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Editorial

The Invention of the Telephone

THE suggestion that a mural tablet should be placed on the house in Edinburgh where Alexander Graham Bell first saw the light has revived the old question as to who invented the telephone. The name "telephone" had been applied in 1831 by Wheatstone to an acoustic arrangement for transmitting sounds through wooden rods in a purely mechanical manner, but leaving this, and several other mechanical contrivances to which the name had been applied, out of count and limiting ourselves to electrical devices for the transmission of speech and music, the question of priority of invention has been the cause of a great amount of controversy. No one devoted more time and energy to the elucidation of the question than Professor Silvanus P. Thompson, who after patient research in every possible direction, including a visit to Germany in order to obtain first-hand information, published in 1883 a book of 182 pages entitled "Philipp Reis, Inventor of the Telephone." Thompson's biographers admit, however, that "many thought that Thompson had estimated too highly the work of Reis as a pioneer of Telephony." This view was apparently shared by the American and British Courts which decided in favour of Bell against those who maintained that his invention was anticipated by the work of Reis. In 1914, in a letter to *The Times,* Thompson said: "Surely the work accomplished by Dr. Alexander Graham Bell is sufficiently well recognised that there is no excuse for his admirers to advance, on his behalf, an untenable claim." The untenable claim being that no one before Bell had "succeeded in sending spoken words along an electrified wire." Was this claim untenable?

Who was Philipp Reis?

Philipp Reis was born in 1834 and died in 1874. He lived and died at Friedrichsdorf, near Frankfort, where he taught in a school known as Garnier's Institute. In 1860 he invented an apparatus which he named a telephone, and in 1861 he read a paper "On Telephony by the Galvanic Current," before the Physical Society of Frankfort, to be followed three weeks later by another entitled "Explanation of a new theory concerning the perception of chords and of timbre as a continuation and supplement of the report on the telephone." At this time Alexander Graham Bell was a boy of fourteen living in Edinburgh. No one has ever doubted that Reis demonstrated on this occasion the transmission of musical sounds, but grave doubts have been expressed as to whether his apparatus was capable of transmitting intelligible speech. Two things are beyond doubt, the first, that the transmission of speech was one of his objects and was attempted; the second, that any success obtained was very imperfect. In describing the theoretical considerations which had guided him in his experiments he says: "How could a single instrument reproduce, at once, the total actions of all the organs operated in human speech? This was ever the cardinal question." In 1863 Reis drew up a prospectus of instructions to be sent out with the telephones which were made and sold by Albert of Frankfort. Both the transmitter and the receiver had a signalling key attached, whereby the former could call the latter and the latter send back instructions to the transmitter according to a code, "for example,"

"1 beat = sing
2 beats = speak."

This disposes of any doubts as to the inventor's intentions, but not as to his attainments. Perhaps the most reliable document in this respect is a report drawn up by Inspector von Legat, of the Prussian Telegraph Service, and published in the Journal of the Austro-German Telegraph Society in 1862. He says: "In the practical investigations heretofore carried on, chords, melodies, etc., were transmitted with marvellous fidelity; while single words uttered as in reading, speaking, and the like, were perceptible more indistinctly. Nevertheless, here also the inflexions of the voice, the modulations of interrogation, exclamation, wonder, command, etc., attained distinct expression."

In 1864 Reis demonstrated and explained his invention to the Annual Assembly of German Scientists at Giessen; he does not appear to have made any further improvements after this, but from the fact that he intended to exhibit a new type of Atwood machine, at Wiesbaden, in 1872, but was prevented by failing health, it would seem that he had turned his inventive energies in other directions. He died in 1874, the year before Bell's invention.

The Reliability of the Evidence

Prof. Thompson obtained the testimony of a number of people who had known Reis and who had taken part in his experiments and demonstrations, but it must be remembered that these testimonies were memories of experiments made twenty years before. As an example, Professor Quincke, of Heidelberg, who was present at Giessen in 1864 wrote in 1883: "I distinctly remember having heard the words of the German poem, 'Ach! du lieber Augustin, Alles ist hin!'" It is probably not irrelevant to remark that these are the words of a very well-known song and would immediately come automatically to the mind of any German on hearing the tune merely hummed. Dr. C. Bohn was rather more guarded; he wrote: "Words sung, especially well accentuated and peculiarly intoned, were somewhat better (or rather less incompletely) understood than those spoken in the ordinary manner." Another person wrote: "I distinctly heard the words 'Guten Morgen, Herr Fischer,'" whilst another who helped Reis in his experiments said: "We never (in my time) got the length of transmitting complete sentences successfully, but certain words, such as 'Wer da? gewiss, warm, kalt,' were undoubtedly transmitted without previous arrangement." In their attempts to prove that Reis anticipated Bell, some American telephone experts obtained some Reis telephones from Germany and tried to make them work, but in the controlled tests the listeners only recognised fifteen words out of a thousand and of these eight were wrong! As Edison said in a similar case, "When you knew what it was the man was saying it sounded awful like." It is interesting to note that a translation of Legat's Report referred to above came into Edison's hands in 1875 or 1876 and formed the starting point of his telephonic researches; it is also referred to by Graham Bell in a paper read in 1876, but there is no reason to suppose that the latter's invention was inspired in the remotest degree by the earlier work of Reis.

What did Reis Invent?

Having seen what the Telephone of Reis did, and did not, accomplish, let us see what it was and how it worked. The transmitter consisted of a wooden cone or box, or a carving representing the ear, closed at the narrow end with a diaphragm of stretched sausage skin or something similar, to the centre of which was attached a small piece of platinum which made contact with another spring-supported piece of platinum. He made many different models with various contact arrangements, but they all had this in common that on speaking into the mouth-piece, and thus causing the diaphragm to vibrate, the degree of contact between two pieces of platinum was varied. Although Prof. Thompson did his best to support the opposite view, it is very doubtful whether Reis contemplated a contact of variable resistance and not merely a make and break. His language generally supports the latter view, especially when describing the action of the receiver, which consisted of a horizontal knitting needle supported at each end by a small pillar on a sounding board and surrounded by a solenoid through which the received current was passed. This was not a new device but had been described by Page in 1837; when the circuit is made the wire is magnetised and increases in length, when the circuit is broken the wire goes back to its original length with a tick "which can be heard at two or three feet distance." If the circuit is rapidly made and broken the wire emits a tone of corresponding pitch.

A Make-and-break Device

That Reis did not contemplate changes of resistance of varying amplitude depending on the amplitude of the sound wave is proved conclusively by his Frankfort paper in which he says: "Moreover, the strength of this tone is proportional to the original tone, for the stronger this is the greater will be the movement of the drum-skin, the greater therefore the movement of the little hammer, the greater finally the length of time during which the circuit remains open, and consequently the greater, up to a certain limit, the movement of the atoms in the reproducing wire, which we perceive as a stronger vibration." He pictured the movement of the atoms taking place relatively slowly, so that to get a large effect on remaking the circuit it was necessary to keep the circuit open for a longer time. Although Reis made no claim to have invented the receiver, his explanation of its action leaves one in no doubt as to his conception of the action of his transmitter; it was a make-and-break apparatus. In Legat's report an ordinary electromagnet and spring-controlled armature constitute the receiver, but he also says that the condensation and rarefaction of the air at the transmitter opens and closes the galvanic circuit; there is no suggestion of variable contact resistance.

It is noteworthy that although a number of Reis telephones were made and sold about 1863, neither he nor anyone else appears to have made any further improvement in them; in fact the subject seems to have lain dormant from 1864 till 1875 when Bell made his discovery of the electromagnetic telephone.

A Telephone but not the Telephone

On the monument erected over his grave in 1878 by the Physical Society of Frankfort, Reis is described as the inventor of the telephone. One cannot help wondering, however, whether the instrument which inspired the Society to erect the monument was the telephone invented by Reis or that invented by Bell. Reis certainly invented an electric telephone by means of which the human voice was transmitted, but there is no indisputable evidence that it was capable of the intelligible transmission of a sentence of plain, straightforward speech. Nor did it form the nucleus from which the telephone was developed. It may perhaps be regarded as the forerunner of the microphone in that, after the discovery of the electromagnetic telephone transmitter by Bell, anyone seeking an alternative method of causing the current to vary in accordance with the sound waves of the voice, and coming across von Legat's report on the Reis transmitter, as Edison did, might see that the secret lay in replacing the make and break of Reis by a continuously variable resistance, but this is a long way from suggesting that Reis invented the microphone transmitter.

G. W. O. H.

Reproduction of Transients by a Horn Loud Speaker*

By N. W. McLachlan

1. Introduction

THE performance to be expected from various types of horn loud speaker when reproducing sinusoidal wave forms is well known. The reproduction of transients by such speakers has not been discussed hitherto, so in the present article we shall deal with this problem. The type of loud speaker to be considered is illustrated diagrammatically in Fig. 1. The aluminium alloy diaphragm is coupled to the horn by a throat chamber which acts as an acoustical transformer, whereby the mechanical impedance of the diaphragm is matched to that of the horn. The obstruction H is to prevent interference at frequencies where the wavelength of sound is comparable with the radius of the diaphragm†. The clearance between H and the diaphragm increases from the centre outwards. Thus the air particle velocity decreases from the centre outwards, and in this way the contributions from all parts of the diaphragm arrive at the horn throat in substantially the same phase, provided the frequency is not too high. The diaphragm is driven in the well-known manner by a circular coil situated in an intense radial magnetic field. Electrical power is supplied to the coil from a thermionic valve associated with a step-down transformer of appropriate turns ratio. To effect simplification, we shall consider a circuit which is equivalent to that of the valve and transformer referred to its secondary winding, in which the loud speaker coil is connected. This circuit is illustrated in Fig. 2. The resistance R includes that of the loud speaker coil plus the effect of the valve and the resistances of the transformer windings, whose self and mutual capacities are assumed to be negligible. This latter condition can be fulfilled by the well-known method of winding the primary and secondary in sections and interleaving them.

* MS. accepted by the Editor, May, 1936.
† McLachlan, "Loud Speakers," Fig. 82.

2. The Electrical Analogue of the Horn Speaker

In dealing with the mechanical part of the loud speaker system, it is convenient to use the electrical analogue of Fig. 1, this being shown in Fig. 3. The inductance L_0

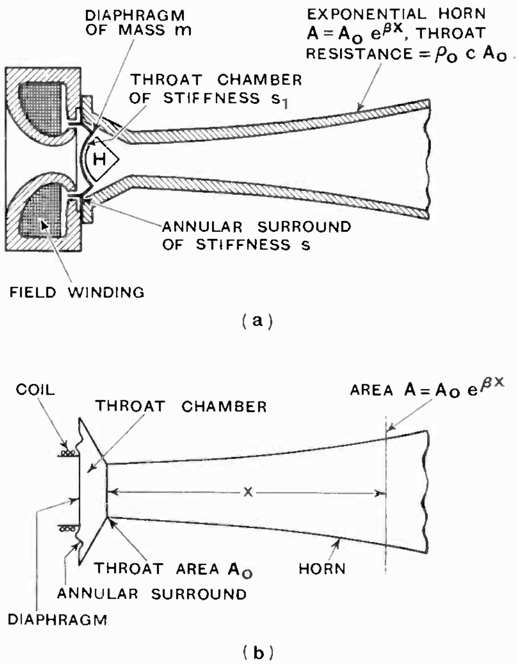
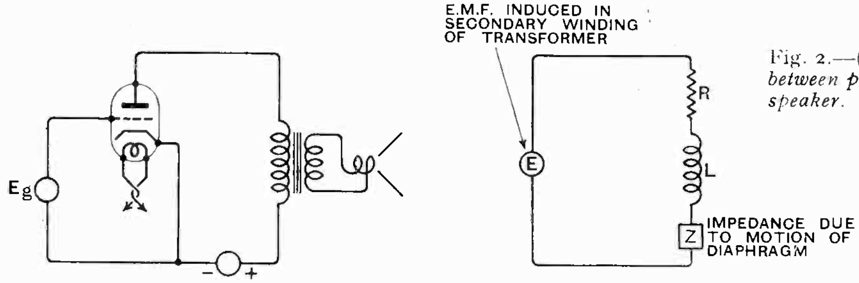


Fig. 1.—(*a*) *Diagram showing longitudinal section of horn loud speaker.* (*b*) *Schematic arrangement of* (*a*).

is equivalent to m the mass of the moving coil and diaphragm, which is assumed to move as a rigid structure. C_0 is equivalent to $1/s$ the compliance of the annular supporting ring on which the coil and diaphragm are mounted, i.e., s is the stiffness. R_1 is equivalent to r_1 the mechanical resistance opposing motion of the diaphragm, this being due to the load imposed by the horn. At frequencies above the cut-off point of the horn, where the throat impedance is chiefly resistive, the value of r_1 is very nearly* $\rho_0 c A_0 (A_d/A_0)^2$. In this formula A_d is the effective area of the diaphragm, A_0 the area of the horn throat, c the velocity of sound waves of infinitesimal amplitude, and ρ_0 the density of air. The velocity ratio of the acoustical transformer introduced by the throat chamber is A_d/A_0, and the above formula is obtained on multiplying the horn impedance $\rho_0 c A_0$ by the square of the ratio of transformation. This is the ratio of the air particle velocity in the throat to that in the throat chamber. C_1 is equivalent to $1/s_1$, the compliance of the throat chamber when the throat of the horn is closed by a plug, so that the air within the chamber acts like a massless helical spring when the diaphragm is displaced from its central position. I_0 is equivalent to $d\xi/dt$ the axial velocity of the diaphragm, and I_1 is equivalent to A_0/A_d times the velocity of the air particles at the throat



(a) (b)

Fig. 2.—*(a) Showing coupling between power valve and loud speaker. (b) Equivalent circuit of (a).*

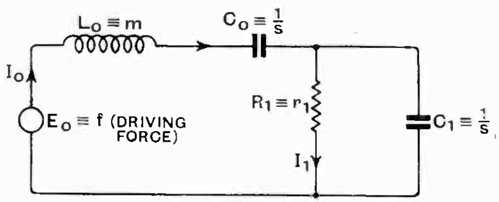


Fig. 3.—*Electrical analogue of mechanical system in* Fig. 1.

of the horn. E_0 is equivalent to f the mechanical driving force on the moving coil, due to the current supplied from the valve via the transformer.

* "Loud Speakers," pp. 349, 350.

3. Form of Applied Transient: Numerical Data

It was shown in a previous article* that the wave form of any transient applied to the grid of the power valve differed from that of the current in the loud speaker coil, this being due mainly to the influence of inductance. To simplify the mathematical analysis, we assume that the voltage applied in the secondary winding of the output transformer takes the form $E = E_1 e^{-at} \sin \omega t$. We desire to know the ensuing sound pressure at the throat of the horn. The analysis has been worked out using Heaviside's operators and contour integration, but is omitted owing to its complexity. In order to obtain an answer all quantities involved were assumed to be independent of frequency. The following numerical values were taken:

L = inductance of speaker coil when stationary, plus leakage inductance of transformer referred to secondary winding = 8.4×10^5 cm.;

R = effective resistance in secondary circuit of transformer (coil stationary), including the influence of the valve = 7×10^{10} cm. sec.$^{-1}$;

C = electromechanical conversion or force factor;
= $2\pi r n B_g$ where r = mean radius of coil of n turns, and B_g = mean flux density in air gap of magnet;
= 1.52×10^7 cm.$^{\frac{1}{2}}$ gm.$^{\frac{1}{2}}$ sec.$^{-1}$;

m = mass of diaphragm and coil = 1 gm.;

r_1 = resistive load on diaphragm due to horn = 1.45×10^4 dyne sec. cm.$^{-1}$;

* *Wireless Engineer*, 13, 630, 1936.

s = axial stiffness of annular diaphragm surround = 6.4×10^6 dyne cm.$^{-1}$;

s_1 = axial stiffness of throat chamber = 6.4×10^8 dyne cm.$^{-1}$;

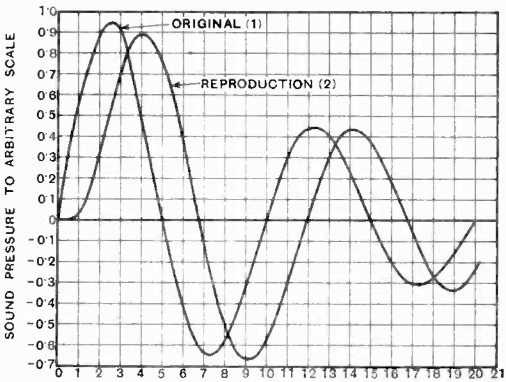
A_d = effective area of diaphragm = 28.3 cm.^{2} ;

A_0 = area of horn throat = 2.27 cm.^{2} ;

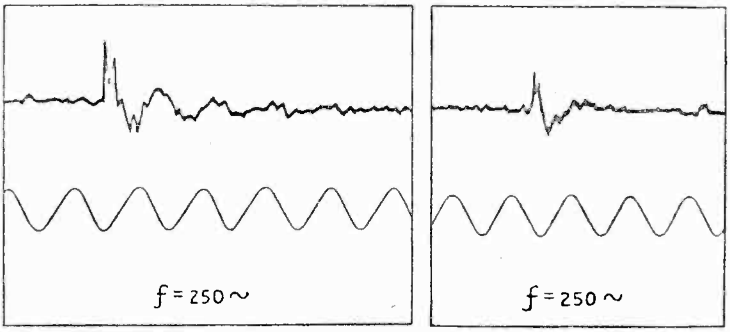
E = applied transient = $E_1 e^{-1800t} \sin 1.582 \times 10^4 t$.

4. Sound Pressure Waveform at Throat of Horn

Using the numerical values given in section 3, the sound pressure at the horn throat is found to be



(*Above*) Fig. 4.—*Curve* 1 *is the form of the sound pressure wave of the impressed transient. Curve* 2 *is the form of the sound pressure wave at the throat of the horn.*



(*a*) (*b*)

(*Right*) Fig. 5.—(*a*) *Sound wave form when transient like Heaviside's unit function is applied to grid of power valve which is transformer coupled to type of speaker discussed herein (without horn).* (*b*) *As at* (*a*) *but with horn* 4*ft.* 6*in. long in place.*

$$p \doteq E_1\{-14.6\,e^{-350t} + 28.2\,e^{-7.95\times10^4 t} + 872\,e^{-2.363\times10^4 t}\sin(1.582\times10^4 t + 41^\circ) + 650\,e^{-1800t}\sin(1.582\times10^4 t - 65^\circ 30')\} \quad \ldots \quad (1)$$

dyne cm.$^{-2}$, where E_1 is in volts.

The purely exponential terms in (1) contribute nothing of importance to the sound output. The highly damped oscillation represented by the third term is due mainly to interaction of the throat chamber compliance and the diaphragm mass, these constituting a mechanical oscillating system. As explained in section 5, this oscillation is modified by the remainder of the electromechanical system. Owing to the high damping, the amplitude at the first maximum is negligible compared with that of the reproduced version of the impressed transient, which is represented by the fourth term in (1). Strictly, of course, the sum of the four terms in (1) gives the reproduced version, but the first three are " additions " due to the effect of the " impulsive blow " on the system.

The wave form represented by formula (1) is plotted in Fig. 4, together with that of the impressed transient. Apart from the slow start and the relative displacement of the two wave forms, they bear a close resemblance to each other, so that one would not expect the difference in a " dead " room to be detectable by ear. In practice, where the loud speaker is used in a reverberant enclosure, the wave form of the sound which arrives at the ear will differ from that in a " dead " room or in free air. Consequently in an ordinary room, distortion due to the loud speaker may be unimportant, but this can be verified by experiment only.

The value of $\omega/2\pi$ for the impressed transient was chosen equal to the natural frequency of the oscillatory system, since this would probably give the greatest degree of distortion. In reproducing speech or music, where transients follow each other in rapid succession, there may at times be an almost continuous oscillation at a frequency $\omega/2\pi = \frac{1.582 \times 10^4}{2\pi}$ c/s. Here again its effect (if any) on the ear can be determined by experiment only.

Although the diaphragm mounted on its annular surround constitutes an oscillatory system *in vacuo* ($n \doteqdot 400$ c/s) the damping due mainly to the horn renders the motion aperiodic. In obtaining this result we assumed the resistive load due to the horn to be independent of frequency, whereas it is zero below the cut-off frequency as explained in section 6. In an experiment performed some years ago with a loud speaker of the type discussed herein, there was a damped oscillation with and without the horn in place. Oscillograms of sound pressure are given in Fig. 5, the damping effect of the horn being clearly shown.* The horn, however, was only 4ft. 6in. long and full resistive loading at the natural frequency of the diaphragm was not obtained.

5. The Equivalent Electrical Circuit of the Loud Speaker

In studying an electro-acoustical device, it is very useful to know the equivalent electrical circuit. It is important to emphasise that this circuit is *not* an electrical analogue. If the equivalent electrical circuit were substituted for the loud speaker in the secondary of the transformer, the current, its phase and the power absorbed would be identical in both cases. This circuit can be obtained by making an addition to the equivalent circuit of the hornless moving coil loud speaker illustrated in Fig. 6†.

The differential equation of the horn loud speaker differs from that of the hornless loud speaker due to the compliance of the throat chamber, which is absent in the latter case. This compliance is represented in Fig. 3 by a condenser in *parallel* with the load resistance R_1. By the principle of reciprocity, this is represented in the equivalent electrical circuit by a resistance in *series* with an inductance, as shown in Fig. 7a. In this diagram E is the e.m.f. induced in the secondary winding of the transformer: R is the resistance of the driving coil when it is stationary, plus the resistance due to the influence of the valve and the transformer windings: L is the inductance of the coil when it is stationary plus the leakage

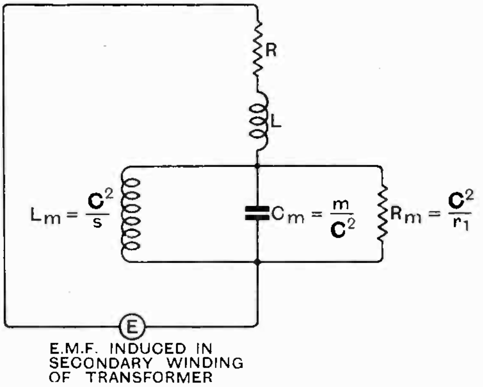


Fig. 6.—*Equivalent electrical circuit of hornless loud speaker.*

inductance of the transformer referred to the secondary winding: $L_m = \mathbf{C}^2/s$ is the motional inductance equivalent to the compliance of the annular surround of the diaphragm: $C_m = m/\mathbf{C}^2$ is the motional capacity equivalent to the mass of the coil and diaphragm: $L_{m1} = \mathbf{C}^2/s_1$ is the motional inductance equivalent to the throat chamber compliance; whilst $R_m = \mathbf{C}^2/r_1$ is the motional resistance equivalent to the load imposed by the horn. Since the value of r_1 decreases as the cut-off frequency of the horn is approached, R_m steadily increases, so the damping steadily decreases. The equivalent circuit can be used to study the action of the speaker at any frequency, provided the corresponding circuital values are used. Since these values vary with frequency the equivalent circuit is not rigorously applicable to transients. For wave forms of the type $e^{-\alpha t} \sin \omega t$, Fig. 7 can be regarded as a useful approximation, provided ω is well above the cut-off frequency of the horn and the damping factor α is not too large.

Without the horn r_1 is very small, R_m is correspondingly large, and the circuit can be represented closely by Fig. 6. The natural frequency of the coil and diaphragm on the annular surround (in the absence of

* "Loud Speakers," p. 335.

† "Loud Speakers." Fig. 51c. In Fig. 51c the valve and coil resistances are shown separately, and they are referred to the *anode* circuit of the valve, whereas in Fig. 6 they are represented by R and referred to the secondary circuit of the transformer.

damping) namely

$$\frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{(s/m)} = \frac{1}{2\pi}\sqrt{\left(\frac{1}{L_m C_m}\right)}$$

is altered by the presence of R, L and R_m. Apart from the influence of R, L and L_m, the natural frequency due to interaction of the mass of the diaphragm and the throat chamber compliance is (Fig. 7b)

$$\frac{\omega_1}{2\pi} = \frac{1}{2\pi}\sqrt{\left(\frac{1}{L_{m_1} C_m} - \frac{R_m^2}{4L_{m_1}^2}\right)} = \frac{1}{2\pi}\sqrt{\left(\frac{s_1}{m} - \frac{r_1^2}{4m^2}\right)}$$

$$\doteqdot 1.24 \times 10^4/2\pi \sim \quad \dots \quad \dots \quad (34)$$

The frequency obtained from the preceding mathematical analysis is $1.582 \times 10^4/2\pi$ c/s, and the difference between the two values is due to R, L and L_m being in parallel with the oscillatory circuit.

6. Horn Theory

In the theory of loud speaker horns, two of the assumptions made are as follows: (*a*) the wave front remains plane as it travels down the horn, (*b*) the horn is infinite in length to avoid reflection at the mouth, which precludes sound being radiated into space and the steady state ever being attained throughout the entire horn. Hypothesis (*a*) is usually accepted to avoid difficulties. It is untenable when a linear dimension of the cross-section is comparable with the wavelength. If the throat is small enough, this condition occurs some distance therefrom, so the formula for throat impedance probably holds. Above 1,000 c/s the radiation from the mouth of a large horn is concentrated near the axis. These difficulties can be surmounted if the air column is divided up into a large number of conduits by thin rigid frictionless partitions, as indicated in Fig. 8. The section of each conduit expands exponentially from the throat outwards. The major linear dimension of a conduit at the mouth should be small compared with the wavelength. The section distant x from the throat is that intercepted by the curved surface orthogonal to the centre lines of the conduits.* This condition can be realised fairly well in practice provided the upper frequency range is given by a unit having a small horn. When one speaker is used for the range 40 to

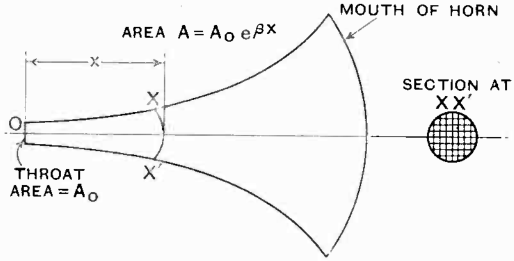


Fig. 8.—*Illustrating a loud speaker horn with conduits.*

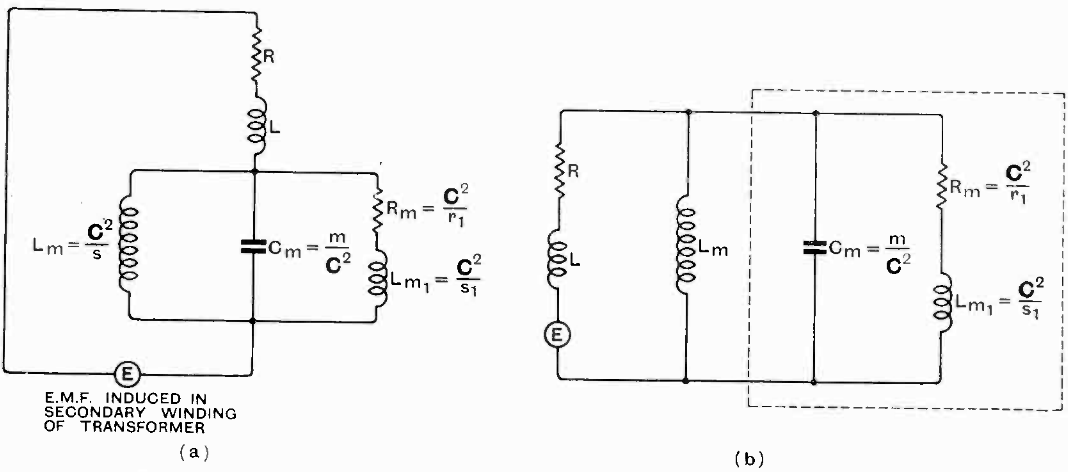


Fig. 7.—(*a*) *Equivalent electrical circuit of horn loud speaker.* (*b*) *Equivalent electrical circuit of horn loud speaker. The portion within the dotted line is equivalent to the oscillating system comprising diaphragm mass and throat chamber compliance.*

* McLachlan, "Bessel Functions for Engineers," p. XI.

10,000 c/s, the conduits are too numerous for practical construction, whilst the frictional loss might be serious.

Hypothesis (*b*) can be modified by taking a finite length of horn, making the radius at the mouth large enough to avoid appreciable reflection at low frequencies, and assuming that the speaker operates in a "dead" room or in free-air.

With the old hypotheses there is a certain frequency (cut-off) below which no power is transmitted in an exponential horn. The resistive component of the throat impedance is $\rho_0 c A_0 \sqrt{(1 - \beta^2/4k^2)}$, where $k = \omega/c$, and β is the flaring index in the formula $A = A_0 e^{\beta x}$ (see Fig. 1). This component vanishes at the cut-off point where $k = \frac{1}{2}\beta$ or $\omega_c = \frac{1}{2}\beta c$. Below this point the impedance is reactive. We have, however, modified the hypothesis by taking a finite length, so reflection at the mouth must be considered. The acoustical impedance of a conduit of section A is $z_a = \rho_0 c/A$, provided there is absence of reflection throughout. Thus the acoustical impedance of a horn decreases with increase in distance from the throat. In free space $z_a \to 0$, since $A \to \infty$. To avoid a pronounced change in acoustical impedance, the value at the mouth of the horn should be very small. Provided the mouth radius is not less than from $\frac{1}{6}$ to $\frac{1}{4}$ the wavelength of the lowest frequency to be reproduced, the reflection is not serious, so this rule is adopted in practice. In a room where sound is reflected from the walls, the impedance at the mouth will be modified appreciably, so also may the performance of the horn at low frequencies.

7. Behaviour of Horn to Transients

The horn influences transients in two ways, (*a*) it introduces a transient oscillation of its own, (*b*) it assists in damping the driving mechanism. We shall consider (*a*) when there is no reflection at the mouth of the horn, and the speaker operates in a "dead" room. If at time $t = 0$ a sine wave motion is given to the air particles at the throat, the sound pressure can be divided into two parts: (1) a sinusoidal pressure, (2) a transient due to the horn.* The form of the transient is illustrated in Fig. 9. A time $t_1 = x/c$ elapses before the sound arrives at a section distant x from the throat. The form of damped oscillation is a combination of Bessel functions. The frequency is variable at first, but ultimately settles down to that at the cut-off point of the horn. Whenever a change in particle velocity occurs at the throat, the horn transient ensues. If $\omega^2 \gg \frac{1}{4}\beta^2 c^2$ and the frequency is sufficiently high, the transient is unimportant, for the ratio of the maximum steady pressure to the first minimum of the transient is approximately $130\, n/n_c^2$, $n_c = \beta c/4\pi$ being the cut-off frequency. The relative importance of the transient increases as n decreases. Apart from this inherent transient, the horn has little influence on either the amplitude or the phase of a transient of the form $e^{-at} \sin \omega t$, provided ω is in the range where the horn impedance is mainly resistive. If the horn cuts-off at 31.8 c/s, say, whilst the mouth radius is such that waves whose frequencies are below 100 c/s, suffer serious reflection thereat, the transient will doubtless be modified. There may be resonance below 100 c/s due to reflection, i.e., an organ pipe effect. Whatever the diameter of the mouth, during operation in an ordinary room, the conditions are too complex for analytical treatment, and the problem must be studied experimentally.

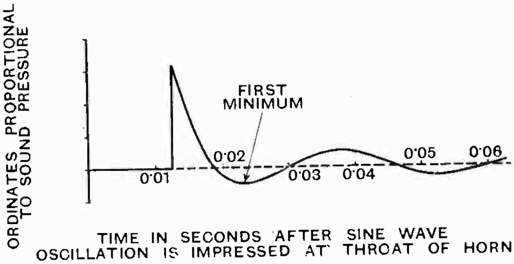


Fig. 9.—*Illustrating wave form of "inherent" transient of loud speaker horn 427 cm. from the throat: cut-off frequency 31.8 c/s. at time $t = 0$ a sine wave motion is given to the air particles at the throat.*

The second way in which the horn affects transients is its damping of the diaphragm. Referring to the equivalent circuit of Fig. 7a, $\mathbf{C}^2/R_m = r_1$ is the resistive load imposed by the horn. It is zero below the cut-off point and rises steadily above it to a value $\rho_0 c A_0 (Ad/A_0)^2$. Using the numerical data herein, we have seen that the motion

* McLachlan & McKay, *Proc. Camb. Phil. Soc.*, 32, 265, 1936.

of the diaphragm on its annular surround is aperiodic, but in obtaining this result we tacitly assumed r_1 to be independent of frequency, i.e., no cut-off.

Let us consider the system comprising merely the diaphragm on its annular surround, loaded resistively by the horn. The electrical analogue is the LCR circuit of Fig. 10b, where R steadily decreases in conformity with the reduction in loading of the diaphragm as the cut-off point of the horn is approached, and the inertia of the air is neglected. If R were constant, the natural frequency would be $\omega/2\pi = \frac{1}{2\pi}\sqrt{\left(\frac{1}{LC} - \frac{R^2}{4L^2}\right)}$, and the condition for aperiodicity $R^2/4L^2 > 1/LC$. When R is not independent of ω the system is non-linear, and it is difficult to treat the circuit analytically.

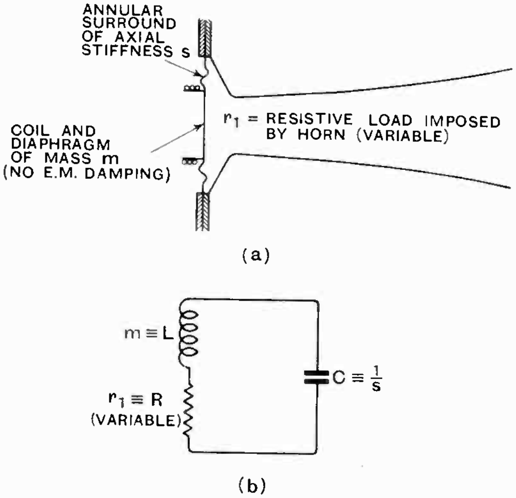


Fig. 10.—(*a*) *Mechanical arrangement of diaphragm, annular surround and horn.* (*b*) *Electrical analogue of* (*a*).

