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Editorial.

Physical Research and the Wireless Industry.

WITHIN the last few weeks we have read two papers of an historical character dealing with the physical research associated with wireless telegraphy and telephony. One entitled, "A Summary of Progress in the Study of Radio Wave Propagation Phenomena," by Kenrick and Pickard was published in the April Number of the Proceedings of the Institute of Radio Engineers; the other was delivered by Dr. Eccles as his Presidential Address before the Institute of Physics on 27th May. The latter covers much the wider field as it was prepared with the object of giving an historical analysis of the direct influence of physical research on the whole industry of wireless telegraphy and telephony, showing how the industry grew out of the work of pure scientists, whereas the American paper gives a review of a branch of scientific research which has grown out of the wireless industry. We commend Dr. Eccles' address to all our readers, but especially to those of the younger generation who are not acquainted with the pioneer work of the scientists who, by probing the secrets of nature, made the discoveries, which others, no less worthy of our admiration, applied and developed into one of the greatest achievements of this age of wonders. Lest any of these latter should feel hurt at the omission of their names Dr. Eccles states that he necessarily omits all reference to "the great engineers who have adorned the industry," and admits that many of the contributions of the physicist to wireless would have remained puny and ineffective, had they not been nurtured and adopted by the engineer. As we read of the work of Hertz in 1885 to 1888, of Lodge in 1889, of Minchin and Branly in 1890, and of the demonstration by Lodge in 1894 of the transmission of signals through several walls at the Royal Institution, we feel moved to send a message of congratulation to Sir Oliver on being still with us to witness and take part in the stupendous developments which have taken place since that demonstration thirty-six years ago. We are pleased to see that Dr. Eccles emphasises the great debt of early wireless to Sir Oliver Lodge's clear enunciation of the principles of the oscillatory circuit and the dependence of selectivity upon a small decrement. After referring to the work of Duddell and Poulsen on the arc and the quenched spark researches of Max Wien, reference is made to the important work of Fessenden whose invention of the heterodyne method of reception is regarded by Dr. Eccles as one of the four or five universally important steps in the history of wireless technique. Reference is made to the thermionic researches of Hittorf, Preece, Elster and Geitel and Fleming between the years 1883 and 1896, but it will surprise many to know that " the first vacuum tube containing a hot filament and a separate electrode with external lead, that is, the first thermionic diode, was made by Edison in 1883." " It is sometimes said that Wehnelt invented the thermionic valve, but this is a fallacy ; he invented the coated filament and he invented the name, perhaps, but thermionic tubes with two electrodes had long been commonplaces in physical laboratories." Dr. Eccles traces the evolution of the triode through the inventions of de Forest, von Lieben and von Baeyer and its lying dormant and almost useless for want of a sufficiently good vacuum. Was there ever a greater tragedy in the world of patents than de Forest's British triode patent being offered in vain to various firms and allowed to lapse for want of payment of the £5 renewal fee ? Dr. Eccles then refers to the wonderful applications of piezo-electric effects to wireless and finally to the coming of short waves, but these are recent developments with which all are familiar.

We were very struck by the fact that the other paper which deals with the study of radio wave phenomena enumerates on its first few pages fourteen names of scientists not one of whom is mentioned in Dr. Eccles' address, but they are mostly mathematicians who worked at the propagation problem. It is interesting to note that Balfour Stewart in 1882 and Arthur Schuster in 1886 postulated a conducting layer in the upper atmosphere to explain certain phenomena of terrestrial magnetism ; this layer is more hyphenated than we had suspected, and when we noticed that the authors refer to the echoes of long delay as the Störmer-Hals-van der Pol echoes, we should not have been surprised at a reference to the Stewart-Schuster-Kennelly-Heaviside layer. This sort of thing can be overdone. If we refer to the layer as the Heaviside layer it does not follow that we believe that Heaviside was the first or only person who postulated its existence or its effects in radio transmission.

In discussing radio direction finding the authors state that " the presence of abnormal polarisation (resulting from transmission phenomena) therefore represents a problem in radio direction finding which has as yet found no satisfactory solution." This statement is hardly justified in view of the results obtained by the Radio Research Board with the Adcock type of aerial. Such historical summaries, however, serve a very useful purpose, especially when they are accompanied, as in this case, by a complete bibliography.

G. W. O. H.

The Numerical Expression of Selectivity*

By R. T. Beatty, M.A., B.E., D.Sc.

1. Introduction.

THE discussion of the selectivity of a receiver or of the high-frequency tuned circuits incorporated in it is hampered by the lack of a precise definition of selectivity and of a numerical figure by which it can be expressed. It is impossible to reason closely about a thing which is defined in vague terms and indeed, some psychologists have asserted that all thought is accompanied by microscopic speech movements and that in the absence of names for things thought itself is impossible.

When we consider the selectivity of a tuned circuit which is picking up a carrier wave we first imagine it tuned to resonate to the incoming frequency and then detuned by a certain number of cycles per second till the response—either the current round the circuit or the P.D. across the condenser—falls to some value, say, 1/10th of the original response.

It is then natural to regard the selectivity as the change in frequency (whether produced by rotating the tuning condenser or due to a change in the frequency of the carrier wave) divided by the original frequency: thus, if the original frequency for maximum response is 1,000 kilocycles, and a change of 10 kilocycles causes the response to drop to 1/10th of its initial value, the selectivity might be given as 10/1,000 = 0.01.

Such a definition, however, involves the difficulty that as selectivity *increases* the number which represents it *decreases*: obviously the property of the circuit which *decreases* is the breadth of the resonance curve or the *tolerance*† of the circuit in responding to a small range of carrier frequencies.

The difficulty may be surmounted by inverting the number in question; that is, taking the original frequency divided by the change in frequency to represent the selectivity. This is the method which is adopted in this article, and it will be shown that it leads to rapid mental calculation of the selectivity of a single circuit or of a multistage amplifier and that this number bears a simple relation to the important quality of a circuit known as the coil magnification.‡

2. The Resonance Curve of an Acceptor Circuit.

In the acceptor or series circuit shown in Fig. 1, the current i is given by

$$e = i[R + j \,.\, L\omega - j/C\omega] \quad \ldots \quad (1)$$

where $\omega = 2\pi \times$ frequency of the injected e.m.f. e.

At resonance $L\omega_0 = 1/C\omega_0$ and the reactances cancel, leaving

$$e = iR \,. \quad \ldots \quad \ldots \quad (2)$$

At any frequency near that of resonance put

$$\omega = \omega_0[1 + \partial\omega/\omega_0] \,.. \quad \ldots \quad (3)$$

and the reactances become

$$L\omega_0[1 + \partial\omega/\omega_0] - 1/C\omega_0[1 + \partial\omega/\omega_0] \quad (4)$$

or since $L\omega_0 = 1/C\omega_0$, (4) becomes

$$L\omega_0[1 + \partial\omega/\omega_0 - 1/(1 + \partial\omega/\omega_0)] \,.. \quad (5)$$

Since $\partial\omega/\omega_0$ is a small quantity

$$1/(1 + \partial\omega/\omega_0) = 1 - \partial\omega/\omega_0$$

very nearly, and (5) becomes

$$L\omega_0 \,.\, 2\partial\omega/\omega_0 \quad \ldots \quad \ldots \quad (6)$$

or

$$L\omega_0 \,.\, 2\partial f/f_0 \quad \ldots \quad \ldots \quad (7)$$

Hence the impedance of the circuit shown in Fig. 1 and given in brackets in equation (1) becomes

$$R + j \,.\, L\omega_0 \,.\, 2\partial f/f_0$$

or

$$R[1 + j \,.\, L\omega_0/R \,.\, 2\partial f/f_0] \quad \ldots \quad (8)$$

* MS. received by Editor, August, 1929.

† This term was proposed by the writer (*Phil. Mag.*, 4, 1927, 1081) but has not met with general acceptance, perhaps rightly so, since the introduction of a new term into the crowded vocabulary of wireless is a grave step.

‡ Mr. F. M. Colebrook (*E.W. & W.E.*, 1929, p. 422) proposes a definition of selectivity which involves the second differential of the impedance of a circuit with respect to frequency. [See also a letter by Mr. E. A. Biedermann in *E.W. & W.E.*, 1929, p. 552]. In the simple case of a single tuned circuit Mr. Colebrook finds the selectivity given by the expression $2m$, where m is the coil magnification. In the method here proposed the expression for a single tuned circuit is similar to that given by Mr. Colebrook except that the numerical coefficient is 0.2 instead of 2, but the treatment differs widely when more complicated circuits are considered.

The expression $L\omega_0/R$ occurring in (8) is the ratio of coil reactance to coil resistance and is known as the coil magnification m: it is the ratio of the P.D. across the coil in Fig. 1 to the injected e.m.f. when the circuit is in resonance: putting in m (8) becomes

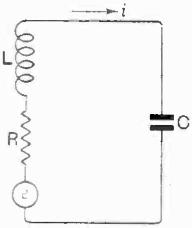

Fig. 1.—*A series or acceptor circuit.*

$$R[1 + j \cdot 2m \cdot \partial f/f_0] \quad (9)$$

This is the complex impedance of the circuit: the numerical impedance can be seen from the construction of Fig. 2 to be

$$R[1 + 4m^2 \cdot \partial f^2/f_0^2]^{\frac{1}{2}} \quad (10)$$

Expression (10) is the impedance of the series or acceptor circuit shown in Fig. 1. R, the resistance at frequency f_0, remains substantially constant for small frequency changes: m is the coil magnification (coil reactance divided by coil resistance): ∂f is the small increase of frequency of the injected e.m.f. over the original frequency f_0, to which the circuit is tuned.

The fraction of the applied P.D. which appears across the coil is the ratio of the coil impedance to the total impedance of the circuit. For small changes in frequency the coil impedance may be taken as constant so that the P.D. which appears across the coil is inversely proportional to the impedance of the circuit, and so the resonance curve can be plotted as in Fig. 3.

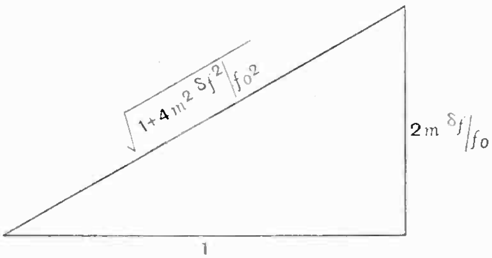

Fig. 2.—*When the horizontal line represents resistance and the vertical line represents a series reactance, the slant line represents the numerical impedance.*

The ordinates give the induced voltage at any stage of detuning relative to the maximum induced voltage at resonance, *i.e.*, when $\partial f = 0$.

3. The Selectivity Number for an Acceptor Circuit.

From Fig. 3 it appears that the induced P.D. across the coil or the condenser falls to 1/10th of its value at resonance when $m \cdot \partial f/f_0 = 5$. *i.e.*, when $f_0/\partial f = 0.2 \times m$. Let us designate this special value of ∂f by the symbol $\triangle f$ and define the number expressing the selectivity of the circuit as follows:

$$\text{Selectivity number} = f_0/\triangle f = 0.2 \times m \quad (11)$$

The number which expresses the selectivity of the series or acceptor circuit shown in Fig. 1 is 0.2 times the coil magnification m. The number of kilocycles by which the frequency of the injected e.m.f. e must be changed from the resonance frequency f_0 in order to reduce the induced voltage across the coil to 1/10th of its value at resonance is found by dividing f_0, expressed in kilocycles, by the selectivity number.

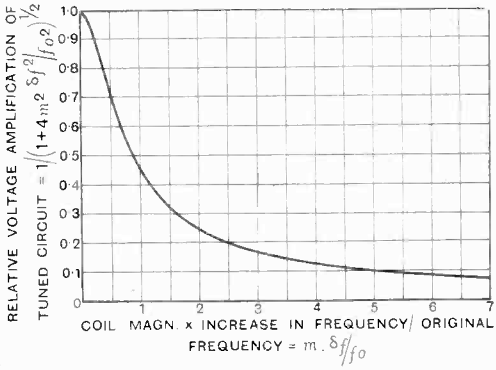

Fig. 3.

As an example, take the circuit in Fig. 1 and put in the following numerical values:

Resonance frequency . .	f_0	= 1,000 kilocycles.
Coil reactance	$L\omega$	= 2,000 ohms.
Coil resistance	R	= 10 ohms.

These figures are typical for a frame aerial working near 300 metres. The problem is to find the amount of detuning necessary to reduce the voltage induced across the coil to 1/10th of its value at resonance.

The coil magnification m is 2,000/10 = 200.
The selectivity number is 0.2 × 200 = 40.
Hence $\triangle f$ = 1,000 kc./40 = 25 kc.

As a second example, take a tuned grid circuit coupled to a typical aerial: the whole circuit is equivalent to a single circuit with increased resistance due to aerial damping. Put $f_0 = 1{,}000$ kc. $m = 50$: then the selectivity number $= 0.2 \times 50 = 10$, and $\triangle f = 1{,}000/10 = 100$ kc.

It is evident that the first circuit is more selective than the second, but the comparison is made more definite by giving 40 and 10 for the respective selectivities.

Since the change in *wavelength* corresponding to a given change in *frequency* is represented by

$$\lambda/\triangle\lambda = f/\triangle f = \text{selectivity number},$$

we see that the detuning can be expressed in metres by dividing the resonance wavelength in metres by the selectivity number. Thus in Example 1, $\triangle\lambda = 300$ metres/40 $= 7.5$ metres: in Example 2, $\triangle\lambda = 300$ metres/10 $= 30$ metres.

4. The Selectivity Number for a Rejector Circuit.

In the parallel or rejector circuit shown in Fig. 4 we imagine an alternating current of fixed amplitude to be impressed on the circuit and we consider the changes in v, the P.D. across the condenser, as the circuit is detuned.

When, as in the cases here considered, the frequency does not vary by more than about 10 per cent., Fig. 4 (*a*) may be replaced, to a high degree of approximation, by Fig. 4 (*b*), which is easier to treat mathematically.

Since $\qquad i = i_1 + i_2 + i_3$

we have

$$i = v[R/L^2\omega^2 + jC\omega - j/L\omega] \quad .. \quad (12)$$

$$= \frac{v}{L^2\omega^2}[R + j\,.\,C\omega\,.\,L^2\omega^2 - j\,.\,L\omega] \quad (13)$$

As in Section 2, we put, for frequencies near the resonance frequency, $\omega = \omega_0[1 + \partial\omega/\omega_0]$ and (13) becomes, after simplification,

$$i = \frac{v}{L^2\omega^2}[R + j\,.\,L\omega_0\,.\,2\partial f/f_0] \quad (14)$$

or finally, $i = v\,.\,\frac{R}{L^2\omega^2}[1 + j\,.\,2m\,.\,\partial f/f_0]$ (15)

Accordingly the numerical impedance of the circuit is, as shown in Fig. 2,

$$\frac{L^2\omega^2}{R}\,.\,\frac{1}{[1 + 4m^2\,.\,\partial f^2/f_0^2]^{\frac{1}{2}}} \quad .. \quad (16)$$

and the P.D. across the condenser is proportional to this expression: hence, comparing (16) with (10) we see that the resonance curve is the same as for the same circuit treated as a series circuit.

The resonance curve, i.e., the variation with frequency of the P.D. across the condenser of a tuned circuit, remains the same whether the circuit be treated as an acceptor circuit with an e.m.f. of constant amplitude injected in series, or a rejector circuit with a current of constant amplitude impressed across the circuit.

Consequently the selectivity number is the same in each case.

5. Rejector Circuit Following a Valve.

An impedance z in the plate circuit of a H.F. valve, as in Fig. 5 (*a*), may be represented as regards the A.C. components of current and voltage as in Fig. 5 (*b*).

In Fig. 5 (*b*) the sum of the downward currents through the two parts of the circuit is zero.

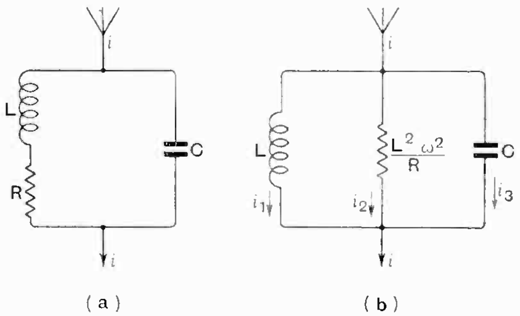

Fig. 4.—(*a*) *A parallel or rejector circuit.* (*b*) *This circuit is equivalent to (a), to a high degree of approximation.*

Hence $\qquad (v - \mu e)/R_v + v/z = 0$

or $\qquad v = \mu e\,.\,z/(z + R_v)$

$\qquad\qquad = g\,.\,e\,.\,z\,.\,R_v/(z + R_v)$

where g is the mutual conductance of the valve in plate amps. per grid volt. ge is evidently the A.C. plate current which would flow under A.C. grid voltage e if the plate load were zero.

