conditions. Deterioration of the cathode by ion bombardment, in such a cell, may be decreased by the use of a fourth electrode (*H* in Fig. 2, Type IV).

3985. A MULTI-STAGE PHOTOCELL CURRENT AMPLIFIER [Difficulties avoided by Superposing A.C. Potential at Grid of First Valve].—W. Richter. (*Electronics*, August, 1935, pp. 245 and 247.)

3986. THE MEASUREMENT OF THE TIME LAG OF THALOFIDE [and Other] PHOTOCELLS.—V. Balakov. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 5, 1935, pp. 109–117.)

A method was developed by the State Optical Institute of Leningrad for measuring the time lag of photocells without the use of amplifiers. This method enables oscillograms to be plotted of the current flowing through the cell when the light falling on it is interrupted 200 times per second. The method employed for taking these oscillograms is similar to that proposed by Bonn for studying the current curve of a 1 000-cycle alternator (Abstracts, 1929, pp. 163–164) and is based essentially on making instantaneous electrical contacts at exactly the same phase of every cycle.

A description of the experiments is given and the necessary corrections for taking into account the inertia of the measuring apparatus are discussed. It was found that the time lag of thalofide cells for a rising current varies from 2.5×10^{-4}

to 7×10^{-4} second, while the corresponding values for a falling current are about 1.5 times higher. These figures show a considerable discrepancy when compared with the results obtained by Sewig (1930, p. 516). As was expected, no time lag was detected in the case of caesium vacuum cells, and similar results were obtained with argon-filled calcium cells. The accuracy of these measurements is within 5×10^{-5} sec.

3987. ON THE PHOTOELECTRIC EFFECT AT SELENIUM BARRIER LAYERS.—P. Görlich. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 16, 1935, pp. 268–271.)

So much of the research on barrier-layer processes has been carried out on copper-oxide cells (owing to the simpler conditions holding for these —such as the fact that the oxide does not occur in several modifications) that the writer has now investigated the processes in cells using selenium as the semi-conductor, taking into account the results already obtained by Barnard (2346 of July). He finds the following conditions for maximum current output:—The optimum thickness of the layer of semi-conductor is 0.08 ± 0.01 mm (Fig. 1). For pure selenium the best "forming" temperature is 218–219°C (Fig. 2). The barrier electrode must be a good conductor and transparent to light; if it is too thin it will have too high a transverse resistance, if too thick it will absorb too much light. For maximum current output a definite ratio of transparency to transverse resistance must be satisfied. Silver foils, of the same order of thickness as the usual platinum barrier electrodes, show spontaneous transparency variations (Jagersberger, 1934 Abstracts, p. 515) connected with gas absorption, chemical changes, etc. These variations are accompanied by electrical changes, and it is possible that the ageing phenomena noticed with selenium cells are partly due to such changes.

It was also found that the barrier electrode should not make complete surface contact with the selenium layer, but should allow enclosed gas atoms to produce regions of high resistance. If the gas absorption at the selenium surface is reduced by heating the selenium while the barrier layer is being sputtered on to it, the current output is diminished. The effect of the absorbed gas varies with the nature of the gas: the highest current output was obtained when the sputtering took place in rarefied air (Fig. 3). Preliminary bombardment of the selenium surface by electrons did not improve results with all cells; but a few thus treated gave surprisingly high current output. Other results are discussed, such as the effects of roughening the surface of the carrier for the selenium layer.

3988. PHOTOELECTRIC CELLS WITH ARTIFICIALLY DEPOSITED BARRIER LAYER [Artificial Resin, MgO, or CaF_2 as Barrier Layer, with Selenium as Semi-Conductor].—van Geel and de Boer. (*Physica*, August, 1935, Vol. 2, No. 8, pp. 892–900: in French.) For papers by Jusé and by van Geel, on similar barrier layers in rectifiers, see 2048 of June and 1934 Abstracts, p. 106.

3989. THE TEMPERATURE DEPENDENCE OF THE PHOTOELECTRIC EFFECT [Calculation of Photoelectric Emission from Image Field Form of Surface Potential Barrier, for Frequencies near the Threshold: Comparison of Resulting Formula with Previous Formulae: Discussion of Methods of Threshold Determination].—K. Mitchell. (*Proc. Camb. Phil. Soc.*, July, 1935, Vol. 31, Part 3, pp. 416–428.) For previous work *see* 230 of January.

3990. SOME REMARKS ON THE ENERGY LEVEL SCHEME OF THE ELECTRONS IN CRYSTALS [NaCl, KCl, Diamond: Levels deduced from Optical and Internal and External Photoelectric Effects].—P. Tartakowsky. (*Zeitschr. f. Physik*, No. 3/4, Vol. 96, 1935, pp. 191–197.)

3991. THE REFLECTION OF SOME METALS [Cu, Zn, Ni, Ag, Hochheim's Alloy] IN THE SPECTRAL REGION 300–186 mμ [Short-Wave Ultra-Violet: Correlation between Selective Photoelectric Maxima and Optical Anomalies].—F. Hŭcka. (*Zeitschr. f. Physik*, No. 3/4, Vol. 96, 1935, pp. 230–235.) *See* also 1933 Abstracts, p. 335 (three), and 818 of March.

3992. A NEW VACUUM MONOCHROMATOR AND SPECTROGRAPH WITH QUARTZ OR FLUORITE OPTICAL PARTS FOR THE REGION 700 mμ to 160 mμ (QUARTZ) OR 700 mμ TO 130 mμ (FLUORITE) [of Possible Use in Photoelectric Investigations].—C. Leiss. (*Zeitschr. f. Physik*, No. 11/12, Vol. 95, 1935, pp. 778–780.)

MEASUREMENTS AND STANDARDS

3993. SIGNAL GENERATOR [and Associated Equipment] FOR RECEIVER MEASUREMENTS WITH THE CATHODE-RAY OSCILLOSCOPE.—G. Berger. (*Telefunken-Zeit.*, August, 1935, Vol. 16, No. 71, pp. 37–43.)

The apparatus embodies a number of new devices. Amplitude regulation is continuous between 1 and 100000 μV. The wave range of the generator itself is 18–2 500 m. Anode-voltage modulation is provided from 10 to 6 000 c/s, in two stages. The motor-driven "detuning" condenser (for resonance curve production) repeats the detuning process 10–20 times per second so as to give, by persistence of vision, a standing image on the screen: it is provided with an adjustable gap between rotor and stator plates, so that over a frequency range of 120–1 500 kc/s it can give the same detuning, *e.g.* of 9 kc/s. The difficulties in the way of a satisfactory connection of this rotating condenser to the circuit condenser (slip-rings, mercury contacts, etc., all producing noises in the receiver) are overcome by the use of a capacitive coupling (rotating disc close to a fixed disc). The "orthodox" method of linking the detuning device to the cathode-ray time base, by a rotating potentiometer, is also discarded as unsatisfactory, and the cathode-ray deflection is controlled by way of a photocell whose illumination is varied (by a disc on the axle of the motor-driven condenser) so as to be proportional to the angle of rotation of the condenser. Special precautions are taken to prevent mains hum reaching the cathode-ray tube. This tube is of the television type with electron lens and electrostatic deflection; its anode voltage is 2 000 v. A number of resonance curves are given, illustrating the use of the apparatus; they are ordinary photographs of the screen images.

3994. Measurements of Loss in Coils at High Frequencies [Critical Discussion of Available Data: Methods of Measurement: Experimental Curves].—H. Schwarz. (*Hochf: tech. u. Elek:akus.*, August, 1935, Vol. 46, No. 2, pp. 50–55.)