Judging from the influence of a short horn, as shown in Fig. 5, if (1) the cut-off frequency is well below that of the diaphragm on its surround *in vacuo* $\frac{1}{2\pi}\sqrt{(s/m)}$, (2), the mouth diameter of the horn is large enough to maintain the resistive loading in the neighbourhood of the cut-off, the motion may be almost—if not actually—aperiodic.* Frictional loss in the annular surround and electromagnetic damping due to the coil in the magnetic field, will assist in this direction.

In view of the limitations of the mathematical treatment when the complete conditions of practical working are so complicated, there appears to be an interesting field of research for anyone who has the requisite experimental equipment.

It may be remarked that the analysis leading to formula (1) was published in *Electrische Nachrichten Technik.*, Aug., 1936, Vol. 13, pp. 251-259, by McLachlan & McKay.

* This applies to a loud speaker having the numerical constants used herein. Each speaker design has to be considered individually.

Television Exhibition

THE first public exhibition devoted solely to the development and modern attainments of television is to be opened at the Science Museum, South Kensington, early in June. All the principal British manufacturers interested in the development of television are co-operating with the Radio Manufacturers' Association and the B.B.C. to make the exhibition truly representative.

The history of television may be said to date from the year 1873 when a telegraph operator named May discovered that the electrical resistance of the metal Selenium was altered by light, and ever since 1880 experimenters have attempted to send pictures and scenes, first by wire, and then by wireless.

Demonstrations will be given of the B.B.C. transmissions on modern receivers, and a local transmitter will be shown in operation so that the receivers can operate when no B.B.C. transmission is available.

Radio Beacons.

By V. I. Bashenoff and N. A. Myasoedoff, pp. 670 with 507 Figs. Moscow.

This book is in Russian. It is evidently a most thorough investigation of the whole theory and practice of the subject of radio beacons. Several chapters have already been published in English, Chapter III in this journal (May, 1928) and other chapters in the Proc. of the Institute of Radio Engineers. Bashenoff is well known for his work on this subject to which he has devoted himself for many years. He is a Professor at the Moscow Aviation Institute and Chief of the Radio Section of the Central Aero-Hydrodynamical Institute. In the preface it is stated that all but 9 of the 21 chapters have been previously published, but to a radio engineer who can read Russian the book will prove invaluable in the completeness of the treatment of a subject of ever-growing importance, especially in aviation. A whole chapter is devoted to radio beacons for blind landing, with sections on various German and American systems.

The book concludes with a very extensive bibliography of the subject, but also in Russian.

G. W. O. H.

Quartz and Tourmaline

By Peter Modrak, M.Sc., B.E., A.M.I.E.E.

(Concluded from page 134 of last issue.)

THE chemical formula for tourmaline is very complicated, being of the form

$$H_8 Na_4 Al_{16} B_6 Si_{12} O_{63},$$

The simplest form of tourmaline crystal is shown in Fig. 9. In this case Z is the optic axis, X and Y are the crystallographic axes.

Tourmaline used for piezoelectric purposes should be of uniform structure free from mechanical injuries. The colour of tourmaline is green, blue or brown. In thin plates tourmaline is practically transparent.

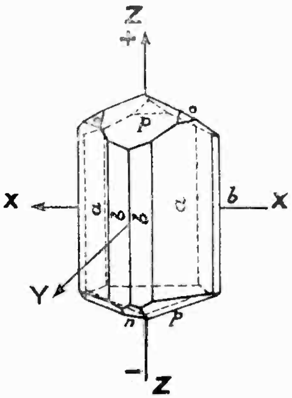


Fig. 9.

Hardness of tourmaline is 7. Density 3.1.

Tourmaline crystals have a double index of refraction. The indices are 1.6397; 1.628. The index varies to some extent depending upon chemical composition of crystal.

Tourmaline crystals exhibit piezoelectric and pyroelectric properties.

Tourmaline is polarised in the direction of the optic axis and for that reason tourmaline plates are cut at right angles to the optic axis.

The dielectric constant of tourmaline is 5.7 Young's modulus $E = 1.6 \times 10^6$ kg/cm² in the plane at right angles to the Z-axis and changes very little in other directions.

The temperature coefficient of frequency of tourmaline is about -46.6×10^{-6} per 1° C.

Frequency variation with change of temperature is very uniform; no jumps of frequency have been noticed.

Tourmaline is excited very easily. It is usually accepted that 1 mm of thickness of tourmaline plate corresponds to an 80-meter wave.

Parasitic frequencies in tourmaline crystals are less prominent than in quartz.

If parasitic vibrations occur their intensity is less than that of quartz. These vibrations are as a rule farther removed from the fundamental frequency.

Tourmaline is more convenient for cutting, grinding and polishing than quartz.

The methods of cutting, grinding and polishing of tourmaline are the same as for quartz.

Tourmaline plates may be prepared for waves down to 1.2 m or frequencies as high as 25×10^7 cycles.

Tourmaline plates are generally cut round.

The electrodes of a tourmaline holder form a condenser of a certain capacity. When making tourmaline for higher frequencies it is necessary to keep this capacity as low as possible by decreasing the diameter of the tourmaline plate. Thus for 5-meter waves the diameter of the plates should be about 8 mm.

For waves between 5 and 7 meters the diameter of the plates should be about 12 mm and for waves above 7 meters 20 mm.

As the wavelength is decreased the efficiency of the oscillator decreases and at about 2 meters the oscillations disappear. The decrease of efficiency of the oscillator is due to the large capacity of the tourmaline holder.

Tourmaline sustains oscillations under pressure better than quartz.

With plates of 12 mm diameter the pressure may reach 500 gr/cm².

Silvering of tourmaline plates is not recommended as it changes the frequency of the plate and at higher frequencies it may peel off.

When the crystal has been tested for twins and the optic axis has been determined, one may proceed to cut plates of suitable orientation.

It is not proposed to describe the methods of cutting, grinding and polishing, as these have already been described in *The Wireless Engineer*.

It should be noted that the design formulae given above serve only as a guide for cutting plates for certain frequencies.

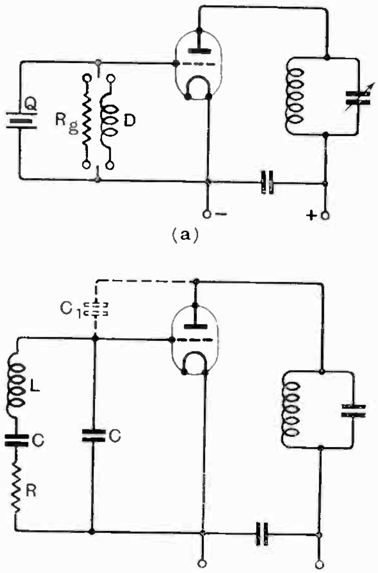


Fig. 10.

When the plate has been cut it is necessary to test it for oscillation. For this purpose the following circuit may be used (see Fig. 10a).

In this case the quartz Q is connected between the grid and the filament. For carrying away positive electric charge from the grid, a grid leak R_g or coil D is provided.

In both cases the resistance should be large in comparison with the equivalent resistance of the quartz crystal. In the selection of a suitable valve it is necessary to take care that grid current should be as small as possible.

The intensity of vibrations will be a maximum if the tuning circuit is tuned to a frequency slightly less than the natural frequency of the quartz.

Piezoelectric crystal may be represented as a combination of inductance L, resistance R and capacitance C connected in series and capacitance C' connected in parallel (see Fig. 10b).

In this case:

L is the electrical equivalent of the vibrating mass of the crystal.

C is the electrical equivalent of the stiffness of the crystal.

C' is the electrostatic capacitance between the crystal electrodes when crystal is not vibrating.

The values of L, C, R and C' may be calculated from the following formulae:

$$L = \frac{Da^3}{8\epsilon^2 A}$$

$$C = \frac{8\epsilon^2 A}{\pi^2 E a}$$

$$R = \frac{\pi 2 D Q a}{8\epsilon^2 A}$$

$$C' = \frac{\epsilon A}{4\pi a} \quad \text{where}$$

D = density of quartz
a = thickness of crystal
A = area of electrode
E = Young's modulus
ϵ = dielectric constant
Q = viscosity of quartz.

Generally C' is about 100 times C.

This circuit has its resonant and antiresonant frequency very close together on account of the high value of $\frac{C'}{C}$.

Mechanical resonance is taking place at the same frequency at which L and C are in resonance.

The magnitude of the resonant effect depends upon the ratio of $\frac{\omega L}{R}$ of the equivalent circuit.

The resonant frequency of the crystal vibrator varies inversely with the dimension of the crystal in the direction of the principal vibration. For maintenance of oscillations the ratio of L/C known as the stiffness of the equivalent circuit should have a certain value.

For that reason for ultra short waves the dimensions of the quartz plate should be kept small, thus reducing the static capacitance of this plate.

The coupling between the crystal and the anode circuit is due to the internal anode-grid capacitance of the valve.

In normal valves the capacitance C_1 is about 3 to 4 cm. To secure vibrations the coefficient of coupling must be about 10 per cent.

It is generally accepted that by increasing the area of the quartz plate it is possible to increase the load sustained by the crystal. This is not so.

When the area of the plate is increased the ratio of L/C is decreased and with a given coupling the alternating voltage acting between the electrodes of the quartz will be decreased also.

When larger valves are used it is necessary to use crystal plates of larger area on account of the larger internal anode-grid capacity of the valve.

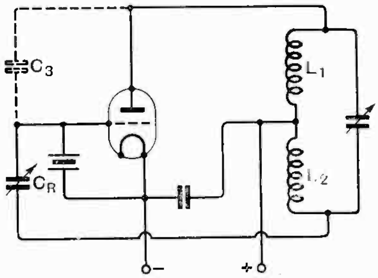


Fig. 11.

When a grid leak is used the anode current decreases when the crystal begins to vibrate. When a coil is used instead of a grid leak it should have the least number of turns. When the number of turns is large the generator oscillates without the quartz. The number of turns should be determined experimentally.

When a coil is used the anode current increases when the crystal is excited.

To test a crystal it is necessary to place it in a suitable holder, tune the anode circuit and observe the current in D.C. milliammeter.

The current drops whenever the condenser is moved in the tuning circuit, but rapidly returns to its original value. This behaviour is the best indication of oscillation of the quartz plate.

If the plate is not oscillating this may be due to several causes, e.g., lack of cleanliness or the fact that the dimensions of the plate are unsuitable.

In the first case it is necessary to clean the plate by washing with soap and water and drying with a perfectly clean linen cloth. Also it is recommended to rub the quartz with a cloth moistened with alcohol or carbon tetrachloride and rinse with distilled water and dry with a piece of clean and grease-free chamois leather.

If the oscillations do not take place it is necessary to grind one of the edges of the plate.

When quartz oscillates it is necessary to test it for parasitic frequencies.

The following circuit is generally used for detection of parasitic frequencies (see Fig. 11).

In this case $L_1 = L_2$. C_3 is the capacitance between the grid and anode which must be neutralised. C_R is a variable condenser of small capacitance.

To neutralise C_3 it is necessary to disconnect the quartz from the system and make $C_R = C_3$. When this is the case the generator will not oscillate.

When the quartz is connected between cathode and grid the vibrations appear as in the generator stabilised by quartz. By varying the condenser C_R it is possible to change the back-coupling at will, whereas formerly the back-coupling due to anode-grid capacitance had a fixed value.

By increasing the coupling one can easily excite the frequencies which normally would not appear.

When dealing with short waves it is necessary to use this scheme with care because with strong coupling the quartz plate may be damaged.

It may also occur that with inaccurate tuning there may appear self-excited vibrations near plate-frequency.

When the plate has been tested for parasitic frequencies, it is necessary to grind it for the assigned frequency.

The quartz plate should be connected to the same valve and placed in the same holder in which it will operate normally.

When the quartz plate has been tested for parasitic frequencies it is necessary to test it for jumps of frequency. These jumps are due to mechanical coupling between vibrations in one direction and harmonic vibration in the other direction. They are very undesirable and any plate exhibiting such jumps should be rejected. These jumps may appear when the temperature of the crystal is varied.

For the purpose of testing the plate is placed in a suitable thermostat and a reference crystal whose frequency is about 1 kilocycle or so apart is placed in an electrically controlled thermostat in which a constant temperature is maintained. The diagrammatic arrangement is shown in Fig. 12.

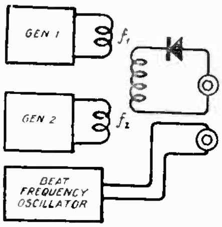


Fig. 12.

The difference of frequencies of the two generators is determined by varying the frequency of a beat frequency oscillator until zero beat is secured and reading the condenser dial marked in cycles. If there are any jumps of frequency they are easily detected when the temperature of the crystal drops.

From variations of temperature and frequency it is possible to calculate the temperature coefficient of frequency.

This temperature coefficient is $= \dfrac{df}{dt\,.\,f}$,

where df is change of frequency

dt = change of temperature

f = frequency of crystal.

Jumps of frequency may occur in *X*-, *Y*- and *R*- or *AT*-cut plates.

As a rule jumps of frequency are more frequent with *Y*-cut plates. They are absent in tourmaline plates.

Figs. 13 a and b represent variations of

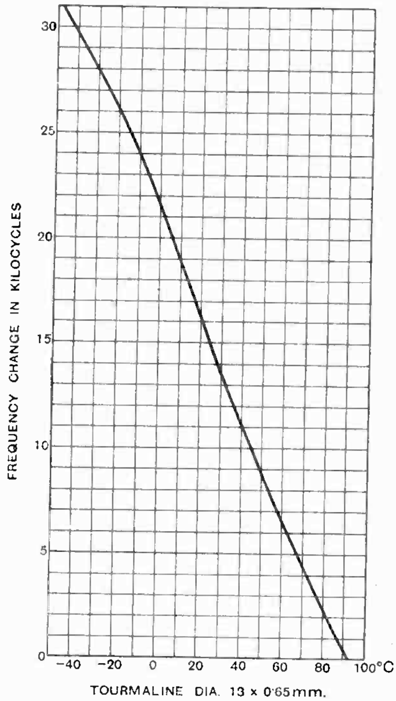


Fig. 13 (*b*).

frequencies with change of temperature for *X*-cut quartz plate and also for tourmaline plate.

In 1929 it was pointed out by F. R. Lack[1] that considerable difficulties arise in preparation of *Y*-cut plates on account of jumps of frequencies appearing with very small changes of thickness of plates.

It has been pointed out that these jumps of frequency appear at frequencies which coincide with harmonic frequencies which the

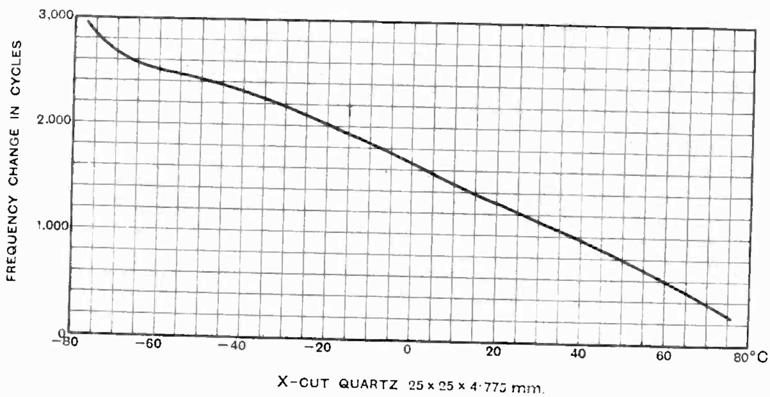
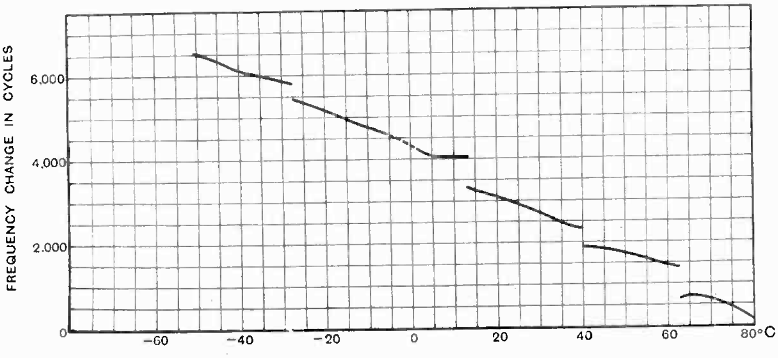


Fig. 13 (*a*).

[1] Observations on Modes of Vibration and Temperature Coefficient of Quartz Crystals, F. R. Lack, *Proc. Inst. Rad. Eng.*, July, 1929.

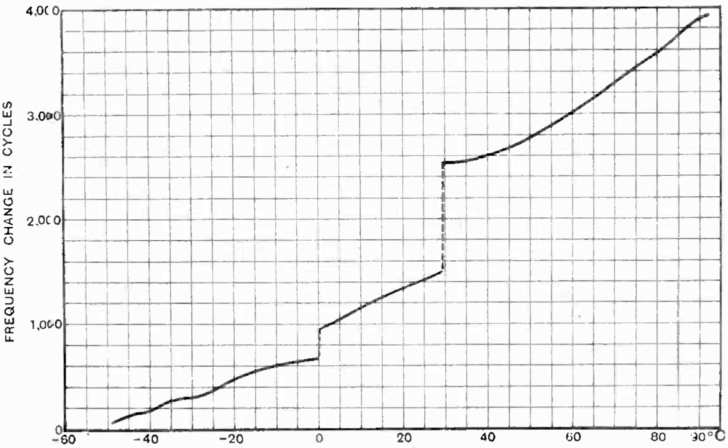
crystal would have if it vibrated in the direction at right angles to the electric field.

Further experiments proved also that these jumps of frequency depended upon the width of the crystal. This proved that a system of coupled mechanical vibrations is produced which are analogous to the electrical vibrations in coupled circuits.



X-CUT QUARTZ 25 × 25 × 2·67 mm.

Fig. 14 (*a*), *and right* Fig. 14 (*b*).



Y-CUT QUARTZ 25 × 25 × 4·03 mm. F = 505·1 kc/s

That these jumps may occur in *Y*-cut as well as *X*-cut plates is shown in Figs. 14a and b. These jumps are very undesirable in radio practice. For that reason each plate should be tested for these jumps of frequency. For this purpose the same apparatus is used as for determination of temperature coefficient of frequency.

Generally before a jumping frequency is attained, the temperature coefficient of frequency rapidly decreases and frequently reaches zero value.

When jumps of frequency occur, it is necessary to grind one of the edges of the plate in order to change the mechanical coupling between vibrations in the direction of the electric field and those at right angle to it.

In 1931, H. Straubel[1] introduced a formula taking into consideration the coefficient of linear expansion of the crystal in different directions. Straubel's experiments point out that the results differ considerably from the formula proposed by him. His experiments prove that interference of various vibrations has considerable influence upon change of temperature coefficient of frequency. It has been shown that the temperature coefficient of *Y*-cut plates approaches zero values before jumps occur.

In 1929, W. A. Marrison[2] carried out experiments with ring-shaped quartz of *Y*-cut plates.

According to Marrison's experiments the temperature coefficient of frequency for ring-shaped plates having an internal diameter = $\frac{1}{3}$ of the outer diameter is positive and decreases with increase of the inner diameter of the ring.

In the author's experiments, *Y*-cut quartz

[1] Schwingungsform und Temperaturkoeffizient von Quartzoszillatoren *Jahrbuch der drahtlosen Telegraphie und Telephonie*, Band 38, H. 1 July, 1931.

[2] "A High Precision Standard of Frequency," *Proc. Inst. Rad. Eng.*, July, 1929.

has been used having an outside diam. of 43.435 mm and 9.075 mm thick.

The temperature coefficient for circular plate was -28×10^{-6}. The temperature coefficient with ring-shaped quartz having an inner diameter of 10.5 mm was -16.8×10^{-6}.

When the inner diameter was increased to 28 mm the temperature coefficient was $+94 \times 10^{-6}$.

It is necessary to state that the frequency of the ring-shaped quartz did not change appreciably when the inner diameter of the ring was increased.

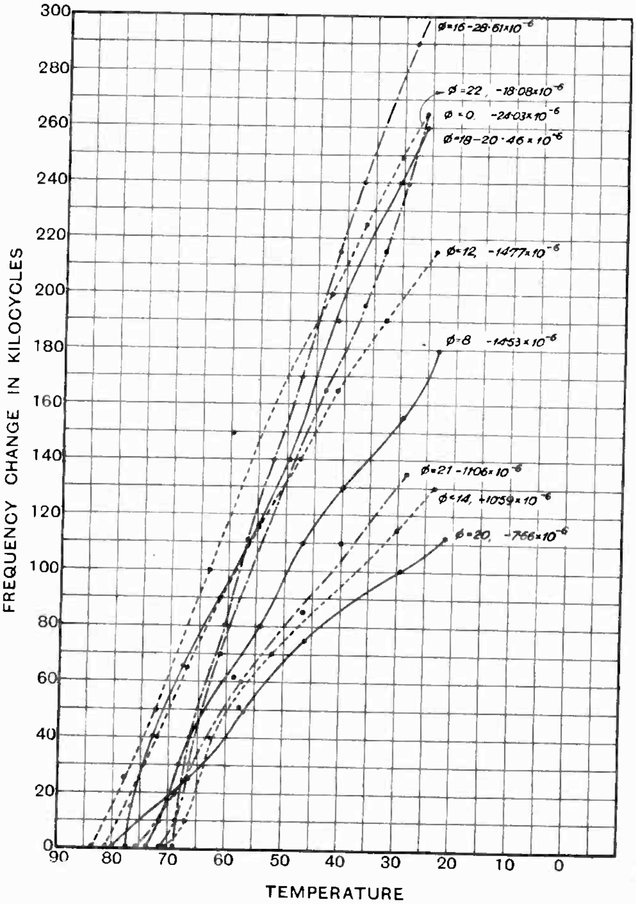


Fig. 15.

The frequency of the circular plate was 230 330 cycles at 23° C., whilst the frequency of the ring of inner diameter 28mm, was 229 670 cycles at 20.4° C.

On account of considerable discrepancy between the author's experiments and those of Marrison it was decided to test two other ring plates, care being taken to select the best possible material free from twins.

To secure the most uniform material a cylindrical block of quartz was prepared and tested for oscillations. This cylinder has been cut into two parts, each being carefully finished.

The results obtained for these rings are tabulated on the next page, and are represented in Fig. 15:

These results indicate that the preparation of ring-shaped quartz plates of small temperature coefficient is a rather difficult matter.

They show that the frequency may be changed not only by reduction of thickness of plate but also by the change of inner diameter of ring.

The least temperature coefficient with the same thickness of plate depends to a certain extent upon the ratio of inner to outer diameter of ring and this ratio is not constant, being 3 : 1, 2 : 1, and 3 : 2 approximately for different plates.

At the end of 1934, Prof. T. Koga in Japan [1], Dr. Bechmann, Germany [2], and F. R. Lack, G. W. Willard and L. E. Fair, in America [3] described their *R*- or *AT*-cut, giving zero temperature coefficient of frequency.

If the angle of rotation of plate about the *X*-axis is changed as indicated in Fig. 16a, it may be shown from theoretical considerations that for thin plates the relation between temperature coefficient of frequency and angle of rotation is as shown in Fig. 16b. It is recom-

[1] Thermal Characteristics of Piezo-electric Oscillating Quartz Plates Report of Radio Research in Japan, Vol. IV, No. 2.

[2] R. Bechmann: Über die Temperatur-Koeffizienten der Eigenschwingungen, piezo-elektrischer Quarzplatten und Stäbe, *Jahrbuch der Drahtlosen Telegraphie und Telephonie*, November, 1934.

[3] Some Improvements in Quartz Crystal Circuit Elements, *The Bell System Technical Journal*, July, 1934.

mended to use plates cut at 35°; the other cut at − 48° giving zero temperature coefficient is not to be used on account of the increase and subsequent decrease of frequency with temperature.

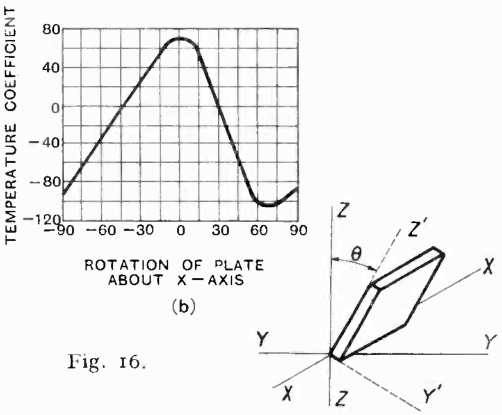


Fig. 16.

(a)

The above-mentioned investigators point out that experimental results are in close agreement with theory.

QUARTZ No. 1.

Inner diam. of ring in mm	Temperature coefficient	Frequency	Remarks
0	-24.03×10^{-6}	243 650	*By grinding and changing thickness from 7.48 to 7.26 frequency was changed to 236 420 cycles. Frequency 245 450 was secured by increasing diam. of ring to 18 mm.
8	$-10.53 \times$,,	243 650	
12	−14.77 ,,	254 150	
14	−10.54 ,,	257 153	
16	−28.61 ,,	231 400*	
18	−20.46 ,,	245 450	
20	− 7.66 ,,	251 320	
21	−11.06 ,,	260 850	
22	−18.08 ,,	261 300	

Inner diam. of ring in mm	Temperature coefficient	Frequency	Remarks
0	-19.94×10^{-6}	259 180	Thickness of quartz was the same.
12	−13.56 ,,	267 550	
14	−16.19 ,,	268 460	
16		303 800	
18		246 900	
20	+ 2.42 ,,	249 800	

Frequency jumps do not occur in these plates so often as with *Y*-cut plates.

These plates oscillate under pressure and in that respect resemble *Y*-cut plates.

The author carried out a series of experiments with plates cut very close to 35° with respect to the *Z*-axis.

The conclusions that may be drawn from the author's experiments are as follows:

(1) It is possible to secure temperature coefficients approaching zero value for thick and thin plates if suitable relations between length along the *X*-axis and length along *Z'* are chosen (Fig. 16a).

(2) Jumps of frequency are less troublesome with *R*- or *AT*-cut plates than with *Y*-cut plates; by slight changes of the dimensions of the plate it is possible to get rid of these jumps.

(3) Spurious frequencies occur very seldom in these plates.

It was pointed out in 1925 by Giebe and Scheibe that if a quartz plate is placed between two electrodes as shown in Fig. 17, a luminous effect may be produced.

In this case electrodes E_1 and E_2 are fixed on ebonite or glass. The quartz rests

Fig. 17.

freely upon the lower electrode. Between the electrodes an air gap of about 0.5 mm is provided for observation of the luminous effect.

If the frequency of the potential difference applied to these electrodes corresponds to the natural frequency of the quartz plate, a luminous effect appears as a result of the considerable mechanical stresses produced in it.

If a quartz plate be placed in a vacuum corresponding to about 10 or 15 mm of mercury the luminous effect appears at a potential difference considerably less than that at atmospheric pressure. The resonance point may be determined with an accuracy of 1 in 10 000.

Luminous resonators are used for stabilising the wavelength of transmitters, for calibration of wavemeters or checking their accuracy and for international comparison purposes.

Giebe and Scheibe experimented with vibrations along the length of the bars having rectangular cross-section.

In the case represented in Fig. 18, the

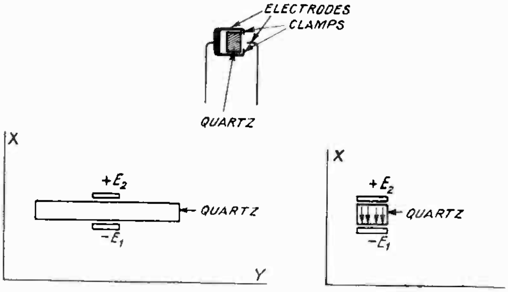


Fig. 18.

direction of length is perpendicular to the X-axis. In Fig. 19 the length is parallel to the X-axis.

In both cases the direction of electric field is as shown.

In the case represented in Fig. 18, the quartz rests freely upon the surface of the electrode and is being kept in position by means of clamps as shown, being thus free to move slightly along the electrode.

The other electrode consists of a sharp point or of a wire placed parallel to the

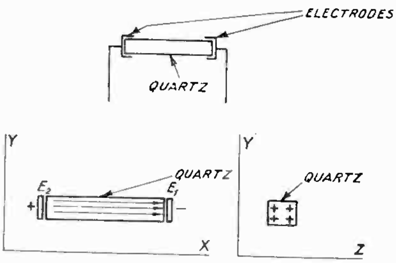


Fig. 19.

quartz bar in the case of long bars. An air gap of about 0.5 mm is generally provided.

In the case shown in Fig. 19, quartz bars are supported by electrodes suitably pressed.

This type of electrode is used for bars for lower frequencies.

It is obvious that for the same voltage applied to the electrodes the intensity of electric field is considerably less in the second case than in the first. This intensity is sufficient, however, for production of luminious effect in bars up to 50 mm in length.

In both cases loose and fixed electrodes are used. Quartz bars are generally mounted inside glass bulbs partially exhausted and filled with a mixture of neon and helium at a pressure corresponding to a few millimeters of mercury.

For elimination of parasitic frequencies and also for securing low temperature coefficient of frequency, the dimensions of a bar for 250 kc/s were $y = 11$ mm, $x = 1.5$ mm, $z = 2$ mm.

For frequency of 1 000 kc/s dimensions of bar will be

$$y = 3 \text{ mm}, x \text{ and } z = 1.5 \text{ mm}.$$

It is obvious that preparation of quartz bars of these dimensions is a difficult matter.

Quartz resonators of this type have small temperature coefficient and are suitable for determination of frequency with an accuracy

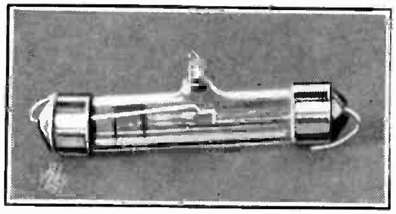


Fig. 20.

of $10 - 20 \times 10^{-6}$ with loose electrodes and 5×10^{-6} with fixed electrodes. It was pointed out that the preparation of bars of the above type is difficult for frequencies below and above 1 000 kc.

For frequencies corresponding to wavelengths below 100 meters it is possible to use X-cut plates, using vibrations along the thickness of the plate. 1 mm thickness of these plates corresponds to wavelength of 100 meters.

For this reason it is possible to prepare luminious quartzes for frequencies of 7.5 megacycles.

Fig. 20 represents a luminous resonator for a wavelength of 50 meters prepared in the laboratory for experimental purposes.

In this case thickness vibrations have been used and no spurious frequencies have been detected.

Quartz resonators are being applied in radio transmitters and receivers.

For tuning radio transmitters to a fixed wavelength the scheme represented in Fig. 21 is recommended. For coupling purposes a coil of suitable number of turns is used.

The natural frequency of this coil should be as near as possible to the frequency of the resonator.

For fine tuning a precision condenser should be provided in the tuning circuit of the generator in order to tune it to the resonator whose resonance is very sharp.

The coupling between generator and resonator should be as loose as possible in order to avoid luminosity of the gas. A quartz resonator may be connected in parallel with the circuit coupled to the

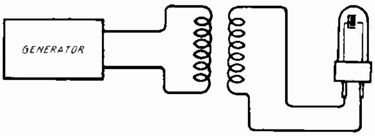


Fig. 21.

tuning circuit of the radio transmitter, as shown in Fig. 22. In this case a neon valve is connected in parallel with the quartz resonator.

The neon valve extinguishes when resonance is reached, i.e., when the resonator appears bright. A galvanometer may also be used to indicate resonance.

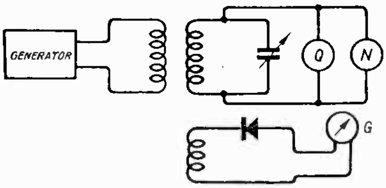


Fig. 22.

In order to tune a radio receiver by means of a quartz resonator, it is necessary to connect one electrode of the resonator to the grid circuit or couple it inductively to the tuning circuit as shown in Fig. 23.

When the tuning condenser is turned round one hears characteristic clicks at various harmonics.

As the audion is generating harmonics it is possible to determine a wavelength three or four times longer than that of the resonator.

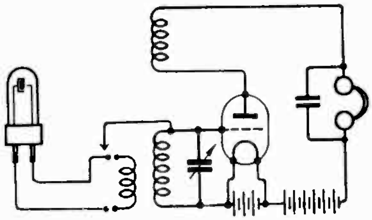


Fig. 23.

To secure the maximum resonance effect an amplifier should be employed.

In the first part of this article published last month the following errors should be noted :—

p. 127, line 5, col. 1, should read : " Crystals of quartz form hexagonal prisms terminated ", etc.

p. 131, line 2, col. 1, for " positive " read " position."

p. 131, line 36, col. 2, for " hold " read " hole."

p. 132, line 14, col. 1, for " O′ " read " O_1."

p. 133, line 13, col. 2, read 20 to 35 × 10^{-6}. line 16, col. 2, read 40 to 70 × 10^{-6}.

Physik und Technik der ultrakurzen Wellen. Vol. II. By H. E. Hollmann, pp. viii + 306, with 283 Figs. Julius Springer, Linkstrasse 22–24, Berlin, W.9. 33 Marks.