Hence a tuned plate circuit may be represented as in Fig. 5 (*c*) where the valve resistance R_v is put in *parallel* and a current $i = ge$ is impressed, or to a high degree of approximation as in Fig. 5 (*d*) where $L^2\omega^2/R_v$ is the equivalent *series* resistance due to the valve.

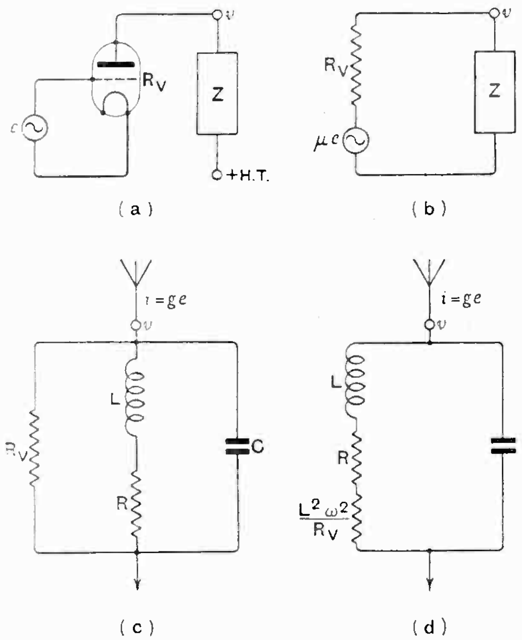

Fig. 5.—(*a*) *An impedance Z in the plate circuit of a H.F. valve.* (*b*) *Equivalent diagram for A.C. currents.* (*c*) *Equivalent diagram from which the valve has disappeared.* (*d*) *Equivalent diagram with valve resistance as an equivalent series resistor.*

Accordingly the system behaves as an isolated rejector circuit of resistance

$$R + L^2\omega^2/R_v = R[1 + m \,.\, L\omega/R_v]$$

and the original coil magnification m is changed as follows:

$$\text{corrected } m = m/[1 + m \,.\, L\omega/R_v] \quad .. \quad (17)$$

Thus if the coil has $m = 200$, and if

$$L\omega = 2{,}000\ \Omega,\ R_v = 200{,}000\Omega,$$

the corrected m is

$$200/[1 + 200/100] = 67.$$

If the coupling is by means of a high-frequency transformer with a turns ratio of $1 : n$ from aperiodic primary to tuned secondary, equation (17) becomes

$$\text{corrected } m = m/[1 + m \,.\, L\omega/n^2R_v] \quad .. \quad (18)$$

Thus in the preceding example, if a H.F. transformer were used with a step-up turns ratio of 1 : 2, the corrected m would be

$$200/[1 + 200/100 \times 2^2] = 133.$$

6. The Selectivity Number of a Single-stage H.F. Amplifier with Tuned Grid and Plate Circuits.

If the coil magnifications of the two tuned circuits are m_1 and m_2, the induced voltage divided by the voltage at resonance is

$$1/[1 + 4m_1^2\,\delta f^2/f_0^2]^{\frac{1}{2}} \text{ for one coil}$$

and $\quad 1/[1 + 4m_2^2\,\delta f^2/f_0^2]^{\frac{1}{2}}$ for the other,

as shown in Section 2.

The relative voltage for the two coils, when connected by the valve, is

$$1/[1 + 4m_1^2\delta f^2/f_0^2]^{\frac{1}{2}}[1 + 4m_2^2 \,.\, \delta f^2/f_0^2]^{\frac{1}{2}} \quad (19)$$

and a resonance curve can be plotted for any given values of m_1 and m_2, using expression (19) as the ordinate: as abscissa we choose the expression

$$\sqrt{m_1 \,.\, m_2} \,.\, \delta f/f_0 \quad .. \quad (20)$$

for reasons which will appear immediately.

If we choose values for m_1 and m_2 so that m_1/m_2 remains constant, then a single resonance curve can be drawn for this ratio: a different curve will appear for each ratio chosen.

In Fig. 6 two curves are shown: one for the case when $m_1 = m_2$: the other when either m is double the other. In practically all receiving H.F. sets the ratio does

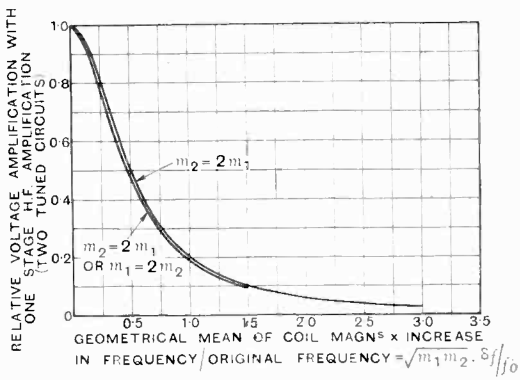

Fig. 6.

not exceed 2; Fig. 6 shows that the curves are nearly coincident, and so we may say that in practice any single stage set may be represented by one and the same resonance curve.

It was with this end in view that expression (20) was chosen for the abscissa of Fig. 6. No other function of m_1 and m_2 would result in an approximately single curve for all cases.

The voltage amplification falls to 1/10th its value at resonance when

$$\sqrt{m_1 \,.\, m_2} \,.\, \partial f / f_0 = 1.5.$$

$$\text{Hence } f_0 / \triangle f = 0.667 \times \sqrt{m_1 m_2}$$
$$= \text{selectivity number} \quad .. \quad (21)$$

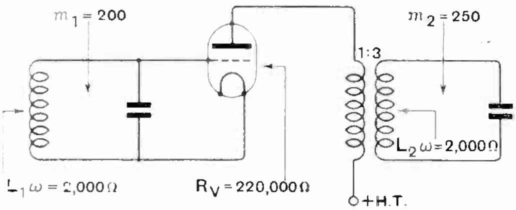

Fig. 7.—*Simple stage H.F. amplifier with frame aerial and transformer coupled tuned plate circuit.*

Equation (11) should be compared with this.

To find the selectivity number of a single stage H.F. amplifier calculate (1) the coil magnification of the tuned-grid circuit, corrected for any load which may be thrown on it by the aerial, (2) the coil magnification of the tuned plate circuit, corrected for the load thrown upon it by the preceding valve [Equations (17) and (18)]. The selectivity number is 0.667 times the geometric mean product of these two coil magnifications. [Equation (21)].

As an example take the amplifier shown in Fig. 7. The coil magnification of the tuned secondary, corrected for the load thrown upon it by the valve resonance through the transformer, is by equation (18)

$$250/[1 + 250 \,.\, 2{,}000/3^2 \,.\, 220{,}000] = 200$$

and m_1, the coil magnification of the frame aerial, is 200.

Hence the selectivity number is, by equation (21)

$$0.667 \times [200 \times 200]^{\frac{1}{2}} = 133.$$

7. The Selectivity Number for a Multi-stage H.F. Amplifier with Tuned Grid and Plate Circuits.

For two stages, with three tuned circuits, an extension of the reasoning in Section (6) gives the result that a resonance curve can be drawn with ordinate

$$1/[1 + 4m_1^2 \partial f^2/f_0^2]^{\frac{1}{2}}[1 + 4m_2^2 \,.\, \partial f^2/f_0^2]^{\frac{1}{2}}$$
$$[1 + 4m_3^2 \,.\, \partial f^2/f_0^2]^{\frac{1}{2}}$$

and abscissa

$$[m_1 \,.\, m_2 \,.\, m_3]^{\frac{1}{3}} \partial f / f_0 \quad .. \quad .. \quad .. \quad (22)$$

Whatever values are taken for m_1 m_2 m_3 it will be found that substantially the same curve results, provided that no m exceeds twice the magnitude of any other m.

The value of expression (22) which corresponds to the ordinate whose magnitude is 0.1, is 1.05.

Accordingly the selectivity number for a two-stage amplifier is

$$1.05 \times [m_1 \,.\, m_2 \,.\, m_3]^{\frac{1}{3}}.$$

Similar calculations can be worked out for a three- and four-stage amplifier and the results are summarised in the Table.

TABLE.

No. of Stages.	No. of Tuned Circuits.	Selectivity Number.
0	1	$0.2 \times m$
1	2	$0.667 \times [m_1 \,.\, m_2]^{\frac{1}{2}}$
2	3	$1.05 \times [m_1 \,.\, m_2 \,.\, m_3]^{\frac{1}{3}}$
3	4	$1.36 \times [m_1 \,.\, m_2 \,.\, m_3 \,.\, m_4]^{\frac{1}{4}}$
4	5	$1.63 \times [m_1 \,.\, m_2 \,.\, m_3 \,.\, m_4 \,.\, m_5]^{\frac{1}{5}}$

The figures in the third column are proportional, with an error not exceeding 10 per cent., to the numbers 1, 3, 5, 7, 9, and accordingly we get the extremely simple approximate formula

Selectivity number = 0.2 × geometric mean m × [number of valves + number of tuned circuits] .. .. (23)

For any H.F. amplifier in which each valve is preceded and followed by a tuned circuit, the selectivity number is approximately 0.2 multiplied by the geometric mean of the corrected coil magnification multiplied by the sum of the number of valves and the number of tuned circuits.

8. Applications of the Selectivity Number.

Before discussing the utility of the selectivity number in practice it is desirable to draw a set of resonance curves as in Fig. 8. The horizontal scale is in kilocycles and the curves have been drawn to intersect at a point where the amplification has dropped to

0.1 of its value at resonance. This means that the selectivity number is the same for each curve, *i.e.*, 200 if the resonance frequency is 1,000 kc., 100 if the resonance frequency is 500 kc.

For an amplifier of selectivity 50 at 500 kc. the set of curves must be displaced horizontally to the right till the intersection falls at 500/50 = 10 kc. on the horizontal axis.

With the help of these curves we may now consider the requirements of those who wish primarily for good reproduction. It will be generally agreed that a resonance curve which drops to 0.1 at 10 kc. gives fairly good quality. Accordingly for this requirement the selectivity should not exceed the value,

resonance frequency in kc./10 kc.

e.g., 83 for London (on the 830 kc. frequency). The number of stages is of little importance in this case, since although four stages give a sharper cut-off than one stage, yet the difference is not considerable up to 10 kc.

This degree of selectivity also enables one to separate two equally strong stations 20 kc. apart since it is easily seen that, if the curves are displaced till the intersection occurs at 10 kc., then even with one stage one station will be reduced to 0.025 times the strength of the other and so will be completely demodulated.

The limit of tolerable reproduction may be taken as given by a drop to 0.1 at 5 kc.: this is the actual condition shown in Fig. 8. The corresponding selectivity for London is 830 kc./5 kc. = 166. A multi-stage set, though it gives better reproduction of the lower notes than a single stage, cuts off the higher harmonics more sharply, so that the quality on the whole is unaffected by the number of stages.

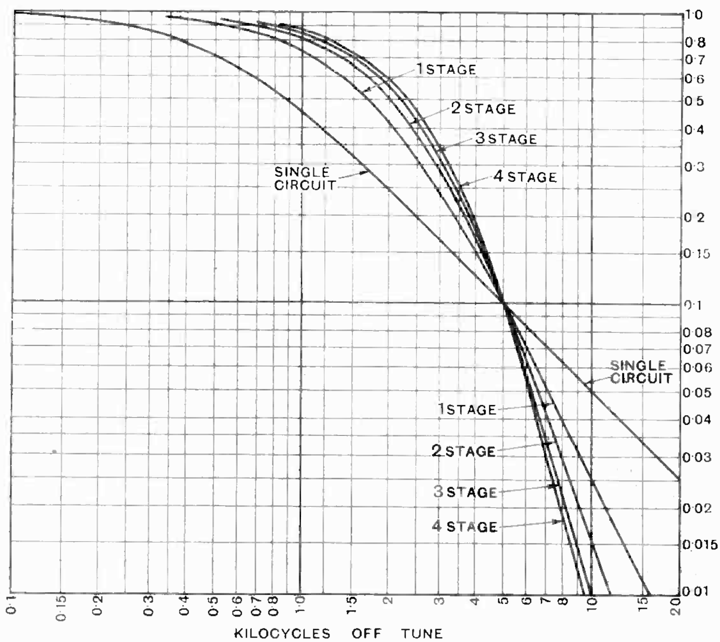

Fig. 8.

The elimination of the local station, however, is more easily effected by a multi-stage set as is seen by the trend of the curves near the bottom of Fig. 8. Hence with given selectivity foreign stations can more easily be brought in by a set which incorporates four or five tuned circuits of considerable decrement than by one with two circuits of small decrement. *It is better to use several bad coils than a few good ones.*

Summary.

A numerical definition of selectivity is proposed and a simple formula given at the end of Section 7 allows this quantity to be easily calculated for any H.F. amplifier which does not employ reaction, or H.F. filter circuits.

Notes on the Detuning Method of Measuring the High Frequency Resistance of a Circuit.*

By E. B. Moullin, M.A.

Introduction.

THE two best-known methods of measuring the high frequency resistance of a circuit depend on the observation of the alteration of current due either to a given change of resistance or to a given change of reactance. We are concerned here with the second method. We shall discuss the process of measurement and various causes of error, and in particular the error due to a small change of frequency: the likelihood of this error does not seem to be widely appreciated.

We shall presume that an oscillatory circuit, with tuning condenser, is coupled loosely to a valve generator and that there is some means of indicating the relative values of current in that circuit when certain changes are made to it. In particular we presume that the indicator is a thermionic voltmeter which is coupled loosely to the measuring circuit so as to reduce the effect of the power absorbed by the voltmeter. The generator is supposed to induce in the measuring circuit an E.M.F. $e = E \sin pt$, and we assume that the magnitude and frequency of this E.M.F. is independent of the condition of the measuring circuit. Let C_0 be the value of the tuning capacity at resonance when the current induced in the circuit is I_0, and let the current be I when the capacity is C. Then it is well known that

$$I_0/I = \sqrt{1 + \frac{p^2L^2}{R^2}\left(1 - \frac{1}{p^2LC}\right)^2}$$

$$= \sqrt{1 + \frac{1}{\gamma^2}\left(1 - \frac{C_0}{C}\right)^2} \quad \ldots \quad (1)$$

where $\gamma = R/pL$ is the power factor of the circuit which is related to the decrement δ by the equation $\gamma = \delta/\pi$. There are various methods of deducing γ from the observed relation between I and C. Thus, for example, let ϕ be the angle by which the current lags, or leads, on the induced E.M.F., then we have

$$\tan\phi = \frac{pL - 1/pC}{R}$$

and so $\quad I_0/I = \sqrt{1 + \tan^2\phi}$

or $\quad \cos\phi = I/I_0$

again $\quad \tan\phi = \frac{pL}{R}\left(1 - \frac{1}{p^2LC}\right)$

$$= \frac{1}{\gamma}\left(1 - \frac{C_0}{C}\right)$$

$$= \frac{1}{\gamma}\frac{\delta C}{C}$$

$$\doteq \frac{1}{\gamma}\frac{\delta C}{C_0}$$

Hence, if the resonance curve is plotted, or tabulated, then $\tan\phi$ may be deduced from the observed values of the ratio I/I_0: if $\tan\phi$ is then plotted against the change of capacity the result should be a straight line through the origin having a slope $1/\gamma C_0$. This process tests the shape of the whole resonance curve and all the observed points are used to obtain the value of the power factor. The process is somewhat laborious and it is perhaps more common to deduce the power factor from the width of the resonance curve at some specified height. Thus, suppose $I/I_0 = x$, then $\gamma \doteq \dfrac{\triangle C/C_0}{\sqrt{x^2 - 1}}$.

If $\quad x = 1/\sqrt{2},\ \gamma = \pm\left(1 - \frac{C_0}{C}\right)$

$$\doteq \frac{1}{2}\frac{\triangle C}{C_0} \quad \ldots \quad \ldots \quad (2)$$

where $\triangle C$ is the width across the resonance curve at $1/\sqrt{2}$ of its maximum height. Similarly if the width at half height had been chosen we should have had $\gamma = \dfrac{1}{2\sqrt{3}}\dfrac{\triangle C}{C_0}$

So if the observations are correct, the width at half height should be $\sqrt{3}$ times as great as the width at $1/\sqrt{2}$ the height: if this relation is found to obtain, then the power factor may be deduced from equation (2).

In practice this method is probably as

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* MS. received by Editor, May, 1930.

accurate as that which utilises the whole curve, for no importance is attached to small readings of current, whereas in the line-plot method it is the small readings which carry most weight. This they should not do as they are likely to be the least accurate, and further, the error in tan ϕ is very much greater than the error in I/I_0.