A practical discussion of the data which are necessary for the characterisation of losses in h.f. coils, and of the material which is available in published papers and may be used for purposes of comparing the coils. The methods of measurement and the possible sources of error are reviewed and measurements on various coils are described and discussed. Curves are given of the logarithmic decrement of an oscillating circuit as a function of the frequency, with and without insulating materials giving dielectric losses (Fig. 3); of the h.f. resistance of a single-layer cylindrical coil, constructed (1) of solid wire and (2) of "litz" wire (Fig. 4); of the loss angle of single-layer coils of constant geometrical dimensions but constructed of wire of various thicknesses (Fig. 5); of the loss angle of porcelain coils as a function of frequency (Fig. 6); of the h.f. resistance of different "litz" coils as a function of frequency (Fig. 7)—here the relatively large rise in resistance at very high frequencies is thought to be due to the mutual action of the component wires in compressing the current into narrow surface channels; of the loss angle of coils as a function of the frequency for various coil-former materials, (1) "calan" and (2) pertinax (Fig. 8), and for coils with and without iron cores (Fig. 9). A list of literature references is appended.

3995. The Magnetic Force at a Point on Its Axis due to a Current in a Helical Coil of One Turn [Calculation].—G. F. C. Searle. (*Proc. Phys. Soc.*, 1st Sept. 1935, Vol. 47, Part 5, No. 262, pp. 900–903.)

3996. The Electrical Properties of Soil at Frequencies up to 100 Mc/s: with a Note on the Resistivity of Ground in the United Kingdom.—Smith-Rose. (*See* 3764.)

3997. A Highly Sensitive Instrument for Measuring Attenuation [of Oscillating Circuits].—O. Schütte and G. Weiss. (*E.N.T.*, July, 1935, Vol. 12, No. 7, pp. 204–210.)

The apparatus consists of a quartz-controlled emitter and a valve voltmeter as indicator. § 1 describes the method of measurement; the oscillating circuit whose attenuation is to be measured is coupled capacitatively to the emitter through a very small condenser, so that there is no reaction on the emitter (Fig. 1). The voltage across the oscillating circuit is measured with a valve voltmeter, used in an anode-rectification circuit. The circuit is tuned to resonance, the voltage and condenser value read off; the circuit is then detuned towards both sides till the voltage is half its resonance value and the detuning capacity determined. The theory of the measurement is given; Fig. 2 shows the resonance curve, with notation. The final expression for the decrement is given in eqn. 10 and the (negligible) error in eqn. 11. § 2 gives details of the apparatus; Fig. 3 shows the emitter circuit, Fig. 4 details of a capacitative potentiometer used to couple the measuring circuit to the amplifier, Fig. 5 the circuit of the valve voltmeter, and Fig. 6 a photograph of the whole arrangement, which is mains-driven and can be used over a wavelength range of 200–2 000 m, with possible further extension by using a second emitter.

Possible sources of error, and their elimination, are discussed in § 3; the measurements which can be made with the apparatus are described in § 4. They are measurements of (1) coil quality, (2) loss angles of condensers, (3) attenuation in oscillating circuits, and (4) high ohmic resistances at high frequencies. Reference is made to the degree of accuracy of the measurements in § 5, with examples. Fig. 7 shows the influence of frequency on the quality factor $\omega L/R$ of some coils: Fig. 8 shows the increase of losses in solid-cored coils as the voltage across the oscillating circuit increases, owing to hysteresis. Fig. 9 gives the results of measurements of loss angle in a Pertinax plate 2 mm thick.

3998. On the Barretter Method of Prof. M. Wien [Increase of Sensitivity, for Short Waves especially, by Series Condenser to compensate for Self-Inductance of Barretter-Bridge Circuit].—P. Mortier. (*Physik. Berichte*, No. 16, Vol. 16, 1935, p. 1446.)

3999. Thermionic Peak Voltmeters for Use at Very High Frequencies [Estimation of Errors due to Resonance and Electron Flight Time: Greater Importance of Latter Type, and the Choice of Diodes: a Portable Voltmeter].—C. L. Fortescue. (*Journ. I.E.E.*, September, 1935, Vol. 77, No. 465, pp. 429–432.)

4000. R.F. Indicators for Ultra-High Frequencies.—(*QST*, July, 1935, Vol. 19, No. 7, pp. 49–50.)

4001. Radio-Frequency Multi-Range Milliammeter [accurate to 1 in 1 000 for Frequencies up to 6½ Mc/s].—Barlow. (*Journ. Scient. Instr.*, September, 1935, Vol. 12, No. 9, pp. 300–302.)

4002. The Utilisation of Foucault Currents and Hysteresis Phenomena for Measurements at High Frequency: Thermo-Gaussmeters and Thermo-Ammeters.—M. Laporte and V. Vasilesco. (*Journ. de Phys. et le Radium*, July, 1935, Vol. 6, No. 7, pp. 289–294.)

4003. On the Construction of a Sensitive Vacuum Thermoelement [using Thin Metallic Films instead of Wires].—Picker and Rudinger. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 16, 1935, pp. 265–268.)

4004. An Improved Electrothermic Instrument: Discussion.—Lincoln. (*Elec. Engineering*, September, 1935, Vol. 54, No. 9, pp. 987–989.) *See* 2361 of July.

4005. The Simultaneous Error-Free Measurement of Voltage and Current [Circuits avoiding Corrections for Voltage Drop in Current Meter and Current Consumption in Voltage Meter].—W. Bader. (*E.T.Z.*, 8th Aug. 1935, Vol. 56, No. 32, pp. 889–891.)

4006. A Recent Improvement in Precision Potentiometers [overcoming Residual Potential above Zero].—D. C. Gall. (*Journ. Scient. Instr.*, September, 1935, Vol. 12, No. 9, pp. 284–285.)

4007. The Construction of Sensitive Moving-Coil Galvanometers.—A. C. Downing. (*Journ. Scient. Instr.*, September, 1935, Vol. 12, No. 9, pp. 277–281.)

4008. Current Measurement with the Cathode-Ray Tube: Correction.—Holzer. (*Bull. Assoc. suisse des Élec.*, No. 19, Vol. 26, 1935, p. 543.) *See* 2774 of August.

4009. Effect of Ultra-Violet Light on Breakdown Voltage [and Its Application to Sphere Gaps for Impulse Voltage Measurement].—G. L. Nord. (*Elec. Engineering*, September, 1935, Vol. 54, No. 9, pp. 955–958.)

4010. Coil Testing Methods for Use in Radio Plants.—E. Messing. (*Electronics*, August, 1935, pp. 248–250.)

4011. A Dynamometer Null Method of Measuring the Inductance and the Effective Resistance of Iron-Cored Chokes carrying Direct Current.—G. D. Pegler. (*Proc. Phys. Soc.*, 1st Sept. 1935, Vol. 47, Part 5, No. 262, pp. 964–971: Discussion pp. 972–973.)

4012. A R.F. Measurement of Resistance, Reactance and Impedance [Direct Method by Injection].—T. C. Macnamara. (*Wireless Engineer*, September, 1935, Vol. 12, No. 144, pp. 471–477.) The r.f. generator is so designed that its frequency cannot be "pulled" by adjustment of output circuit, and great attention is paid to screening.

4013. Use of a Frequency-Doubling Stage as Buffer for Frequency-Stabilisation of R.F. Oscillator, to avoid "Pulling" by Output Circuit Changes.—Macnamara. (*See* 4012.)

4014. The Theory, Design and Calibration of Absorption Wavemeter for One-Metre Range [Micro-Wave Meter with Accuracy ½% on 0.4–1.4m Waves: Tubular Ring with Micrometric Air Gap].—Ts'en and Tsai. (*Physik. Berichte*, No. 16, Vol. 16, 1935, p. 1447.)