The first volume, published in 1936 dealt with the production of ultra short waves ; this second volume carries the subtitle " Die ultrakurzen Wellen in der Technik," and deals with their practical applications and the phenomena which are met with in ultra short-wave work. The six chapters are entitled (1) The reception of quasi-optical waves ; (2) Radiation and directional beams ; (3) Transmission of ultra short waves ; (4) Practical applications ; (5) Demonstrations and model experiments ; (6) Measurements. One receives an excellent impression on picking up and opening the book, for the binding, printing, illustrations, etc. are all of the high standard which one associates with the name of Springer. The contents of the book are also of a high standard ; the author is well known as a worker in this field and writes from first-hand knowledge of the subject. The descriptions are clear and eminently readable, and, if the detailed theory is not always so exhaustive as some readers might wish, references are always given to original papers which such readers can consult. It is a book which can be recommended to all who are interested in ultra short-wave work, but the price will probably act as a powerful deterrent.

G. W. O. H.

Frequency Changers in All-Wave Receivers*

The Performance of Some Types

By M. J. O. Strutt

(Natuurkundig Laboratorium der N. V. Philips' Gloeilampenfabrieken, Eindhoven-Holland)

SUMMARY.—The various conditions, to be imposed on frequency changers generally and especially in the short-wave range, are set forth in eleven points. Sections II and III explain and discuss some of the more important effects inherent to octodes on short waves: interlocking by electron coupling and frequency drift. Some means for partially curing them are given. In the next section the general features and specially their performance in the short-wave range is dealt with, discussing the different effects, related with their use in those ranges. Section V deals with triode hexodes. Section VI briefly sets forth the latest developments in octode construction, giving figures for the performance of the new types in the short-wave range, which compare favourably with those for the octodes now in use in this country.

I. Conditions to be Imposed on Frequency Changers

When considering the use of frequency changers (mixer tube combined with oscillator) in all-wave receivers, it might make discussion easier if we enumerate the different conditions, which should, if possible, be satisfied by such first detectors.

High amplification is a term often met in bulletins. However, gain alone is not the point; what we desire is high gain and a small noise-level. As noise is closely related to output d.c. milliamps, we get three conditions out of this: (1) high conversion slope; (2) small d.c. anode current; (3) high internal resistance. Besides the shot noise level there is also noise from (4) whistling notes which should be small, compared with the music level, assuming a normal percentage of modulation.

Total current consumption (5) may be an important factor, e.g. in battery and car receivers. Disturbances like cross modulation and distortion of the modulation (6) should be reasonably small. Requirements are widely different in this respect. It should be pointed out that better cross modulation characteristics lead invariably to higher anode current and hence to increased shot noise. Microphonic action (7) should, of course, be absent. Whereas the points (1) to (7) apply to any waveband, there are some effects, more specially related to short waves. Interlocking of oscillator and input circuits (8) should be avoided. Variation of input capacity (9) should be small to prevent detuning of the input circuit during volume control. Finally, frequency drift of the oscillator (10), caused either by variation of positive tensions or by volume control, should not exceed a reasonable value. No radiation (11) from the oscillation should come on the input grid circuit. There are still some effects, not expressed in the points (1) to (11), but these will turn up in the discussion below. Thus we have the following chief requirements for frequency changers:

(1) high conversion conductance;

(2) small d.c. anode current;

(3) high internal resistance;

(4) reasonably small whistling note level;

(5) low total current consumption;

(6) reasonably small cross modulation and distortion;

(7) no microphonic action;

(8) no interlocking of input and oscillator circuits;

(9) small variation of input capacity;

(10) small frequency drift of oscillator;

(11) no radiation.

It will not need much comment if we say that an ideal frequency changer, fulfilling all these requirements in an optimum way, does not exist. Two modern types, octodes and triode-hexodes will here be discussed, taking these 11 points as a base.

* MS. accepted by the Editor, June, 1936.

II. Coupling Effects in Octode Frequency Changers

Perhaps one of the most interesting effects is interlocking and coupling of oscillator and input circuits in octode frequency changers. The actual static capacity between input grid (grid 4) and oscillator grids (see Fig. 1) (grids 1 and 2) is of the order of one-tenth of a micromicrofarad and would seem to warrant complete independence of input

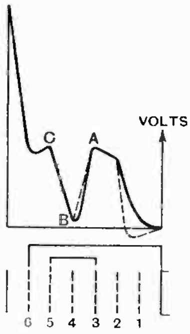


Fig. 1.—*Lower part: grid constellation of octode. Upper part: rough sketch of potential distribution in an octode; full line for positive swing of grid one; broken line for negative swing of grid one.*

and oscillator circuits. But already at the short-wave end of the medium waveband (200–600 metres) a voltage of oscillator frequency appears on the input circuit, often amounting to something like one volt with the FC4, depending, of course, on the data of the input circuit.* This voltage, if the oscillator frequency is above input frequency, as usual in this band, is opposite in phase, compared with oscillator voltage swing on grid 1 and hence tends to lower conversion slope. This voltage cannot be explained numerically by the above-mentioned static capacities. It is due to "electron coupling." Consider the potential distribution in the tube under working conditions, which is approximately pictured in Fig. 1. The full line represents the state of affairs, while grid 1 is zero or thereabout; the broken line corresponds with grid one being far negative. We are specially interested in the portions between A, B and C, as these surround the input grid. The slope of BC in the point B is practically unaltered during one oscillator swing period. But the slope of BA in the point B is greater for negative voltage on grid one than for positive swing voltage on this grid one due to space charge between grids three and four in the latter case. As the oscillator frequency is above input frequency, the input circuit, connected to grid four, is a capacity for the oscillator frequency. This capacity is charged alternatively by the oscillator swing; its momentary charge is proportional to the difference of the slopes of BC and BA at B (gradients of potential distribution). The slope of BA at B is greater in the negative position of grid one. Hence the charge induced on the grid four circuit and the corresponding voltage are opposite in phase to grid one voltage swing. This electron coupling between grid one and grid four may be represented by a negative capacity from grid one to grid four, but not back from grid four to grid one. The value of this capacity is about two micromicrofarads in the FC4. If, with such a valve, under operating conditions, we connect a small condenser of about two micromicrofarads between grid one and grid four, the induced oscillator voltage on the grid four circuit practically disappears. Of course, this means of neutralising leaves a one-sided positive capacity from grid four to grid one. Not much harm is known at present, due to this latter capacity.

We now consider some practical aspects of the electron coupling between grid one and grid four. By considering the impedance of the grid four circuit for the oscillator frequency (being above the input frequency) it is found that in one waveband, coming from the short-wave end, electron coupling diminishes inversely as the third power of the frequency. In different wavebands, at equal tuning positions of the variable condenser in the lead to grid four, it increases proportional to the frequency. It is inversely proportional to the intermediate frequency in any band. Thus it is only serious at the lower wavelength ends of the bands and causes most nuisance in the short-wave ranges. For instance, on 14 metres, with an input variable condenser of about 30 $\mu\mu$F. at its minimum position, induced oscillator voltage on the grid four input circuit may be of the order of 10 volts under normal conditions with the FC4 without neutralisa-

* This phenomenon was detected, within the Philips-Mullard organisation, in the beginning of 1934 by Mr. R. Clark (Mullard) and Messrs. Tellegen and van Loon (Philips, Eindhoven). This effect was investigated numerically and put to practical use by Messrs. Bakker and de Vries (see bibliography, No. 3 and No. 18).

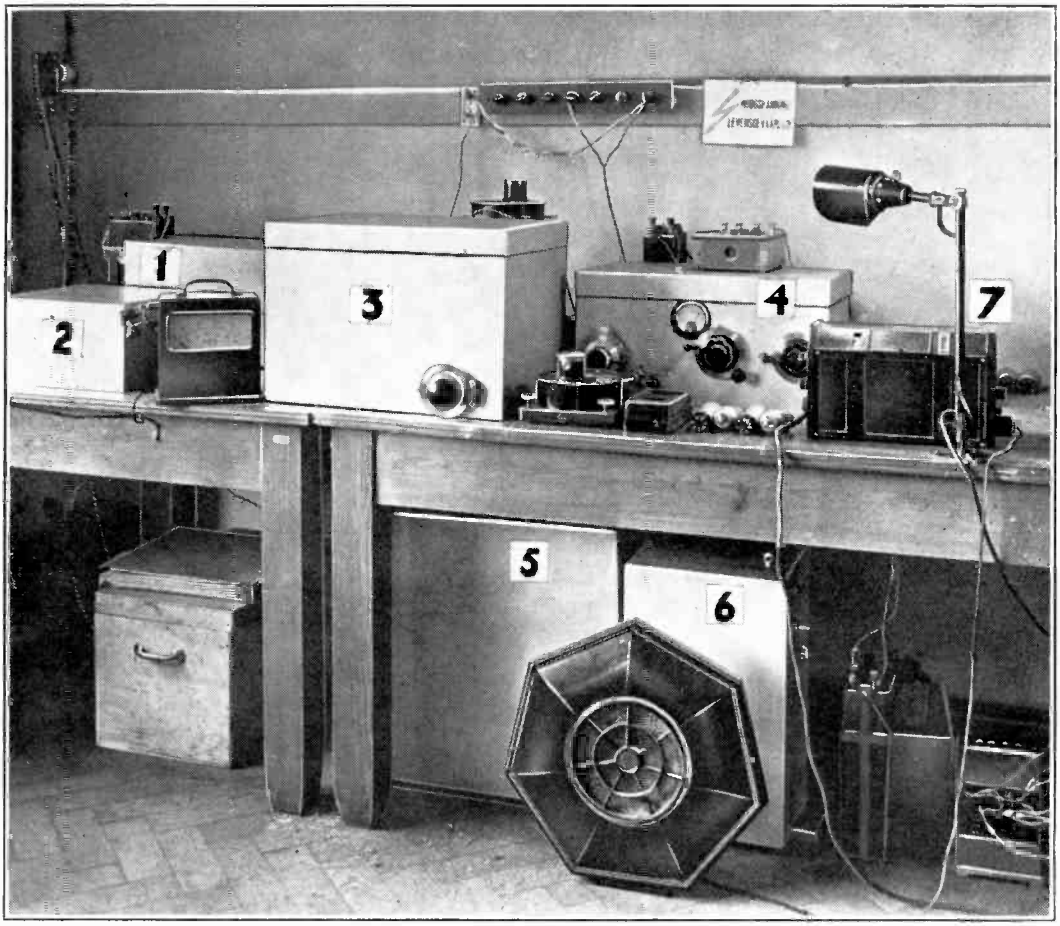


Fig. 2.—*Photograph of measuring arrangement for determining the characteristic properties of frequency changers in the short wave range.*

(1) *Box containing signal generator of frequency range 230—4 m wavelength.*

(2) *Filter circuit between a.c. 220 volts mains and receiver 3.*

(3) *All-wave receiver, Philips 335 A in box, coupled to input circuit of frequency changer by a condenser of 0.1 μμF. and used to measure input signal voltage on this circuit (a.v.c. of receiver shorted).*

(4) *Box containing several screened compartments, for diode voltmeter measuring total voltage on input circuit of frequency changer (including induced volts of oscillator frequency), for frequency changer valve, for input circuit, for oscillator circuits and for output circuits (100, 500 and 1,000 kc/s intermediate frequency).*

(5) *Box containing batteries for positive and bias tensions of frequency changer.*

(6) *Box containing heater battery.*

(7) *All-wave receiver (with audion) for control of oscillator of frequency changer, for frequency drift measurements, etc. All boxes are earthed and interconnected by soldered copper tubes, containing the necessary conductors.*

tion at 100 kc/s intermediate frequency. Condition (II) (no radiation) is heavily violated under these circumstances.

Owing to the induced oscillator volts on the input circuit conversion conductance is, for instance, in the 200–600 metre band lower on 200 metres than on 300 metres and longer waves. As circuit impedances increase towards the short-wave end of the band, this tends to neutralise the decrease of conversion conductance.

Using an elaborate arrangement (Fig. 2) several series of measurements were taken on short waves. In these measurements it was possible to determine the voltage of input signal frequency and the volts of oscillator frequency across the input circuit separately. Some figures of input impedance (considered as a resistance and a capacity in parallel), conversion conductance, noise level and direct currents are given here for the valve FC4 at a wavelength of 13 metres, i.f. of 500 kc/s, input circuit capacity of about 30 $\mu\mu$F.

Case.	Inp. par. res.	Inp. cap.	Conv. cond.	Anode mA.	Total mA.	Noise.
A	200 000 ohms	10.6 $\mu\mu$F.	0.27 mA/volt	0.76	6.5	311
B	200 000 ,,	10.6 ,,	0.33 ,,	0.88	6.7	351

The input circuit is connected to grid four via a by-passed series resistance of one megohm ;

Case A = oscillator frequency higher than input signal frequency ;

Case B = oscillator frequency lower than input signal frequency.

A small neutralising condenser of about 2.3 $\mu\mu$F. is placed between the grids one and four. The noise figure is equal to conversion conductance in microamp/volts over square root of anode milliamps (see Nos. 46 and 47 of the bibliography). This figure is about 500 for the FC4 in the long waveband. Measurements were taken at normal operating potentials, with a bias of − 1.5 volt between cathode and earth.

III. Frequency Drift in Octode Frequency Changers.

Different cases of frequency drift occur and may cause nuisance in the short-wave region.

In the first place, considering the octode, we have variations of the positive (and hence implicitly of the negative) potentials of the octode. These variations may be due to variations of mains a.c. supply of the set. They may amount to several per cents., e.g. 6 per cent. being a not uncommon figure. Obviously, the oscillator frequency will drift if this occurs ; ten kc/s is not even a high figure for this drift at e.g. 13 metres wavelength. This frequency drift is much less, if the oscillator tuned circuit, instead of being connected to the first grid is connected to the second grid. It diminishes to about one-third of its original value by this simple measure. The frequency drift due to variations of the positive set potentials may practically be altogether overcome by the use of a small neon tube for stabilising these potentials. This was tried in sets with much success.

A second cause of drift of oscillator frequency is volume control by biasing grid four. By increasing this bias tension, oscillator conditions are altered and a drift of some 20 kc/s at 13 metres is not infrequent. This drift also may be reduced to about one-third of its value by connecting the oscillator tuned circuit to grid two instead of to grid one. It is possible, by using a neon-tube in combination with properly chosen series resistances connected to the positive grids, to reduce this frequency drift still further. Individual set constructions should be considered separately with regard to this point.

A third effect may also be considered as a cause of oscillator frequency drift. It is essentially interlocking between input and oscillator circuits. We measured this as follows. An input circuit of some 10,000 ohms resonant impedance and 30 micromicrofarads capacity, tuned at 13.7 metres was connected to grid four. The FC4 was operated at 500 kc/s intermediate frequency. Now, with fixed potentials, the input circuit was detuned about 0.7 $\mu\mu$F. The oscillator frequency shifted some 20 kc/s. It may be mentioned in passing, that no trimming difficulties should result from this interlocking. For in trimming the circuits at this wavelength, mistakes of about 0.2 $\mu\mu$F. are a common figure, which results in some 5 or 6 kc/s oscillator shift. The h.f. circuits have a flat tuning curve in this region, and so this shift is immaterial. During volume control the input grid capacity varies and hence the input circuit is automatically detuned. But, fortunately, this variation of input capacity is very small with octodes, being about 0.15 $\mu\mu$F. at most. This will not cause a frequency shift of the oscillator by which the i.f. is blown out of the band, passed by the i.f. filter circuit.

IV. Additional Features of Octodes

Referring to the list of conditions, given in Section I, some general features of octodes will be discussed here. This will lead to a better comparison with the corresponding properties of triode-hexodes, dealt with in Section V.

The noise level of a converter is chiefly determined by the conversion slope and the anode d.c. milliamps. In fact, a certain voltage E_n may be imagined on the input grid, giving the noise. This voltage is:

$$E_n = f \cdot \frac{\sqrt{i_a}}{S_c} \sqrt{\frac{B}{10{,}000}} \text{ microvolts.}$$

Here i_a is the anode current in milliamps. S_c the conversion conductance in milliamps/volts, B the total equivalent band width of the i.f. filter circuit in cycles/sec. and f a factor, varying between 0.6 and 1.3, depending on the type of tube, cathode, and so on.

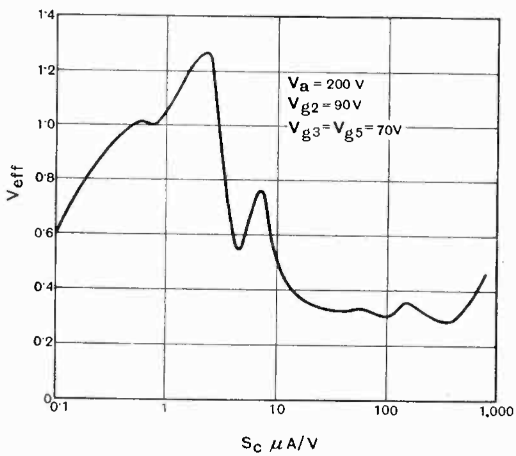


Fig. 3.—*Vertical: effective input volts on grid four, which cause 6 per cent. cross modulation (or 3 per cent. variation of modulation depth or 2.25 m per cent. distortion of modulation). Horizontal: conversion conductance in micro-amperes/volts. For tube FC4 (Mullard).*

Thus the expression $S_c/\sqrt{i_a}$ is a measure for the good quality of a converter with respect to amplification over noise. This is about $700/\sqrt{1.6}$ or 550 for the octode, if S_c is in microamps/volts. As was pointed out previously, whistling notes generally diminish by lowering the oscillator volts on grid one. But by doing so, the anode current and hence the noise is increased. However, if nuisance is caused by some whistling notes originating in the mixer stage, the oscillator volts may be decreased to 4 volts instead of the usual 8.5, whereby the noise level increases not more than some 20 per cent., whereas whistling note strength falls down to a fraction of its value on 8.5 volts (see No. 47 of the bibliography).

The internal resistance is high (more than one megohm), thus allowing for the use of high quality i.f. circuits and resulting high amplification. This high value is due to a "suppressor grid" between screen and anode. It holds good for low anode volts also (e.g. battery valves), where tetrode constructions often fall off.

Low total current consumption is especially useful in the battery sets. For the battery octode FC2, for instance, total current is about 4 mA, whereas at 200 m wavelength $S_c = 0.27$ mA/volt.

If input voltage, leading to a fixed percentage (being here 6 per cent.) of cross modulation is measured as a function of conversion slope (by volume control), the curve of Fig. 3 results for the octode FC4. This curve is closely related to the slope versus grid bias curve (Fig. 4). In fact, it may be proved that the input voltage for 6 per cent. is equal to 0.246/a in the straight portions of the logarithmical slope (mA/Volts) versus bias curve, if a is the slope of the logarithmic conductance curve at any one point. On the other hand, the volume control curve of Fig. 4 is chiefly determined by the construction and the dimensions of the input grid and these features also determine the anode direct current. If the slope of the logarithmic volume control of Fig. 4 at small bias values (right side) is small, input volts for 6 per cent. cross are high and at the same time anode current is high and noise to signal ratio is high. Hence, a compromise between tolerable noise level and tolerable cross modulation must be fixed and the octode FC4 represents a fair solution.

In measuring the microphonic action of frequency changers, the following procedure was laid out (first applied by Mr. Heins van der Ven, of this laboratory): an unmodulated signal is put on the input grid circuit of the frequency converter via a dummy antenna. Behind this converter, i.f. amplification, detection and l.f. amplification take place. The output of the set is connected to a loud speaker, which can be brought in the

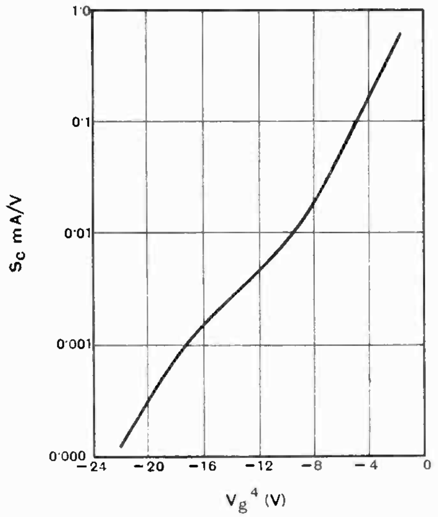


Fig. 4.—*Vertical: conversion conductance (microamps/volts). Horizontal: grid bias tension on grid four. Tube FC4.*

vicinity of the frequency changer, in order to produce microphonic action of this tube. The low frequency voltage on the loud speaker terminals is measured with a triode voltmeter. The loud speaker is brought into such a position that with the lowest possible volume control setting (a.v.c. shorted), some volts are indicated on the loud-speaker terminals. In other words, the relative position of the loud speaker and the frequency changer is so chosen, that the highest possible microphonic action results. Then the loud speaker is put into a sound box, such that it hardly produces any sound at all in the room. Hereupon, with the volume control remaining unaltered, the input signal of the frequency changer is modulated to such a degree, as to cause the same low frequency voltage on the loud-speaker terminals. This degree of modulation is a measure of the microphonic action of the tube, low values being favourable. With the FC4 and the TH4 this degree of modulation is between one and five per cent. on about 200 metres wavelength, at all negative bias values of the input grid.

V. Triode-Hexodes

The triode-hexode was at one time regarded as a cure for almost all the points encountered with octodes. However, as time went on, several disagreeable effects of triode-hexodes turned up. It will be tried to give a comprehensive view of these problems here, following again the list of requirements, announced in Section I.

A curve, giving input volts for 6 per cent. cross modulation versus conversion conductance is presented in Fig. 5 for the TH4. This curve tends to be somewhat higher than for the FC4 (see Fig. 3). Naturally, this better result is obtained at the cost of more anode current and a higher noise to signal ratio. The number $S_c/\sqrt{i_a}$, being 550 for the FC4 is about 450 for the TH4. Thus, increase of noise is not very much and setmakers, interested in a low cross level will probably prefer the TH4. The whistling note level is comparable with that of the FC4. Total current consumption is higher with the TH4, being about 14 milliamps. It is doubtful at present, if the current consumption can be lowered as much as was done for octodes in the case of battery valves. Microphonics could be kept as low as for the octode.

Interlocking of input signal and oscillator

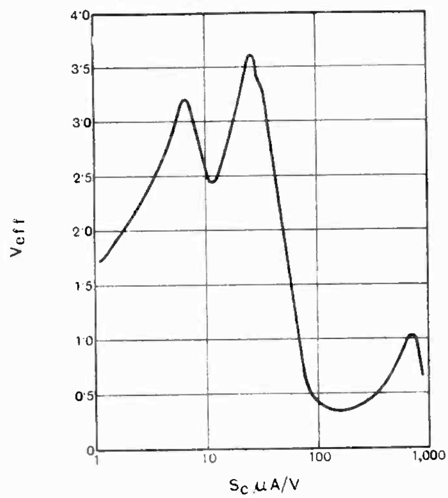


Fig. 5.—*As Fig. 3, but for tube TH4. Input volts are on grid number one of hexode portion.*

circuits is definitely better for the TH4. The coupling effect described in Section II for octodes, exists only in a very slight measure in triode hexodes. At 14 metres and 100 kc/s i.f., with a total input circuit capacity of about 30 $\mu\mu$F. induced oscillator volts on the input circuit do not exceed one volt. No nuisance is caused by this small residual electron coupling.

An interesting effect was observed in this type of tube on short waves. A picture of the potential distribution in the hexode portion is given in Fig. 6. Obviously, the speed of electrons, drawn through grid two is slowed down in the space between grids two and three and a certain fraction of the electron stream will be returned in the

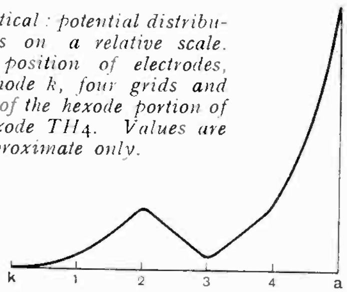


Fig. 6.—*Vertical: potential distribution in volts on a relative scale. Horizontal: position of electrodes, being the cathode k, four grids and the anode a of the hexode portion of the triode hexode TH4. Values are approximate only.*

opposite direction by the positive potential of grid two. These electrons will again come in the vicinity of grid one. During the rather long time-interval necessary for this way, the alternating tension on grid three will have altered its phase and hereby given an additional acceleration to some of the electrons. These electrons will have acquired so much energy, that they can land on grid one (being at -2) and cause a current to that grid. It may amount to some 20 microamperes at 12 metres wavelength, but it can be diminished by putting additional bias tension on grid one and by lowering the oscillator volts on grid three. By the first measure the conversion conductance is lowered and by the latter one noise is increased.

Frequency drift by positive potential variations (variation of mains tension) is about the same as with octodes. It may be lowered to a quite tolerable amount, to even less than with octodes, by increasing the triode anode potential and connecting the oscillator tuned circuit to this anode instead of to the triode grid. Of course, if use is made of a neon tube for stabilising the positive potentials, this type of frequency drift may be effectively overcome. Frequency drift due to volume control of the hexode portion (additional bias on grid one of the hexode) is not so bad as with the octode and may also be lowered by connecting the oscillator tuned circuit to the triode anode.

An apparently disagreeable point, especially on short waves, is the large variation of input capacity with volume control. Whereas this value is between 0.1 and 0.2 $\mu\mu$F. with the FC4, it is between 1.2 and 1.5 $\mu\mu$F. for the TH4. It might be useful to dwell a little longer on this point. The circuit quality on short waves is limited by:

(*a*) losses in coil, leads and condensers;

(*b*) tolerance values of valve capacities;

(*c*) variation of valve capacities depending on potential variations of the valves and on volume control.

It appears that the limitation (*a*) is much less stringent than (*b*) and (*c*); the point (*b*) is important if it is desired that valves in a set are interchangeable without necessitating fresh trimming due to excessive detuning of the circuits. The present tolerance values lead to a very simple rule for the circuit tuned impedances between 4 and 50 metres. Make this impedance not higher than as many times 1 000 ohms as the wavelength is in metres. Hence, such a circuit of recommended quality would have 12 000 ohms at 12 metres, and so on. Let this be the lower end of a short waveband and let the total capacity here be 30 $\mu\mu$F. Then, a variation of input capacity of 1 $\mu\mu$F. will correspond to a detuning of about 400 kc/s. But half the resonance breadth of a circuit having the specified impedance of 12 000 ohms is about 250 kc/s. Hence, nuisance can be caused by this capacity variation.

A second disagreeable point of the TH4 and apparently of any hexode construction on short waves is its small equivalent input parallel resistance. This is something like 9 000 ohms at -2 volts on grid one and 14 metres wavelength under normal operating conditions. Obviously, this interferes seriously with the input circuit quality. The low input resistance occurs also with hexodes used as h.f. amplifiers and is due to long electron paths, causing extra losses. Care should be taken, when using hexodes, that no very short-wave oscillations occur, by inserting small unbypassed series resistances in the electrode leads (especially to grid one) when necessary. With the TH4, screen grid volts should not exceed 70, in order to securely prevent parasitic oscillations.

VI. Latest Type Octodes

The chief points with octodes are electron coupling and frequency drift. In order to overcome these, many experimental valve types were constructed, leading up to a type, now here known in the laboratory as EK2. In this type, the grid dimensions were chosen such, that the positive potential on grids three and five could be lowered to 50 volts. Hereby electron coupling was materially reduced, as compared with the FC4. Whereas with the latter type, electron coupling was equivalent to a one-sided negative capacity from grid one to grid four, amounting to about 2 $\mu\mu$F., it amounts to less than 1 $\mu\mu$F. with the grid construction and potentials of the EK2. The electron coupling was successfully further lowered by inserting a small condenser of about 0.8 $\mu\mu$F. between the grids one and four. It is built into the valve in the form of a small mica condenser. By the use of this improved valve type the following figures could be secured on 13 metres wavelength and 500 kc/s i.f., with an input tuning condenser setting of 28 $\mu\mu$F.

Inp. par. resist.	Inp. cap.	Conv. cond. mA/volts.	Anode mA.	$Sc/\sqrt{i_a}$
67 000 ohms	9.9	0.510	1.40	431

Here, oscillator frequency was *lower* than input frequency, which condition is very essential for obtaining these figures. As is seen by comparison with the FC4, the noise figure is also better.

Frequency drift of the oscillator was largely overcome in this valve, by putting 200 volts on the second grid, in combination with connecting the oscillator tuned circuit to grid number two, as was already mentioned (Section III).

Variation of input capacity, by volume control, is slightly higher in this valve than with the FC4, being about 0.5 $\mu\mu$F. However, this cannot be considered an objectionable value.

As regards the other figures, cross modulation is slightly better than with the FC4, being about intermediate between the curve of the FC4 and the TH4. This better cross modulation curve, however, hardly entails an increase of noise level in this valve, as compared with the FC4, the figure being about 550 for both valves on medium waves (see Section 4).

By the use of this new construction, avoiding some of the drawbacks of the FC4 as well as of the TH4, a definite progress was made in frequency changer design.

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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

Electric and Magnetic Dimensions

To the Editor, The Wireless Engineer.

SIR,—In your Editorial in the January issue referring to the book of Dr. Lanchester "The Theory of Dimensions and its Applications for Engineers," you are expressing the opinion (on page 3) that Ampere's theory should have nothing to do with the question whether μ_0 or κ_0 is dimensionless or not.

Regarding this question, which has been discussed so much in recent times, I should like to draw your attention to J. Clerk Maxwell's: "A Treatise on Electricity and Magnetism." Vol. II, 3rd edition, page 254, where Maxwell discusses the same question.

He says: ". . . . if our mathematical methods are supposed capable of taking account of what goes on within the individual molecules, they will discover nothing but electric circuits, and we shall find the magnetic force and the magnetic induction everywhere identical."

This conclusion seems to me very logical if one remembers that from the standpoint of electron theory every electric and magnetic field is a field in vacuum.

Then by the equation $B = \mu H$ it follows that μ must be a dimensionless quantity.

As to the dielectric constant κ this must be a dimensionless quantity in the electrostatic system from its definition as the ratio of the capacity of a condenser when its dielectric is the given substance, to its capacity when the dielectric is a vacuum. (Ref. J. Clerk Maxwell, Vol. I 3rd edition, p. 55). But as the electric field can only be a field in vacuum it also seems reasonable to assume κ always to be a dimensionless quantity.

In this way we arrive at the so-called "System of Gauss" in which both μ and κ are regarded as dimensionless.

Is it not now a general opinion among physicists as well as electricians that the choice of a dimension for μ or κ is only a matter of convenience? And that if we choose a dimension for μ this has no *physical* meaning? For instance it does not postulate that a magnetic field can be two different things.

Trondheim, Norway. R. S. SKANCKE.

[The quotation from Clerk Maxwell is included in that given by Sir James Henderson and reprinted by Dr. Lanchester in an Appendix to his book. Other statements made by Maxwell leave one in some doubt, however, whether by "identical" he meant anything more than everywhere numerically equal in the e.m. system of units. If one assumes, as Prof. Skancke obviously does, that H is merely a symbol for B in a vacuum, then of course the relation between B and H must be regarded as a mere numeric, but if one regards H

as a symbol for the magnetising force expressed in ampere-turns per cm or other such units which is related to the resulting magnetic induction B, somewhat as stress is related to the resulting strain, then, even in the absence of ferro-magnetism, μ_0 is not necessarily dimensionless. We can understand the point of view of one who, on the ground of convenience, advocates that either μ_0 or κ_0 should be regarded as a numeric; our quarrel is with those who apparently think that they have proved that μ_0 is a numeric and that it is not a matter of arbitrary choice. G. W. O. H.]

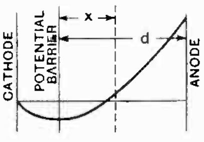
The Three Halves Power Law of the Diode

To the Editor, The Wireless Engineer

SIR,—Lately I have realised a method new to me for deriving the classic 3/2 power law of a space-charge limited diode. Clearly there can now be nothing novel about this equation, but the method I speak of does not appear in any text book I know of. It seems to me more direct and explicitly to lay more stress on the basic physical principle than does the usual process of derivation. Accordingly, it is useful in teaching. I venture to write this letter, in the hope that the following note may be of passing interest to others who, like myself, are occupied mainly in teaching elementary principles.

Experience shows that the anode current of a diode tube can be a function of the anode potential: in such circumstances the anode current is less than the rate of emission from the cathode, which depends only on its temperature. Since electrons are emitted with an appreciable velocity towards a positive anode and yet do not all arrive there, it follows that the field at the cathode must be directed towards the cathode. Thus there must be a definite boundary round the cathode at which the field passes through zero: this boundary is commonly called the barrier. Between the barrier and the cathode the electric field is directed to the cathode and between the barrier and the anode it is directed to the anode. Some emitted electrons perform a journey towards the anode and are brought to rest short of the barrier; they return to the cathode and reach it with the same velocity with which they departed. Other electrons reach the barrier, pass through it and proceed to the anode. We shall presume that any electron which crosses the barrier does so with zero velocity.

Now consider plane electrodes and take the origin of co-ordinates in the barrier plane (see figure): admittedly the position of the barrier is unknown.



Now consider the electric force F at a distance x from the barrier. Since the force at the barrier is zero, then by Gauss' theorem F is equal to 4π times the charge situated between unit area of the x and barrier planes. The distribution of this charge is immaterial and at present is unknown.