The change of reactance, or detuning, method has much to recommend it because it involves no geometrical changes to the circuit other than the movement of the condenser plates. For resistance measurements at frequencies of many megacycles per sec. it is admirable, for then resistance could seldom be added without increasing appreciably the inductance of the circuit, and further, the effective value of the resistances themselves would generally be doubtful. The detuning method requires an accurately calibrated condenser of very small value, thus, for example, suppose $\gamma = 1$ per cent. and $C_0 = 40\mu\mu F.$, then $C = 0.8\mu\mu F.$ Perhaps many laboratories may not contain a suitable condenser, but its construction presents no serious difficulty.

Assumptions in the Distuning Method.

The formulæ just deduced make certain tacit assumptions. First, the circuit is assumed to be a simple series resonant circuit in which the inductance is devoid of capacitance and the capacity is devoid of inductance: this is impossible, but the methods of making the first order corrections are well known and need not be dealt with here. Secondly, it is assumed that the magnitude of the induced E.M.F. is independent of the current induced in the measuring circuit. Again this is impossible unless steps are taken to keep the generator current constant, for it assumes that the effect of the measuring circuit on the generator is inappreciable while depending on the converse action being appreciable. It is achieved approximately by a very loose coupling, for then the measuring circuit increases the effective resistance of the generator by a very small amount; however, it may always be achieved precisely by restoring the generator current to a fixed value after each readjustment of the measuring circuit. When this has been performed it might appear that the previous equations are strictly applicable: but it is necessary to consider whether the reaction of the measuring circuit may not perhaps have caused a change of frequency even though there is no detectable change of output current. If this be so, then constancy of generator current is a necessary but insufficient criterion of constant input E.M.F. We will consider the effect on the induced current of a small change of frequency: let p have the value p_0 at resonance, when C has the value C_0.

$$\text{Then } \left(\frac{I_0}{I}\right)^2 = x^2 = 1 + 1/\gamma^2 \left\{1 - \frac{1}{p_0^2\left(1+\frac{\delta p}{p_0}\right)^2 LC_0\left(1+\frac{\delta C}{C_0}\right)}\right\}^2$$

$$\doteq 1 + 1/\gamma^2\left\{2\frac{\delta p}{p_0} + \frac{\delta C}{C_0}\right\}^2$$

$$\therefore \qquad \gamma = \pm\frac{2\frac{\delta p}{p_0} + \frac{\delta C}{C_0}}{\sqrt{x^2 - 1}} \qquad \ldots (3)$$

So to obtain the power factor from the width of the resonance curve we must add twice the fractional aberration of frequency to the fractional change of capacity. For circuits of small power factor, where $\delta C/C_0$ is small, it is clear that a very small variation of frequency is competent to modify the shape of the resonance curve considerably. Thus, suppose the true power factor of a certain circuit is 1 per cent., then at $1/\sqrt{2}$ of the maximum height $\delta C/C_0$ should also be 1 per cent.; but if this condition of the measuring circuit has caused a frequency change of 1/20 per cent., the measured value of $\delta C/C_0$ will be incorrect by 10 per cent.

To understand the change of frequency caused by the reaction of the measuring circuit we must consider the effective input impedance Z of an inductance which is the primary of a transformer. It is well known that

$$Z = r_1 + \frac{p^2M^2r_2}{r_2^2 + x_2^2} + \gamma\left(pL_1 - \frac{p^2M^2x_2}{r_2^2 + x_2^2}\right)$$

In interpreting this equation we shall assume that the secondary is the measuring circuit and that L_1 is the inductance of the valve generator. As the capacity of the tuning condenser is increased from below to above the resonance value, x_2 changes from negative to positive. The apparent inductance of the generator is thus increased by the measuring circuit on the rising side of the resonance curve and *vice versa*: this will make the frequency less than the nominal value on the rising side of the curve and *vice versa*. Consequently, the current will always be less than it should be for a given value of δC, except at resonance when the frequency change is zero. So the observed resonance curve will tend to be too sharp and the power factor tends to be under-estimated when measured by the detuning method. The fractional change of induct-

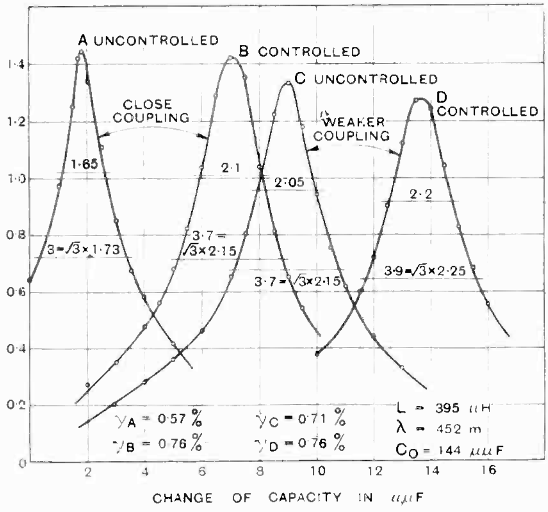


Fig. 1.

ance is a maximum when $x_2 = r_2$, and so this occurs at $1/\sqrt{2}$ of the maximum height. Thus the place usually chosen for measuring the width is the place where the aberration of frequency is greatest. But the fractional change of inductance is $\sqrt{3}/2$ of the maximum when $x_2 = \sqrt{3}r_2$, $(I_0/I = 2)$ and it follows from this that the relative widths at $1/\sqrt{2}$ and at $\frac{1}{2}$ height are in the ratio

$$\delta C^1/\delta C = \sqrt{3}(1 + \delta p/p_0 \times C_0/\delta C).$$

So in the numerical example cited previously the check ratio would be 5 per cent. greater than $\sqrt{3}$. Had the frequency change been unsuspected, then this error of 5 per cent. would probably have been shared up between the two widths and then γ would have been underestimated by 7.5 per cent. A drift of frequency may be detected by the help of a separate heterodyne generator, but there may be danger of the two generators synchronising with one another, especially if the batteries are common to both. It is perhaps better to set one generator to beat with the second harmonic of the other and then there is much less chance of synchronisation.

But the wisest plan is to control the frequency of the generator by means of a quartz crystal and then the frequency is independent of a small change of inductance.

The four resonance curves shown in Fig. 1 illustrate the effect of the frequency being modified by the measuring circuit: they refer to a coil of 395μH. working at a frequency of 66.5 k.c.s ($\lambda = 452$ m.). Thus consider curves C and D: no change of any sort was made in the measuring circuit, but curve C was obtained from an uncontrolled generator, while curve D was obtained from a generator controlled by a quartz crystal. The coupling was so loose that absolutely no change could be detected in the magnitude of the generator current as the measuring circuit was tuned through resonance. Yet the power factor deduced from curve C is 10 per cent. less than that deduced from curve D, and presumably this is due to the drift of frequency caused by the measuring circuit. Curves A and B are further examples but obtained with a much closer coupling; but even then a coupling so loose that the generator current was reduced at resonance by only 2 per cent. Here the apparent power factor with the uncontrolled generator is 20 per cent. less than that with the controlled generator. It may be noticed that the power factor for curve B is less than that for D; this is because the voltmeter was coupled more closely in D than it was in B and so added more to the power factor.

These curves should suffice to show the very great danger of obtaining a false value for the power factor when this is measured by the change of reactance method: it is clear that the generator ought to be quartz controlled if accurate measurements are required. (Note: the change of frequency due to the coupling is well known, and the Willans method of resistance measurement, see *E.W. & W.E.*, 1925, vol. 2, pp. 350–352, depends on this frequency change. But so far as the author is aware, the bearing of this effect on the change of reactance method of measurement has not been pointed out before.)

Effect of the E.M.F. Induced Directly in the Voltmeter Coil.

Sometimes resonance curves show an appreciable lack of symmetry about the maximum ordinate. It is true that all resonance curves are unsymmetrical and it may be shown that the half width at $1/\sqrt{2}$ of the maximum height are in the ratio $\frac{1-\gamma}{1+\gamma}$; but with power factors of the order of 1 per cent. this fraction is so nearly unity that the dissymmetry is not noticeable. A noticeable lack of symmetry is a sure sign of incorrect measurement. One potent cause of this effect is the E.M.F. induced in the voltmeter coil by the flux from the generator. The E.M.F. induced in the voltmeter coil should be strictly proportional to the current in the measuring circuit, but in reality the coil experiences the combined effect due to this current and the field of the generator. Suppose first that the axis of the voltmeter coil is to one side of the measuring circuit. When the tuning capacity is much above the resonance value the net flux inside the measuring circuit is reduced by the induced current and almost proportionally thereto since the current then lags by nearly a quarter cycle. So the net flux outside the coil will be approximately the algebraic sum of that due to the generator and that due to the coil, and so the E.M.F. measured by the voltmeter will be greater than it should be. At resonance the two E.M.F.s are in phase quadrature and so the effect of that induced by the generator will be negligible. When the tuning condenser is much below the resonance value the two E.M.F.s will be nearly opposed and the voltmeter will read less than it should. This last effect may be demonstrated very readily. Let the voltmeter coil be placed so that a measurable E.M.F. is induced in it directly by the generator: let the measuring circuit now be connected to the tuning condenser which initially has a very small value. As the tuning capacity is increased the first effect is a reduction of the voltmeter reading which will fall to a minimum or zero and then rise up to the resonance value.

The general effect of the direct E.M.F. will consequently be to increase the steepness of the ascending side of the curve and make the descending side less steep. But if the voltmeter coil is placed inside the measuring circuit, or on its axis, the converse will result and it is the descending side which is made more steep.

Fig. 2 shows two resonance curves in which these effects have been made very pronounced on purpose. For curve *A* the voltmeter coil was on the axis of the measuring circuit and the direct E.M.F. was 0.68 v. For curve *B* the voltmeter coil was at the side of the measuring circuit and the direct E.M.F. was 0.33 v.

Hence, if an unsymmetrical resonance curve is obtained the effect is probably due to the E.M.F. induced directly in the voltmeter coil. The curve of Fig. 2 shows how important it is to obtain the voltmeter E.M.F. by a coil of few turns coupled closely rather than by a coil of many turns coupled loosely.

A general expression for the error due to a direct E.M.F. of given fractional value is too complicated to be of value, but a numerical example will serve as an illustration. Thus, suppose the direct E.M.F. is 10 per cent. of the induced E.M.F. due to

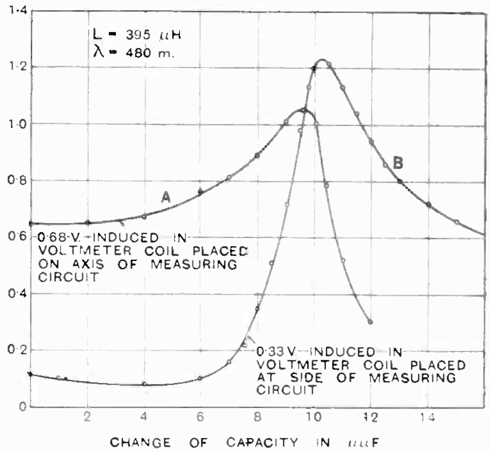


Fig. 2.

the current at resonance. Then the measured E.M.F. at resonance will be in excess of the desired value by 0.5 per cent. At $1/\sqrt{2}$ of maximum height the direct E.M.F. will be 15.1 per cent. of that due to the current and out of phase with it by an eighth or by three-eighths of a cycle. The measured E.M.F. will therefore be about 11 per cent. greater than or less than the desired value.

Grid or Anode Rectification?*

A Plea for the Grid Rectifier in Sets Designed for Broadcast Reproduction.

By P. K. Turner, M.I.E.E.

MR. A. G. WARREN'S admirable article on Distortion in Anode Rectification, in *E.W. & W.E.* for August, 1929, moves me to contribute a few remarks on the general subject of distortion in rectifiers.

First, I have a minor criticism to put forward. I do not think his measure of distortion is a sound one. He derives, quite correctly, the expression for a distortion ratio

$$\rho = \frac{Em}{4} \frac{d^2V/dE^2}{dV/dE},$$

which is the ratio of second harmonic to fundamental after rectification by a square-

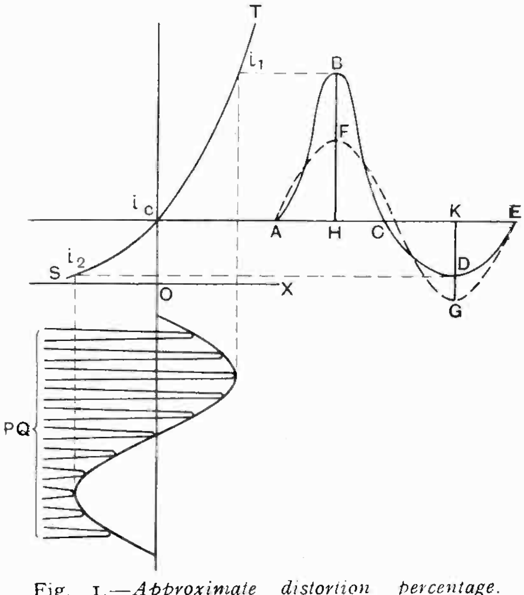


Fig. 1.—*Approximate distortion percentage. PQ represents a modulated carrier, ABCDE the resulting audio current if ST is the A.C.-input, DC output curve of the rectifier.*

law rectifier, and is also an approximation whenever the modulation is small, even if the rectifier is not square-law.

But he then uses this expression for the case of satisfactory (*i.e.*, more or less distortionless) rectification of fairly deep modulation, to which it does not apply.

His expression, in fact, is obtained from the behaviour of the curve at the state-point for the unmodulated carrier, whereas the correct expression involves its behaviour all over that part of the curve covered by the grid swing. We should substitute for Mr. Warren's expression the corresponding one derived from the complete equation to the curve.

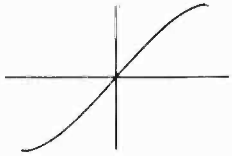


Fig. 2.—*A symmetrical curve of this nature would cause failure of the approximate distortion calculation; but such a curve does not occur under proper conditions of working.*

If we try to express analytically the rectification curve of a valve over the part which gives fair rectification of deep modulation, we are always confronted with an equation of high degree, and the derivation of the true distortion percentage is awkward.

There are three possibilities:—

(1) Complete analysis, which is slow and difficult, but accurate.

(2) Plotting the output wave-form on a large scale, and finding the harmonics by analysis: also slow and difficult, and only accurate if great care is taken.

(3) An approximation based on all that part of the curve which is in use, and which I will explain further.

If, as in Fig. 1, an applied sine wave envelope has given a distorted output wave *ABCDE*, we can to a first approximation consider the sine wave *AFCGE*, of amplitude equal to the mean of the + and − amplitudes of *ABCDE*, $\left(= \frac{HB + KD}{2}\right)$ to be the fundamental output, and $FB = DG$ to be the amplitude of unwanted harmonics, so that $\rho = \frac{FB}{FH}$. This expression can be derived directly from the

* MS. received by Editor, August, 1929.

curve, for if OX is the axis of current measurement, and we take i_1, i_c, and i_2 as the currents at the carrier and the extremes of modulation, we have

$$i_1 - i_c = HB\ ;\ i_c - i_2 = KD.$$

By definition,

$$FH = \frac{HB + KD}{2} = \frac{i_1 - i_2}{2}$$

and $FB = HB - FH = \frac{1}{2}(i_1 + i_2 - 2i_c)$

or $$\rho = \frac{i_1 + i_2 - 2i_c}{i_1 - i_2}$$

The mathematician will see at once that this expression corresponds to Mr. Warren's, but is obtained from the empirical Finite Differences over the working range, instead of the derivatives at the carrier-wave state-point. It should be noted that this approximation fails in the case as a curve such as that in Fig. 2, which is symmetrical about the carrier state-point. It would indicate no distortion, whereas in fact there would be strong odd harmonics. This, however, does not arise except in the case of a grossly overloaded rectifier.

Now for a larger matter. When is the present rage for "anode bend" going to die a natural death? Mr. Warren shows very well and clearly how to get the best out of it. I hope now to prove that, at its best, it distorts much more than our old friend, the leaky grid.

When I began to design the new Amplion receivers, I was given an exceptionally free hand, being instructed to make first-class quality an essential, even if it involved greater cost. Naturally I investigated detectors, among other things.