4015. Influence of Temperature on the Electrical Conductivity of Quartz.—R. Radmanèche. (*Comptes Rendus*, 19th Aug. 1935, Vol. 201, No. 8, pp. 448–449.)

The law of variation was found to be exponential between −64°C and 300°C, above which temperature the curve of the logarithm of the current showed an "elbow" (Fig. 1). Fig. 2 shows the result of an experiment with a closed cycle of temperature; a fatigue effect is evident.

4016. Piezoelectric Crystal with Very Low Natural Frequency.—J. Gruetzmacher. (*E.N.T.*, August, 1935, Vol. 12, No. 8, p. 257.)

A quartz crystal can be made to oscillate with a natural frequency below 1 000 c/s if it is cut in the form shown in Fig. 1; the transversal oscillation giving this frequency is shown schematically in Fig. 2. The ratio of the crystal dimensions for the minimum frequency is given. Still lower frequencies may be attained by loading the ends of the crystal. The method of mounting the crystal for optimum results is described. Natural frequencies down to 86.6 c/s may be obtained by appropriate cutting.

4017. A Method for Determining the Orientation of a Crystal under a Microscope.—Wood and Ayliffe. (*Journ. Scient. Instr.*, September, 1935, Vol. 12, No. 9, p. 299.)

4018. Dilatations in Rochelle Salt [Inverse Piezoelectric Effect studied with Mechanical Dilatometers: Permanent Electric Polarisation: Fatigue Effect: Relaxation Times: Thermal Expansion through Upper Critical Temperature].—I. Vigness. (*Phys. Review*, 1st Aug. 1935, Series 2, Vol. 48, No. 3, pp. 198–202.) For previous work *see* 168 of January.

4019. The Dependence of the Dielectric Properties of Rochelle Salt Crystals on Mechanical Strains.—R. David. (*Helvetica Phys. Acta*, Fasc. 5, Vol. 8, 1935, pp. 431–484: in German).

4020. Measurement of Dielectric Constants of Solid Bodies by the Method of Mixing [Immersion of the Solid in Liquids forming Condenser Dielectric: Theory of Method].—Else Kleinke. (*Physik. Zeitschr.*, 15th Aug. 1935, Vol. 36, No. 16, pp. 565–566.) For the limitations of this method *see* 831 of March.

4021. On the Resonance Method of Measuring Dielectric Constants [Simple Practical Variation giving Great Accuracy, using a Broadcast Signal as Generator and an Audion Receiver as Resonance Circuit].—F. Hummel. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 16, 1935, pp. 264–265.)

4022. Unit of Force in the M.K.S. System ["Newton" suggested as Name].—L. Hartshorn and P. Vigoureux. (*Nature*, 7th Sept. 1935, Vol. 136, p. 397.)

4023. AEF List of Electrical, Magnetic and other Symbols in Electrical Machine Design *and* General Physical Constants.—(*E.T.Z.*, 22nd Aug. and 5th Sept. 1935, Vol. 56, Nos. 34 and 36, pp. 952–954 and 1007–1011.)

SUBSIDIARY APPARATUS AND MATERIALS

4024. The Sensitivity and Limiting Frequency of the Sensitive High-Vacuum Cathode-Ray Oscillograph with Incandescent Filament.—Graupner. (*Arch. f. Elektrot.*, 1st Aug. 1935, Vol. 29, No. 8, pp. 529–530.)

A theoretical example is given to show that, in the cathode-ray oscillograph with simple concentration (Fig. 1), "the product of relative sensitivity and limiting frequency depends essentially only on the properties of the electron source employed." For a given value of beam intensity, the source should be designed so that the product of beam velocity, diameter of emitting surface and angle of beam divergence is as small as possible.

4025. A Sensitive Cold-Cathode Cathode-Ray Oscillograph of High Performance for Low Exciting Voltages.—Westermann. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 16, 1935, pp. 262–264.)

Further development of the work dealt with in 1934 Abstracts, pp. 626–627. The new tube here described is designed to combine high sensitivity (0.01 to 1 mm/v) and very high recording speed (10^4 km/s), in spite of the low voltage (4–13 kv). It is of the all-metal type, of overall length 110 cm, and is suitable for internal and external recording. An example of internal recording is Fig. 3, an oscillogram of a single process (breakdown of a spark-gap by a surge voltage), the resulting oscillations having a frequency of 90 Mc/s; Fig. 4 is an external record of 1 Mc/s oscillations. A footnote mentions that the advantages of the discharge tube of small dimensions (high recording performance with low exciting voltages) can be obtained with the cold-cathode oscillograph with *single* vacuum if the suggestion of Rogowski and Malsch is adopted, according to which the discharge voltage is considerably reduced by artificial ionisation by an auxiliary discharge. Results on these lines have already been obtained at the Aix-la-Chapelle Institute.

4026. The Cathode-Ray Oscillograph of the Laboratoire Ampère.—Schuep and Sollima. (*Rev. Gén. de l'Élec.*, 17th Aug. 1935, Vol. 38, No. 7, pp. 241–246.)

4027. The Recording of Transients on Overhead Transmission Lines [High-Speed Cathode-Ray Oscillograph and Associated Equipment: including Special Condenser for Purely Capacitive Coupling].—Whelpton and Edwards. (*Met.-Vickers Gazette*, September, 1935, Vol. 15, No. 269, pp. 371–376.)

4028. The Cathode-Ray Oscillograph and Its Applications in Radio Research.—Herd. (*Journ. Television Soc.*, March, 1935, Vol. 2, Part 1, pp. 12–14: lecture summary.)

4029. The Siemens Oscilloscope [Photograph, with Circuit Diagram and Paths of Light Rays].—(*Hochf:tech. u. Elek:akus.*, August, 1935, Vol. 46, No. 2, pp. 68–69.)

4030. The RCA-6E5 Electron-Ray Indicator Tube [High-Vacuum Heater-Cathode Tube with Fluorescent Target, for Voltage Indication, *e.g.* for Receiver Tuning].—(*Rad. Engineering*, August, 1935, Vol. 15, No. 8, pp. 20–21.)

4031. The Production and Focusing of Intense Positive Ion Beams [with Gaseous Low Voltage Arc: Electrostatic Lens Arrangements], *and* High Voltage Technique for Nuclear Physics Studies [Electrostatic Generators: Apparatus for focusing Positive Ion Currents].—Tuve, Dahl and Hafstad. (*Phys. Review*, 1st and 15th Aug. 1935, Series 2, Vol. 48, Nos. 3 and 4, pp. 241–256 and 315–337.)

4032. Note on L. Tumermann's Paper "On the Dependence of the Fluorescent Spectrum on the Viscosity of the Solvent."—Jablonski: Tumermann. (*Physik. Zeitschr. der Sowietunion*, No. 1, Vol. 8, 1935, pp. 105–108: in German.)

4033. The Absolute Colour Sensitivity of Photographic Films [using Spectrograph with Thermoelement: Graphs of Results for Various Films].—Biltz. (*Physik. Zeitschr.*, 15th Aug. 1935, Vol. 36, No. 16, pp. 559–563.)

4034. A Valve for the Fine Regulation of Gas Pressures, and Its Application to Ionic Discharge Tubes.—Kunzl and Slavik. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 16, 1935, pp. 272–276.)

4035. A New Material with Applications in Radioelectricity: Colloidal Graphite in Water ["Aquadag"].—Vincent. (*L'Onde Élec.*, August, 1935, Vol. 14, No. 164, pp. 547–550.) *Cf.* 3472 of October.