Let the anode current per unit area of electrode be I and let every electron take a time t to pass from the barrier to the plane x; crossing the barrier with zero velocity. During the time taken by any specimen electron to reach the plane x, other electrons having total charge, It will have crossed the barrier. This then is the charge situated somewhere behind the specimen electron and consequently the force on it is proportional to $4\pi It$. Now writing the equation of motion we have

$$m\frac{d^2x}{dt^2} = eF$$

$$= 4\pi eIt$$

$$\therefore \frac{d^2x}{dt^2} = BIt, \text{ where } B = \frac{4\pi e}{m} \qquad \ldots \quad \ldots \quad (1)$$

$$\therefore \frac{dx}{dt} = \frac{BIt^2}{2}, \text{ since by hypothesis the initial velocity is zero} \quad \ldots \quad \ldots \quad (2)$$

$$\therefore x = \frac{BIt^3}{6}. \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

Let V be the potential and u the velocity in the plane x; then

$$\tfrac{1}{2}mu^2 = eV$$

$$\text{or } V = \frac{2\pi}{B}u^2$$

$$= \frac{\pi B}{2}I^2t^4 \text{ from (2)}$$

$$= \frac{\pi}{2}\frac{I^{2/3}}{B^{1/3}}(6x)^{4/3} \text{ from (3).}$$

$$\therefore I = \frac{1}{9\pi}\left(\frac{2e}{m}\right)^{\frac{1}{2}}\frac{V^{3/2}}{x^2}$$

$$= \frac{1}{9\pi}\left(\frac{2e}{m}\right)^{\frac{1}{2}}\frac{V_a^{3/2}}{d^2}, \quad \ldots \quad \ldots \quad (4)$$

where V_a is the potential of the anode with respect to the barrier and d is the distance from barrier to anode.

In this derivation the integration is very direct and straightforward: the whole process calls for no effort of memory or technique to deflect the student's mind from the basic physical concept expressed by $F = 4\pi Q$. Also the transit time appears explicitly in equation (3): thus

$$T = \left(\frac{6d}{BI}\right)^{1/3}$$

$$= 3\sqrt{\frac{m}{2e}}\frac{d}{V^{\frac{1}{2}}}, \text{ from (4).} \quad \ldots \quad (5)$$

No appreciable difficulty is added if all electrons which cross the barrier are presumed to do so with a velocity u_1.

I trust this very very elementary piece of work may be useful to some readers.

E. B. MOULLIN.

Engineering Laboratory, Oxford.
22nd February, 1937.

"Wireless Engineering"

To the Editor, The Wireless Engineer.

SIR,—On principle I do not believe in replying to reviewers of books and do not propose to initiate any correspondence concerning a recent review by "C.R.C." of my book *Wireless Engineering*. Consequently I shall not discuss my reasons for retaining certain facts of historical interest in a general text book which is not intended to be limited merely to matters of present-day practice. The inclusion or exclusion of such topics is a matter of policy and the advisability of any policy is a question of opinion. This however does not apply to numerous serious mis-statements of fact which indicate that the reviewer has not assimilated the book as thoroughly as he should have done.

In particular, "40 additional pages" should read "63 additional pages," because 23 pages of the earlier work have been omitted from the present book. "Loud speakers are given two pages" should read "approximately seven pages," namely pages 349 (part), 350, 351, 352, 353, 451 (part), 452, 453 and 454 (part). The statement "all the diagrams of H.F. amplifiers employ triodes" is incorrect. Figs. 233, 234 and 235 employ tetrodes to illustrate principles underlying the use of additional electrodes in one envelope.

I am, however, grateful to the reviewer for pointing out an arithmetical error in a footnote on page 405, where 0.1 should be 8.68 or, to quote the reviewer when referring to this footnote, "not only does this astounding statement contain most remarkable arithmetical errors (of course 0.1 $\log_e$ should be 20 $\log_{10}$) but this is the only place in the book where the decibel is mentioned!" Evidently the reviewer did not even read as far as the next page!

Concerning "end-effect" with inductances; had the reviewer worked in a wireless laboratory with ultra-high frequency wireless waves, he would have soon realised that such effects are even more important to-day than they were in 1928.

The statement "nowhere is there is any sign of provision of negative grid bias" is a truly "astounding statement" in view of the fact that grid bias is shown in Figures 228, 229, 232, 235.1, 246 (where it is even marked "Grid bias"!) and 247. Also reference to the Index would have been an easy way of checking the matter before publishing the above misleading criticism.

I am prompted to write concerning this particular review because its content is as misleading to the public as it is incorrect in fact.

University College, Hull. L. S. PALMER.

The Super-Regenerative Receiver

To the Editor, The Wireless Engineer.

MONSIEUR,—J'ai lu avec beaucoup d'intérêt, dans le numéro de Novembre 1936 de votre revue *The Wireless Engineer*, l'article de Mr. Scroggie sur "The Super-regenerative Receiver."

Je suis heureux de voir que l'auteur a utilisé, et, dans son ensemble, approuvé, le travail déjà ancien que j'avais publié dans *l'Onde Electrique* en 1928.

Mais je regrette qu'il n'ait pas eu connaissance d'un autre travail antérieur, qui formait l'introduction à celui-ci, et qui a été publié en mai 1925 sous la triple signature de MM. David, Dufour et Mesny. Je me permets de joindre un exemplaire de cette revue, en vous priant de bien vouloir le lui communiquer.

Il y trouvera, par exemple (Fig. 10 et 11) la forme très précise des oscillogrammes montrant la croissance et l'extinction des oscillations; je ne crois pas que les relevés d'Ataka soient meilleurs.

Par ailleurs je voudrais répondre au reproche que me fait Mr. Scroggie, p. 584 "Oscillogrammes shown by David were taken under rather artificial conditions, and do not show oscillations building up in the absence of signal."

Tout d'abord quelles sont ces "rather artificial conditions"? Je ne comprends pas bien. Les oscillogrammes ont été relevés en reliant simplement aux plaques de l'oscillographe, les grilles ou les plaques des lampes d'un récepteur absolument de série, nullement modifié pour la circonstance. La seule . . . condition un peu anormale était que le signal appliqué était plus fort qu'un signal de trafic, comme il était dit p. 251, et ceci afin d'avoir des amplitudes suffisantes à l'oscillographe.

Mais je suis persuadé que cette condition anormale ne m'est pas personnelle. Les autres expérimentateurs ont certainement trouvé la même difficulté: leurs oscillographes n'étaient pas, en ondes courtes, sensibles au centième de volt. Ils ont donc, comme moi, exagéré la force du signal. La seule différence est qu'ils ne l'ont pas dit; tandis que j'ai eu la franchise de le dire. Je ne pense pas que cela mérite un reproche particulier.

Enfin, les "oscillations building up in the absence of signal" sont parfaitement mentionnées dans l'article de 1928: voir Fig. 21 et texte p. 259. Elles font l'objet d'une attention particulière dans l'article de 1925: voir Fig. 1 et 2, repères *bbb*, et texte p. 183–184.

Je serais heureux s'il vous était possible de porter ces remarques à la connaissance de Mr. Scroggie d'abord, et de vos lecteurs ensuite.

Veuillez agréer, Monsieur, mes salutations distinguées.

Laboratoire National and Radioélectricité, Paris. PIERRE DAVID, Ingénieur en Chef.

To the Editor, The Wireless Engineer.

SIR,—I have noted with interest the comments made by M. David on my article "The Superregenerative Receiver," and am indebted to him for drawing my attention to the article published by him in conjunction with MM. Dufour and Mesny in *L'Onde Electrique* of May, 1925. I confess that this work had escaped my notice, and I must congratulate M. David and his colleagues on achieving such informative experimental results at so early a date.

I also wish to apologise to M. David for the part of a sentence in my article which stated that his oscillograms do not show oscillations building up in the absence of a signal. I now see that some of them do.

With regard, however, to M. David's enquiry "what are these 'rather artificial conditions'?" this is most emphatically answered by M. David himself. I quote from p. 251 of the 1928 paper:—"la principale difficulté rencontrée provient du manque de sensibilité de l'oscillographe. Seules sont visibles, les amplitudes de l'ordre *de quelques volts*. Par suite, les oscillations forcées, dues à un signal *normal*, ne sont jamais visibles; seules,

les oscillations libres consécutives, le sont. Pour arriver à rendre perceptibles les oscillations forcées, il a fallu employer des signaux *anormalement forts*, c'est-à-dire des F.E.M. d'excitation *ridiculement plus grandes* que celles recontrées dans la pratique. Nous pensons que les résultats sont cependant instructifs, puisque le phénomène étudié demeure de même nature : il est simplement grossi ; mais nous devions mentionner que ce n'est pas tout à fait le cas réel."

The italics are M. David's, and, together with the wording used, makes my reference to "*rather* artificial conditions" seem relatively tame.

Although I did not explicitly endorse M. David's belief that his results are instructive, if I had not agreed on that point I would not have troubled to quote with approval so many of his findings.

I am sorry if my reference—I will not call it a reproach—to the artificial conditions under which oscillograms were taken should appear to attach exclusively to M. David's work ; as he rightly points out, the same applies to oscillograms taken by other workers. At the same time, it must be admitted that if it were practicable to take oscillograms of operation under weak signal conditions they *might* show results appreciably different in nature from those taken with signal voltages "ridiculement plus grandes."

Bromley, Kent. M. G. SCROGGIE.

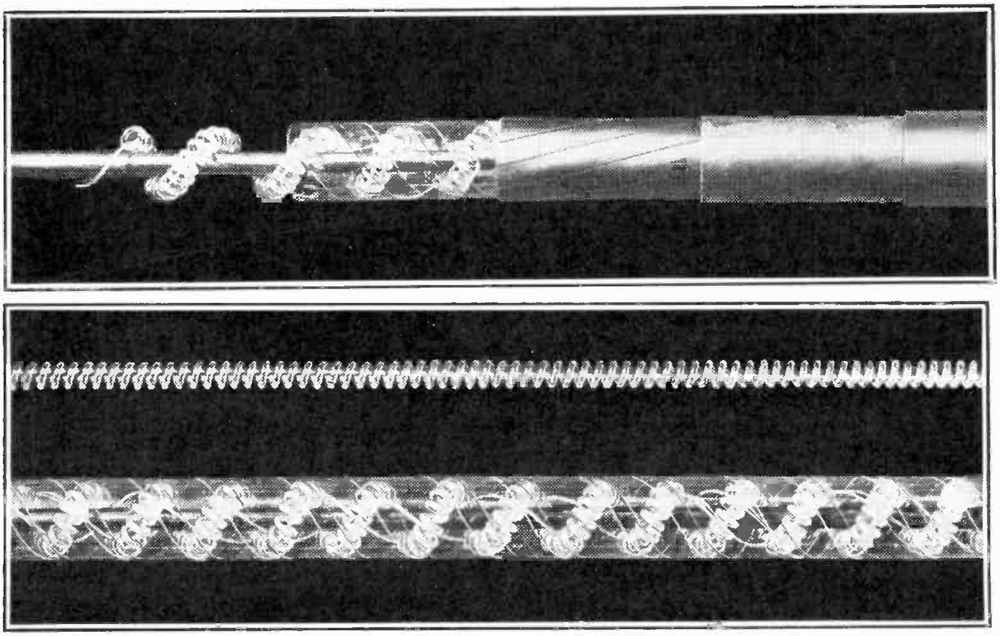
Conditions in the Anode Screen Space of Thermionic Valves

To the Editor, The Wireless Engineer

SIR,—The problem dealt with by Mr. H. C. Calpine in the above-named work (*The Wireless Engineer*, Sept., 1936, see also Abstract 4062 of 1936) has already frequently excited the interest of your journal, without, however, a general solution being arrived at. We would like to call your attention to the fact that an exact mathematical treatment of this problem, and a thorough discussion of the processes, are given in the paper "Space-Charge Equation for Electrons Possessing Initial Velocity," by G. Plato, W. Kleen, and H. Rothe (*Zeitschrift fur Physik*, No. 7/8, Vol. 101, 1936, pp. 509–520) (Abstract 3772 of 1936), and in the continuation in the March, 1937, issue of the same journal.

DR. HORST ROTHE.
DR. WERNER KLEEN.

Broad-band Television Cables



Last month's Editorial referred to the use of Styroflex as the insulating material in high-frequency cables for television work. These photographs show : top, *a Styroflex-insulated concentric cable made by Felten and Guilleaume*, centre, *a spiral of Styroflex and* below, *a copper conductor surrounded by such a spiral the whole being covered with a band of the same material.*

Dependence of Thyratron Characteristics on Electrode Spacing and Design*

By J. A. V. Fairbrother, Ph.D., F.Inst.P.

(Research Laboratory of the British Thomson-Houston Co., Ltd., Rugby)

THE Thyratron has become by now a well-known "vacuum" device and is finding increasing uses in research and engineering for handling and controlling large and small amounts of power. In the field of electrical engineering robust power tubes are finding increasing applications, one of the most spectacular of which is in electric welding equipment in which some 350 kVa can be controlled by two tubes each about 15in. long.

Perhaps one of its most novel applications in the field of physical research has been in counter circuits used for the measurement of α-particle emission. Another well-known application is in time bases for cathode ray oscillograph equipment and television sweep circuits.

The Thyratron consists essentially of a hot cathode coated with alkaline earth oxides, a grid, an anode and a filling of gas or vapour at low pressure.

If the grid of such a tube is maintained at a fixed negative voltage with respect to the cathode there is a critical positive anode voltage below which only a few microamps of current flow to the anode. Above this critical voltage the small electron current causes sufficient ionisation of the gaseous or vapour filling to annihilate the space charge and an arc is established between anode and cathode, the current through which is limited only by external resistance in series with the tube and by the total emission current which can safely be drawn from the cathode. The ratio of the critical anode voltage to the grid voltage is called "the grid control ratio" and in most cases for anode voltages greater than a few multiples of the ionisation potential of the gaseous filling this ratio is constant and the curve of grid voltage against critical anode voltage is a straight line passing through a point close to the origin. The value of the grid control ratio for a fixed value of the gas or vapour pressure is determined by the relative positions of anode, grid and cathode. Using a tube in which the anode and cathode are mounted on the axis of a cylindrical grid the author has determined the dependence of the grid control ratio on anode to cathode distance.

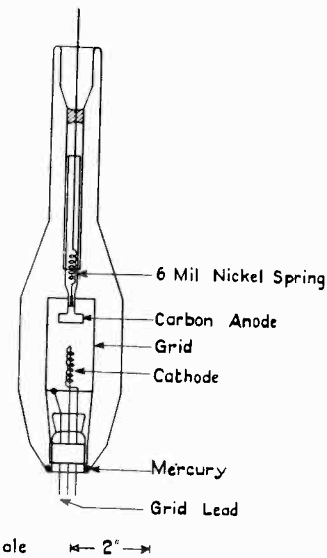


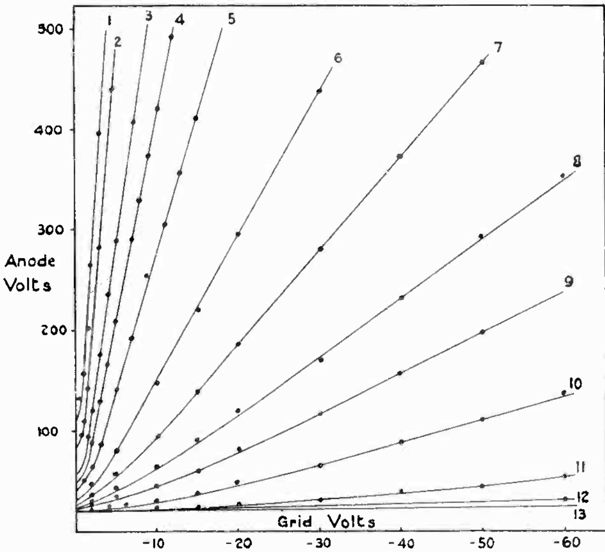
Fig. 1.—*Thyratron with movable anode.*

Fig. 1 is a scale drawing of the experimental tube used. The grid is a nickel cylinder 2¼in. high and 1¼in. diameter. A carbon anode, electrical connection to which is made by means of a spiral nickel spring, is mounted on telescoping glass tubing which permits the anode to cathode distance to be varied. The cathode is a nickel strip coated with barium and strontium oxides suitably activated during exhaust. The tube was filled with mercury vapour maintained at a pressure throughout the experiments

* MS. accepted by the Editor, June, 1936.

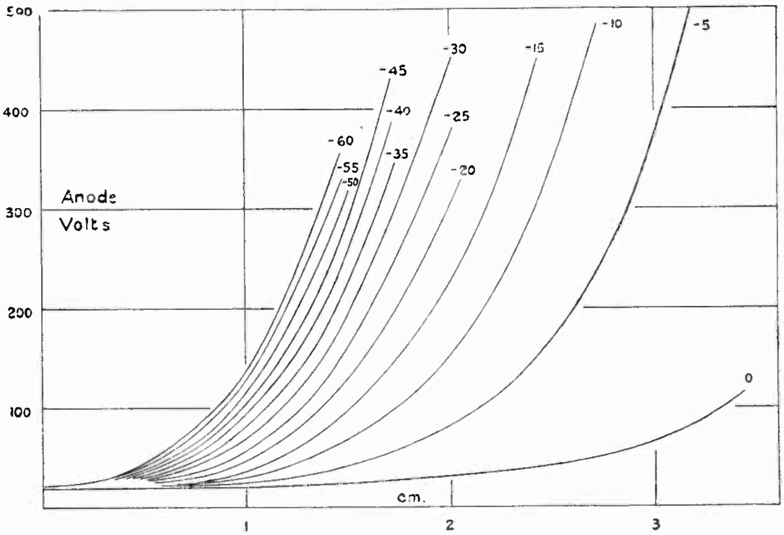
corresponding to a room temperature of 20 deg. C.

The grid control ratio characteristics for different anode to cathode distances are shown in Fig. 2. Distances are measured between the anode face and the tip of the cathode. It is seen that at anode voltages above about 100 the characteristics are straight lines passing close to the origin. No arc current passes at anode voltages below 20, which is termed the starting voltage. By erecting ordinates at grid voltages of −60, −55, etc. down to −5, a set of curves is obtained showing the variation of anode voltage with anode to cathode distance at fixed grid voltages. These curves are shown in Fig. 3.



Curve No.	Distance
1	3·378 cm.
2	3·164
3	2·842
4	2·618
5	2·368
6	1·976
7	1·686
8	1·444
9	1·228
10	0·976
11	0·546
12	0·330
13	0·120

Fig. 2.—*Grid control ratio curves for a range of anode to cathode distances.*



(*Right*) Fig. 3.—*Curves of critical anode voltage versus cathode to anode distance for grid voltages between* 0 *and* −60.

On plotting the logarithm of the anode voltage less the starting voltage against the logarithm of the distance a series of straight lines is obtained shown in Fig. 4, showing that the relationship of the anode voltage and anode to cathode distance for a given grid voltage is of the form

$$\log (E - 20) = h + m \log x,$$

where m and h are constants and $E - 20$ is the anode voltage less the starting voltage.

This may be written

$$E - 20 = kx^m$$

The slope of each of the lines in Fig. 4 gives the value of m and the anti-log of the intercept on the y axis at the point of $\log x = 0$ gives the value of k.

The values of k and m for the range of grid voltages covered are given in Table I.

From this it may be seen that at low values of e_g, k is equal to e_g and at high values of e_g, $k = 2\,e_g$. At low values of e_g the value of m approaches 4 and at high values it is 2.72 or $\frac{8}{3}$ approximately.

Hence at values of e_g less than about 10 volts negative

$$E - 20 = e_g x^4$$

and at values of e_g greater than 50 volts negative

$$E - 20 = 2\, e_g\, x^{\frac{5}{3}}.$$

For values of E which are large compared with the starting voltage E may be substituted for $E - 20$ and the grid control ratio $\frac{E}{e_g}$ is in the one case proportional to x^4 and in the other to $x^{\frac{5}{3}}$.

TABLE I

$-e_g$	k	m
5	5	3.92
10	10	3.80
15	17.4	3.62
20	28.2	3.44
25	37.1	3.32
30	47.8	3.28
35	63.1	2.96
40	75.9	2.80
45	87.1	2.84
50	100	2.72
55	109.6	2.74
60	120.2	2.72

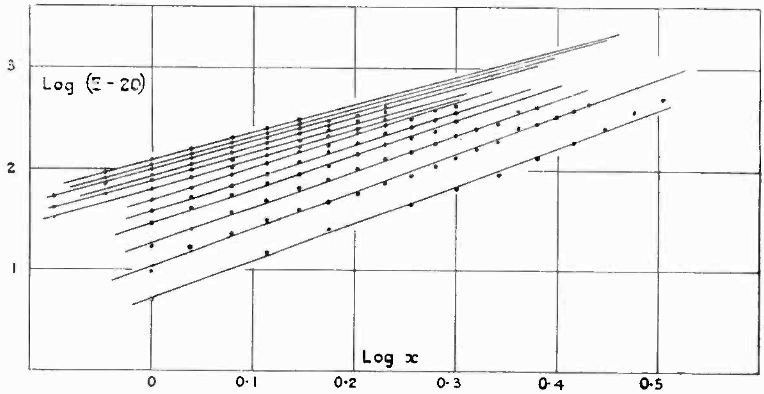


Fig. 4.—*Log of anode voltage less the starting voltage versus the log of anode to cathode distance.*

It is thus seen that a variation of anode to cathode distance of 1 per cent. can, for a fixed anode voltage, cause a variation of from 4 per cent. to $2\frac{2}{3}$ per cent. in the critical grid voltage and great care must be taken in assembly if it is desired to manufacture a large quantity of tubes with identical characteristics.

To ensure constancy of characteristics throughout the life of a Thyratron it is necessary so to design, position and operate the cathode that the arc current drawn from it is distributed uniformly over its surface, thus avoiding as far as is practicably possible the production of inactive regions.

If Thyratrons are not constructed in accordance with these features of design the grid control ratio changes throughout the life. Sometimes an initial decrease takes place, followed by slow increase which becomes more rapid towards the end of life. This can be accounted for by a change in the effective distance of the cathode to anode distance. The small anode current which must flow prior to the establishment of the arc is a space charge limited one and as such it is proportional to the area of the cathode exposed to the field from the anode. If any part of the cathode becomes deactivated so that the total emission of this part is smaller than the space charge current which could be drawn from it by the anode field the anode current is reduced. Alternatively in order to draw the same electron current necessary for starting the arc the anode voltage must be raised.

The author makes grateful acknowledgment to the B.T.-H. Company for permission to make this contribution and to Mr. R. W. Conway for making the movable anode tube.

University College, London

Engineering Society (Founded 1884)

THE Society has in preparation the first issue of a year book, which will be sent free to former students.

Will Old Members kindly send in their names, addresses, years at College, academic and professional qualifications, present appointment, and news of their contemporaries to P. H. Walker, Engineering Department, University College, Gower Street, W.C.1.

The Industry

THE Westinghouse Brake and Signal Co., Ltd., have been awarded the contract for battery-charging equipment including metal rectifiers, for the new L.C.C. Fire Brigade headquarters.

Sets of interference-suppressing devices are to be let out on hire by Belling and Lee, Ltd., for the benefit of those who wish to receive the Coronation broadcasts as perfectly as possible.

Abstracts and References

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

PROPAGATION OF WAVES

1270. REFLECTION OF RADIO WAVES FROM THE MIDDLE ATMOSPHERE.—Watson Watt, Wilkins, & Bowen. (*Nature*, 13th Feb. 1937, Vol. 139, pp. 277, 299: short notes on recent Roy. Soc. paper.) *See* also 2509 of 1936.

1271. SOME NOTES ON ULTRA-HIGH-FREQUENCY PROPAGATION [the Four Mechanisms involved, and Present State of Knowledge of Each: Curve of Attenuation beyond Horizon: etc.].—H. H. Beverage. (*RCA Review*, Jan. 1937, Vol. 1, No. 3, pp. 76–87.)

1272. ON THE FOUNDATIONS OF THE THEORY OF LIPPMANN COLOUR PHOTOGRAPHY [Deductions from Experiments on the Phase Changes of the Electric Vector, etc., in the Reflection of 26 cm Micro-Waves at Various Types of Discrete Reflecting Surfaces].—K. F. Lindman. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 18, 1937, pp. 25–29.)

The surfaces dealt with included little squares (0.3 cm sides) of tin spaced 0.3 cm apart on a non-reflecting base, and a 3.2 cm layer of sand with and without the addition of 4.5 mm diameter shot to a density of about 2.5 shot per cm^3. The refractive index of the plain sand was found to be 1.21, of the sand-and-shot mixture 1.18 only; but the reflecting power and absorbing power were both considerably increased by the addition of the shot.

1273. PROPAGATION OF RADIO SIGNALS BETWEEN TWO DISTANT POINTS [Certain Conditions give Two Theoretically Possible Trajectories: Calculated Equivalent Paths: Possible Effects of Absorption].—Irène & C. Mihul. (*Comptes Rendus*, 1st Feb. 1937, Vol. 204, No. 5, pp. 340–343.)

Starting from a theory of short-wave propagation already given by Jonescu & Mihul (868 of 1936), the writers have made calculations, of which only the results are here summarised, of the time taken by radio pulses on a wavelength of 75 m to travel from Berlin to Munich on the assumption that there is a single ionised region in the upper atmosphere. Assuming given variations of collision frequency and ionisation density with height, they have calculated the dielectric constant, conductivity, and refractive index of the medium for a wavelength of 75 m, and also the trajectories between two points 560 km apart. They have found that, for certain ionisation distributions, there are two possible trajectories; calculated curves of equivalent path are illustrated and found to show a striking resemblance to the experimental curves of Crone, Krüger, Goubau & Zenneck (3974 of 1936) and also to agree with the results of Farmer & Ratcliffe (437 of February). The relatively large intensity of the ray of high trajectory is considered to be due to the fact that the coefficient of absorption is small along its ionospheric path in comparison with that holding for the lower ray. Similar phenomena are expected to hold for other ionisation conditions and wavelengths: the absorption conditions may however be such that the upper ray is so strongly absorbed that it is not observed.

1274. HEIGHTS OF REFLECTION OF RADIO WAVES IN THE IONOSPHERE.—F. H. Murray & J. B. Hoag. (*Phys. Review*, 1st Jan. 1937, Series 2, Vol. 51, No. 1, p. 60: abstract only.)

"A general method [not here described] has been developed whereby, from the virtual-height/frequency curves, it is possible to calculate an upper limit to the height of reflection of a radio wave of a particular frequency in the ionosphere. . . . A discontinuity in a virtual-height/frequency curve is a necessary but not a sufficient condition for the existence of two distinct layers. . . . At certain times and for certain frequencies, the highest altitudes to which the waves can travel are very much lower than the virtual heights . . . . during the morning hours and for the range of frequencies studied [2.5 to 4.4 Mc/s], the upper limits of the true heights in the F_2 region decreased whereas the virtual heights increased."

1275. CONTROL OF WIRELESS SIGNAL VARIATIONS, *and* CONTROL OF PHASE FADING IN LONG-DISTANCE RADIO COMMUNICATION.—Green & Builder: Green & Pulley. (*Electrician*, 8th Jan. 1937, Vol. 118, p. 34.) Short summaries of I.E.E. papers. *See* also 428 of 1936.

1276. ABNORMAL IONISATION OF THE IONOSPHERE AT NIGHT [Sporadic E Layer: Its Nature, Spread, and Effect on Propagation].—K. Maeda & Y. Isagawa. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 485–488.)

1277. A CONTINUOUS RECORDER FOR IONOSPHERE HEIGHTS, AND ITS RECENT RESULTS [and a Comparison between the "Positive" and "Negative" Methods of Photographic Pulse-Recording: Meteor Effects: D Region: Sporadic E Layer: Dispersion Layer at 350–500 Kilometres or Re-Radiation from Secondary Electronic Discharges?].—Minohara, Ito, Shinkawa, & Yamamoto. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 505–511.)

1278. MEASUREMENT OF THE INCIDENT ANGLE OF DOWNCOMING WAVES.—Namba, Maeda, & Yokoyama. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 480–485.)

Disadvantages of the A.T. & T. methods, and of the N.P.L. method with two horizontal aerials several wavelengths apart, are discussed. The authors' method, using three horizontal aerials in a vertical plane, is claimed to have several advantages, including that of giving results independent of the direction of the arriving waves and of the electrical properties of the ground. Some results are given. *See* also 2516 of 1936.

1279. IONOSPHERE AND SOLAR ECLIPSE [Ionosphere totally or partially At Rest with respect to Earth's Rotation: Highest Layers due to Electrons direct from Sun].—Leithäuser. (*Funktech. Monatshefte*, Nov. 1936, No. 11, pp. 401–403.) *See* also 2 & 3 of January.

1280. THE RELATIONSHIP BETWEEN MAGNETIC STORMS AND SUNSPOTS AND THE RELATION OF RADIO COMMUNICATION WITH EUROPE TO THE EARTH CURRENTS ACCOMPANYING MAGNETIC STORMS.—H. Mayeda & I. Ozeki. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 491–497.)

1281. MAGNETIC EFFECTS ASSOCIATED WITH BRIGHT SOLAR ERUPTIONS AND RADIO FADE-OUTS.—A. G. McNish. (*Nature*, 6th Feb. 1937, Vol. 139, p. 244.)

"The magnetic effects may be ascribed to an increase of ionisation, produced by radiation of shorter wavelength than visible light," accompanying the intensity increase of the hydrogen eruption; this increase of ionisation causes an increase in the currents flowing in "the lower, short free-path region of the ionosphere. This hypothesis is consistent with the obvious explanation of the radio fade-outs," that they are due to increased ionisation, and therefore absorption, in this "short free-path region."

1282. RECENT SOLAR ACTIVITY AND RADIO FADINGS [Sunspot Data: Bright Eruption and Short-Wave Fading on 27.1.37: Apparent 27-Day Sequence].—(*Nature*, 6th Feb. 1937, Vol. 139, p. 228: short note.)

1283. AURORAL DISPLAY ON 3.2.1937 [Data of Aurora in N. England: Associated Magnetic Disturbance and Sunspots].—(*Nature*, 13th Feb. 1937, Vol. 139, p. 277: short note.)

1284. SHORT-WAVE RECEPTION IN ROXBURGHSHIRE SPOILT BY FADING AND ATMOSPHERICS ACCOMPANYING AURORA BOREALIS.—(*World-Radio*, 12th Feb. 1937, p. 14.)

1285. SOLAR RADIATION AT CALCUTTA [Photographic-Photometric Method of Measurement of Intensity of Extreme Ultra-Violet Rays: Daily and Monthly Variations].—Ghosh, Ukil, & Sen. (*Nature*, 23rd Jan. 1937, Vol. 139, pp. 159–160: short note on paper in *Journ. Indian Med. Assoc.*, Nov. 1936.)

1286. THE INTERACTION OF RADIO WAVES.—V. A. Bailey. (*Wireless World*, 26th Feb. 1937, Vol. 40, pp. 204–205.)

1287. MOTIONS OF ELECTRONS IN GASES IN ELECTRIC AND MAGNETIC FIELDS [Correct Formulae for Velocity of Drift, Lateral Deviation of Electronic Stream by Transverse Magnetic Field, etc.].—L. G. H. Huxley. (*Phil. Mag.*, Feb. 1937, Series 7, Vol. 23, No. 153, pp. 210–230.)

Corresponding to the correct formula for the motion in an electric field given by Townsend (3285 of 1936), who showed "that an error had been introduced into many previous derivations by neglect of the influence of the field on the time spent between collisions. This error is inherent also in analogous formulae which have been found for the velocity of drift when the electric field is accompanied by a magnetic field."

1288. HERTZIAN WAVES IN AN ELECTRONIC GAS [Editorial Closure of Argument].—Todesco: De Pace. (*Alta Frequenza*, Dec. 1936, Vol. 5, No. 12, p. 815.) Pending further experiments which alone can clear up the disagreement between the results (*see* 862 of March).

1289. ARE THERE METASTABLE MOLECULES IN THE LEWIS-RAYLEIGH GLOW? [Experiments say "No"].—J. Kaplan. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, pp. 143–144: abstract only.)

1290. THE COEFFICIENT OF RECOMBINATION OF PURE OXYGEN AS A FUNCTION OF PRESSURE AND TEMPERATURE [Measured Values].—M. E. Gardner. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, p. 144: abstract only.)

1291. A NEW BAND OF ATMOSPHERIC OXYGEN.—H. D. Babcock. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, p. 148: abstract only.)

1292. PHOTOELECTRIC STUDY OF THE COLOUR OF THE NIGHT SKY [Importance of Red and Infra-Red Radiation].—R. Grandmontagne. (*Comptes Rendus*, 1st Feb. 1937, Vol. 204, No. 5, pp. 337–340.)

1293. ON THE THEORY OF SPHERICAL WAVES [and Their Production from Plane and Cylindrical Waves].—A. Erdélyi. (*Physica*, Feb. 1937, Vol. 4, No. 2, pp. 107–120: in German.) Leading from van der Pol's work (3650 of 1936). On the simplifying assumptions that $m = n = 0$, equation 4.6 yields equation 4.7, used by Sommerfeld & Weyl in their investigation of the propagation of wireless waves over the earth's surface.

1294. THE EFFECT AT A DISTANCE OF THE ORDER OF A WAVELENGTH OF A VERTICAL DIPOLE EMITTER ON A PLANE EARTH.—Niessen. (*See* 1354.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

1295. ON THE NATURE OF ATMOSPHERICS. IV.—E. V. Appleton & F. W. Chapman. (*Proc. Roy. Soc.*, Series A, 1st Jan. 1937, Vol. 158, No. 893, pp. 1–22.)

From the authors' summary:—A series of observations on rapid changes of the earth's electric field associated with lightning flashes has been made using a Wilson sphere as the exposed conductor and a cathode-ray oscillograph with photographic registration. The measurements have included observations on the temporal changes of both the electric field and the rate of change of the electric field. . . . The discharge of the thundercloud moment is, in the main, a periodic one, but during the period of maximum current density subsidiary oscillations or pulsations are superimposed on the main discharge. The majority of net changes of field are found to take place in a series of steps . . . the same relative frequencies of grouping [as those of the numbers of steps] are found in the incidence of atmospherics of distant origin.

