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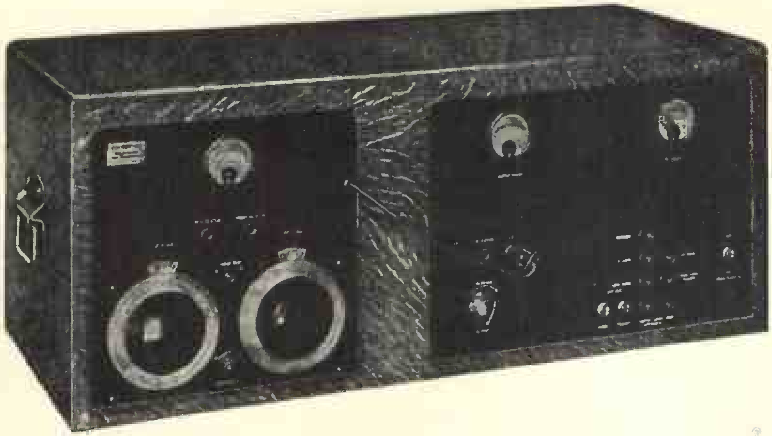

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A Journal of Radio Research & Progress

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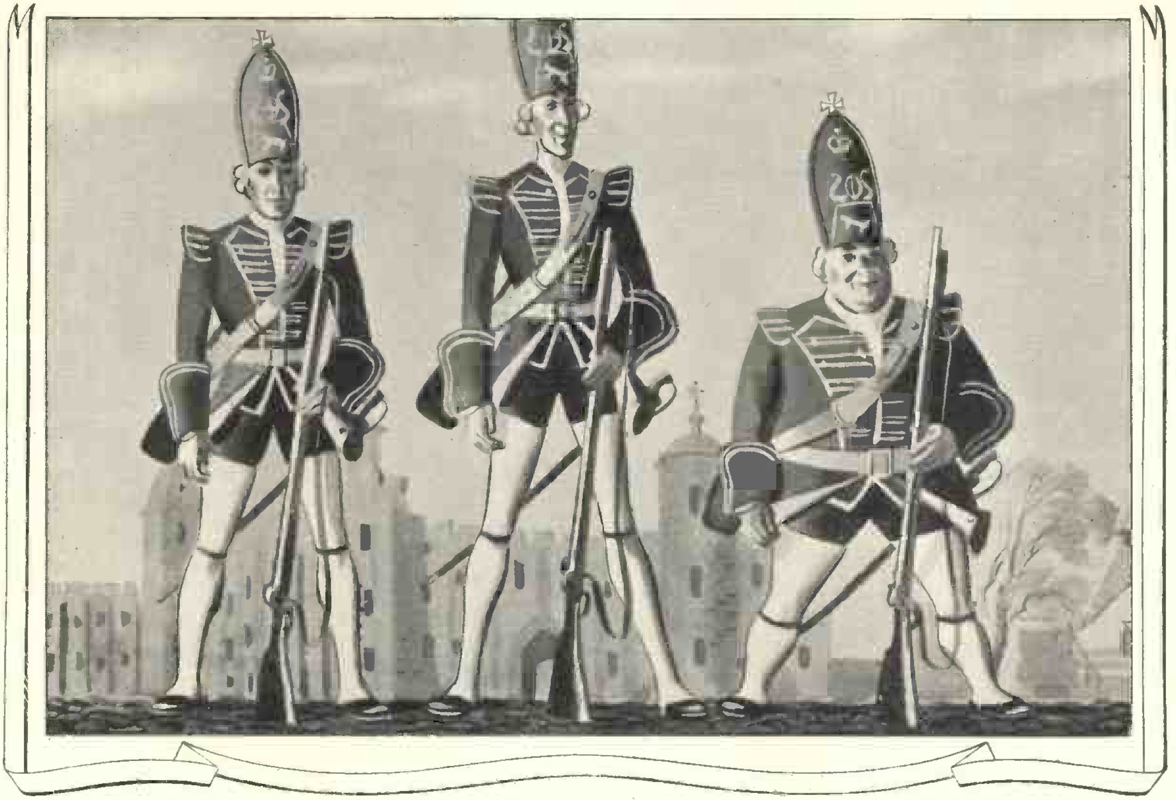

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THE

WIRELESS ENGINEER

VOL. XIII. NOVEMBER, 1936. No. 158

Editorial

Magnetron Oscillators

IN the July editorial we discussed the recent developments in the theory, construction and use of the magnetron as a generator of high-frequency currents. We feel compelled to return to the subject by a paper by G. R. Kilgore which was published in the August number of the *Proceedings of the Institute of Radio Engineers*. The author, who is in the Radiatron Division of the R.C.A. Manufacturing Co. of New Jersey, has been working at the subject for some years and had a paper on "Magnetostatic Oscillators" in the *Proceedings* in 1932. The present paper is confined to the generation of frequencies between 300 and 600 megacycles ($\lambda = 1$ metre to 0.5 metre) by means of the 2-section split-anode magnetron. There was for some years a tendency to concentrate on the production of ever higher frequencies, even although the power might be very small, but, as we pointed out in July, there has recently been a great deal of research directed to the development of greater power at a wavelength of about a metre, more especially since the introduction of the acorn type of valve has made it possible to design a receiver to work satisfactorily at these frequencies.

The author divides magnetrons into two classes. He defines those in which the frequency depends essentially on the electron-transit time as electron magnetrons, whereas those in which the frequency is controlled by the constants of the circuit he calls negative resistance magnetrons. In our opinion this nomenclature is not very fortunate, since in both cases the action is closely associated with the path of the electron and it is possible to regard the effect of transit time as equivalent to endowing the valve with a negative resistance. The former could be called transit-time magnetrons and the latter dynatron magnetrons, since the word dynatron is now well known as a designation for a valve with a static characteristic over a part of which the slope is negative.

The author throws considerable light on the action of this dynatron type of magnetron, not only metaphorically but also literally, for by introducing a little argon into a specially constructed magnetron the paths of the electrons were made visible and were photographed.

In the study of the static characteristics care must be taken to avoid oscillations occurring. If the two halves of the anode are maintained at the same potential, say 500 volts, the magnetic field can be increased until no current flows, all the emitted electrons returning to the filament. If now the potential of one half of the anode is increased while that of the other half is decreased by an equal amount, current begins to flow, but, strange to say, not to the anode sector at the higher potential, but to that at the lower. A decreasing voltage on this sector leads thus to an increasing current—the requisite for a negative differential resistance—and this goes on until the one voltage is three or four times the other. On a further increase in the voltage difference, the conditions change very rapidly, the currents becoming equal and then the larger current going to the anode sector at the higher potential. This latter portion of the characteristic is of no importance, since the magnetron can only operate as an oscillation generator over the negative resistance portion. When generating oscillations of 600 megacycles per second the electron stream switches over from the one half anode to the other 1,200 million times a second, always flowing predominatingly to the one which is momentarily at the lower potential.

The first of the figures which we reproduce from Kilgore's paper shows the electron path when the two sectors are at the same potential and the electrostatic field therefore approximately radial; the equipotential electric lines are concentric circles. The magnetic field is 1.5 times the critical value at which the electron only just missed striking the anode. In Fig. 2 the mean anode voltage is unchanged, but the upper section has three times the voltage of the lower. The path shown in Fig. 2 is that of an electron which leaves the cathode towards the middle of the more positive sector, whilst in Fig. 3 the electron is assumed to start off in the opposite direction. The magnetic field is without effect on a stationary electron and the force is proportional to the speed. In the immediate neighbourhood of the cathode, where the electrons are moving slowly, they will tend to move at right angles to the equipotential lines and thus to move off towards the more positive sector even if they were emitted in the opposite direction.

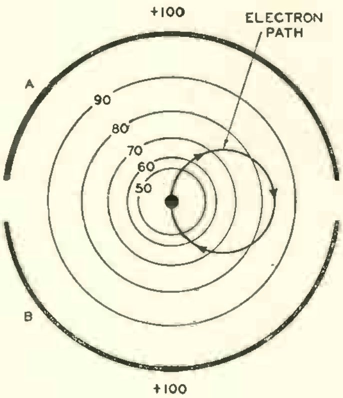

Fig. 1.

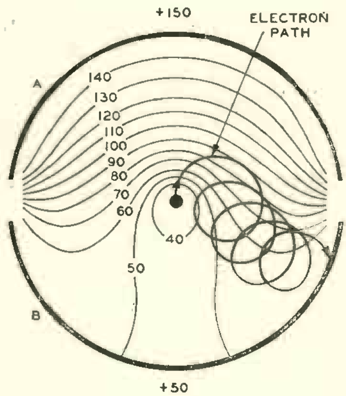

Fig. 2.

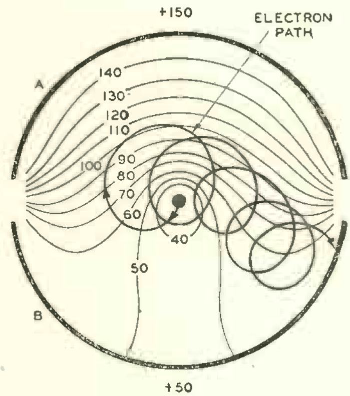

Fig. 3.

This is clearly indicated in Fig. 3. Fig. 4 is a reproduction from a photograph of the electron path in the special magnetron containing a little gas and having a special cathode with an emitting spot. This cathode could be rotated so that the electrons could be made to start in any direction. By coating the anode sectors with willemite the spot at which the electron stream impinged upon the anode could be made luminous. This photograph provides a very beautiful confirmation of the general correctness of

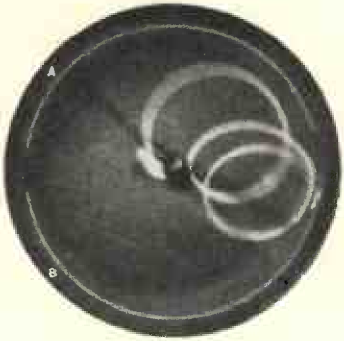

Fig. 4.

Figs. 2 and 3. In Fig. 4, the magnetic field was only 1.25 times the critical and the anode voltages were 300 and 250 volts. It must not be assumed that all the electrons reach the lower sector, but under suitable conditions the majority appear to do so. The potential distribution shown in Figs. 2 and 3 will be modified in practice by the space charge, which will limit the number of the emitted electrons which reach the anode.

The determination of the efficiency at frequencies of 300 to 600 megacycles is no easy matter and the author claims no greater accuracy than plus or minus 20 per cent. for the method finally adopted, which was that of absorbing the output power in a lamp filament which had been calibrated photometrically on direct current. The skin effect can be calculated and allowed for in determining the resistance, but this has no appreciable effect on the relation between the power and the luminosity.

Experiments showed that for a given frequency the efficiency increased (*a*) as the anode diameter was reduced, (*b*) as the anode voltage was increased and (*c*) as the magnetic field was increased. One of the principal factors which limits the efficiency is the transit time of the electrons expressed as a fraction of the period. As this increases the efficiency falls.

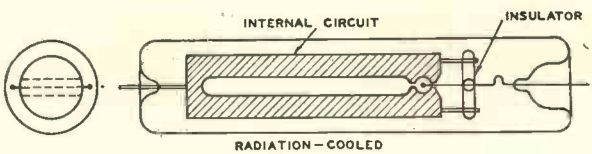

Fig. 5.

It is interesting to compare the magnetrons developed by Kilgore with those described in our July number. The problem is not an easy one. To get a high efficiency at these frequencies the anode diameter should not exceed 5 mm. for an anode voltage of 1,500. The axial length cannot exceed a few centimetres because of the difficulty of producing the magnetic field. When several hundred watts are supplied to a valve which has a maximum efficiency of 20 or 30 per cent., 70 to 80 per cent. of the input is dissipated at the anode and has to be got rid of. Figs. 5 and 6 show two magnetrons described by Kilgore. In both cases the anode sectors are semicircular grooves in large masses of good conducting metal which at the same time constitute the circuit around which the high frequency current flows. In Fig. 5 the metal is entirely within the valve and gets rid of the heat by radiation. The power is transferred to an external circuit by bringing the latter near the magnetron and thus coupling it by mutual inductance with the internal circuit. This magnetron had an output of about 50 watts at 550 megacycles, the efficiency being about 30 per cent. The magnetron shown in Fig. 6 is almost entirely of metal and is water-cooled. Here another method must be used to get the power out to the external circuit; this is done by means of two leads passing through the glass in addition to those connected to the cathode. This magnetron gives an output of about 100 watts at 600 megacycles with an efficiency of 25 per cent.

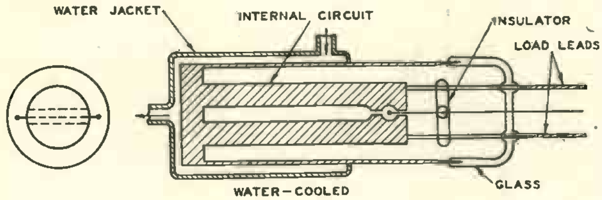

Fig. 6.

Kilgore mentions the phenomenon of filament bombardment to which we referred in July and the fact that it can so heat the filament that the valve will continue to oscillate with the normal filament heating circuit open. We suspect that the phenomenon causes the experimenter some anxious moments. The author is careful to point out that these specific tubes are to be regarded as laboratory models rather than commercial designs. They are certainly of great scientific interest and, like those which we described in July, mark a great advance in the generation of an appreciable amount of power at these very high frequencies. G. W. O. H.

An Apology

IN the July editorial we mentioned the researches on the magnetron carried out by Groszkowski and Ryzko and published in the *Proceedings of the Institute of Radio Engineers*. We regret that we referred to the authors as Russian and thus gave the impression that the work had been done in Russia. The authors are Poles and the researches were carried out at the State Institute of Telecommunications in Warsaw.

The Characteristics of Thermionic Rectifiers

By W. H. Aldous, B.Sc., D.I.C.

(Communication from the Research Staff of the M.O. Valve Co., Ltd., at the G.E.C. Research Laboratories, Wembley, England)

SUMMARY.—With the assumptions of infinite smoothing capacity and no emission limitation it is shown that a three halves power law characteristic leads to simple formulae which represent the anode wattage, output voltage, and peak current for thermionic rectifiers in terms of the input voltage and output current with an error of less than one per cent. over the normal working range.

Introduction

MOST published work on small thermionic rectifiers covers their use in circuits, and for this purpose some ideal form for the rectifier D.C. characteristic is assumed, and relations between the D.C. output, A.C. input, and circuit capacity and resistance obtained. From the point of view of the valve itself, however, the two things which influence the design are the wattage dissipated at the anode, and the peak current that is required from the cathode. These should be expressible in terms of the input A.C. voltage and the output D.C. current, which are the two independent variables that are most easily measured, together with some easily determinable constant of the rectifier.

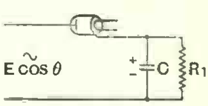

Fig. 1.—*Basic single phase half-wave rectifier circuit.*

The necessary calculations are relatively simple if a linear law is assumed for the anode current v anode voltage relation on the positive side[1], but a difficulty usually arises in practice in determining the most suitable straight line to take to represent the curved characteristic. In actual practice a three halves power law much more closely represents this characteristic, as would be expected from space charge relations. The calculations for this case have been carried out by Fortescue[2], but the results of the integrations concerned are given only as graphs, in which neither ordinates nor abscissae represent direct functions of a single variable. The present derivation gives the results in a much more readily useable form.

[1] *W.E. and E.W.*, 8, 522, 1931.
[2] *Proc. Phys. Soc.*, 39, 313, 1927.

Single Phase Half-Wave Circuit

The basic circuit considered (Fig. 1) consists of a rectifier feeding a parallel combination of capacity and resistance. If the capacity of the condenser is assumed to be infinite, no fluctuation of the D.C. voltage developed across it will occur. With an input represented by the cosinusoidal wave $E \cos \theta$ (Fig. 2) the constant D.C. output voltage across the condenser will be given by $V = E \cos \alpha$.

Let the rectifier static characteristic be given by

$$i = Kv^{3/2} \qquad \ldots \quad \ldots \quad \ldots \quad (1)$$

where i = anode current
v = anode voltage
K = constant.

Since anode current will flow only when the input voltage is greater than the condenser voltage, and will depend on the

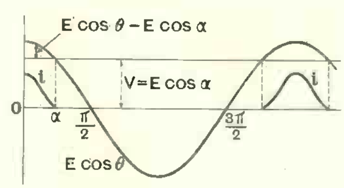

Fig. 2.—*Time variation of voltage and current.*

difference between these two voltages, the mean anode current over the whole cycle is given by

$$I = \frac{1}{\pi}\int_0^{\alpha} K(E\cos\theta - E\cos\alpha)^{3/2}\, d\theta \quad (2)$$

The mean anode wattage is given by

$$W = \frac{1}{\pi}\int_0^{\alpha} K(E\cos\theta - E\cos\alpha)^{5/2}\,d\theta \quad \ldots \quad (3)$$

The peak current is given by

$$I_{\max.} = K(E - E\cos\alpha)^{3/2} \quad \ldots \quad \ldots \quad (4)$$

For the evaluation of I and W, the integral is required of the expression

$$P = \int_0^{\alpha} (\cos\theta - \cos\alpha)^{n+1/2}\,d\theta \quad \ldots \quad (5)$$

where n is either 1 or 2.

Putting $\sin\frac{\alpha}{2} = k$ this becomes

$$P = \int_0^{2\sin^{-1}k}\left(2k^2 - 2\sin^2\frac{\theta}{2}\right)^{n+1/2} d\theta \quad \ldots \quad (6)$$

If now we let $\sin\frac{\theta}{2} = k\sin\phi$

so that $\cos\frac{\theta}{2}\frac{d\theta}{2} = k\cos\phi d\phi$.

Equation (6) takes the form

$$P = 2^{n+3/2}\int_0^{\pi/2}\frac{[(1-k^2\sin^2\phi) - (1-k^2)]^{n+1}}{(1-k^2\sin^2\phi)^{1/2}}\,d\phi$$

By means of the reduction formula

$$\int(1 - k^2\sin^2\phi)^{m+1/2}\,d\phi$$
$$= \frac{k^2}{2m+1}(1-k^2\sin^2\phi)^{m-1/2}\sin\phi\cos\phi$$
$$- \frac{2m}{2m+1}(k^2-2)\int(1-k^2\sin^2\phi)^{m-1/2}\,d\phi$$
$$+ \frac{2m-1}{2m+1}(k^2-1)\int(1-k^2\sin^2\phi)^{m-3/2}\,d\phi \quad \ldots \quad \ldots \quad (7)$$

the required integrals may be set in terms of the complete elliptic integrals of the first and second kinds denoted by

$$E_1 = \int_0^{\pi/2}(1 - k^2\sin^2\phi)^{1/2}\,d\phi$$

$$F_1 = \int_0^{\pi/2}(1 - k^2\sin^2\phi)^{-1/2}\,d\phi$$

respectively, giving

$$\int_0^{\alpha}(\cos\theta - \cos\alpha)^{3/2}d\theta = \frac{4\sqrt{2}}{3}[(-2 + 4k^2)E_1 + (2 - 5k^2 + 3k^4)F_1] \quad \ldots \quad (8)$$

$$\int_0^{\alpha}(\cos\theta - \cos\alpha)^{5/2}d\theta = \frac{8\sqrt{2}}{15}[(8-23k^2+23k^4)E_1 + (-8+27k^2-34k^4+15k^6)F_1] \quad \ldots \quad (9)$$

The values of E_1 and F_1 may be obtained from tables, and thence I and W computed accurately for any given value of k.

If, however, E_1 and F_1 are expanded and integrated term by term, substitution of the series so obtained in equations (8) and (9), leads to the expressions

$$\int_0^{\alpha}(\cos\theta - \cos\alpha)^{3/2}d\theta = \frac{3\sqrt{2}}{4}\pi k^4 + \frac{\sqrt{2}}{16}\pi k^6 + \ldots \quad \ldots \quad \ldots \quad (10)$$

$$\int_0^{\alpha}(\cos\theta - \cos\alpha)^{5/2}d\theta = \frac{5\sqrt{2}}{4}\pi k^6 + \frac{5\sqrt{2}}{64}\pi k^8 + \ldots \quad \ldots \quad \ldots \quad (11)$$

The error caused by neglecting the second terms in these two expressions is quite small. For example, at $\alpha = 45°$ i.e., $k = 0.38$, which is rather larger than any angle likely to occur in practice, the contributions of the second term in the two expressions are 1.3 per cent. and 1.0 per cent. respectively.

Therefore, combining equations (2) and (10) we have

$$k^4 = \frac{4}{3\sqrt{2}}\frac{I}{KE^{3/2}} \quad \ldots \quad \ldots \quad (12)$$

whence, from equation (11)

$$\int_0^{\alpha}(\cos\theta - \cos\alpha)^{5/2}d\theta = \frac{5\sqrt{2}}{4}\pi\left[\frac{4}{3\sqrt{2}}\cdot\frac{I}{KE^{3/2}}\right]^{3/2} \quad \ldots \quad \ldots \quad (13)$$

giving, from equation (3)

$$W = 1.62\, K^{-1/2}E^{1/4}I^{3/2} \quad \ldots \quad (14)$$

Also since

$$V = E\cos\alpha = E(1 - 2k^2)$$

$$E - V = 1.94\, K^{-1/2}E^{1/4}I^{1/2} \quad \ldots \quad (15)$$

and from (4) $I_{\max.} = KE^{3/2}\,.\,2\sqrt{2}k^3$

$$= 2.71\, K^{1/4}E^{3/8}I^{3/4} \quad \ldots \quad (16)$$

From (14) and (15) we may obtain the anode wattage in a form independent of the rectifier constant K.

$$W = 0.83\,(E - V)I \quad \ldots \quad \ldots \quad (17)$$

Biphase Half-Wave Circuit

This will differ from the single phase case only in that there are two conduction periods per cycle. The equations corresponding to (2) and (3) are

$$I = \frac{2}{\pi}\int_0^{a} K(E\cos\theta - E\cos a)^{3/2}\,d\theta \quad \ldots \quad (18)$$

$$W = \frac{2}{\pi}\int_0^{a} K(E\cos\theta - E\cos a)^{5/2}\,d\theta \quad \ldots \quad (19)$$

whilst equation (4) is unchanged.

It therefore follows that k^4 has half of its value in equation (12). Since W, $E - V$, and $I_{max.}$ are proportional to k^2, k^2, and k^3 respectively, they must be reduced to $(\frac{1}{2})^{\frac{1}{2}}$, $(\frac{1}{2})^{\frac{1}{2}}$, and $(\frac{1}{2})^{\frac{3}{4}}$ of their values in equations (14), (15) and (16), giving

$$W = 1.14\, K^{-1/2} E^{1/4} I^{3/2} \quad \ldots \quad (20)$$

$$E - V = 1.37\, K^{-1/2} E^{1/4} I^{1/2} \quad \ldots \quad (21)$$

$$I_{max.} = 1.61\, K^{1/4} E^{3/8} I^{3/4} \quad \ldots \quad (22)$$

It should be noted that in this case, K is the constant in the current voltage relation for one anode taken alone.

Practical Application

The equations (14) to (16) for the single phase case and (20) to (22) for the biphase case represent extremely useful new relationships for the design of thermionic rectifiers. The constant K for any design may be obtained either by calculation using exact formulae for cylindrical or plane parallel electrodes[1] and approximate formulae for filamentary cathodes[2], or by actual measurement. Calculation of the anode wattage and peak anode current then enables the valve to be designed with the correct anode radiating area and filament emission.

The equations (14) and (15) have been checked experimentally for a particular single phase half wave rectifier, the results being shown in Fig. 3. The anode wattage was determined by measuring the anode temperature under running conditions by means of a thermocouple attached to the anode, a preliminary calibration under D.C. conditions showing the relationship between temperature and wattage.

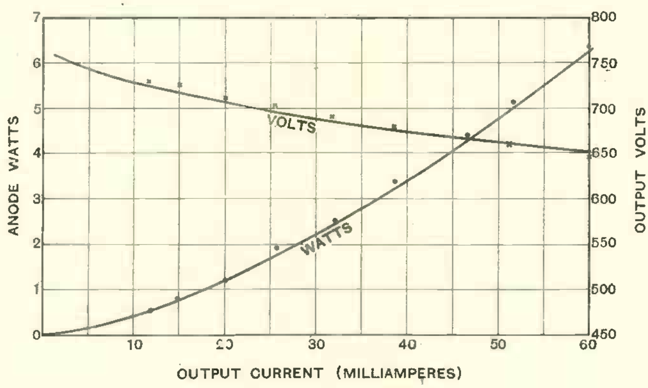

Fig. 3.—*Results of check on equations for anode wattage and output voltage. Points are measured values. Full lines are calculated from formulae.*

The table shows the constant K and the calculated wattage and peak current for selected samples from the range of Marconi and Osram rectifiers when run under their maximum conditions in biphase half-wave circuits.

Limitations of Equations

The initial assumptions in the derivation of the above equations were that unlimited emission was available, no resistance or inductance existed in the supply, and infinite smoothing capacity was used across the load. If these assumptions are departed from, the equations for the mean output current and anode wattage corresponding to (2) and (3) become very complicated, and in general can only be solved by graphical or numerical methods, and are unlikely to lead to definite formulae such as have been

Valve	K amps/(volts)$^{3/2}$	$E/\sqrt{2}$ Volts	I amps.	W Watts	$I_{max.}$ amps.
U.10	4.2×10^{-4}	250	0.06	3.6	0.25
U.12	2.7×10^{-4}	350	0.12	13.6	0.42
U.14	2.7×10^{-4}	500	0.12	14.9	0.49
MU.12	5.2×10^{-4}	350	0.12	9.8	0.49
MU.14	5.2×10^{-4}	500	0.12	10.7	0.58
U.30	6.2×10^{-4}	250	0.12	8.2	0.46

[1] Langmuir & Compton, *Rev. Mod. Phys.*, 3, 191, April 1931.

[2] Y. Kusunose, *Proc.* IRE. 17, 1706, Oct. 1929.

obtained for the simpler case. Only a general discussion of the effects on the anode wattage, peak current and output voltage of departure from the initial assumptions can, therefore, be attempted. This discussion is on the basis of a constant output current, which can easily be effected by adjustment of the load resistance.

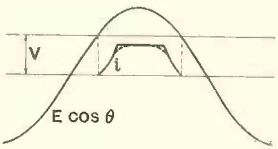

Fig. 4.—*Current wave form with limited emission.*

(a) *Emission Limitation*

With a sharply defined total emission available, the form of the current v time curve will be as shown by the solid line in Fig. 4. This will be approximately the case for a tungsten filament rectifier. With an oxide-coated cathode, which has not such a definite saturation value for the emission, the dotted line will represent the working conditions more closely. The general effect of this form of curve is that the rectifier behaves approximately like one having unlimited emission but with a smaller value for K. The anode wattage will, therefore, be higher, the output voltage lower, and the peak current lower than with no emission limitation.

(b) *Resistance of the supply*

During the conducting part of the cycle the rectifier behaves as a non-linear resistance to the flow of current. The effect of adding resistance in the supply is, therefore, approximately equivalent to reducing the value of K, which can be regarded as the non-linear conductance of the rectifier. The peak current and output voltage will, therefore, be decreased, whilst the total wattage is increased. This total wattage is shared between the rectifier and the added resistance. Since, however, from (14), a given percentage reduction in K only produces one-half that percentage increase in wattage, the effect is to produce a reduction of wattage in the rectifier itself.

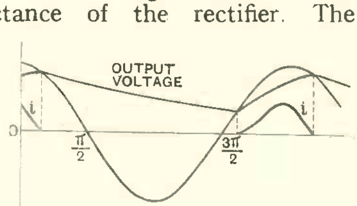

Fig. 5.—*Time variation of voltage and current with finite smoothing capacity.*

(c) *Inductance of the supply*

This will delay both the rise and fall of anode current. The full difference between the input voltage and the steady condenser voltage will not be applied to the valve, and the anode current will flow for a longer time. Both the output voltage and peak current will, therefore, be reduced. With lower anode voltage, but with a longer conduction period, it is not easy to determine whether the anode wattage will be increased or decreased. Practical experience, however, shows that the presence of inductance in series with the rectifier gives a considerable decrease in the anode wattage for the same output current.

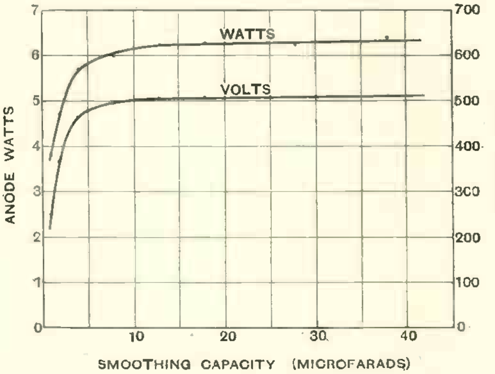

Fig. 6.—*Results of test on variation of anode wattage and output voltage with smoothing capacity.*

(d) *Finite smoothing capacity*

The effect of not using infinite smoothing capacity is to allow a fluctuation of the output voltage, which will rise during the conducting part of the cycle and fall during the non-conducting part (Fig. 5). The relationships between output voltage, conduction period and value of capacity, have been worked out for the case of a rectifier with a linear current v, voltage law by Marique[1], and the results will apply qualitatively to the present case. It follows that reduction in smoothing capacity with constant mean output current

[1] *W.E. & E W.*, 12.17.1935.

will reduce the output voltage and, by virtue of the longer conduction period, will reduce the peak current. For this case again, it is difficult to predict the effect on the anode wattage, but practical experience shows that a reduction occurs. Fig. 6 demonstrates this for a particular single phase half-wave rectifier working with 450 volts A.C. input and 60 mA mean D.C. output current.

These considerations show that the equations derived for wattage and peak current give the maximum values which should occur in practice, and for which the rectifier should be designed.

Care should be taken in applying equation (17) in practice, especially to published output *v.* input curves of rectifiers. These are usually taken under conditions involving some resistance and inductance in the supply, and also a finite value of smoothing capacity, which will tend to depress the available output voltage. The use of this voltage value in (17) would give a fictitiously high value to the calculated wattage.

In conclusion, the author desires to tender his acknowledgments to The General Electric Company and the Marconiphone Company, on whose behalf the work was done which has led to this publication.

Service Equipment

PERHAPS the most generally useful of the series of testing instruments recently introduced by Pye Radio for the benefit of agents and their service engineers is the "All-Wave Trimeasy Signal Generator." This modulated oscillator covers a wave range of from 12–3,000 metres (25 Mc/s–100 kc/s) in five steps controllable by a switch, and thus covers all the requirements of service men dealing with broadcast receivers. An attenuator calibrated in decibels controls the radio-frequency output, which ranges from below 1 microvolt to about 0.1 volt. The output is modulated to a depth of 30 per cent. at 400 c/s and for special purposes an R.F. signal up to 0.5 volt may be obtained.

The instrument also serves as an audio-frequency generator giving up to 2.3 volts maximum, controllable by an additional attenuator and delivered through a separate socket.

This is a battery-operated instrument, and current consumption is stated to be extremely low. The scale is hand calibrated and the equipment comprises two dummy aerials. A somewhat similar instrument without short wavebands is available at a lower price.

The Pye Complete Tester comprises the signal generator described above combined in a portable case with a Weston Selective Analyser. The Pye Valve Tester gives direct readings on a 6-inch scale of emission and mutual conductance of all types of valves and provides a check on inter-electrode insulation.

Among other Pye service equipment is an output meter calibrated in milliwatts and decibels, a set of trimming tools and an outfit comprises the necessary materials—polishes, compounds, etc.—for the renovation and repair of broadcast receiver cabinets.

A multi-range meter is combined with a signal generator in the Pye All-purpose Tester.

Co-ordination of Radio and Land-Line Services

A PUBLICATION of obvious importance to telephone engineers, and one that is of interest to radio engineers insofar as it deals exhaustively with the technical problems of co-ordinating radio telephonic and wire systems, is the recently published Proceedings of the International Telephone Consultative Committee (plenary meeting at Budapest); English Edition. The formulation of international standards for line characteristics and their measurement, which have an important influence on the technical arrangements for the international exchange of broadcast programmes by wire, are dealt with. The book contains 660 pages, with many illustrations and diagrams, and is published by The International Standard Electric Corporation, Connaught House, 63, Aldwych, London, W.C.2, at 25s. nett.