4036. Progress in the Field of High-Speed Cinematography.—Cranz and Schardin. (*Zeitschr. V.D.I.*, 7th Sept. 1935, pp. 1075–1079.)

4037. An Electrical Test Recorder [for Recording Continuance or Discontinuance of a Number of Separate Events].—Chelioti. (*G.E.C. Journal*, May, 1935, Vol. 6, No. 2, pp. 107–111.)

4038. The Cycle Recorder [with Inkless Recording on Thin Paper Tape].—Gardner and Newell. (*Gen. Elec. Review*, August, 1935, Vol. 38, No. 8, pp. 384–385.)

4039. Radio Relaying Devices using Super-Regeneration.—Ataka. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 448: Japanese only.)

4040. A Simple Technique for Preparation of Photon Counters for Visible Light.—Kolin. (*Review Scient. Instr.*, August, 1935, Vol. 6, No. 8, pp. 230–231.)

4041. Ionising Particle Counters [Improved Technique].—Dunning and Skinner. (*Review Scient. Instr.*, August, 1935, Vol. 6, No. 8, pp. 243–246.)

4042. "Packet" Switches: a Contribution to the Theory of Switching and of Systems of "Packet" Switches [with Examples].—Edler. (*Arch. f. Elektrot.*, 1st Aug. 1935, Vol. 29, No. 8, pp. 531–555.)

4043. High-Voltage Cut-Outs and Fuses.—Lohausen. (*Elektrot. u. Masch:bau*, 18th Aug. 1935, pp. 385–390.)

4044. Optimum Design of [Single-Turn] Toroidal Inductances, *and* Some Possibilities for Low-Loss Coils.—Reber: Terman. (*See* 3844 and 3845.)

4045. Multi-Band R.F. Choke Coil Design [and an Improved Type of "Pie-Wound" Choke].—Miller. (*Electronics*, August, 1935, pp. 254–255.)

4046. Iron-Cored Resonance Coils for Audio-Frequencies [Measurements of Logarithmic Decrement for Various Core Materials].—Dannehl and Kotowski. (*See* 3917.)

4047. Switch-On Phenomena in Iron-Cored Choke Coils with Eddy Currents.—Eckart. (*See* 3820.)

4048. The Variation with Magnetic Field and Temperature of the Thermoelectric Properties of Ferromagnetics.—Lowance and Constant. (*Phys. Review*, 1st Aug. 1935, Series 2, Vol. 48, No. 3, pp. 257–260.)

4049. Contribution to the Theory of Magnetic Hysteresis [Hysteresis superposes Small Free Phenomenon, with Exponential Decay, on Transient Switch-On Phenomena in D.C. Circuits].—Wittke. (*Ann. der Physik*, Series 5, No. 5, Vol. 23, 1935, pp. 442–458.)

4050. Magnetic Hysteresis at Low Flux Densities [Measurements confirming and extending Rayleigh's Findings].—Ellwood. (*Physics*, July, 1935, Vol. 6, No. 7, pp. 215–226.)

4051. Magnetic Investigations on Pupin Cores of a New Type [Highly Anisotropic Nickel-Iron Alloys produced by Special Treatment].—Snoek. (*Physica*, April, 1935, Vol. 2, No. 4, pp. 403–412: in German.)

4052. Influence of Recrystallisation Texture and Cooling in Magnetic Field on Magnetic Properties [of Fe/Ni Alloys].—Dahl and Pawlek. (*Zeitschr. f. Physik*, No. 7/8, Vol. 94, 1935, pp. 504–522.)

4053. On the Relation between Permeability and Magnetostriction in Iron-Nickel Alloys of High Permeability.—Mihara. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 384: English summary pp. 52–53.)

4054. The Mechanical Theory of Textural Irreversibilities and Its Application to Recent Discoveries [of Methods of obtaining Very High Magnetic Permeabilities].—Perrier. (*Helvetica Phys. Acta*, Fasc. 5, Vol. 8, 1935, pp. 421–430: in French.)

4055. Methods of Increasing the Useful Flux of Magnets and Electro-Magnets [Principles of "Longitudinal Joints," "Apolar Orientation," and "Pseudodiamagnetic Gap"].—Perrier. (*Helvetica Phys. Acta*, Fasc. 4, Vol. 8, 1935, pp. 327–329: in French.)

4056. Diagram of States and Magnetic Properties of Platinum-Iron Alloys [Hysteresis Curves: Effect of Temperature and Composition of Alloy].—Graf and Kussmann. (*Physik. Zeitschr.*, 15th Aug. 1935, Vol. 36, No. 16, pp. 544–551.)

4057. Abnormal Magnetic Behaviour of Treated Cobalt Wire [Different (B,H) curves obtained after Heating for Various Periods and Cooling].—Wall. (*Nature*, 7th Sept. 1935, Vol. 136, p. 397.)

4058. "Der Kupferarme Transformator" [Low Copper Content Transformer: Book Review].—Vidmar. (*Gen. Elec. Review*, August, 1935, Vol. 38, No. 8, p. 398.)

4059. Wireless [Broadcast Reception] and the Small Lighting Plant.—Beatt. (*World-Radio*, 6th Sept. 1935, p. 11.)

4060. The "Stabilovolt" Voltage Stabiliser [including the "Reflex" Connection].—Higonnet. (*Rev. Gén. de l'Élec.*, 17th Aug. 1935, Vol. 38, No. 7, pp. 247–251.) *See* also 2415 of July.

4061. A New Thermionic Motor Speed Regulator [using Small Magneto Tachometer coupled to Shaft].—Boyd Norris. (*Electronics*, August, 1935, p. 244.)

4062. Small Self-Starting Synchronous Time Motors.—Holmes and Grundy. (*Journ. I.E.E.*, September, 1935, Vol. 77, No. 465, pp. 379–406.)

4063. Some New Designs of the Valve Motor.—Tikhmenev. (*Elektrichestvo*, No. 12, 1935, pp. 39–46.)

4064. Half Cycles [Use and Advantages of Half-Wave Rectification for Power Supply in Rectifier-Controlled Systems: Basic Circuits, Equations, etc.].—Cockrell. (*Gen. Elec. Review*, August, 1935, Vol. 38, No. 8, pp. 367–372.)

4065. Development Prospects of the Grid-Controlled Vacuum Rectifier for Heavy Currents.—Gaudenzi. (*Bull. Assoc. suisse des Élec.*, 16th Aug. 1935, pp. 465–472: in German.)

4066. THE CONTROL OF RECTIFIERS BY BLOCKING THE ANODES [particularly by Magnetic Field, after weakening the Anode Field by a Special Grid].—Risch. (*Bull. Assoc. suisse des Élec.*, 30th Aug. 1935, pp. 507–511: in German.)

4067. ANALYSIS OF RECTIFIER FILTER CIRCUITS [Solution on Basis of Hypothetical Perfect Rectifier, and Corrections for Departures from This].—Stout. (*Elec. Engineering*, September, 1935, Vol. 54, No. 9, pp. 977–984.)

4068. FIRING TIME OF AN IGNITER TYPE OF [Mercury Rectifier] TUBE.—Dow and Powers. (*Elec. Engineering*, September, 1935, Vol. 54, No. 9, pp. 942–949.)

4069. ARC RECTIFIERS USING GAS AT ATMOSPHERIC PRESSURE AND COMPRESSED GAS.—Di Pieri. (*L'Elettrotec.*, 25th Aug. 1935, Vol. 22, No. 16, pp. 574–582.)

4070. LUMINOUS EMISSION FROM HIGH-PRESSURE MERCURY ARCS [measured with Photocell].—Waguet. (*Comptes Rendus*, 19th Aug. 1935, Vol. 201, No. 8, pp. 450–451.)