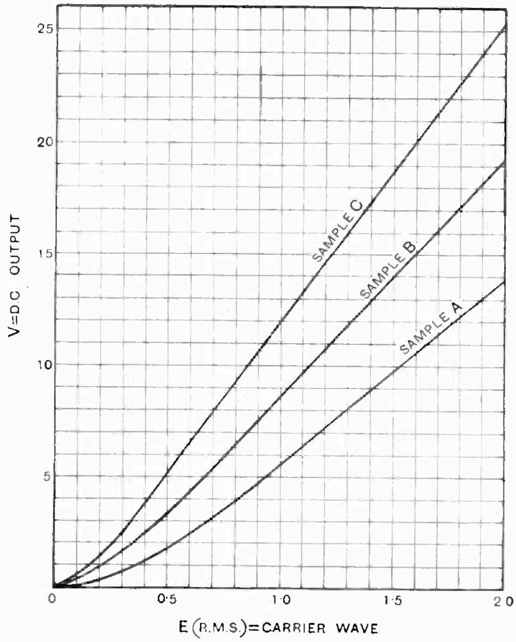


Fig. 4.—*Curves, comparable with* Fig. 3, *for three valves used as grid rectifiers. A, ov. 0.1 A, $\mu = 15$, $R_a = 7500$. B and C, separate heater valves of about the same μ and R_a as A. Note that in* Fig. 4 *the input is r.m.s.*

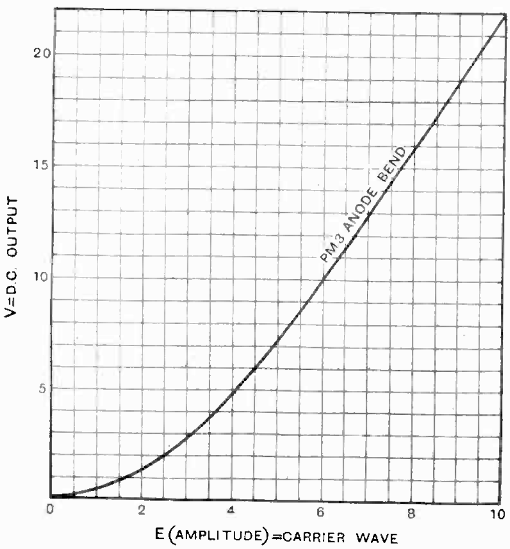


Fig. 3.—*The A.C.-input curve, or rectification characteristic, of the PM3 used as anode rectifier (copied from* Fig. 9 *of Mr. Warren's article).*

Various anode-bend rectifiers gave A.C.-input curves very much of the same type as Mr. Warren's Fig. 9, and I have therefore adopted that for these notes as typical of the type. I repeat it in Fig. 3, and in Fig. 4 give the curves of three grid rectifiers. A is a well-known valve of the $\mu = 15$, $R_a = 7500\ \Omega$ type. B and C are two samples of a separately heated valve of about the same μ and R_a. The anode battery was 180–200 v., the same value as used by Mr. Warren for Fig. 3. The curves correspond almost exactly, the voltage V being measured across the anode resistance, which was 10,000 Ω for A, 20,000 Ω for B and C, 130,000 Ω for the *PM3* as anode rectifier (*vide* original article). The only difference is that in Fig. 4 the input is R.M.S. instead of amplitude.

It is only necessary to glance at these to see that the grid rectifiers offer hope of better rectification. But as a quantitative check I have worked out the distortion by the approximation defined above. In working by differences, any errors in copying values from the curves are magnified, as when the distortion is small the numerator of our fraction, which is now $\frac{V_1 + V_2 - 2V_c}{2}$ (v being substituted for i), is a small quantity found as the difference between two large ones. I therefore take no account of distortion below 1 per cent.

Fig. 5 shows the distortion for various carrier-wave strengths, in each case for a modulation of 50 per cent. To make the anode and grid rectifiers comparable, the carrier is expressed in per cent. of maximum, the maximum being such that the extreme modulated input swings up to 12 v. for the *PM*3, to agree with Mr. Warren's figures, and 2 v. for the grid rectifiers.

The superiority of the grid rectifiers is shown very clearly: not only are they better at their best carrier input, but there

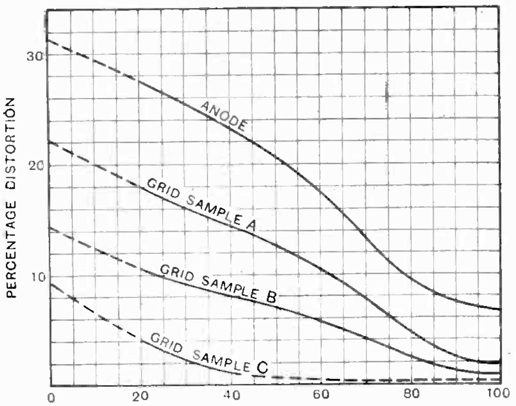


Fig. 5.—*Percentage distortion against strength of carrier, for constant modulation percentage* (50 *per cent.*). *The carrier taken as* 8*v. ampl. for the anode rectifier, and* 1.3*v. r.m.s. for the grid rectifier, giving a swing up to* 12*v. and* 2*v. respectively.*

is more latitude: they work well down to half the best input.

Fig. 6 shows similar curves for 66 per cent. modulation. All the curves show less latitude than in Fig. 5, but the grid rectifiers are still much better, especially the A.C. types—it does not yet seem to be realised that the equipotential cathode is, both in theory and

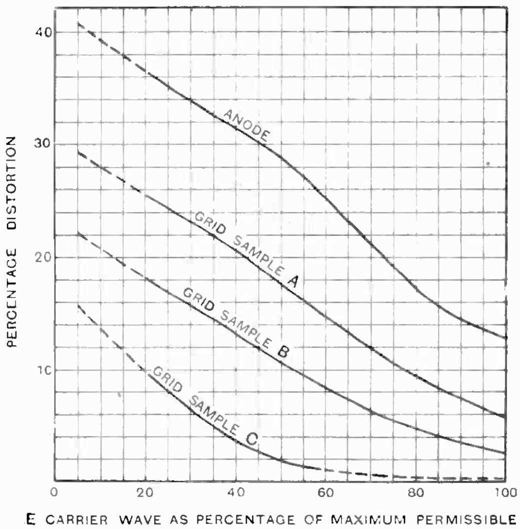


Fig. 6.—*Conditions exactly as* Fig. 5, *except for the modulation percentage, which is here* 67 *per cent.*

practice, *the* thing for rectification, quite apart from its use in A.C. sets.

Fig. 7 is, in my opinion, a better test. It shows the distortion for a constant carrier, as a function of the depth of modulation. We know that the B.B.C. sometimes commit a *faux pas*—the conductor is too smart for the control merchant—and lets the modulation get pretty deep, so Fig. 7 is based on a carrier half the maximum shown in Figs. 3 and 4, to allow 100 per cent. modulation without going off the map. We see that the grid rectifiers have the best of it every time.

In case it may be considered unfair to hold down the carrier to allow for 100 per cent. modulation, I also show in Fig. 8 the curves for a carrier allowing a maximum of 66 per cent. modulation, *i.e.*, 7.2 v. amplitude for the anode rectifier and 1.2 for the grid rectifiers. The superiority of the grid rectifiers is as marked as usual, sample *C* showing no measurable distortion over this range.

Since these results run contrary to popular opinion at the present moment, I should like to emphasise (1) that the distortion curves, Figs. 5 to 8, follow simply and obviously from the rectification characteristics, Figs. 3 and 4; (2) that the latter are not freaks; they are typical: *B* and *C* were chosen as the best and worst of a set of production samples.

I maintain, then, that the grid rectifier, *properly managed,* is inherently freer from wave-form distortion than the anode rectifier. It remains to consider in a few words their comparative performance in other respects.

1. Variation of Response to Various Radio Frequencies.

The anode rectifier has an advantage if a universal receiver is being designed: if the detector is to respond with equal efficiency

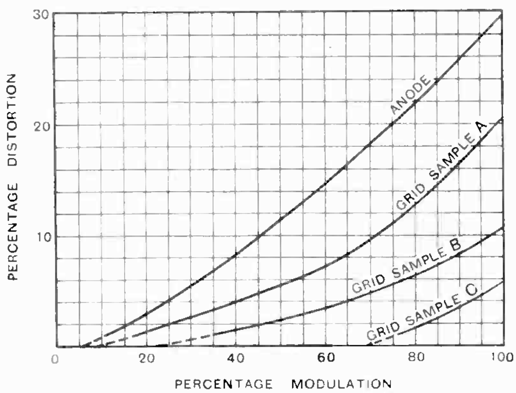


Fig. 7.—*Percentage distortion against modulation, for a constant carrier. In these curves, the carrier is taken at half the max. permissible, to allow of* 100 *per cent. modulation.*

to a wave range of more than 10 : 1, the grid-leak-condenser combination should be varied: but for reception on the two broadcast bands this is quite unnecessary, and the two are in practice equal: they are in any case equal if the proper changes are made.

2. Variation of Response to Various Modulation Frequencies.

The grid rectifier has a quite undeserved bad reputation in this respect, it being alleged that the grid-leak-condenser combination seriously cuts the high audio frequencies. To this I reply (*a*) It does not (up to a frequency of 10,000) if the combination is properly chosen. The usual $0.0002\mu F$ and $3M\Omega$ is ridiculous. With $0.0001\mu F$ and $0.5M\Omega$, the cut-off is negligible.

(*b*) The by-pass condenser in the anode rectifier produces cut-off in the same way, which may be equally serious if too large a

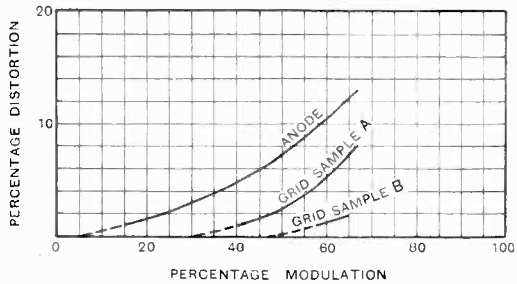


Fig. 8.—*Similar to Fig. 7, but with a larger carrier, permitting only* 67 *per cent. modulation as a maximum before swinging beyond the limit. Note that sample C gave no distortion over this range.*

value is installed, and equally harmless if properly designed. Either type really calls for a properly designed filter in the anode circuit, as in Fig. 9. This is installed in the Amplion sets and is patented.

3. Convenience of Coupling to the Audio Amplifier.

Here the grid rectifier has the best of it. The anode rectifier is of high anode impedance, and calls for a high load resistance. This notoriously makes it difficult to couple to the next valve without top cut-off, and makes resistance coupling essential. The grid rectifier *can* be used with a transformer.

4. Coupling to the R.F. Amplifier.

The anode rectifier has an undeserved good reputation here, it being alleged to cause "no damping." Personally I consider this point of little importance (see below); but would still state that the anode rectifier causes much more damping than is usually believed. Still, it has the advantage over the grid rectifier.

5. Retroaction.

It is the fashion at the moment to say "no reaction if quality is required." But this is just as foolish as any other parrot cry. If we fix a low limit to the resistance of a circuit, beyond which it will be too selective and cut side-bands, it is quite unimportant whether this limit is attained by "low-loss" design or by using a large resistance and then introducing negative resistance by reaction. Of course, reaction may be abused; but it is completely justifiable to use a low-efficiency arrangement, and bring its efficiency up to normal by reaction; and the grid rectifier lends itself admirably to this, having also the practical advantage of making the efficiency and selectivity variable at will.

6. Flexibility.

Figs. 5 and 6 show that the grid rectifier distorts less than the anode on inputs too weak for best results. On too strong an input, the grid rectifier is probably worse, but both are so horrible that there is not much in it.

7. Efficiency.

Here, of course, the grid rectifier is superior. If we define the "efficiency" by finding the output amplitude, dividing by the modulation amplitude, and expressing the result as a percentage of the μ of the valve, we get, for example, with the *PM*3, as anode rectifier at an input varying between 4.8 and 7.2 V. carrier amplitude, *i.e.*, Mod. Ampl. = 1.2 V., an output varying between 6.6 and 13.4 V. = 3.4 V. ampl. This gives an apparent amplification of $\frac{3.4}{1.2} = 2.83$, and (taking Mr. Warren's figure of $\mu = 11.75$), an "efficiency" of 24 per cent. The corresponding figures for the grid rectifiers are *A*, 39 per cent.; *B*, 52 per cent.; *C*, 63 per cent.

It might be remarked that the usual claim of "enormous" superiority of the grid rectifier applies only to excessively weak inputs, such as may occur in telegraphy; for reasonable inputs, from the distortion point of view, the superiority, though distinct, is not overwhelming, as just shown.

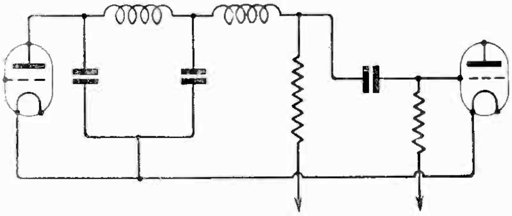


Fig. 9.—*For best results, all detectors should be followed by a filter such as this, which gives not more than 5 per cent. loss at or below 10,000 cycles, while stopping all but* $\frac{1}{10,000}$ *of the radio currents (at 5XX wavelength).*

8. Order of Input Required and Output Given.

This, of course, is purely a matter of convenience. The anode rectifier calls for more input, but may give greater output. If so, it is merely a matter of more H.F. and less L.F. amplification, or *vice versa* for the grid rectifier.

Books Received.

ELECTRICAL WIRING AND CONTRACTING. Vol. V, Edited by H. Marryat, M.I.E.E., M.I.Mech.E.

Comprising: Heating and Cooking, Converting Plant, Transformers, Rotary Converters, Rectifiers, etc., Electric Bells, Alarm and Clock Systems. Pp. 237 + VII, with numerous illustrations and diagrams. Published by Sir Isaac Pitman & Sons, Ltd., London. Price, 6s. net.

The following publications have been issued by the Superintendent of Documents, Washington, D.C., U.S.A.

ENGINE-IGNITION SHIELDING FOR RADIO RECEPTION IN AIRCRAFT. By H. Diamond and F. G. Gardner. (Bureau of Standards, Research Paper, No. 158). Pp. 10, with 22 illustrations and diagrams, including 10 half-tone plates. Price, 15 cents.

A 12-COURSE RADIO RANGE FOR GUIDING AIRCRAFT WITH TUNED REED VISUAL INDICATION. By H. Diamond and F. G. Kear. (Bureau of Standards, Research Paper, No. 154). Pp. 19, with 22 illustrations and diagrams, including 3 half-tone plates. Price, 10 cents.

NEW PIEZO OSCILLATIONS WITH QUARTZ CYLINDERS CUT ALONG THE OPTICAL AXIS. By A. Hund and R. B. Wright. (Bureau of Standards, Research Paper No. 156). Pp. 12, with 23 plates. Price, 20 cents.

DEVELOPMENT OF THE VISUAL TYPE AIRWAY RADIOBEACON SYSTEM. By J. H. Dellinger, H. Diamond, and F. W. Dunmore. (Bureau of Standards, Research Paper, No. 159). Pp. 25, with 28 illustrations and diagrams, including 9 half-tone plates. Price, 20 cents.

A TUNED-REED COURSE INDICATOR FOR THE 4 AND 12 COURSE AIRCRAFT RADIO RANGE. By F. W. Dunmore. (Bureau of Standards, Research Paper, No. 160). Pp. 14, with 14 illustrations and diagrams, including 2 half-tone plates. Price, 15 cents.

Applications of the Method of Alignment to Reactance Computations and Simple Filter Theory.

By W. A. Barclay, M.A.

(*Continued from page* 314 *of June issue.*)

PART V.

§38. A Resistance Load.