The Super-Regenerative Receiver*

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

ABSTRACT.—The principles of the super-regenerative receiver are recapitulated together with the more important theories and experimental results so far published. Divergency among these is ascribed to the number of variables involved and the impracticability of taking them all into full account in any rigorous investigation. Some results of tests made by the writer under representative working conditions are summarised, and the practical effect of various conditions such as quenching frequency, operating voltages, point of injection, signal strength, and r.f. circuit resistance are noted and discussed. The application of a number of types of multiple-electrode valve, intended as frequency-changers, is described. The practical outcome of the foregoing is summarised.

Introduction

AFTER the first flush of enthusiasm aroused by Armstrong's disclosure in 1922[1] of the remarkable results obtainable by employing the super-regenerative principle, this device has been something of a radio Cinderella. Its adoption has been hindered by the fact that the majority of the serious papers on the subject are in German ; and they for the most part are *so* serious as to make only a restricted appeal to the practical man who has no time to flounder in a morass of somewhat speculative mathematics.

Anticipating a little, it may be said that the factors controlling the performance of a super-regenerative receiver are so numerous and complex that precise design based on theoretical investigation, such as can be undertaken with other types of receiver, is impracticable. For the same reason it is extraordinarily difficult to establish definite principles of design on the basis of experimental results. In the writer's opinion this accounts for the measure of disagreement that exists among both theoretical and practical publications on the subject, and for the unpopularity that the receiver has endured.

On the other hand, both lines of attack can be helpful if their limitations are appreciated ; and what follows is an attempt to sort out and possibly to supplement what is most useful and generally applicable among the material, and to present it in non-mathematical form. This may not be untimely, in view of the growing interest in ultra-high frequencies, for which (anticipating again) super-regeneration is particularly adapted.

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

Regenerative Amplification

Various theories of super-regeneration have been developed to a greater or less extent (see references at the end of this article), and are by no means in perfect agreement in their details ; nor is it easy to test them experimentally. The main principle of working is clear enough. Explanation of it is usually approached by way of the well-known regeneration or reaction device. It should be realised, however, that the contrasts between the working of the two methods are more significant than the comparisons.

Both systems depend on control of the effective resistance in an oscillatory circuit. Reaction is the most convenient method of cancelling a proportion of the positive resistance and thereby improving the sensitivity and selectivity of the circuit. It is extremely easy by means of a back-coupled valve to introduce enough negative resistance to cancel the damping of even a very inferior tuned circuit, and thus to go far beyond what can be accomplished by the most meticulous and expensive " low-loss " construction. Amplification of a signal can be pushed to any amount up to and including infinity, which is reached when the effective resistance is zero. An amplification of infinity sounds very attractive, but actually is undesirable, because it means that any signal, however small, would give rise to a continually increasing train of oscillations, which would continue at a constant amplitude after the signal had ceased (Fig. 1). This " hangover " would be a very inconvenient adjunct to the output from the tuned circuit. And, paradoxically enough, infinite amplification does not mean that the signal necessarily is amplified to an infinite or even a large extent. It is only so when the signal is active for an infinite length of time.

The oscillation due to the signal grows at a rate which is proportional to the signal voltage, but also inversely proportional to the inductance ; and, as inductance is one of the two essentials of an oscillatory circuit, it is obvious that a signal of short duration may not succeed in making much impression on such a receiving system, even if it were gifted with infinite amplification.

And even if the goal were worth striving for it is not within practical reach, for it would be necessary to adjust the reaction control, and keep it adjusted, at one particular setting, with no latitude for errors, or variations due to temperature, etc. And, furthermore, the negative resistance obtained by the means available—valves and their associated circuits—is a function not only of the adjustments of the apparatus, but also of the amplitude of the received signal ; so that whenever the signal is injected it either sends the resistance negative, causing instability, or positive, causing finite amplification.

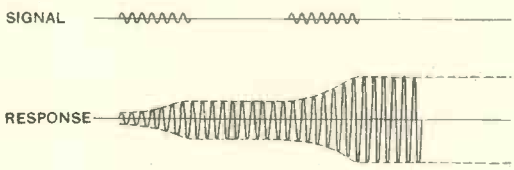

Fig. 1.

This is the reason why it is fallacious to assume that it does not matter how " bad " the coils and condensers may be, on the ground that the loss resistance can always be nullified by reaction. The lower the intrinsic resistance, and hence the less one depends on reaction, the less in proportion are the inevitable variations in the amount of reaction, and the nearer one can approach to zero resistance with consistency of performance.

Limitations of Regenerative Amplification

When the radio frequency of the signal is low, the time limitation is the most serious one, because there are then relatively few oscillations to each " unit of intelligence " (as a dot in morse or a single modulation wave in telephony may loosely be termed), and the inductance in the circuit is high, so that before the limit in stability of adjustment has been reached the growth or decay of the oscillations is so slow as to distort the " intelligence " seriously.

There are ways of compensating for such distortion—tone-correction or the " Stenode "—but there are also alternative effective methods of amplifying low radio frequencies ; so we turn to consider the high frequencies, and more particularly the " ultra-high " frequencies (defined arbitrarily as those above 30 Mc/s, or below 10 metres in wavelength). Here there are very many oscillations per unit of intelligence, and the inductance is small, so the distortion due to inertia is less serious a limitation than the precision and stability of reaction control. Reaction is an important aid to the amplification of ultra-high frequency signals, because other methods tend to lose their effectiveness as the frequency is raised. But the extreme selectivity accompanying its use may not be an unmixed blessing, for " searching " becomes so difficult and tedious that much or all of the transmission may be over before it is tuned in. Searching over a band of only 5–6 metres wavelength is equivalent to covering the whole of both medium and long broadcast bands nine times. Coupled with the necessity for very precise adjustment of reaction all the time, this renders simple types of ultra-high frequency receivers extremely troublesome to operate, or alternatively (by using only moderate reaction) extremely insensitive.

Super-Regeneration : Quenching

The principle of the super-regenerative receiver is to vary the effective resistance of the circuit periodically at some frequency intermediate between the radio frequency of the signal (which we shall call r.f.) and the " intelligence " or modulation frequency (m.f.). This intermediate frequency is often called the modulation frequency, but to avoid confusion we shall refer to it as the quenching frequency (q.f.).

The q.f. must be lower than the r.f. in order to allow the oscillation time, during the portion of the cycle when the resistance is low or negative, to build up to a useful amplitude. In fact, viewed from this standpoint alone, it would seem that the q.f. ought to be as low as possible in order to achieve maximum amplification. On the other hand, it must be greater than the m.f., because it is only once during each cycle of q.f., that the modulation amplitude of the signal has any appreciable control over the free oscillations set up in the tuned circuit. Moreover, suppression of the q.f. from the final output ought not to carry away with it part of the m.f. band.

The q.f. is usually chosen, then, to be only just above the m.f. band—about 5 to 10 kc/s in the case of telephony. There are, however, other considerations that ought to be taken into account in selecting the q.f. This is where there appears to be some divergency of result among the authorities. During the negative resistance period of the q.f. cycle, theoretically oscillations need not start at all unless some impulse is applied. In the absence of a signal an impulse always exists due to "shot" effect in valves, similar effects in conductors, and stray interference. These being of an irregular character, and the ultimate amplitude to which oscillations build up being dependent on the intensity of the impulse and the time of its occurrence during the cycle, the amplitudes of successive q.f. cycles are also irregular and give rise to a characteristic hissing or rushing sound.

When a signal carrier wave is injected, if it is at least comparable in intensity with the irregularities, it tends to regularise the response by virtue of its continuity and its agreement with the natural frequency of the r.f. circuit. Consequently the hiss tends to be suppressed if the carrier wave is of constant amplitude, or replaced by modulation frequencies if the carrier is modulated.

During the positive resistance period of the q.f. cycle any oscillations that have been built up during the preceding period are wholly or partly quenched by the more or less large decrement introduced; if wholly, then the apparatus starts the next q.f. cycle with a clean sheet.

It is obvious that there is room for a good deal of variety in the final result of this process, depending on such factors as frequency, intensity, and waveform of quenching, radio, and modulation frequencies; constituents of the r.f. oscillatory circuit; and characteristics of the valve or valves associated with the circuit. Consequently any theoretical or experimental investigation, even if well founded, can hardly take account of all these comprehensively in a simple manner, and are likely to show divergencies according to the particular conditions selected for investigation. Thus Armstrong[1] came to the conclusion that the lower the q.f.—subject only to the m.f. limitation—the better. Ataka[3], on the other hand, adduces theoretical and experimental results pointing to a much higher optimum q.f.; 200 kc/s for example. According to him, only the initial part of the train of oscillations during a q.f. cycle is subject to influence by the signal. After that, any prolongation of the period of negative resistance merely sustains an amplitude which would have been reached by that time even without the stimulus of a signal.

Fig. 2 shows the growth and decay of oscillation during one quenching cycle, derived from oscillograms by Ataka. The shaded area represents the increase due to the injection of the signal, and it is seen that its effect is to advance the growth of oscilla-

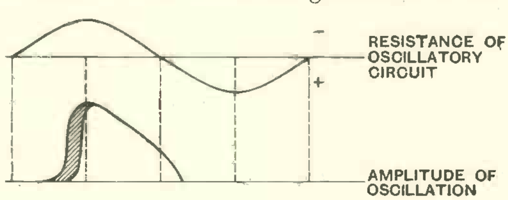

Fig. 2.

tion, but not to increase the rate of growth. The maximum amplification is attained when the number of shaded areas per second is as great as possible, short of encroaching on their duration; which leads to quite a high q.f.

At the same time, Ataka states that the amount of advance due to the signal is greater when the q.f. is low, and therefore an excessively high q.f. results in a falling off in sensitivity. The optimum q.f. varies to some extent with circuital conditions.

The manner of growth described by Armstrong and some subsequent writers[9] is more like that illustrated in Fig. 3. Here the oscillations grow exponentially at a rate controlled from the start by the strength of signal, and therefore so long as the amplitude is not restricted by valve saturation the amplification increases as the q.f. is reduced. It should be pointed out that a rectangular quenching waveform is assumed.

The oscillograms shown by David[2] were taken under rather artificial conditions, and do not show oscillations building up in the absence of a signal. They agree with those of Ataka, however, to this extent, that it is the place in the quenching cycle at which oscillations start that varies with the signal strength, while the finishing point is independent of the signal. They agree, also, in showing a considerable angle of lag between the start of the negative resistance half-cycle and the start of oscillations, even with a very strong signal.

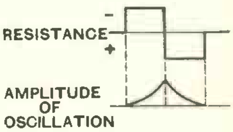

Fig. 3.

Characteristics of Super-Regenerative Reception

Whatever the precise form the growth of oscillations assumes (and undoubtedly it varies considerably with conditions) the action is very different from that of simple reaction, which results in extreme selectivity as it is pressed to its limit where the decrement tends to zero. As super-regeneration is increased, on the contrary, the increments and decrements become greater and the operating point is carried farther away, above and below, from the zero resistance line. Selectivity, then, is comparatively very poor under the usual conditions of super-regeneration. This has ruled it out from the medium broadcast band (to which it was originally applied), and with the growing congestion of the higher frequency bands its usefulness has now become questionable up to about 10–20 Mc/s. But in the ultra-high frequency bands inselectivity may be, as we have seen, a considerable advantage.

The actual degree of selectivity obtained depends very largely on operating conditions, as will be discussed in detail later. In the meantime it may be noted that David has proposed the use of a quenching waveform of the type shown in Fig. 4 to give greater selectivity, by making the resistance nearly zero during the greater part of the quenching cycle. High selectivity in association with the characteristics of the super-regenerative receiver is obtained by combining it with the superheterodyne principle.[13] This device also gets rid of another objectionable feature of the super-regenerator—its radiation.

As regards sensitivity the super-regenerative receiver far exceeds the best of which simple reaction is practically capable. But too much importance should not be laid on an unqualified comparison of sensitivity. Sensitivity being almost unlimited, what really counts most is signal/noise ratio; for if one strives after mere sensitivity it may happen that the result is a signal/noise ratio which is much worse than that given by critical reaction, the product of which can always be amplified at audio frequency to bring it up to the volume given by super-regeneration. The real advantage lies in this high sensitivity in conjunction with non-critical and stable adjustment of very simple apparatus. In the design of receivers, then, sensitivity should be considered in its proper relation to signal/noise ratio and ease of control.

Those who have any experience of the super-regenerative receiver will agree that for variety of unexpected noises and effects it is probably unrivalled. It seems to be largely a matter of luck whether a circuit that is tried performs in a useful and controllable fashion, or behaves with exasperating perversity. It is possible, for example, to provide all the conditions for operation and yet to obtain no super-regenerative effect at all. Or reception is accompanied by all sorts of whistles; or noise is less of a mere background than an all-pervading confusion. Or the receiver responds sharply to the signal at numerous points over a wide band of tuning.

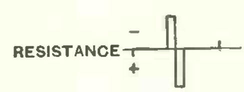

Fig. 4.

In examination of these effects several states or zones of super-regeneration have been distinguished by investigators. David describes three of these (for all details see his paper[2]) :—

A. This is the normal super-regeneration described by Armstrong. The negative resistance is small enough for the growth of oscillations to fall short of valve saturation; the positive resistance is great enough for the free oscillations to be completely extinguished at each quenching period; and the maxima attained during each period are proportional to signal e.m.f. Reception of telephony is unaccompanied by self-generated whistles.

B. In this state whistles are produced by an incoming carrier wave beating with the partially extinguished free oscillations left over from the previous period. These beats are themselves of inaudible frequency, but audible beats are produced by a stroboscopic effect due to the phase relationship between the two sets of oscillations varying from one quenching cycle to another. Obviously in this case the positive resistance must be insufficient to cause complete extinction each cycle. This state is unsuitable for reception of telephony, but David points out its advantages over simple reaction for receiving high frequency c.w. signals: in addition to the sensitivity being higher, adjustment, both of regeneration and frequency controls is far less critical. (These features, together with the large output power released by a signal, make the super-regenerative receiver particularly suitable for operating automatic call devices). It is almost impossible to hold an audible beat note for long periods with simple apparatus depending on ordinary reaction. But obviously the method is open to interference, and if inapplicable for this reason it is necessary to adopt very refined methods for maintaining frequency stability at both transmitter and receiver.

C. This is described as the "anti-jamming" state, and is obtained when the negative resistance is great enough to cause valve saturation in the presence of a c.w. signal. In these circumstances there is a condition of immunity from interference by damped impulses—atmospherics, spark, etc.—a property that is utilised, for example, in police car receivers.[13]

The quenching cycles in each of these cases are compared in Fig. 5.

The present writer's experiments, detailed later, confirm the above divisions—or at least the first two of them—but suggest that the classification is not entirely comprehensive.

Another important factor in super-regenerative reception is what might be called the A.V.C. effect. When a modulated signal from a standard generator is applied to a sensitive superheterodyne receiver of the usual delayed A.V.C. type, the background noise is at first large when the signal is zero. The modulation frequency output then grows as the signal is brought in, and, when it reaches full volume, any further increase in signal strength causes the background gradually to disappear.

Exactly the same is characteristic of the super-regenerative receiver. It should be noted that, although the output may remain constant within a few db. while the input is varied from 10^2 to 10^6 μV, over the whole of this range the output is reasonably proportional to the percentage modulation. This distinguishes the effect from the

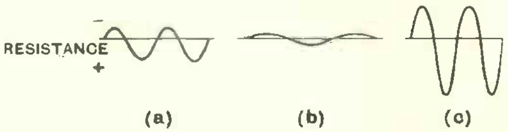

Fig. 5.

saturation obtained with the simple regenerative detector, in which the modulation proportionality is much upset. The effect is the subject of a paper[4] of which an abstract appears on page 35 of *The Wireless Engineer* for January, 1934, and is also dealt with by Ataka[3] (p. 874) and Lewis & Milner.[12]

An extremely novel and ingenious application of this effect is a cathode-ray voltmeter having logarithmic characteristics over a very large range (10–10^5 μV), forming part of a resonance curve indicator such as is used in the examination of highly selective receivers.[11]

Means for Obtaining Super-Regeneration

Having considered the characteristic features of super-regeneration, we now go on to the means for obtaining it, and the influence of operating conditions on results. So far reference has been made to the quenching process as a cycle of alternately negative and positive resistance. In practice this is obtained by providing some form of regeneration to set off against the intrinsic resistance of the r.f. oscillatory circuit, and then varying it periodically by means of a valve oscillating at the q.f. Sometimes this is so arranged that a normally stable circuit is brought into the oscillating condition by the q.f. oscillator, and sometimes the circuit is normally in the oscillating condition and the effect of the q.f. oscillator is to bring positive resistance into it. Although theoretically it does not matter in which manner a given periodic resistance characteristic is obtained, in practice the types of characteristic actually possible and the amenability to control depend on how the quenching is applied.

The variety of operating conditions to be considered, and the impossibility of taking full account of all these factors mathematically so as to be able to predict the performance of any actual design, have already been pointed out. A complete experimental investigation would also be too laborious. And it is curiously difficult to derive any really general conclusions about super-regeneration by trying to isolate and tackle individual problems experimentally. In attempting to do so the difficulty is to simplify the conditions without rendering them highly artificial. The experimental work to be described makes no claim to rigour or strict generality, but is rather an attempt to examine the performance of receivers under typical working conditions.

Test Circuit

The circuit used for many of the tests is shown in Fig. 6. The r.f. receiver portion was of the Hartley type, with a 9-turn coil of 12 s.w.g. bare copper 2 cm. dia. by 3.5 cm. long. The tuning range with this coil was about 40–60 Mc/s (7.5–5 metres). A Hivac XL valve was used unless otherwise noted, being a midget valve with very small inter-electrode capacitances. The reaction condenser RC was of the trimmer type, having a maximum of about 100$\mu\mu$F, but was generally set very low. R.f. chokes wound with about 50 turns on half-inch ebonite tubes, one inch long, separated the r.f. circuit from the q.f. oscillator and m.f. circuits, which were also kept at a distance of about 2 feet to allow the orientation of the receiver portion to be controlled. The q.f. was generated by a separate oscillator and introduced into the anode lead to the r.f. valve, and V_q (quenching voltage) measured by a cathode-ray oscillograph and expressed in *peak* volts. The r.f. signal was derived from a modulated oscillator with variable screening (biscuit-tin type) and the m.f. output from the receiver coupled to an amplifier ("Gram" terminals of an ordinary receiver) and output meter.

Signal strengths on this u.h.f. band were only roughly comparative, but below 10 Mc/s were derived from a standard signal generator and were therefore under more exact control.

Results of Tests

The performance of this receiver was examined at a signal frequency of 43 Mc/s

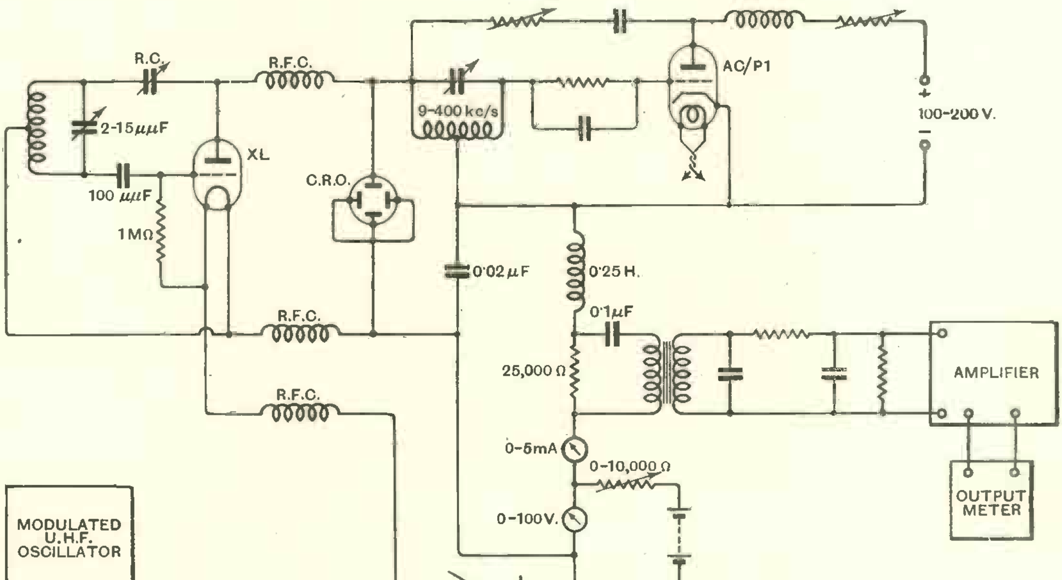

Fig. 6.

(7 metres), and at a wide selection of q.f.s, with variation of V_q and actual anode voltage (V_a) of the receiver valve. Under typical conditions the threshold of oscillation was reached with $V_a = 35$, at which I_a was 0.5. mA. As it would be tedious to give the results in full detail the following are the principal conclusions drawn :

(1) As q.f. is raised, a higher V_q is necessary. Thus while at 20 kc/s the optimum V_q is of the order of 12 volts, at 100 kc/s it is more like 70 volts. This is what theory would lead one to expect.

(2) As q.f. is raised, the optimum V_a is lower.

(3) As q.f. is raised up to 300 kc/s, super-regeneration becomes less certain, control is more tricky, sensitivity is lower, but signal/noise ratio tends to improve.

(4) Over certain bands of q.f., super-regeneration fails altogether. This is in agreement with theory set forth in a paper by Barrow[8]; see also [3].

(5) From about 40 kc/s upwards in q.f. (depending on the signal strength) the response divides into a number of more or less separate resonances (Fig. 7). Measurement shows the intervals between these resonances to be equal to q.f. The free oscillations tend to synchronise with a multiple of the q.f. This spreading into a number of separate responses is another objection to a high q.f.

(6) Optimum q.f. is difficult to determine with certainty, but although V_q was varied over a wide range the comparatively high optimum q.f. of Ataka definitely was not confirmed, but rather a continual increase in amplification as q.f. is lowered, and a choice probably in the region of 15 kc/s on the grounds of background noise and ease in separation of q.f. from m.f.

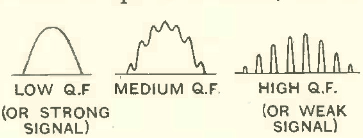

Fig. 7.

(7) At any one q.f. there is a tendency for the optimum V_q for any value of V_a to be such that $V_q + V_a$ is constant, with a very flat optimum for $\frac{V_q}{V_a}$. As q.f. is increased, $V_q + V_a$ rises.

(8) Under certain conditions—notably, high q.f.—behaviour is similar to that with simple reaction, except for increased sensitivity; the output increases at a rapidly growing rate as V_a or V_q or both are increased, until a "threshold of oscillation" (? change from "A" to "B" states distinguished by David) is reached, at which adjustment is very critical, and beyond which the modulation loses its characteristic tone and becomes "mushy."

(9) With V_a substantially higher than that required for self-oscillation in the absence of V_q, the noise level is very high and increases with V_q, the sensitivity is low, and there is a tendency towards David's "B" state.

(10) Other things being equal, sharper responses are obtained when V_q is low and V_a high (approximating to that necessary to start self-oscillation). This agrees with theory, for it corresponds to a condition of numerically low average oscillatory circuit resistance.

(11) The signal/noise ratio sometimes improves as $\frac{V_q}{V_a}$ is increased; sometimes the reverse. The controlling factor is obscure.

(12) Increasing the receiver tuning from 43 Mc/s to 60 Mc/s, the q.f. required to give similar results is greater, but it is not possible on the evidence available to say definitely that it is *proportionately* greater.

(13) If it is desired to cover a wide band of receiver frequency, the most important practical aid is a closely constant reaction setting. This corresponds to a constant level of the base-line in Fig. 5. It has already been noted what a wide variation of results depends on the nature of the characteristics exemplified in Fig. 5. While other factors—V_q, q.f., etc.—are ordinarily unaffected by receiver tuning, the base-line level may not be, and this is a prominent cause of difficulty in handling the receiver.

Anode versus Grid Injection

Ease of obtaining and maintaining favourable working adjustments is of outstanding practical importance, and is the feature which the super-regenerative type of receiver has notoriously lacked. Working with a low q.f., and a V_a well below the threshold of oscillation, the circuit of Fig. 6 has been found reliable and stable (except in so far as no special provision in this respect is made for tuning over a wide waveband). But most of the super-regenerative circuits that have been published show grid injection of the quenching oscillation. Next, therefore, a comparison was made between anode and grid injection.

The preceding circuit (Fig. 6) was supplemented by a grid coupling coil as shown in Fig. 8.

Grid injection introduces an extra complication—the depression in grid voltage due to rectification of V_q. This makes the receiver considerably more difficult to control, because a readjustment of V_q alters the grid bias of the valve, and hence the "lumped voltage" ($V_a + \mu V_g$) of the valve, on which r.f. reaction depends. It is still worse in a single valve super-regenerator, in which the quenching oscillation is set up by the same

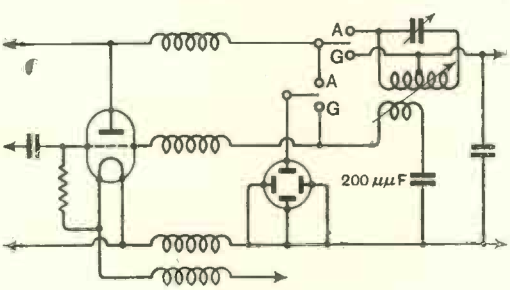

Fig. 8.

valve responsible for the r.f. reaction; for then the two adjustments are interlocked. What happens, for example, is that when V_q is reduced the resulting increase in grid voltage causes "squegging" due to excessive r.f. oscillation. If then q.f. oscillation is increased, r.f. reaction is inadequate.

After having made allowance for depression of mean grid potential by grid injection, all tests showed the behaviour to correspond with that resulting from anode injection. Thus, V_a must of necessity be greater than that at which r.f. oscillation starts; but, if only slightly more, and V_q is large, results correspond to those with anode injection when V_a is low and V_q large. When at the same time the q.f. is high, it is possible to duplicate the "oscillation threshold" type of tuning previously noted in the case of anode injection (par. 8 above). And with *very* low V_q the extremely noisy and unfavourable condition described in par. 9 is obtained. The values of V_q are, of course, lower—tests showed them to be lower, as one would expect, at least approximately in the ratio of $\frac{1}{\mu}$. It is difficult to confirm this with exactness, owing to the difficulty in measuring μ under equivalent working conditions for the valve.

Careful quantitative comparisons of the two methods at a fixed q.f. of 20 kc/s, employing a valve voltmeter for more accurate measurement of low values of V_q, were (like most results of our investigation of super-regenerative receivers) singularly barren of clear conclusions, in spite of strenuous attack by graphical analysis. The following are of interest however:

(1) With anode injection the m.f. output for a given r.f. input rises with both V_q and V_a, but signal/noise ratio tends to fall.

(2) With grid injection, output also rises with V_a, but falls as V_q is increased. With constant V_q, varying V_a has little or no effect on I_a. Because of this it is difficult to deduce how sensitivity depends on lumped voltage, and hence how much the raising of V_q in grid injection affects results by depressing the grid and how much by increasing quenching, but there appears to be no doubt that the fall in output as V_q is raised is due to grid depression, and that if V_a were raised sufficiently to compensate for this the output would rise above the original level.

(3) With either method of injection, increasing V_q (V_a constant) decreases I_a.

From a practical point of view the lower V_q required for grid injection is an advantage, and the possibility of doing everything with a single triode may appear to some workers in that light also; but in the author's opinion these considerations are outweighed by the greater battery voltage required, and (more especially with the single-valve circuit) the much lower stability and ease of control.

Mention must be made of what used to be called the Flewelling circuit. This is a single-valve super-regenerator in which no quenching components appear. The quenching action is obtained by suitable choice of grid leak and condenser and tightening the reaction coupling in such a way as to cause squegging at a workable frequency for quenching. Although it is possible to obtain very good sensitivity in this way, adjustment is very tricky, especially when tuning over a r.f. band; it is sometimes quite useful when an extremely simple compact receiver is required for working on a more or less fixed frequency.

Signal Generator Tests

Owing to the technical difficulties of measurements at u.h.f., further investigation was made at lower signal frequencies between 6 and 10 Mc/s, with a standard signal generator as the source.

The previous test circuit, although it worked quite well after substitution of an appropriate r.f. coil, was unsuitable for measurement purposes owing to the large amount of interference picked up by leads. A more compact arrangement was therefore adopted (Fig. 9). To minimise the load of the receiver valve on the q.f. oscillator, a 5 : 1 step-down was adopted. Three q.f.s were available: 20, 15 and 9 kc/s. The r.f. was kept at 7.5 Mc/s.

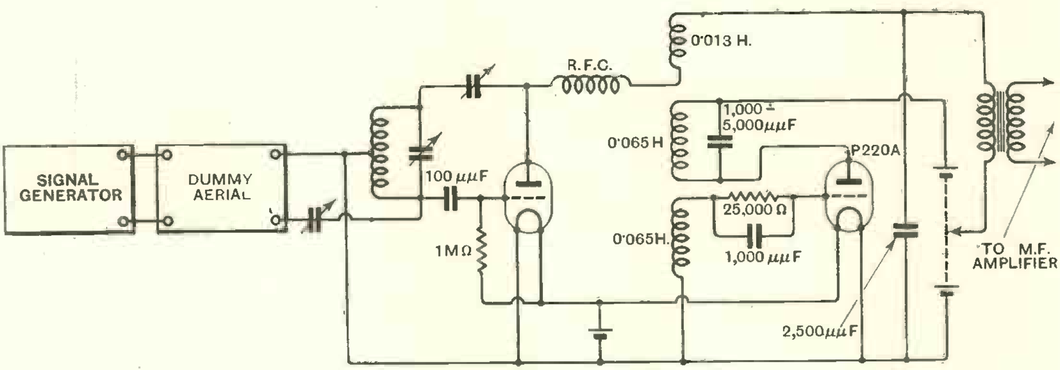

Fig. 9.

Fig. 10 (*a*) shows the input/output characteristic. The curves shown were actually taken with a q.f. of 9 kc/s, but those with 15 and 20 are similar. The output scale is arbitrary, being variable by means of the m.f. amplifier gain control. The rise in output above 10^4 μV input was due to a shift in tuning caused by the increasing signal intensity. It is interesting to compare the slope of these curves with that relating to an ordinary receiver without A.V.C. To show that this super-regenerative "pseudo-A.V.C.," like the genuine article, affects the r.f. but not the m.f. amplitude, the r.f. input was kept constant at the point marked (1000 μV) and the modulation percentage varied. The proportionality of output may be judged from Fig. 10 (*b*).

It is also interesting to note the effect of varying r.f. inputs on the shape of the response curve. Some typical results are sketched in Fig. 11. The effect of increasing the signal strength beyond that necessary to overcome what may be referred to as the imaginary A.V.C. delay voltage is to broaden the response. The shape of the response curve is, in general, irregular; and there are usually multiple side responses. Some response curves with ordinary critical reaction instead of super-regeneration are included for comparison.

Influence of R.F. Circuit Resistance

Certain writers (*e.g.*, [2] and [9]) have suggested that it is advantageous to use a highly damped r.f. circuit, in conjunction with a large amount of reaction. This point was

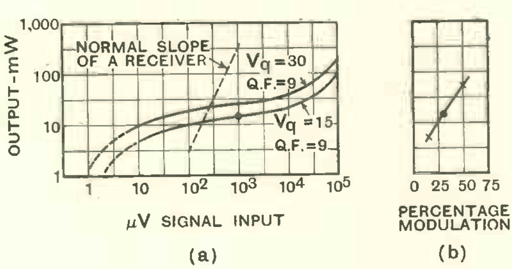

Fig. 10.

therefore given special attention, and careful tests were made to determine what sort of influence circuit damping has on performance. The tests were made at approximately 9 Mc/s r.f., using a coil of 14 μH selected for low r.f. resistance, giving a fairly high dynamic resistance (of the order of 0.1 MΩ). Artificial damping was introduced by connecting non-reactive resistors, of 10,000 Ω upwards, across the whole coil, which was centre-tapped in the usual Hartley circuit.