4071. ON THE DESIGN AND CONSTRUCTION OF INDIRECTLY HEATED OXIDE CATHODES [for Thyratrons].—Ivanchenko and others. (*See* 3909.)

4072. HIGH TENSION ARC-IN-AIR RECTIFIER [Survey].—Marx. (*E.T.Z.*, 15th Aug. 1935, Vol. 56, No. 33, p. 922: summary only.)

4073. SKIN EFFECT IN CYLINDRICAL CONDUCTORS WITH ELLIPTICAL CROSS-SECTION [Calculation from Vector Potential: Solution for Low Frequencies].—Lettowsky. (*Arch. f. Elektrot.*, 1st Aug. 1935, Vol. 29, No. 8, pp. 556–567.)

4074. VARIATIONS IN THE RESISTANCE OF THIN CARBON FILMS [due to Load, Temperature and Resistance Values: Investigation of Commercial Resistances].—Meyer and Thiede. (*E.N.T.*, August, 1935, Vol. 12, No. 8, pp. 237–242.)

Commercial carbon resistances of different types and sizes were investigated to find how the change of resistance and the "rustle" voltage depended on the resistance value, the d.c. load and the temperature, and to determine the spectrum of the "rustle." The measuring apparatus is shown in Fig. 1 and described in § 2. The frequency response of the amplifier is given in Fig. 2. For spectrum analysis (§ 3) a Grützmacher apparatus (1928 Abstracts, p. 168) was used instead of the filter choke of Fig. 1. Fig. 3 shows spectra of resistances under different loads; the behaviour of all was fundamentally similar. The "rustle" voltage rapidly falls as the frequency increases, in contrast to the "shot effect" spectrum (Fig. 4) where the voltage is practically independent of frequency. At high frequencies the "rustle" voltage is negligible.

Variation of "rustle" voltage with load is shown in Fig. 5 (§ 4); the voltage increases as the square root of the load. For heavy loads the "rustle" voltage increases with the time for which the load is applied. "Rustle" voltage shows linear increase with temperature, for constant load (Fig. 6). Fig. 7 gives a comparison of the behaviour of 25 resistances under various loads. Table I compares the various types of resistance; the "rustle" voltage decreases as the carbon film thickness increases and is always greater than that due to electron movement. A short theoretical explanation is attempted. For papers on similar lines *see* 1445 of May and 3091 of September.

4075. TESTS ON RESISTANCES WHICH VARY WITH VOLTAGE [Over-Voltage Leaks].—Vieweg and Pfestorf. (*Physik. Zeitschr.*, 15th Aug. 1935, Vol. 36, No. 16, pp. 539–544.)

Over-voltage protecting shunts consist of a spark-gap and a resistance, which is essentially a semi-conductor. Tests of semi-conductors as to their suitability for this purpose are here described; the three chief points are (1) the determination of the value of the resistance for a given voltage, (2) the determination of its variation with voltage, and (3) tests for its ability to carry current when subjected to a high impulsive voltage. Fig. 1 shows a circuit with a spark gap and Fig. 2 one using a cathode-ray oscillograph for obtaining current/voltage characteristics; Fig. 3 gives the beam-locking circuit. Details of the experiment are given; characteristics of various resistances are shown in Fig. 6. The general nature and effects of high-voltage conditions are discussed.

4076. A FURTHER NOTE ON HIGH RESISTANCES AT HIGH FREQUENCIES [New Simple Approximation for R/R': Comparison with Various Experimental Values].—G.W.O.H. (*Wireless Engineer*, August, 1935, Vol. 12, No. 143, pp. 413–414.) *See* 3694 of October.

4077. THE SIZE AND ARRANGEMENT OF BISMUTH MICROCRYSTALS FORMED FROM VAPOUR [Discontinuity in Magneto-Resistance at Critical Film Thickness: Bearing of Results on Structure of Metallic Films].—Lane. (*Phys. Review*, 1st Aug. 1935, Series 2, Vol. 48, No. 3, pp. 193–198.)

4078. AIR CONDENSER, INDEPENDENT OF TEMPERATURE.—Runge. (German Pat. 606 094: *Hochf:tech. u. Elek:akus.*, July, 1935, Vol. 46, No. 1, p. 34.) The coatings of the plates are made of a material with a suitable coefficient of expansion, to compensate for variations of the dielectric constant of the air.

4079. TANTALUM [Electrolytic] CAPACITORS.—Porter. (*Rad. Engineering*, August, 1935, Vol. 15, No. 8, pp. 14–15.)

4080. EMPIRICAL FORMULAE FOR DISCHARGE PERIOD CURVES [Voltage/Time Characteristics of Insulators and Spark Gaps].—Gorev and Mashkileison. (*Elektrichestvo*, No. 13, 1935, pp. 32–36: in Russian.)

4081. The Breakdown of Dielectrics under High Voltage, with Particular Reference to Thermal Instability [Thermal and Non-Thermal Breakdown: Theory of Electric Strength for Thermal Breakdown: Theory of Ionisation Coefficients: Experimental Results for Non-Thermal Breakdown].—S. Whitehead and W. Nethercot. (*Proc. Phys. Soc.*, 1st Sept. 1935, Vol. 47, Part 5, No. 262, pp. 974–997.)

4082. The Nature of the Conductivity of Solid Dielectrics. I.—The Electrolysis of Films of Varnish.—Quittner and Pruschinina. (*Physik. Zeitsch. de Sowietunion*, No. 1, Vol. 8, 1935, pp. 41–58.)

4083. Tabulated Properties of Ceramic Insulating Materials [in Five Main Groups: Mechanical and Electrical Data].—Weicker, Kunstmann and Demuth. (*E.T.Z.*, 15th Aug. 1935, Vol. 56, No. 33, pp. 915–917.)

4084. Ceramic Insulating Materials at High Temperatures [200–600°C: Test Method and Curves].—Weicker. (*E.T.Z.*, 22nd Aug. 1935, Vol. 56, No. 34, pp. 937–939.)

4085. Confusion exists in Rating of Low-loss Insulation [especially for Ultra-High-Frequency Apparatus: Erroneous "Loss Factors" given by Manufacturers].—Björndal. (*Elec. Engineering*, August, 1935, Vol. 54, No. 8, p. 911.)

4086. The Elimination of Effect of Edge Discharges in Breakdown Tests [and the Use of Xylene under High Pressure for Testing Thin Dielectrics in Sheet Form].—Morris Thomas. (*World Power*, September, 1935, Vol. 24, No. 141, pp. 125–133.) Report L/T59 of the British E.R.A.

4087. [Humidity] Tests on R.F. Circuit Hook-Up Wire.—Zender. (*Electronics*, August, 1935, p. 257.)

4088. Determination of the Refractive Index of Aqueous Solutions of Electrolytes with Free Electric Waves.—Dember. (*Ann. der Physik*, Series 5, No. 6, Vol. 23, 1935, pp. 507–528.)

The principle of the method used is that plane waves (air wavelength 92.5 cm) are projected by a parabolic reflector into a trough containing the aqueous solution; they are reflected from a movable mirror at the back of the trough and the standing waves formed are received by a fixed aerial in the trough. The mirror is adjusted for resonance, so that the wavelength in the electrolyte is measured (Fig. 1). The apparatus is described in detail, with the sources of error and their magnitudes. The apparatus was tested by measuring the temperature variation of the refractive index of water. The measurements made were in good agreement with the Debye–Falkenhagen theory.

4089. [Absolute] Measurements of the Dielectric Constants of Aqueous Solutions of Strong Electrolytes by means of a High-Frequency Bridge [Variation with Concentration and Frequency: Description and Diagrams of Bridge and Method: Sources of Error: Agreement with Debye-Falkenhagen Theory].—Fischer. (*Physik. Zeitschr.*, 1st Sept. 1935, Vol. 36, No. 17, pp. 585–593.)