FROM the outset of this paper we have considered the load as reactive. It may be useful to digress here with the object of finding the response curves of the same reactive filters as were previously considered when a resistance is taken as the load. To do this, we first recall that the whole of the previous analysis has been based on the assumption that all the quantities involved were reactive in nature, so that the vectorial j sign could be omitted as superfluous. If a resistance load is now introduced, it will operate in quadrature with the reactive components, so that account must now be taken of the vectorial nature of the quantities. It will be found convenient to apply the operator j to the resistance load itself, writing it jW. There is no logical difficulty in doing this, and it is much easier than having to rewrite all the complicated filter formulæ already obtained with the addition of j in the orthodox way. Equation (32) now becomes the vector equation

$$F = A \,.\, jW + B$$

or, taking absolute magnitudes,

$$|F| = \sqrt{A^2W^2 + B^2}$$

If, now, the value of the resistance W be h times the ohmic value of the reactance $\omega_0 L$, we may rewrite the formulæ (34) to (37) as follows :—

(*a*) High Pass

$$\frac{F}{\omega_0 L} = \sqrt{\left(1 - \frac{1}{p^2}\right)^2 . h^2 + \left(\frac{1}{p^3} - \frac{2}{p}\right)^2} \quad (38)$$

(*b*) Low Pass

$$\frac{F}{\omega_0 L} = \sqrt{(1 - p^2)^2 h^2 + (2p - p^3)^2} \quad (39)$$

(*c*) Band Pass

$$\frac{F}{\omega_0 L} = \sqrt{\left\{1 - \left(p - \frac{1}{p}\right)^2\right\}^2 . h^2 + \left\{2\left(p - \frac{1}{p}\right) - \left(p - \frac{1}{p}\right)^3\right\}^2} \quad .. \quad .. \quad (40)$$

(*d*) Band Stop

$$\frac{F}{\omega_0 L} = \sqrt{\left\{1 - \frac{1}{\left(p - \frac{1}{p}\right)^2}\right\}^2 . h^2 + \left\{\frac{1}{\left(p - \frac{1}{p}\right)^3} - \frac{2}{\left(p - \frac{1}{p}\right)}\right\}^2} \quad .. \quad .. \quad (41)$$

The labour of evaluating equations (38)—(41) for different load factors h through varying values of p might well be regarded as prohibitive. Indeed, it is generally considered that the difficulties in the way of the numerical interpretation of such formulæ preclude entirely the profitable study of these filters from the theoretical side. The "parallel-alignment" charts of Figs. 27 and 28 go to remedy this defect, and enable values of $\frac{F}{\omega_0 L}$ to be computed for the first three of these equations at sight. The Chart of Fig. 27 carries the values of p for both high- and low-pass filters on the same supporting curve, thus solving equations (38) and (39). The method of use is the same as that for Fig., 23 on page 311, with the difference that the point Z is joined to h instead of to k on the vertical scale, to provide the direction of the parallel index-lines. Fig. 28 has been constructed to solve equation (40) in the same manner. Unfortunately, the *loci* of the p points for each of these filters happen to coincide ; it is impossible, therefore, to represent them all in a single diagram as was done in the case of inductive loads in Fig. 23, and the chart for the band-stop filter of equation (41) has perforce been omitted through lack of space. In Fig. 29 are shown the response curves derived for the high- and low-pass filters of Figs. 22(a) and (b), with a resistance load equal in ohmic value to 0.5 times that of $\omega_0 L$, *i.e.*, with $h = 0.5$. Fig. 30 gives the response curves for the band-pass filter of Fig. 22(c) when used with resistance loads for which $h = 0.5$ and $h = 1.0$. It is a matter of interest to compare these curves with those obtained in Figs. 24 and 26 (pages 312 and 313) for similar inductive loads. To facilitate such a comparison, Fig. 24 should be redrawn as suggested in para. 36.

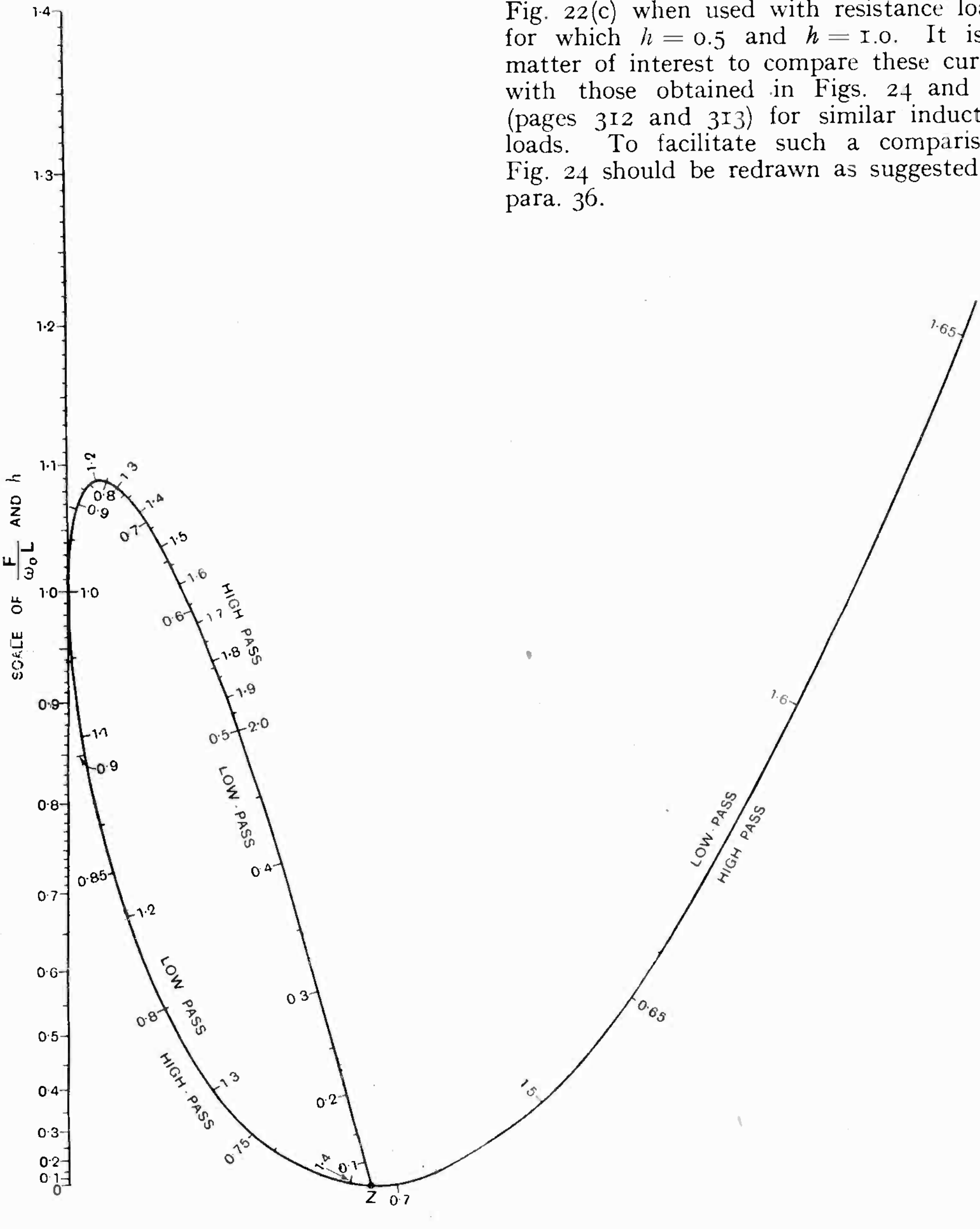


Fig. 27.—*Alignment Chart for high- and low-pass symmetrical T-filters of* Figs. 22 (*a*) *and* (*b*) (*on page* 310) *when used with a resistance load. The graduations on the curve give values of* p.

§39. Variation of Components of Symmetrical Band-pass T-Filter.

We shall now consider the effect of varying some of the components of the band-pass filter dealt with above. This (Fig. 22(c)) has been assumed to be composed of inductances and capacities which are all of the same value, viz.: L and C. If this filter be modified so that it is now as illustrated in Fig. 31(a), the inductance and capacity of the "vertical" arm being multiplied and divided respectively by the same constant r, the equation (36) (see page 312) representing its performance with an inductive load kL will also require to be modified. It may be easily shown that under these conditions

$$\frac{F}{\omega_0 L} = \left\{ p - \frac{p\left(p - \frac{1}{p}\right)^2}{r} \right\} . k + 2\left(p - \frac{1}{p}\right) - \frac{\left(p - \frac{1}{p}\right)^3}{r} \quad .. \quad (42)$$

which is seen to reduce to equation (36) when $r = 1$. The numerical solution of (42) for

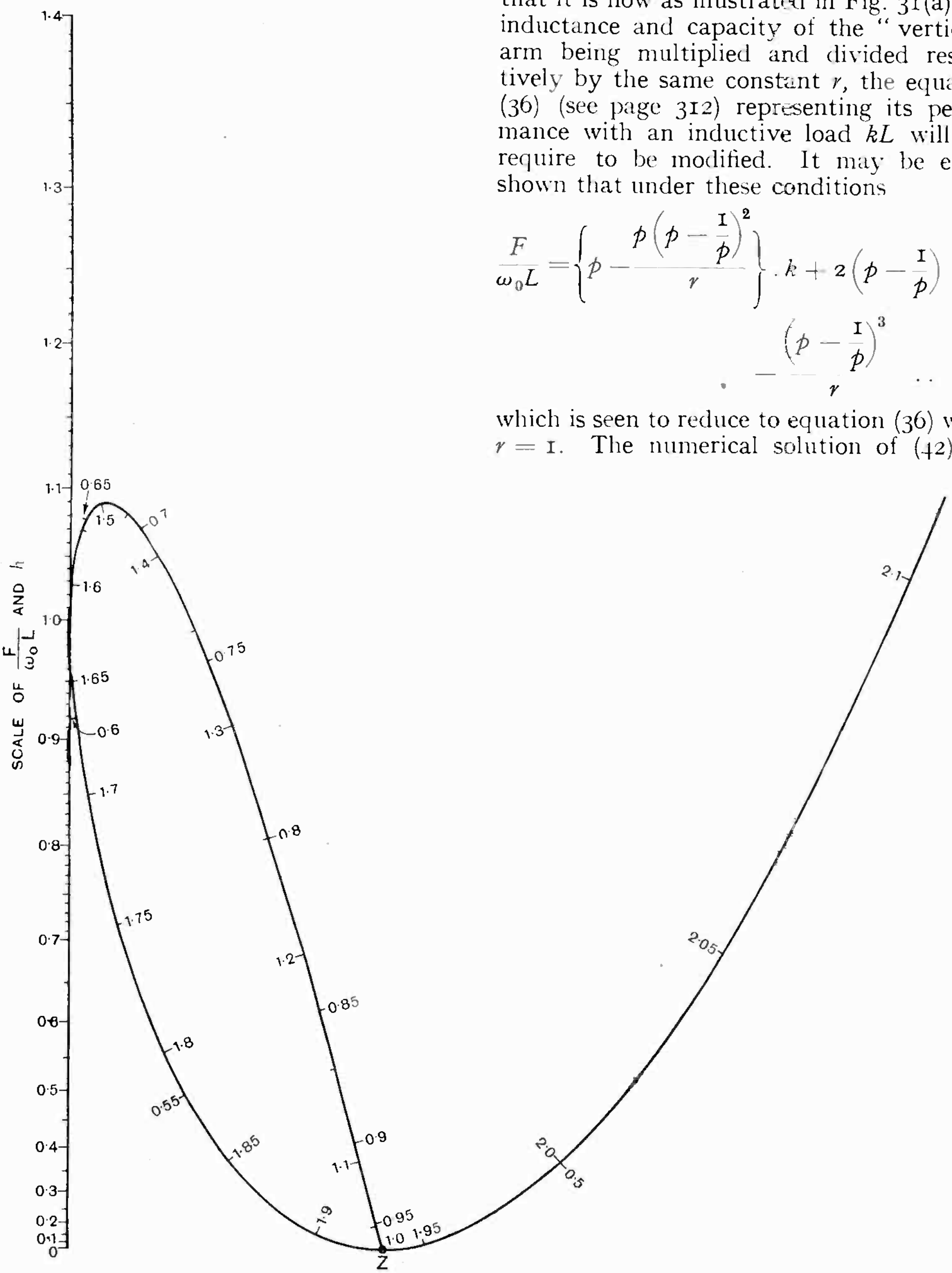


Fig. 28.—*Alignment chart for the band-pass symmetrical T-filter of Fig. 22 (c) (on page 310) when used with a resistance load. The graduations on the curve give values of p.*

various selected values of r is effected by the Alignment Chart of Fig. 32, the use of which is similar to that of the others previously given in this series. The curve I of this Chart gives values of p for $r = 1$, a case

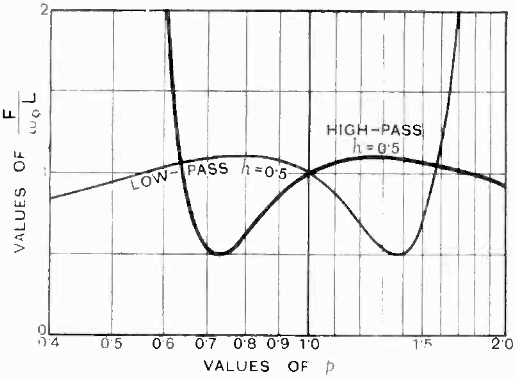


Fig. 29.—*Response curves of filters of Figs. 22 (a) and (b) used with resistance load.*

previously represented by the broken curve of Fig. 23 (page 311). Curve II of Fig. 32 represents the case where $r = 2$, curve III the case where $r = 0.5$, and curve IV that where $r = 0.1$.

A further modification of the standard band-pass filter (Fig. 22(c)) is shown in Fig. 31(b), in which the values of both the "vertical" components are s times those of the others. The equation representing the performance of this filter can be shown to be

$$\frac{F}{\omega_0 L} = p \cdot \left\{1 - \left(p - \frac{1}{p}\right)\left(sp - \frac{1}{sp}\right)\right\} \cdot k + \left(p - \frac{1}{p}\right)\left\{2 - \left(p - \frac{1}{p}\right)\left(sp - \frac{1}{sp}\right)\right\} \quad (43)$$

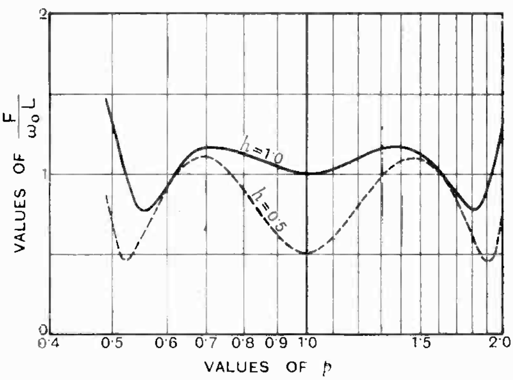


Fig. 30.—*Response curves of band-pass filter Fig. 22 (c) used with different resistance loads.*

Its numerical interpretation for the case $s = 1.5$ can be ascertained by means of the broken curve V of Fig. 32, no other values of s being illustrated in order to avoid unduly complicating the diagram. When s is unity, as in the case of r above, the curve I of Fig. 32 is applicable.

Other variations from the standard filter of Fig. 22(c) can be similarly dealt with, a particularly interesting case being that in which the capacity element alone is variable. Considerations of space, however, preclude the multiplication of further examples. The general algorithm from which the different support curves of Fig. 32 are deduced is exceedingly comprehensive, in-

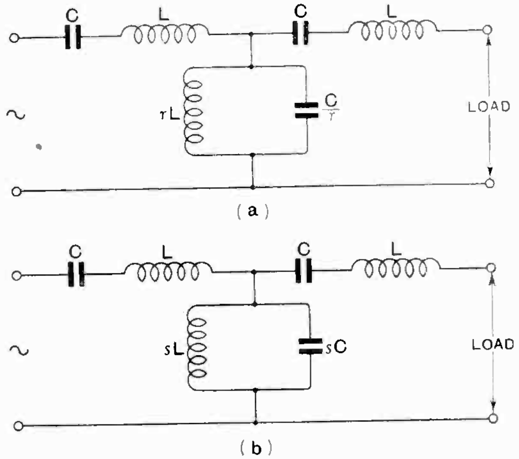


Fig. 31.—*Modifications of band-pass symmetrical T-filter.*

cluding many possible varieties of filter. Although, as already explained, the theory of their construction is meantime necessarily omitted, it may be said that the practical setting-out of these curves is not a difficult matter. It is, in fact, much simplified by the fact that the same value of p for each curve is found to lie on the same straight line. A few lines for values of p between 0.7 and 1.4 have been shown on Fig. 32; intermediate values may readily be interpolated by eye.

As an example of the use of Fig. 32, response curves were plotted for the two filters shown at Figs. 31(a) and (b), the load in both cases being taken as an inductance of $0.71L$. In the first of these filters, the factor r had the value 0.1, so that the "vertical" capacity component of the filter had 10 times the value of the " horizontal " capacities, while the inductance in parallel with it was $0.1L$. Using curve IV of Fig. 32 the resulting response is shown by the dotted curve of Fig. 33, giving cut-off frequencies at about $0.7\ f_0$ and $1.25\ f_0$. For facility of comparison, the response curve for the same load ($k = 0.71$) when $r = 1$ is shown by the full curve on Fig. 33, the difference in the values of cut-off frequencies being readily appreciable. Again, the response of the filter of Fig. 31(b) taking s as 1.5 was obtained before, the changed values of cut-off frequencies will be noticeable.