The results obtained with this circuit under a great variety of operating conditions consistently led to the conclusion that the most favourable conditions are :

(1) No added damping.

(2) Full normal V_a for the type of valve (60–80 volts).

(3) Adequate V_q (say, 20 volts ; but not critical) all three allowing of

(4) Minimum reaction (capacity control).

The most favourable all-round conditions, for sensitivity, signal/noise ratio, and m.f. output, appeared to coincide with the threshold of r.f. oscillation (in the absence

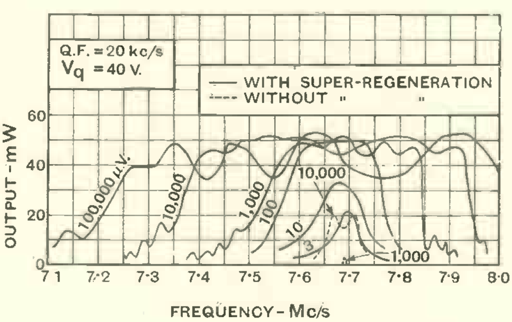

Fig. 11.

of quenching oscillation). It is quite possible to obtain super-regeneration with zero, or even negative V_a, by liberal use of reaction and V_q, but these conditions are relatively unfavourable. *Any adjustment necessitating an increase in reaction led to inferior results*, whether tested by signal generator or actual reception.

Application of Multiple-Electrode Valves

Up to this point the circuits illustrated have employed triode valves, with separate quenching oscillators. There is virtually no limit to the variety of valve and circuital arrangements ; it is not practicable to devote space to even a representative selection of them. But one class is considered by the writer to be worthy of special notice, on the grounds of theoretical interest, practical value, and paucity of published information ; namely, the use of valves of types now in common use as superheterodyne frequency-changers.

The first valve of this class to be applied thus by the author was the Mullard FC4

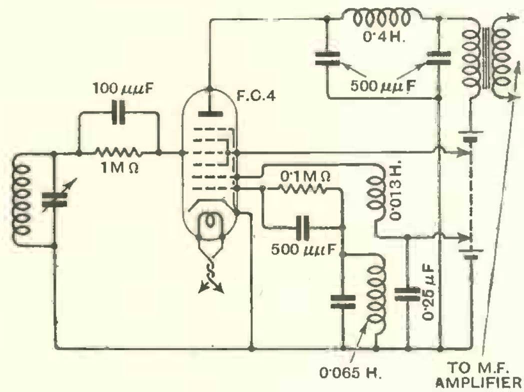

Fig. 12.

octode (Fig. 12). The two innermost grids, forming the usual oscillator section, found a congenial task as the quenching oscillator, with about 40 volts on G_2, which was also supplied to G_3 and G_5 (which are normally run at about double this voltage). The r.f. input was taken to the control grid (G_4). The output was taken from the anode, run at 100–200 volts ; the actual voltage being of minor importance.

At first sight it may not be clear how r.f. reaction is obtained, as no provision appears to be made for it. Remembering that the virtual cathode, so far as the anode and control grid are concerned, is somewhere between the physical cathode and G_4, the r.f. circuit is effectively a variety of the Colpitts or capacitance potential divider circuit (Fig. 13). The dotted condensers represent the capacitances from the virtual cathode to physical cathode and control grid.

A curious feature—with this valve at least—is that, contrary to the usual experience, oscillation is less free at lower radio frequencies. At medium broadcasting frequencies, for example, oscillation could not be obtained at all. No difficulty was experienced in obtaining vigorous oscillation at

75 Mc/s (4 metres). Even on the 6 Mc/s band, a high $\frac{L}{C}$ ratio was essential—the series capacity from the dummy aerial had to be limited to 2 or 3 $\mu\mu$F—and a shunt of 0.1 MΩ was nearly enough to kill it. On the 40–60 Mc/s band, however, greater liberties could be taken, and a wide band covered by tuning condenser.

Oscillation appears to be freest with G_1 and G_2 at zero (cathode) potential, but whereas G_2 may be varied considerably without important effect, G_2 controls I_a and $I_{g\,3+5}$ very steeply, and oscillation also. As might be expected, therefore, the quench coil coupling influences the r.f. regeneration as well as the q.f., and, in fact, is the only control apart from r.f. tuning. Contrary to what might be expected, control is notably easy and stable. Depending to some extent on the q.f. chosen, and on other conditions, sensitivity reaches a maximum at or near the point where coupling is loosened sufficiently to bring q.f. oscillation to the verge of stopping. Alternatively, the coupling may be fixed, and V_{g2} varied by a suitable potential divider.

Quantitative comparison with a triode receiver showed results not unlike those shown in Fig. 11, but sensitivity was higher. The octode also " handles " better; and it is an obvious advantage to work with an untapped uncoupled r.f. coil.

It was while examining this arrangement that the world's simplest super-regenerative

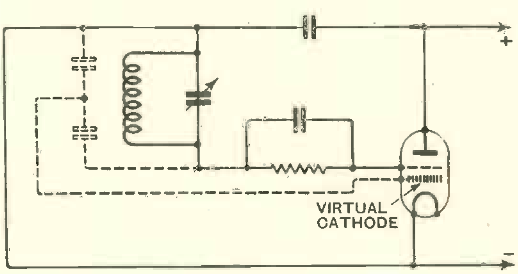

Fig. 13.

circuit was accidentally arrived at (Fig. 14). This clearly works on the squegger principle; the q.f. is controlled by the grid condenser and leak. The lead from G_1 must be long enough to have appreciable inductance; otherwise a high potential point in the electron stream is short-circuited and oscillation is weakened below squegg point. Unlike most circuits of this type, it is able to cover quite a wide band (*e.g.*, 4–6 Mc/s) without adjustment of q.f. But the best results were inferior to those obtainable with the quench coils. It is interesting to note that the " auto-super-regeneration " would only take place with V_{g2} below about 3 volts; above this, it ceased, while quench coil action then became possible.

The corresponding battery octode, the FC2, quite expectedly oscillates less readily,

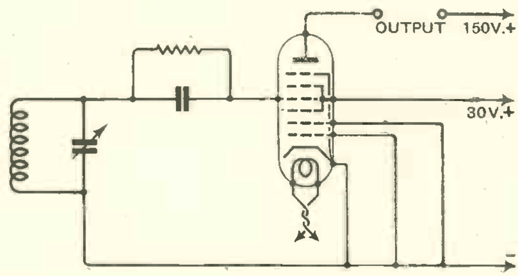

Fig. 14.

and the loading on the r.f. circuit must be kept very small. The electrode voltages should also be selected carefully by trial; the writer found it advantageous as regards noise level and sensitivity to work with quite a low anode voltage—of the order of 50—and slightly higher voltages on grids 2, 3, and 5; 70 for example.

A battery heptode was also tried—the Osram X21. Results are similar to those with the FC2, and satisfactory r.f. oscillation obtained, with suitable lay-out of wiring, by applying 15 volts to G_2, 60 to G_{3+5}, and 100 to the anode. The optimum voltages, however, seem to depend very largely on other circumstances.

With the untapped r.f. circuit illustrated, the virtual tapping, and hence the extent to which reaction approaches the optimum, depends for the most part fortuitously on the internal arrangement of the valve. When the approach is not sufficiently close, better results can be obtained by tapping the coil. With the X21, for example, the virtual tapping appears to be too near the grid end, for stronger oscillation was obtained with the filament approximately one turn further away from the grid end (Fig. 15). A similar circuit can be used embodying the Osram X41 triode-hexode frequency-changer valve.

An attempt to use a tetrode, with the anode providing q.f. dynatron oscillation, and the outer grid giving r.f. oscillation by means of an ordinary reaction circuit, was successful up to the point of setting up the necessary oscillations, but very little further (Fig. 16). The circuit handles badly and results are poor.

Summing Up

In the super-regenerative type of receiver sensitivity is very high; selectivity and signal/noise ratio (if one considers internally generated noise only), in general, low; and there is considerable radiation. For these reasons it is unsuitable for long or medium wave reception, doubtful for short waves, but useful for ultra-short wave work—more especially for compact portable sets or for simple apparatus.

When suitably adjusted, discrimination against interference is markedly better than with other types of receiver.

A useful feature, particularly for mobile receivers or transmitters, is that, in spite of being much less elaborate than the superheterodyne, it shares the benefits of A.V.C. as commonly provided in the latter.

Selectivity can be improved by arranging the amplitude and waveform of the quenching oscillation, so that the mean resistance (regardless of sign) of the oscillatory circuit is reduced; and the signal/noise ratio by avoiding a very low quenching frequency or much reaction, and by adjustment of quenching voltage.

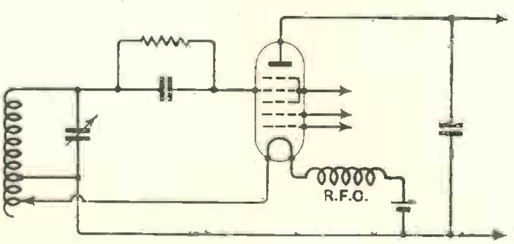

Fig. 15.

When high selectivity and absence of radiation are necessary, a superheterodyne pre-selector can be added.

A high quenching frequency is, in general, undesirable; it necessitates greater quenching power, reduces sensitivity, causes multiple responses, and is associated with uncertainty of operation. On the other hand, an excessively low quenching frequency increases noise, distortion, and filtering difficulties. Approximately 15 kc/s is suggested as a useful compromise.

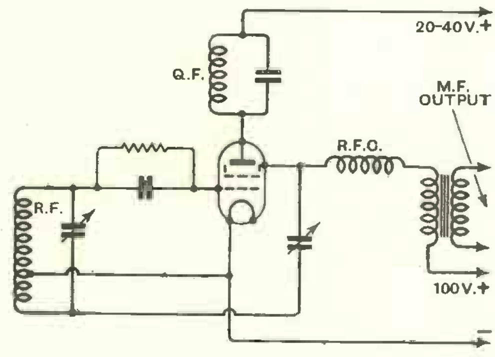

Fig. 16.

It is preferable to obtain a low radio-frequency circuit resistance by "low-loss" construction rather than by much reaction.

It is much easier to achieve satisfactory operation and ease of control by providing separate quenching and regenerating valves; and anode injection is preferable to grid injection. Alternatively a frequency-changer type of valve may be used, which avoids having to provide the appreciable power needed for anode injection, and also dispenses with radio frequency reaction components.

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A Continuously Variable Phase-Shifting Device*

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In present day cathode ray oscillographic equipment, it is usual to provide a time base synchronous with the power supply frequency as a general purpose and stand-by unit, because of the essential simplicity of the apparatus. In the investigation of power supply problems, e.g., switching transients and the like, such a synchronous time base is essential. It is frequently desirable to be able to alter the phase of the time base so that the portion of the cycle under observation occurs on the useful part of the oscillograph screen and it is with a device for effecting the necessary phase shift that this article is concerned.

The usual phase shifting transformer (or voltage regulating transformer) as used in power engineering is usually far too bulky for use as an oscillograph adjunct and its incomplete iron circuit gives rise to large leakage fields so that it must be placed some distance from the oscillograph itself. Also, if a multi-phase supply is not already available, special phase-splitting apparatus must be incorporated. Another type in common use is the resistance-capacity combination, either single circuit or bridge connection, in which phase changes are effected by varying the resistance; the apparatus operates from a single phase supply but the phase variation is limited to considerably less than 180° and the input impedance varies over wide limits. The use of potentiometers in place of variable resistances maintains a constant input impedance but the phase shift is then limited to 90°. The complete shift of 360° can be effected by switching devices but the lack of continuity and the frequently concomitant "blind" spots are a disadvantage.

Fig. 1*a* gives a schematic diagram of the apparatus to be described; one arm of the circuit consists of capacitances and a resistance in series, while the other has inductances in series with a resistance. The elements are so proportioned that $1/\omega C_1 = 1/\omega C_2 = R_c/2 = R_L/2 = \omega L_1 = \omega L_2$, where ω is the angular frequency of the supply (in this case, 50 c/s). The vector diagram for the circuit has been drawn in Fig. 1*b*,

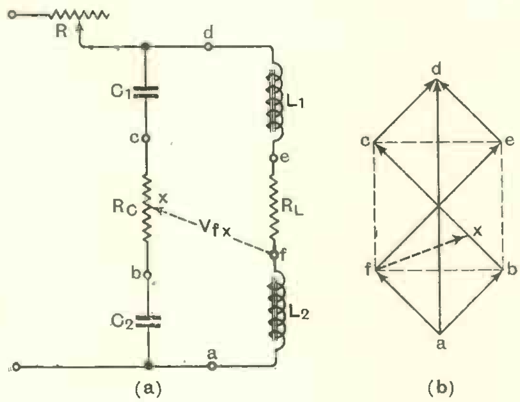

Fig. 1.

where V_{C_1} is the voltage across the condenser C_1, or, more precisely, V_{ac} is the potential of the point *c* with respect to that of point *a*=and so on. If the resistances have a sliding contact, i.e., if they are potentiometers, then it is possible to select potentials along *bc* and *fe* and by suitable choice the relative potentials of the two points may have any required phase difference. Suppose the two potentiometer arms are at the lowest points of their travel, i.e., at the points *b* and *f*; then the potential of *b* with respect to *f* is the vector $\overline{fb}$. If the tapping on the resistance R_C is moved to a point such as *x* then the end *b* of the vector $\overline{fb}$ is moved to the point *x* and the relative potential is the vector $\overline{fx}$; if the potentiometer is moved to the upper limit of its travel (to the point *c*), the potential difference becomes $\overline{fc}$ and the phase has been moved through $+90°$. If then the potentiometer R_C is left at this upper setting and the potentiometer R_L is

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

moved to its upper limit, the potential difference becomes $\overline{ec}$ and a further phase shift of $+90°$ has been accomplished. With R_L now fixed, R_C is turned to its lower setting, and with R_C fixed at this point, R_L is returned to the point f and the total phase change is 360°. The process can, of course, be repeated indefinitely and also, the reverse process will give phase changes in the opposite direction.

The amplitude of the voltage varies from a maximum to a minimum and back to a maximum during each phase change of 90°; the ratio of the maximum to the minimum is $\sqrt{2}$, or 1.4. Also it is possible to reduce the amplitude by the use of intermediate position of the sliders (e.g., when both are at the mid-positions, the voltage is zero) but it is considered preferable to vary the amplitude by a resistance in series with, or a potentiometer across the supply. Since the total current through the apparatus is in phase with the applied voltage, a regulating resistance will not affect the phase of the output voltage relative to that of the input.

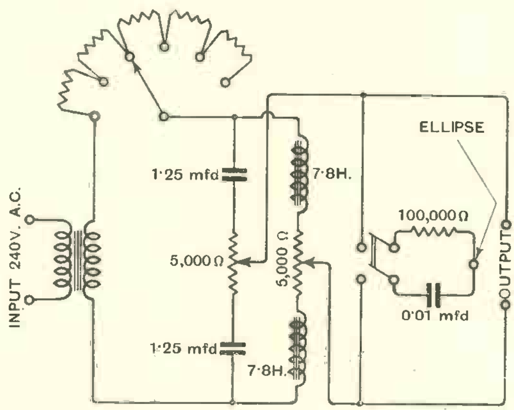

Fig. 2.

In the design of such a unit, it is advisable to keep the input impedance as low as possible in order that moderately high impedance circuits may be connected across the output without appreciably affecting the operation. The lower limit will be sent by the heat dissipation of such potentiometers as are available; a suitable value of resistance is 5,000 ohms which gives an impedance for each arm of $\sqrt{2}.5{,}000$ and a total input impedance of 5,000 ohms, which value, it may be noted, is independent of the settings of the potentiometers. The capacitances are then 1.25 μF and the inductances $7.8H$; the latter will usually have to be specially adjusted. The series regulating resistance or amplitude control consists of fixed resistances selected by a multi-contact switch, since it is not possible to obtain a variable resistance with sufficient heat dissipation from the average laboratory store.

An elliptic time base is usually preferable to the simple harmonic type and the dephased voltages required for this purpose can be obtained from a high impedance resistance-capacity combination across the output terminals; suitable values are 100,000 ohms and 0.01 μF, giving an ellipse with a ratio of axes of 3 to 1, and this addition can be conveniently built into the complete apparatus. (See Fig. 2.)

It is advisable to isolate the unit from the power mains and for this reason a 240–240 volts transformer is included. The apparatus can then be earthed as desired. If, when using the elliptic time base, the mid-point of the phase splitting circuit is earthed, unwanted voltages may appear at the other output terminals because of the high impedance between the rest of the apparatus and earth. Should this effect be troublesome, it may be preferable to earth one side and to use the resultant skewed ellipse in place of the rectangular one given by the normal connection.

In conclusion, it is to be emphasised that, in making any alteration of the phase, it is essential that the potentiometers R_C and R_L be operated alternately, with that potentiometer which is not being varied at one of its extreme positions. Adherence to this procedure avoids confusion of the direction of phase change and prevents unnecessary amplitude variation, which should be controlled solely by the series resistance R.

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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

The Magnetron

To the Editor, The Wireless Engineer

SIR,—In the July editorial you state that the push-pull method of producing very short wavelength oscillations with a split-anode magnetron was first invented by Manns. My patent application regarding this was, however, a few months earlier than that of Mr. Manns. Moreover, I published a paper entitled "Production of extra-short electromagnetic waves by split-anode magnetron" in English in the Proceedings of the Imperial Academy, Vol. 3, No. 8, 1927, whereas, so far as I am aware, Manns has not published any paper on the subject. The paper by Pfetscher and Puhlmann (Hochfreq-neuz, April 1936) to which you refer, seems to pay little attention to work done in other countries, especially Japan.

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Japan.

Mutual Inductance

To the Editor, The Wireless Engineer

SIR,—I should like to add some remarks to Mr. Greig's article published in your July issue.

Let us consider the simple case of an inductance

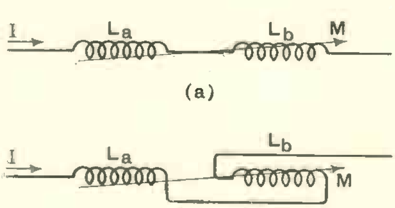


Fig. 1.

made up of two coupled coils. As stated by Mr. Greig:

$$L = (L_a + M) + (L_b + M)$$

The potential drop in L_a is:

$$V_a = \omega(L_a + M)I \quad \text{(Fig. 1)}$$

If the coupling is inverted, M becomes negative but the algebraic expression of L remains the same:

$$L = (L_a + M) + (L_b + M) \text{ with } M < 0$$
$$V_a = \omega(L_a + M)I$$

The state of affairs is unchanged if the coils carry different currents, or are in different circuits. (Fig. 2)

$$V_a = \omega L_a I_a + \omega M I_b\,; \; M > 0$$

If the direction of I_b is inverted:

$$V_a = \omega L_a I_a + \omega M I_b\,; \; M < 0$$

Generally speaking, the potential drop in a leg Z_m possessing resistance, capacitance, and self

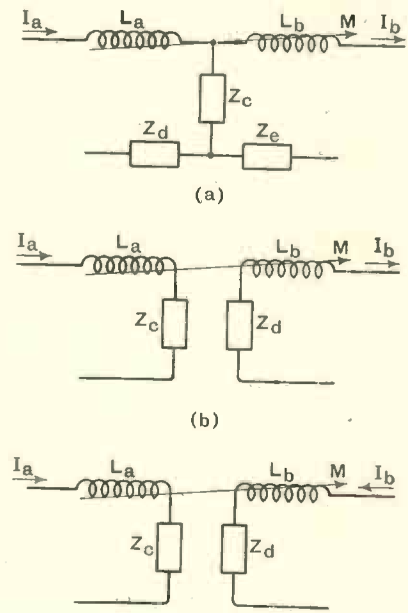


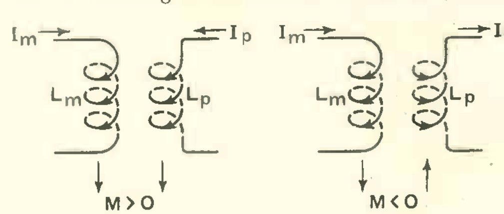
Fig. 2.

and mutual inductance, is:

$$Z_m I_m + j\omega \Sigma M_p{}^m I_p$$

with obvious convention of suffixes m and p.

The sign of $M_p{}^m$ depends on connections, direction of winding and direction of current. It is



(a) (b)

Fig. 3.

determined by the "bonhomme d'Ampère" rule*: The positive normal of the coil is on the left of the "bonhomme d'Ampère" lying on the current which enters his body from his feet to his head,

* Or by the right-handed screw rule.

and looking at the coil centre. Now, if cosine of positive normals of coils L_m and L_p is > 0, $M_p{}^m$ is > 0, and < 0 if < 0 (Fig. 3)

For writing down the mesh equation, one can follow the rule given hereafter :

1°—Arbitrarily choose a current direction for each leg.

2°—Choose a circulation direction on the mesh.

3°—Write $\Sigma \pm [Z_m I_m + \Sigma j\omega M_p{}^m I_p] = 0$

for each mesh. Sign is + whenever current and circulation directions are same, − otherwise. The rule is reversed for the e.m.f., if any.

Paris. JACQUES SELZ.

Book Reviews

Radio Interference and its Suppression.

By J. H. REYNER. Pp. 130. Chapman and Hall, 11, Henrietta Street, London, W.C.2. 9s. 6d. net.

The subject of radio interference is one which is more and more claiming the attention of electrical and radio engineers. Particular attention has been directed to it since the recommendation of the Ullswater Commission that legislation against interference caused by electrical machinery should be introduced.

This book deals with the subject mainly from the listener's point of view, and remedies which can be applied at the receiving end are very fully described. The problems confronting the manufacturer of electrical appliances and the designer of interference suppression equipment are less adequately dealt with. Various standard remedies for application to electrical plant are briefly described, but the principles underlying the suppression of generated disturbances are not explained in detail.

If the book is intended to give a very understandable outline of the subject for the non-technical reader, the author's object has been achieved. The full instructions contained in the first five chapters for analysing and suppressing interference at the listener's premises will be of considerable assistance to those whose work brings them into contact with this aspect of the problem.

J. N.

The New Acoustics

By N. W. MCLACHLAN, D.Sc., M.I.E.E. 172 pages. 7s. 6d. net. Oxford University Press, 11, Warwick Square, London, E.C.4. (1936).

In this book the author is concerned with the new developments in acoustics which have given such striking results in the course of the last twenty years under the initial stimulus of the problems of detecting aircraft and submarines during the Great War. Scarcely had the new knowledge, with its further applications to novel methods of navigation, been made generally known to the scientific public after the establishment of peace, when fresh problems arose in the domain of the production and control of sounds owing to the rapid rise of universal broadcasting.

The practice and classical theory of the old acoustics are dismissed in the first 15 pages. Then, after a description of anti-submarine devices and an account of the arrival of broadcasting, an excellent review is given of the development of loud speakers—a development in which the author has played a leading part for many years. Here, as elsewhere in the book, no attempt is made to introduce mathematical theory but the results of theory and practice are given in numerous diagrams and photographs which are sufficiently explanatory for the reader who is content to take the analysis for granted. The vast amount of research which has gone to the production of the modern gramophone is described and the author disposes of the still prevalent idea that needle scratch is due to irregularities in the record, while actually the prime source is resonance in the needle itself, which can be dealt with by suitable design. A good account is given of the behaviour of the ear and of the cognate subject of deaf-aids. The modern forms of the latter show a profound advance in technique compared with the naive instruments of ten years ago which assaulted the ear with a barrage of uncouth and largely unintelligible sounds.

Dr. McLachlan's book should appeal to a wide circle of readers. Physicists, engineers and medical workers will find it an exposition in simple language of the present state of the art of acoustics and the scientifically minded layman will find it well within his power of understanding. R.T.B.

The Industry

FULL information regarding the new season's Osram valves is presented in a handy pocket-size booklet issued by the General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2.

The offices of Tungsram Electric Lamp Works has been transferred to 82–84, Theobalds Road, London, W.C.1 ; telephone Holborn 3563.

The principles, construction and installation of the "Eliminoise" screened aerial system are described in a 20-page booklet issued by Belling & Lee, Ltd.

Cossor receiving equipment is being used for the public demonstrations of television reception which are being given daily at the Science Museum, South Kensington, until further notice.

A series of new constant-frequency records covering in steps the whole of the recorded range from 8,500 c/s to 25 c/s, and including a gliding frequency record, has been issued by H.M.V. A leaflet describing the series is available.

Marconi's Wireless Telegraph Co. has produced a leaflet describing an improved direction finder (Type DFg. 10) which enables the Marconi-Adcock aerial system to be used at a distance from the receiver, or, alternatively, permits two receivers to be operated simultaneously at the centre of a common aerial system.

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

3968. PROPAGATION OF ELECTROMAGNETIC WAVES IN A TUBE.—L. Brillouin: Southworth. (*Rev. Gén. de l'Élec.*, 22nd Aug. 1936, Vol. 40, No. 8, pp. 227–239.)

Editorial introduction:—"The Bell Telephone Laboratories have studied waves capable of being propagated in a conducting tube of circular section [2502/4 of July: *cf.* also Barrow, 3665 of October]; the physical nature of these waves seems to have escaped the authors. M. Brillouin expounds, in the following article, a closely similar problem—that of waves in a tube of rectangular section; he shows that this problem is very easily solved, starting from the systems of fringes obtained (first) in front of a single plane mirror and (later) in front of two plane mirrors at right angles. All the effects are then readily explicable and are seen to be connected with the well-known properties of interference fringes; incidentally, the questions discussed by Louis de Broglie regarding photon theory are encountered, and the detailed explanations given in this connection throw a great deal of light on the complexity of the subject. It is possible to calculate, besides the phase velocity, an energy-transport velocity in these interference fringes, and these two velocities are closely interconnected. Finally, in discussing some particular cases, the very special nature of the "H_0 wave" of the writers mentioned above is recognised, for this wave can only be formed in tubes of symmetrical section (square, circular . . .) but becomes impossible when the section is no longer symmetrical. This remark should be of practical importance, since any irregularity in the tube would dissociate the H_0 wave."

3969. HYPER-FREQUENCY WAVE GUIDES.—G.W.O.H.: Southworth. (*Wireless Engineer*, September, 1936, Vol. 13, No. 156, pp. 459–461.) Supplement to the Editorial mentioned in 2502 of July.

3970. WORKING BELOW THE ULTRA-SHORTS [" Guided-Wave " Transmission].—(*Wireless World*, 28th Aug. 1936, Vol. 39, p. 200.) *Cf.* 3968/9, above.

3971. THE PROPAGATION OF ULTRA-SHORT WAVES (CM, DM, M WAVES) ALONG THE CURVED SURFACE OF THE EARTH.—P. von Handel and W. Pfister. (*Hochf:tech. u. Elek:akus.*, June, 1936, Vol. 47, No. 6, pp. 182–190.)

For previous work *see* 3429 of 1935. The present paper refers to diffraction formulae obtained by other writers (Epstein, 934 of 1935, and Burrows, Decino & Hunt, 863 of March) and to work on decrease of field-strength with distance (*e.g.* Burrows, 2929 of 1935); eqn. 3 is deduced for the field-strength along the course of a single ray (Fig. 2) for heights such as those used by aircraft. Fig. 4 gives calculated field-strength/distance curves at points in the optical range (§ II 4) which determine the hitherto unknown amplitude factor A in eqn. 3; the curves of Fig. 5 can then be drawn for the field-strength at points where the effect of diffraction is felt. Measured values are given for comparison. Fig. 6 shows how the field-strength varies with height for a given distance; Fig. 7, the variation of field-strength with distance for various heights; and Fig. 8, curves of equal field strength. Figs. 9–16 give field-strength/distance curves for various heights with an emitting aerial at a height of 30 m and various wavelengths. Agreement with measurement was good, except that near the ground the measured field was stronger than that calculated. This is ascribed to the presence of hills and buildings. Fig. 17 shows the increase of field-strength with the height of the emitting aerial and gives the factors by which the data of Figs. 9–16 must be multiplied for the various aerial heights. The effect of directional arrays is expressed in eqn. 5, which gives the factor by which an array increases the field-strength given by eqn. 3. Numerical examples are given to illustrate the use of the curves in field-strength calculations; comparisons are made with the results of Epstein and Burrows. The effect of refraction (probably in the troposphere) is detected in some experimental results (§ IV: Figs. 18, 20); it is connected with very marked fading (Fig. 19) and is being further investigated.

3972. THE VELOCITY OF RADIO WAVES [along the Ground].—R. C. Colwell, A. W. Friend, N. I. Hall and L. R. Hill.—(*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, pp. 381–382.)

The writers have measured the velocity of radio waves along the ground by making a receiving station B transmit pulses to a sending station A at the exact instant at which it receives pulses from A. The time between emission and reception of pulses at A was measured upon a cathode-ray time-base. The velocity was found to be "somewhat less than two-thirds the velocity of light." [The frequency at which the experiments were made is not stated.]

3973. PAPERS ON WIRELESS RECEPTION IN CAVES AND MINES.—Fritsch. (*See* 4271/3.)

3974. ECHO MEASUREMENTS WITH LONG-DISTANCE PROPAGATION. A CONTRIBUTION TO RESEARCH ON THE IONOSPHERE AND SHORT-WAVE PROPAGATION.—W. Crone, K. Krüger, G. Goubau and J. Zenneck. (*Hochf:tech. u. Elek:akus.*, July, 1936, Vol. 48, No. 1, pp. 1–7.)

A description of simultaneous echo measurements on pulses at stations some hundred kilometres apart, one at Adlershof near Berlin and the other at Kochel. Reflected pulses from emitters at each station were received at the two stations, at each of which a record of simultaneous echoes at vertical and oblique incidence was thus obtained. The geometrical scheme of the ray paths is given in Fig. 1; the wavelengths used were about 50 and 80 m. For reference to the apparatus used *see* 16 of January and back references. The method of synchronisation *via* a telephone cable is described. Typical records are shown in Fig. 3 (scheme Fig. 2). They were interpreted by combining the records at Adlershof and Kochel (§ III); eqn. 6 gives the effective height of the reflection point between the stations on the assumption of optical reflection.

The results of experiments during the months Nov. 1935–Feb. 1936 are discussed with reference first to the states of the ionosphere at the two stations (§ B I). It is found that these correspond in general but that the electron concentration during the night decreases sooner at Adlershof than at Kochel. The bearing of the influence of geographical longitude and latitude on this is discussed; no definite conclusion is reached as to which has the larger effect. Further observations on the relative rise of electron density during morning hours are needed for this. Curves showing the variation with time of the effective layer heights at the two stations are given in Figs. 4, 5. The effects of short-period disturbances and of abnormal E ionisation are generally different at the two stations.

At oblique incidence (§ B II) echoes may be present when they are absent at vertical incidence; the effective heights of the various regions may also be greater for oblique incidence since the waves have then longer paths in regions where their group velocity is small. The various possible paths are enumerated and illustrated by the record in Fig. 8. Fig. 9 shows the two paths which the waves may take when the frequency is almost critical, one given by optical reflection and the other by penetration of the waves for a short distance into the ionised region (*see* also Lassen, *Jahrb. d. drahtl. T. u. T.*, 1926, Vol. 28, p. 139). Consideration of how this case will be expressed in the records leads to the conclusion that just before fade-out these wlll take the form shown in Fig. 10, in which two echoes gradually draw nearer until they finally join and the trace goes no further. This case has been regularly found to occur in practice with the reflections from F region, and is illustrated in Figs. 11, 12; it has not yet been observed with E echoes.

3975. ABNORMAL IONISATION OF THE IONOSPHERE [E Region].—F. Schultheiss. (*Hochf:tech. u. Elek:akus.*, July, 1936, Vol. 48, No. 1, pp. 7–21.)