The decay of thundercloud moment during a lightning flash occurs in two parts . . . these correspond respectively to the leader-stroke and return-stroke in the lightning discharge. Evidence of a "fine structure" radiation field on the first portion has been observed. A new estimate is made of the maximum current flowing in a lightning discharge channel. . . . The evolution of the atmospheric wave-form has been studied. . . . The most frequently observed wave-form of the atmospheric ultimately developed is a brief [quasi-oscillatory] steep-fronted train . . . [of which many are] followed by a slower disturbance. . . . Such a slow disturbance may possibly be due to an upward discharge from the top of the thundercloud to the ionosphere. The quasi-oscillatory disturbance is found to move ahead of the slower disturbance during propagation, indicating a difference of group velocities brought about by ionospheric influences.

1296. CONNECTIONS BETWEEN THUNDERSTORMS AND ATMOSPHERIC DISTURBANCES IN SOUTH AFRICA.—Schonland & Hodges. (*Trans. Roy. Soc. S. Africa*, No. 2, Vol. 24, 1936, p. 81: abstract only in *E.N.T.*, Dec. 1936, Vol. 13, No. 12, pp. 434–435.) The paper referred to in 450 of 1936.

1297. ELECTROCONVECTIVE EDDIES IN A LIQUID SHEET [Experimental Description].—Avsec & Luntz. (*Comptes Rendus*, 8th Feb. 1937, Vol. 204, No. 6, pp. 420–422.) *See* also 459 of February.

1298. LIGHTNING CURRENTS IN 132-KV LINES [as High as 220 000 A: rarely exceed 150 000 A: only 10% in Range above 70–100 000 A].—Sporn & Gross. (*Elec. Engineering*, Feb. 1937, Vol. 56, No. 2, pp. 245–252 and 259, 260.) *Cf.* Bell, 885 of March.

1299. LIGHTNING: FLASH MECHANISM, EFFECTS OF DIRECT STROKES TO OVERHEAD TRANSMISSION CIRCUITS, PROTECTIVE DEVICES.—B. L. Goodlet. (*Electrician*, 8th Jan. 1937, Vol. 118, p. 35.) Summary of I.E.E. paper. For Discussion see *ibid.*, 15th Jan. 1937, p. 63.

1300. AN ANOMALOUS LIGHTNING DISCHARGE [Data of Velocity in Space: Length and Spread of Visible Portion of Stroke].—E. J. Workman & R. E. Holzer. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, p. 149: abstract only.)

1301. ON THE REMARK OF R. HOLM ON OUR PAPER "ELECTRICAL BREAKDOWN IN GASES FROM CLOUD-CHAMBER INVESTIGATIONS" [Form and Growth of Canals, etc.].—Flegler & Raether. (*Zeitschr. f. Physik*, No. 3/4, Vol. 104, 1937, pp. 219–220.) For the papers in question *see* 3991 of 1936. *See* also 1544, below.

1302. POSITIVE NEEDLE POINT CORONA STUDIES AT ATMOSPHERIC PRESSURE.—L. B. Loeb & W. Leigh. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, p. 149: abstract only.)

1303. ELECTRON AND NEGATIVE ION MOBILITIES IN OXYGEN, AIR, NITROUS OXIDE AND AMMONIA [measured by Electrical Shutter Method: Inelastic Collisions].—R. A. Nielsen & N. E. Bradbury. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, pp. 69–75: abstract only p. 143.)

1304. AN EXPERIMENTAL TEST OF THE SUPER-NOVA HYPOTHESIS: INTENSITY OF COSMIC RAYS IN THE EARTH'S CRUST.—Clay & others. (*Physica*, Feb. 1937, Vol. 4, No. 2, pp. 121–137.)

PROPERTIES OF CIRCUITS

1305. GENERAL FORM OF A RESONANCE CURVE.—H. Ataka. (*Phil. Mag.*, Feb. 1937, Series 7, Vol. 23, No. 153, pp. 306–310.)

The writer takes the expression found by Spangenberg (2545 of 1936) for the current in any branch of a network of linear impedances, and plots in rectangular coordinates a curve of the absolute value of the current against one self-impedance which varies so that its locus is a straight line in the complex plane. The "general resonance curves" thus found are of the types observed in coupled resonant circuits.

1306. BAND-PASS TYPE AMPLIFIER CIRCUIT BY COMBINING DIFFERENTIALLY TWO RESONANCE CURVES.—Y. Watanabe & K. Kikuchi. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 396–398.)

"By differential combination [of two anti-resonant circuits with slightly differing resonant frequencies, in series] the space between the two resonant points becomes additive, while both the outer sides become subtractive, producing a new characteristic curve of band-pass filter."

1307. A DUPLEX FEEDBACK AMPLIFIER-FILTER.—Y. Watanabe & S. Narumi. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 398–405.)

Application of the duplex feedback principle (1043 of 1936) to give an amplifier-filter of high stability and suitable frequency characteristic, free from matching difficulties, and with its gain adjustable by varying the feedback, without affecting the frequency characteristic.

1308. NEW CONSTANT-GAIN AMPLIFIER AND PHASE-SHIFTING CIRCUIT [with only 10% Variation over 100 c/s to 50 kc/s Range].—Y. Watanabe & T. Aoki. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 405–407.)

1309. FREQUENCY VARIATION OF REACTANCES [Effect of Thermal Noise Voltage: Breadth of Pass Bands of Filter Chain connected to Amplifying Valve].—R. Feldtkeller. (*E.N.T.*, Dec. 1936, Vol. 13, No. 12, pp. 401–404.)

"If a reactance is in parallel with an ohmic resistance and approximates at high frequencies to the apparent impedance of a condenser C_0, the thermal noise voltage across the resistance is independent of the value of the ohmic resistance and of all circuit elements in the reaction except the capacity C_0." This theorem is demonstrated with reference to the general circuit diagram of such reactances (Fig. 1), and tested experimentally (Fig. 6). A general reactance theorem is also formulated (eqn. 9) "which determines the total breadth of the pass regions of a filter chain when it is closed by the dynamic capacity of an amplifying valve."

1310. "M-DERIVED" BAND-PASS FILTERS WITH RESISTANCE CANCELLATION.—V. D. Landon: Bode. (*RCA Review*, Oct. 1936, Vol. 1, No. 2, pp. 93–101.)

On Bode's principle of cancellation of the effect of losses in rejector circuits (U.S. Pat. 2 002 216: for papers by Bode *see* 2211/3 of 1935). A crystal filter may be designed to have a slightly narrower pass band, but the network with dissipative reactors and resistance cancellation "is expected to have a wider field of usefulness because of its lower cost and greater flexibility of design."

1311. EXPERIMENTAL INVESTIGATION OF THE ENERGY RELATIONS IN TWO INDUCTIVELY COUPLED OSCILLATING CIRCUITS.—A. Zátopek. (*E.N.T.*, Dec. 1936, Vol. 13, No. 12, pp. 404–414.)

An experimental confirmation of the theoretical results due to Petržílka (Abstracts, 1930, p. 625: 1931, p. 378) and an extension of the results to cases where the mathematical discussion becomes too complicated to be practicable. The arrangement of the oscillating circuits is shown in Fig. 1; care was taken that it should fulfil the theoretical assumptions made by Petržílka. Measured curves of the total and partial energies in the circuits in various cases are given and the existence of an optimum transference of energy is demonstrated. Energy curves are also given for frequency changes which were not theoretically considered (Parts II, IV); attenuation measurements (Part V) confirm the theory.

1312. EFFECT OF LOSS UPON ALL-PASS NETWORK [*e.g.* Retardation Network: Analysis].—K. Nagai & R. Kamiya. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 391–396.)

It is concluded that losses do not affect the phase angle very much but do, in many cases, affect the attenuation. In networks having numerous resonant and anti-resonant points the attenuation does not vary uniformly, but changes about a certain point.

1313. CALCULATION OF PASSIVE LINEAR IMPEDANCE NETWORKS BY MEANS OF FREQUENCY TRANSFORMATIONS.—T. Laurent. (*E.T.Z.*, 7th Jan. 1937, Vol. 58, No. 1, pp. 19–20.)

Summary of a Swedish paper covering the same ground as that dealt with in 471 of February.

1314. CROSS-TALK IN NON-LINEAR TRANSMISSION SYSTEMS.—H. Tischner. (*E.N.T.*, Dec. 1936, Vol. 13, No. 12, pp. 419–425.)

The writer uses the "growling buzzer" ["Schnarrsummer": Siemens & Halske patent, inventor Küpfmüller], which produces trains of damped waves with characteristics similar to those of the human voice, to investigate the cross-talk due to non-linearity in transmission systems. The phenomena to be expected theoretically are predicted by analysing the "growls" into their Fourier components (Figs. 4, 5, 6) and determining the new value of each coefficient after its non-linear distortion, for various forms of the non-linear characteristic. The theory is tested experimentally on a two-channel carrier current system. The sign of the curvature of the non-linear characteristic gives rise to differences between the cross-talk due to the buzzer and that due to speech (Figs. 8, 9).

1315. A DOUBLE-ACTION ELECTRON RELAY [Hexode with Resistance in Fourth Grid Circuit: Opposite and Simultaneous Discontinuities in Currents in Anode and Second-Grid Circuits].—Ghiron & Viti. (*Alta Frequenza*, Jan. 1937, Vol. 6, No. 1, pp. 3–15.)

The discontinuities may be of various types, but are always simultaneous and of opposite sense. They are controlled by voltages on the first and third grid, which are negative and absorb no current.

1316. On the Question of Electro-Mechanical Analogies.—Charkewitsch: Warshavsky & Fedorovich. (*Journ. of Tech. Phys.* [in Russian], No. 11, Vol. 6, 1936, pp. 2031–2034.) Continuation of the discussion referred to in 60 of January.

1317. Mutual Inductance.—J. Selz: Greig. (*Wireless Engineer*, Nov. 1936, Vol. 13, No. 158, pp. 595–596.) Prompted by Greig's paper (3315 of 1936). For a letter from Astbury, and an editorial criticism of an N.P.L. convention on the polarity of a mutual inductance, see *ibid.*, March, 1937, p. 126.

TRANSMISSION

1318. A Study of the Surplus Heating of a Cathode in a Magnetron.—Wigdorchik. (*Physik. Zeitschr. der Sowjetunion*, No. 5, Vol. 10, 1936, pp. 634–648.) English version of the paper dealt with in 923 of March.

1319. The Oscillations of Magnetic-Field Valves and Their Elucidation: Part II —Theory.—Herriger & Hülster. (*Telefunken-Röhre*, Nov. 1936, No. 8, pp. 221–256.)

For Part I *see* 3721 of 1936. A footnote to the present paper points out the omission of a line from the authors' summary of the previous paper: accordingly, the second half of the second paragraph (r-h column of p. 550) of the above-named abstract, which quotes this authors' summary, should read: "The four-segment magnetron has only one oscillation region, with a first, sharp maximum *at the second order* and a second, flat one between the 10th and 25th order."

In the present paper the authors refer to the many forms of oscillation phenomena occurring in a magnetron, and to the various theories which have been evolved more or less disconnectedly to deal with them. Their own object is to obtain a *single complete picture* of the behaviour of a magnetron, making use for this purpose of such parts of the existing individual theories as are helpful. "The motion of the electrons in a radial electric field and a homogeneous magnetic field perpendicular to this is made up of two components: the 'rolling-circle' motion and the 'guiding-path' [in the purely hypothetical case (considered first for the sake of simplicity) of the electric field being homogeneous as well as the magnetic field, this latter motion—"Leitbahnbewegung"—is in a straight line perpendicular to the two fields, with a velocity $\bar{v} = E/B$ (for system of units employed *see* footnote 11 on p. 222), and has superposed on it the "rolling-circle" motion of amplitude ρ and angular velocity ω_m, which depends only on the magnetic field and is referred to as the "magnetic angular velocity." For given values of E and B the amplitude ρ is dependent on the magnitude and direction of the initial velocity, and according to the magnitude of ρ various path types are obtained (Fig. 11, and the velocity diagram Fig. 12 derived from eqn. 6 and allowing the type of path to be read off according to the particular initial velocity). The corresponding types of path in the actual approximately homogeneous electric field in the neighbourhood of the anode are shown in Fig. 13].

"The alternating electric field in the two- and four-segment magnetrons most often employed can be considered as analysed into two rotating fields rotating in opposite directions with frequency ω/p [where p is the number of pairs of segments]. The nature of the exchange of energy between the electrons and the alternating field is seen to constitute a suitable view-point from which the various types of magnetron oscillations can be classified. Thus if the frequency of the rotating field coincides with the frequency of one of the two motion-components, the electrons can give up their energy continuously. The oscillations thus made possible are called 'transit-time' oscillations. If the electrons move in quasi-stationary fields [*i.e.* if both "rolling-circle" and "guiding-path" frequencies are large compared with the alternating-field frequency] Habann oscillations are excited by reason of the static negative resistance.

"If the frequency of the rotating field coincides with the 'rolling-circle' frequency, the 'rolling-circle' energy can be given up to the oscillatory circuit. Oscillations of this type are possible with the two-segment valve and have been designated 'first-order oscillations' (theory of K. Fritz—3379 of 1935: *see* also 1736 of 1936). If the rotating-field frequency coincides with the 'guiding-path' frequency, 'higher-order' oscillations occur. The 'guiding path' is a spiral. Synchronism is imposed by the radial component of the rotating field. Posthumus's formula $\omega/p = 2V_a/Br_a^2$ describes the relation between the optimum working conditions: it is confirmed by our measurements, which extended to the three-segment valve and two-phase and three-phase six-segment valves. At the lower orders, departures occur from the Posthumus theory, as regards efficiencies: this discrepancy is explained [pp. 245–247] by the neglect [by Posthumus] of the 'rolling-circle' motion.

"If the order numeral n is equal to the phase numeral ϕ, in a magnetron with pole-pair number p equal to or greater than 2 the alternating field may enter into energy-exchange simultaneously with 'rolling-circle' and 'guiding-path' motions. This accounts for the high efficiency of the four-segment magnetron on second-order oscillations.

"The negative resistance, on account of which the Habann oscillations are excited [*see* above], also occurs with the cycloidal motion of the electrons. The oscillation zone of the Habann oscillations is limited, in comparison with higher-order oscillations, by the necessary condition that the working data for Habann oscillations must be independent of frequency. The transitional region between the two [transit-time and Habann oscillations] is vague, since before the entry of synchronism a periodic migration of the electrons along the 'guiding-paths' is possible" [pp. 254–255].

1320. Correction to the Paper: The Static Characteristics of the Split-Anode Magnetron [Reasoning in Paper holds for Presence of Space-Charge].—H. Zuhrt. (*Hochf:tech. u. Elek:akus.*, Jan. 1937, Vol. 49, No. 1, pp. 23–24.) *See* 65 of January.

1321. **Remarks on the Paper by O. Pfetscher & W. Puhlmann: On High-Efficiency Habann Generators for Ultra-Short Waves** [Production of Dynatron and Class B Oscillations by Split-Anode Magnetron: Class B Oscillations conditioned by Negative Dynamic Resistance].—K. Okabe. (*Hochf:tech. u. Elek:akus.*, Jan. 1937, Vol. 49, No. 1, pp. 24–25.) *See* 2950 of 1936.

1322. **Electronic Oscillations of Constant Wavelength** [in Retarding-Field Circuit but with slightly Positive Anode: Amplitude Modulation, free from Frequency Modulation, by Variation of Anode Voltage: Meshwork Anode particularly Effective].—S. Nakamura & S. Ohshima. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 474–478.)

1323. **A Determination of the Fundamental Types of Electron Oscillations in a Triode Valve.**—R. Cockburn. (*Proc. Phys. Soc.*, 1st Jan. 1937, Vol. 49, Part 1, No. 270, pp. 38–58: Discussion pp. 58–60.)

For previous work *see* 3894 of 1935. It is here confirmed experimentally "that in general the retarding-field triode can maintain both Gill-Morell and Barkhausen-Kurz oscillations." It is found that there exist two distinct types of Barkhausen-Kurz oscillations: "one [shorter type] due to the periodic to-and-fro motion of the electrons about the grid of the valve, and the other [longer type] to a resonant circuit formed by the grid/plate capacity in parallel with the equivalent inductance of the electron cloud between these electrodes." Separate characteristics are obtained for these two types of oscillation. Data of the effect of valve dimensions and operating conditions are given. The cause of maintenance of the oscillations will be considered in a future paper. An appendix deals with the calculation of the two types of characteristic.

1324. **Electron-Beam Oscillators** [Micro-Wave Oscillations produced by Beam passing through Several Electrodes with Relative Potentials varied by Feed-Back from Other Parts of Beam].—J. B. Hoag & G. E. Flodin. (*Phys. Review*, 1st Jan. 1937, Series 2, Vol. 51, No. 1, p. 60: abstract only.)

1325. **Ultra-Short-Wave Simultaneous Radio Telephony with Single-Tube Circuit.**—S. Ohtaka & T. Hasegawa. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 470–472.) Results of tests with the system dealt with in 504 of 1936.

1326. **Method of Determining the Degree of Modulation of a Doubly-Modulated Oscillation.**—Hollmann. (*See* 1492.)

RECEPTION

1327. **Measuring Technique in the Manufacture of Broadcast Receivers** [Components and Finished Instruments].—E. Mittelmann. (*Elektrot. u. Masch:bau*, No. 45, Vol. 54, pp. 533–539.)

1328. **Measuring the Total Gain of Receivers by Thermal Agitation Noise.**—H. Seki. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 498–500.)

Based on the author's formula for the relation between noise, side-band width, and gain: $A_m = E_{nr}/e_n\sqrt{\beta}$, where A_m is the max. over-all gain, β the "equivalent width" of side-band, E_{nr} the noise on the detector grid (obtained, by subtraction, from measurements with a combination of valve amplifier and thermo-couple meter), and e_n the thermal-agitation noise, on each frequency, at the first grid (obtained from the resonance impedance of the first grid resonant circuit, measured by a dynatron or a resonance curve method).

1329. **The Response of Rectifiers to Fluctuation Voltages, *and* Papers on Fluctuation Voltages.**—Williams: Schottky. (*See* 1364: 1361/3.)

1330. **Anti-Noise Circuits** [Some Momentarily "Muting" Arrangements for Suppression of Interference from Man-Made Static].—(*Wireless World*, 12th Feb. 1937, Vol. 40, pp. 154–155.)

1331. **A Noise-Reducing Circuit** [particularly for Telephonic Reception: Two Limiting Converters in Push-Pull with Outputs in Opposition: One biased to be Inoperative to Signal less than 100% Modulated].—M. G. Nicholson. (*Electronics*, Oct. 1936, Vol. 9, No. 10, pp. 14–16.)

1332. **Method for Disturbance-Free Reception** [Circuit setting Reproducing Apparatus in Action only when Voltages obtained by Separate Demodulation of Upper and Lower Sidebands of Desired Signal are exactly Equal].—Aubert, Berthon, Gabrilovitch & Isnard. (*Hochf:tech. u. Elek:akus.*, Jan. 1937, Vol. 49, No. 1, pp. 34–35: French Pat. 797 805 of 4.2.1935.)

1333. **Method for Producing Disturbance-Free Reception** [All Received Oscillations uniformly Frequency-Multiplied before Filtering and Demodulating the Desired Signal].—L. Gabrilovitch. (*Hochf:tech. u. Elek:akus.*, Jan. 1937, Vol. 49, No. 1, p. 34: French Pat. 797 840 of 7.2.1935.) Thus increasing the frequency intervals and improving the filtering.

1334. **The "Cord Condenser"** [Flexible Lead embodying Interference-Suppressing Condenser].—Siemens & Halske. (*Elektrot. u. Masch:bau*, No. 50, Vol. 54, 1936, p. 602.)

1335. **The Electrical Behaviour of Insulator Chains at Voltages between the Working and Flash-Over Values.**—F. Obenaus. (*Elektrot. u. Masch:bau*, No. 40, Vol. 54, 1936, p. 481: summary only.)

1336. WPA [Works Progress Administration, Newark] **Project for Survey to Locate Causes of Interference.**—(*Electronics*, Nov. 1936, Vol. 9, No. 11, p. 66.)

1337. EXTENSION OF THE LEGAL PROVISIONS AGAINST INTERFERENCE WITH BROADCAST RECEPTION IN AUSTRIA.—Pfeuffer. (*Elektrot. u. Masch:bau*, No. 52, Vol. 54, 1936, p. 625.)

1338. THE INTERACTION OF RADIO WAVES [Luxembourg Effect].—V. A. Bailey. (*Wireless World*, 26th Feb. 1937, Vol. 40, pp. 204–205.)

1339. SENSITIVITY OF RETARDING-FIELD AUDION INCREASED BY CONDENSER ACROSS GRID AND ANODE, PROVIDING CURRENT REGENERATION.—(*Funktech. Monatshefte*. Nov. 1936, No. 11, p. 438 : summary only.)

1340. A NEW 6E5 [Fluorescent-Screen Tuning Indicator] CIRCUIT USED IN NEW STROMBERG-CARLSON RECEIVERS.—M. L. Levy. (*Electronics*, Oct. 1936, Vol. 9, No. 10, pp. 28–29.) Unlike the usual methods of using the 6E5, the new circuit gives good sensitivity for weak signals and "effective and accurate tuning" for very strong.

1341. AUTOMATIC TUNING CORRECTION SYSTEMS. —(*Wireless World*, 19th Feb. 1937, Vol. 40, pp. 177–180.)

1342. IMPROVEMENTS IN AUTOMATIC FREQUENCY CONTROL [Automatic Tuning Correction] CIRCUITS.—R. L. Freeman. (*Electronics*, Nov. 1936, Vol. 9, No. 11, pp. 20–23.) From the Crosley Radio laboratories: including motor-boating and its prevention.

1343. SUPERHETERODYNES WITH SINGLE-KNOB TUNING.—R. C. Couppez. (*L'Onde Élec.*, Dec. 1936, Vol. 15, No. 180, pp. 804–822.)

I. Preliminary considerations. II. Study of the ordinary ("straight") receiver. III. Study of the ideal case of single-knob control of a superheterodyne (and the "regrettable disappearance" of condensers with plates of special profile—but see *ibid.*, April, 1936, p. 211). IV. Single-knob control by the method of the reducing condenser (and the technique of the "padding" and "trimmer" condensers: the choice of the intermediate frequency). V. Single-knob control by the rejector-circuit method.

1344. A GERMAN "ALL-WAVE" IDEA [and Its Advantages: Intermediate Frequency of 1750 kc/s].—(*World-Radio*, 22nd Jan. 1937, Vol. 24, p. 14.) *Cf.* Cocking, 1934 Abstracts, p. 322 (and many later abstracts such as 1849 of 1935) on "single-span" receivers.

1345. THE *Wireless World* EXPERIMENTER'S I.F. AMPLIFIER [5-Valve, for A.C. Mains: for Investigation of Merits of Different Types of Short-Wave Frequency Changer].—H. B. Dent. (*Wireless World*, 29th Jan. 1937, Vol. 40, pp. 96–99.)

1346. EXPERIMENTS ON POWER MATCHING [in Broadcast Receivers: the Correct Tapping Point, on the Tuned-Circuit Inductance, for the Audion-Grid Connection].—(*Funktech. Monatshefte*, Nov. 1936, No. 11, p. 436.)

1347. ELECTROMAGNETIC SCREENING [for Prevention of Hum and Crosstalk: Relative Effectiveness of Various Materials].—J. E. R. Constable. (*Wireless World*, 26th Feb. 1937, Vol. 40, pp. 198–199.)

1348. WINDING THE UNIVERSAL COIL [Details of Calculation of Various Factors involved].—A. W. Simon. (*Electronics*, Oct. 1936, Vol. 9, No. 10, pp. 22–24 and 67.) For corrections see *ibid.*, Nov. 1936, p. 52.

1349. RADIO EXPORTS REACH PEAK LEVEL [Data for U.S.A., Holland, Germany, and Great Britain].—A. J. G. Smith. (*Electronics*, Oct. 1936, Vol. 9, No. 10, pp. 54, 56, 58, 60.)

1350. NBC RADIO IN THE CLIPPER SHIPS [Pan American Airways].—See. (*RCA Review*, Oct. 1936, Vol. 1, No. 2, pp. 102–106.)

1351. RADIO RELAY EQUIPMENT.—G. S. Lucas, & E. S. Hall. (*BT-H Research Laboratory*, Publication RLP 116, 9 pp.)

1352. ARRANGEMENT FOR TELEGRAPHY AND TELEPHONY RECEPTION [Switching out or in of Beat Oscillator transfers Circuit from Grid to Anode Rectification: Reception Strength almost equal in the Two Cases].—Lorenz Company. (*Hochf:tech. u. Elek:akus.*, Jan. 1937, Vol. 49, No. 1, p. 35: German Pat. 636 083 of 8.2.1935.)

1353. AUTOMATIC ALARM [to receive Special Distress Signal preceding the SOS Signal: Design Requirements: the AR-8600 Auto Alarm].—I. F. Byrnes & H. B. Martin. (*RCA Review*, Jan. 1937, Vol. 1, No. 3, pp. 49–64.)

AERIALS AND AERIAL SYSTEMS

1354. THE EFFECT AT A DISTANCE OF THE ORDER OF A WAVELENGTH OF A VERTICAL DIPOLE EMITTER ON A PLANE EARTH.—K. F. Niessen. (*Ann. der Physik*, Series 5, No. 3, Vol. 28, 1937, pp. 209–224.)

For previous work *see* Abstracts, 1933, p. 382; 1934, p. 259 and back references. The present calculations discuss the case of a complex numerical distance, *i.e.* of an earth with an arbitrary ratio of conduction to displacement current. Expressions (eqns. 21) are derived which give the normalised product of field-strength and distance in the cases when the horizontal component of magnetic force, the vertical or horizontal electrical components, are used to measure the field. The evaluation of these expressions is discussed (§ 4) in the case when the modulus of the numerical distance is small and the first-order correction term to Sommerfeld's formula is included; the resulting formulae (eqns. 22) can be used for practical calculations. Revised expressions (eqns. 25) are given for the case when the numerical distance is real; the mathematical analysis for the precise evaluation of Sommerfeld's formula in the case of complex numerical distance is given in an appendix. The writer points out that the work has important bearing on the problem of determining the intensity of an emitter from measurements of field-strengths in its vicinity.

1355. EFFECTIVE GAIN OF THE SHORT-WAVE BEAM ANTENNA [for Transmission and Reception: by Comparison with Single Horizontal Aerial of Length and Height $\lambda/2$].—M. Nakagami & K. Miya. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 478–479.)

Among the conclusions are the following:—the effective gain and its variation with time show a considerable difference even between two points 40 or 50 km apart and of a few degrees difference in direction: the effective gain of a transmitting beam aerial sometimes becomes negative, and it is affected by the receiving aerial. *See* also 857 of March.

1356. VDE SAFETY REGULATIONS FOR AERIAL INSTALLATIONS, TRANSMITTING AND RECEIVING.—(*E.T.Z.*, 28th Jan. 1937, Vol. 58, No. 4, pp. 107–108.) Introductory remarks by Eppen, p. 89.

VALVES AND THERMIONICS

1357. DISTORTION EFFECTS IN MIXING VALVES [calculated assuming Characteristics to be Sums of Exponential Functions].—M. J. O. Strutt. (*Hochf:tech. u. Elek:akus.*, Jan. 1937, Vol. 49, No. 1, pp. 20–23.)

§ I gives a short account of the present-day mixing valves and their uses. In § II calculations are given for various distortion effects, based on the representation of the static valve characteristics as a sum of exponential functions. Effects considered are the increase of modulation, modulation distortion, cross-modulation, and formation of combination tones of the modulation frequencies. In § III whistling tones and their measurement are discussed with the same assumption as regards the characteristics. Determination of the distortion by measuring the whistling tones is worked out theoretically in § IV.

1358. MODERN MULTI-GRID VALVES [Lecture to Zurich Physical Society].—M. J. O. Strutt. (*E.T.Z.*, 4th & 11th Feb. 1937, Vol. 58, Nos. 5 & 6, pp. 113–117 and 149–153.) Survey, with 200 literature references. The last sections deal with the effects due to oscillating space charges in hexodes and octodes, and with short-wave phenomena such as the decrease of input and output impedances and transit-time effects in hexodes used as mixing valves.

1359. NON-LINEAR DISTORTION OF TRIODE WITH IMPEDANCE LOAD [Analysis].—Y. Degawa. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 409–411.)

1360. THE EFFECT OF SPACE CHARGE ON THE SECONDARY CURRENT IN A TRIODE.—D. M. Myers, D. R. Hartree, & A. Porter. (*Proc. Roy. Soc.*, Series A, 1st Jan. 1937, Vol. 158, No. 893, pp. 23–37.)

"The potential distribution in the space between the anode and grid of a triode with cylindrical electrodes has been determined theoretically in the condition where the grid collects current due to secondary emission from the anode, and this current is limited by electronic space charge." Various approximations were made and solutions were derived by means of the differential analyser. Experimental results with a triode having a nickel anode agreed with the theoretical predictions if the initial energy of secondary electrons was assumed to be about 4 volts.

1361. SHOT EFFECT AND THE SPACE CHARGE THRESHOLD.—W. Schottky. (*Telefunken-Röhre*, Nov. 1936, No. 8, pp. 175–195.)

The writer's 1926 interpretation of the decrease of shot effect in the presence of a space charge, according to which the current fluctuations are diminished by the space charge in the same ratio as the emission current itself is decreased, was revived by Llewellyn in 1930 and is now accepted by many experts. But the numerous subsequent publications on the subject show that there are many difficulties in the way of a clear understanding of the problem, and the writer has been induced to take it up again, prompted particularly by the paper by Rothe & Plato (3765 of 1936) and by Rothe's personal request that he should find an explanation of the systematic occurrence, mentioned in that paper, of fluctuations far greater than those predicted by the theory of space-charge-limited fluctuations. The present paper does not attempt to give a complete interpretation of these results (which were obtained with commercial valves and therefore do not involve the simplest theoretical conditions) but to provide a purely theoretical contribution replacing the old theory by a new one which gives considerably higher values of fluctuation.

By his new treatment the writer arrives at formula 13 for the relation between the space-charge-diminished shot effect and the undiminished shot effect. The corresponding formula obtained by Llewellyn (transformed to the same terminology) is given in equation 16, and gives a diminished shot-effect current $\sqrt{i/s}$ times smaller than that given by equation 13: i is that portion of the saturation current s which reaches the anode. In the region of strong space-charge limitation this factor may well make a difference of a whole order of magnitude. This discrepancy between the two formulae is attributed to Llewellyn's neglect of the *relative increase of the fluctuations of corpuscular particles* accompanying the decrease of the absolute number of the particles (*cf.* Williams, 4069 of 1936).

Further examination (pp. 188–190) confirms that in all practically important cases, whatever the electrode arrangement, the new formula is valid. Compared with observed results, it still gives too high a value for the reducing effect of the space charge: the experimental reduction is smaller, the fluctuations themselves are larger. This discrepancy may be attributed to positive ions from the cathode and/or to inhomogeneity of emission, the latter arising from highly emitting portions of the cathode being interspersed with poorly emitting portions, so that the total emission is partly space-charge-saturated and partly temperature-saturated. This effect would be particularly noticeable with high grid voltages, and actually it is found that the new formula gives almost exactly the shot-effect values obtained with small grid voltages and that the discrepancy between theory and experiment increases (for a given cathode temperature) as the grid voltage is increased.

1362. Weakening Action of the Space Charge in the Shot and Flicker Effects.—W. Schottky. (*Physica*, Feb. 1937, Vol. 4, No. 2, pp. 175–180: in German.)

"The fluctuations of the electron current passing through a space-charge threshold can—as shown more fully elsewhere [*see* 1361 & 1363]—be calculated by finding first the current-fluctuations for a constant threshold potential, and then taking into account, as a secondary influence, the effect of the fluctuation currents on the position and depth of the potential threshold. The determination of the corresponding secondary current-fluctuations can then follow according to continuum theory.

"It is then found—a fact previously unknown—that the squared primary current-fluctuation I^2_{prim} varies differently, for shot effect and flicker effect, with the current i passing [the threshold] and the saturation current s originally emitted by the cathode." The difference is seen in the equations 1 and 2, where the suffixes F and S indicate the unweakened flicker and shot effects respectively, while the suffixes F' and S' indicate the corresponding space-charge-weakened values; a combination of 1 and 2 gives eqn. 3, from which it is seen that "the space-charge weakening effect, given by the square of the ratio of the primary current-fluctuation to the fluctuation of the saturation current flowing from the cathode, is i/s times more effective in the flicker effect than in the shot effect." Considering then the actual observable fluctuations, made up of the results of the primary and secondary effects mentioned at the beginning of this abstract, the writer obtains eqn. 9; rough calculations of the β factor in this show that it is less than unity, so that it may be concluded that the ratio of the squares of the resultant current fluctuation per frequency unit and of the saturation-current fluctuations in the same frequency interval is, with sufficiently high space-charge potential, less in the flicker effect than in the shot effect by more than the ratio i/s. Since the saturation-current fluctuation for the flicker effect increases in proportion to s, whereas S_s for the shot effect increases in proportion to $\sqrt{s}$, it follows also from eqn. 9 that for a constant i and sufficiently large s the ratio of the final fluctuation-current squares for flicker effect and for shot effect is independent of s.

The last page and a half deals with the estimation of the *absolute* values of the space-charge weakening of the two effects.

1363. The Connections between Corpuscular and Thermal Variations in Electron Tubes.—W. Schottky. (*Zeitschr. f. Physik*, No. 3/4, Vol. 104, 1937, pp. 248–274.)