It will be particularly observed that the

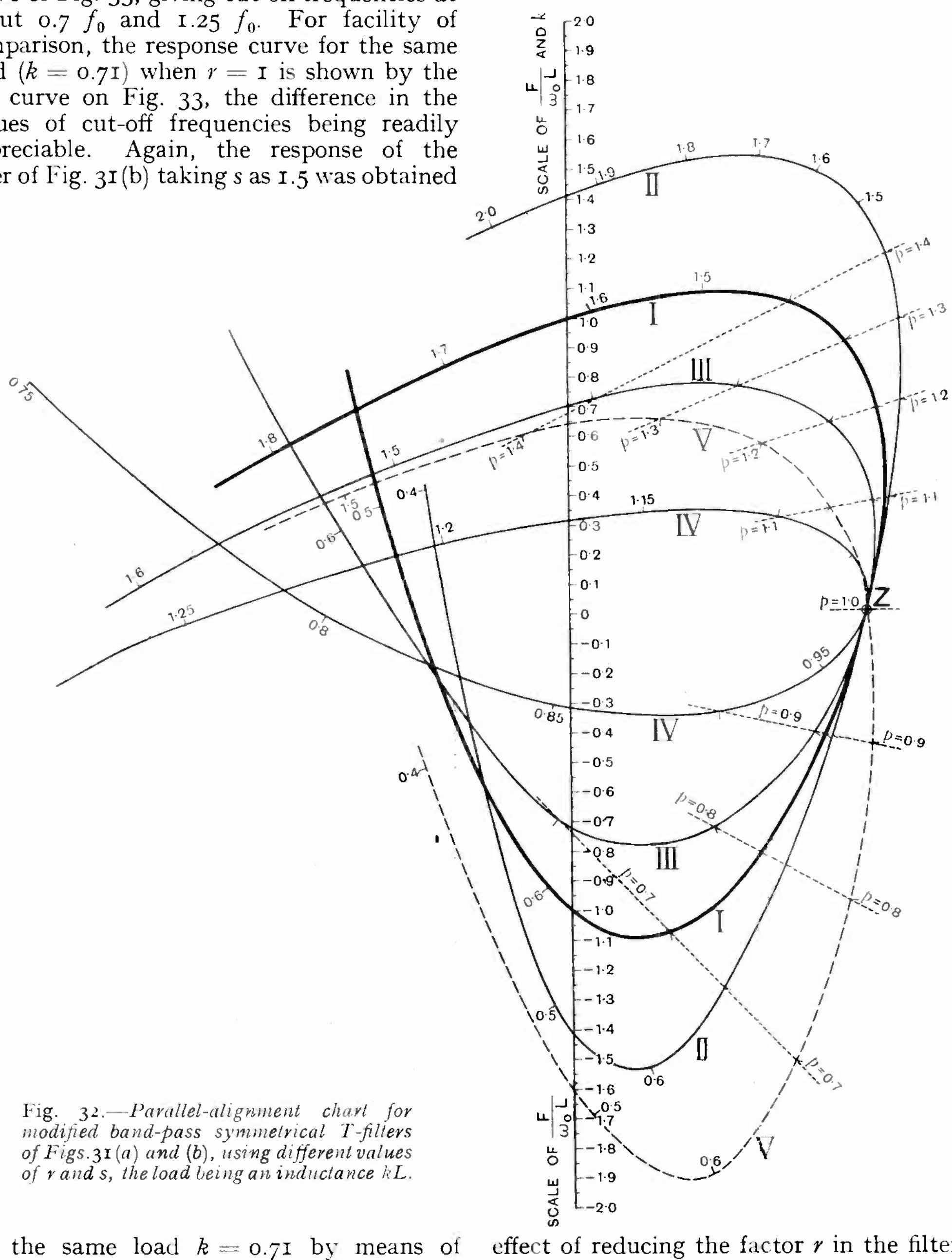


Fig. 32.—*Parallel-alignment chart for modified band-pass symmetrical T-filters of Figs. 31 (a) and (b), using different values of r and s, the load being an inductance kL.*

for the same load $k = 0.71$ by means of curve V of Fig. 32. This response curve is shown in Fig. 33 by the broken line. As effect of reducing the factor r in the filter of Fig. 31(a) is to reduce the width of the frequency band " passed " by the filter.

§40. Conclusion.

In conclusion, the writer is very conscious that he has but touched the fringe of a vast subject, and has omitted much that the practical experimenter might look for. Such topics as inductively coupled filters and other more complicated arrangements do not come within the scope of this series, the aim of which is, primarily, to introduce readers of *E.W. & W.E.* to the immense advantages which may be derived from the application of alignment methods to complicated algebraical formulæ. Unfortunately the foregoing illustrations of the practical use of these new methods must remain incomplete as no account has been taken of one of their most important features, namely, the ease with which the diagrams may be constructed and applied by the practical worker to different cases as they arise. It is, however, the writer's hope that he may to some extent have stimulated interest in these methods, which are at present all too little known. If, in addition, he has succeeded by this means in facilitating the study of the more elementary portions of filter theory, his purpose will have been more than achieved.

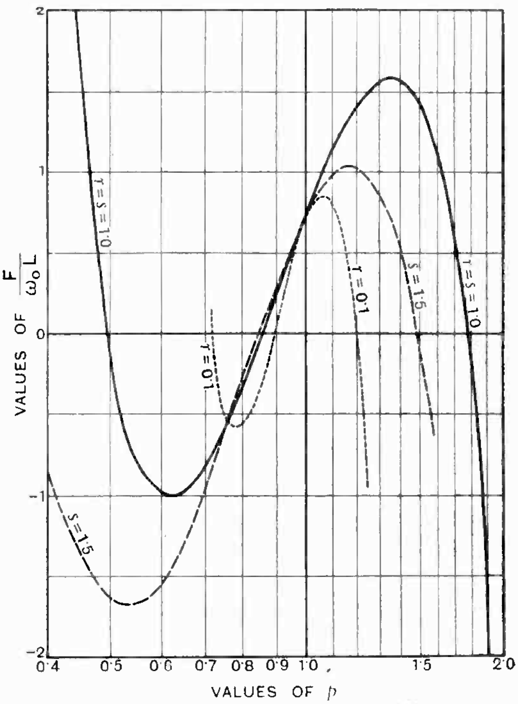


Fig. 33.—*Response curves of filters of Figs. 31 (a) and (b) for different values of r and s for the load* 0.71*L*.

Book Reviews.

Die Physikalischen Grundlagen der Rundfunk-Anlagen. By Manfred von Ardenne. 116 pp. with 84 Figs. Rothgiesser and Diesing, Berlin. 3.50 marks.

This is really a second edition of " Die Wirkungsweise der Rundfunk-Empfänger," but the book has been largely rewritten and new material added, so that the change of name was considered justified. The book is a non-mathematical but yet rigorous physical description of the principles of the design and construction of broadcast receivers. It begins with a description of the action of inductance and capacity in A.C. circuits, then passes to a consideration of single grid and double grid valves, detectors, amplifiers, back-coupling, etc. The various types of detectors and amplifiers are discussed very thoroughly in the manner which is familiar to those who are acquainted with the author's writings—a happy combination of theory and practice. A section is devoted to special circuits such as the neutrodyne and super-regenerative circuits, and a concluding section has been added dealing very briefly with the principles of loud-speakers. The book can be unreservedly recommended to those with sufficient knowledge of the language; it contains sufficient material to enable one to design scientifically each stage of a receiver and to realise the advantages and disadvantages of the various alternative methods.

G.W.O.H.

I.E.E. Regulations for the Electrical Equipment of Buildings.

The Institution of Electrical Engineers has issued additional clauses to their ninth edition of Regulations, which supersede those dated June, 1928, and are concerned with Radio Receiving and Valve Amplifying Apparatus for connection to public or private supply mains.

The old Regulation, No. 126, which relates to the construction and position of A.C. transformers, Choking Coils, Rectifiers, etc., is specifically stated to except Radio Apparatus and Ten new clauses, Nos. 129–138, have been added to deal with mains-operated wireless apparatus. These include the use of fuses as protection against excess current, the insulation of cables and external connections, protection of live parts to guard against accidental contact with the mains supply, and especially the efficient isolation of the terminals of battery chargers. A table is given of the suitable precautions to be adopted for various wireless components when used with A.C. and D.C mains respectively and the insulation tests required.

Electrical Wave Filters.

By M. Reed, M.Sc., A.C.G.I., D.I.C.

(Continued from page 322 of June issue.)

Section E.

Unsymmetrical Structures.

Before considering the subject of composite wave filters, the question of unsymmetrical structures must first be investigated.

Up to the present we have assumed that the wave filter under consideration consisted of a symmetric T network, which can be regarded as equivalent to a structure composed of an infinite number of recurrent symmetrical sections (see page 122). Also the formulæ for the characteristic impedance and the propagation constant have been derived on the assumption of an infinitely recurrent structure.

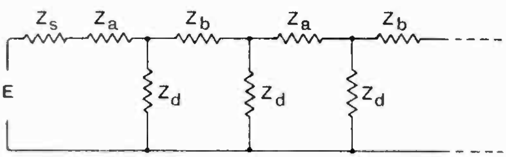


Fig. 44.

Suppose now that we have the general case of a structure composed of an infinite number of unsymmetrical networks as shown in Fig. 44.

Now any passive network can be replaced by an equivalent T or Π network (see pages 122 and 123), therefore the structure of Fig. 44 can be regarded as equivalent to the unsymmetrical T network of Fig. 45.

Image Impedances.

Suppose now that the terminals 3 and 4 of the above structure are connected to an impedance Z_2', and let the currents resulting from the applied e.m.f. E_1 be as shown in Fig. 45(a).

The impedance looking into the T network at the 1 and 2 terminals will be :—

$$Z_{1-2} = Z_A + \frac{Z_C(Z_B + Z_2')}{Z_B + Z_C + Z_2'} \quad .. \quad (97)$$

Similarly if the terminals 1 and 2 are terminated by an impedance Z_1', the impedance looking into the 3 and 4 terminals will be (see Fig. 45(b))

$$Z_{3-4} = Z_B + \frac{Z_C\,(Z_A + Z_1')}{Z_A + Z_C + Z_1'} \quad .. \quad (98)$$

If Z_{1-2} is equal to the terminal impedance Z_1', and if Z_{3-4} is equal to Z_2', the network will then be so terminated that, at either junction, the impedance in the two directions is the same. Under these conditions Z_1' and Z_2' will be called the "image impedances" of the T network. If equations (97) and (98) are solved explicitly for Z_1' and Z_2', we have :—

$$Z_1' = \sqrt{\frac{(Z_A+Z_C)(Z_AZ_B+Z_BZ_C+Z_CZ_A)}{Z_B + Z_C}} \quad .. \quad (99)$$

$$Z_2' = \sqrt{\frac{(Z_B+Z_C)(Z_AZ_B+Z_BZ_C+Z_CZ_A)}{Z_AZ_C}} \quad (100)$$

From (99) and (100) it is seen that in the case of the symmetrical structure where $Z_A = Z_B$, we have :—

$$Z_1' = Z_2' = \sqrt{Z_A^2 + 2Z_AZ_C}$$

Comparing this with equation (1), it is seen that in the case of the symmetrical structure the characteristic and image impedances are identical.

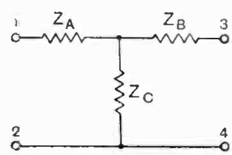


Fig. 45.

If we let Z_0 and Z_S be the impedances as measured from the 1–2 terminals when terminals 3 and 4 are open, and short circuited, respectively, and Z_0' and Z_S' be the corresponding impedances as measured from terminals 3 and 4, then

$$Z_0 = Z_A + Z_B \quad .. \quad .. \quad .. \quad (101)$$

$$Z_S = \frac{Z_AZ_B + Z_BZ_C + Z_CZ_A}{Z_B + Z_C} \quad .. \quad (102)$$

$$Z_0' = Z_B + Z_C \quad .. \quad .. \quad .. \quad (103)$$

$$Z_S' = \frac{Z_AZ_B + Z_BZ_C + Z_CZ_A}{Z_A + Z_C} \quad .. \quad (104)$$

$\therefore$ equations (99) and (100) become

$$Z_1' = \sqrt{Z_0 Z_S} \quad \ldots \quad \ldots \quad \ldots \quad (105)$$

$$Z_2' = \sqrt{Z_0' Z_S'} \quad \ldots \quad \ldots \quad \ldots \quad (106)$$

Transfer Constant.

The propagation characteristics of an unsymmetrical network may be completely expressed in terms of the "transfer constant." The transfer constant of any structure may be defined as one-half the natural logarithm of the vector ratio of the steady-state volt-amperes entering and leaving the network when the latter is terminated in its image impedances.*

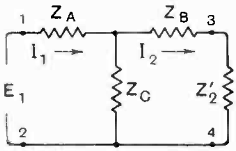


Fig. 45(a).

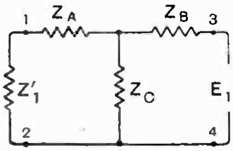


Fig. 45(b).

"Volt-amperes" denotes the product of the voltage and current vectors.

Consider now Fig. 45(a) and assume that the currents resulting from the application of E_1 are as shown. Assume further that the voltage across Z_2' is E_2.

We have then, by applying Kirchhoff's laws, that :—

$$I_1/I_2 = \frac{Z_B + Z_C + Z_2'}{Z_C}$$

and

$$E_1/E_2 = \frac{Z_A Z_B + Z_B Z_C + Z_C Z_A + Z_2'(Z_A + Z_B)}{Z_C Z_2'}$$

$\therefore$ if the transfer constant is represented by θ, we have by definition :—

$$\theta = \tfrac{1}{2}\log_e \frac{E_1 I_1}{E_2 I_2} = \tfrac{1}{2}\log_e \left[\frac{(Z_B + Z_C + Z_2')\{Z_A Z_B + Z_B Z_C + Z_C Z_A + Z_2'(Z_A + Z_B)\}}{Z_C^2 Z_2'}\right]$$

Now

$$\frac{Z_A Z_B + Z_B Z_C + Z_C Z_A + Z_2'(Z_A + Z_B)}{Z_C^2 Z_2'}$$

$$= \frac{(Z_B + Z_C - Z_2')[Z_A Z_B + Z_B Z_C + Z_C Z_A + Z_2'(Z_A + Z_B)]}{Z_C^2 Z_2'(Z_B + Z_C - Z_2')}$$

$$= \frac{(Z_B + Z_C)(Z_A Z_B + Z_B Z_C + Z_C Z_A) - Z_2'^2(Z_A + Z_C) + Z_2' Z_C^2}{Z_C^2 Z_2'(Z_B + Z_C - Z_2')}$$

$$= \frac{1}{Z_B + Z_C - Z_2'}$$

by combination with equation (100).

$$\therefore \quad \theta = \tfrac{1}{2}\log_e \frac{Z_B + Z_C + Z_2'}{Z_B + Z_C - Z_2'} \quad \ldots \quad (107)$$

From equations (103) and (104), we have that :—

$$\tanh^{-1}\sqrt{\frac{Z_A Z_B + Z_B Z_C + Z_C Z_A}{(Z_A + Z_C)(Z_B + Z_C)}} = \tanh^{-1}\sqrt{Z_S'/Z_0'}$$

$$= \tfrac{1}{2}\log_e \frac{1 + \sqrt{Z_S'/Z_0'}}{1 - \sqrt{Z_S'/Z_0'}}$$

$$= \tfrac{1}{2}\log_e \frac{Z_0' + \sqrt{Z_0' Z_S'}}{Z_0' - \sqrt{Z_0' Z_S'}} \quad \ldots \quad (107a)$$

But from equation (106), we have

$$Z_2' = \sqrt{Z_0' Z_S'}$$

and from equation (103) we have

$$Z_0' = Z_B + Z_C$$

$$\therefore \quad \tfrac{1}{2}\log_e \frac{Z_0' + \sqrt{Z_0' Z_S'}}{Z_0' - \sqrt{Z_0' Z_S'}} = \tfrac{1}{2}\log_e \frac{Z_B + Z_C + Z_2'}{Z_B + Z_C - Z_2'}$$

which from equation (107) is seen to be equal to θ.

Therefore we have from equation (107a), that :—

$$\theta = \tanh^{-1}\sqrt{\frac{Z_A Z_B + Z_B Z_C + Z_C Z_A}{(Z_A + Z_C)(Z_B + Z_C)}} \quad (108)$$

By means of equations (101) and (102) or by means of equations (103) and (104), equation (108) reduces to :—

$$\theta = \tanh^{-1}\sqrt{Z_S'/Z_0'} = \tanh^{-1}\sqrt{Z_S/Z_0} \quad (109)$$

If we compare Fig. 3 with Fig. 45(a), it is seen that in the case of the symmetrical structure $Z_A = Z_B = Z_1/2$ and $Z_C = Z_2$.