For apparatus used *see* 16 of January and back references. The experiments here described refer to the period 15.9.1934, to 1.8.1935 and in particular to the abnormal ionisation of E region; the writer aims at a systematic investigation and classification of its properties (a list of papers in which the subject has already been discussed is given on p. 21). He characterises as "abnormal" (§ A I) cases when the ionisation increases during the night or after the intensity at the ground of the sun's radiation has passed its maximum. The occurrence and typical characteristics of abnormal E ionisation (§ A II) are illustrated by records (Figs. 2, 3); no increase in the effective height of F region is found when the frequency approaches the critical frequency of abnormal E region. Figs. 4 a, b, c show what happens during short periods of abnormal E ionisation. The ionisation gradient is discussed with examples; the maximum electron concentration of abnormal E region can be higher than that of E or F region. The occurrence of intermediate regions and magnetic splitting in abnormal E region is shown in Figs. 6, 7. Inversion of heights may occur (§ A II 4) with moderate abnormal ionisation and weak normal E ionisation. The absolute values of the concentration for normal and abnormal E ionisation are compared (§ A II 5); simultaneous reflection at different regions may occur (Fig. 10). This may be due to partial reflection or to electron clouds (Fig. 11). A statistical treatment of the frequency with which abnormal E ionisation occurs is given in § A III; there is no preferred time of day or night for its occurrence. Its seasonal occurrence fluctuates strongly but shows no regular behaviour.

Intermediate reflections are discussed in § C; the possible ray paths are enumerated (§ C I; Fig. 14) and typical examples given (§ C II, III). It is found that intermediate reflections only occur when abnormal E ionisation is present. Observed effective heights given by intermediate reflections are discussed in § C IV, with the theoretical effect of thickness of the ionised region and group velocity delays. It is found to be most probable that abnormal E region is extremely thin as a rule but that electron clouds may occur in it which cause retardation. The relative frequency of the various types of intermediate reflection is discussed (§ C v). Abnormal phenomena in F region (§ D) are not found except for the "evening concentration" first noted by Rukop & Wolf (1932 Abstracts, p. 275).

3976. Abnormal Attenuation in Short Radio Wave Propagation [lasting from 15 Min. to over an Hour, at Intervals between Feb. and May, 1936: Heavy Attenuation in 4–20 Mc Band, Not Much Effect in 35 Mc Band: Short-Distance and Long-Distance Communication affected].—D. Arakawa. (*Rep. of Rad. Res. in Japan*, May, 1936, Vol. 6, No. 1, pp. 31–38: in English.)
A pronounced example was that of 8th Feb. 1936. The effects must be closely related to solar activities (they are noticed mostly on the daylight routes): they are less marked in high-latitude routes (contrary to magnetic storm effects). High noise often accompanies the sudden fadings, especially in local circuits. *Cf.* Leithäuser, 3674 of October.

3977. A Large Sunspot [Development while crossing Sun's Disc, Aug. 25–Sept. 6].—(*Nature*, 5th Sept. 1936, Vol. 138, p. 399.)

3978. Sunspots [Theory that Sunlight is produced by Emanations from Radio-Active Solar "Crust" entering Earth's Atmosphere: Sunspots due to Penetration of Radio-Active Crust by Non-Radio-Active Material].—F. E. Stowe. (*Journ. Inst. Engineers*, Australia, July, 1936, Vol. 8, No. 7, p. 268). A slight increase of temperature is first produced on earth while the spot is forming, followed by a temperature drop (partly masked by convection) and widely varying and disturbed conditions.

3979. Oxygen Content of the Stratosphere [Decrease at 20 km and above: Height of Ozone Layer should be Lower in Polar than in Equatorial Regions].—E. Regener. (*Nature*, 26th Sept. 1936, Vol. 138, p. 544.)

3980. A Photoluminescent Phenomenon in the Upper Atmosphere: Excitation by Solar Light of the Oxygen Line 6300 Å [Altitude/Intensity Curve].—J. Cabannes and H. Garrigue. (*Comptes Rendus*, 31st Aug. 1936, Vol. 203, No. 9, pp. 484–487.) For previous work *see* 2910 of August.

3981. High-Pressure Afterglow in Nitrogen [Discussion of Energy Levels: Mechanism for Regeneration of Metastable Atoms], *and* Two Afterglow Phenomena in Nitrogen [Relative Intensities of Certain Bands: Most Probable Origin of Auroral Spectrum lies in Excitation of "Auroral" Active Nitrogen].—J. Kaplan. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, pp. 384–385: p. 390: abstracts only.)

3982. Recombination in the Negative Glow. Investigations in Hydrogen [Measurements with Network Probe].—H. Fischer. (*Ann. der Physik*, Series 5, No. 1, Vol. 27, 1936, pp. 81–91.)

3983. Ionisation, Excitation and Chemical Reaction in Uniform Electric Fields. I—The Townsend Coefficient of Ionisation [Calculation of Absolute Values in Various Gases: Comparison with Experimental Results].—K. G. Émeleus, R. W. Lunt and C. A. Meek. (*Proc. Roy. Soc.*, Series A, 17th Aug. 1936, Vol. 156, No. 888, pp. 394–411.)

3984. Absolute Values of the Electron Drift Velocity in the Rare Gases [measured with High-Frequency Electrical Shutter: Effects explained by Inelastic Collisions of Electrons with Atoms or Molecules].—R. A. Nielsen. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, p. 386: abstract only.) *See* also 2348 of June.

3985. Distribution of the Energy in the Extreme Ultra-Violet of the Solar Spectrum [and an A.F. Generator varied in Frequency by Very Small Photocell Currents, for Sounding Balloon Transmitter].—W. W. Coblentz and R. Stair. (*Journ. of Res. of Nat. Bur. of Stds.*, July, 1936, Vol. 17, No. 1, pp. 1–6.)
Special triple-electrode neon tubes were first tried (Fig. 3), but (although these "may find valuable applications in the operation of relays without the use of auxiliary radio amplifying apparatus") the final arrangement (Fig. 4), using instead a standard radio valve in the way described by Herold (77 of January), "was about one hundred times as sensitive . . . and should be practical for measuring currents as low as about 10^{-12} or 10^{-13} ampere." In operation, the variable condenser is adjusted to give a suitable audio signal when the photocell is illuminated; on covering the cell the signal frequency decreases to one or two cycles per second.

3986. On the Propagation of Disturbances in Water Channels [Treatment by Operational Methods].—A. M. Angelini. (*L'Elettrotec.*, 25th Aug. 1936, Vol. 23, No. 16, pp. 486–494.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

3987. Atmospherics and Meteorology [Correlation between Atmospherics (recorded on 30 m) and Ionospheric-Layer Observations].—G. Leithäuser. (*Funktech. Monatshefte*, August, 1936, No. 8, pp. 317–318.)
Summary of an address to the VDE on observations extending from Autumn, 1935, to the present time. "The results were of great interest. If, by the 75 m pulse tests, no layer was observed, the number of atmospherics was small. On the appearance of the layer it increased. Every change in height of the layer showed itself in a change in the number of atmospherics. For a marked rise of the layer, the number decreased during the rise; during

a fall of the layer it increased. Just before the beginning of a rise of the layer, a clear increase in the number generally occurred. Apparent splitting-up of the layer also produces at first an increase. With multiple reflection of the electric waves at, for example, the F layer, it is possible and probable that a number of atmospherics are extinguished by interference.

"The daily curve of atmospherics shows few sources in the morning; at noon, an increase up to a maximum in the afternoon and at sunset. At night there is again a decrease; the morning appearance of the layer is associated with an immediate increase in atmospherics. For the observation of the general meteorological situation it is important to follow on the one hand the dying down of atmospherics in the morning and on the other hand their rise in the early afternoon. The course of events at these times gives information on the presence of low-pressure regions and their nearness. The investigations prove that, with the proper choice of wavelength, the observed number of atmospherics can undoubtedly be used to judge the general meteorological situation. It will, however, be necessary to increase the observational material by continuous recording, so that in the near future reliable conclusions may be drawn."

The atmospherics were received on a highly sensitive receiver connected to an apparatus (devised by Menzel) by which they were counted by a telephone counter, while the quantity of electricity was recorded by an electricity meter. The artifice employed was that the voltages produced by the atmospherics released a note frequency. The short 30 m wavelength was chosen for particular attention because the atmospherics due to lightning were greatly reduced on this wavelength, the majority of those recorded coming apparently from cold fronts.

3988. WEATHER CYCLES AND THEIR CAUSES [Earth and Sun surrounded by Gyrating Electron Shells permitting or retarding Reception of Sun-Emitted Electrons by Earth's Atmosphere: 23, 5.72 and 2.8-Year Cycles not related to 11-Year Sunspot Cycle].—H. P. Gillette. (*Science*, 14th Aug., 1936, Vol. 84, p. 145: summary only.)

3989. IMPULSE VOLTAGES CHOPPED ON RISING FRONTS [as produced by Direct Lightning Strokes].—P. L. Bellaschi. (*Elec. Engineering*, September, 1936, Vol. 55, No. 9, pp. 985–990.)

3990. CATHODE-RAY-OSCILLOGRAPHIC STUDIES OF THE PROPAGATION OF SURGES IN NETWORKS, AND OF THEIR PENETRATION INTO THE WINDINGS OF ELECTRICAL MACHINES.—J. Kopeliowitch and P. Fourmarier. (*Rev. Gén. de l'Élec.*, 8th and 15th Aug. 1936, Vol. 40, Nos. 6 and 7, pp. 163–176 and 197–206.)

3991. SOME REMARKS ON THE PAPER: "CLOUD-CHAMBER INVESTIGATIONS OF ELECTRICAL BREAKDOWN IN GASES" BY E. FLEGLER AND H. RAETHER.—R. Holm. (*Zeitschr. f. Physik*, No. 1/2, Vol. 102, 1936, pp. 138–142.) For the paper in question *see* 2536 of July.

3992. THE NATURE OF THE EFFECT OF THE SIGN OF CHARGE ON IONS IN THE C.T.R. WILSON CLOUD CONDENSATION EXPERIMENTS [Character of Impurity Molecules does not exert Marked Influence on Sign Preference: Assumptions in Theory of Condensation].—A. F. Kip and L. B. Loeb. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, p. 392.)

3993. THE CONTROL GAP FOR LIGHTNING PROTECTION.—R. Higgins and H. L. Rorden. (*Elec. Engineering*, September, 1936, Vol. 55, No. 9, pp. 1029–1034.)

3994. THE SIZE OF ATMOSPHERIC NUCLEI: SOME DEDUCTIONS FROM MEASUREMENTS OF THE NUMBER OF CHARGED AND UNCHARGED NUCLEI AT KEW OBSERVATORY.—H. L. Wright. (*Proc. Phys. Soc.*, 1st Sept. 1936, Vol. 48, Part 5, No. 268, pp. 675–689.)

3995. THE EFFECT OF WIND UPON THE ELECTRIC POTENTIAL GRADIENT AT THE EARTH'S SURFACE [Diurnal Variations accounted for by Phase Relations between Unitary and Local Variations and Prevailing Seasonal and Wind Conditions].—J. G. Brown. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, p. 388: abstract only.)

PROPERTIES OF CIRCUITS

3996. THE LIMITATIONS OF RESISTANCE-COUPLED AMPLIFICATION [and the Relationship between Resistance-Coupled and Tuned Amplifiers: Luck's Curves for Former applicable to Approximate Calculation of Latter: Limitations on Stage Gain and Frequency Band for R-C Amplifier, inherent in Luck's Formula: Use of Pliodynatron to exceed These Limitations].—W. F. Curtis. (*Proc. Inst. Rad. Eng.*, September, 1936, Vol. 24, No. 9, pp. 1230–1238.) The resemblances and differences between the resistance-coupled pliodynatron and Cabot's "resistance-tuned" amplifier (1934 Abstracts, p. 497) are discussed. For Luck's paper *see* 1932 Abstracts, p. 635.

3997. THE NATURE OF ELECTRON COUPLING [and Its Advantages and Field of Application in Transmitters and Receivers].—A. Rapp. (*Funktech. Monatshefte*, August, 1936, No. 8, pp. 284–286.)

3998. APPLICATION OF NON-LINEAR MECHANICS TO SOME PROBLEMS OF MODERN RADIO TECHNIQUE [Report to U.R.S.I. Committee].—N. Kryloff and N. Bogoliuboff. (*L'Onde Élec.*, August, 1936, Vol. 15, No. 176, pp. 508–531.)

1. Theoretical results (and the authors' use of semi-convergent series of the type employed in astronomy: comparison of the equations of the first approximation, thus obtained, with the strict solutions: the use of the "mean impedance": analysis of triode oscillators: etc.). 2. New foundations of the theory of auto-excitation of oscillations in circuits containing a variable parameter (and the use of the "mean impedance" to derive the equations of the first approximation:

detailed study of the circuit as a generator: a non-linear element, such as an iron-cored choke, is necessary for the existence of stable régimes). 3. Oscillators in the condition of "synchronous excitation" (with parameters so adjusted that outside resonance small oscillations die out while at resonance they grow: applicable as amplifiers of power or as non-linear filters for the protection of radiotelegraph receivers against parasites). For earlier work *see* 1934 Abstracts, p. 33 and back references: *also* 914 of 1935.

3999. THE NON-LINEAR THEORY OF THE MAINTENANCE OF OSCILLATIONS.—Ph. le Corbeiller. (*Journ. I.E.E.*, September, 1936, Vol. 79, No. 477, pp. 361–378.) The full paper, a *Wireless Engineer* summary of which was referred to in 2218 of 1935. For a previous paper *see* 1933 Abstracts, p. 445.

4000. ON THE HARMONIC EXCITATION OF A PARAMETRICALLY COUPLED SYSTEM WITH TWO DEGREES OF FREEDOM.—A. N. Charakhch'yan. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 6, 1936, pp. 1230–1243.)

In studying the operation of a system with periodically varied parameters it is usual to consider the auxiliary excitation system as an external harmonic force. In some cases, however, it is also necessary to take into account the retroactive effect of the oscillating system on the auxiliary system. In such cases the two systems can be regarded as being coupled through the varied parameter and acted upon by an external force.

In the present paper a study is presented of one such system, in which the magnetic flux is varied through the cores of two transformers connected in a circuit (Fig. 1) developed by Winter-Günther (1931 Abstracts, p. 437). Differential equations are derived and solutions of these found. Conditions for stable oscillations are determined and an account is given of experiments carried out to check the theoretical results obtained.

4001. SOME [Mathematical] CONSIDERATIONS ON THE CORRECTION OF DISTORTION.—A. A. Kharkevich. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 6, 1936, pp. 1071–1075.)

The question of distortion and correction is treated generally from the standpoint of differential equations representing the system under investigation. It is shown that distortion in a system decreases when the terms of the differential equation containing derivatives of the function are small in comparison with the term containing the function itself. This may be met by a suitable alteration of the system. If, however, the term independent of derivatives does not appear at all in the equation, or for some reason or other cannot be increased to the desired magnitude, the necessary correction can be introduced by the addition of another system, the equation of which would give the desired compensation. The method proposed is illustrated by two examples.

4002. THE "BENDING" THEORY OF SYMMETRICAL ELECTRICAL NETWORKS.—Selach. (*Izvestiya Elektroprom. Slab. Toka*, No. 7, 1936, pp. 40–52.) Conclusion of the paper dealt with in 2941 of August.

4003. DISCUSSION ON "EQUIVALENT CIRCUITS—2 COUPLED CIRCUITS."—Balsbaugh & others. (*Elec. Engineering*, September, 1936, Vol. 55, No. 9, pp. 1037–1039.) *See* 2112 of June.

4004. CIRCULAR LOCI OF CURRENTS AND VOLTAGES IN A GENERAL NETWORK [Theoretical Study at Fixed Frequency: Currents and Voltages follow Circular Loci when Any One Self-Impedance is varied: Numerical Example].—A. C. Seletzky. (*Journ. Franklin Inst.*, August, 1936, Vol. 222, No. 2, pp. 197–209.)

TRANSMISSION

4005. WORKING AT ONE METRE AND BELOW: A NEW TUBE [W.E. 316 A in Heavy Glass Dome-Shaped Bulb] SIMPLIFIES THE PROBLEM: TROUGH LINES [Variation of Zottu's Concentric Lines] SUGGESTED FOR FREQUENCY CONTROL.—R. A. Hull. (*QST*, September, 1936, Vol. 20, No. 9, pp. 22–25.)

Of the new valve (nominal carrier power 6.5 w at 500 Mc/s) the writer remarks that "its ability to take a terrific beating on, say, 600 Mc/s cannot fail to thrill any u.h.f. worker who has been obliged to battle along with tubes designed for the lower frequencies" Of the "trough lines" he says that measurements made by Zottu (2553 of July) indicate that the use of a square section and the elimination of one of the walls does not appreciably influence the performance of the line, while the construction has many advantages.

4006. TRANSMISSION AND RECEPTION OF CENTIMETRE RADIO WAVES [1–10 cm Micro-Waves generated in Long Single-Anode Water-Cooled Magnetron with Short Coaxial Filament: "Filament-Swing" Oscillations: Results and Applications].—C. W. Rice. (*Gen. Elec. Review*, August, 1936, Vol. 39, No. 8, pp. 363–369.)

Large Alnico permanent magnets with truncated conical iron pole-pieces bored axially to house the magnetron tube: adjustable magnetic shunt: small iron ring surrounding air gap (gives 13-fold increase in output). Reception by special triode oscillating in B-K electronic mode. Very good quality speech and music. Detection and speed-measurement of moving objects, by Doppler-effect modulation (Doppler frequency produced by aeroplane "clearly detected out to about one mile"): additional effect ("chopper modulation") due to variation of scattered and reflected radiation: stationary objects detected by modulated transmission which is first "neutralised" in absence of object. Among other applications envisaged are "radiation transmission lines" (*cf.* Marro, 4231, below) for television distribution; radio-beam protection of harbours, etc; "fog light" for navigational purposes; radio-echo altimeter; etc.

4007. DIAGRAMS OF THE ELECTROSTATIC FIELD IN MULTIPLE-ANODE MAGNETRONS.—Groszkowski and Ryżko. (*Wiadomości i Prace Państ. Instytutu Telekom.*, Warsaw, No. 6, Vol. 6, pp. 25–28: in Polish.) *See* 2127 of June.

4008. THEORY OF ELECTRON OSCILLATIONS [Review of B-K and G-M Circuits, and a New Treatment on Lines of Ordinary Feed-Back Oscillators].—J. E. Anderson. (*Electronics*, Aug. 1936, Vol. 9, No. 8, pp. 9–11 and 46, 47.)

4009. THE EXCESSIVE LOSSES OF COPPER-TUBE COILS FOR ULTRA-SHORT WAVES: SUPERIORITY OF RIBBON.—Lehmann. (*See* 4210.)

4010. THE NON-LINEAR THEORY OF MAINTENANCE OF OSCILLATIONS.—le Corbeiller (*See* 3999.)

4011. ON THE INFLUENCE OF THE NON-LINEARITY OF THE CHARACTERISTICS ON THE FREQUENCY OF DYNATRON AND TRIODE OSCILLATORS [Formulae based on van der Pol's Non-Linear Analysis, and Their Experimental Confirmation: a Dynatron Circuit with Symmetrical Characteristic].—C. J. Bakker and C. J. Boers. (*Physica*, July, 1936, Vol. 3, No. 7, pp. 649–665: in English.)

4012. INVESTIGATIONS ON THE ELECTRIC ARC (THE MERCURY-ARC GENERATOR).—Scharff. (*Hochf:tech. u. Elek:akus.*, July, 1936, Vol. 48, No. 1, pp. 22–32.)

The aim of this work was the investigation of the generation of h.f. oscillations by a mercury arc in parallel with an oscillatory circuit. Fig. 1 shows the circuit for measurements with an a.c. arc, Fig. 2 that for a d.c. arc. Oscillograms (Fig. 2) show the h.f. oscillations during the transitions from glow to arc discharge with an a.c. arc. They were not produced continuously but occasionally during a large number of a.c. periods. Details of apparatus for the d.c. arc are shown in Figs. 4–6. Steady h.f. oscillations were produced only when the arc was fixed by introducing hydrogen into the discharge tube at suitable pressure (§ II). These oscillations are described in § III and illustrated by cathode-ray pictures (Figs. 13–17). They were strong at wavelengths down to 800 m; the writer could not obtain them at wavelengths below 300 m. They were undamped oscillations of the first kind, of amplitude very little below the value of the direct current in the arc. Oscillations of the third kind and "trip" oscillations could also be produced. The optimum working conditions are described in § IV. Plasma oscillations were also observed (§ V; Figs. 25, 26); they appeared to be independent of the oscillatory circuit in parallel with the arc.

4013. THE ELECTRICAL STABILITY OF CONDENSERS [Predominance of Temperature Variation as Cause of Undesired Capacitance and Power-Factor Changes: Analysis of Causes of Abnormally Large Temperature Coefficients: General Lines for Minimisation of Temperature Coefficients (and particularly the Choice of Dielectrics and Insulators): Methods of Compensation and Their Defects: Advantages of Bimetallic Expansion Devices for Air-Dielectric Condensers: Design of Such a Condenser: Bibliography].—H. A. Thomas. (*Journ. I.E.E.*, September, 1936, Vol. 79, No. 477, pp. 297–335: Discussion pp. 336–341.) Complementary to the writer's treatment of inductances (82 of January).

4014. QUARTZ CRYSTALS FOR THE CONTROL AND MEASUREMENT OF FREQUENCY.—Builder. (*See* 4169.)

4015. SOME TRICK CRYSTAL CIRCUITS [for Small Short-Wave Transmitters: including a Push-Pull Circuit *without* Suppression of Second Harmonic].—J. S. Brown. (*QST*, September, 1936, Vol. 20, No. 9, pp. 19–21.) Experimental results in evolving the oscillator referred to in 3339 of September.

4016. UNDESIRED FREQUENCY MODULATION [as a Frequent Cause of Distortion in Output of Receiver: Stray Coupling between Modulation and Master-Oscillator Circuits as a Cause: Permissible Value of Undesired Frequency Modulation (in particular for Signal Generators used in plotting Selectivity Curves of All-Wave Receivers): Methods of Measurement, including a Rapid Cathode-Ray-Oscillograph Method].—L. G. Dobbie. (*A.W.A. Tech. Review*, July, 1936, Vol. 2, No. 3, pp. 92–103.) Roder's analysis (1932 Abstracts, p. 162) is used, some of his formulae being presented in alternative forms more convenient for the purposes of this paper.

4017. ON THE EFFECT OF INTERFERENCES WHEN RECEIVING BY ARMSTRONG'S FREQUENCY-MODULATION METHOD.—Siforov. (*See* 4030.)

4018. PHASE MODULATION OF RADIO TRANSMITTERS.—E. Meinel. (*E.N.T.*, July, 1936, Vol. 13, No. 7, pp. 235–245.)

An investigation of the degree to which Fitch's theory of phase shift (1932 Abstracts, p. 520) is valid and of the accuracy with which the oscillating circuits of a transmitter must be tuned in order to avoid non-linear distortion. I. *Theory*. § A. General remarks on resonance and detuning of oscillating circuits. §§ B and C. Fitch's theory; discussion of Class A and Class B amplifiers. II. *Experiment*. § A. The mixture of high frequencies produced by simultaneous amplitude- and phase-modulation was analysed into its component frequencies with a square-law electrometer (circuit Fig. 3, with string electrometer whose resonance curve is shown in Fig. 4). Spectra of the same sound obtained with the electrometer and with a detector are shown in Fig. 5 a, b. § B. Results of measurements with a four-stage transmitter (circuit Fig. 6) are given. Fig. 7 shows its statical modulation characteristics: in Fig. 8 these are given for various amounts of detuning of the anode circuit of the modulation stage. They are linear, which is a necessary but not sufficient condition for avoidance of non-linear distortion; their steepness decreases as the amount of detuning increases. Table 1 shows the decrement of the oscillating circuit for various degrees of detuning. It remains practically constant. Fig. 9 gives the side-band frequencies with simultaneous amplitude- and phase-modulation, for various degrees of detuning. Second-order side-band frequencies do not become inconveniently large until the detuning is considerable. A small degree of detuning gives rise to noticeable asymmetry in the amplitudes of first-order side-bands. This asymmetry is investigated further as a function of degree of detuning and modulation frequency. Asymmetry of phase behaves in a similar way. § C. The non-linear distortions in the reception of asymmetrical two-side-band modulation are calculated (vector diagram Fig. 10). The envelopes of the amplitude-modulated oscillations are shown in Fig. 11, for symmetrical and asymmetrical two-side-band modulation and for one-side-band modulation. A small degree of amplitude assymmetry may give rise to a "klirr" factor of from 3 to 5 per cent. § D. A new valve phasemeter for the phase-pure tuning of anode circuits is described (circuit Fig. 12, resonance curves Fig. 13).

4019. ON METHODS OF MULTIPLEX RADIO TELEGRAPHY.—P. I. Evdokimov. (*Izvestiya Elektroprom. Slab. Toka*, No. 7, 1936, pp. 31–40.)

A systematical survey is given of all the methods by which it is possible in principle to effect simultaneous transmission of two telegraph messages from a single transmitter. It is obvious that for simultaneous transmission of two messages *A* and *B* there are periods during which the station must transmit signals relating to (i) *A*; (ii) *B*; (iii) *A* and *B*; and (iv) neither *A* nor *B*. Considering the equation for an unmodulated continuous wave $i = I_m \sin(\omega t + \phi)$ it is seen that periods i, ii and iii can be differentiated by varying either the amplitude, frequency, phase, or a combination of any two of these parameters. Applying this reasoning to the cases of M.C.W. telegraphy and telegraphy with suppressed carrier, all possible methods of simultaneous transmission are considered. These are presented in a number of tables in which the relative advantages and disadvantages of each method are stated, together with observations as to the desirability of further work in this particular direction.

The main conclusion reached is that only with systems based on phase variation (*cf.* 2612 of 1935) can multiplex transmission be carried out without either impairing the efficiency of the transmitter or extending the width of the frequency channel required.

4020. A NEW HIGH-EFFICIENCY POWER AMPLIFIER FOR MODULATED WAVES.—W. H. Doherty. (*Proc. Inst. Rad. Eng.*, September, 1936, Vol. 24, No. 9, pp. 1163–1182.) The full paper, abridged versions and summaries of which have already been dealt with (*see* 3727 of October).

4021. A VOLUME-COMPRESSING METHOD FOR 'PHONE TRANSMISSION: AUTOMATIC AUDIO GAIN CONTROL USING THE DIFFERENTIAL THERMAL BRIDGE [with Tungsten-Filament Lamps].—W. B. Smith. (*QST*, September, 1936, Vol. 20, No. 9, pp. 28–29.) A variation of about 26 db is reduced to about 10 db, with a time lag of 1/5th to 1/10th second. With special lamps this lag could be made smaller.

RECEPTION

4022. A NOISELESS SUPER-REGENERATIVE RECEIVER FOR ULTRA-SHORT WAVES [using "Anti-Phase" Quenching].—T. Hayasi. (*Rep. of Rad. Res. in Japan*, May, 1936, Vol. 6, No. 1, pp. 13–22: in English.)

"The detector consists of two oscillators, of nearly the same frequency [elsewhere they are described as 'of like frequency,'] to which quenching voltages 180° out of phase are impressed. The tail of the decaying oscillation of one valve is utilised as a shock for initiating the oscillation of the other oscillator. The amplitude of the e.m.f. induced from the decaying tail of oscillation must be slightly larger than the irregular impulses that originate in the oscillator, which is believed to be the ultimate source of the noise. At the same time, in order that its high sensitivity shall not suffer, it must be small compared with the incoming signal voltage." Good results are obtained with wavelengths down to 72 cm. The writer refers to the American "super-infra-generator" receiver (525 of February): its disadvantage "seems to lie in its requiring too many tubes."

4023. SUPERHETERODYNE – SUPER-REGENERATIVE RECEIVERS FOR ULTRA-SHORT-WAVE POLICE SYSTEMS.—Becker and Leeds. (*See* 4232.)

4024. THE THEORY OF THE SUPER-REGENERATIVE RECEIVER.—Lewis and Milner. (*See* 4230.)

4025. ULTRA-SHORT-WAVE FREQUENCY CHANGER [and Methods of Improving Its Performance.].—H. B. Dent. (*Wireless World*, 25th Sept. 1936, Vol. 39, p. 333.)

4026. TRANSMISSION AND RECEPTION OF CENTIMETRE RADIO WAVES [1–10 cm Micro-Waves].—Rice. (*See* 4006.)

4027. THE EXCESSIVE LOSSES OF COPPER-TUBE COILS FOR ULTRA-SHORT WAVES: THE SUPERIORITY OF RIBBON.—Lehmann. (*See* 4210.)

4028. MEASUREMENTS WITH UNDAMPED DECIMETRE WAVES [on Use of Crystal Detectors].—E. C. Metschl. (*Hochf:tech. u. Elek:akus.*, June, 1936, Vol. 47, No. 6, pp. 207–211.)

The measurements were made with undamped 14 cm waves received with a crystal detector, whose behaviour with wavelengths of this order is the subject of this paper. The effect on the sensitivity of varying the pressure of the parts of the detector on one another is discussed in § 1; a steel point was pressed against a silicon surface and each was lengthened so that a half-wave dipole aerial was formed (Fig. 1a); Fig. 1c shows how the pressure could be adjusted. Measurements of the current as a function of the contact pressure are shown for direct voltage across the detector (Fig. 2a), low-frequency (Fig. 2b) and high-frequency (2×10^9 c/s: Fig. 3a) alternating voltage. The theory of the high-frequency pick-up is considered. It is found that the detector can be used normally with decimetre waves if the current in its half-wave aerial and its capacity are correctly determined. Its sensitivity increases as the contact pressure (and therefore surface) decreases;

this is directly opposite to the behaviour at low frequencies. The attenuation in a Lecher wire system is determined (§ 11) by measurement of the decrement from the resonance curve obtained by detuning the system and also from measurements at various frequencies. The difference in the results from those derived theoretically is explained as due to radiation losses.

4029. Oscillating Crystals, and the Possibility of an Amplifying Metal-Oxide Rectifier.—(*Wireless World*, 25th Sept. 1936, Vol. 39, p. 341.)

4030. On the Effect of Interferences when Receiving by Armstrong's [Frequency-Modulation] Method.—V. I. Siforov. (*Izvestiya Elektroprom. Slab. Toka*, No. 7, 1936, pp. 1–9.)

Author's summary :—A short description of a method of receiving frequency-modulated radiotelephone signals proposed by Armstrong is given. The theoretical analysis of the degree of detrimental effect of interferences when using this method is set forth. A comparison of this method with the usual method of receiving amplitude-modulated signals is given. It is shown that the improvement obtained with Armstrong's method, as regards the attenuation of interference, is equivalent to the hundredfold increase of power of the transmitter. The influence of the frequency band-width and interference level on the effectiveness of Armstrong's method is derived.

4031. Technical Progress in the Measures and Devices of Protection against Radio-electric Interference [in France].—M. Adam. (*Génie Civil*, 22nd and 29th Aug. 1936, Vol. 109, Nos. 8 and 9, pp. 159–162 and 182–184.)

The following sources are dealt with separately :—rotating machinery, luminous signs, h.t. lines, tramways, and motor-cars. Baize's tests on the propagation of interference (resonance in the leads sometimes causes a multiplication of a hundred thousand times in the effect of a disturbance, at about 325 m from the source) are then discussed : the first instalment ends with practical results in suppression at the receiving end, by screened down-leads, aerial in prismatic cage earthed through a resistance-capacity system, compensating systems of frame with opposed aerial, etc. The second instalment deals particularly with international committees and with recent reports of results in France and other countries.

4032. The Reduction of Broadcast Interference due to H.T. Insulators [including the Use of Semi-Conducting instead of Metallic Coats].—A. Dennhardt. (*Funktech. Monatshefte*, August, 1936, No. 8, p. 318.) Summary of VDE paper.

4033. Calculation of Mains-Hum Voltages in Mains Units [with Help of Nomograms].—K. Nentwig. (*Funktech. Monatshefte*, August, 1936, No. 8, pp. 314–317.)

4034. The Third Harmonic in Amplifiers with Negative Feed-Back [Black's Approximate Solution not always sufficiently Accurate : a More Exact Treatment : Third Harmonic and Third-Order Combination Oscillations, produced by Curvature of Characteristic, may be Increased instead of Decreased by Weak Negative Feed-Back].—R. Feldtkeller : Black. (*T.F.T.*, August, 1936, Vol. 25, No. 8, pp. 217–218.)