Author's summary:—The chance variations of the number of particles, which must be assumed to occur in the electrons forming an electron current passing through a vacuum, are known as the "shot effect." This contains, with the differential resistance of the discharge path, all the factors necessary to give rise naturally, under certain conditions, to variations of semi-thermal or completely thermal character. The case when the starting path of the electrons is free from space charge is explained on these lines and brought into connection with the thermal variations in a quiescent ideal electron gas. A new theory of the variations of space-charge-limited discharges, already published by the author [1361 & 1362, above] is discussed from the thermal standpoint. It is found that, in a space-charge path, the part of the discharge between the incandescent cathode and the space-charge threshold acts like a semi-thermal resistance, whose variations are however lessened by the part of the discharge between the threshold and the anode. In amplifying valves, the variations of a space-charge path between cathode and control grid are amplified in proportion not to the current but to the power. This gives rise to a variation in the anode circuit which, under normal conditions, is not as large as the power, amplified in the anode circuit, due to thermal noise from the external grid circuit. In § 5 the general methods are discussed for determining the variation effects in conductors where electrical transport takes place by corpuscles; a final paragraph deals shortly with the important influence of a spatial displacement of the potential threshold.

1364. The Response of Rectifiers to Fluctuation Voltages [Derivation of Formulae for Mean-Square Output Voltage from Square-Law and Linear Rectifiers, in presence of a Dominant Harmonic Voltage: Experimental Verification: Behaviour of Linear Rectifier in Absence of Dominant Harmonic Voltage: Signal/Noise Ratio: "Note Corrected" Reception superior to "Uncorrected"].—F. C. Williams. (*Journ. I.E.E.*, Feb. 1937, Vol. 80, No. 482, pp. 218–226.) For previous work *see* 4069 of 1936.

1365. The Valves in the Broadcast Receiver. Part 4: Diode Detection.—K. Wilhelm. (*Telefunken-Röhre*, Nov. 1936, No. 8, pp. 196–220.)

For previous parts see 2579 of 1936. "The theme [of diode detection] will be dealt with in two parts. The first [and present] part assumes an ideal diode and [by means of an equivalent circuit which reduces the rectification processes to pure l.f. and d.c. treatment] shows the main effects of the circuit and the circuit elements as regards linear and non-linear distortion [the cases chosen are: capacitive load, additional ohmic load, and the loading of a band filter by a second diode—the regulating diode in a delayed a.v.c. system (Fig. 15a). In this last case, use is made of the equivalent circuit (Fig. 15b) for a band filter, derived in the appendix (pp. 214–220) and yielding Fig. 15c as the equivalent circuit of Fig. 15a. Fig. 15d is a simplified equivalent circuit which applies when only small modulation frequencies are considered, so that the effect of frequency-dependent elements can be neglected]. A diode driven by sufficiently large h.f. voltages (10–20 v) represents an almost ideal rectifier, so that the results obtained in the first part are applicable to this case. The departures from the ideal case, and their effects, will be dealt with in the second part."

1366. THE IMPORTANCE OF ELECTRON OPTICS IN THE TECHNIQUE OF AMPLIFYING VALVES [for Calculation of Action of Orthodox Multi-Grid Valves and for Development of New Types with New Methods of Control].—H. Rothe & W. Kleen. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 635–642.)

"The laws of the slit stop and of total reflection form the bases for the [satisfactorily approximate] calculation of the modulation characteristics of space-charge-grid valves and double-modulation [mixing] valves. For the pentode, anode-current/anode-voltage characteristics, internal resistance, and amplification factor are derived from the lens action, governing the current-sharing process, of the spaces between the wires of the screen grid [*cf.* 3774 of 1936 and 537 of February].

"The possibilities of the production of electron rays in systems of the size of ordinary receiving valves are discussed. With the help of such rays new types of control processes and electrode arrangements for the production of negative resistance are arrived at."

1367. FOCUSING CRITERIA FOR ELECTRONS IN SUPERIMPOSED ELECTRIC AND MAGNETIC FIELDS, *and* MOTIONS OF ELECTRONS IN GASES IN ELECTRIC AND MAGNETIC FIELDS.—Shaw: Huxley. (*See* 1512, 1287.)

1368. APPLICATIONS OF VISUAL-INDICATOR TYPE TUBES [6E5 and 913 (Midget) Cathode-Ray Indicator Tubes].—L. C. Waller. (*RCA Review*, Jan. 1937, Vol. 1, No. 3, pp. 111–125.)

The Type 913, with its two sets of deflecting plates, its 1″ diameter viewing screen and its metal-shell design (eliminating wall-charge difficulties), forms a compact & economical c-r oscillograph. Among the many easy applications of the 6E5, it can be used as a tuning indicator in receivers having neither avc nor a diode detector (acting in the reverse way to its usual pattern movement), as a null indicator, and as a valve voltmeter.

1369. PENTODES FOR HIGH-FREQUENCY OPERATION [Western Electric 240 H for Ultra-High Frequencies: Push-Pull Pentodes in 3″ × 2″ Bulb].—Samuel & Sowers. (*Electronics*, Nov. 1936, Vol. 9, No. 11, p. 60.) *See* 127 of January.

1370. PROGRESS IN VALVES IN 1936 [including the Type HA1 Miniature Triode].—(*G.E.C. Journal*, Feb. 1937, Vol. 8, No. 1, pp. 46–47.)

1371. MODERN ASPECTS OF THE TECHNOLOGY OF LARGE VALVES [Medium and High Power, including Ultra-Short-Wave Types].—G. Rutelli. (*Alta Frequenza*, Jan. 1937, Vol. 6, No. 1, pp. 16–49.)

1372. EVOLUTION OF THE DIRECT-CURRENT AMPLIFIER [and Electrometer Valves].—(*Electronics*, Nov. 1936, Vol. 9, No. 11, pp. 62, 64.)

1373. ELECTRONIC TUBE NOMENCLATURE BEING STUDIED.—American Standards Association. (*Elec. Engineering*, Feb. 1937, Vol. 56, No. 2, p. 284.)

1374. THE MODIFICATION OF APPARENT THERMIONIC CONSTANTS FOR OXYGENATED TUNGSTEN BY THE TEMPERATURE VARIATION OF ADSORPTIVE EQUILIBRIUM.—M. C. Johnson & F. A. Vick. (*Proc. Roy. Soc.*, Series A, 1st Jan. 1937, Vol. 158, No. 893, pp. 55–68.)

It is shown theoretically that "the temperature coefficients of chemical reaction, at any composite surface whose state cannot be maintained steady, will cause definite changes in the plot of thermionic emission; these lead to intercepts and slopes being measured which neither coincide with nor are even intermediate between the genuine thermionic constants for bare or covered surface." "A series of experiments on the pressure and temperature dependence of emission from a tungsten/oxygen interface" shows that "the 'anomalous' constants of oxygenated tungsten are examples of the above principles." The apparent constants of platinum and the alkalis may contain temperature coefficients of diffusion, etc.; for tungsten, the experimental data "can, in principle, be made to yield information concerning the progressive change of θ [the covering ratio of the surface] with temperature and pressure."

1375. FIELD CURRENT EMISSION FROM METALS INTO GASES AT HIGH PRESSURES.—J. B. Adams, J. C. Hubbard, & R. T. K. Murray. (*Phys. Review*, 1st Jan. 1937, Series 2, Vol. 51, No. 1, p. 63: abstract only.)

1376. CONTACT POTENTIAL BETWEEN FILAMENTS IN VACUUM BY KELVIN METHOD [with Measurement of Temperature Increase in Work Function of Tungsten].—A. T. Waterman & J. G. Potter. (*Phys. Review*, 1st Jan. 1937, Series 2, Vol. 51, No. 1, p. 63: abstract only.)

DIRECTIONAL WIRELESS

1377. THE [Mathematical] RELATIONS FOR THE QUASI-STATIONARY FIELD OF A CLOSED RECTANGULAR CONDUCTING LOOP ABOVE THE EARTH WITH SINGLE-WAVE ALTERNATING CURRENT.—H. Buchholz. (*E.N.T.*, Dec. 1936, Vol. 13, No. 12, pp. 425–434.)

For previous work *see* 581 & 1818 of 1936. The present paper combines the results there obtained and deduces the equations determining the field of the complete conducting loop (§ 2). The equations for the subsidiary cases of a loop extending to infinity at one side (§ 3a) and of a loop extending to infinity at both sides, with one earthed point (§ 3b) are also found. The equations are exact for point electrodes but only approximately so for electrode discs of finite radius.

1378. APPLICATION OF ULTRA-SHORT WAVES TO RADIO RANGE BEACONS [Equi-Signal Method: Japanese Experiments].—M. Okada & R. Kimura. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 465–467.)

1379. AN INVESTIGATION OF MEDIUM-WAVE RADIO RANGE BEACONS [with Adcock Transmitting Aerials].—T. Amishima & M. Okada. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 467–470.)

1380. METHOD FOR ELECTRICAL ROTATION OF BEAM [by Connection of Emitter Signal to Various Points of Connecting Leads and so to Required Groups of Radiators].—Telefunken: A. Gothe. (*Hochf:tech. u. Elek:akus.*, Jan. 1937, Vol. 49, No. 1, p. 35: German Pat. 635 500 of 29.3.1935.)

1381. METHOD OF DETERMINING THE HEIGHT OF AN AIRCRAFT IN FLIGHT [Emitter, thrown from Aircraft, gives Signals from the Time It is ejected until It reaches Ground: Height determined from Duration of Signals].—Siemens App. & Machine Co: G. Klein. (*Hochf:tech. u. Elek:akus.*, Jan. 1937, Vol. 49, No. 1, p. 35: German Pat. 635 633 of 22.6.1935.)

ACOUSTICS AND AUDIO-FREQUENCIES

1382. CONTRIBUTION TO THE QUESTION OF THE TRANSMISSION OF SPEECH FROM NOISY ROOMS [Advantages of Directional Microphone].—H. J. von Braunmühl & W. Weber. (*E.N.T.*, Dec. 1936, Vol. 13, No. 12, pp. 414–419.)

The writers have found (*see* 1039 of 1936) that the pick-up of sound in noisy rooms is improved by using directional microphones. Here a pressure-gradient pick-up microphone is compared theoretically with a non-directional pressure microphone; the decreased amount of noise which it picks up is demonstrated. Fig. 2 shows the frequency/sensitivity curve of the pressure-gradient pick-up at a distance of 2 cm from the source of sound; the sensitivity increases rapidly towards the low-frequency end of the spectrum. This increase does not however hold for the noise, which comes from a greater distance. The distortion produced by this sensitivity increase can also be compensated by electrical devices, which will at the same time decrease the low-frequency noise level. These considerations are expressed numerically on the assumption that the speech wave reaching the microphone is spherical, while that from the noise is plane. This assumption is tested experimentally with an octave filter and found to hold for frequencies up to 3200 c/s; Figs. 3–6 show the variation of the microphone output voltage with distance from the acoustic source. The intensity of the speech at a distance of 2 cm from the mouth was measured for normal, loud, and very loud speech; Fig. 7 shows the relation between the intensity and the noise threshold above which it was just audible. Fig. 8 gives curves of speech comprehensibility as a function of intensity in the presence of various degrees of noise. "Even at noise levels which are above the pain threshold of the ear, a comprehensibility ratio of 40 per cent. can be attained for syllables."

1383. A METHOD OF CALIBRATING AN ELECTROSTATIC MICROPHONE, BASED ON ITS BEHAVIOUR WITH RESPECT TO AN ALTERNATING ELECTROMOTIVE FORCE.—O. M. Corbino. (*La Ricerca Scient.*, 15th/30th Nov. 1936, Series 2, 7th Year, Vol. 2, No. 9/10, pp. 491–497.)

Avoiding the complications of the r.f. capacity-change method by the use of "a new characteristic in the functioning of a condenser microphone under the action of an alternating current"—namely the appearance of a third harmonic (easily isolated by a suitable bridge) the value of whose voltage bears a simple relation to the capacity change due to the motion of the diaphragm ($E_3 = \frac{1}{2}. a/C_0 . E_e$, where a is the capacity change, C_0 the normal capacity of the microphone, & E_e the applied alternating voltage). Thus a measurement of E_3, together with a knowledge of E_e, gives the value of a/C_0 and thus the movement of the diaphragm. This measurement may be made with a voltmeter V_2 (Fig. 2) or with a cathode-ray oscillograph, the latter giving more easily a true value of the third harmonic, independent of background-noise voltages.

1384. CONDENSER MICROPHONE USING SILK MEMBRANE [sputtered with Gold: Tension very Low compared with Duralumin Diaphragms: Explanation of Unexpected Results].—S. Oshida & M. Okahara. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 375–377.)

The tension of the membrane does not have much effect on the frequency characteristic. This is uniform, with low sensitivity, when the clearance is very small: irregular, also with low sensitivity, when the clearance is large: and uniform, with high sensitivity, when the clearance has a certain value ($3–6 \times 10^{-3}$ cm).

1385. A NEW CAPACITIVE METHOD FOR THE CONVERSION OF MECHANICAL INTO ELECTRICAL OSCILLATIONS AND *vice versa* [using Solid Dielectric instead of Air: including Condenser Microphone and Telephone].—H. Sell. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 18, 1937, pp. 3–10.)

The full paper, a summary of which was referred to in 1267 of March. Preliminary tests showed that although a solid dielectric between rigid electrodes gave consistent and reliable results and the advantage of ease in maintaining a small gap, the sensitivity was low owing to the large restoring force. In these tests mica and other highly insulating materials were used in thin foils which were metallised on both sides to avoid the inclusion of air, and the electrodes were of highly polished steel. In spite of the low sensitivity such arrangements are practicable for the measurement of high pressures over wide ranges. Quite different results were obtained when air inclusions were allowed to exist between the dielectric and the electrodes, as occurred even with carefully prepared electrode surfaces if the metallising of the dielectric was omitted: the sensitivity was very high but inconstant, with hysteresis effects, owing to the action of adhesion and friction.

The true solution was found to be the replacement of the carefully smoothed electrodes by carefully roughened ones such as could be obtained by sand-blasting or grinding the surfaces. Such surfaces have a fine structure consisting of a number of statistically distributed very small surfaces. Owing to the smallness of these surfaces the *specific* pressure on the dielectric is very high, so that elastic deformation occurs and gives a reliable bedding of electrode on dielectric without the inclusion of air. Hysteresis disappears (unless the fine structure is made *too* fine, as in the top curve of Fig. 2—

steel surface obtained by grinding) and smooth curves resembling hyperbolae are obtained. Various practical designs of the device are dealt with, for purposes ranging from very high pressure measurement (including high-temperature working: the new ceramic dielectrics are useful here) to microphones and telephones. Fig. 6 shows the various frequency characteristic curves, for five bias voltages from 50 to 195 volts, of such a microphone. Compared with the ordinary air-gap microphone it has the advantages of greater frequency range for the same sensitivity, and 5 to 10 times higher capacity, making easy the use of long cables. For special purposes very small as well as very large microphones can be made, and since the diaphragms can be of any shape (*e.g.* cylindrical) non-directivity is easily obtained. The new principle can also be used for highly efficient sound generators.

1386. THE CARBON MICROPHONES [and a Suitable Measure of the Quality of Various Carbon Powders: Equivalent Circuit].—K. Kobayasi. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 377–380.)

1387. INTELLIGIBILITY AND VOLUME RESULTING FROM FREQUENCY AND [particularly] AMPLITUDE LIMITING.—F. Strecker. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 568–572.)

Section 2, dealing with the effects of limitation of the frequency band, is a discussion of Harvey Fletcher's measurements (curves of Fig. 1). The rest of the paper deals with limitation of amplitude (*see* also 177 of January).

1388. ON THE [Distortion introduced by] AUTOMATIC VOLUME COMPRESSION.—B. S. Galperin. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2162–2170.) A theoretical investigation of the various kinds of distortion in sound recording introduced by automatic volume compressors using variable-mu amplification stages.

1389. MIXER CIRCUIT DESIGNS.—R. F. Smeltzer. (*Electronics*, Nov. 1936, Vol. 9, No. 11, pp. 32–33 and 54, 56.)

1390. THE SUPERVISION OF SOUND-REPRODUCING SYSTEMS.—L. D. Rosenberg. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2180–2182.) Some considerations on the organisation of technical control of sound-film apparatus. An outline is given of tests necessary to ensure satisfactory operation of the apparatus.

1391. THE VOLUME RANGE IN SOUND RECORDING ON FILMS.—A. V. Rabinovich. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2183–2187.) An account of experiments carried out to determine the difference between the noise level and the highest sound level for distortionless reproduction from films, with a discussion of the results obtained.

1392. THE RCA SOUND RECORDING SYSTEM.—M. C. Batsel & E. W. Kellogg. (*RCA Review*, Oct. 1936, Vol. 1, No. 2, pp. 3–34.) With bibliography of 30 items.

1393. SOUND FILM EQUIPMENT FOR THE NARROW-FILM AMATEUR [using Home-Recording Discs: Complete Synchronisation in Recording and Reproducing], *and* THE HOME RECORDING OF GRAMOPHONE RECORDS.—Zipfel: Steinbrenner. (*Funktech. Monatshefte*, Nov. 1936, No. 11, pp. 419–424: pp. 425–430.)

1394. SOUND-ON-DISC: PRESENT-DAY RECORDING TECHNIQUE.—(*Electronics*, Oct. 1936, Vol. 9, No. 10, pp. 6–10 and 48, 50.)

1395. INVESTIGATIONS ON THE BUILDING-UP PROCESSES IN ORGAN PIPES [using Six Octave Filters each connected to One Loop of Oscillograph].—F. Trendelenburg. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 578–580.)

1396. THE WELTE "LIGHT TONE" ORGAN [with Photoelectric Note Generator using Discs with "Amplitude Process" Recording].—Welte. (*Funktech. Monatshefte*, Nov. 1936, No. 11, pp. 437–438: *E.T.Z.*, 28th Jan. 1937, Vol. 58, No. 4, p. 99.)

1397. THE GLOW-DISCHARGE-TUBE ELECTRIC ORGAN OF THE DIETRICH-ECKART OPEN-AIR STAGE AND AT THE RADIO EXHIBITION.—O. Vierling. (*E.T.Z.*, 28th Jan. 1937, Vol. 58, No. 4, pp. 90–91.)

1398. ADJUSTABLE RESONATORS AND ORCHESTRATION [Difficulty of changing Pitch of Instrument without Change of Quality].—E. G. Richardson: Osborne. (*Nature*, 23rd Jan. 1037, Vol. 139, p. 157.) Prompted by Osborne's suggestion (1011 of March).

1399. ON THE IMPORTANCE OF THE INITIAL MOMENT IN THE FORMATION OF A NOTE IN A MUSICAL INSTRUMENT.—S. Skrebkov. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2190–2193.) A report on experiments in comparing the ease of discrimination between two notes of the same intensity and pitch but of different quality, when the two notes are listened to (a) from the moment of their commencement and (b) when they have reached the steady state.

1400. ON THE RESONANCE PROPERTIES OF STRINGED INSTRUMENTS [and Their Analogy to Intermediate-Circuit Valve Transmitters].—H. Backhaus. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 573–578.)

With several violin resonance curves taken with the apparatus described. The much-discussed "wolf-tone," occurring frequently with 'cellos but also sometimes with violins, is explained as a beat effect between the two simultaneously regenerated coupling-frequencies of an oscillatory circuit with two degrees of freedom.

1401. ELECTRICAL TRANSMISSION AND REPRODUCTION OF SPEECH AND MUSIC [including Sound Amplification for Concert Halls, etc.].—H. J. von Braunmühl. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 539–549.)

1402. ADDRESSING THE AMERICAN PUBLIC [Recent Developments in Large-Scale Sound-Amplification].—(*Wireless World*, 5th Feb. 1937, Vol. 40, pp. 122–123.)

1403. 6L6s IN A DEGENERATIVE AMPLIFIER [12 Watt Output for P.A. Purposes].—E. F. Kiernan. (*Electronics*, Nov. 1936, Vol. 9, No. 11, p. 50.)

1404. A DUPLEX FEEDBACK AMPLIFIER-FILTER, *and* A NEW CONSTANT-GAIN AMPLIFIER AND PHASE-SHIFTING CIRCUIT.—Watanabe & Narumi : Watanabe & Aoki. (*See* 1307/8.)

1405. A THREE-STAGE 10-WATT AMPLIFIER WITH PUSH-PULL TRIODE [AD1] OUTPUT.—H. Hertel. (*Funktech. Monatshefte*, Nov. 1936, No. 11, pp. 431–434.) For the merits of the AD1 *see* 132 of January.

1406. THE INFLUENCE OF THE SIZE AND SHAPE OF BAFFLES ON THE SOUND RADIATION OF LOUDSPEAKERS.—G. Buchmann. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 563–568.)

Author's summary :—" By experimental tests the effect of shape and size of baffles is shown. With circular baffles, pronounced interference occurs on the loudspeaker axis owing to secondary radiation produced by diffraction at the edge of the baffle. If the path difference of the two components is equal to $\lambda/2$, a maximum occurs : if it equals λ, a minimum [Figs. 2 and 3, for baffles of 45 and 65 cm radius respectively : the ordinates represent the sound-pressure ratio for the actual baffle and an infinite baffle. Both figures show that the maxima considerably exceed the values given by an infinite baffle. In Fig. 2 the distance of the microphone is 104 cm for curve *a* and only 60 cm for curve *b* : the position of the minimum shifts slightly towards the higher frequencies as the distance is increased]. This also holds good for multiples of λ, until the directivity of the loudspeaker diaphragm no longer allows any sound to reach the baffle edge. The path difference is taken as the shortest path from loudspeaker to microphone, over the edge of the baffle, less the loudspeaker/microphone distance.

" The rectangular baffle behaves very similarly, but the effective path difference is rather larger than half the length of the side of the baffle. This is explained by the varying distances between loudspeaker and various points along the edges of the baffle, giving a larger mean value of path. The use of markedly asymmetrical baffles smoothes out the frequency characteristic [*cf.* Ashworth, 162 of January]. Suppression of the radiation from the back does not completely eliminate interference, since the radiation from the front is also diffracted at the baffle edges towards the observation point." The writer points out that in practical use this baffle interference is usually swamped by the effects, on the sound field, of the neighbouring reflecting walls : " on the other hand, in loudspeaker investigations in open air and in damped rooms they must be taken into account."

1407. ON THE RELATIONSHIP BETWEEN THE MASSES OF THE MOVING COIL AND OF THE RADIATING SYSTEM IN AN ELECTRODYNAMIC HORN LOUDSPEAKER.—V. V. Furduev. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2171–2174.)

It has been shown by various authors that in the case of an electrodynamic loudspeaker of the direct-acting diaphragm type the maximum efficiency is obtained when the masses of the radiating diaphragm and of the moving coil are equal. In the present paper a similar investigation is carried out for the horn-type loudspeaker, and an equation (7) is derived showing that in this case the mass of the radiating system should be somewhat *less than* the mass of the moving coil. It is suggested that in practice the two masses could be made equal, but a more detailed analysis is also given enabling the efficiencies of the loudspeaker at various frequencies to be computed for a given ratio of the masses.

1408. ON THE COIL-CENTERING DEVICE [Spider] OF A LOUDSPEAKER.—L. Rosenberg. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2175–2179.)

An efficient coil-centering device in an electrodynamic loudspeaker should satisfy the following conditions : (a) It should have an elastic constant of the right magnitude for the required natural frequency of the system. (b) This constant should be independent of the amplitude (Hooke's law). (c) This constant should not vary with time (absence of ageing). (d) Absence of internal friction. An account is here given of tests carried out, with respect to the above requirements, on a number of centering devices. Some of the experimental curves obtained are shown and the question of internal losses (mechanical hysteresis) is discussed in greater detail. The effect of these losses on the operation of a loudspeaker is also investigated.

1409. POLYMORPHISM OF ROCHELLE SALT [Curie Points regarded as Crystallographic Inversion Points : Dielectric Anomalies, Electro-Optical and Piezoelectric Effects, etc., discussed in Light of New Crystallographic Classification : Comparison with Symmetry Conditions in Ferromagnetic Crystals].—H. von R. Jaffe. (*Phys. Review*, 1st Jan. 1937, Series 2, Vol. 51, No. 1, pp. 43–47.)

1410. REPRODUCING EQUIPMENT FOR MOTION-PICTURE THEATRES.—M. C. Batsel & C. N. Reifsteck. (*RCA Review*, Jan. 1937, Vol. 1, No. 3, pp. 65–75.)

1411. ON PUBLIC ADDRESS SYSTEMS FOR OPEN SPACES.—L. Rosenberg & D. Weinstein. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2156–2161.)

The propagation of sound from horn-type loudspeakers is discussed, and theoretical considerations are compared with experimental data. A number of practical suggestions are given on the use of loudspeakers in open spaces.

1412. COLLABORATING WITH THE ARCHITECT [Loudspeaker System in Royal Empire Society's Building].—P. G. A. H. Voigt. (*Wireless World*, 5th Feb. 1937, Vol. 40, pp. 118–121.)

1413. THE EARLY HISTORY OF ACOUSTICS, *and* THE POSITION OF ACOUSTICS IN THE WHOLE FIELD OF PHYSICS AND ENGINEERING.—Schimank: Meyer & Waetzmann. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 500–508: pp. 508–512.)

1414. THE PHYSICAL FOUNDATIONS OF THE ACOUSTICS OF ROOMS.—L. Cremer. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 528–539.)

1415. ROOM ACOUSTICS FROM A GEOMETRICAL VIEWPOINT: THE USE OF SUPERSONIC-WAVE PHOTOGRAPHY [on Models, with 350 kc/s Waves and Illumination by 10^{-6} sec. Sparks: Examples of Valuable Information obtained].—F. M. Osswald. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 561–563.)

1416. ACOUSTICS OF THEATRES [Optical Exploration Technique and Its Application to Construction of Theatre].—Philips Company. (*Wireless World*, 5th Feb. 1937, Vol. 40, pp. 131–132.)

1417. SOUND-WAVE STROBOSCOPE [Photography of Sound or Seismic Waves, using Valve Control of Illuminating Spark: for Building Acoustics Research, etc.].—B. F. McNamee. (*Electronics*, Nov. 1936, Vol. 9, No. 11, pp. 24–26 and 34.)

1418. BROADCAST STUDIO DESIGN.—R. M. Morris & G. M. Nixon. (*RCA Review*, Oct. 1936, Vol. 1, No. 2, pp. 64–79.)

1419. REVERBERATION CONTROL [by Electrical Methods: as recently adopted at Poste Parisien Headquarters].—E. Aisberg. (*Wireless World*, 12th Feb. 1937, Vol. 40, pp. 148–150.)

1420. THE OPTIMUM REVERBERATION [Period of a Studio].—G. Békésy. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2094–2102.)

A report on investigations carried out over a number of years in Budapest to determine the optimum reverberation period of a studio. Use was made of large portable screens having a layer of cotton wool supported on a frame with wire netting and covered by impregnated cloth. By placing these screens at various angles to the source of sound the frequency characteristic of absorption could be altered. Experiments were made in a number of studios. Some of the reverberation curves so obtained are shown and the article ends with a brief description of studios designed on the basis of this investigation. One of the conclusions reached is that in the case of large studios of 2000 m³ and more the acoustic effect is not determined by the reverberation period alone.

1421. ON SOUND ABSORPTION BY RESONATORS OF A SPECIAL TYPE.—M. S. Antsyferov. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2118–2126.)

An investigation into the possibility of using special resonators for selective sound absorption. The resonators under examination consist of two large parallel discs mounted on a short cylindrical tube; in practice one of the discs can be omitted and the tube with the remaining disc mounted directly on a wall so that the resonator takes the shape of a mushroom. The theory of the resonator is given and methods are indicated for calculating its sound-absorption characteristic. Experiments have shown a good agreement with the theory, and the general conclusion is that these or similar resonators could be used for correcting the frequency characteristics of rooms.

1422. ON THE DISTRIBUTION OF SOUND-ABSORBING MATERIALS IN A RADIO STUDIO.—I. G. Dreisen. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2131–2144.) A theoretical investigation into the propagation of sound waves in a room, leading to a number of practical suggestions.

1423. A SIMPLIFIED METHOD FOR DETERMINING THE SOUND-INSULATION CONSTANTS OF MATERIALS.—Kelberg, Myasnikov & Statsenko. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2145–2146.) Using an apparatus similar to that used by Meyer & Berger but of much smaller dimensions.

1424. ON THE MEASUREMENT OF SOUND-ABSORPTION CONSTANTS OF MATERIALS BY THE REVERBERATION METHOD.—Yu. I. Schneider. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2147–2150.) The sound-absorption constant is derived by measuring the reverberation period of a room first empty, and then containing a sample of the material to be tested. An account is given of such measurements and the results obtained with various materials are discussed.

1425. ON THE MEASUREMENT OF SOUND ABSORPTION FOR VARIOUS ANGLES OF INCIDENCE OF SOUND.—L. G. Ipatov. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2151–2155.) A description of the apparatus developed in Moscow in which use is made of parabolic reflectors. Methods are indicated for calculating from these measurements the reverberation characteristic of the material.

1426. THE OPTIMUM FREQUENCY CHARACTERISTIC OF A SOUND-ABSORBING MATERIAL.—S. Ya. Lifschitz. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2127–2130.) A brief survey of the research work carried out by the author and other investigators to determine the requirements to be met by sound absorbing materials used in studios.

1427. THE ABSORPTION OF SOUND BY PLATES CAPABLE OF VIBRATION.—H. Lauffer. (*Hochf:tech. u. Elek:akus.*, Jan. 1937, Vol. 49, No. 1, pp. 9–20.)

In these experiments the plates were fixed some centimetres from and parallel to a wall or floor. § II. An electrodynamic tone pick-up was used to measure the velocity-amplitude as a function of frequency for various distances from the floor (Fig. 1, a–d), when the (cardboard) plate was excited by air oscillations in the room. The curves have the form of resonance curves with the resonance points in the low and medium audio-frequency range. The amplitude and resonance frequency are calculated and compared (Fig. 2; Table 1) with the experimental values: disagreements are ascribed to neglect of the natural elasticity of the plate in the calculations. The damping was measured by the time in which the oscillations die away (records in Fig. 3a; frequency variation in Fig. 4). § III. The acoustic absorption was determined by the reverberation method, in which the reverberation time of a room is measured with and without the absorbing material. The possibilities and limitations of the method are discussed; measured values of absorption of various kinds of plates under various conditions are shown in Figs. 6–10. The absorption curve is similar to the amplitude curve for low and medium frequencies. It rises again at high frequencies; this is ascribed to the porosity of the plate. The absorption can be much increased by filling the space between the plate and the floor with porous material (Fig. 10). Results of investigations of the velocity-amplitude in the space between the plate and the floor are shown in Figs. 11, a–c; it has a horizontal component (in addition to the vertical one) on which the presence of absorbing material has most effect. If a number of holes are made in the plate, it can no longer absorb energy by oscillating but acts as a porous sound absorber with absorption maxima at distances of uneven multiples of a quarter-wavelength from the floor (Fig. 14). The writer suggests that a combination of porous material with one which could oscillate would give a good absorbing material, independent of frequency.

1428. AN ASYMPTOTIC BEHAVIOUR OF FORCED PLATE VIBRATIONS AT HIGH FREQUENCIES [with Application to Transmission of Sound through Walls].—A. Schoch. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 582–584.)

1429. SOUND ABSORPTION IN GASES IN A KUNDT'S TUBE, ESPECIALLY AT PRESSURES BELOW ATMOSPHERIC: THE MOLECULAR COMPONENT OF THE ABSORPTION IN THE TUBE.—H. Oberst. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 580–582.)

1430. ON THE DISTRIBUTION OF SPEECH VOLTAGES IN THE TRANSMISSION OF A NUMBER OF CARRIER-FREQUENCY CONVERSATIONS.—D. Thierbach & H. Jacoby. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 553–557.)

The measured distribution function of the voltages of a single conversation is approximately represented by an exponential function, which is employed (using Probability laws) to give the required summation curves for a number of simultaneous conversations.

1431. UNIFORM LOADING OF LINES BY MAGNETIC COATING [using Permalloy Dust or Sendust Particles suspended in Shellac, etc.].—K. Tsukamoto. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 452–455.)

1432. CROSSTALK IN OPEN-WIRE TELEPHONE CIRCUITS AT CARRIER FREQUENCY, *and* THE RELATION BETWEEN THE MUTUAL INDUCTANCE AND QUAD PITCHES OF NON-LOADED CABLE PAIRS.—Negoro: Simizu & others. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 416–426: pp. 426–431.)

1433. CROSSTALK IN NON-LINEAR TRANSMISSION SYSTEMS.—Tischner. (*See* 1314.)

1434. A NEW METHOD OF MEASURING THE [Overall Transmission] LOSS/FREQUENCY CHARACTERISTICS OF A TELEPHONE CIRCUIT.—T. Yoshida & I. Inami. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 443–451.)

1435. A METHOD OF MEASURING MINUTE "KLIRR"-FACTORS [of Non-Linear Distortion] AND ITS ILLUSTRATIONS [Measurements on Permalloy Sheet and Dust-Core Coil].—K. Kobayashi & G. Hakata. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 438–443.)

1436. THE HARMONICS [in A.F. Non-Linear Distortion].—L. Boë. (*L'Onde Élec.*, Dec. 1936, Vol. 15, No. 180, pp. 785–803.)

"This study is based on the series development of the intensity i by means of the formulae 1 and 3. Its interest lies in the fact that the various coefficients $d_0 d_1 d_2 d_3$ . . . can be determined by means of the general formulae 5 and 6, and a simple graphical interpretation can be given of the results found. It is sufficient to have at one's disposal the I_a/V_a characteristics of a valve, and to know its charge impedance, in order to be able to construct its dynamic characteristic and thus to determine the essential factors of its functioning: modulated power, mean current, sensitivity, efficiency, and 2nd and 3rd harmonic distortion, etc. The graphical method must be used with caution and gives exact results only under certain conditions which we have indicated in the appropriate places. In general, distortion percentages of the order of 5–6% can be determined with good precision, and since from a musical point of view these values should not be exceeded, the range of usefulness of the method is sufficient." An exaggerated value should not be placed on the *absolute* figures obtained, since speech and music waves are not of simple sinusoidal form: the importance is rather for purposes of comparison.