4090. The Electrical Conductivity of Some Strong Electrolytes in Dilute Solution and its Variation over the Temperature Range 18°C to 85°C [Agreement with Debye-Hückel Theory: Some Anomalies].—Clews. (*Proc. Phys. Soc.*, 1st Sept. 1935, Vol. 47, Part 5, No. 262, pp. 818–823.)

4091. "Das flüssige Dielektrikum" [Book Review].—Nikuradse. (*Electronics*, August, 1935, p. 251.)

4092. The Welding of Wires of Chromium Nickel and High Temperature Resisting Alloys by Condenser Discharges.—Wrana. (*E.T.Z.*, 5th Sept. 1935, Vol. 56, No. 36, pp. 991–993.) For previous work *see* 2502 of July.

4093. Electric Charges from Stretched Rubber Bands [for charging Electroscopes, etc.].—Larson. (*Review Scient. Instr.*, August, 1935, Vol. 6, No. 8, p. 242.

4094. A New [Tungsten-Nickel-Copper] Alloy specially suitable for [Protective] Use in Radium Beam Therapy.—McLennan and Smithells. (*Journ. Scient. Instr.*, May, 1935, Vol. 12, No. 5, pp. 159–160.)

STATIONS, DESIGN AND OPERATION

4095. The Hawaiian Radiotelephone System [Ultra-High Frequencies 30/60 Mc/s, and a New Experimental Circuit on 220/230 Mc/s].—Harrington and Hansell. (*Elec. Engineering*, August, 1935, Vol. 54, No. 8, pp. 822–828.)

4096. Post Office Activities on Ultra-Short Waves [including the 110-Mile Glastonbury/Channel Islands Link].—(*Television*, September, 1935, Vol. 8, No. 91, pp. 551–552.)

4097. W1XR: the Story of New England's Highest Radio Station [Mount Washington Observatory: Results on 5 m and 2.5 m Waves].—McKenzie. (*QST*, July, 1935, Vol. 19, No. 7, pp. 33–34 and 74, 76.)

4098. The Lisbon Reunion of the C.C.I.R.—Picault. (*L'Onde Élec.*, August, 1935, Vol. 14, No. 164, pp. 487–510.)

4099. The Physical Processes in the Interference Zone of a Common-Wave Broadcasting Network.—F. Vilbig. (*T.F.T.*, July, 1935, Vol. 24, No. 7, pp. 163–174.)

For the writer's treatment of a pair of common-wave stations *see* 1934 Abstracts, p. 166. Author's summary:—"The receiving conditions in the interference zone of a common-wave system is investigated. The current is calculated which occurs, after rectification, in a receiver situated in this zone. From the equation it is possible to draw conclusions as to the possibility of avoiding distortions in the interference zone. The influence of the number of stations and of the synchronism of their frequencies on the quality of reception is next examined. In this way 'loss' curves are obtained which can be used to give curves of 'equal loss' for the individual stations: by 'loss' is here meant the ratio of time of bad reception to the total time of transmission. The mean beat period of a common-wave network is determined as a function of the mean beat period of each pair of stations. Finally, the variation of the quality of reception with the 'loss' and with the mean interference time (and thus with the mean beat period) is found. From this the quality of reception to be expected in the interference zone can be calculated."

4100. RADIOELECTRIC COMMUNICATIONS: VARIATIONS OF THE FACTORS INFLUENCING COMMUNICATION.—de Bellescize. (*L'Onde Élec.*, August, 1935, Vol. 14, No. 164, pp. 511–530.)

Conclusion of the paper referred to in 3699 of October. The present part includes sections on:—curves representing the variations of a field as a function of one parameter—range, frequency, etc.; dispersion of a result which depends on several parameters varying at random; and a long section on the mechanism of selective fading.

4101. NEW BROADCASTING STATION AT DELHI [Main Points already Settled].—(*Current Science*, Bangalore, August, 1935, Vol. 4, No. 2, p. 121.)

4102. AIRCRAFT RADIO EQUIPMENT FOR USE ON EUROPEAN AIR LINES [for Commercial and Private Aircraft: with Electrical Remote Tuning, AVC, etc.: Plessey Company, England].—Hodgson. (*Proc. Inst. Rad. Eng.*, September, 1935, Vol. 23, No. 9, pp. 979–984.)

4103. SHIP-TO-SHORE RADIO IN PUGET SOUND AREA.—Hansen. (*Elec. Engineering*, August, 1935, Vol. 54, No. 8, pp. 828–831.)

GENERAL PHYSICAL ARTICLES

4104. THE OPTICAL PROPERTIES OF SOLIDS.—Wilson. (*Proc. Roy. Soc.*, Series A, 2nd Sept. 1935, Vol. 151, No. 873, pp. 274–295.)

Theoretical discussion of phenomena in visible and ultra-violet regions: generalisation of Kramers-Heisenberg dispersion formula: dispersion formula for metals, particularly silver: reasonable agreement with experiment for threshold for internal photoelectric absorption: dispersion formula for insulators: relation between absorption and dispersion.

4105. A MODERN CONCEPTION OF THE ELECTRODYNAMIC EFFECTS OF AN ELECTRIC CURRENT.—Guery. (*Rev. Gén. de l'Élec.*, 10th Aug. 1935, Vol. 38, No. 6, pp. 197–207: to be continued.)

4106. THE NUCLEAR PHOTOELECTRIC EFFECT [Disintegration of Deuterium and Beryllium Nuclei by Gamma Rays].—Chadwick and Goldhaber. (*Proc. Roy. Soc.*, Series A, 2nd Sept. 1935, Vol. 151, No. 873, pp. 479–493.)

4107. THE NEWLY DISCOVERED ELEMENTARY PARTICLES [Survey].—Darrow. (*Elec. Engineering*, August, 1935, Vol. 54, No. 8, pp. 808–816.)

4108. A THEORY OF ELECTROMAGNETIC PARTICLES. Part I. [Models in the Form of Systems of Electromagnetic Waves in Free Space: Electromagnetic "Whirls" and Their Properties: Principle of Relativity explained on Basis of Maxwell's Equations].—Japolsky. (*Phil. Mag.*, September, 1935, Series 7, Vol. 20, No. 133, pp. 417–468.) For preliminary work *see* 2176 of July.

4109. COMMUNICATION *re* PAPERS BY RUPP.—Ramsauer. (*Zeitschr. f. Physik*, No. 3/4, Vol. 96, 1935, p. 278.) Arising out of the incident referred to in 3709 of October.

4110. ON THE VELOCITY DISTRIBUTION OF ELECTRONS MOVING IN AN ELECTRIC FIELD.—Davydov. (*Physik. Zeitschr. der Sowietunion*, No. 1, Vol. 8, 1935, pp. 59–70: in German.)

The electrons are considered to be diffusing in a (not necessarily small) electric field and to be undergoing elastic collisions with molecules whose velocity distribution follows Maxwell's law. Theoretical expressions are found for the magnitude and direction of the electron velocity distribution, and formulae are given for the mean energy and mobility of the electrons. The writer is of the opinion that the formulae are probably valid for arc discharges at atmospheric pressure.

4111. NEW FORMULA FOR THE PROBABILITY OF PRODUCTION OF AN ELECTRON PAIR BY COLLISION OF A LIGHT QUANTUM WITH A NUCLEUS.—Stueckelberg. (*Helvetica Phys. Acta*, Fasc. 4, Vol. 8, 1935, pp. 324–326: in French.)