4035. Measurements of the Selectivity of Receivers.—P. David. (*L'Onde Elec.*, September, 1936, Vol. 15, No. 177, pp. 533–568.)

Paper read before the Société des Radioélectriciens. The C.C.I.R. definition of selectivity, and its incompleteness : a suggested improvement. The complications caused by the variation of selectivity with input and output levels (and the distinction between " linear " detection as regards a single isolated signal and as regards several superimposed signals). The " single-signal " method of selectivity measurement (two variations —constant input and constant output levels) : the " two-signal " method (three variations) : different results on same receiver by the two methods (Fig. 12), with analysis of the cause : C.C.I.R. recommendation of the latter method. Other conditions affecting the selectivity : choice of artificial aerial : type of signal utilised : defects in the r.f. generator (earthing effect or capacity to earth, frequency modulation, harmonics—the last effect often under-estimated because the amplitude of the " fringes " is supposed to be " relatively small," whereas even a 1% harmonic can make an enormous difference in the curve of a highly selective receiver) : adjustments of the receiver : direct action of a strong interfering field on leads, coils, etc. Two ways of using the selectivity curves—for the study of the receiver or for allotting wavelengths, etc., by the use of such information as is given in Table II and in propagation curves : the latter use demands that the methods of measurement should be carefully standardised in such a way that the selectivity curves may be reliable within a few decibels.

4036. The Alignment of Broadcast Receivers [High-Fidelity Superheterodynes with Variable Selectivity] by a Cathode-Ray Oscillograph Method.—E. Severini. (*Alta Frequenza*, September, 1936, Vol. 5, No. 9, pp. 539–550.)

4037. Lines of Development of Broadcast Receivers [Critical Examination of the Five Prominent Types for 1936].—H. Penner. (*Zeitschr. V.D.I.*, 29th Aug. 1936, Vol. 80, No. 35, pp. 1084–1086.)

This year the German receiver industry appears to have concentrated particularly on five types : the 2-valve 1-circuit and 3-valve 2-circuit " straight " receivers, the 3- and 4-valve superhets, and the 2-valve 1-circuit " reflex " receiver (simplified circuit Fig. 1). The writer considers whether these designs are correct in their relations between price and performance (including ease of adjustment). He concludes that the difference in price between the 3-valve and 4-valve superhets does not correspond to the difference in the merits of the two types, in view of the high performance of the 4-valve type; more especially the 4-valve type with 3 variable circuits, where the simple input circuit of the 2-variable-circuit type (which, in spite of the 2 i.f. filters, has to have a fairly sharp resonance curve for the sake of selectivity, and which therefore causes a certain high-note cut-off) is replaced by a band filter. "These 4-valve receivers with 3 variable circuits well fulfil every requirement that can be demanded as regards the easiest adjustment and the highest selectivity and fidelity." Although the 3-valve superhet possesses possibilities of improvement, such improvement would raise its price, so that the discrepancy would still remain.

Regarding the "straight" receivers, the writer considers that the difference in ease of adjustment between the 2-valve 1-circuit and the 3-valve 2-circuit types is so great that the 2-valve 1-circuit "reflex" receiver must be considered to form an important stage half-way between the two. Day reception on this receiver (which has a h.f. amplifier aperiodically coupled to a duo-diode, not "counted" as a valve because it is a detector, from which the a.f. is taken back to the first valve, amplified, and then brought to the second, output valve) is equal to that of a 3-valve 2-circuit receiver; thanks to the h.f. amplication, the aerial coupling can be loose (and thus can be varied without serious de-tuning) so that for evening reception the selectivity is quite good, though not equal to that of the 2-circuit receiver.

4038. THE GERMAN "OLYMPIA PORTABLE" RECEIVER [Description of Winning Design, now on Market].—E. Schwandt: Stanienda. (*Funktech. Monatshefte*, August, 1936, No. 8, pp. 291–292.) Designed for the German Broadcast Wholesalers' competition: a 4-valve 2-circuit hand-portable receiver with p.m. dynamic loudspeaker, medium and long waves: weight 9.35 kg, dimensions 34 × 36 × 11 cm. Sensitivity and selectivity are "quite remarkable," and the quality "astonishingly good."

4039. NEW "CRACK KILLER" CIRCUITS.—T. Sturm. (*Funktech. Monatshefte*, August, 1936, No. 8, pp. 287–289.)

The better types of silent-tuning circuits only remove the blocking of the a.f. circuit when the wanted carrier is accurately tuned-in, the blocking device being supplied by its own rectifier and its own oscillatory circuit (tuned to the carrier) whose damping is kept very low—*e.g.* by regeneration (Fig. 1). With such a circuit there is no actual need of a tuning indicator; but the adjustment is so sharp that to make it foolproof the addition of automatic tuning correction seems justified. As a contrast to such complicated arrangements the writer and Leithäuser have evolved a very simple "crack killer" (Fig. 2) which does not attempt to do away with the tuning indicator but combines with it in such a way that one glow-discharge tube (with a Sirutor rectifier) serves in the double capacity. Fig. 3 shows a still simpler circuit which has, however, certain disadvantages.

4040. AUTOMATIC CONTRAST EXPANSION BY A TWO-VALVE AUXILIARY UNIT [Triode, Hexode and Sirutor Rectifier Combination giving 3 : 1 Expansion].—H. Lamparter. (*Funktech. Monatshefte*, August, 1936, No. 8, pp. 289–290.)

Completion of 3741 of October. For experimental purposes a still greater expansion can be obtained by the addition of a potential divider as in Fig. 3. Certain curious effects when using the normal expander on those gramophone records which were recorded with manual volume control, and on manually controlled broadcasting (particularly speeches) are described. The effect on automatically controlled recordings is, however, excellent.

4041. A.F. VOLUME CONTROL [and Its Advantages in Certain Cases if "Over Control" is avoided].—(*Rad. Engineering*, August, 1936, Vol. 16, No. 8, pp. 11 and 31.)

4042. OSCILLATOR-MIXER DESIGN CONSIDERATIONS FOR THE AMATEUR-BAND SUPERHET [3.5 to 30 Mc/s: the Behaviour of Various New Valves—6L7, 6A8, etc.].—C. B. De Soto. (*QST*, September, 1936, Vol. 20, No. 9, pp. 31–32 and 62, 64.)

4043. DESIGN OF A BROADCAST AND PUBLIC ADDRESS INSTALLATION FOR LARGE FACTORIES.—W. Mörs. (*E.T.Z.*, 27th Aug. 1936, Vol. 57, No. 35, pp. 993–996.)

4044. REMOTE RECEIVER TUNING AT KDYL [for Reception of Short-Wave Press Services: Receiver at Transmitting Terminal, away from Interference at Studios, tuned from Studios over Phantomed Line].—J. M. Baldwin. (*Electronics*, August, 1936, Vol. 9, No. 8, pp. 19 and 31.)

4045. "RÈGLES DE SÉCURITÉ DES APPAREILS RADIOPHONIQUES ET AMPLIFICATEURS RELIÈS À UN RESEAU DE DISTRIBUTION D'ÉNERGIE" [Book Review].—(*Rev. Gén. de l'Élec.*, 29th Aug. 1936, Vol. 40, No. 9, p. 258.) Serving as basis for the allocation of the mark "U.S.E." on mains-driven broadcast receivers, etc.

4046. PAPERS ON WIRELESS RECEPTION IN CAVES AND MINES.—Fritsch. (*See* 4271/3.)

AERIALS AND AERIAL SYSTEMS

4047. A DISCUSSION OF METHODS EMPLOYED IN CALCULATIONS OF ELECTROMAGNETIC FIELDS OF RADIATING CONDUCTORS [Vector-Scalar Potential Method applicable only to Unfed and Unterminated Radiators: Hertz Dipole Method Free from This Limitation: etc.].—A. Alford. [*Elec. Communication*, July, 1936, Vol. 15, No. 1, pp. 70–88.)

"In view of the fact that the limitation of the first method. . . . . is not generally mentioned in the literature, it appears advisable to include a somewhat detailed discussion of this subject." An example is given of the erroneous result of the application of the vector-scalar potential method to a terminated wire where current must enter and leave. The application of the Hertz dipole method to terminated aerials (rhombic, Beverage) and to open-ended conductors is shown; regarding the former, incidentally, it is seen that "an aerial employing terminated conductors is made more efficient by reducing the surge impedance of these conductors." Radiation resistances are calculated: the radiation-resistance/length-of-wire curve for open-ended conductors (obtained on the assumption of equal amplitudes for forward and reflected waves, so as to be comparable with the results of Abraham and of Pistolkors) was found to be wavy and not smooth—"this result is at variance with the accepted radiation-resistance curves found in current literature." The effect of a phase-delay device at the centre of a wire terminated into its surge impedance is considered in some detail.

4048. "ZIEHEN" PHENOMENA IN RADIATION-COUPLED AERIALS.—W. Klein. (*T.F.T.*, July, 1936, Vol. 25, No. 7, pp. 192–196.)

Examining the simple case of two parallel tuned rod-aerials, one of which is set in oscillation, the writer shows that no "ziehen" effect can take place because the damping of the second aerial is too large (its resistance is at least equal to the radiation resistance). If however the damping of this second aerial is reduced sufficiently (without its being set into oscillation) then "ziehen" effects will occur for distances between the aerials of about 0.43 and 0.96 of the wavelength. The influence of the ground is neglected, and the aerials are taken to be at the same height and of the same length.

4049. ON THE CALCULATION OF THE RESISTANCE OF AERIALS [Simple T and Inverted L Types: with Simplifying Tables and Graphs].—G. S. Ramm. (*Izvestiya Elektroprom. Slab. Toka*, No. 7, 1936, pp. 9–20.)

4050. TELEVISION AND THE AERIAL [Aerial Design for Ultra-Short-Wave Reception].—M. G. Scroggie. (*Wireless World*, 28th Aug. 1936, Vol. 39, pp. 198–200.)

4051. ON THE THEORY OF THE WIDE-BAND CO-AXIAL CABLE OF IDEAL DESIGN.—Droste. (*See* 4134.)

4052. THE DECREASE OF EFFECTIVE HEIGHT OF TRAILING AERIALS WITH THE INCREASE IN SPEED OF MODERN AIRCRAFT.—Carr. (In the paper referred to in 4233, below.)

4053. AUXILIARY AIRCRAFT AERIAL WOUND ON PAPER CYLINDER AND SHOT OUT OF SPRING GUN.—(*Communication & Broadcast Eng.*, August, 1936, Vol. 3, No. 8, p. 22: photograph p. 23.)

4054. ARRANGEMENT FOR COMPENSATING THE HORIZONTAL COMPONENT IN FRAME AERIALS [Horizontal Dipoles connected in Series with the Frame].—Lorenz Company. (*Hochf:tech. u. Elek:akus.*, July, 1936, Vol. 48, No. 1, p. 40: German Patent 624 706 of 7.4.1934.)

4055. AERIAL SCREENED FROM NEIGHBOURING INTERFERENCE SOURCES [by Cone-Shaped Conductor, open above and connected to Screened Leads].—Soc. Franç. Radioélectrique. (*Hochf:tech. u. Elek:akus.*, July, 1936, Vol. 48, No. 1, p. 40: French Patent 795 828 of 28.12.1934.)

VALVES AND THERMIONICS

4056. THE W.E.316 A MICRO-WAVE VALVE FOR FREQUENCIES UP TO 750 Mc/s, NOMINAL OUTPUT RATING 8.5 WATTS AT 300 Mc/s AND 4 WATTS AT 600 Mc/s.—Hull. (*See* 4005.)

4057. GRAPHICAL DETERMINATION OF THE ELECTRON PATHS IN A MAGNETIC FIELD.—J. Dosse. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 17, 1936, pp. 315–318.)

Author's summary:—The electron-optical refraction law, which allows a simple graphical determination to be made of the electron paths in plane and circularly symmetrical electric fields, can be applied also [on Störmer's lines] to the plotting of the electron paths in circularly symmetical magnetic fields, by the use of a potential function easily derived from the vector potential or the magnetic field function. As an example, [the paths in] a homogeneous magnetic field of a very thin conductor bent into a circle [basis of magnetic lens] are worked out; the procedure for more complicated cases is indicated.

4058. TRANSIT-TIME EFFECTS IN DIODES, IN PICTORIAL FORM [calculated Curves for Saturated and Space-Charge-Limited Plane Parallel Diodes].—R. W. Sloane and E. G. James. (*Journ. I.E.E.*, September, 1936, Vol. 79, No. 477, pp. 291–296.)

"This method has two advantages over purely analytical methods. It describes the mechanism of the effects, and it shows the presence of harmonics which usually disappear in the approximations made in analysis." The saturated diode appears as a finite resistance in parallel with an effective capacitance greater than the geometrical capacitance: the space-charge-limited diode as a resistance in parallel with an effective capacitance smaller than the geometrical capacitance.

4059. ON THE DESIGN OF ELECTRON-MULTIPLYING DEVICES BASED ON SECONDARY EMISSION. Luk'yanov. (*See* 4122.)

4060. A.C. ELECTRON MULTIPLIERS OF NEW DESIGN [Magnetic Types].—Okabe. (*See* 4123.)

4061. THERMIONIC VALVES—AN ACCOUNT OF SOME RECENT RESEARCH [on Relationships in the Anode Space, leading to Design of "Critical-Distance" Valves].—J. H. O. Harries. (*Journ. of Television Soc.*, March, 1936, Vol. 2, Part 4, pp. 106–116.) Covering the same ground as the paper dealt with in 2182 of June. The subsequent discussion is reported on pp. 116–117: N.P.L. investigations on the behaviour of long-path valves at ultra-high frequencies are referred to. The comparative importance of harmonic distortion on a single sine wave and on a complex wave is discussed.

4062. CONDITIONS IN THE ANODE/SCREEN SPACE OF THERMIONIC VALVES [Elementary Treatment of Potential Distribution in Special Case of Planar Diode, providing Approximation for Anode/Screen Space receiving a substantially "Saturated" Current from Cathode Space].—H. C. Calpine. (*Wireless Engineer*, September, 1936, Vol. 13, No. 156, pp. 473–474.) Prompted by Harries's remark on the difficulties of obtaining useful results from a theoretical consideration of the conditions in the anode/screen space (2182 of June).

4063. THE 6L6 [Metal "Beam-Power" Valve] AS AMPLIFIER AND DOUBLER.—(*QST*, September, 1936, Vol. 20, No. 9, pp. 30 and 52, 54, 56.)

4064. NEW DEVELOPMENTS IN AUDIO POWER TUBES [particularly the Schade Beam-Power Valve, and Its Use of Inverse Feed-Back].—R. S. Burnap: Schade. (*RCA Review*, July, 1936, Vol. 1, No. 1, pp. 101–108.)

4065. THE BEHAVIOUR OF THE NEW VALVES 6L7, 6A8, ETC., IN SUPERHETERODYNE RECEIVERS FOR THE WAVE-RANGE 3.5–30 Mc/s.—De Soto. (*See* 4042.)

4066. NEW TUBES [Triple-Grid Super Control Amplifier 6S7G, Single Diode-High-Mu Triode 6Q6G, Tuning Indicator 6N5, etc.]. —Raytheon Corporation. (*Rad. Engineering*, August, 1936, Vol. 16, No. 8, pp. 19 and 31.)

4067. TRIODE FOR VALVE VOLTMETERS [Osram A 577, Indirectly Heated].—(*Journ. Scient. Instr.*, September, 1936, Vol. 13, No. 9, pp. 304–305.)

4068. JOHNSON NOISE CONFUSED WITH SHOT EFFECT IN GRID/CATHODE SPACE, ON WAVELENGTHS BELOW ABOUT 15 METRES.—S. B. Smith. (In paper dealt with in 4163, below.) At such frequencies, the resistive impedance of the grid/cathode path may constitute a shot-effect generator in parallel with the first circuit of the receiver; the usual "open-and-short-circuit" method of measuring the relative magnitude of Johnson and shot effects is thus liable to confusion.

4069. FLUCTUATION VOLTAGE IN DIODES AND IN MULTI-ELECTRODE VALVES [particularly with Space-Charge Limitation].—F. C. Williams. (*Journ. I.E.E.*, September, 1936, Vol. 79, No. 477, pp. 349–360.)

Further development of the work dealt with in 1793 of May. Eqn. 7 is suggested as satisfactory experimentally, for commercial valves: it involves a correction factor A which is found to be independent of the type of valve, and of the nature of the cathode surface, so long as the operating conditions are such that flicker effect is unimportant: the variation of A under different conditions is studied. Among other points, for low currents A is always unity, and provided the operating conditions are such that A decreases as I increases, flicker effect can be ignored. "The optimum operating conditions as regards signal/noise ratio usually lie in this region, and indirectly-heated oxide-coated cathodes are therefore found to be the most satisfactory on account of the high mutual conductance that can be obtained." ["It is only in circumstances when the amplifier cuts off all frequencies above, say, 100 c/s that it may be advantageous to use a thoriated cathode; for example, in the normal use of electrometer valves"]. A variation of A with frequency is taken as an indication of the presence of flicker effect; the latter predominates over shot effect with oxide cathodes for large anode currents (*e.g.* 5 mA for MH/D4), but presumably the true shot effect of such a valve could be studied by using a frequency high enough to abolish the flicker effect. With multi-electrode valves it is shown that the value of A relevant to the current leaving the cathode is independent of the electrode arrangement and of the subsequent distribution of current between the electrodes; the current to the actual anode should be made a large fraction of the total current so as to preserve a high value of g^2/I, and give (*see* section 5) a correspondingly good signal/noise ratio: incidentally, connecting several similar valves in parallel increases g^2/I proportionately.

4070. SHOT NOISES FROM HIGH-FREQUENCY TETRODES AND PENTODES WITH INDIRECTLY HEATED CATHODES [with Empirical Formula: Ratio of Valve Noise to Thermal Agitation Noise in High-Gain Receiver: etc.].—H. Iinuma and M. Konomi. (*Rep. of Rad. Res. in Japan*, May, 1936, Vol. 6, No. 1, pp. 39–50: in English.) "We see that the tube noise is still somewhat far from being negligible as compared with thermal noise in short-waves receiving sets in which L/CR' is generally very low. It may therefore be concluded that what are wanted are types of tube having a still lower noise e.m.f., *i.e.* still lower I_v/g_m^2.

4071. LIMITS OF AMPLIFICATION [Discussion of Brownian Movement, Shot and Flicker Effects, Influence of Ions, and Microphonic Effect].—S. Dierewianko. (*Wiadomości i Prace Państ. Instytutu Telekom.*, Warsaw, No. 6, Vol. 6, pp. 28–33: in Polish.)

4072. A DOUBLE AMPLIFIER ARRANGEMENT FOR DEMONSTRATING SINGLE THERMIONIC ELECTRONS.—E. H. Winkler. (*Physik. Zeitschr.*, 1st Aug. 1936, Vol. 37, No. 15, pp. 557–558.)

4073. THE ELECTRON EMISSION OF PURE METAL CATHODES: THE REQUIREMENTS OF THE LARGE TRANSMITTING VALVES [and Various Possible Ways of Increasing the Output: Magnetic-Field Difficulty for Large Heating Currents, and Methods of Overcoming It: Use of Tantalum and Niobium in place of Tungsten]. — A. Allerding. (*Funktech. Monatshefte*, August, 1936, No. 8, pp. 281–283.)

4074. HEATER-CATHODE INSULATION PERFORMANCE [Cathode-Ray-Oscillographic Investigation of Effects of Operating Temperature, Heat Treatment, and Impurities on MgO, Al_2O_3, BeO and Other Materials].—H. Klemperer. (*Elec. Engineering*, September, 1936, Vol. 55, No. 9, pp. 981–985.)

4075. INFLUENCE OF CRYSTAL STRUCTURE ON ELECTRON EMISSION FROM "218" TUNGSTEN WIRE [Observations explained by Theory assuming Sinusoidal Variation of Work Function].—W. B. Nottingham. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, pp. 398–399: abstract only.)

4076. FIELD CURRENTS AND THERMIONIC CURRENTS FROM THORIATED TUNGSTEN AND PURE TUNGSTEN [Effect of Breakdown and Low and High Temperature Treatments].—A. J. Ahearn. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, p. 398: abstract only.)

4077. TRANSITION PHENOMENA IN THE CONDENSATION OF SILVER VAPOUR ON CLEAN AND GAS-COVERED TUNGSTEN.—M. N. Sampson and P. A. Anderson. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, pp. 385–386: abstract only.)

4078. THE RELATION BETWEEN ELECTRON FIELD EMISSION AND CONTACT ELECTROMOTIVE FORCE FOR LIQUID MERCURY [Qualitative but not Quantitative Agreement with Theory of Relation between Work Function and Breakdown Field for Distilled Mercury].—D. H. Moore. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, pp. 344–347.)

4079. CONTINUOUS MEASUREMENT OF CHANGES IN THE ELECTRONIC WORK FUNCTION DURING THE FUSION OF TIN.—P. A. Anderson. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, pp. 386–387: abstract only.) *See* also 3071 of 1935 and 1808 of May.

4080. THE INTERACTION OF ATOMS AND MOLECULES WITH SOLID SURFACES. III AND IV—THE CONDENSATION AND EVAPORATION OF ATOMS AND MOLECULES [Theory giving Formulae for Constants in Langmuir's Adsorption Isotherm: Theory of Diffraction and Reflection of Molecular Rays at Crystal Surfaces: Potential Energy of Gas in Field of Solid].—J. E. Lennard-Jones and A. F. Devonshire. (*Proc. Roy. Soc.*, Series A, 1st Aug. 1936, Vol. 156, No. 887, pp. 6–28: pp. 29–44.) For I and II *see* 3463 of 1935.

DIRECTIONAL WIRELESS

4081. DIRECTIONAL ERRORS FROM LOCAL TRANSMITTERS [Local Calibration of Adcock D.F. sometimes more Inaccurate than a Distant One: Theoretical Possible Causes at Transmitter: Experimental Confirmation].—T. L. Eckersley. (*Marconi Review*, May/June, 1936, No. 60, pp. 21–25.)

Theoretically, the transmitter may cause "diagram error" (if its polar diagram is not circular, "there must be a radial h.f. magnetic force which, when linked with a frame aerial, will produce an error": this will decrease as the distance increases) or error due to polarisation distortion. Thus "the use of local transmitters for calibrating a frame aerial or Adcock D.F. (where polarisation error is not wholly eliminated) is not above suspicion." In the test described a T-aerial was used at the transmitter and reception was on a newly erected rotatable spaced-frame arrangement with a h.f. phase-balancer in the central hut, and on a portable frame aerial balanced with respect to its receiver so that there should be no "vertical": the distance was 2.96 km. The spaced-frame receiver (which is independent of polarisation distortion and of diagram error) gave an accuracy within 1/5 degree; but its frames used separately, and also the portable frame receiver, gave errors of about 10° and 18° respectively (on 26 m) and flat and erroneous readings on 30 m. The T-aerial, which was originally drawn up closer to one steel lattice mast than to the other, was then pulled over in the reverse position: the spaced-frame receiver showed a change of only 0.2° (practically corresponding to the change of the mid-point of the aerial) but the bearing on its single separate frame changed from + 12° to + 3°: "it was not accurate even in the symmetrical half-way position, an effect probably due to different electrical characteristics of the two masts."

4082. THE SIMON RADIOGUIDE [for Aircraft: using Two Small Electrostatically Shielded Loops in Zero-Coupling Position at 60° to Each Other and to Transverse Axis of Aeroplane: Free from Night Error: Immune from Rain and Snow Static].—H. W. Roberts: Simon. (*Communication & Broadcast Eng.*, August, 1936, Vol. 3, No. 8, pp. 5–7 and 20.)

4083. VISUAL DIRECTION FINDING [Cathode-Ray-Tube Reception on U.S. Coastguard Aeroplanes].—(*Wireless World*, 18th Sept. 1936, Vol. 39, p. 317.)

4084. THE CATHODE-RAY AIRCRAFT COMPASS [U.S. Coastguard Tests: Directional Accuracy not materially affected by Night Effect: Details of Apparatus: "Stream-Line" Loop Aerial].—S. Ostrolenk: Hefele. (*Electronics*, August, 1936, Vol. 9, No. 8, pp. 12–15 and 45.)

4085. THE EFFECT OF AIRCRAFT DESIGN UPON THAT OF AIRCRAFT RADIO EQUIPMENT.—Carr. (*See* 4233.)

ACOUSTICS AND AUDIO-FREQUENCIES

4086. THE NEW STEEL TONE TAPE MACHINE [Lorenz Company's Steel Band Recorder].—Lorenz Company. (*Elec. Communication*, July, 1936, Vol. 15, No. 1, pp. 62–69.)

For the uniform transport of the 0.08 mm band (3 mm wide) the drive is by a wheel mounted between the two drums: a seamless textile belt presses the band against this wheel. As a result of recent successful trials of this machine by the German Broadcasting Company, "problems involving electro-magnetic tone recording are being given increased attention." *See* also 2218 of June.

4087. PIEZOELECTRIC PICK-UPS [Steps to be taken when Changing-Over from a Moving-Iron Type].—(*World-Radio*, 28th Aug. 1936, Vol. 23, p. 10.)

4088. AUTOMATIC CONTRAST EXPANSION BY A TWO-VALVE AUXILIARY UNIT.—Lamparter. (*See* 4040.)

4089. EXPERIMENTAL INVESTIGATIONS WITH RESONANCE TELEPHONES [Measurements of Efficiency: This depends on Ear except when Long Tubes intervene between Telephone and Ear: Sensitivity of Ear: Discussion of Experimental Methods].—E. Waetzmann and H. Kalusche. (*Ann. der Physik*, Series 5, No. 1, Vol. 27, 1936, pp. 15–28.) For previous work, here confirmed, *see* Waetzmann, 1932 Abstracts, p. 99.

4090. 'PHONES [Design of Earphones for High-Quality Reception].—(*Wireless World*, 11th Sept. 1936, Vol. 39, pp. 276–278.)

4091. THE ELECTROACOUSTIC BASIS OF THE QUALITY OF TELEPHONE APPARATUS [Design of Microphones and Mouthpieces].—T. Korn. (*E.N.T.*, July, 1936, Vol. 13, No. 7, pp. 219–229.)

The experiments described here provided a basis for the design of new telephone microphones and mouthpieces of improved electroacoustic efficiency. Special attention was paid to the transmission of the high frequencies, the most important factor in intelligibility. Fig. 1 shows an arrangement for comparing intelligibility of speech passing through different channels. Sensitivity is discussed in § II; the effect of distance from the microphone for various microphones is shown in Fig. 2. Fig. 4 gives curves showing the variation of microphone impedance with the distance apart of the electrodes, for carbon and gold electrodes; the latter give the better result. The damping introduced by the induction coil is also investigated. Linear distortions (§ III) are described with reference to the mouthpiece (Figs. 8, 9) and the microphone capsule (frequency curves Fig. 10). Non-linear distortions in the microphone capsule (§ IV) are discussed theoretically and with reference to the microphone characteristics (Fig. 13). Fig. 14 shows a movable microphone electrode, free from distortion, Fig. 15 the "klirr" factors of various microphones as a function of the output. The properties of the microphone designed by the writer as a result of this work (electrode in Fig. 14) are practically independent of its position (§ V; Figs. 17, 18).

4092. A NEW METHOD OF CALIBRATING A CONDENSER MICROPHONE.—V. Thorsen. (*Zeitschr. f. Physik*, No. 9/10, Vol. 101, 1936, pp. 578–592.)

This method permits the complete calibration of the microphone, both as regards acoustic pressure and field, to be carried out in one field of sound waves. The microphone is placed in a standing-wave system; the disturbance it causes is measured by a Rayleigh disc. Calculations of the wave-fields are given on the assumption that the microphone is a radiator of zero order, for long waves a pulsating sphere and for short waves a piston membrane. Experimental results including the distortion factor are given.

4093. THEORY OF THE LOUDSPEAKER AND OF MECHANICAL OSCILLATORY CIRCUITS: PART II.—H. Roder. (*Rad. Engineering*, August, 1936, Vol. 16, No. 8, pp. 21–25.) For Part I *see* 3804 of October.

4094. A NEW SYSTEM FOR THE DISTRIBUTION OF SOUND OVER LARGE AREAS [such as the Grand Stands of a Sports Stadium: Auxiliary Rows of Loudspeakers fed with Suitable Time Lag].—C. Trage: Gladenbeck and Flanze. (*T.F.T.*, May, 1936, Vol. 25, No. 5, pp. 120–123.) Magnetic time-delay methods were abandoned (though their development will no doubt continue) in favour of the use of a suitable length of buried tube (P.O. pneumatic dispatch tube) with a loudspeaker at one end and a condenser-microphone at the other. Results were excellent.

4095. "SOUND REINFORCING" SYSTEMS [for Theatres and Outdoor Gatherings: also "Public Address" and "General Announce and Paging" Systems].—H. F. Olson. (*RCA Review*, July, 1936, Vol. 1, No. 1, pp. 49–59.)

4096. THE SOUND EQUIPMENT OF THE DIETRICH-ECKART OPEN-AIR THEATRE ON THE STATE SPORTS GROUND [for an Audience of 20 000].—L. Bialk and A. Mainka. (*Zeitschr. V.D.I.* 29th Aug. 1936, Vol. 80, No. 35, pp. 1087–1089.)

4097. DESIGN OF A BROADCAST AND PUBLIC ADDRESS INSTALLATION FOR LARGE FACTORIES.—W. Mörs. (*E.T.Z.*, 27th Aug. 1936, Vol. 57, No. 35, pp. 993–996.)

4098. THE BELL TELEPHONE MANUFACTURING COMPANY'S "SPEECH TRANSLATING SYSTEM" FOR CONFERENCES.—(*Elec. Communication*, July, 1936, Vol. 15, No. 1, pp. 98–99.)

4099. THE FÖRSTER "ELECTROCHORD" [Electric Grand Piano].—O. Vierling. (*Zeitschr. V.D.I.*, 29th Aug. 1936, Vol. 80, No. 35, pp. 1069–1074.)

The conversion of the vibrations of the strings with electric currents is by a capacity-change method free from the distortion given by the older electro-magnetic method. It has been found that the essential tone of a good piano demands the presence of a sounding board—nothing can replace it: here it has been reduced to about half the full length of the strings, so as to radiate as little as possible—and also special attention to the torsional vibrations (perpendicular to the direction of striking) of the bridge: this is achieved by the provision of special pick-ups for this purpose. Various tone colours are obtained by the use of four lines of pick-ups, at different points along the strings; the line for the natural piano tone is at the extreme end of the strings and, unlike the others, is above the strings. These lines can be used separately or in combination, thus providing a number of different tone colours. Further, the building-up and decay processes can be controlled electrically by resistance-capacity circuits, with switching-in contacts worked by the keyboard action: this mechanism can be put out of use by a pedal, so that for piano tone, for example, the "touch" may not be affected in the slightest degree. The main amplifier and loudspeaker combination gives the "loudest" piano strength (85 phon at a distance of 2.5–3 metres) with a non-linear distortion factor (at 800 c/s) of only about 2%, while according to Janovsky such distortion, in a piano, is only noticeable when the factor is 5% or over.

4100. PHYSICAL AND TECHNICAL FOUNDATIONS OF LISTENING APPARATUS FOR AIRCRAFT NOISE [Components of Total Noise: Silencing: Propagation: Requirements of Listening Apparatus: Procedure: Design].—E. Kutzscher. (*Zeitschr. V.D.I.*, 15th Aug. 1936, Vol. 80, No. 33, pp. 995–1000.) With literature references, all German except one Japanese.

4101. DIRECTION FINDING BY SOUND [General Account of Modern Methods, Sound Locators, etc.]—W. S. Tucker. (*Nature*, 18th July, 1936, Vol. 138, pp. 111–118.)