1437. A SIMPLE METHOD FOR THE MEASUREMENT OF THE SELF-INDUCTANCE OF [Interstage or Output] TRANSFORMERS CARRYING DIRECT CURRENT.—Nowotny & Söchting. (*See* 1490.)

1438. ACOUSTIC MEASUREMENTS WITH THE "TONE METER" [Peak Voltage Meter with Logarithmic Scale] IN CONJUNCTION WITH THE "ATTENUATION RECORDER" [M.C. Instrument giving Curve traced by Spot of Light on Screen with After-Glow or on Gas-Light Paper].—H. G. Thilo. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 558–561.)

Primarily for contrast monitoring of broadcast transmissions but useful also for many other purposes (frequency characteristics, reverberation tests, etc.). For the Siemens & Halske "tone meter" *see* 3457 of 1936: the already very short time of the instrument is reduced from 100 to 50 msecs. by a choke coil connected in parallel.

1439. THE RELATION OF MODULATION PRODUCTS WITH MULTI-TONE SIGNAL TO HARMONIC DISTORTION WITH MONO-TONE SIGNAL IN AUDIO-AMPLIFIER ANALYSIS.—Ken-Rad Corporation. (*Electronics*, Oct. 1936, Vol. 9, No. 10, p. 52: notice of pamphlet.)

1440. THE HARMFULNESS OF NOISE IN THE LIGHT OF NEW RESEARCHES, *and* THE MODERN TECHNIQUE OF THE FIGHT AGAINST NOISE.—G. L. Navjagskij: V. S. Kasanskij. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2195–2199: pp. 2200–2205.)

1441. THE CHIEF CAUSES OF THE NOISES OF ELECTRICAL MACHINERY.—V. G. Springman. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2206–2210: with bibliography.)

1442. ON THE SENSITISING EFFECT OF SOUND EXCITATION ON THE ORGAN OF HEARING: *also* ON THE CHARACTERISTIC OF THE FUNCTIONAL CONDITION OF THE FATIGUED EAR: *and* THE TIME DEPENDENCE BETWEEN THE RESTORATION OF THE ORIGINAL EXCITATION CONDITION OF THE ORGAN OF HEARING AND THE PITCH OF THE INCIDENT NOTE.—Bronstein: Bronstein & Tschurilova. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2079–2081: 2082–2084: 2085–2087.)

1443. AN ANALYSIS OF THE EFFICIENCY OF THE AUDITORY MECHANISM FOR ALTERNATING CURRENTS OF SOUND FREQUENCY.—G. V. Gerschuni. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2088–2090.)

1444. ON THE LAW FOR MINIMAL DISCRIMINATION OF INTENSITIES, *and* ON THE PSYCHOPHYSICS OF HEARING: MONAURAL AND BINAURAL DIFFERENTIAL SENSITIVITY AND EXPOSURE-TIME.—Crozier & Holway: Upton & Holway. (*Proc. Nat. Acad. Sci.*, Jan. 1937, Vol. 23, No. 1, pp. 23–28: pp. 29–34.)

1445. ON SYMMETRY AND HEREDITY PROBLEMS OF THE HUMAN EAR.—E. Waetzmann. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 549–553.)

1446. ELECTRICAL STIMULATION OF THE HUMAN COCHLEA [Observations of "Phase Change Beat" confirm "Movement" Theory of Cochlea Excitation by A.F. Stimulation].—Hallpike & Hartridge. (*Nature*, 30th Jan. 1937, Vol. 139, p. 192.)

1447. PROGRESS IN THE PHYSIOLOGY OF HEARING.—G. von Békésy. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 522–528.)

1448. ON THE USE OF ELECTRO-ACOUSTIC EXERCISES IN CURING DEFECTIVE HEARING.—B. S. Preobrazhenski. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2091–2093.)

A brief survey of the results obtained in various medical institutions in the USSR with the apparatus developed by Prof. Skritski. In this apparatus the beat frequency between two h.f. oscillators is transmitted to the patient through headphones. Several hypotheses are put forward to explain the improvement in hearing obtained by this method.

1449. ON SOUND-EXCLUDING DEVICES.—A. S. Shapranova. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2188–2189.) A brief report on various devices for excluding unwanted sound from the ear, such as soft and solid wads, devices for covering the ear cavity, etc.

1450. QUESTIONS ON THE BOUNDARY BETWEEN PHYSICAL AND PHYSIOLOGICAL ACOUSTICS [Report on Modern Electrical Analysis of Sounds: Oscillograms of Onset of Sounds from Various Organ Stops, Speech, etc: Summary of Present Knowledge of Aural Acoustics].—F. Trendelenburg. (*Naturwiss.*, 22nd Jan. 1937, Vol. 25, No. 4, pp. 49–59.)

1451. CLINICAL ACOUSTICS [Oscillograms of Auscultation and Percussion Sounds, etc.].—A. Pierach. (*Naturwiss.*, 29th Jan. 1937, Vol. 25, No. 5, pp. 67–70.)

1452. NEW PROPERTIES OF THE THERMAL ELASTIC WAVES OF LIQUIDS [Experimental Determination of Existence of Radiation Pressure].—R. Lucas. (*Comptes Rendus*, 8th Feb. 1937, Vol. 204, No. 6, pp. 418–420.)

1453. ON SUPERSONIC SURFACE WAVES AND THEIR OPTICAL DEMONSTRATION.—H. Ludloff. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 518–522.)

"Supplementing the Schaefer-Bergmann researches [*see*, for example, 586 of February], an explanation and theoretical deduction will be given of the interference phenomena in reflected light found in those researches, on which a precision method for determining the elastic constants of opaque bodies can be built up."

1454. OPTICAL INVESTIGATIONS OF SUPERSONIC FIELDS IN LIQUIDS AND GLASSES.—E. Hiedemann & K. H. Hoesch. (*Zeitschr. f. Physik*, No. 3/4, Vol. 104, 1937, pp. 197–206.)

The amplitude distribution in supersonic fields is studied by an optical method similar to that used by Bär (585 of February) but using only one order of diffraction spectrum. Photographs are given showing the fine structure of various supersonic fields, including those radiated from oscillating piezo-quartz crystals. The method is compared with other known methods of studying supersonic fields. Favourable conditions for the excitation of flexural waves in glass are deduced from photographs.

1455. A VERY SIMPLE METHOD OF DEMONSTRATING SUPERSONIC WAVES IN LIQUIDS [Light passed through Standing-Wave System in a Direction Parallel to Wave-Fronts: Photographs].—L. Bergmann & H. J. Goehlich. (*Physik. Zeitschr.*, 1st Jan. 1937, Vol. 38, No. 1, pp. 9–13.)

1456. New Problems in the Field of Supersonics [including Use for determining Elastic Constants, for testing Materials, in Colloidal Chemistry, etc.].—L. Bergmann. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 512–518.)

1457. Chemical Action of Supersonic Waves, *and* The Influence of Supersonic Waves on the Development of Plants.—L. R. Solovjeva: O. Istomina & G. Ostrovsky. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2059–2064 : pp. 2065–2070.)

1458. A Special Magnetostriction Resonator and Experimental Investigation of 20 kc/s Under-Water Supersonic Carrier Telephone.—K. Aoyagi & K. Miyakoshi. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 384–391.)

1459. Depth-Sounding by Radio [with "Sono-Radio" Buoys automatically transmitting Reception of Explosion Wave].—(*Electronics*, Oct. 1936, Vol. 9, No. 10, pp. 20–21.)

1460. The Absorption of Supersonic Waves in Benzene [Measurements at Various Frequencies].—E. Baumgardt. (*Comptes Rendus*, 8th Feb. 1937, Vol. 204, No. 6, pp. 416–418.)

1461. On Infrasonic Measurements and the Theory of the Rotary Type of Infrasonic Radiator.—L. L. Myasnikov. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2049–2055.)

A theoretical investigation of the infrasonic field produced by a rotary radiator. The latter consisted of a rubber ball of 30 cm diameter attached to the periphery of a horizontal disc rotating with a speed of 15 to 20 r.p.s. Experiments were also carried out with a pulsating ball.

PHOTOTELEGRAPHY AND TELEVISION

1462. Partial Suppression of One Side-Band in Television Reception.—W. J. Poch & D. W. Epstein. (*Proc. Inst. Rad. Eng.*, Jan. 1937, Vol. 25, No. 1, Part 1, pp. 15–31.)

"No serious difficulties are encountered when a television system is operated with the carrier at one edge of the over-all selectivity curve. The necessity for fewer stages of amplification in the i.f. amplifier of the receiver makes it very desirable to adopt this system. In addition to this, if one side-band can be suppressed at the transmitter there will be a considerable saving in channel requirements."

1463. Methods of decreasing Fading in Radio-Photo Transmission by Amplitude Modulation.—T. Amishima & T. Nagata. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 502–505.)

(A). Existing a.v.c. methods are quite ineffective for selective fading. "By applying a method of fixing the average value of current level, regardless of light and shadow of pictures, transmitted during one revolution of the transmitter cylinder, the use of the rectified voltage of the l.f. output of the receiving set was made possible for volume control." (B). By rectifying the separated waves of the two side-bands and then combining the resulting currents. (C). Since dark lines on the received picture, caused by fading, have very little effect on the final result if they are only narrow, fading can be greatly decreased by interlaced or by multiple scanning.

1464. High-Frequency Utilisation of Telephone Cables [and the Construction of Coaxial and Symmetrical Cables for Television].—G. Wuckel. (*E.T.Z.*, 4th Feb. 1937, Vol. 58, No. 5, pp. 130–131 : summary only.)

1465. Equipment used in the Current RCA Television Field Tests [New York City Area].—R. R. Beal. (*RCA Review*, Jan. 1937, Vol. 1, No. 3, pp. 36–48.)

1466. Television Radio Relay [177 Mc/s Link between RCA Building and Empire State Building: Apparatus and Test Results].—B. Trevor & O. E. Dow. (*RCA Review*, Oct. 1936, Vol. 1, No. 2, pp. 35–46.) *See* also 3666 of 1936.

1467. Frequency Assignments for Television [Proposal of 42–90 Mc/s satisfactory as regards Propagation, Apparatus, and Distribution of Channels at Reasonable Distances].—E. W. Engstrom & C. M. Burrill. (*RCA Review*, Jan. 1937, Vol. 1, No. 3, pp. 88–93.) For Beverage's work, here referred to, *see* 1468.

1468. Some Notes on Ultra-High-Frequency Propagation.—Beverage. (*See* 1271.)

1469. The Electron-Optical Image Transformer.—W. Schaffernicht. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 596–604.)

Comprehensive survey, with special photographs of results obtained with the transformers due to Holst & colleagues (1934 Abstracts, p. 331: for later work—published since the present lecture was delivered—*see* 1045 of March), Heimann (1951 of 1935), Zworykin & Morton (2354 and 3144 of 1936), and the author himself (1949 of 1935). A paper by the author & Katz will shortly appear which will describe applications in the AEG laboratories: Figs. 16–19 show examples (visible and infra-red spectrum of Hg & Na lamps and carbon arc; absorption spectrum of various organic and inorganic materials in the range 0.8 to 1.2μ; and the comparison of an ordinary microphotograph of a wasp's leg and an infra-red version taken with the transformer). The work of von Ardenne (4123 *bis* of 1936) is also referred to.

1470. Secondary-Electron Multipliers [Survey, including the German P.O. "Netzverstärker" (Wire-Gauze-Electrode Electron Multipliers) and Their Use, giving 10^{10} Stable Amplification in Range 0–5 Mc/s].—G. Weiss. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 623–629.) *See* also 3496 of 1936.

1471. THE BAIRD ELECTRON CAMERA AND ELECTRON MULTIPLIER.—V. A. Jones. (*Television*, Sept. & Oct. 1936, Vol. 9, Nos. 103 & 104, pp. 487–490 and 568, 605.)

1472. ELECTRON OPTICS IN TELEVISION TECHNIQUE [Long Survey including Matter appearing only in Patent Specifications].—M. Knoll. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 604–617.)

1473. SURVEY OF THE DEVELOPMENT AND PRESENT POSITION OF TELEVISION, *and* PHYSICAL FOUNDATIONS, POSSIBILITIES AND LIMITS OF TELEVISION TRANSMISSION.—F. Banneitz: F. Schröter. (*Funktech. Monatshefte*, Nov. 1936, No. 11, Supp. pp. 81–83: pp. 83–87.) Summaries of the first two papers of the series on the whole field of Television, recently given in Berlin under the auspices of the VDE.

1474. TELEVISION: FUNDAMENTAL PRINCIPLES.—G. C. Marris. (*G.E.C. Journal*, Feb. 1937, Vol. 8, No. 1, pp. 78–91.) Future articles will elaborate theoretical and practical detail.

1475. THE OPTICAL FLATTENING OF THE CURVED SCREEN OF THE CATHODE-RAY TUBE [by the Attachment of Liquid Lens: Larger Pictures and Wider Viewing Angle obtained with Simple Means].—H. Boucke. (*Funktech. Monatshefte*, Nov. 1936, No. 11, pp. 435–436.)

1476. ON THE THEORY OF COLOURED CRYSTALS [and the Difference between the Thermal and Optical Work Function for the Freeing of Electrons from F-Centres].—D. Blochinzew. (*Physik. Zeitschr. der Sowjetunion*, No. 4, Vol. 10, 1936, pp. 431–441: in German.)

1477. CALCULATION OF THE ULTRA-VIOLET ABSORPTION FREQUENCIES OF THE ALKALI HALIDES.—T. Neugebauer. (*Zeitschr. f. Physik*, No. 3/4, Vol. 104, 1937, pp. 207–218.)

1478. THE EFFECT OF HYDROGEN ON THE TIME-LAG OF ARGON-FILLED PHOTOELECTRIC CELLS [Determination of Amount of Hydrogen required for Time-Lag Reduction: Use of Pirani Gauge for determining Small Proportion of Hydrogen in Argon].—N. R. Campbell & R. S. Rivlin. (*Proc. Phys. Soc.*, 1st Jan. 1937, Vol. 49, Part 1, No. 270, pp. 12–13.) Addition to work referred to in 4150 of 1936.

1479. THE ABSOLUTE PHOTOELECTRIC YIELDS OF Mg, Be AND Na [Measurements for Distilled Surfaces: Values of Work Function and Proportionality Constant: Fraction of Light absorbed by Electrons in Surface Potential Barrier].—M. M. Mann & L. A. DuBridge. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, pp. 120–124.)

1480. EXACT AND APPROXIMATE EXPRESSIONS FOR THE PERMEABILITY OF POTENTIAL BARRIERS TO LIGHT PARTICLES [Theoretical Discussion of Solutions of Schrödinger Equation].—R. P. Bell. (*Proc. Roy. Soc.*, Series A, 1st Jan. 1937, Vol. 158, No. 893, pp. 128–136.)

1481. ON THE NON-ASSOCIATION OF PHOTOCONDUCTIVITY WITH OPTICAL ABSORPTION IN NON-CONDUCTING CRYSTALS [Theory].—C. Zener. (*Phys. Review*, 1st Jan. 1937, Series 2, Vol. 51, No. 1, p. 64: abstract only.)

1482. CORRECTION TO [Calculations and Graphs in] "THE PHOTOELECTRIC EFFECT OF THE DEUTERON."—Breit, Stehn, & Condon. (*Phys. Review*, 1st Jan. 1937, Series 2, Vol. 51, No. 1, p. 56.) *See* 3514 of 1936.

1483. METHOD OF INCREASING THE LIGHT VARIATION OF A BRIGHT EMITTER TUBE, AND ITS APPLICATION TO PHOTOTELEGRAPHY [Use of Short Filament and Hydrogen as Cooling Gas].—S. Suzuki. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 407–409.)

1484. NEON LIGHT TUBES WITH LUMINOPHORES [Recent Developments]. — Rüttenauer. (*E.T.Z.*, 18th Feb. 1937, Vol. 58, No. 7, p. 178: summary only.)

1485. BROADENING OF THE GREEN RAY IN HIGH-PRESSURE MERCURY-VAPOUR ARCS [with Bearing on Its Use as a Source of Monochromatic Radiation].—L. Grillet. (*Comptes Rendus*, 8th Feb. 1937, Vol. 204, No. 6, pp. 426–429.)

MEASUREMENTS AND STANDARDS

1486. A NEW PIEZO-OSCILLATOR [with Specially Good Frequency-Stability: comprising a Voltage - Controlled Negative - Resistance (Pentode) Circuit and a Parallel Resonant Circuit specially coupled to a Quartz Resonator].—C. Borsarelli. (*Alta Frequenza*, Dec. 1936, Vol. 5, No. 12, pp. 763–772.)

By such a combination the current-resonance of the quartz resonator is converted into voltage resonance without change in frequency. Thus the resonant circuit, which includes the quartz-plate electrodes in series with L and C (Fig. 1), presents a sharp voltage resonance at a frequency practically coinciding with the series-resonance frequency of the quartz plate, giving extremely high stability. Fig. 5 shows the experimentally found variation in a 0.5 Mc/s frequency as the tuning capacity is varied within the range of possible oscillation: for a change of $\Delta C/C_0$ from -0.4 through zero to $+0.4$ the frequency variation ranges from about $+15$ to -10 c/s, while if $\Delta C/C_0$ passes from -0.1 to $+0.1$ the frequency variation ranges from about $+2.75$ to -3.5 c/s.

1487. THE TRANSVERSE CIRCULAR VIBRATION OF A HOLLOW QUARTZ CYLINDER [Theoretical Determination of Frequency: Agreement with Experimental Value].—N. Tsi-Zé. (*Comptes Rendus*, 25th Jan. 1937, Vol. 204, No. 4, pp. 226–228.) For the experimental determination *see* 4171 of 1936.

1488. A NEW PIEZOELECTRIC QUARTZ CRYSTAL HOLDER WITH THERMAL COMPENSATOR [for Use with Low-Temperature-Coefficient Crystals].—W. F. Diehl. (*RCA Review*, Oct. 1936, Vol. 1, No. 2, pp. 86–92.) The whole unit, with its heating coil and bimetallic thermal control, weighs only 12½ oz.

1489. A 20 TO 60 Mc/s OSCILLATOR [with Formerless Interchangeable Coils with New Method of Plugging-In suitable for Ultra-High Frequencies].—A. Binneweg, Jr. (*Electronics*, Oct. 1936, Vol. 9, No. 10, pp. 12–13 and 38.)

1490. A SIMPLE METHOD FOR THE MEASUREMENT OF THE SELF-INDUCTANCE OF D.C.-POLARISED TRANSFORMERS [Interstage or Output].—W. Nowotny & F. Söchting. (*Elektrot. u. Masch:bau*, No. 40, Vol. 54, 1936, pp. 473–474.)

Usual bridge methods are elaborate and only applicable with difficulty in the specially interesting case of large inductance and heavy d.c. component. The authors use 50 c/s current from the mains, and the transformer itself separates the d.c. and a.c. components, since the d.c. polarisation is effected on the secondary and the a.c. and voltage measurement on the primary, the polarising d.c. being proportioned to take the transformation ratio (measured or calculated) into account. An example is given of a 4 : 1 output transformer.

1491. "TABELLEN UND KURVEN ZUR BERECHNUNG DES MAGNETFELDES VON KREISZYLINDRISCHEN SPULEN" [Air-Core Coils: Book Review].—K. Foelsch. (*E.T.Z.*, 4th Feb. 1937, Vol. 58, No. 5, p. 144.)

1492. METHOD OF DETERMINING THE DEGREE OF MODULATION OF A DOUBLY-MODULATED OSCILLATION [from Dimensions of Trapezium Figure produced on Screen of Cathode-Ray Tube with Oscillation on Ordinate Plates and Modulating Low-Frequency Oscillation on Abscissa Plates].—Telefunken : H. E. Hollmann. (*Hochf:tech. u. Elek:akus.*, Jan. 1937, Vol. 49, No. 1, p. 34 : German Pat. 635 498 of 12.10.1934.)

1493. MEASURING THE TOTAL GAIN OF RECEIVERS BY THERMAL AGITATION NOISE.—Seki. (*See* 1328.)

1494. MEASURING TECHNIQUE IN THE MANUFACTURE OF BROADCAST RECEIVERS [Components and Finished Instruments].—E. Mittelmann. (*Elektrot. u. Masch:bau*, No. 45, Vol. 54, pp. 533–539.)

1495. HIGH-FREQUENCY AMMETERS [and the Measurement of Current in Aerials : the Use of Shielded Current Transformers, etc.].—D. Möhring & O. Zinke. (*Elektrot. u. Masch:bau*, No. 50, Vol. 54, 1936, p. 602 : summary only.)

1496. BRIDGE MEASUREMENTS WITH A VISUAL NULL INDICATOR [6E5 "Cathode-Ray" Tube].—(*Electronics*, Nov. 1936, Vol. 9, No. 11, p. 52.)

1497. ELECTRICAL MEASURING INSTRUMENTS, INDUSTRIAL AND SCIENTIFIC [Review of Progress].—Ockenden & Whipple. (*Journ. I.E.E.*, Feb. 1937, Vol. 80, No. 482, pp. 190–202.)

1498. SELF-CALIBRATING VALVE VOLTMETER [independent of Changing Valve Values] OF THE TRIPLETT ELEC. INST. COMPANY.—(*Electronics*, Oct. 1936, Vol. 9, No. 10, p. 69.)

1499. DIELECTRIC CONSTANTS OF SOLIDS AT HIGH FREQUENCIES AND THE INFLUENCE OF WATER OF CRYSTALLISATION ON DIELECTRIC CONSTANT [Measurements on Various Salts : Constancy of Change in Molecular Refractivity per Molecule of Water of Crystallisation].—E. F. Burton & L. G. Turnbull. (*Proc. Roy. Soc.*, Series A, 1st Jan. 1937, Vol. 158, No. 893, pp. 182–198.)

1500. ON THE HOMOGENEITY OF PHYSICAL FORMULAE AND THE FORMATION OF SYSTEMS OF UNITS.—Genillon : Roy. (*Rev. Gén. de l'Élec.*, 23rd Jan. 1937, Vol. 41, No. 4, pp. 99–106.)

1501. BRITISH STANDARD GRAPHICAL SYMBOLS FOR TELEPHONY, TELEGRAPHY, AND RADIO COMMUNICATION.—(*British Standards Institution*, Publication No. 530, Jan. 1937, 62 pp.)

1502. AEF REPORT NO. 32 ON TERMS IN OSCILLATION THEORY.—(*E.T.Z.*, 11th Feb. 1937, Vol. 58, No. 6, pp. 164–166 : to be continued.)

SUBSIDIARY APPARATUS AND MATERIALS

1503. A MAINS-DRIVEN DIRECT-CURRENT AMPLIFIER FOR THE CATHODE-RAY OSCILLOGRAPH.—von Ardenne. (*E.T.Z.*, 21st Jan. 1937, Vol. 58, No. 3, pp. 66–68.)

An earlier paper (1581 of 1936) dealt with oscillograph amplifiers with a uniform voltage amplification from 0.2 c/s to 2 Mc/s, and d.c. amplifiers were described in the author's book on the c-r oscillograph. The latter, however, were battery-driven, and the bibliography in Holzer's book on c-r oscillography in biology and medicine (1936) indicates the lack of designs of mains-driven d.c. amplifiers ; it also shows that existing d.c. amplifiers possess uniform amplification only up to about 500, or at most 2000, c/s. The author considers that to make full use of the c-r oscillograph this upper limit should be raised to 10 000 c/s. The mains-driven d.c. amplifier here described, using three stabilising gaseous-discharge tubes and two screen-grid valves, has a practically uniform amplification of 30 000 up to a frequency of 10 000 c/s. Careful screening is provided : without this, the amplification would begin to fall at about 1200 c/s, and the low limits of earlier d.c. amplifiers were probably due to lack of such screening.

1504. A DOUBLE-BEAM CATHODE-RAY TUBE.—von Ardenne. (*Electronics*, Oct. 1936, Vol. 9, No. 10, pp. 31–33.)

The two electron-gun systems are led out separately, so that the two curves can be adjusted to differing brightness (for separation of overlapping curves) or to the same brightness for different recording speeds ; also convenient for introducing time-scale markings. One diaphragm electrode of each gun system is of magnetic material, so that a slight final adjustment of the spot positions can be made by stroking a permanent magnet along the outside of the tube near these electrodes.

1505. DISCUSSION ON "EXPERIMENTAL VERIFICATION OF THE THEORY OF THE CATHODE-RAY OSCILLOGRAPH; AND THE INFLUENCE OF SCREEN POTENTIAL" [with Correction of Equation].—MacGregor-Morris & Hughes. (*Journ. I.E.E.*, Feb. 1937, Vol. 80, No. 482, pp. 228–229.) *See* 319 of January.

1506. THE OPTICAL FLATTENING OF THE CURVED SCREEN OF THE CATHODE-RAY TUBE.—Boucke. (*See* 1475.)

1507. THE COURSE OF DEVELOPMENT OF THE CATHODE-RAY TUBE [Survey].—Heimann. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 630–635.)

1508. FUNDAMENTALS AND DEVELOPMENT OF ELECTRON OPTICS, *also* SURVEY OF EXPERIMENTAL ELECTRON OPTICS AND ITS APPLICATION, *and* THE FUTURE TASKS OF THEORETICAL ELECTRON OPTICS.—Busch: Brüche: Scherzer. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 584–588: 588–593: 593–596.)

1509. ELECTRON MOTION [in an Electromagnetic Field] AS AN OPTICAL PROBLEM.—Glaser. (*Zeitschr f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 617–622.)

Application of Hamiltonian methods to the electron-optical case of rotation-symmetrical arrangements. "The appropriate refraction exponent is given, and with its help the Gaussian dioptric and the third-order image errors are developed. There are eight such errors." The writer refers to his own previous paper on image errors (303 of 1936) and also to papers by Scherzer (4195 of 1936) and by Funk (*Monatshefte f. Math. u. Phys.*, Vol. 43, 1936, p. 305), the latter worker employing Hamilton-Jakobi methods.

1510. THE ELECTRON-OPTICAL EXHIBITION AT THE SALZBRUNN "DEUTSCHER PHYSIKER- UND MATHEMATIKERTAG."—Brüche. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 17, 1936, pp. 622–623 and Plates.)

1511. THE IMPORTANCE OF ELECTRON OPTICS IN THE TECHNIQUE OF AMPLIFYING VALVES.—Rothe & Kleen. (*See* 1366.)

1512. FOCUSING CRITERIA FOR ELECTRONS IN SUPERIMPOSED ELECTRIC AND MAGNETIC FIELDS [with Measurement of *e/m* for Electrons].—A. E. Shaw. (*Phys. Review*, 1st Jan. 1937, Series 2, Vol. 51, No. 1, p. 58: abstract only.)

1513. ELECTRIC AND MAGNETIC FOCUSING IN MASS SPECTROSCOPY [Theory of Mass Spectrograph with Counterbalanced Electric and Magnetic Velocity Dispersions].—Dempster. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, pp. 67–69.)

1514. A METHOD FOR THE SIMULTANEOUS RECORDING OF TWO PHENOMENA WITH A SINGLE CATHODE-RAY TUBE.—Holzer & Schwarz: Garceau. (*Elektrot. u. Masch:bau*, No. 35, Vol. 54, 1936, pp. 409–411.)

Using a current "shunting points" device consisting of two screen-grid valves, suggested by Garceau (3203 of 1935) on account of their wide limits of variation of voltage amplification by changing the screen-grid potentials, but with increased sharpening of the switching process by the use of a square-topped control-voltage curve. The whole equipment is mains-driven.

1515. IMPULSE CIRCUITS FOR OBTAINING A TIME SEPARATION BETWEEN THE APPEARANCE OF POTENTIAL AT DIFFERENT POINTS IN A SYSTEM.—Snoddy, Trotter, Ham & Beams. (*Journ. Franklin Inst.*, Jan. 1937, Vol. 223, No. 1, pp. 55–76.)

Circuits for acceleration of ions to high speeds, giving time delays between two successive points of the system down to 2 or 3 $\times$ 10^{-8} sec. and operating at voltages above 100 kv. Discussion of possibilities and limitations of real and artificial transmission lines, spark gap lines, and discharge tube lines.

1516. CONSIDERATIONS ON THE RECORDING OF OSCILLOGRAPHIC CURVES AND SUGGESTIONS FOR THEIR IMPROVEMENT [Inaccuracies in Calculation due to Lack of Uniform Thickness and Intensity of Light- or Cathode-Ray Trace: the Use of Circuits giving Voltage or Current which is a First Derivative of the Recording Speed].—Alberti. (*E.T.Z.*, 4th Feb. 1937, Vol. 58, No. 5, pp. 121–123.)

1517. APPLICATIONS OF VISUAL-INDICATOR TYPE TUBES [as Cathode-Ray Oscillograph, etc.]—Waller. (*See* 1368.)

1518. THE PHOTOGRAPHIC RECORDING OF SHORT-TIME PROCESS [Controlled or Uncontrolled] WITH LOOP OSCILLOGRAPHS, BY THE USE OF A LIGHT-RAY LOCKING DEVICE.—Schnettker. (*E.T.Z.*, 28th Jan. 1937, Vol. 58, No. 4, pp. 95–96.) The light ray is kept away from the slit in front of the sensitised material by the action of a biasing current through the oscillograph loop; it is "unlocked," by the action of a triode, for a time regulated by a thyratron circuit.

1519. THE VACUUM CELL LUMINESCENCE MICROSCOPE AND ITS USE IN THE STUDY OF LUMINESCENT MATERIALS [for Fluorescent Screens: Magnifications of 100 (Photography) and 500 (Visual Observation) using Self-Illuminated Field: Some Results].—Gallup. (*RCA Review*, Oct. 1936, Vol. 1, No. 2, pp. 80–85.) One result is the proof of the need for wet grinding-together of the raw materials before firing.

1520. INFLUENCE OF TEMPERATURE OF URANIN SOLUTION ON THE FLUORESCENCE DECAY TIME.—Cram. (*Phys. Review*, 1st Jan. 1937, Series 2, Vol. 51, No. 1, p. 62: abstract only.)

1521. Phosphorescent Glasses. Influence of Crystallisation [of Zinc Borate with Various Luminescent Materials, on Duration and Character of Luminescence].—Curie. (*Comptes Rendus*, 1st Feb. 1937, Vol. 204, No. 5, pp. 352–353.)

1522. A Remarkable Fluorescence Phenomenon in Aqueous Diacetyl Solution [Appearance of Fluorescence a Short Time after Beginning of Irradiation by Ultra-Violet Light: Reversible Appearance and Disappearance of Phenomenon].—Kalle. (*Naturwiss.*, 22nd Jan. 1937, Vol. 25, No. 4, p. 61.)

1523. Analysis of the Linear Amplifier [Signal/Noise Ratio: Reduction of Natural Alpha-Particle Background in Ionisation Chamber].—Tatel. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, p. 146: abstract only.)

1524. A New Design of Manometer for Very Small Pressure Differences.—Röbbelen. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 18, 1937, pp. 11–14.) Further development of the special "flat capillary" construction dealt with in 2369 of 1936.

1525. A New Manometer for Low Gas Pressures, particularly between 10^{-3} and 10^{-5} mm [Glow Discharge in Magnetic Field].—Penning. (*Physica*, Feb. 1937, Vol. 4, No. 2, pp. 71–75: in German.)

1526. Electronic Tube Nomenclature being Studied.—American Standards Association. (*Elec. Engineering*, Feb. 1937, Vol. 56, No. 2, p. 284.)

1527. Tabulation of Vacuum, Gas-Filled, and Grid-Controlled Rectifiers for Industrial and Transmitting Purposes [Data from Eight American Manufacturers].—(*Electronics*, Oct. 1936, Vol. 9, No. 10, pp. 35–36.)

1528. A New Welder Tube [Type KU-676 Grid-Glow Tube passing 50–75 A for Average (over 30 Seconds) of 6.4 A].—Knowles, Lowry & Gessford. (*Electronics*, Nov. 1936, Vol. 9, No. 11, pp. 27–29.) Using the self-protecting cathode referred to in 1186 of 1936.

1529. Small Glass Mercury-Vapour Rectifiers with "Contraction" Ignition.—Micza. (*Elektrot. u. Masch:bau*, No. 6, Vol. 55, 1937, pp. 65–67.)

1530. Mercury-Pool Cathode Arc Single-Tube Inverter.—Watanabe & Aoyama. (*Journ. I.E.E. Japan*, Sept. 1936, pp. 983–990: English summary pp. 77–78.)

1531. The Use of Valves and Gas- or Vapour-Filled Discharge Tubes for the Control of Electrical Machines [Survey].—Sequenz. (*Elektrot. u. Masch:bau*, No. 40, Vol. 54, 1936, pp. 475–481.)

1532. An Improved High-Frequency Stroboscope and Its Application to Gas Discharges with Rapidly Alternating Fields.—Kern. (*Ann. der Physik*, Series 5, No. 2, Vol. 28, 1937, pp. 169–184.)

A phase-shifter is introduced into the circuit of the Kerr-cell stroboscope (Fig. 1); any section of the period of the high-frequency phenomena can then be observed. The afterglow of high-frequency discharges with very short afterglow duration can be studied by combining the stroboscope with a photometer (Figs. 2, 3). Curves of the variation of the light intensity and measurements of the time-constants of the afterglow of various discharges are given.