Therefore equation (108) becomes :—

$$\theta = \tanh^{-1}\sqrt{\frac{Z_1^2/4 + Z_1 Z_2}{Z_1/2 + Z_2}}$$

* See Reference 2.

If we put $x = 1 + Z_1/2Z_2$ then :—

$$\theta = \tanh^{-1} \sqrt{\frac{x^2 - 1}{x^2}} = \cosh^{-1} x$$

Comparing this equation with equation (6), it is seen that in the case of the symmetrical structure, the transfer constant and the propagation constant are identical. Hence the transfer constant in the case of the unsymmetrical structure has the same significance as the propagation constant has in the case of the symmetrical structure.

Unsymmetrical Structure in Series.

Consider two unsymmetrical structures connected together as in Fig. 46, and assume that at their junction the image impedances of the two structures are equal.

Let the image impedances at 1 — 2, 3 — 4, 5 — 6, and 7 — 8 be Z_1, Z_2', Z_1', Z_2, respectively. Also let θ_1 be the transfer constant of the first structure and θ_2 that of the second structure.

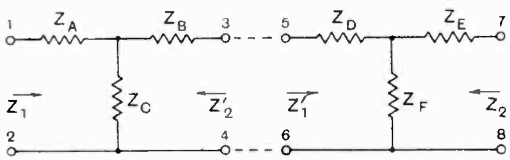


Fig. 46.

From equations (99) and (100), we have :—

$$Z_1 = \sqrt{\frac{(Z_A + Z_C)(Z_A Z_B + Z_B Z_C + Z_C Z_A)}{Z_B + Z_C}} \quad (110)$$

$$Z_2' = \sqrt{\frac{(Z_B + Z_C)(Z_A Z_B + Z_B Z_C + Z_C Z_A)}{Z_A + Z_C}} = Z_1'$$

$$= \sqrt{\frac{(Z_D + Z_F)(Z_D Z_E + Z_E Z_F + Z_F Z_D)}{Z_E + Z_F}} \quad (111)$$

$$Z_2 = \sqrt{\frac{(Z_E + Z_F)(Z_D Z_E + Z_E Z_F + Z_F Z_D)}{Z_D + Z_F}} \quad (112)$$

Now the structures of Fig. 46 are equivalent to the network shown in Fig. 47, which in turn can be reduced to a more convenient form by the following method.

Consider the mesh-connected network of Fig. 47(a), and suppose that it is required to replace this network by a simple star-connected system of three impedances Z_A, Z_B, and Z_C, as shown in Fig. 47(b,) which shall be equivalent with respect to the external circuit joined to terminals A, B, and C.

For the two networks to be identical as far as the external circuit is concerned, the impedance, as measured across any pair of

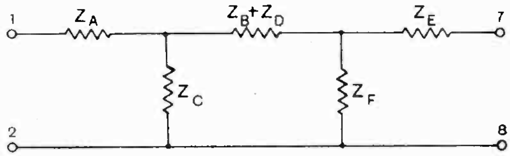


Fig. 47.

terminals, must be the same for both networks.

$\therefore$ for terminals A and C :

$$Z_a' + Z_c' = \frac{Z_b(Z_a + Z_c)}{Z_a + Z_b + Z_c}$$

for terminals C and B :

$$Z_c' + Z_b' = \frac{Z_a(Z_b + Z_c)}{Z_a + Z_b + Z_c}$$

for terminals B and A :

$$Z_b' + Z_a' = \frac{Z_c(Z_a + Z_b)}{Z_a + Z_b + Z_c}$$

Solving for Z_a', Z_b' and Z_c' in the above

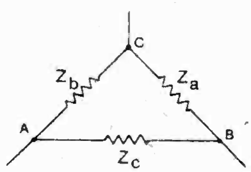


Fig. 47(a).

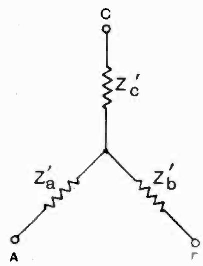


Fig. 47(b).

three equations, we obtain :—

$$Z_a' = \frac{Z_b Z_c}{Z_a + Z_b + Z_c}$$

$$Z_b' = \frac{Z_c Z_a}{Z_a + Z_b + Z_c}$$

$$Z_c' = \frac{Z_a Z_b}{Z_a + Z_b + Z_c}$$

Comparing Fig. 47(a) with Fig. 47, it is seen that

$Z_a = Z_F$, $Z_b = Z_C$, and $Z_c = Z_B + Z_D$.

Therefore, it follows from the above that Fig. 47 can be reduced to the form shown in Fig. 48 where

$$Z_P = Z_A + \frac{Z_C(Z_B + Z_D)}{Z_B + Z_C + Z_D + Z_F}$$

$$Z_Q = Z_E + \frac{Z_F(Z_B + Z_D)}{Z_B + Z_C + Z_D + Z_F}$$

If Z_p and Z_q are the image impedances of the network shown in Fig. 48, then we have from equation (99) that :—

$$Z_p = \sqrt{\frac{(Z_P + Z_R)\ (Z_P Z_Q + Z_Q Z_R + Z_R Z_P)}{Z_Q + Z_R}}$$

Substituting for Z_P, Z_Q, and Z_R the values given in Fig. 48, and making use of the relationship given in equation (111), it is seen that :—

$$Z_p = \sqrt{\frac{(Z_A + Z_C)(Z_A Z_B + Z_B Z_C + Z_C Z_A)}{Z_B + Z_C}}$$

$$= Z_1 \text{ from } (110)$$

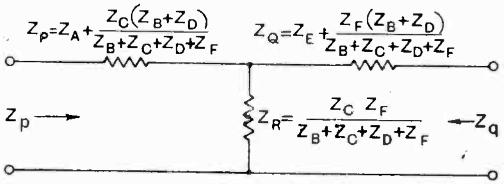


Fig. 48.

Similarly it can be shown that :—

$$Z_q = \sqrt{\frac{(Z_E + Z_F)\ (Z_D Z_E + Z_E Z_F + Z_F Z_D)}{Z_D + Z_F}}$$

$$= Z_2 \text{ from } (112)$$

From the above proof it can be seen that if any number of symmetrical or unsymmetrical T networks are combined so that at each junction the image impedances are equal, then the image impedances of the T network which are equivalent to the entire structure will be equal, respectively, to the terminating image impedance of the first and last T network of the complete structure.

Let us now obtain the total transfer constant for the combined structure of Fig. 46.

From this figure and equation (108) it is seen that :—

$$\theta_1 = \tanh^{-1}\sqrt{\frac{Z_A Z_B + Z_B Z_C + Z_C Z_A}{(Z_A + Z_C)(Z_B + Z_C)}}$$

$$\equiv \tanh^{-1} x = \log_e \sqrt{\frac{1 + x}{1 - x}}$$

$$\theta_2 = \tanh^{-1}\sqrt{\frac{Z_D Z_E + Z_E Z_F + Z_F Z_D}{(Z_D + Z_F)\ (Z_E + Z_F)}}$$

$$\equiv \tanh^{-1} y = \log_e \sqrt{\frac{1 + y}{1 - y}}$$

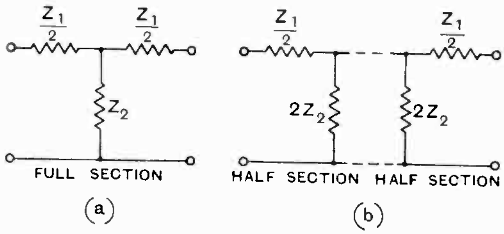


Fig. 49.

$$\therefore \quad \theta_1 + \theta_2 = \log_e \sqrt{\frac{1 + x}{1 - x}} + \log_e \sqrt{\frac{1 + y}{1 - y}}$$

$$= \log_e \sqrt{\frac{(1 + x)(1 + y)}{(1 - x)(1 - y)}} \quad \ldots \quad (113)$$

Referring to Fig. 48, which is equivalent to the structure of Fig. 46, we have for its transfer constant θ :

$$\theta = \tanh^{-1}\sqrt{\frac{Z_P Z_Q + Z_Q Z_R + Z_R Z_P}{(Z_P + Z_R)(Z_Q + Z_R)}}$$

$$\equiv \tanh^{-1} z = \log_e \sqrt{\frac{1 + z}{1 - z}} \quad \ldots \quad (114)$$

If we substitute in (114) the values of Z_P, Z_Q, and Z_R, as given in Fig. 48, and make use of the relations expressed in (111), equation (114) can be shown to be equal to equation (113) hence :—

$$\theta = \theta_1 + \theta_2$$

As before, this proof can be applied to any number of structures, combined in the manner indicated on page 384, to show that the transfer constant of the composite structure is equal to the sum of the transfer constants of the constituent structures.

Note.—The terms "Image Impedance" and "Transfer Constant" are used by American engineers, and to the knowledge of the present writer no alternative terms are used in this country.

Image Impedance and Transfer Constant of a Half-Section.

In the design of composite filters it is frequently found desirable to make use of a half-section rather than a full section (see below). Fig. 49(a) represents a full section of a filter and Fig. 49(b) represents the corresponding half-sections. From these diagrams it is seen that whereas the full section is represented by a symmetrical T network, the corresponding half-section is represented by an unsymmetrical T network in which the impedance of one of the series arms is zero (see Fig. 50).

If Z_A' and Z_B' are the image impedances of the half-section, then from Fig. 50 and equations (99) and (100) it is seen that :—

$$Z_A' = \sqrt{\frac{Z_1(Z_1/2 + 2Z_2)}{2}} = \sqrt{Z_1Z_2(1 + \tfrac{1}{4}Z_1/Z_2)} \quad \ldots \quad \ldots \quad (115)$$

$$Z_B' = \sqrt{2Z_2\left(\frac{Z_1Z_2}{Z_1/2 + 2Z_2}\right)} = \sqrt{\frac{Z_1Z_2}{1 + \tfrac{1}{4}Z_1/Z_2}} \quad \ldots \quad (116)$$

Comparing equations (115) and (116) with equations (1) and (8), respectively, it is seen that Z_A' and Z_B' are respectively the mid-series and mid-shunt characteristic impedances of the full section shown in Fig. 49(a). Therefore, the image impedances Z_A' and Z_B' of any half-section are equal, respectively, to the mid-series and mid-shunt characteristic impedances of the corresponding full section.

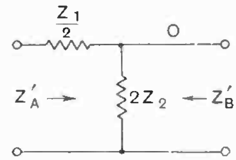


Fig. 50.

If θ_S is the transfer constant of the half-section, then from equation (108), we have :—

$$\theta_S = \tanh^{-1}\sqrt{\frac{Z_1/2}{Z_1/2 + 2Z_2}}$$

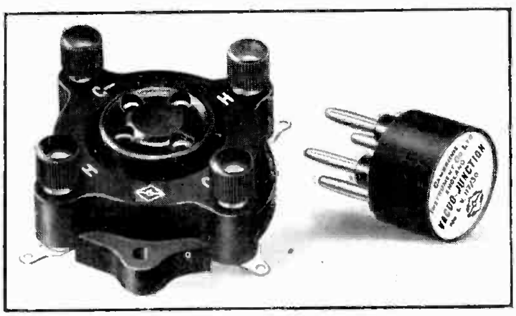
$$= \tanh^{-1}\sqrt{\frac{Z_1}{Z_1 + 4Z_2}} = \sinh^{-1}\tfrac{1}{2}\sqrt{Z_1/Z_2}$$

Comparing this equation with equation (7) it is seen that θ_S is equal to one-half of the propagation constant of the full section shown in Fig. 49(a). Therefore, the transfer constant of any half-section is equal to one-half the propagation constant of the corresponding full section.

(To be concluded.)

A New Vacuo-Junction.

THE Vacuo-Junction illustrated, which is a comparatively new product of the Cambridge Instrument Co., Ltd., has a somewhat higher sensitivity than the independent junction. The improvement which it represents on former types is that the thermo-junction is now electrically insulated from the heater, thus avoiding the possibility of errors due to capacity. The range has been extended so that a junction taking as small a current as 2.5 mA. on the heater to give an open circuit, couple e.m.f., of 6 millivolts, is available. The Vacuo-Junction has a four-pin terminal so that it can be inserted in a standard valveholder.



The following table gives the types of readings available :—

Cat. No.	Heater Resistance (Ohms).	Couple Resistance (Ohms).	Current Corresponding to an open circuit e.m.f. of 6 mV. (Milliamps).	Safe Current (Milliamps).
41,676	400	8	2.5	5
41,677	90	8	5	10
41,671	30	8	10	20
41,672	12	4	25	50
41,678	8	4	50	100
41,673	1	4	150	300
41,679	0.4	4	500	1,000
41,674	0.2	4	1,000	1,500
41,675	0.12	4	700	1,100

Abstracts and References.

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PROPAGATION OF WAVES.

REFLEXIONSMESSUNGEN MIT SEHR KURZEN ELEKTRISCHEN UND MIT AKUSTISCHEN WELLEN (Reflection Measurements with Very Short Electrical and Acoustic Waves).—M. J. O. Strutt. (*E.N.T.*, Feb., 1930, Vol. 7, No. 2, pp. 65–71.)

The full paper, a preliminary announcement of which was dealt with in November Abstracts, 1929, p. 623. The theory, which is shortly to be published, shows that even for distances of the emitter from the reflecting plane of magnitude smaller than a wavelength, the radiated field at a great distance from the emitter can be regarded as produced by the superposition of two "rays," one coming directly from the emitter and one which has undergone one reflection at the surface of the ground. This is confirmed by the experiments.

The method is also extended to the investigation of acoustic waves and their reflection from an opening (see under "Acoustics").

REPORT ON EXPERIMENTS WITH ELECTRIC WAVES OF ABOUT 3 METERS: THEIR PROPAGATION AND USE.—A. Esau and W. M. Hahnemann. (*Proc. Inst. Rad. Eng.*, March, 1930, Vol. 18, pp. 471–489.)

A survey of the work done, from 1925 to the end of 1928, under the auspices of the Jena Institute and the C. Lorenz Company. This includes the tests referred to in 1929 Abstracts, p. 150; duplex telephony over 85 km. on 0.5 w., between elevated positions, the difference in wavelength being only 2 cm.; reflector tests (Gresky, 1929 Abstracts, p. 106) summed up here by the statement that parabolic wire reflectors give a concentration of energy of 1 to 12 (distance of sender from vertex of parabola should be greater than $0.25\,\lambda$—actually $0.28\,\lambda$); tests on the screening effect, for signals from an elevated transmitter, of hills, houses, etc.:—"it was found, contrary to expectation, that a screening effect caused by groups of buildings and conductors could not be observed, or only to a very slight degree."

The establishment of the "optical path" theory; picture telegraphy from aeroplane; reception of signals in aeroplane:—"reception in the aeroplane never started before the 'plane had reached a lateral position in relation to the sending station, and became most favourable when the 'plane was flying away from the latter. Probably this phenomenon was due to a screening action exerted by the wings of the aeroplane which are located underneath and in front of the cabin in which the receiver was placed."

After dealing with the Brocken tests (1929 Abstracts, p. 203, Gerth and Scheppmann) the paper ends by considering the possible applications of such 3 m. waves: they are "the most appropriate signalling means for short-distance communication. As far as can be seen at present, they do not have undesirable ranges; within the attainable short ranges, they guarantee good reception, without the possibility of disturbances inherent in the long and short waves used up to now." Fog signalling; television; medical purposes (a separate report will deal with these). If it becomes possible to reduce the wavelength down to (say) 0.5 m., still maintaining the transmitting power and reception sensitivity, beams as sharp as a searchlight beam will be possible: "the consequences of a development of this kind cannot be foreseen at present."

CARTES DE PROPAGATION D'ONDES COURTES (Short Wave Propagation Charts).—R. Bureau. (*L'Onde Élec.*, March, 1930, Vol. 9, pp. 93–114.)

An extension of the work dealt with in 1929 Abstracts, pp. 262 and 442. Reference is also made to the writer's paper in *La Météorologie*, Vol. 5, 1929, pp. 395–442, and the results summarised. The writer has now been able to develop these charts more completely, thanks to an increased number of observers, and he no longer classifies strengths of signal as zero, weak and strong, but gives the full range from "0" to "9." He gives various charts under the following headings:—A. Medium waves, by day; B. Short waves, evening; C. Medium waves, evening; D. Birth and development of a zone of silence:—these observations are on a 36 m. wave; the chart for 15^h55 shows only a few isolated groups of spots of zero audibility; by 17^h55 five large "crescents" of silence have appeared all round the transmitter, and by 19^h55 these have merged into two large bands separated by a ring of audibility; the inner (very broad) band of silence is broken in places by crescents of audibility.