4102. POWER AMPLIFIERS FOR REDIFFUSION.—Adorjan. (*See* 4240.)

4103. ON THE CORRECTION OF AMPLIFIERS AT LOW FREQUENCIES.—Braude. (*See* 4130.)

4104. RESISTANCE-COUPLING DESIGN CHARTS [for Audio-Amplifiers: Separate Charts for Low, Medium and High Frequencies].—G. Koehler. (*Electronics*, August, 1936, Vol. 9, No. 8, pp. 25–26.)

4105. THE THIRD HARMONIC IN AMPLIFIERS WITH NEGATIVE FEED-BACK.—Feldtkeller: Black. (*See* 4034.)

4106. DISCUSSION OF THE AMBIGUITY IN THE DEFINITION OF "COMPLEX POWER" [in connection with Telephone Transformers]. —Treves: Calosi. (*Alta Frequenza*, September, 1936, Vol. 5, No. 9, pp. 576–579.) Prompted by Part I of Calosi's paper (3835 of October).

4107. PAPERS ON TRANSFORMERS: SHIELDING CONSIDERATIONS.—Constable & Aston: Heald: Oatley: McLachlan. (*See* 4221/4.)

4108. MEASUREMENTS OF NOISE [in terms of British Standard Phon, by Two-Telephone Meter with Calibrated Reference Tone].—B. G. Churcher and A. J. King. (*Nature*, 22nd Aug. 1936, Vol. 138, p. 329.)

4109. AUTOMATIC LINE-LEVEL RECORDING APPARATUS [for the Routine Checking of Transmission Lines and Apparatus for Broadcasting].—F. A. Peachey. (*Wireless Engineer*, September, 1936, Vol. 13, No. 156, pp. 462–472.) Giving results accurate within 1 db in a range of 20 db. Closer investigations can be made at any time by manual operation. Details are included of the construction of the cam to drive an ordinary condenser so as to vary the frequency according to the time law specified by the C.C.I.F.

4110. INSTRUMENTS FOR THE OBJECTIVE MEASUREMENT OF NOISE.—H. Sell. (*Hochf:tech. u. Elek:akus.*, July, 1936, Vol. 48, No. 1, pp. 34–38: Industry Review.)

A description of the noise meters recently developed by Siemens & Halske. The principles underlying the subjective and objective measurement of noise are discussed. The properties required for the pick-up microphone are defined; a condenser microphone is chosen for low and high intensities; its output is directly proportional to the acoustic pressure and it has uniform sensitivity over the audio range. A carbon microphone is used for the range 25/100 phon. The amplifier, ranges of measurement, and indicator are discussed; the construction of a universal noise meter and of one for measuring traffic noise is described and typical ink records are shown (Figs. 5–7). Applications to measurements of noise in traffic, aircraft, &c. are outlined.

4111. MEAN LEVEL DETERMINATION [from Response Curve given by High-Speed Level Recorder: Formula and Convenient Power-Ratio/Decibel Chart].—G. H. Logan. (*Electronics*, August, 1936, Vol. 9, No. 8, p. 27.)

4112. THE BROADCASTING OF AN ACCURATE 400 C/S NOTE ["A" on Piano] ON 5, 10 AND 15 MC/S WAVES.—National Bureau of Standards. (*Science*, 14th Aug. 1936, Vol. 84, Supp. p. 8.)

4113. THE APPLICATION OF M.K.S. ELECTROMAGNETIC (GIORGI) UNITS TO THE FIELD OF ELECTRO-ACOUSTICS.—G. Sacerdote: Giorgi. (*Alta Frequenza*, September, 1936, Vol. 5, No. 9, pp. 570–575.) "Their use presents the advantage of a greater uniformity and homogeneity in calculation, as is shown by a practical example."

4114. ON DAMPING IN SOUND RESONATORS.—B. P. Konstantinov and I. M. Bronstein. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 6, 1936, pp. 1209–1216.)

An investigation of the damping of sound waves in pipes. The theory of the phenomenon is discussed and formulae are derived for determining the decrements of a flanged pipe for the fundamental tone as well as for the overtones. This is followed by an account of experiments carried out with a number of pipes without flanges and having one or both ends open. A comparison between the theoretical and experimental results shows that the calculated figures are somewhat low if only radiation losses are considered. If, however, losses due to thermal conductivity and internal friction are also taken into account, a sufficiently close agreement between the two sets of figures is obtained.

4115. SOUND ABSORPTION AND VELOCITY IN MIXTURES [of Gases: Effect of Collisions: Theoretical Formulae].—D. G. Bourgin. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, pp. 355–369.)

4116. THE ELIMINATION OF THE EFFECT OF STRAY SOUND UPON THE MEASUREMENT OF ACOUSTIC ABSORPTION BY THE PARALLEL BEAM METHOD.—P. M. Higgs and F. A. Osborn. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, p. 384: abstract only.)

4117. The Orientation of the Natural Acoustic Vibrations in a Room with Concentrated Absorbents and of Anomalous Shape.—I. Dreisen. (*Tech. Phys of USSR*, No. 8, Vol. 3, 1936, pp. 743–753 : in English.)

"The analysis . . . shows that the concentration of the absorbent and the geometrical form of a room may be factors which affect the distortion of the polar reverberation diagram. In this case it is not a matter of indifference whether the sound is received binaurally (hearing) or monaurally (microphone). . . . A uniform frequency characteristic (after Békésy) of the studio only guarantees really high-quality transmission when combined with uniform absorption."

4118. The Effect of an Acoustically Absorbent Lining upon the Sound-Insulating Value of a Double Partition [Formula : Measurements : Judicious Use of Absorbent gives Considerable Increase in Sound-Insulation].—J. E. R. Constable. (*Proc. Phys. Soc.*, 1st Sept. 1936, Vol. 48, Part 5, No. 268, pp. 690–698.)

4119. The Acoustic Diffraction Spectrum as an Optical Relay [with Circuits for Production and Test of Modulated Light and for Measurement of Degree of Modulation].—O. Maercks. (*Physik. Zeitschr.*, 1st Aug. 1936, Vol. 37, No. 15, pp. 562–565.) *See* also Becker, 2248 of June (and 3475 of September).

4120. Intensity Measurements in the Diffraction of Light by Ultrasonic Waves [and the Correctness of the Raman-Nath Theory].—F. H. Sanders. (*Canadian Journ. of Res.*, August, 1936, Vol. 14, No. 8, Sec. A, pp. 158–171.) *Cf.* 3852 of October.

4121. The Mechanism of Oscillation of a Quartz Plate in Liquids.—H. E. R. Becker. (*Ann. der Physik*, Series 5, No. 7, Vol. 26, 1936, pp. 645–658.)

Continuation of previous work (*see* 1892 of May). Here experiments are described which were designed to test whether detachment of surrounding liquid from the surface of the oscillating crystal really takes place, as was previously assumed to explain the anharmonic oscillations then observed. No detachment was found up to pressure amplitudes of 0.3 atmospheres. The anharmonic oscillation did not occur when the quartz was hanging freely, but arose when the crystal was resting on a plane support. This result is found not to contradict the measurements given in the previous paper.

PHOTOTELEGRAPHY AND TELEVISION

4122.—On the Design of Electron-Multiplying Devices based on Secondary Emission.—S. Yu. Luk'yanov. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 6, 1936, pp. 1256–1260.)

Methods are indicated for determining the optimum number of stages and the maximum amplification factor of an electron multiplier for a given total working voltage. As is well known, the over-all amplification factor Σ of an electron multiplier is given by $\Sigma = \sigma^n$ . . . (1), where n is the number of stages in the multiplier and σ the coefficient of secondary emission for the surface material under the given conditions. The following expression is derived for σ : $\sigma = A V e^{-\mu V}$ . . . (4), where A and μ are constants and V is the working voltage. Substituting this in (1), and expressing V in terms of V_0, where V_0 is the voltage per stage and equals V/n, we have $\Sigma = (A V_0/n)^n \, . \, e^{-\mu V_0}$. . . . (7), from which it follows that Σ is a maximum when $n = A V_0/e$ . . . (8). The corresponding value of Σ is thus $\Sigma_{max.} = e^{(A/e - \mu)V_0}$ . . . (9).

In order to determine the constants A and μ, use is made of formula (4) and of an experimental curve showing the relationship between σ and V for a given surface. The maximum value of σ and the corresponding value of V (in c.g.s. units) are read off this curve and substituted in (4). On the other hand, it can be shown from (4) that σ reaches its maximum when $V = 1/\mu$ . . . (5). From these two expressions A and μ can be determined. Three typical σ/V curves are shown, of which the first (Fig. 1) refers to pure metal cathodes and the other two (Figs. 2 and 3) to caesium (Cs–Cs_2O–Ag) cathodes. Curves calculated by the above methods are also shown (dotted lines), and a very close agreement between the theoretical and experimental results can be observed. *Cf.* Weiss, 3496 of September.

4123. A.C. Electron Multipliers of New Design [Analysis of the Farnsworth Electrostatic Type, followed by Description and Analysis of the Writer's Magnetic Multiplier—Three Types].—K. Okabe. (*Rep. of Rad. Res. in Japan*, May, 1936, Vol. 6, No. 1, pp. 1–11 : in English.)

Papers in Japanese were referred to in 2186 of June and 3497 of September. The magnetic multiplier, first type, consists of two semi-cylindrical cathodes (a "four-split" type is also referred to) inside a cylindrical anode which—for a photo-electron multiplier—must be of meshed metallic material or else perforated, so that the light flux may reach the cathodes : this type corresponds to the electrostatic multiplier. The second type, to which there can be no corresponding electrostatic version, has a cylindrical cathode inside a longitudinally split anode : its construction is exactly the same as that of a split-anode magnetron (though there are some differences in the diameter and in the cathode material) : "consequently, it may be safe to say that electron-multiplier action must be taken into consideration in certain cases of magnetron oscillation of type B."

4123 *bis*. The Conversion of Optical Images from One Region of the Spectrum to Another by the Formation of Electron-Optical Images of Photocathodes.—M. von Ardenne. (*E.N.T.*, July, 1936, Vol. 13, No. 7 : long summary in *Wireless Engineer*, October, 1936, Vol. 13, No. 157, pp. 536–538.) Including sections on the "amplification of light" and on unwanted optical retroaction and background glow.

4124. APPLIED ELECTRON-OPTICS [Survey].—B. von Borries and E. Ruska. (*Zeitschr. V.D.I.*, 15th and 29th Aug. 1936, Vol. 80, Nos. 33 and 35, pp. 989–994 and 1075–1083.) The second instalment deals particularly with television, image transformers, and electron multipliers depending on secondary emission.

4125. ICONOSCOPES AND KINESCOPES IN TELEVISION.—V. K. Zworykin. (*RCA Review*, July, 1936, Vol. 1, No. 1, pp. 60–84.)

4126. HIGH-VOLTAGE CATHODE-RAY TUBE FOR HIGH-DEFINITION FILM SCANNING.—M. von Ardenne. (*Wireless Engineer*, September, 1936, Vol. 13, No. 156, pp. 483–485.) Long summary of the paper dealt with in 1866 of May.

4127. CATHODE-RAY TUBES IN TELEVISION [Considerations on Manufacturers' Problems in Testing and Performance].—G. Parr. (*Wireless World*, 11th Sept. 1936, Vol. 39, pp. 284–285.)

4128. STUDY OF THE FLUORESCENT POWER OF SOME FLUORESCENT SOLUTIONS EXCITED BY ULTRA-VIOLET RADIATION [Perrin's Exponential Law holds for Variation of Fluorescent Power with Concentration].—A. Boutaric and J. Bouchard. (*Comptes Rendus*, 15th July, 1936, Vol. 203, No. 2, pp. 167–169.)

4129. REPRODUCTION OF TRANSIENTS BY A TELEVISION AMPLIFIER.—N. W. McLachlan. (*Phil. Mag.*, September, 1936, Series 7, Vol. 22, No. 147, pp. 481–491.)

A television amplifier circuit for screen-grid valves, described by C. H. Smith in *World-Radio* of 1934, p. 834, is analysed theoretically; its response to a transient in the form of Heaviside's unit function is calculated by operational methods, and curves are given showing the form of the transient when the circuit is (1) oscillatory and (2) rendered aperiodic by the introduction of a damping resistance. The response to a transient of damped sinusoidal form is also calculated; the effect of n identical amplification stages is considered. Numerical estimates are made of the times of rise in the various cases and the reduction of overshooting of the voltage by introduction of the aperiodic condition. "The influence of R_3 [the damping resistance mentioned above] is also to retard the occurrence of the maximum value (although this is of little consequence since the top of the curve is so flat) and to reduce the amplification in the upper part of the frequency range. Whether the reduction in definition of the televiewed image is of importance can, of course, be decided by experiment only."

4130. ON THE CORRECTION OF AMPLIFIERS AT LOW FREQUENCIES.—H. Braude. (*Tech. Phys. of USSR*, No. 8, Vol. 3, 1936, pp. 729–742: in German.)

In his Russian paper dealt with in 2337 of 1935, Braude gave "a general method for the construction and calculation of correction circuits for the frequency- and phase-characteristics of amplifiers at any frequencies. Concretely this method was set out as applied to correction in the region of high frequencies." Literature published since the appearance of this paper suggests the necessity for a similarly concrete exposition of his method as applied to lower frequencies: thus Veisbrut & Kreutzer (232 of January) have applied it to the usual inductance-in-anode-circuit correction for high frequencies but have failed to use it for calculating the usual decoupling-resistance correction for low, substituting "an extremely inconvenient and inaccurate graphical method." In the present paper, therefore, the writer first gives a short description of the principle of his method and then shows its application to the calculation of low-frequency correction by a decoupling resistance-capacity combination in the anode circuit (Schiffenbauer, 2336 of 1935), and by more complex variations of this arrangement possessing certain advantages (*e.g.* where available voltage is limited—the decoupling resistance is shunted by an inductance of low ohmic resistance: a higher degree of correction is also possible with these more elaborate circuits).

4131. THE KERR CELL AND ITS USE IN TELEVISION [Kerr Memorial Lecture].—J. L. Baird. (*Journ. of Television Soc.*, March, 1936, Vol. 2, Part 4, pp. 118–124.)

4132. POLAROID LIGHT-POLARISING MATERIAL.—(*Engineering*, 28th Aug. 1936, Vol. 142, pp. 235–236.)

4133. THE ACOUSTIC DIFFRACTION SPECTRUM AS AN OPTICAL RELAY.—Maercks. (*See* 4119.)

4134. ON THE THEORY OF THE WIDE-BAND COAXIAL CABLE OF IDEAL DESIGN.—H. W. Droste. (*T.F.T.*, June, 1936, Vol. 25, No. 6, pp. 145–173.)

Among the conclusions reached in the course of this very long analysis (that of Schelkunoff is regarded as not completely satisfactory in parts, from the mathematical point of view) are that the resistance of the wide-band cable for very high frequencies changes with temperature only half as much as for direct current, and that the optimum ratio of diameters depends only on the specific resistances and permeabilities of the materials of the inner and outer conductors, and not on the frequency or the insulating material.

4135. LONDON'S TELEVISION STATION, *and* ALEXANDRA PALACE TELEVISION TRANSMISSIONS.—(*Wireless World*, 28th Aug. and 4th Sept. 1936, Vol. 39, pp. 216–217: pp. 256–257.)

4136. THE LONDON TELEVISION-BROADCASTING STATION.—(*Engineering*, 28th Aug. and 4th Sept. 1936, Vol. 142, pp. 232–234 and 258–260.)

4137. TELEVISION COMPARISONS [Demonstrations at London and Berlin Exhibitions compared].—L. M. Gander. (*Wireless World*, 11th Sept. 1936, Vol. 39, p. 289.)

4138. DUAL TELEVISION RECEIVERS [Practical Considerations in Design of Apparatus for Reception of Baird 240-line and Marconi-E.M.I. 405-line Transmissions].—E. G. O. Anderson. (*Wireless World*, 4th Sept. 1936, Vol. 39, pp. 249–250.) For a note on various types of receiver shown at Olympia see *Wireless Engineer*, October, 1936, Vol. 13, No. 157, p. 523.

4139. ULTRA-SHORT WAVES: MANY REPORTS OF RECEPTION FROM ALEXANDRA PALACE OUTSIDE THE 25-MILE RADIUS.—(*Electrician*, 4th Sept. 1936, Vol. 117, p. 278.)

4140. DEMONSTRATION OF 240-LINE INTERLACED-SCANNING ULTRA-SHORT-WAVE TELEVISION AT THE GRAMMONT LABORATORIES (LOEWE PATENTS).—Grammont Laboratories. (*L'Onde Élec.*, September, 1936, Vol. 15, No. 177, pp. 593–594.) Film transmission with lens-disc scanning: cathode-ray-tube reception. Synchronisation untouched during nearly an hour's demonstration.

4141. TELEVISION AT THE 1936 OLYMPIC GAMES: "DIRECT" TRANSMISSIONS OF THE EVENTS [by Zworykin Iconoscope, Farnsworth Electron-Camera, and Intermediate Film Transmitter].—(*Funktech. Monatshefte*, August, 1936, No. 8, Supp. pp. 57–59.) For reports on the results obtained see *Wireless World* of 21st August and 11th September, pp. 191 and 280.

4142. RCA TELEVISION FIELD TESTS [Survey of 1931/2 and 1933 Tests, and Short Description of Equipment for 1936 Test].—L. M. Clement and E. W. Engstrom. (*RCA Review*, July, 1936, Vol. 1, No. 1, pp. 32–40.)

4143. COLLECTED ADDRESSES AND PAPERS ON THE FUTURE OF THE NEW ART AND ITS RECENT TECHNICAL DEVELOPMENTS.—RCA Staff. (*Television* [*RCA*], July, 1936, Vol. 1: at Patent Office Library, London.) Most of these papers are reprinted from *Proc. Inst. Rad. Eng.*

4144. HOW WILL TELEVISION AFFECT THE RADIO INDUSTRY?—(*Rad. Engineering*, August, 1936, Vol. 16, No. 8, pp. 5–7.)

4145. THE DEVELOPMENT OF TELEVISION IN USSR.—P. Shmakov. (*Journ. of Television Soc.*, March, 1936, Vol. 2, Part 4, pp. 97–105.)

For a previous survey *see* 1932 Abstracts, p. 468: *also* same Abstracts, p. 415 (Rosing). The present paper deals first with general theory (including a reference to various scanning systems) and continues with Riftin's work on quality as a function of definition, brightness, and flicker (2719 of 1935); the number of possible gradations of neon lamp and Kerr cell (661 of February and 254 of January); the sensitivity of photocells (should be expressed in μA per watt of incident flux, not per lumen—482 of 1935); measurement of phase shift (3132 of 1935); Janchevsky's work on electron-optical systems (2353 of June); the work of Katayev and of Kubetsky on secondary electrons ("Kubetsky, investigating the question of electron-beam scanning in systems of the iconoscope type, has come to the conclusion that the secondary electrons emitted by an element at the moment of scanning by the beam may be collected and, after further repeated amplification, may be utilised for the production of signal impulses. This is contrary to the usual method of converting the accumulated charges into signal impulses by means of a capacitive connection, a method liable to certain losses"); Gourov's work on large-screen images (2712 of 1935); Konstantinov's 1930 patent of mosaic cathode and electron-beam scanning (and Kataiev's 1931 patent); Krusser's development (with particulars of his mosaic-cathode tube—a 240-line tube is now being tested); amplifiers with 200–250 $\times 10^3$ amplification, linear within 3% up to 700 kc/s (232 of January); receiving tubes and receivers; increasing the sensitivity of television systems by use of secondary emission (1878 of May: double-cathode secondary emission photocell, sensitivity 380–400 μA/lumen, of Timofeev and Shipalov: Kubetsky's ring-tube converter giving 1×10^6 amplification of primary photocurrent: combined with a 60-line mechanical scanner—Fig. 9—with an objective of f/1.8, this tube provides "the possibility of transmitting various objects with an illumination of about 150 lux"); Polevoy's projection tube; Janchevsky's projection tube with ray length only 10–12 cm and plane fluorescent screen of 6 cm diameter, beam current 500 μA for 8000 volts; broadcasting data; organisation.

4146. SOME OPTICAL PROBLEMS IN TELEVISION [Relations of Frame Frequency and Lines-per-Frame to Flicker and Definition: Comparison with Cinematography].—P. W. Harris. (*Wireless World*, 25th Sept. 1936, Vol. 39, pp. 339–340.)

4147. THE NEW YORK/PHILADELPHIA ULTRA-HIGH-FREQUENCY FACSIMILE RELAY SYSTEM.—H. H. Beverage. (*RCA Review*, July, 1936, Vol. 1, No. 1, pp. 15–31.)

4148. A NEW TELEPHOTOGRAPH SYSTEM [giving 100-Lines/Inch Pictures up to 11 × 17 Inches at One Inch/Minute].—F. W. Reynolds. (*Elec. Engineering*, September, 1936, Vol. 55, No. 9, pp. 996–1007.)

4149. A SIMPLE APPARATUS FOR THE MEASUREMENT OF SMALL PHOTOELECTRIC CURRENTS DOWN TO 10^{-13} AMPERE.—Coblentz and Stair. (*See* 3985.)

4150. TIME LAG IN PHOTOELECTRIC CELLS.—N. R. Campbell, H. R. Noble and L. G. Stoodley. (*Proc. Phys. Soc.*, 1st July, 1936, Vol. 48, Part 4, No. 267, pp. 589–604: Discussion p. 605.)

Continuation of work referred to in Abstracts, 1931, p. 332 (Joint Meeting) and 1932, p. 648. "Frequency-response curves are compared with oscillograph traces of the current through the cell when light is suddenly thrown on or off it. A theory of the comparison is given"; this is shown to provide a test of the "assumption of independence," *i.e.* that "time lag arises wholly in processes following a single instantaneous light-impulse, and not from the interaction of succeeding impulses. The experiments are wholly adverse to the assumption; low-frequency time lag must arise in great part from such interaction." The effects of the size of the cell, of temperature, and of hydrogen are investigated. "The distinction previously made between low-frequency and high-frequency time lag must be maintained; the latter is undoubtedly due to the finite velocity of the ions, the former is not. For the low-frequency lag metastable states are still the most plausible explanation."

More experiments are required before any new theory can be adequately tested.

4151. ON THE COMPLEX PHOTOCATHODE MECHANISM [Comparison of Methods of determining Work Function: Work Function and Its Connection with Thermionic Emission: Spectral Characteristics of Four Types of Cathode, from Pure Metal to Complex Cs-Cs_2O-Ag: Deduced Mechanisms of Photoeffect].—P. Lukirsky. (*Tech. Phys. of USSR*, No. 8, Vol. 3, 1936, pp. 685–699: in English.)

Thermionic emission method only applicable with caution, for composite cathodes: method of red limit of photoeffect gives exaggerated values for a cathode whose sensitivity curve has a long "tail," such as composite types: reliability, and insufficient use, of method based on photoelectron velocity distribution for various monochromatic rays (*e.g.* Prilejaev, 1934 Abstracts, p. 161): the "characteristic displacement" method (and the effect of treatment of potassium with atomic hydrogen). De Boer's theory of the nature of the photocurrent from a metal covered with a monomolecular layer of an alkali metal is criticised. Special attention is given to the influence of a number of factors on the spectral characteristics of the composite caesium cathode, and its peculiarities are thus explained.

4152. SOME PHOTOELECTRIC PROPERTIES OF EXCITED CATHODES.—P. V. Shmakov. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 6, 1936, pp. 1261–1266.)

An experimental investigation of the secondary emission from caesium cathodes (Cs-Cs_2O-Ag) when these are subjected to the simultaneous action of electrons and photons. In the tubes used in these experiments a stream of electrons from a filament was directed on the caesium cathode, which at the same time was illuminated by a beam of light. It has been found that generally speaking the resultant secondary current from the caesium cathode is not equal to the sum of currents which would be obtained were the cathode bombarded separately by either electrons or photons. Moreover, under certain conditions the secondary current actually falls when the intensity of illumination is increased; this effect is very pronounced, and it may therefore be possible to build a "negative action" photocell having a sensitivity 70 times as high as an ordinary photocell.

4153. INTENSITY DISTRIBUTION IN THE LINE EMISSION SPECTRUM OF CAESIUM.—F. L. Mohler. (*Journ. of Res. of Nat. Bur. of Stds.*, July, 1936, Vol. 17, No. 1, pp. 45–54.)

4154. NORMAL ENERGY DISTRIBUTION OF PHOTOELECTRONS FROM POTASSIUM FILMS AS A FUNCTION OF TEMPERATURE.—C. L. Henshaw. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, p. 398: abstract only.)

4155. ABSOLUTE PHOTOELECTRIC YIELD OF BERYLLIUM, MAGNESIUM AND SODIUM.—M. M. Mann and L. A. DuBridge. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, p. 398: abstract only.)

4156. ALKALI METAL FILMS TRANSPARENT IN THE SCHUMANN REGION.—W. W. Watson and D. G. Hurst. (*Canadian Journ. of Res.*, August, 1936, Vol. 14, No. 8, Sec. A, pp. 153–157.)

4157. ABSORPTION BANDS AND ENERGY BANDS OF ALKALI HALIDE CRYSTALS [Discussion of Photoelectrically Active Absorption Bands of Colour Centres].—A. Smekal. (*Zeitschr. f. Physik*, No. 11/12, Vol. 101, 1936, pp. 661–679.)

"It is deduced from the theory of electron bands in crystal lattices that the permitted energy bands are affected by the crystal surfaces and asymmetrically broadened by the presence of inhomogeneous elastic deformation of the crystal. . . . The absorption bands of alkali halide crystals depend on electron transits from sharp surface energy levels to the next higher energy bands of the crystal lattice." The distinction between symmetrical and asymmetrical absorption bands is discussed.

4158. SOME FUNDAMENTAL VIEWPOINTS OF THE SPECTROSCOPY OF IONIC CRYSTALS AND APPLICATIONS TO ALKALI HALIDES [Difference between Electron Transits in Gases and Ionic Crystals: Ultra-Violet Absorption: External Photoeffect and Internal Potential: Colour Bands: Phosphorescence, etc.].—A. von Hippel. (*Zeitschr. f. Physik*, No. 11/12, Vol. 101, 1936, pp. 680–720.)

4159. THE NATURE OF "EXCITED" COLOUR CENTRES [Absorption Spectrum shows Long-Wave Extension and Displacement of Maximum towards the Red, caused by Presence of Foreign Atoms and Internal Voltages].—H. Wolff. (*Physik. Zeitschr.*, 1st Aug. 1936, Vol. 37, No. 15, pp. 552–554.)

4160. THEORY OF THE ABSORPTION SPECTRA OF INSULATING CRYSTALS [Effect of Foreign Atoms and Internal Voltages].—A. Smekal. (*Physik. Zeitschr.*, 1st Aug. 1936, Vol. 37, No. 15, pp. 554–556.)

4161. THE EFFECT OF A MAGNETIC FIELD UPON THE PHOTOELECTRIC PROPERTIES OF IRON [Practically No Change in Emission].—D. H. Loughridge and N. K. Olsen. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, p. 389: abstract only.)

MEASUREMENTS AND STANDARDS

4162. MULTIFREQUENCY GENERATORS FOR FREQUENCY MEASUREMENTS [including Defects of Multivibrator as Frequency Divider, leading to Design of A.W.A. Synchronised Oscillator for Frequency Division and Harmonic Generation].—O. O. Pulley and C. A. Saxby. (*A.W.A. Tech. Review*, July, 1936, Vol. 2, No. 3, pp. 81–87.)

"A satisfactory frequency divider must remain synchronised in spite of supply fluctuations, ageing of valves, and any other changes which may be expected. It is also desirable that it should be incapable of 'locking' at any other than the wanted submultiple frequency. For division ratios of about 10 to 1, a tuned circuit oscillator defines the correct submultiple without ambiguity . . ." The A.W.A. device uses a tuned push-pull oscillator circuit consisting of a triode type 76 and a thyratron type 885, the latter introducing the non-linearity necessary for synchronisation. The scheme of the complete multifrequency generator unit embodying this locked oscillator is given in Fig. 4.

4163. THE MICROVOLT AND RECEIVER NOISE LEVEL [Commercial Standard Signal Generators above 5 Mc/s liable to Errors exceeding 10 db: Need of Greater Uniformity and Higher Precision: Noise Performance Data subject to Wide Limits].—S. B. Smith. (*Marconi Review*, May/June, 1936, No. 60, pp. 26–28.) "It is interesting to observe that in no case has a signal source been tested where the error has been minus at low levels. An inspection of the attenuator design will show the reasons why this result would be anticipated." *See* also 4068, above.

4164. 20–100 Mc SIGNAL GENERATOR [for testing All-Wave Receivers].—C. J. Franks. (*Electronics*, August, 1936, Vol. 9, No. 8. pp. 16–18.)

4165. SIGNAL GENERATORS: HIGH OR LOW POWER? [Comparative Advantages of Quarter-Watt and Milliwatt Types].—M. Ferris. (*Rad. Engineering*, August, 1936, Vol. 16, No. 8, pp. 8–10.)

4166. INTERCOMPARISON OF FREQUENCY STANDARDS BY MEANS OF MODULATION EMISSION—SIXTH AND SEVENTH REPORTS OF THE SUB-COMMITTEE FOR FREQUENCY STANDARDS.—Takatsu, Minohara & others. (*Rep. of Rad. Res. in Japan*, May, 1936, Vol. 6, No. 1, pp. 23–29.) The final comparison between various Japanese laboratories showed agreement well within 6 parts in ten million.

4167. WAVEMETER FOR ULTRA-SHORT WAVES [3–12 Metres in 4 Stages: Absorption Type: H.F. Part carried on Smaller End of Tapered Metal Tube projecting from Control and Indicating Portion: "Gland" Valve (RCA 965) as Grid-Bend Detector: Over-All Accuracy 0.1%].—P. Gantet. (*L'Onde Élec.*, September, 1936, Vol. 15, No. 177, pp. 577–584.)

4168. PORTABLE ABSORPTION WAVEMETER TYPE 4377.—H. Tinsley & Company. (*Journ. Scient. Instr.*, September, 1936, Vol. 13, No. 9, pp. 305–306.)

4169. QUARTZ CRYSTALS FOR THE CONTROL AND MEASUREMENT OF FREQUENCY [including Table of Various Types used by A.W.A. for Different Purposes and Frequencies, all with Low Temperature Coefficients].—G. Builder. (*A.W.A. Tech. Review*, July, 1936, Vol. 2, No. 3, pp. 104–105.)

Except for bars for "standards" (50–100 kc/s) and cubes for "filters" (100–250 kc/s), all the types are V-cut plates, thin or thick. Mention is made of a simple R.C.A. oscillator using a crystal alternatively oscillating at 100 kc/s in its length-breadth mode or at 1000 kc/s in its thickness mode: the circuit is designed to be rich in harmonics and forms a simple multifrequency generator of considerable accuracy.

4170. ON THE CALCULATION OF THE FREQUENCY OF A QUARTZ CRYSTAL OSCILLATOR.—B. K. Shembel: Vigoureux. (*Izves'iya Elektroprom. Slab. Toka*, No. 7, 1936, pp. 21–31.)

An approximate method is proposed in which the crystal-controlled oscillator is reduced to an equivalent circuit and the frequency calculated from its parameters. The method is similar to that developed by Vigoureux (1930 Abstracts, p. 343) but a number of factors of secondary importance are neglected and the construction of the equivalent circuit is simplified. As a result of the analysis the relative importance of the various factors affecting the frequency of oscillation is brought forward. A comparison between the calculated frequencies and experimental data given by Vigoureux indicates that the method proposed is sufficiently accurate within the region of stable oscillations, but is not suitable for regions near the cessation of oscillations. Since in practice it is the former regions that are important, the method proposed may be of practical value.

4171. TRANSVERSE CIRCULAR VIBRATION OF A HOLLOW QUARTZ CYLINDER [Frequency: Variation of Temperature Coefficient with Cylinder Dimensions: Possibility of Oscillator with Zero Temperature Coefficient].—N. Tsi-Ze and F. Sun-Hung. (*Comptes Rendus*, 24th Aug. 1936, Vol. 203, No. 8, pp. 461–463.) Details of a mode of vibration already referred to in 1578 of 1935: also 1934 Abstracts, p. 569.