4112. ON THE THEORY OF IONIC RECOMBINATION: A CORRECTION [of Numerical Error].—Harper. (*Proc. Camb. Phil. Soc.*, July, 1935, Vol. 31, Part 3, pp. 429–430.) *See* 1933 Abstracts, p. 210.

4113. INITIATION OF THE HIGH-FREQUENCY DISCHARGE [Curve of Variation of Spark Potential with Pressure explained by Ionisation by Positive Ions at Cathode and Electronic Impact in Gas].—Thomson. (*Nature*, 24th Aug. 1935, Vol. 136, p. 300.)

4114. THE DYNAMICS OF NON-STATIONARY GAS DISCHARGES. II: HYSTERESIS PHENOMENA FOR DYNAMICAL CHARACTERISTICS OF THE GLOW DISCHARGE [analysed as Distortions of Curves in Current/Voltage Plane].—Gawehn and Valle. (*Ann. der Physik*, Series 5, No. 5, Vol. 23, 1935, pp. 381–412.) For previous work *see* 898 of March and 1704 of May.

4115. "THEORETICAL PHYSICS" [Book Review].—Joos. (*Electronics*, August, 1935, p. 251.)

MISCELLANEOUS

4116. On Some Properties of the k-Function [defined as $k_n(x) = (2/\pi)\int_0^{\frac{\pi}{2}} \cos(x \tan\theta - n\theta)d\theta$: Function occurring in Circuit Theory, discussed by Operational Methods].—Shastri. (*Phil. Mag.*, September, 1935, Series 7, Vol. 20, No. 133, pp. 468–478.)

4117. Resonant Functions: Notes on Their Use in Electric Circuit Calculations.—Baggally. (*Wireless Engineer*, August, 1935, Vol. 12, No. 143, pp. 430–436.)

The principle can be applied to entire networks or parts thereof, "with much saving in both algebra and arithmetic." An example worked out is the calculation of the response curve of an equalising network for correcting the side-band cutting in a broadcast receiver.

4118. "Symmetrical Components" [Book Review].—Wagner and Evans. (*World Power*, September, 1935, Vol. 24, No. 141, p. 146.)

4119. The Statistical Theory of Errors [General Arguments for the Thesis that the Adjustment of Observations is *not* a Statistical Problem].—Campbell. (*Proc. Phys. Soc.*, 1st Sept. 1935, Vol. 47, Part 5, No. 262, pp. 800–809.)

4120. New Method of Geophysical Prospecting [using A.C. of 0.1 to 5 c/s Frequency: based on Electrolytic Effects].—Hecker. (*E.T.Z.*, 1st Aug. 1935, Vol. 56, No. 31, pp. 871–872: summary only.)

4121. A Valve Generator [4 kW Output] for Induction Furnaces.—Fischer. (*E.T.Z.*, 1st Aug. 1935, Vol. 56, No. 31, pp. 870–871: summary only.)

4122. A New Method of Testing Photographic Snap Shutters [using Photocell and Cathode-Ray Tube].—van Liempt and de Vriend. (*Zeitschr. f. Physik*, No. 3/4, Vol. 95, 1935, pp. 198–201.)

4123. Testing "Cat's Eyes" [Road-Sign Button Reflectors] with Photocells.—(*Electronics*, June, 1935, p. 186.)

4124. Infra-Red Photo-Telephony [Table of Systems and Ranges obtained].—Guasco. (*La Ricerca Scient.*, 15/31 May, 1935, 6th Year, Vol. 1, No. 9/10, pp. 483 and 484.) In a survey by Todesco of the applications of infra-red rays.

4125. Elongation of Pattern, in Automatic Steel-Strip Stamping, notified by Photocell.—(*Electronics*, July, 1935, p. 221.)

4126. A Photocell Temperature Regulator.—Weinland. (*Electronics*, July, 1935, pp. 224–225.)

4127. On the Technique of Photoelectric Analysis [Titrations, etc.] with Intermittent Light.—Müller and Dürichen. (*Die Chemische Fabrik*, 17th July, 1935, Vol. 8, No. 27–28, pp. 267–269.) To permit amplification, particularly when feeble light sources are necessary (*e.g.* with strictly monochromatic light). For the amplifier used *see* 3171 of September. *Cf.* 3985.

4128. Comments on "A Simple Recording Microphotometer."—Brentano. (*Journ. Scient. Instr.*, August, 1935, Vol. 12, No. 8, pp. 269–270.) Prompted by Bhatt and Jatkar's paper (2908 of August).

4129. The Employment of Photoelectric Cells in Photometry.—Gouffé. (*Génie Civil*, 27th July, 1935, Vol. 107, No. 4, p. 98: summary only.)

4130. Electrical Device aids in measuring Speeds of Cars [Condenser Charging Circuit, using Two Light Beams 18 Inches Apart].—De Silva. (*Sci. News Letter*, 27th July, 1935, pp. 51–52.)

4131. "Electric Eye" [Photocell] improves Recording of Earthquakes.—Wolfe. (*Sci. News Letter*, 27th July, 1935, p. 56.)

4132. When Smelter Bag tears [wasting Metal up Flue] Photocell sound Horn.—(*Electronics*, July, 1935, p. 221.)

4133. Savings with Photoelectric Colour-Control in Bakery.—(*Electronics*, July, 1935, p. 220.)

4134. Photoelectric Counter [Two Types, for Counting Speeds up to 10 per Second and from 10 to 50 per Second].—Sato and others. (*Journ. I.E.E. Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 254: English summary p. 50.)

4135. Industrial Photoelectric Controls.—Wilfart. (*Ann. des P.T.T.*, July, 1935, Vol. 24, No. 7, pp. 648–685.)

4136. The So-Called "Barrier-Layer" Cells and Their Utilisation [Report to International Illumination Commission].—Cohu. (*Rev. Gén. de l'Élec.*, 27th July, 1935, Vol. 38, No. 4, pp. 123–127.)

4137. "Photoelectric and Selenium Cells" [and Their Applications: Book Review].—Fielding. (*Journ. Scient. Instr.*, August, 1935, Vol. 12, No. 8, p. 273.)

4138. A Multi-Stage Photocell Current Amplifier, applied to Furnace Temperature Control.—Richter. (*See* 3985.)

4139. Phototubes for Testing Power Tubes.—Westinghouse Company. (*Electronics*, August, 1935, p. 253.)

4140. Photoelectrolytic Cells [Short Survey with Particular Reference to Photometry], *and* Photoconductive Cells.—Jouaust: Roy-Pochon. (*Rev. Gén. de l'Élec.*, 24th and 31st Aug. 1935, Vol. 38, No. 8, pp. 263–266: 305–307.)

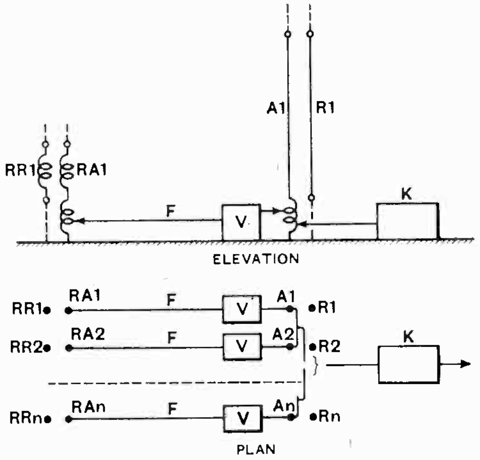
Some Recent Patents

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

DIRECTIVE AERIAL SYSTEMS

Convention dates (*Poland*), *4th and 17th November*, 1933. *No.* 424310

The field characteristic of a directive aerial is improved by a system of inter-aerial "reaction." The figure shows, in elevation and plan, an array of aerials *A*1 . . . *An*, backed by corresponding reflectors *R*1 . . . *Rn* and associated with a "forward" line of aerials and reflectors marked *RA*1 . . . *RAn* and *RR*1 . . . *RRn*, respectively.