1533. The Far Ultra-Violet Spectrum emitted by Electrical Discharges in Air at Reduced Pressure.—Déchène. (*Comptes Rendus*, 25th Jan. 1937, Vol. 204, No. 4, pp. 249–251.)

1534. On the Relation between Electric Conduction and Space Charge in Steady Discharge through Gases.—Miyamoto. (*Journ. I.E.E. Japan*, Aug. 1936, pp. 905–909: English summary pp. 63–64.)

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1551. THE REMOVAL OF THE ION BEAM OF THE CYCLOTRON FROM THE MAGNET FIELD [Partial Refocusing by Additional Inhomogeneous Field].—Alvarez, McMillan, & Snell. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, pp. 148–149: abstract only.)

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1556. THE BEHAVIOUR OF THE SYNCHRONOUS IMPULSE-FIELD MOTOR TOWARDS FLUCTUATIONS OF MAINS VOLTAGE.—Wögerbauer. (*Elektrot. u. Masch:bau*, No. 49, Vol. 54, 1936, pp. 581–585.)

1557. THE VOLTAGE CONSTANCY OF STABILOVOLT TUBES UNDER LONG-PERIOD LOADS [Experimental Investigation of Optimum Working Conditions for Stabilisation of Direct Voltages: Effect of Surrounding Temperature, Normal Mains Variations, and Ageing of Tubes].—Gockel. (*Physik. Zeitschr.*, 15th Jan. 1937, Vol. 38, No. 2, pp. 65–67.)

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1559. D.C. RECORDING AMPLIFIER WITH REGULATING DEVICE CONTROLLED BY HIGH FREQUENCY.—Brandenburger. (*E.T.Z.*, 11th Feb. 1937, Vol. 58, No. 6, p. 156.) *See* also 1167 of 1936.

1560. A DOUBLE-ACTION ELECTRON [Hexode] RELAY.—Ghiron & Viti. (*See* 1315.)

1561. THE MICRO-GAP SWITCH [Separation 5/1000ths Inch for 250 Volts].—Thornton. (*Engineer*, 18th Dec. 1936, Vol. 162, p. 666.) Summary of I.E.E. paper.

1562. HIGHLY EFFICIENT MATERIALS FOR ELECTRICAL CONTACTS [Elmet Metal and Its Varieties].—Rollfinke. (*Elektrot. u. Masch:bau*, No. 3, Vol. 55, 1937, pp. 34–35.)

1563. DRY CELL RESISTANCES [with Chart].—Gray. (*Electronics*, Nov. 1936, Vol. 9 No. 11, pp. 35 & 36.)

1564. A NEW VECTOR-DIAGRAM SLIDE RULE.—Sayers. (*Distribution of Elec.*, Dec. 1936 Vol. 9, No. 103, pp. 2110–2111 and 2113.)

1565. A Machine for testing Enamelled Wire.—Staebner. (*Bell Lab. Record*, Nov. 1936, Vol. 15, No. 3, pp. 76–80.)

1566. Manufacture of Acetic Cellulose Insulated Wire.—Tukamoto & others. (*Nippon Elec. Comm. Engineering*, Sept. 1936, No. 4, pp. 366–368: summary only, in English.)

1567. Some Properties of Insulating Materials under High Frequencies [up to 10 Mc/s].—Ogawa. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 500–502.)

"Comparing the rupture voltage at 10^7 cycles with the rupture voltage at 50 cycles, the ratio was about 1/5 for organic insulating materials and about 1/8 for inorganic insulations. The cause for such a drop in dielectric strength at high frequency was the production of corona. . . . The rupture of insulation by the generation of heat from dielectric loss alone cannot be obtained unless the production of h.f. corona around the insulation is completely suppressed. These experiments are still being continued."

1568. "Herstellung und Verarbeitung von Kunstharzpressmassen" [Book Review: the Manufacture and Working of Artificial-Resin Plastics].—Brandenburger. (*Elektrot. u. Masch:bau*, No. 7, Vol. 55, 1937, p. 84.)

1569. Discussion of "Plastics for Use in Electrical Engineering."—Dunton & Caress. (*Journ. I.E.E.*, Feb. 1937, Vol. 80, No. 482, pp. 229–230.) *See* 703 of February.

1570. New Insulating Materials in the Cable Industry [Polyacrylate, Polyvinylchloride (Vinofol), Geaphane, Igelite, etc.]—Nowak & Hofmeier. (*E.T.Z.*, 4th Feb. 1937, Vol. 58, No. 5, pp. 131–132: summary only.)

1571. The Materials of Electrical Engineering [Conducting, Insulating, and Fixing: Survey, particularly from National Viewpoint].—Thum. (*E.T.Z.*, 4th Feb. 1937, Vol. 58, No. 5, pp. 133–136.)

1572. The Thermal Conductivity of Mica.—Kelberg. (*Journ. of Tech. Phys.* [in Russian], No. 11, Vol. 6, 1936, pp. 2013–2018.)

1573. Humidity [Simple Method of measuring Its Effect on Materials and Parts].—Snow. (*Electronics*, Oct. 1936, Vol. 9, No. 10, pp. 25–27.)

1574. Electrolytic Condensers and Their Manufacture.—Bücking. (*E.T.Z.*, 28th Jan. 1937, Vol. 58, No. 4, pp. 91–95.)

1575. The Definition of the "Curie Point" [Experimental Discussion].—Kussmann & Schultze. (*Physik. Zeitschr.*, 15th Jan. 1937, Vol. 38, No. 2, pp. 42–47.)

Authors' summary:—Exhaustive experiments on the magnetisation/temperature curves at very low field-strengths and comparison with resistance/temperature curves show that (1) the derivation of the magnetic Curie point from the maximum of the temperature coefficient of electrical resistance, much employed in recent literature, is untenable; (2) in the ideal case of absolute homogeneity, the Curie temperature is a sharply defined point and not a "Curie region," as it has recently been repeatedly described; (3) observations which seem to contradict these results are caused by variations of the concentration within very small regions of the sample under test (for example, crystal segregations).

1576. Standardisation in Incremental Magnetism.—Sims. (*Engineering*, 1st Jan. 1937, Vol. 143, pp. 24–26.)

1577. The Manufacture of Compressed Powdered Cores [and a Comparison between "Sendust" and "Stanelec"].—Sadakiyo & Aizawa. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 455–457.)

1578. Molybdenum Permalloy improves Loading Coils.—(*Bell Lab. Record*, Aug. 1936, Vol. 14, No. 12, p. 386.)

1579. Discussion on "The Variation of the Magnetic Properties of Ferromagnetic Laminae with Frequency" [and the Alternative Explanation based on Existence of Surface Layer of Low Permeability].—Dannatt. (*Journ. I.E.E.*, Feb. 1937, Vol. 80, No. 482, p. 231.) *See* 719 of February. For the explanation given by Peterson & Wrathall and quoted here by Reed *see* 1970 of 1936.

1580. Some Characteristics of the Magneto-Elastic [Magnetostriction and Wiedemann] Effects of Iron-Nickel Alloys.—Mihara. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 457–465.)

1581. The Velocity of Propagation of Magnetic Reversal [in Stretched and Twisted Nickel-Iron Alloys]. — Miroschnitschenko. (*Physik. Zeitschr. der Sowjetunion*, No. 4, Vol. 10, 1936, pp. 540–562: in German.)

1582. Ferromagnetic Anisotropy in Ni/Co/Fe Crystals at Various Temperatures [Measurements].—McKeehan. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, pp. 136–139.)

1583. The Paramagnetism of the Cu/Ni Alloys [Measurements at Various Temperatures].—Gustafsson. (*Ann. der Physik*, Series 5, No. 2, Vol. 28, 1937, pp. 121–131.) For experimental arrangement *see* 2822 of 1936.

1584. Automatic Recording of Magnetisation Curves [Apparatus: Various Hysteresis Curves].—Steinhaus & Schoen. (*Physik. Zeitschr.*, 1st Jan. 1937, Vol. 38, No. 1, pp. 1–5.)

1585. The Construction of [Large] Electro-Magnets.—Cotton: Dreyfus. (*Rev. Gén. de l'Elec.*, 2nd Jan. 1937, Vol. 41, No. 1, pp. 3–9.)

1586. Temperature Variation of the Abnormal Unidirectional Diamagnetism of Graphite Crystals.—Krishnan & Ganguli. (*Nature*, 23rd Jan. 1937, Vol. 139, pp. 155–156.)

1587. On the Foundations of the Theory of Lippmann Colour Photography: Experiments with Electric [Micro-] Waves.—Lindman. (*See* 1272.)

STATIONS, DESIGN AND OPERATION

1588. Ultra-Short-Wave Radio-Telephone Circuits.—Thorn & Mitchell. (*Inst. of P.O. Elec. Eng.*, Printed Paper No. 158, 26 pp.)

Including the Cardiff/Weston-super-Mare circuit, the Shetlands phonogram equipment, and the Shaftesbury/Guernsey circuit. One appendix deals with the design of array systems of horizontal elements; others with the theory of a voltage rectifier used for floating a battery on a variable load. A table of data of u.s.w. telephony circuits operated by other administrations is added.

1589. Ultra-Short-Wave Simultaneous Radio-Telephony with a Single-Tube Circuit.—Ohtaka & Hasegawa. (*See* 1325.)

1590. Ultra-Short Band, now being Considered for Addition to Practical Spectrum, is Already Crowded.—Craven. (*Sci. News Letter*, 19th Dec. 1936, Vol. 30, p. 397.)

1591. Partial Suppression of One Side-Band in Television Reception.—Poch & Epstein. (*See* 1462.)

1592. Should Broadcasting occur in the 500–550 kc/s Band?—Aiken. (*Electronics*, Oct. 1936, Vol. 9, No. 10, pp. 17–19 and 60.)

Suggested utilisation of channels now used as guard bands protecting "antiquated marine transmitting and receiving equipment."

1593. The Case for High Power [F.C.C. Arguments: Shall Clear Channels have 500 kW? etc.].—(*Electronics*, Nov. 1936, Vol. 9, No. 11, pp. 13–15.)

1594. Common Frequency Broadcasting [Investigations to determine Feasibility in Japan].—Kayano. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 489–490.)

1595. Engineering at NBC [National Broadcasting Company: Organisation and Personnel].—(*Electronics*, Nov. 1936, Vol. 9, No. 11, pp. 41–48.)

1596. Behind the Scenes at Two Notable Broadcasts [8th & 11th Nov. 1936, NBC's Tenth Anniversary Celebration Week].—McElrath: Milne. (*RCA Review*, Jan. 1937, Vol. 1, No. 3, pp. 94–110.) Streamline trains "Comet" (Boston/Providence) and "Flying Hamburger" (Germany), submarine, etc.: aeroplanes (Buffalo/Washington) to RCA Building and "Elettra" off Genoa.

1597. Harbour Radio-Telephone Service.—Byrnes. (*RCA Review*, Oct. 1936, Vol. 1, No. 2, pp. 47–52.)

1598. Acoustic Measurements with the "Tone Meter" in conjunction with the "Attenuation Recorder" [primarily for Contrast Monitoring].—Thilo. (*See* 1438.)

1599. Automatic Photoelectric Telegraph Transmitter and Receiver [Experimental Speeds of 12 000 Letters/Minute].—Matsumae & Sano. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 412–415.)

GENERAL PHYSICAL ARTICLES

1600. "Experimentelle Grundlagen der Wellenmechanik" [Book Review].—Flügge & Krebs. (*E.T.Z.*, 4th Feb. 1937, Vol. 58, No. 5, pp. 143–144.)

1601. The Limiting Electric Charge of Very Fine Particles.—Pauthenier & Martin. (*Comptes Rendus*, 25th Jan. 1937, Vol. 204, No. 4, pp. 239–240.)

1602. Positive Ion Mobilities in H_2 by the Townsend Deflection Method.—Hershey. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, pp. 146–147: abstract only.)

1603. The Effect of Mercury Vapour on the Townsend Coefficient α in Pure Nitrogen.—Bowls. (*Phys. Review*, 15th Jan. 1937, Series 2, Vol. 51, No. 2, p. 147: abstract only.)

1604. The Influence of Magnetic Field on Adsorption [Experimental Results for Adsorption of Various Salts by Charcoal and $BaSO_4$], *and* Adsorption Forces and Their Electrical Nature. III—On the Nature of the Forces of Wetting.—Bhatnagar, Kapur & Kapur: Iliin, Leontiew & Bragin. (*Phil. Mag.*, Feb. 1937, Series 7, Vol. 23, No. 153, pp. 256–264: pp. 294–301.)

MISCELLANEOUS

1605. On the Integration of Operators.—Birkhoff. (*Proc. Nat. Acad. Sci.*, Jan. 1937, Vol. 23, No. 1, pp. 11–13.)

1606. A Method for the Mapping of Physical Fields [*e.g.* Electrostatic or Magnetic] by means of Instruments effecting Conformal Transformations.—Roth: Barillon. (*Rev. Gén. de l'Élec.*, 14th Nov. 1936, Vol. 40, pp. 619–632.)

1607. French Imports and Exports of Electrical Material in 1936.—(*Rev. Gén. de l'Élec.*, 26th Dec. 1936, Vol. 40, pp. 831–836.)

1608. Care of Filmslides and Motion-Picture Films in Libraries.—Weber & Hill. (*Journ. of Res. of Nat. Bur. of Stds.*, Nov. 1936, Vol. 17, No. 5, pp. 753–860.) *See* also *ibid.*, Dec. 1936, pp. 871–881.

1609. I.E.E. Wireless Section: Chairman's Address [What is Wrong with the Training of Communications Engineers?]—Mallett. (*Journ. I.E.E.*, Feb. 1937, pp. 174–178.)

1610. The 13th Great German Radio Exhibition [Illustrated Account: Transmitting and Emitting Arrangements: New Output Valves: Broadcast Receivers with Methods of Improving Reproduction: Loudspeakers: Television].—Fuchs. (*Hochf:tech. u. Elek: akus.*, Jan. 1937, Vol. 49, No. 1, pp. 2–8.)

1611. "Telefunken" at the "Germany" Exhibition, Berlin, 1936: "Telefunken" at the 13th Great German Radio Exhibition, Berlin, 1936.—(*Telefunken-Zeit.*, 1st Nov. 1936, Vol. 17, No. 74, pp. 55–56: 56–59.)

1612. The Physical Society's Exhibition.—(*Wireless World*, 15th Jan. 1937, Vol. 40, pp. 60–62.) *See* also *Electrician*, 8th & 15th Jan. 1937, pp. 37–41, 67–70: to be concluded.

1613. "Telecommunications, Economics and Regulation" [Book Review].—Herring & Gross. (*P.O. Elec. Eng. Journ.*, Jan. 1937, Vol. 29, Part 4, p. 346.)

1614. "Les Communications Radioélectriques, Vol. 2" [Book Review].—de Bellescize. (*E.T.Z.*, 18th Feb. 1937, Vol. 58, No. 7, p. 191.) "The two volumes . . .give valuable guidance for the planning and estimation of new radio links." For *L'Onde Élec.* papers on which this book is presumably based *see* 891 of 1936.

1615. "Handbook of Engineering Fundamentals" [Book Review].—Eshbach (Edited by). (*Electronics*, Oct. 1936, Vol. 9, No. 10, p. 34.)

1616. "Nomogramme für die Funktechnik" [Book Review].—Nentwig. (*E.T.Z.*, 14th Jan. 1937, Vol. 58, No. 2, p. 63.)

1617. The National Physical Laboratory: Radio Department.—(*Engineering*, 18th & 25th Dec. 1936, Vol. 142, pp. 674–676 and 690–691.) Based on the N.P.L. Report.

1618. Three Decades of Radio.—Sarnoff. (*RCA Review*, Jan. 1937, Vol. 1, No. 3, pp. 5–18.) Lecture by the President of RCA.

1619. The New German Patent Law.—Wolff. (*Engineering*, 15th Jan. 1937, Vol. 143, pp. 76–78.)

1620. The "Specific Action" of Ultra-Short Wireless Waves.—Szymanowski: Curtis, Dickens & Evans. (*Nature*, 26th Dec. 1936, Vol. 138, pp. 1100–1101.) Comments on the paper referred to in 4299 of 1936, with replies by the writers.

1621. A High-Frequency Apparatus for Producing a Measured Heat Stimulus in Studies of Physiological Temperature Regulation.—Hemingway & Witts. (*Physics*, Aug. 1936, Vol. 7, No. 8, pp. 299–301.)

1622. Electric Impedance of Nerve [measured at Frequencies up to 2.5×10^6 c/s].—Cole & Curtis. (*Phys. Review*, 1st Dec. 1936, Series 2, Vol. 50, No. 11, pp. 1097–1098: abstract only.)

1623. A Theory of Electro-Kinetic Effects in Solution: Reaction between Ions and Polar Molecules.—Moelwyn-Hughes. (*Proc. Roy. Soc.*, Series A, 2nd Dec. 1936, Vol. 157, No. 892, pp. 667–679.)

1624. Ultra-Violet Radiation in the Reboul Effect.—Viktorin: Reboul. (*Journ. de Phys. et le Radium*, Nov. 1936, Vol. 7, No. 11, pp. 461–465.)

1625. Study of the [Very Absorbable] Ionising Radiations emitted by Electric Discharges in Air.—Déchène. (*Journ. de Phys. et le Radium*, Dec. 1936, Vol. 7, No. 12, pp. 533–544.)

1626. High-Frequency Conductivity of Biological Structures in the Wavelength Range 3–1400 m.—Rajewsky, Osken, & Schaefer. (*Naturwiss.*, 8th Jan. 1937, Vol. 25, No. 2, pp. 24–25.)

1627. Electron Tubes in Diathermy [Survey, including the Three "Schools of Thought" as to Action of Short and Ultra-Short-Waves].—(*Electronics*, Nov. 1936, Vol. 9, No. 11, pp. 16–19 and 58.)

1628. A Mains-Driven Direct-Current Amplifier for the Cathode-Ray Oscillograph [suitable for Electrocardiographs and Other Physiological Investigations].—von Ardenne. (*See* 1503.)

1629. Clinical Acoustics [Oscillograms of Auscultation and Percussion Sounds, etc.].—Pierach. (*Naturwiss.*, 29th Jan. 1937, pp. 67–70.)

1630. Note on the Permanent Interference affecting Lines of Telecommunication and due to the Electrical Influence of High-Tension Lines.—Loeb. (*Ann. des Postes, T. et T.*, Dec. 1936, Vol. 25, No. 12, pp. 1142–1154.)

1631. Mutual Impedance of Circuits with Return in a Horizontally Stratified Earth [Curves for Rapid Predetermination of Interference between Power and Telephone Lines, etc.].—Radley & Josephs. (*Journ. I.E.E.*, Jan. 1937, Vol. 80, No. 481, pp. 99–103.) Evaluation by the formulae obtained by Riordan & Sunde (Abstracts, 1933, p. 462) and by Josephs (1934, p. 339) is extremely tedious when the earth is not of uniform conductivity.

1632. Carrier Telephony: IV [Wide-Band Systems with Coaxial Line Conductors].—Little. (*P.O. Elec. Eng. Journ.*, Jan. 1937, Vol. 29, Part 4, pp. 329–334.) Last article of a series.

1633. Recent Developments in High-Frequency [Carrier-Current] Telephony for Electrical Generating Stations.—Kleebinder. (*Elektrot. u. Masch:bau*, No. 3, Vol. 55, 1937, pp. 25–31.)

1634. The Sell Air-Jet Bolometer applied to Tension Recording in Spinning.—Oertel: Sell. (*E.T.Z.*, 3rd Dec. 1936, Vol. 57, No. 49, p. 1416). Using an a.c. driven telephone diaphragm as the pump producing the jet. For Sell's work *see* 1934 Abstracts, p. 337.

1635. A Recording Instrument for the Measurement of Variations in the Cross-Section of Fine Wires.—Dahl & Kern. (*E.T.Z.*, 3rd Dec. 1936, Vol. 57, No. 49, pp. 1423–1425.)

Various previous methods are quoted and their defects mentioned. The present method is a purely resistance-measuring bridge process using special mercury contacts. Sell's bolometer-amplifier is used as recorder (*cf.* 1634, above).

1636. A Thermal Extensometer [Gap caused by Movement is gauged by adjusting Heating Current round Metallic Rod until Electrical Contact is made].—Polevoy. (*Tech. Phys. of USSR*, No. 11, Vol. 3, 1936, pp. 973–981 : in English.)

1637. Electric Micrometer [for Continuous Indication of Thickness of Metal Foils and Sheet : Depending on Transfer of H.F. Energy between Two Coils].—(*G.E.C. Journal*, Feb. 1937, Vol. 8, No. 1, p. 35.)

1638. New Developments in Ignitron Welding Control, *and* Sealed-Off Ignitrons for Welding Control.—Dawson : Packard & Hutchings. (*Elec. Engineering*, Dec. 1936, Vol. 55, pp. 1371–1378 : Jan. 1937, Vol. 56, pp. 37–40 and 66.)

1639. A New Welder Tube.—Knowles & others. (*See* 1528.)

1640. The Speaking Clock. Part I—Trunking and Facilities : Part II—The Clock Mechanism.—Magnusson : Speight & Gill. (*P.O. Elec. Eng. Journ.*, Jan. 1937, Vol. 29, Part 4, pp. 261–274.)

1641. On Auto-Regulation [Theoretical and Practical Treatment : Formulae for determining Stability Conditions for Thermocouple-, Photocell-, or Other Regulating Systems].—Kornilov. (*Automatics & Telemechanics* [in Russian], No. 4, 1936, pp. 7–38.)

1642. Cathode [-Ray] Selection [the Use of Cathode-Ray Devices for Remote Control Purposes : C-R Selectors and Their Circuits].—Goncharsky. (*Automatics & Telemechanics* [in Russian], No. 3, 1936, pp. 27–48.)

1643. The Protection of High-Power Transformers [Use of Aluminium-Filings Coherer to detect Incipient Faults].—Bogatenkoff-Stavraky. (*Bull. Soc. franç. des Elec.*, Dec. 1936, Vol. 6, No. 72, pp. 1171–1174.)

1644. Magnetic Detectors for Industrial Applications.—Edgar. (*Gen. Elec. Review*, Nov. 1936, Vol. 39, No. 11, pp. 559–562.)

1645. An Electromagnetic Metal Detector [for Concealed Weapons, etc.].—Luck & Young. (*RCA Review*, Oct. 1936, Vol. 1, No. 2, pp. 52–63.) *See* also 400 of 1936.

1646. A New Capacitive Method for the Conversion of Mechanical into Electrical Oscillations and *vice versa*.—Sell. (*See* 1385.)

1647. A Vibration Method of testing Turbine Rotors.—Miasnikov & Sokolov. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 6, 1936, pp. 2056–2058.)

1648. An Electromagnetic Vibrometer.—Kobayasi & Mori. (*Nippon Elec. Comm. Eng.*, Dec. 1936, pp. 381–384.)

1649. Measurement of Relative, Longitudinal, and Rotational Movements, as regards Magnitude and Direction, with the "Slip-Measuring Motor."—Schmeider. (*E.T.Z.*, 7th Jan. 1937, Vol. 58, No. 1, pp. 5–9.)

1650. Electrical Water-Level Control and Recording Equipment for Model of Cape Cod Canal [depending on Capacitances between Water Surface and Suspended Metal Plates].—Hazen. (*Elec. Engineering*, Feb. 1937, Vol. 56, No. 2, pp. 237–244.)

1651. A New Condenser Apparatus for Pressure Measurements.—Johansson. (*Ann. der Phys.*, Series 5, No. 8, Vol. 27, 1936, pp. 742–752.)

1652. Ballistic Investigations with a Recording Piezo-Quartz Pressure Meter [Rotating Photographic Film replaced by Use of Long Zig-Zag Time Base].—Sigrist & Meyer. (*Helvet. Phys. Acta*, Fasc. 8, Vol. 9, 1936, pp. 646–648 : in German.)

1653. Study of the Methods of Measurement of Explosive Pressures : Comparison of Results with Copper "Crushers" and with Piezo-Quartz.—Langevin. (*Journ. de Phys. et le Radium*, Nov. 1936, Vol. 7, No. 11, pp. 448–452.)

1654. The Determination of Young's Modulus by Flexural Vibration.—Grime & Eaton. (*Phil. Mag.*, Jan. 1937, Series 7, Vol. 23, No. 152, pp. 96–99.) *See* also 3744 of 1935.

1655. Electrical Methods for measuring Pressure [Survey, with Formulae corresponding to Various Methods : a Photoelectric Method].—Aristov. (*Automatics & Telemechanics* [in Russian], No. 4, 1936, pp. 55–70.)

1656. "Die Photoelemente und ihre Anwendung" [Part II—Technical Applications of Barrier-Layer Cells : Book Review].—Lange. (*E.T.Z.*, 24th Dec. 1936, Vol. 57, No. 52/53, p. 1523.) For Part I *see* 1655 of 1936.

1657. Phototube Traffic Recorders [neglecting Pedestrians].—(*Electronics*, Nov. 1936, Vol. 9, No. 11, p. 38.)

1658. A Universal [Portable] Photometer with Optical and Photoelectric Adjustment.—Voege. (*E.T.Z.*, 11th Feb. 1937, Vol. 58, No. 6, p. 156 : summary only.)

1659. Underground Exploration by Wireless Methods (Radio Prospecting).—Fritsch. (*Elektrot. u. Masch:bau*, No. 52, Vol. 54, 1936, pp. 621–625.) Capacity methods (single- and two-point) ; absorption method ; other methods ("$\lambda/4$," "reflection-and-diffraction," "propagation").

Some Recent Patents

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each. A Selection of abstracts from patents issued in the U.S.A. is also included, and these bear a seven-figure serial number.

TRANSMISSION CIRCUITS AND APPARATUS

454 902.—Oscillation generator in which the periodicity of the oscillations is of the same order as the transit time of the electrons from cathode to anode.

Standard Telephones and Cables (assignees of R. A. Heising). Convention date (U.S.A.), 25th April, 1935.

455 279.—Wired wireless carrier-wave system designed to afford reliable and secret intercommunication between subscribers.

Standard Telephones & Cables (assignees of L. Espenschied; W. H. Tidd; and E. I. Green). Convention date (U.S.A.), 26th May, 1934.

457 276.—Transmitter valve fitted with an automatic relay as a safeguard against the failure of the high-frequency supply.

Marconi's W. T. Co. and D. F. George. Application date 24th May, 1935.

RECEPTION CIRCUITS AND APPARATUS

454 435.—Valve circuit designed to give substantially uniform amplification over a definite band of frequencies with a sharp cut-off outside that band.

N. V. Philips' Co. Convention date (Germany) 12th June, 1934.

454 945.—Super-regenerative receiver in which a number of amplifying valves are quenched by the same local oscillator.

L. R. Merdler and Baird Television. Application dates 9th April and 5th July, 1935.

454 954.—Single side-band receiver of the frequency-changing type. *Marconi's W. T. Co. and F. M. G. Murphy. Application date 10th April, 1935.*

455 298.—Super-regenerative circuit based on the use of a pentode valve.

D. M. Johnstone and Baird Television. Application date 17th April, 1935.

455 649.—Wireless receiver designed to operate on the normal broadcast wavelengths and also on the 6-7-meter television band.

Marconi's W.T. Co. and A. A. Linsell. Application date 26th April, 1935.

457 116.—Single-knob tuning control combined with a wave-change switch.

K. H. Kerr. Application date 21st May, 1935.

457 773.—Intervalve transformer-coupling for handling a wide range of signal frequencies, such as are used in television.

Radio-Akt. D. S. Loewe. Convention date (Germany), 5th June, 1934.

457 827.—Amplifier with correcting network for offsetting any loss in gain with rise in frequency.

P. W. Williams; A. J. Brown; and Baird Television. Application date 7th June, 1935.

VALVES AND THERMIONICS

455 137.—Electron discharge device designed with electrodes widely spaced apart in order to increase sensitivity.

P. Schwerin; Electronic Devices; and H. C. Atkins. Application dates 14th January and 9th March, 1935.

455 499.—Construction of cathode-ray tube in which the high-potential leads are sealed into the bulb at the junction between the upper and lower glass portions.

Ferranti; and M. K. Taylor. Application date 16th April, 1935.

DIRECTIONAL WIRELESS

454 256.—Direction-finding system in which the required bearings are indicated visually by television.

Marconi's W.T. Co., R. J. Kemp and D. L. Plaistowe. Application date 27th March, 1935.

458 347.—Radio-navigational system in which the course flown by an aviator is determined by the time-interval between successive signals.

Telefunken Co. Convention date (Germany) 27th May, 1935.

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

454 618.—Double-diode detector circuit, particularly suitable for feeding a push-pull L.F. amplifier.

Magyar Wolframlampa Co. Convention date (Hungary) 23rd November, 1934.

454 903.—Tone control devices for use in wired wireless or broadcast relay systems.

G. A. Barden and Goodmans (Clerkenwell). Application date 17th January, 1936.

TELEVISION AND PHOTOTELEGRAPHY

454 383.—Scanning system designed to keep the derived signals in step with the average brightness of the picture to be televised.

T. M. C. Lance and Baird Television. Application date 29th March, 1935.

454 422.—Method of preparing a photo-sensitive electrode of the mosaic-cell type for cathode-ray television transmitters.

Marconi's W.T. Co. (assignees of L. E. Flory). Convention date (U.S.A.) 28th February, 1934.

454 486.—Eliminating spurious signals from a cathode-ray television transmitter of the mosaic-cell type.
W. S. Brown. Application date 1st February, 1935.

454 589.—Television scanning system utilising electro-optical cells of the kind in which the medium becomes bi-refringent when stressed electrically.
J. L. Baird and Baird Television. Application date, 4th April, 1935.

454 601.—Means for preventing the tailing effect due to decaying luminescence in the viewing screen of a cathode-ray television receiver.
J. C. Wilson. Application date 5th, 1935.

455 233.—Method of producing mosaic screens for cathode-ray television transmitters.
H. E. Holman. Application date 15th April, 1935.

455 237.—Cathode-ray tube with a cathode constructed so that the rate of emission varies over its surface.
J. C. Wilson and Baird Television. Application date 15th April, 1935.

455 479.—Safeguarding the fluorescent screen of a cathode-ray tube from damage by the scanning ray.
Fernseh, Akt. Convention date (Germany) 9th April, 1935.

455 899.—Method of preparing light-sensitive electrodes for photo-electric cells and for the mosaic-cell electrodes of cathode-ray tubes.
W. Heimann. Convention date (Germany) 20th May, 1935.

455 927.—Construction and disposition of the deflecting peaks in a cathode-ray tube.
Marconi's W.T. Co. (assignees of V. K. Zworykin). Convention date (U.S.A.) 28th April, 1934.

455 972.—System of interleaved scanning for television.
J. C. Wilson and Baird Television. Application date 30th April, 1935.

456 135.—Transmitting television signals in successive "trains" separated by intervals in which the amplitude of the carrier-wave drops to zero.
A. D. Blumlein and E. A. Nind. Application date 3rd April, 1935.

456 316.—Flat, metal photo-electric cathodes for television transmission.
W. Heimann. Convention date (Germany) 20th May, 1935.

456 582.—Method of "fading" from one studio to another when transmitting a television programme.
C. F. Chapter and Baird Television. Application date 11th May, 1935.

456 651.—Method of ensuring synchronisation for interlaced scanning in television.
M. Bowman-Manifold. Application date 9th April, 1935.

456 666.—Generating saw-toothed oscillations suitable for scanning in television.
G. R. Tingley; D. W. Pugh; and Baird Television. Application date 17th May, 1935.

457 129.—Circuits for separating or filtering out the synchronising impulses from received television signals.
G. R. Tingley and Baird Television. Application date 22nd May, 1935.

457 135.—Saw-toothed oscillation-generator particularly suitable for interlaced scanning in television.
Marconi's W.T. Co. (assignees of A. W. Vance). Convention date (U.S.A.) 23rd May, 1934.

457 493.—Amplifying the image by secondary emission in an electron-multiplier as used in television.
H. G. Lubszynski and J. E. Keyston. Application date 30th May, 1935.

2 037 166 and 2 037 167.—Transmitter and receiver for producing natural-colour effects in television.
H. E. Ives (assignor to Bell Telephone Laboratories Inc.).

SUBSIDIARY APPARATUS AND MATERIALS

454 973.—Enhancing the efficiency of electron emission, particularly in photo-electric cells, by a method of temperature control.
E. E. Wright and Baird Television. Application date 15th April, 1935.

455 489.—Arrangement of dry-plate rectifiers for modulating or demodulating carrier-frequencies.
Siemens and Halske A.G. Convention date (Germany) 8th June, 1935.

455 541.—Static-suppressor unit to be fitted to domestic labour-saving appliances.
C. D. Gwinn and Telegraph Condenser Co. Application date 20th January, 1936.

MISCELLANEOUS

453 500.—Piezo-electric crystal-oscillator mounted in a hermetically-sealed tube containing hydrogen gas.
Marconi's W.T. Co. and G. F. Brett. Application date 11th March, 1935.

454 061.—Wireless cabinet fitted with lamps for producing indirect illumination.
Etablissements Victor. Convention date (France) 12th December, 1934.

454 567.—Permanent-magnet alloy of aluminium, iron, nickel and cobalt, these being present in proportions representing a true chemical compound.
T. Hamilton-Adams. Application date 2nd April, 1935.

457 737.—Prospecting for hidden conducting masses by observing the standing-wave effects produced by reflected beams of modulated short-wave energy.
Telefunken Co. Convention date (Germany) 18th May, 1935.

2 048 517.—Thermionic valve in which a quartz crystal is used to convert variations in the strength of the electron stream into corresponding variations of light.
H. P. Pratt.