4172. FLEXURAL OSCILLATIONS IN CIRCULAR PLATES EXCITED BY MAGNETOSTRICTION [demonstrated by Dust Figures: Nodal Lines: Agreement with Kirchhoff's Theory].—B. Pavlík. (*Ann. de Physik*, Series 5, No. 7, 1936, pp. 625–630.)

4173. THE EFFECT OF TENSION, PRESSURE AND TORSION ON LONGITUDINAL MAGNETOSTRICTION [Measurements on Nickel, Beryllium and Nickel/Iron Alloys: Agreement with Theory].—H. Kirchner. (*Ann. der Physik*, Series 5, No. 1, Vol. 27, 1936, pp. 49–69.)

4174. THE ELECTRICAL STABILITY OF CONDENSERS.—Thomas. (*See* 4013.)

4175. ACCURATE DETERMINATION OF THE ABSOLUTE CAPACITY OF [Small] CONDENSERS [with Accuracy of 1 in 10 000: by Use of Steel-Cylinder Precision Variable Condensers of Calculable Capacity, and Special Electrometer as Zero Indicator].—J. Clay. (*Physica*, August, 1936, Vol. 3, No. 8, pp. 757–762: in English.) The electrometer (designed to reach equilibrium rapidly and to have a sensitivity of about 1–5 divisions per millivolt) consists of an arc of tungsten wire moving between two sets of two fixed arcs.

4176. A MEASURING APPARATUS FOR DIRECT MEASUREMENT OF THE EFFICIENCY AND LOSS FACTOR OF OSCILLATING CIRCUITS.—O. Zinke. (*Hochf:tech. u. Elek:akus.*, June, 1936, Vol. 47, No. 6, pp. 196–206.)

The fundamental relations between the loss factor and other magnitudes in oscillating circuits are analysed (§ II) by considering circuits excited in series (Fig. 1a) and in parallel (Fig. 1b) with their equivalent circuits (Fig. 2) and vector diagrams (Fig. 3). The resonance relations (§ II 2: vector diagrams Fig. 4) lead to expressions for the increase of voltage and current in the circuit at resonance above those delivered to the external circuits, and to a definition (proposed by Küpfmüller) of the "efficiency" or "quality" factor of the circuit as the common value of the quantities defined by eqns. 1–5; its reciprocal is the "loss" factor, the sum of the loss factors of coil and condenser. The effect of detuning the circuit is analysed in § II 3, for variations of frequency, capacity and inductance. It is found (§ II 5) that there are 8 different possible ways of measuring the loss factor; these are determined by eqns. 1–6 and (§ III) compared with the methods hitherto employed for the technical measurement of loss factor. Only *indirect* methods have so far been developed (Pauli's method of measuring the equivalent impedance using known additional impedances, the dynatron method and the detuning method); *direct* measurement involves finding the ratio of two measurable quantities, and for this eqns. 4 and 5 may be used. The measurement of the ratio of the "blind" current in the oscillating circuit at resonance to the external current (eqn. 5; § III 1; Fig. 6) is discussed, with numerical examples. The instrument here described is based however on measurements of the voltage ratio (eqn. 4; § III 2; Fig. 7). A low resistance R_K is introduced into the circuit and fed from a sender; the impressed voltage can be read off directly across it by measurement of the current if R_K does not vary with frequency. The oscillating voltage in the circuit is read off across the condenser by a valve voltmeter. The sender is adjusted so that the reading of the latter shows a fixed value; the value of the loss factor is then given directly by the instrument reading the current through R_K. The construction of the apparatus is described in detail in § IV; Fig. 8 shows the general arrangement. The apparatus for taking off the input voltage (§ IV 1) includes the measuring resistance (Fig. 10); the valve voltmeter for measuring the resonance voltage (§ IV 2; circuit Fig. 15; views Figs. 16–18; calibration curve Fig. 20) is designed to be loss-free and of low capacity. Measurements with the new apparatus are compared in § V with simultaneous measurements by the detuning method (circuit Fig. 21); the results are shown in Table 4. The methods differ by about 2 per cent on the average.

4177. Electrical Measurements at Wavelengths less than Two Metres [Ultra-Short-Wave Power and Voltage Measurements down to about 25 cm by Special Thermocouples and Diode-Voltmeters: Diode-Voltmeter Errors (Theory and Experiment): Need for Diodes smaller than "Acorn" Type: etc.].—L. S. Nergaard. (*Proc. Inst. Rad. Eng.*, September, 1936, Vol. 24, No. 9, pp. 1207–1229.)

The writer concludes that the methods and technique described are adequate for most present needs. As to the remaining problems, thermocouples seem the most promising method for measuring small *currents*, but an accurate knowledge of their heater reactance and resistance will be necessary. For large currents, the measurement of voltage drop across a resistor seems feasible. *Impedance* measurements have been made satisfactorily by placing the unknown impedance across a transmission line loosely coupled to an oscillator and measuring the length of the line for resonance, and the sharpness of resonance. For Megaw's paper on diode-voltmeters at ultra-high frequencies, reaching the same formula for transit-time error, see 2332 of June.

4178. Dispersion Measurements with Decimetre Waves [in Water, Alcohols and Glycerine].—M. von Ardenne, O. Groos and G. Otterbein. (*Physik. Zeitschr.*, 1st Aug. 1936, Vol. 37, No. 15, pp. 533–544.)

The object of this work was to determine whether narrow absorption bands occur in the anomalous dispersion of decimetre waves by organic liquids; if so, the waves might be expected to give rise to biological and chemical effects. Previous work on the subject is discussed, with the possible methods of measuring anomalous dispersion. The writers adopted Drude's first method, exact measurement of the refractive index by determination of the ratio of the wavelength in air to that in the liquid. The index of absorption was not directly determined, for reasons which are given. The apparatus is shown in Fig. 1; the emitter was coupled to an extensible Lecher system. The trough containing the liquid was moveable and the adjustment to the nodes of the standing-wave system was very exact. Measured dispersion curves are given for water, sugar solutions, some alcohols and glycerine, for three wavelengths below 50 cm. Good agreement with Debye's dipole theory is indicated; narrow absorption bands are not found. Anomalous dispersion in the sense of the dipole theory may occur in water for wavelengths of about 13 cm and below. An arrangement (Fig. 8) for measuring high-frequency losses in alcohols is described. No absorption maxima were found. A list of literature references is appended.

4179. Absorption in Dipole Liquids in the Wavelength Range 3–7 m.—E. Keutner. (*Ann. der Physik*, Series 5, No. 1, Vol. 27, 1936, pp. 29–48.)

An experimental method is described which employs an electrolytic thermometer (Fig. 3). The absorption was measured in various alcohols, glycerine, water, etc. Simple formulae from the Debye theory were found to fit the results for the alcohols but not those for glycerine and nitrobenzol.

4180. Further Investigations on the High-Frequency Dipole Effect in Viscous Liquids [Measurements of Dielectric Constants of Sugar Solutions, Glycerine, etc.: Effect of Change from Liquid to Solid State].—C. Schreck. (*Physik. Zeitschr.*, 1st Aug. 1936, Vol. 37, No. 15, pp. 549–552.) *See* 2343 of June (Wien & others) and 692 of February (Jackson).

4181. Measurement at High Frequencies [250 kc/s to 1.625 Mc/s] of the Dielectric Constant of Some Mineral Salts in Dilute Solutions in Different Solvents [Technique and Results].—M. Beauvilain. (*Rev. Gén. de l'Élec.*, 22nd Aug. 1936, Vol. 40, No. 8, pp. 239–242.)

Reasons are given for the choice of the voltage-resonance method in preference to the current-resonance, bridge, beat, and equivalent-circuit methods. The results are most like those of Walden, from which they differ by 10–50% : they are entirely at variance with those of other writers.

4182. The Dielectric Coefficients [and Electric Moments] of Gases. III—Allene, Butanes, etc : IV—Fluorides of B, N and C : the Refractive Index, Dispersion and Polarisation of Gases.—Watson, Kane and Ramaswamy. (*Proc. Roy. Soc.*, Series A, 1st Aug. 1936, Vol. 156, No. 887, pp. 130–143 and 144–157.) For I and II *see* 1934 Abstracts, p. 279.

4183. An Experimental Investigation of the Validity of Ohm's Law for Metals at High Current-Densities [Simultaneous Measurement of Resistance of Gold Films to Large D.C. and Relatively Small A.C. of Radio Frequency : Resistance rises at High Current Densities].—H. M. Barlow. (*Proc. Phys. Soc.*, 1st July, 1936, Vol. 48, Part 4, No. 267, pp. 549–559 : Discussion pp. 559–562.)

4184. Investigations on the Micro-Resistances of Supraconductors [Rapid Method of Measuring Very Small Resistances].—P. Grassmann. (*Physik. Zeitschr.*, 15th Aug. 1936, Vol. 37, No. 16, pp. 569–578.)

4185. Measurements with Undamped Decimetre Waves [on Use of Crystal Detector].—Metschl. (*See* 4028.)

4186. Modulation Measurement [Comparison of Peak, R.M.S. and Average-Value Meters : Diode Rectifier, followed by Linear D.C. Amplifier, recommended for Production Gain-Testing of Radio Receivers.]—C. G. Seright. (*Electronics*, August, 1936, Vol. 9, No. 8, pp. 23–24 and 38.)

4187. Measurements of the Selectivity of Receivers.—David. (*See* 4035.)

4188. Nomograms for Symmetrical Attenuation Circuits.—E. A. Hanney. (*Wireless Engineer*, September, 1936, Vol. 13, No. 156, pp. 486–487.)

4189. A Symmetry Standard [Precisely Symmetrical Centre-Tapped Coil] for Alternating Currents, and Its Many Applications.—A. Wirk. (*T.F.T.*, August, 1936, Vol. 25, No. 8, pp. 211–217.)

4190. A Sensitive Valve Voltmeter with Stabilised Mains Supply.—H. Boucke : Limann. (*Funktech. Monatshefte*, August, 1936, No. 8, pp. 305–313.) Practical construction of Limann's instrument (1129 of March and back reference).

4191. A Highly Flexible Valve Voltmeter [with "Acorn" Type 954 inside Lamp Socket at end of Flexible "Gooseneck" Tube].—H. G. Boyle. (*Electronics*, August, 1936, Vol. 9, No. 8, pp. 32 and 34.)

SUBSIDIARY APPARATUS AND MATERIALS

4192. Some Applications of the Electrolytic Trough [to Measurements on Accelerating Lenses, Cathode-Ray Tubes, Image-Transformers, etc. : the Necessity for Use of Three Dimensional Models in Certain Cases].—von Ardenne. (*Funktech. Monatshefte*, August, 1936, No. 8, Supp. pp. 60–63.)

See also 3553 of September. Two examples (Figs. 7 & 8) are given of the erroneous results obtained with two-dimensional (plane-electrode) models of cylindrical accelerating lenses : the correct results, obtained with three-dimensional models (semi-cylindrical tubes with their edges at the surface), are shown in Figs. 5 & 6. Figs. 9 & 10 give the potential lines in the pre-concentration system (equi-potential cathode, Wehnelt-cylinder stop and first accelerating electrode) of a high-vacuum cathode-ray tube. The model here used, with plane electrodes, is seen in Fig. 11. The superiority of symmetrical deflecting potentials is seen by comparing Fig. 13 with Fig. 12, both taken with the two-dimensional model of Fig. 14. Fig. 15 (top) shows the field distortion between the deflecting plates when these are surrounded by a glass cylinder ; the middle diagram shows the still worse distortion produced by a screening cylinder connected to the anode (to eliminate wall charges), while the bottom diagram shows what can be done with a suitably chosen resistance layer in addition to the screening cylinder. The action of a screening electrode on the edge field of a pair of deflecting plates is seen in Figs. 16/18. The very imperfect potential field of an image transformer tube with no resistance layer is seen in Fig. 21 : it is improved by a resistance layer (Fig. 19) but is still bad compared with that in the latest type of tube (Fig. 20) where the transparent photo-cathode is extended to meet the resistance layer.

4193. Graphical Determination of the Electron Paths in a Magnetic Field.—Dosse. (*See* 4057).

4194. The Primary and Secondary Image in the Electron Microscope. I. Stopping-Out Parts of the Diffracted [Primary] Image and the Effect on the Final [Secondary] Image. II. Investigation of Structure by Electron Diffraction.—Boersch. (*Ann. der Physik*, Series 5, No. 7, Vol. 26, 1936, pp. 631–644 : No. 1, Vol. 27, 1936, pp. 75–80.)

I. The "primary" image is the diffraction pattern in the plane through the image of the electron source ; the "secondary" image is the image of the object being studied by the microscope. When high-velocity electrons pass through thin foils, the electron diffraction diagram is the primary image, while the electron-optical image of the foil is the secondary image. The latter may be varied by stopping down the primary image so that electrons pass through only a certain system of points out of the Debye-Scherrer diffraction rings; this corresponds to giving preference to certain positions of the crystals in the foil. Thus the effect of the scattering at crystals of various orientations may be investigated and the crystalline structure of the foil may be studied. The optical scheme used is shown in Fig. 3, the experimental arrangement in Fig. 4. The effect of the various ways in which electrons may be scattered, and the "thickness structure" of the image, are discussed (§ 3). The effect of various stops in the primary image with bright field illumination is shown (§ 4; Figs. 6, 7). Dark field illumination (§ 5; Figs. 8–11) gives poorer contrast and sharpness in the image.

II. An electron-optical image is given (scheme Fig. 2, arrangement Fig. 3) for determining the orientation of the crystals of the various parts of a metal foil surface. The advantages of the system are that it is possible to say at once to what part of the foil the diffraction image belongs, and that the size of the diffracting region can be made as small as desired. Photographs of diffraction images for gold foil are given and discussed.

4195. SOME ERRORS IN ELECTRON LENSES [Theory].—Scherzer. (*Zeitschr. f. Physik*, No. 9/10, Vol. 101, 1936, pp. 593–603.)

This theoretical discussion leads to the conclusions that "chromatic and spherical aberration errors are unavoidable in electron lenses without space-charge effects. Distortion (pulling out of shape and twisting) and all kinds of coma can, in principle, be eliminated. The fact that spherical aberration cannot be avoided limits in practice, though not in principle, the resolving power of the electron microscope."

4196. APPLICATION OF ELECTRON OPTICS TO PHOTOGRAPHY [Combined Electric/Magnetic Electron Lens gives Image of Surface on Photographic Plate].—Lallemand. (*Comptes Rendus*, 20th July, 1936, Vol. 203, No. 3, pp. 243–244.)

4196 *bis*. THE CONVERSION OF OPTICAL IMAGES FROM ONE REGION OF THE SPECTRUM TO ANOTHER BY THE FORMATION OF ELECTRON-OPTICAL IMAGES OF PHOTOCATHODES.—von Ardenne. (*See* 4123 *bis*.)

4197. APPLIED ELECTRON-OPTICS [Survey].—von Borries and Ruska. (*See* 4124.)

4198. THE ELECTRONIC COMMUTATOR: AN ACCESSORY FOR THE CATHODE-RAY OSCILLOGRAPH.—Du Mont. (*L'Onde Élec.*, September, 1936, Vol. 15, No. 177, pp. 590–592.) *See* 2775 of July.

4199. FUNDAMENTAL PRINCIPLES OF RECTIFICATION [Full Mathematical Theory of Series Rectification].—Schmidek. (*Arch. f. Elektrot.*, 17th June, 1936, Vol. 30, No. 6, pp. 347–367.)

4200. A NEW METAL RECTIFYING VALVE WITH MERCURY CATHODE [for Power Range usually catered for by Glass Types: Single Phase: Pump dispensed with by Use of Chrome-Steel Chamber: Water-Cooled].—Mulder. (*Philips Tech. Review*, March, 1936, Vol. 1, No. 3, pp. 65–69.)

4201. THE "STROBOTRON": NOTE ON A NEW GASEOUS-DISCHARGE TUBE.—Klemperer: Germeshausen. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 17, 1936, pp. 285–286.) *See* 3564 of September.

4202. POTENTIAL OF A LOW-VOLTAGE ARC [with Externally Heated Cathode: Nature of Cathode as an Additional Factor: Difference between Curves for Tungsten and Oxide-Coated Cathodes: Explanation].—Druyvesteyn. (*Physica*, July, 1936, Vol. 3, No. 7, pp. 724–726: in German.)

4203. THE DESIGN OF EDDY-CURRENT HEATING APPARATUS FOR OUTGASSING ELECTRODES IN A VACUUM [with Method of determining Optimum Working Frequency: Measurements of Efficiency of Heating Coil].—Oatley and Smith. (*Phil. Mag.*, September, 1936, Series 7, Vol. 22, No. 147, pp. 453–462.)

4204. THEORY OF BARRIER-LAYER RECTIFIERS: DISCUSSION AND CRITICISM OF AN ARTICLE BY H. TEICHMANN.—Bernard: Teichmann. (*Rev. Gén. de l'Élec.*, 25th July, 1936, Vol. 40, No. 4, pp. 112–113.)

"To sum up, the theory of Teichmann [1932 Abstracts, pp. 468–469] is obscure, incorrect and incomplete in its development, infantile and obsolete in its conception of electrons reflected at the walls of the imaginary 'craters.' It is not astonishing, therefore, that experiment has been powerless to verify the consequences which can be derived from it."

4205. THE SENSE OF THE RECTIFYING ACTION IN "EXCESS-" AND "DEFICIENCY"- SEMICONDUCTORS.—Hartmann and Schottky. (*Naturwiss.*, 28th Aug. 1936, Vol. 24, No. 35, p. 558.)

A preliminary note on an experimental test of a hypothesis already put forward by Schottky (1593 of April: discussion) that in "excess"-semiconductors the action of the barrier layer is opposite to that in "deficiency"-semiconductors such as copper oxide. Zinc oxide in the form of sintered plates with silver electrodes formed on the surface by evaporation showed no barrier action; but when a thin bakelite varnish was introduced on one side between the zinc oxide and the silver, there arose a marked rectifying action in the opposite sense to that observed with copper oxide, thus supporting the hypothesis.

4206. THE ELECTRICAL BREAKDOWN OF RESIN IN AN INHOMOGENEOUS FIELD [Variation (inverse) with Radius of Curvature of A.C. Electrode, explained by Presence of Weak Spots: D.C. Breakdown Voltage 2½–3 Times Higher than with A.C., attributed to Departure from Electrostatic Field Distribution, and Consequent More Homogeneous Field, due to Potential-Dependence of Resistance of Resin].—Gutin and Sackheim. (*Tech. Phys. of USSR*, No. 7, Vol. 3, 1936, pp. 641–651: in German.)

4207. ALTERNATING-CURRENT INVESTIGATIONS ON ALUMINIUM OXIDISED ANODICALLY [Effect of Voltage, Frequency, Temperature, Moisture on Electrical Losses and Dielectric Constant: Action of Moisture on Film Material: Effect of Electrolytes].—Baumann. (*Zeitschr. f. Physik*, No. 1/2, Vol. 102, 1936, pp. 59–66.)

4208. THE STEPS OF IONISATION IN MICA HIGH-FREQUENCY CONDENSERS.—Zhilinsky. (*Izvestiya Elektroprom. Slab. Toka*, No. 7, 1936, pp. 66–72.)

Author's summary:—The results of laboratory tests for the determination of the initial corona voltages on mica condenser plates for different dimensions of mica, different materials as filling compound, and various high frequencies [up to about 1 Mc/s] are given. On the basis of the results obtained the author draws conclusions as to the rational choice of condenser operating voltages in h.f. circuits of radio transmitters, and the proper selection of the mica thickness and of the filling compound.

4209. THE ELECTRICAL STABILITY OF CONDENSERS.—Thomas. (*See* 4013.)

4210. NOTE ON THE CONSTRUCTION AND OHMIC RESISTANCE OF INDUCTANCE COILS FOR ULTRA-HIGH-FREQUENCY CURRENTS [Investigation of the Undue Heating in Gilded Copper-Tube Solenoids: Superiority of Ribbon Construction over Tubular].—Lehmann. (*L'Onde Élec.*, September, 1936, Vol. 15, No. 177, pp. 585–589.)

Tests showed that at wavelengths of 4–8 m the current concentrates almost entirely along that generatrix of the tube which is nearest the axis of the spiral, so that the usual tubular construction is extremely bad for very high frequencies, the losses being very high and almost independent of the cross-section. The region of minimum diameter, since it has to carry most of the current, should be a surface and not a mere line, so that a copper ribbon is far better than a tube. The width of the ribbon is limited, in the case of a spiral, by the admissible total length of the coil: to use wide ribbons a flat spiral shape (Fig. 8) may be adopted advantageously, but the width must not be too great or the divergent field will cut the edges of the ribbon and cause eddy-current losses.

4211. A POTENTIOMETRIC DIRECT-CURRENT AMPLIFIER AND ITS APPLICATIONS [Automatic Null Potentiometer using Two Photocells differentially connected to control the Bias of Triode in Bridge Circuit with Free-Floating Mirror Galvanometer as Null Indicator: Operating Potential introduced in Galvanometer Circuit].—Gilbert. (*Proc. Inst. Rad. Eng.*, September, 1936, Vol. 24, No. 9, pp. 1239–1246.)

"May be classified as an amplifier because its output is proportional to the input but larger in magnitude." Gives extremely good continuous regulation "under conditions where the usual methods would be either entirely impracticable or unsatisfactory." An example "of doubtful utility but well illustrating the rapidity of response . . . is the regulation of an arc light to a steady level of illumination, using a photocell as the sensitive element. . . ."

4212. A THEORETICAL ANALYSIS OF THE OPERATION OF IONISATION CHAMBERS AND PULSE AMPLIFIERS [Calculation of Shape of Output Pulse as Function of Frequency Characteristic of Amplifier: Cut-Off Frequencies of Amplifier for Optimum Pulse Shape and Amplitude: Signal-to-Noise Ratio].—Johnson and Johnson. (*Phys. Review*, 15th July, 1936, Series 2, Vol. 50, No. 2, pp. 170–176.)

4213. A NOVEL AMPLIFIER FOR USE WITH A PIEZO-CRYSTAL INSTALLATION.—Calvert. (*Electrician*, 7th Aug. 1936, Vol. 117, pp. 164–165.)

For ease and reliability of calibration, it was desired that the spot deflection of the cathode-ray oscillograph should give directly the dead weight loading the crystal: the output p.d. of the amplifier had therefore to have a definite value corresponding to the potential of the input grid, and to maintain this value for so long as the input potential was maintained. The circuit used consisted of an electrometer triode (to ensure that the leakage from the crystal was negligible during the period of calibration) and an amplifying stage composed of a screen-grid valve with a balancing battery.

4214. TIME-LAG IN A CONTROL SYSTEM [Theoretical Study: Use of Heaviside Operators: Numerical and Mechanical Methods of Integration: Optimum Values of Parameters].—Callender, Hartree and Porter. (*Phil. Trans. Roy. Soc.*, Series A, 21st July, 1936, Vol. 235, No. 756, pp. 415–444.)

"Control gear of some kind is often used to keep the value of a physical quantity, subject to random disturbances, as nearly constant as possible. This paper is concerned, firstly, with a general theoretical study of the operation of such control gear when this operation is determined solely by the behaviour of the quantity to be controlled itself, and when there is a time-lag between this behaviour and the effect of the consequent control operation; and secondly, with means of putting the theoretical conclusions into practice." *Cf.* 3705 of October.

4215. AN ELECTRONIC SPEED GOVERNOR.—Ballard. (*Canadian Journ. of Res.*, July, 1936, Vol. 14, No. 7, Sec. A, pp. 134–138.)

4216. FORCES, SENSITIVITY AND EFFICIENCY OF A HIGH-SENSITIVITY DYNAMIC [Moving-Coil] RELAY.—Hiebsch. (*E.T.Z.*, 6th Aug. 1936, Vol. 57, No. 32, pp. 915–918.)

Formulae and their application to a relay with its moving coil almost filling the ring-shaped gap of its magnet (as the usual rotating coil cannot do); it is specially suitable for photoelectric-control equipments without valve amplification. With a moving coil of 14 400 ohms it will close for steady currents down to about 0.052 microampere (3.88×10^{-11} watt) but the contact pressure would be low and the time delay serious (Fig. 3). Ten times that current would give a pressure around 60 mg and a delay of a few seconds.

4217. RADIOELECTRIC TRIODE RELAY GIVING SIMULTANEOUS TRANSMISSION AND RECEPTION.—Marro. (*See* 4231.)

4218. TRANSFORMERS GIVING SHARPLY PEAKED WAVE FORMS [and Their Applications, including a Convenient Wave-Form Analyser].—Leardini. (*L'Elettrotec.*, 10th July, 1936, Vol. 23, No. 13, pp. 396–399.)

4219. DISCUSSION ON "IMPROVEMENTS IN COMMUNICATION TRANSFORMERS."—Ganz and Laird. (*Elec. Engineering*, August, 1936, Vol. 55, No. 8, pp. 890–891.) *See* 736 of February.

4220. H.F. IRON CORES FOR THE HOME CONSTRUCTION OF HIGH QUALITY COILS [Commercial German Types of Core].—Stockhusen. (*Funktech. Monatshefte*, August, 1936, No. 8, pp. 293–298.). With data of suitable windings.

4221. THE SCREENING OF [Intervalve] TRANSFORMERS AGAINST ELECTROMAGNETIC "PICK-UP" EFFECTS [Greatest All-Round Value of High-Permeability Alloy 1/16th Inch thick: etc.].—Constable and Aston. (*Journ. Scient. Instr.*, September, 1936, Vol. 13, No. 9, pp. 295–297.)

4222. HIGH-FIDELITY TRANSFORMERS: SHIELDING CONSIDERATIONS [and the Combination of Hum-Balancing Core Construction and Cast Case (avoiding Magnetic Reluctance of Seams of a Drawn Case) of High-Permeability Metal 1/8th Inch thick].—Heald. (*Rad. Engineering*, August, 1936, Vol. 16, No. 8, p. 29.)

4223. THE POWER-LOSS AND ELECTROMAGNETIC SHIELDING DUE TO THE FLOW OF EDDY-CURRENTS IN THIN CYLINDRICAL TUBES [Mathematical Investigation of Eddy-Current Induction by Alternating Magnetic Field parallel to Tube Axis: Formulae).—Oatley. (*Phil. Mag.*, September, 1936, Series 7, Vol. 22, No. 147, pp. 445–453.)

4224. NICKEL IRON ALLOYS: THEIR APPLICATION IN ELECTRICAL ENGINEERING [including for Magnetic Screening and for Intervalve and other Transformers].—McLachlan. (*Electrician*, 28th Aug. 1936, Vol. 117, pp. 249–252.)

4225. PERMALLOYS AND RELATED FERROMAGNETIC ALLOYS—A REVIEW.—Chaston. (*Elec. Communication*, July, 1936, Vol. 15, No. 1, pp. 38–51.) Including a section on the effect of impurities and the latest views on the nature of the action exerted by hydrogen.

4226. PERMANENT MAGNET STEEL.—Nat. Bureau of Standards. (*Letter Circular* 461, 6 pp: at Patent Office Library, London: Cat. No. 76 481.)

4227. PERMANENT MAGNETISATION OF STEEL IN THE NEIGHBOURHOOD OF A CIRCUIT TRAVERSED BY A RAPID APERIODIC DISCHARGE [Inversion of Direction of Magnetisation near Circuit not due to Oscillatory Character of Discharge].—Chevallier and Laporte. (*Comptes Rendus*, 27th July, 1936, Vol. 203, No. 4, pp. 302–304.)

STATIONS, DESIGN AND OPERATION

4228. ULTRA-SHORT-WAVE RADIO COMMUNICATION [Circuit between New York and Philadelphia operating over 91 miles with Two Automatic Relay Stations on Wavelengths of approx. 3 m].—(*Nature*, 22nd Aug. 1936, Vol. 138, p. 321.) Based on the article referred to in 3943 of October. *See* also 4147, above.

4229. MICRO-WAVES IN NBC REMOTE PICK-UPS [including the "Top Hat" Transmitter used in Broadcasting the Easter Parade].—Morris. (*RCA Review*, July, 1936, Vol. 1, No. 1, pp. 41–48.)

4230. A PORTABLE DUPLEX RADIO-TELEPHONE [on Ultra-Short (3 m) Waves: Transmission alternating with Reception at Supersonic Frequency: Interrupted Oscillation provides Super-Regenerative Amplification requiring No Additional Amplification: Quench Frequency selected to suit Distance so that Pulses arrive in time for "Sensitive Phase": Speech Modulation of Quench Oscillator: Sets suitable for connection to Telephone Network].—Lewis and Milner. (*Wireless Engineer*, September, 1936, Vol. 13, No. 156, pp. 475–482.) The theory of super-regenerative receivers is reviewed briefly, and a description of some results obtained with the sets illustrates some facts about ultra-short-wave propagation. Thus it is emphasised that the best site for an aerial is on the edge of a precipice facing the distant station, or at the top of a high mast or building, not merely because of the more distant horizon thus obtained but also because of the consequent path difference between the direct ray and the ray reflected from the ground. For the use of supersonic alternation of oscillation and detection for u.s.w. duplex working *see* also Ohtaka, 504 of February.

4231. RADIOELECTRIC TRIODE RELAY GIVING SIMULTANEOUS TRANSMISSION AND RECEPTION [of Telegraphy or Telephony: with Special Application as Relay Station in Ultra-Short-Wave Beam Communication—"Hertzian Cable"].—M. Marro. (*Rev. Gén. de l'Élec.*, 22nd Aug. 1936, Vol. 40, No. 8, pp. 248–251.)

A single triode circuit is used which functions either as transmitter or receiver according to the variation of the grid leak resistance. In telegraphy this is controlled by the manipulating key, in telephony by a press-switch. The behaviour of the circuit is explained by reference to van der Pol's work on relaxation oscillations. If the grid leak resistance is suitably adjusted, the circuit can be used as a true radioelectric relay station, detecting an incoming signal and re-transmitting it. The writer has had successful results with six sets in series: once adjusted, the arrangement is very stable, and the only necessity is that the filament-heating batteries should be kept from dropping below a certain voltage.

4232. A Modern Two-Way Radio System [for Municipal Police Service, on Ultra-Short Waves: Duplex Operation between Headquarters and Car, Simplex from Car to Car (relayed through Headquarters): "Bumper" and Other Car Aerials: Superheterodyne-Super-Regenerative Receivers: Special Headquarters Aerial: Concentric-Line Filters for Band Elimination: etc.].—Becker and Leeds. (*Proc. Inst. Rad. Eng.*, September, 1936, Vol. 24, No. 9, pp. 1183–1206.) For previous references to the receivers *see* 2980 of August; to the special Headquarters' aerial, 3246 of 1935.

4233. The Effect of Aircraft Design upon That of Aircraft Radio Equipment [and the Need for Close Co-operation between Manufacturers of Aircraft and Aero-Engines and of Aircraft Radio Apparatus].—Carr. (*Marconi Review*, May/June, 1936, No. 60, pp. 1–9.)

4234. A New System for the Control of Common-Wave Broadcasting Stations [and Some Results obtained].—Vilbig and Brückmann. (*T.F.T.*, May, 1936, Vol. 25, No. 5, pp. 108–114.)

The new Lorenz Company's system "has, in its basic idea, much similarity to that of Telefunken" [Runge, 1933 Abstracts, p. 285]. Each station in the network has its own quartz-controlled oscillator, giving a constancy of 10^{-7} over a quarter of an hour; the cable-carried control oscillation from the main station acts as a reference frequency, the result of the comparison being communicated by a mechanical link, so that there is no electrical connection between the main and subsidiary transmitters.

4235. The Exactness of Synchronisation of Common-Wave Broadcasting Stations [Increased Accuracy means Increased Night as well as Day Coverage: Results are Best when Beats are slower than Sky-Wave Changes].—F. Vilbig. (*T.F.T.*, July, 1936, Vol. 25, No. 7, pp. 196–198.)

4236. Discussion on "The Droitwich Broadcasting Station."—Ashbridge, Bishop and MacLarty. (*Journ. I.E.E.*, September, 1936, Vol. 79, No. 477, pp. 340–343.) *See* 330 of January.

4237. Corrections to "Service Areas of Broadcasting Stations."—Green. (*A.W.A. Tech. Review*, July, 1936, Vol. 2, No. 3, p. 106.) *See* 3633 of September.