No. 424310

Incoming signals are picked up on the first-mentioned aerial array, and from there are fed through an amplifier *V* and feed-lines *F* to the forward line of aerials *RA*1 . . . *RAn*, by which they are radiated through the ether back to the first set of aerials. Finally they are passed to the receiver *K*. The aerial "reaction" serves to sharpen the directive effect by emphasising the phase-difference in the currents picked up from "off-line" stations. Phase-differences may also be deliberately introduced in order to swing the axis of sensitivity of the aerial into a desired direction.

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

FLUORESCENT SCREENS

Convention date (*U.S.A.*), *30th August*, 1932. *No.* 424893

To produce a fluorescent screen having a uniform structure which improves in brilliance under electronic bombardment, fine crystals of zinc sulphide are first sifted over a semi-molten backing-plate of beryllium glass so as to form a uniform layer two or three grains in thickness. The lowermost grains partly sink into the molten glass and form a foundation for the upper layers. As cooling and contraction take place, the whole mass of crystals settles down, each grain being jammed firmly in position by mutual pressure and friction. The beryllium backing-plate is practically non-transparent to X-rays produced by the bombardment.

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

CATHODE-RAY TUBES

Application date, *6th November*, 1933. *No.* 425493

When the cathode-ray tube of a television receiver is burnt out, or otherwise requires replacement, it is often a matter of some difficulty to align the new tube correctly with relation to the external deflecting-coils or magnets. In order to facilitate this operation, the tube and coils are made as one integral unit, the coils being mounted on a metal screen which encloses the whole of the tube except the flared end containing the fluorescent screen.

Patent issued to General Electric Co., Ltd., and L. C. Jesty.

SHORT-WAVE MODULATORS

Convention date (*U.S.A.*) *31st August*, 1933. *No* 425571.

In order to overcome the known difficulty of sending ultra-short wave signals by amplitude modulation alone, i.e., free from any admixture of frequency-modulation, a region containing free electrons is interposed in the path of the carrier-wave, and the electronic density within that region is controlled by the signals to be transmitted, so that it acts as a variable refracting medium upon the carrier.

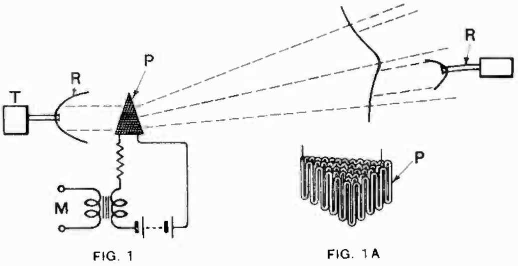


FIG. 1 FIG. 1A

No. 425571

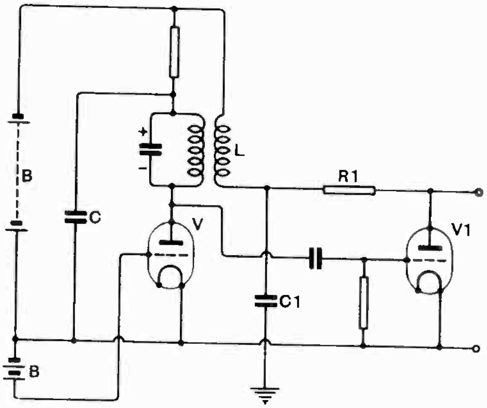
In Fig. 1, for instance, short-wave radiation from a transmitter *T* is concentrated by a reflector *R* into a beam, which passes through a prism *P* containing ionised gas. The prism, as shown in Fig. 1A, consists of a convoluted neon or argon filled tube, the degree of ionisation inside the tube being controlled by the signal voltage from a microphone *M*. The prism "modulates" the carrier by deflecting it in and out of the path of the receiver *R*.

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

SCANNING CIRCUITS

Convention date (Germany) 27th September, 1932.
No. 425685.

In order to prevent the slowing-up of the return or "idle" stroke of the scanning spot, in a cathode-ray tube, from making its presence visible on the screen, an extra control voltage is brought into play at the required moment.



No. 425685

As shown in the Figure the saw-toothed oscillator circuit *V*, *C* is charged from a source of potential *B*. which also supplies voltage to the anode of an auxiliary valve *V*1. A network *R*, *C*1 introduces a delay which corresponds to the first part of the back-traverse of the scanning spot, but towards the end, as the spot is slowing down, an impulse from the coil *L* suddenly renders the discharge-tube *V* non-conducting and so throws the spot off the screen.

Patent issued to Radio Akt. D. S. Loewe and K. Schlesinger.

COLOUR TELEVISION

Convention dates (Germany) 1st October, 1932, and 8th September, 1933. No. 426138.

A cathode-ray tube is fitted with two sets of electrodes, each comprising a heated cathode, wehnelt cylinder, and first and second anodes, so that two independent electron streams are produced. These are passed through separate pairs of scanning electrodes so arranged as to confine the resulting "rasters" to opposite halves of the fluorescent screen. When using the arrangement for reproducing television effects in natural colours, two separate pictures are projected on to a two-part screen, one half of which gives off say a red and the other a green fluorescence. The two pictures are then superposed or merged together on a common viewing-screen by means of two inclined mirrors mounted outside the flared end of the tube.

Patent issued to Radio Akt. D. S. Loewe and K. Schlesinger.

SHORT-WAVE SIGNALLING

Convention date (U.S.A.) 24th January, 1933.
No. 426228.

The system of frequency-modulation outlined in the previous patent is applied to signalling on ultra-short waves of the order of 50 megacycles. The effective range of such waves depends in some measure upon the extent to which they can be amplified at the receiver and this is normally limited by tube noise, due to irregular electron emission from the heating-filaments. As a remedy, the degree of frequency-modulation is increased by passing the modulated carrier through a series of frequency-multipliers until it spreads over a side-band width of 50 Kilocycles, as compared with the normal 10 K.C. side-band used in ordinary amplitude-modulation.

It is practicable to do this (a) because there is plenty of room available in the ether below 10 metres, and (b) because the amount of static is negligible on the ultra-short wave band. The second factor makes it possible to use broadly-tuned receiving circuits without running the risk of atmospherics masking the desired signal.

The receiving circuits are "paired" so as to rectify the wide band of frequency-modulated signals cumulatively. The comparatively narrow bands due to tube noise, representing an amplitude modulated disturbance, are rectified in push-pull, and are therefore eliminated.

Patent issued to E. H. Armstrong.

DIRECTION-FINDING

Application date 2nd August, 1933. No. 426328.

The pick-up voltages from two frame aerials, aligned on two distant beacon stations, are switched over in rapid alternation to the two pairs of deflecting electrodes in a cathode-ray indicator, so as to cause the electron stream to trace two independent paths over the fluorescent screen. Owing to persistence-of-vision, these appear as two continuous straight lines intersecting at a point on the screen. By suitably adjusting the biasing potentials on the tube, this point of intersection is made to coincide with the position of the receiver relative to the two beacon stations.

For use on aircraft, the fluorescent screen of the cathode-ray tube carries a map, say of the aerodrome, and the pilot can observe his path of approach in foggy weather by noting the movement of the point of intersection over the map. A different map is supplied for each aerodrome, and the necessary readjustment of the biasing voltages is effected automatically by causing projections on the under surface of the map to engage a series of movable contacts.

Patent issued to R. A. Watson Watt; J. F. Herd; and L. H. Bainbridge-Bell.