4238. Extension of Sottens Broadcasting Station to 100 kW.—Metzler, Strong and McLean. (*Elec. Communication*, July, 1936, Vol. 15, No. 1, pp. 3–15.)

4239. Field Strength Measurements [and Their Use by the Canadian Radio Commission].—Smith. (*Electronics*, August, 1936, Vol. 9, No. 8, pp. 20–22 and 38.)

4240. Rediffusion in Great Britain [Some Considerations concerning Power Amplifiers and the Effect of Varying Load].—P. Adorjan. (*Communication & Broadcast Eng.*, August, 1936, Vol. 3, No. 8, pp. 8–9 and 29.) General design principles were dealt with in a previous paper (3839 of October).

4241. Field Strengths required for Commercial Telegraphy on Short Waves.—(*Marconi Review*, May/June, 1936, No. 60, pp. 10–20.)

Limitations imposed by receiver noise (min. field strengths referred to a $\frac{1}{2}\lambda$ vertical aerial range from 0.5 μv/m on 15 m to less than 0.2 μv/m on 40/100 m): by external noise: fading ratio: "figure of merit" (ratio of min. signal, for operation of tape recorder, to max. noise; receiver fed by $\frac{1}{2}\lambda$ vertical aerial): directive receiving aerials for reduction of effective noise level: comparative noise measurements at Ascension and Sierra Leone: etc.

4242. The Radio Installation on the Cunard White Star R.M.S. Queen Mary.—Thorpe-Woods, Buttner and Wendell. (*Elec. Communication*, July, 1936, Vol. 15, No. 1, pp. 89–97.)

4243. Safety of Life at Sea [and the Work of the Radiomarine Corporation of America].—Pannill. (*RCA Review*, July, 1936, Vol. 1, No. 1, pp. 85–94.)

4244. The Amateur Regulations of the World: 1936. (*QST*, September, 1936, Vol. 20, No. 9, pp. 41–42.)

MISCELLANEOUS

4245. Some Remarks on Statistical Measurements [Fractionisation of a Series of Measurements: Fortuitous Group Formation].—Bothe. (*Physik. Zeitschr.*, 15th July, 1936, Vol. 37, No. 14, pp. 520–522.)

4246. An Improved Numerical Method of Two-Dimensional Fourier Synthesis for Crystals [using Printed Strips giving Cosine and Sine Waves of Different Wavelengths and Amplitudes].—Lipson and Beevers. (*Proc. Phys. Soc.*, 1st Sept. 1936, Vol. 48, Part 5, No. 268, pp. 772–780.) *See* also 3232 of August and 1934 Abstracts, p. 339: *also* 1328 of March (Robertson).

4247. Fundamentals in the Application of Matrices to Electrical Networks.—Pernice. (*Comm. & Broadcast Engineering*, June, 1936, Vol. 3, No. 6, pp. 10–13: to be continued.)

4248. On the Approximate Calculation of the Roots of Algebraic Equations.—Cesari. (*La Ricerca Scient.*, 15/31 July, 1936, 7th Year, Vol. 2, No. 1/2, pp. 53–78.)

4249. A Graphical Method of Testing whether a Curve is Sinusoidal.—Abason. (*Bull. de Math. et de Phys. de l'École Polytech. Roi Carol II*, Bucarest, 1933/34, Fasc. 14/15, pp. 77–79: in French.)

4250. NOTE ON THE ARTICLE OF M. E. ABASON :—ON THOMPSON'S METHOD AND THE [Lalescu-Abason-Eagle] METHOD OF DISCONTINUITIES FOR THE ANALYSIS OF THE HARMONICS OF PERIODIC FUNCTIONS.—Popesco. (*Bull. de Math. et de Phys. de l'École Polytech. Roi Carol II*, Bucarest, 1933/34, Fasc. 14/15, pp. 79–88 : in French.)

4251. THE APPLICATION OF THE HEAVISIDE-BROMWICH OPERATIONAL METHOD TO THE SOLUTION OF A PROBLEM IN HEAT CONDUCTION [in which Surface Temperature varies with Time : Mathematical Technique of Appropriate Differential Equation and Boundary Conditions].—Luikov. (*Phil. Mag.*, August, 1936, Series 7, Vol. 22, No. 146, pp. 239–248.)

4252. POTENTIAL FUNCTIONS RELATED TO GROUPS OF CIRCULAR CYLINDERS [Mathematical Technique for Various Cylinder Groupings].—Howland and McMullen. (*Proc. Camb. Phil. Soc.*, July, 1936, Vol. 32, Part 3, pp. 402–415.)

4253. DISCUSSION ON "NOMOGRAMS [Alignment Charts] IN ELECTRICAL ENGINEERING."—Kapp. (*Journ. I.E.E.*, Aug. and Sept. 1936, Vol. 79, Nos. 476 and 477, pp. 227–230 and 348.) *See* 2887 of July.

4254. "DIE MATHEMATISCHEN HILFSMITTEL DES PHYSIKERS" [Book Review].—Madelung. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 17, 1936, pp. 286–287.) An enthusiastic recommendation in connection with applied as well as pure physics.

4255. "SHORT-WAVE WIRELESS COMMUNICATION : 3RD EDITION" [Book Review].—Ladner and Stoner. (*Wireless Engineer*, September, 1936, Vol. 13, No. 156, p. 485.)

4256. "1934 REPORT OF C.C.I.R. MEETING AT LISBON" [Book Review].—(*Proc. Inst. Rad. Eng.*, August, 1936, Vol. 24, No. 8, p. 1158.)

4257. "ENCICLOPEDIA DELLA RADIO, II EDIZ." *and* "RADIOTECHNICA, VOLS. I, II" [Book Reviews].—Tucci : Vanni and Tucci. (*L'Elettrotec.*, 25th June, 1936, Vol. 23, No. 12, p. 371.)

4258. "TECHNISCHE KUNSTGRIFFE BEI PHYSIKALISCHEN UNTERSUCHUNGEN" [Technical Artifices in Physical Investigations : Book Review].—Angerer. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 17, 1936, p. 246.) "It is so many-sided that it should be found on the work bench—not merely in the book-case—of every experimental physicist."

4259. "CHILDREN AND RADIO PROGRAMS" [Book Review].—Eisenberg. (*World-Radio*, 4th Sept. 1936, Vol. 23, p. 11.)

4260. RADIO ENGINEERING IN BOOKS AND JOURNALS OF THE YEAR 1934.—Patermann. (*Telefunken-Zeit.*, July, 1936, Vol. 17, No. 73, pp. 75–78.) Concluded from 2049 of May.

4261. FORTY YEARS OF WIRELESS : ANNIVERSARY OF MARCONI'S FIRST PATENT.—(*Marconi Review*, May/June, 1936, No. 60, pp. 29–32.)

4262. THE FUTURE OF RADIO AND PUBLIC INTEREST, CONVENIENCE AND NECESSITY [Statement to FCC, June, 1936].—Sarnoff. (*RCA Review*, July, 1936, Vol. 1, No. 1, pp. 5–14.)

4263. THE TELEFUNKEN AEROPLANE EXPEDITION 1935 [Demonstration Tour in S.E. Europe and Asia Minor in Machine equipped with Various Telefunken Sets].—Nebel. (*Telefunken-Zeit.*, July, 1936, Vol. 17, No. 73, pp. 69–74.)

Among the technical results of the experience was that while the 83 m wave, as was expected, gave certain communication by day over only about 500 km, the 53 m wave was reliable over the whole stretch of 1800 km.

4264. THE "LIBRARY OF PATENTS," PARIS.—Bocquet. (*L'Onde Élec.*, September, 1936, Vol. 15, No. 177, pp. 569–576.)

4265. PLANT SURVEYS [Use of Graphic Meters for tracing Losses, improving Efficiency, etc.].—Wenger. (*Rad. Engineering*, July and Aug. 1936, Vol. 16, Nos. 7 and 8, pp. 5–9 and 16 : pp. 12–16 and 31.)

4266. CONTRIBUTION TO THE STUDY OF TELEPHONIC DISTURBANCES DUE TO CROSSING OF COMMUNICATION LINES AND HIGH-TENSION POWER LINES.—Mirolubov. (*Tech. Phys. of USSR*, No. 5, Vol. 3, 1936, pp. 391–407 : in French.) Theory and experimental confirmation on model lines.

4267. RECENT ADVANCES IN CARRIER TELEPHONY.—Halsey. (*Inst. of P.O. Elec. Eng.*, Printed Paper No. 157, 36 pp.)

4268. IMPROVEMENTS IN TELEMETERING EQUIPMENTS.—Iliovici. (*Bull. de la Soc. franç. des Élec.*, August, 1936, Vol. 6, No. 68, pp. 826–844.)

4269. A HIGH-FREQUENCY FURNACE WITH VALVE GENERATOR [useful Output 250 kW, melting 50 kg of Iron within 15 Minutes : Water-Cooled Coil.].—Heller. (*Philips Tech. Review*, February; 1936, Vol. 1, No. 2, pp. 53–59.) Frequency range is about 6–18 kc/s.

4270. THE USE OF THE ANALOGY BETWEEN ELECTRICITY AND HEAT FOR THE CONSTRUCTION OF AN APPARATUS FOR THE INVESTIGATION OF THE THERMAL CONDUCTIVITY OF SOLID BODIES AND FOR THE EVOLUTION OF "THERMAL BRIDGES."—Loshkin. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 6, 1936, pp. 1281–1291.)

4271. SOME MAIN FEATURES OF RADIO-GEOLOGY.—Fritsch. (*E.T.Z.*, 23rd July, 1936, Vol. 57, No. 30, pp. 857–861.)

A number of the writer's papers on experimental results in caves and mines have been referred to in these Abstracts : *see* 871 of March and back references, and 4273, below. Several other references, to papers in specialised journals, are given at the end of the present survey, and Ambronn's paper on the various electrical methods of geophysical prospecting (2503 of 1935) is referred to in a footnote. As regards such prospecting, the present paper deals only with the two methods most generally employed—the absorption and capacity methods—but it also discusses other aspects of radio-geology, such as its importance in connection with lightning effects. Instances are given of buried cables being struck while neighbouring trees remained untouched, and of lightning conductors escaping strokes which hit much lower buildings supposedly within the protected zone: all such phenomena are attributed to the geological properties of the ground. The final section deals with the possibilities of mine radio, not to replace the ordinary wired telegraphy and telephony installations in mines, but to supplement them for use in catastrophes. *Cf. The Times*, 18th August, 1936, p. 15.

4272. RADIO COMMUNICATION IN MINES AS AN EMERGENCY SERVICE.—(*See* 4271, above.)

4273. THIRD COMMUNICATION ON THE EXPERIMENTS IN WIRELESS RECEPTION IN MINES AT KOTTERBACH.—Fritsch. (*Hochf:tech. u. Elek:akus.*, June, 1936, Vol. 47, No. 6, pp. 190–195.

For previous work *see* 4271, above. Further experiments are here described which showed that reception of 25 m waves was possible in mines at depths down to 50 m; the waves were rapidly absorbed in good geological conductors. The fields produced by emitters in the mines themselves depended on the linear distance of the receiver from the emitter. Practical conclusions are drawn as to the use of wireless experiments in detecting the nature of geological formations.

4274. PHOTOELECTRIC METHODS OF MEASURING THE VELOCITY OF RAPID REACTIONS. I—GENERAL PRINCIPLES AND CONTROLS: II AND III—APPARATUS.—Roughton and Millikan. (*Proc. Roy. Soc.*, Series A, 2nd June, 1936, Vol. 155, No. 885, pp. 258–269: 269–276: 277–292.)

4275. A RECORDING PHYSICAL DENSITOMETER [Comparison of the Three Main Photoelectric Methods and Description of the Instrument designed for Kodak Laboratories].—Tuttle. (*Journ. Opt. Soc. Am.*, July, 1936, Vol. 26, No. 7, pp. 282–292.)

4276. PHOTOELECTRIC TIMING DEVICES [*e.g.* for Motor-Car Speeds].—Briebrecher. (*Zeitschr. V.D.I.*, 13th June, 1936, Vol. 80, No. 24, pp. 761–762.)

4277. A PHOTOELECTRIC APPARATUS FOR DELINEATING THE SIZE FREQUENCY CURVE OF CLAYS OR DUSTS.—Richardson. (*Journ. Scient. Instr.*, July, 1936, Vol. 13, No. 7, pp. 229–233.)

4278. AN ULTRA-VIOLET RECORDING METER [for Irradiation Dosage].—Wolf. (*Electronics*, June, 1936, Vol. 9, No. 6, pp. 12–14.)

4279. PHOTOELECTRIC MEASUREMENTS OF THE LUMINOUS EFFICIENCY OF DAYLIGHT.—Atkins and Poole. (*Proc. Roy. Soc.*, Series B, Vol. 121, p. 1: abstract only in *Proc. Roy. Soc.*, Series A, Vol. 156, No. 888, pp. 233.)

4280. PHOTOMETERING RAW SILK [and the Development of the "Evenometer"].—Finlay: Shepard. (*Electronics*, July, 1936, Vol. 9, No. 7, pp. 12–14 and 66, 67.)

4281. ELECTRICAL MEASUREMENT OF SILK THREAD DIAMETER [by Continuously Recording Ultra-Micrometer].—Schuck. (*Elec. Engineering*, September, 1936, Vol. 55, No. 9, pp. 991–996.)

After tests had proved that the average squared deviation of diameter was a suitable measure of quality, the apparatus was extended by the addition of integrating devices, from which the quality rating can be obtained at the completion of a run.

4282. EXTENSOMETER WITH VERY SMALL TEST-GAP AND PHOTOCELL INDICATION [1–2 mm Gap and 10 000–100 000 Magnification].—Lehr. (*Zeitschr. V.D.I.*, 4th July, 1936, Vol. 80, No. 27, p. 842.)

4283. PIEZOELECTRIC ULTRAMICROMETER [Measurement of Very Small Displacements, using Steep Crevasse of Piezoelectric-Resonator Response Curve].—Hubbard. (*Phys. Review*, 1st June, 1936, Series 2, Vol. 49, No. 11, p. 865: abstract only.) *See* also 2895 of July.

4284. TUBES HELP MAKE AUTOMOBILES [Assistance in Spray Painting, Welding, Titration Control, Spark-Gap Adjustment, Scleroscopy and Other Tests of Cast Parts].—Powers. (*Electronics*, June, 1936, Vol. 9, No. 6, pp. 22–24 and 55.)

4285. ELECTRONIC ENGINEERING: THE POSSIBILITIES OF THE APPLICATION OF "MUTATOR" TUBES TO POWER GENERATION, TRANSMISSION AND CONVERSION PROBLEMS.—Alexanderson. (*Electronics*, June, 1936, Vol. 9, No. 6, pp. 25–26.)

4286. THE "DEMONSTROMETER" [giving "a Surprisingly Contrasting but Accurate Record of Audience-Response."]—Columbia Broadcasting System. (*World-Radio*, 10th July, 1936, Vol. 22, p. 4.)

4287. "INDICATORS FOR HIGH-SPEED INTERNAL COMBUSTION ENGINES" [Book Review].—Kallhardt. (*Zeitschr. V.D.I.*, 25th July, 1936 Vol. 80, No. 30, p. 924.) Including improvements in the piezoelectric indicator which render it superior to all other types at speeds up to 1200 r.p.m.

4288. A NOVEL AMPLIFIER FOR USE WITH A PIEZO-CRYSTAL INSTALLATION.—Calvert. (*See* 4213.)

4289. THE USE OF 1–10 CM MICRO-WAVES FOR DETECTION OF MOVING OBJECTS, AIRCRAFT ALTIMETERS, ETC.—Rice. (*See* 4006.)

4290. THE USE OF OSCILLATORY CIRCUITS FOR ALARM PURPOSES [Photocell Devices replaced by Capacity-Sensitive Circuits giving Alarm at Onset (better than at Breaking Off) of Oscillation].—Nentwig. (*E.T.Z.*, 20th Aug. 1936, Vol. 57, No. 34, pp. 975–976.)

Leading up to the design of a mains-operated apparatus (Fig. 5) embodying a 2000 m regenerative oscillation circuit in which the "antenna" (*e.g.* an insulated wire zig-zagging under a carpet) is connected not to the grid but to the back-coupling coil at *a*. Large fluctuations of mains voltage have no effect on the functioning of the equipment, which is, however, so sensitive that a foot approaching within 20 cm will operate it.

4291. THE THERMAL CONDUCTIVITY OF ELECTRETS [is greater than That of the Unpolarised Substances].—Groetzinger. (*Physik. Zeitschr.*, 15th Aug. 1936, Vol. 37, No. 16, pp. 589–592.)

4292. THE MEASUREMENT OF THE DIELECTRIC LOSS AS A METHOD OF PHYSICO-CHEMICAL INVESTIGATION.—Rohde, Wulff and Schwindt. (*Angewandte Chemie*, 11th July, 1936, Vol. 49, No. 28, pp. 437–443.)

4293. ELECTRIC IMPEDANCE AND PERMEABILITY OF LIVING CELLS [including Changes on Fertilisation of Sea-Urchin and Other Eggs, and on Stimulation of Muscle].—McLendon. (*Science*, 21st Aug. 1936, Vol. 84, pp. 184–185.) Including a number of literature references.

4294. WOOD [also Brick Moulds for Shoe Lasts, and Newly Built Houses] DRIED BY RADIO [Short and Ultra-Short Waves].—(*Electrician*, 21st Aug. 1936, Vol. 117, p. 216.) A paragraph on Russian developments, using frequencies of 20 and 150 Mc/s. *See* also 1660 of April.

4295. DISPERSION MEASUREMENTS WITH DECIMETRE WAVES [in Connection with Likelihood of Biological and Chemical Effects].—von Ardenne, Groos and Otterbein. (*See* 4178.)

4296. TEMPERATURE MEASUREMENTS ON LAYERS OF BIOLOGICAL TISSUE [Fat and Muscle] AT FREQUENCIES 2.7×10^7 TO 1.2×10^9 c/s. Esau, Pätzold and Ahrens. (*Naturwiss.*, 14th Aug. 1936, Vol. 24, No. 33, pp. 520–521.)

4297. BIOLOGICAL AND TECHNICAL-PHYSICAL FOUNDATIONS OF SHORT- [and Ultra-Short] WAVE THERAPY.—Schliephake and Wenk. (*E.T.Z.*, 23rd July, 1936, Vol. 57, No. 30, pp. 863–868.)

Comparison with medium-wave diathermy: effect of different electrode distances and the behaviour of different spacing materials: "unipolar" application of condenser field: requirements of apparatus: properties of various wavelengths (6 m the most generally useful): practical equipment: the Esau-Wechsung generating circuit: special electrode forms: etc. A number of Schliephake's own works have been dealt with in these Abstracts (*see* for example Abstracts, 1933, p. 640; 1934, p. 284); for the Esau-Wechsung circuit *see* 1928 Abstracts, p. 518 (Wechsung); this is now shown in Fig. 1, but "for the larger powers mentioned above the usual push-pull circuit is employed, with its great advantages in convenient change of wavelength." The paper also gives references to the works of Schereschewsky, Schmid, Bessemans & Vanhoutegham, Kowarschik, Leistner & Schaefer, and others, mostly in biological and medical journals.

4298. PRODUCTION AND THERAPEUTIC ACTION OF MICRO-WAVES [80 cm].—Denier. (*Sci. Abstracts*, Sec. A, 25th May, 1936, Vol. 39, No. 461, p. 554.)

"It is claimed that the effects of such radiation are due to cellular oscillation and are not simply heat effects. In respect to human subjects, details of combined treatment with ultra-short waves and radiotherapy are given and remarkable therapeutic results are reported. It is considered that ultra-short-wave therapy increases the radio-sensitivity of tumours."

4299. THE "SPECIFIC ACTION" OF ULTRA-SHORT WIRELESS WAVES [Critical Review of Evidence of Direct Biological Action of Short-Wave Radiation: Absence of Incontrovertible Proof of Its Existence].—Curtis, Dickens and Evans. (*Nature*, 11th July, 1936, Vol. 138, pp. 63–65.)

4300. THE DIATHERMIC EFFECT OF THE CONDENSER-SOLENOID CIRCUIT.—I. V. Fedorov-Rion. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 6, 1936, pp. 686–688.)

This circuit comprises a conductive cylinder mounted within a solenoid. An h.f. current is passed through the solenoid and a certain potential difference is maintained between the turns of the solenoid and the cylinder (Fig. 1.). In this paper formulae are derived for determining the amount of heat generated in a conductive object placed between the solenoid and the cylinder, and it is pointed out that this amount is much higher than would be obtained were the object placed in the field due to either a condenser or a solenoid by itself.

4301. VARIOUS ARTICLES ON RADIOLYMPIA, 1936.—(*Wireless Engineer*, October, 1936, Vol. 13, No. 157, pp. 524–533: *Wireless World*, 28th Aug. and 4th Sept. 1936, pp. 218–235: pp. 242–248, 253–254, 260–262, and 264–273: *Nature*, 5th Sept. 1936, pp. 410–411: *World-Radio*, 28th Aug. and 4th Sept. 1936.)

4302. BERLIN RADIO SHOW.—(*Wireless World*, 18th Sept. 1936, Vol. 39, pp. 302–305.)

4303. PARIS SHOW.—(*Wireless World*, 25th Sept. 1936, Vol. 39, pp. 330–332.)

4304. RADIO IN FRANCE ["Salon de T.S.F." and "Foire de Paris"].—Aisberg. (*Wireless World*, 5th June, 1936, Vol. 38, pp. 554–565.)

4305. THE 13TH SALON OF WIRELESS [May, 1936: including Some Criticisms of Makers' Claims, etc.].—(*L'Onde Élec.*, July, 1936, Vol. 15, No. 175, pp. 397–410.)

4306. REVIEW OF 1935 [Telegraphy, Telephony Phototelegraphy, Ultra-Short-Wave Links, Broadcasting, Telediffusion, Television].—(*Ann. des Postes, T. et T.*, May and June, 1936, Vol. 25, Nos. 5 and 6, pp. 445–483 and 505–530.) Extracts from a *Journal des Télécommunications* article.

4307. I.R.E. ANNUAL CONVENTION [Doherty High Efficiency Amplifier-Modulator, Morrison Shunt-Excited Aerial, Volume Expansion, Difference in Efficiency of Transmission in E–W and N–S Directions: etc.].—(*Electronics*, June, 1936, Vol. 9, No. 6, pp. 18–21.)

4308. CAVALCADE OF WIRELESS [Development during 25 Years of *Wireless World*].—(*Wireless World*, 1st May, 1936, Vol. 38, pp. 433–445.)

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.

AERIALS AND AERIAL SYSTEMS

446 680.—Utilizing the bumper bars of a motor-car to support or house a wireless aerial.
Marconi's W.T. Co. and A. A. Linsell. Application date 3rd November, 1934.

2 021 734.—Elevated broadcast receiving aerial with balanced transmission line as down-lead designed to cut out inductive interference.
W. W. Macalpine (assignor to International Communications Laboratories).

2 027 733.—Lattice-work aerial mast, insulated at base, and resting on two principal supports, with two auxiliary guy-wires at right-angles.
R. L. Jenner (assignor to Lapp Insulator Co., Inc.).

TRANSMISSION CIRCUITS AND APPARATUS

445 582.—Automatic grid-biasing arrangement for a small-powered transmitter.
Marconi's W.T. Co. and E. H. Trump. Application date 12th October, 1934.

445 748.—Wired wireless system in which the inherent impedances of an existing network are utilised to advantage.
F. R. Tate (communicated by Radio Systems Inc.). Application date 27th August, 1935.

446 497.—Valve generator for low-powered transmitters, as used in aeroplanes or for mobile purposes generally.
The Plessy Co. and A. D'A. Hodgson. Application date 25th September, 1934.

2 020 813.—Coupling and transmission line for distributing broadcast programmes, in high-frequency form, from a common aerial to different receivers.
J. van Slooten (assignor to Radio Corporation of America).

2 023 222.—Transmitter with simplified means for radiating a " calling signal " say to a fleet of police patrol cars.
G. W. Fyler (assignor to General Electric Co.).

2 024 219.—Automatic keying device for transmitting the recognised " distress " signal at sea, in times of emergency, so that an alarm is operated at any unattended receiver within range.
R. W. Hart (assignor to Submarine Signal Co.).

RECEPTION CIRCUITS AND AMPLIFIERS

445 763.—" Switch " Method of cutting-out static and similar interference from the loud-speaker of a wireless receiving set.
N. V. Philips Co. Convention date (Germany) 1st February, 1935.

445 893.—Amplifier wherein the output coupling resistance consists of the internal resistance of a diode or triode having the same power law as the amplifier. Designed to ensure a straight-line response.
Marconi's W.T. Co. and H. J. Round. Application date 19th October, 1934.

446 018.—Image-suppression circuit for a superhet receiver.
Marconi's W. T. Co. (assignees of J. Yolles). Convention date (U.S.A.) 28th October, 1933.

446 634.—Static-eliminator circuit for a wireless receiver.
Ideal Werke Akt. Convention date (Germany) 15th December, 1934.

446 671.—Screen-grid valve biased to give a dynatron effect and used as a rectifier free from grid-current damping.
D. C. Birkinshaw. Application date 30th October, 1934.

447 559.—Tuning arrangement for a wireless receiver in which one element is adjusted in a series of " stepped " movements, whilst another element is continually varied to and fro about each step.
Ideal Werke Akt fur drahtlose Telephonie.

448 448.—Receiving circuits in which a phase-modulated or frequency-modulated carrier-wave is converted into an amplitude-modulated wave and then rectified.
Marconi's W. T. Co. (assignees of M. G. Crosby). Convention date (U.S.A.) 27th December, 1933.

450 606.—Automatically controlling the volume of a motor car set in accordance with the speed of the vehicle.
E. K. Cole and E. J. Wyborn. Application date 25th January, 1935.

450 616.—Adjustable means for varying the grid-bias applied to push-pull valves of the " quiescent " type, in order to avoid distortion.
General Electric Co. and K. A. Macfadyen. Application dates 14th June and 11th November, 1935.

450 664.—Automatic tuning circuit designed to operate with equal efficiency over the whole tuning range.
N. V. Philips' Co. Convention date (Germany) 18th June, 1935.

VALVES AND THERMIONICS

445 464.—Cathode-ray tube of double-coned shape with a fluorescent screen in the middle and " gun " electrodes at each end.
Ferranti and M. K. Taylor. Application date 6th September, 1934.

445 975.—Cathode-ray tube with a filling of argon, neon, or helium, together with hydrogen, at a pressure of from 5 to 250 mm. of mercury.
F. J. G. Van den Bosch. Application date 13th February, 1935.

446 180.—Method of assembling the electrodes so as to facilitate focusing in a cathode-ray tube.
F. H. Nicoll. Application date 24th October, 1934.

446 635.—Electrode construction and assembly in a cathode-ray tube.
Radio Akt. D. S. Loewe. Convention date (Germany) 2nd October, 1933.

DIRECTIONAL WIRELESS

446 619.—Reflector system for concentrating wireless waves into a parallel beam.
Telefunken Co. Convention date (Germany) 3rd September, 1934.

2 028 856.—Direction-finder of the Bellini-Tosi type adapted to operate over a wide range of wavelengths.
F. Woods (assignor to Radio Corporation of America).

TELEVISION AND PHOTOTELEGRAPHY

445 665.—Magnetic deflection coils for applying the line and frame scanning voltages to a cathode-ray tube.
C. Lorenz Akt. Convention date (Germany) 30th July, 1934.

445 912.—Method of synchronising in an interlaced scanning system for televising from a film.
C. O. Brown. Application date, 18th October, 1934.

445 938.—Controlling the size of the spot as projected on the fluorescent screen of cathode-ray television receiver, in order to reduce picture distortion.
Marconi's W. T. Co.; H. M. Dowsett; and L. E. Q. Walker. Application date 19th October, 1934.

445 978.—Producing a coloured area of illumination surrounding the fluorescent screen of a cathode-ray tube so as to improve the natural appearance of the projected picture.
The General Electric Co. and B. P. Dudding. Application date 26th March, 1935.

446 171.—Safety device for protecting a cathode-ray tube against excess voltages.
Radio Akt. D. S. Loewe. Convention date (Germany) 11th October, 1933.

446 346.—Transformer coupling for passing a wide band of frequencies, such as are used in television.
Radio Akt. D. S. Loewe. Convention date (Germany) 27th October, 1933.

446 432.—Separating synchronising from picture signals used in television, by a method based upon their relative amplitudes.
P. W. Willans and Baird Television. Application date, 2nd November, 1934.

446 547.—Safety circuit for use with cathode-ray tubes, to prevent damage to the fluorescent screen.
Radio Akt. D. S. Loewe. Convention dates (Germany) 12th February and 19th April, 1934.

446 585.—Cathode-ray television receiver fitted with a photo-sensitive "storage" plate not subject to the direct scanning action of the electron stream.
D. M. Johnstone and Baird Television. Application date 6th November, 1934.

446 618.—Magnetic deflection circuit for a cathode-ray television receiver.
C. Lorenz, Akt. Convention date (Germany) 7th September, 1934.

446 661.—Regulating the operating potentials in a cathode-ray tube having a photo-sensitive electrode of the Iconoscope type.
A. D. Blumlein and J. D. McGee. Application date 3rd August, 1934.

446 663.—Means for preventing the appearance of spurious white flashes in television pictures, whether caused by interference or by strong synchronising signals.
A. D. Blumlein. Application date 4th September, 1934.

450 675.—Methods of minimising interference due to spurious signals in television.
C. O. Browne; J. Hardwick; F. Blythen; and E. L. C. White. Application dates 19th November, 1934; 1st and 3rd April, 1935.

2 021 889.—Helical scanning-drum for television, combined with concave mirrors for increasing the size of the received picture.
C. D. Fahrney.

SUBSIDIARY APPARATUS AND MATERIALS

445 614.—Composition and preparation of a high-permeability powdered core for inductances.
K. Z. Kenkyusho. Convention date (Japan) 21st April, 1934.

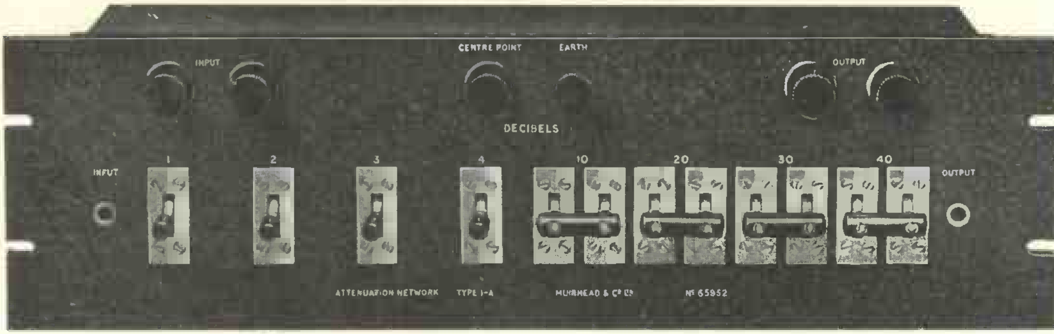
446 673.—Centering and suspension of the speech coil in an electrodynamic loud speaker.
Ferranti and A. Bennett. Application date 31st October, 1934.

447 461.—Holders or supports for ultra-short-wave valves of the so-called Acorn type.
Marconi's W. T. Co. (assignees of B. Selzberg). Convention date (U.S.A.) 12th September, 1934.

2 023 112.—Holder for a piezo-electric crystal which prevents the crystal from shifting without exerting appreciable pressure.
J. G. Beard (assignor to Westinghouse Electric and Manufacturing Co.).

MISCELLANEOUS

2 021 907.—Reproducing objects normally invisible to the human eye by projection on the fluorescent screen of a cathode-ray tube.
V. K. Zworykin (assignor to Radio Corporation of America).



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Apply, quoting Ref. No. A. 265, and stating age, and full particulars of training and experience to the Chief Superintendent, Royal Aircraft Establishment, South Farnborough, Hants. The closing date for the receipt of applications is 14th November, 1936. [386

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