E. An extension of the observations on the same 36 m. wave beyond the limits of France to the rest of Europe, to N. Africa and the Eastern Atlantic—to a radius up to 2,500 km. Beyond a 600 km. radius the charts show, on a larger scale, the main features of the short-distance ones—namely, the alternation of rings of weak and strong reception up to the setting-in of night, the fragmentary appearance of crescents and then circles of silence, leaving between them an inner circle of audibility; and the gradual disappearance of this inner circle.

The writer ends by pointing out that the question whether the zones of silence observed at thousands of kilometres' distance are of the same nature as those shown in these charts can only be answered by increased co-operation, yielding observations covering practically a hemisphere; or by complete European charts of American transmissions or vice versa.

TRANSMISSION CHARACTERISTICS OF A SHORT-WAVE TELEPHONE CIRCUIT.—Potter. (*See* under "Acoustics.")

Field Intensity Measurements around some Australian Broadcast Stations.—R. O. Cherry. (*Proc. Physical Soc.*, 15th April, 1930, Vol. 42, Part 3, pp. 192–211.)

The field strength contours of three stations have been determined and the following conclusions drawn from them :—(i) Very rapid attenuation of the signal is caused by Australian forest areas ; this enormously curtails the areas for which a satisfactory service is provided. (ii) The effective conductivity of the various types of ground surface met with varies from 4×10^{-13} to 0.07×10^{-13} e.m.u., according to the number of trees in the areas covered. (iii) The use of a longer wavelength [484 m. compared with 371 m.] gives a marked increase of intensity at distant points beyond forest areas. (iv) For daylight transmission over sea water up to a distance of 85 miles, after the application of curvature-corrections to the intensity, Sommerfeld's formula is correct to within the limits of experimental error. (v) The efficiency of radiation of the three aerials examined ranges from 48 to 60 per cent. Finally, the limits of signal intensity for satisfactory reception under Australian conditions are discussed, and it is suggested that atmospherics and other disturbances are less prevalent in Victoria than in Europe or America.

The paper begins by a description of the loop, condenser and valve voltmeter circuit used, and the procedure followed ; it ends with a discussion (Watson Watt, Smith-Rose and Owen) in which are included criticisms of the apparatus, comparison of the results with Sommerfeld's analysis and Barfield's conception of a "pseudo-ground-conductivity" including absorption by trees, comments on a definite undulation in the transmission-over-sea curve and the suggestion that this may be due to interference not from a space wave but to a wave produced by coastal boundary reflection.

Graphs to Prof. Sommerfeld's Attenuation Formula for Radio Waves.—B. Rolf. (*Proc. Inst. Rad. Eng.*, March, 1930, Vol. 18, pp. 391–402.)

". . . As far as I am aware, the first attempt to use Prof. Sommerfeld's formula was made by Messrs. Ratcliffe and Barnett not earlier than 1925 . . . Mr. Barfield, in 1927, repeated the process on his extensive measurements around 2LO. . . . The propagation of radio waves when sliding along accidented soil of variable composition and with various prominences, natural or man-made, is not so well understood that theory can be altogether dispensed with. . . . That Professor Sommerfeld's theoretical formula for wave propagation has not been used by radio engineers studying the broadcasting problem cannot be ascribed to doubt or controversy as to its value or validity ; the reason is, evidently, that this formula has not been given to the engineer in the form of simple approximate expressions or graphs, or tables. The aim of this paper is to supplement Prof. Sommerfeld's work in this respect. . . . Time is ripe for an extensive use of this formula when studying various broadcasting schemes. . . ."

For an abstract of a great part of this paper, see Jan. Abstracts, pp. 29 and 30. In addition to the abac there mentioned, the writer gives a second graph which enables the user to grasp instantly the effect of changing wavelength, over whatever kind of ground may be in question, and over the whole gamut of wavelengths.

A simple semi-empirical formula is given [multiplying the field-strength value, as calculated, by $e^{-0.000083(r^3/\lambda)^{\frac{1}{2}}}$, r and λ being in km.] to allow for the curvature of the earth at moderate distances.

The principal aim of Sommerfeld's papers is the predicting of field-strengths *at* the ground, though in his 1926 *Annalen der Physik* paper he gave further extensions which allow the field higher up to be calculated. "The study of these upper-air fields is important, as they give rise to the down-coming rays so detrimental to broadcast schemes" ; the writer mentions that "certain rather simple arrangements of the transmitting antennas" will be described in another paper ; "when the radiating part of the antenna is confined, *e.g.*, to a height of about one-third of a wavelength above the soil, its vertical characteristic becomes in fact so depressed that with equal power the field along zenith distance 45 deg. will be halved, while the field along the soil will be increased by one-third ; viz., 44 per cent. economy of power to attain the same field strength at the soil, and a lessening of the ratio sky ray to ground ray to $\frac{3}{8}$ of its ordinary value at 200 km."

A Transformation of a Formula of Sommerfeld.—L. H. Thomas. (*Proc. Camb. Phil. Soc.*, April, 1930, Vol. 26, No. 2, pp. 123–126.)

A transformation of Sommerfeld's Hertzian function of cylindrical co-ordinates r, z, giving the electromagnetic field set up by a Hertzian oscillator placed on the infinite plane surface separating two media, normal to that surface. The transformed formula may prove to be more convenient than Sommerfeld's original expression for numerical calculation in regions in which Sommerfeld's asymptotic expression is insufficiently accurate.

Summary of Progress in the Study of Radio Wave Propagation Phenomena.—G. W. Kenrick and G. W. Pickard. (*Proc. Inst. Rad. Eng.*, April, 1930, Vol. 18, pp. 649–668.)

(A) Historical review ; (B) Recent developments ; (C) Conclusions and outlook for future development : "theoretical progress is much handicapped by lack of accurate quantitative data as to the actual conditions in the upper atmosphere, and workers in this field hence view with much interest the progress of such experiments as those now being carried on by Prof. R. H. Goddard of Clark University, with a view to devising a rocket which would render a direct observation of the conditions existent in the upper air possible. . . ." The paper closes with a bibliography of no less than 100 items.

Weather Forecasting by Signal Radio Intensity : Part I.—R. C. Colwell. (*Proc. Inst. Rad. Eng.*, March, 1930, Vol. 18, pp. 533–536.)

This first part is based on observations at Morgantown from KDKA, on the same meridian. "A rising curve after nightfall indicates an approaching storm, while a falling curve is followed by fair weather." *Cf.* 1929 Abstracts, pp. 100 and 204, same author.

COMPARISON BETWEEN SUNSPOT NUMBERS, INTENSITY OF EARTH'S MAGNETIC FIELD, AND STRENGTH OF RADIO-TELEGRAPHIC SIGNALS.—L. W. Austin. (*Journ. Washington Ac. of Sci.*, 4th March, 1930, Vol. 20, pp. 73–74.)

Curves of (1) sunspot numbers, (2) horizontal component, and (3) and (4) signal strength of Bordeaux and Nauen at Washington. (1) differs considerably from all of the remaining curves; but (2) strongly resembles (3) and (4)—in fact it resembles (3) more closely than (3) and (4) resemble each other. All these three curves show a sudden and deep drop in November. The writer concludes that the seasonal variations of the magnetic field and the strength variations of east-to-west signals have common causes.

LA PRÉSENCE DE L'OZONE DANS LA HAUTE ATMOSPHÈRE (The Presence of Ozone in the Upper Atmosphere).—(*Génie Civil*, 26th April, 1930, Vol. 96, pp. 410–411.)

A short survey of our present knowledge and its gaps.

UNE NOUVELLE FORMULE POUR DÉTERMINER LA DENSITÉ ATMOSPHÉRIQUE EN FONCTION DE L'ALTITUDE (A New Formula for Determining the Density of the Atmosphere as a Function of the Height).—R. Esnault-Pelterie. (Summary in *Génie Civil*, 3rd May, 1930, Vol. 96, pp. 435–436.)

Appears to cover the same ground as the papers dealt with in 1928 Abstracts, pp. 517 and 579. The formula leads to the result that at 5 km. the density is practically independent of the ground temperature.

ON THE BACK WAVE IN WAVE MOTION.—Satyendra Ray. (*Bull. int. Acad. Polon.*, (A), No. 4/5, 1929, pp. 229–232.)

When simple wave-motion treatment is applied to physical examples in which the velocity of propagation depends on the amplitude (so that the wavelength depends upon the distance from the origin), certain anomalies arise which are here briefly discussed.

FOURIER ANALYSIS SUBJECT TO CERTAIN QUANTUM CONDITION.—N. N. Bose. (*Bull. int. Acad. Polon.*, (A), No. 4/5, 1929, pp. 225–227.)

A note on a modified Fourier analysis applicable when the ratio of amplitude to wavelength is constant for the harmonics.

NEUE APPARATE ZUR WELLENLEHRE (New Apparatus for Instruction in Wave Motion).—A. Klaus: W. Heintze. (*Zeitschr. f. Unterr.*, No. 6, Vol. 42, and No. 1, Vol. 43, pp. 241–246 and 10–11.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

DIE REICHWEITE DER LUFTSTÖRUNGEN. RUNDFUNKSENDUNGEN FÜR WISSENSCHAFTLICHE ZWECKE (The Range of Atmospherics: Broadcast Transmissions for Scientific Purposes).—F. Schindelhauer. (*Die Sendung*, 16th May, 1930, Vol. 7, No. 20, p. 323.)

A general account of the investigations on the range of atmospherics made by the Telegraphentechnischen Reichsamt and the Royal Meteorological Society, the conclusion being that this range must be very large. Mention is made of a particularly interesting case occurring during the evening of December 16th, 1926. During this time the observation region was almost completely free from atmospherics and it was found that a magnetic storm was in progress at the time. The author remarks that the swarm of electrons coming from the sun made the conductivity of the upper atmosphere so high that atmospheric disturbances were not propagated, just as short wave communication is interrupted by magnetic storms, and concludes that atmospherics must arise in very high atmospheric levels.

Transmissions for experimental purposes are being sent from English stations at given times and possessors of Fultograph receiving systems are asked to send results to the Radio Research Station, Slough, Bucks.

LIGHTNING INVESTIGATIONS ON TRANSMISSION LINES.—W. W. Lewis and C. M. Foust. (*Gen. Elec. Rev.*, March, 1930, Vol. 33, pp. 185–198.)

Two new instruments are referred to in the course of this paper: the Field Intensity Recorder, giving a film record of the vertical component of electric field intensity (voltage gradient) *versus* time; and the Rate of Change of Field Intensity Recorder, giving a film record of the vertical component of the time rate of change of electric field intensity. The adjustment is made so that only relatively large values, such as occur during thunderstorms, are recorded. The data so obtained are expected to be helpful in acquiring further knowledge of the nature of lightning strokes and in measuring the relative severity of thunderstorms.

SPECTROSCOPY OF THE LIGHT FROM THE NIGHT SKY.—J. C. McLennan and H. J. C. Ireton. (*Canadian Journ. of Res.*, April, 1930, Vol. 2, pp. 279–290 and Plates.)

DARK FLASHES ON LIGHTNING PHOTOGRAPHS.—R. D. Boynton. (*Electrician*, 2nd May, 1930, Vol. 104, p. 556.)

Referring to photographs published in a previous issue, and to the explanation of the dark flashes on one of these as due to "red flashes of low actinic power," the writer quotes experiences of his own with high voltage spark photographs to show that dark flashes are the result of photographic reversal and re-reversal. As the exposure-time-intensity product increases, the density of the negative increases up to a point, beyond which it decreases to a minimum and then increases again; this cycle may be repeated two or more times.

THE EARTH'S ENERGY AND ELECTRICAL CHARGE.—G. Maneff. (*Terr. Magnetism*, Sept., 1929, Vol. 34, pp. 225–229.)

The value obtained for the earth's charge, by the method of inversion of the gravitational and magnetic fields, is of the same order of magnitude as that found from measurements of atmospheric electricity. Suggestions are made with regard to the nature of the back current and the physical causes of the earth's magnetism.

DIE FEINSTRUKTUR DES LUFTELEKTRISCHEN FELDES (The Fine Structure of the Atmospheric Electric Field).—A. Wigand. (*Zeitschr. f. Geophys.*, No. 7, Vol. 5, 1929, pp. 319–321.)

ZUR THEORIE DES ELEKTRISCHEN FELDES DER ERDE (On the Theory of the Earth's Electric Field).—T. Schlomka. (*I Special Issue Gerlands Beitr.*, Vol. 24, 1929, pp. 241–272.)

PROPERTIES OF CIRCUITS.

ON A TYPE OF AUTOMATICALLY INTERRUPTED TRIODE OSCILLATIONS.—J. A. Ratcliffe and L. G. Vedy. (*Proc. Camb. Phil. Soc.*, April, 1930, Vol. 26, No. 2, pp. 236–251.)

Authors' summary:—A type of automatically interrupted triode oscillations is described which depends on the interaction between an oscillating triode circuit and a circuit containing a non-linear resistance and a time-constant device. The theory of the circuit is developed and tested experimentally by means of oscillograms. The theory of the rise and decay of currents in a circuit containing an inductance and a non-linear resistance is dealt with in an appendix.

MEHRFACHE ELEKTRISCHE SCHWINGUNGSERZEUGER MIT BEQUEMER REGULIERUNG DER GEMEINSAMEN FREQUENZ UND DER GEGENSEITIGEN PHASE UND AMPLITUDE (The Generation of Multiple Electrical Oscillations with Convenient Regulation of the Common Frequency and of the Relative Phase and Amplitude).—W. Grösser. (*Wiss. Veröff. Siemens-Konz.*, Vol. 8 [2], pp. 14–21.)

Contrary to the usual methods, this apparatus allows of the generation of several a.c. voltages of the same frequency, each one of which can be adjusted to any desired phase angle and amplitude, independently of each other and of the frequency. The voltages are obtained by the rectification of beats of high-frequency voltages, the adjusters for phase and amplitude being in the high-frequency circuits.

ÜBER OPTIMALE UND MAXIMALE LEISTUNGEN BEI ENDRÖHREN (On the Optimum and Maximum Outputs of Output Valves).—A. Forstmann. (*Zeitschr. f. hochf. Tech.*, March, 1930, Vol. 35, pp. 109–115.)

The writer begins by pointing out that a certain confusion still exists on this subject in spite of the enormous amount of literature available; in this connection he quotes about 50 papers by various workers. He then defines the various separate requirements to be satisfied, and deals with each one in turn: each entails a series of conditions and one series partly conflicts with the others. These requirements are (i) Economy of anode voltage, (ii) Economy of circuit (*i.e.*, as few stages of r.f. amplification as possible), (iii) Economy of valve ("getting the most out of a valve with a given anode dissipation"). These three lead to (iv) Absolute economy, *i.e.*, the greatest possible output with small a.c. grid potential, small anode voltage, and the valve used at its best. Finally the writer deals with the question of distortion.

He sums up as follows:—An output independent of frequency under conditions fulfilling (i) and (ii) is approximately possible only if the driven instrument is such that

$$R_{a\,\max.} \leqq 12R_i \text{ and } R_{a\,\min.} \geqq \frac{R_i}{12}$$

But apart from the difficulty of fulfilling these conditions for the whole frequency range of speech and music, they are not very favourable from the practical point of view. For practical purposes the following conclusions serve: for the avoidance of linear distortion, the old relation $R_a \simeq R_i$ is the most unfavourable; much better results are given by either

$$R_a \gg R_i \text{ (limit } R_{a\,\min.} \geqq 4R_i)$$

or

$$R_a \ll R_i \left(\text{limit } R_{a\,\max.} \leqq \frac{R_i}{4}\right).$$

Under these conditions the maximum amplification is missed but a greater frequency-independence is obtained and the valve can give a larger output. The first condition (fulfilling "economy of valve") is applicable to single-grid, the second (fulfilling "absolute economy") to screen-grid valves.

Non-linear distortion in all cases (*i.e.*, for all ratios R_a/R_i) is avoided by observing various conditions for which equations are given.

ON RECTIFICATION AND DETECTION: RECTIFICATION AND POWER PACK DESIGN.—R. Ruedy. (*Canad. Journ. of Res.*, February, 1930, Vol. 2, pp. 101–130.)

The writer has a pessimistic idea as to our knowledge of the theoretical side of recent developments in the Broadcasting field. "Cut and try methods play an important part. Thus the filtering devices used in connection with a.c. supply introduced as early as 1925, and recommended in the instruction sheets of manufacturers of tubes, are known to overload the rectifying tube during the peak value, and to reduce the life of the tube. The problem of the detector is another example in point; the experimental results claimed by different investigators are contradictory, for instance as far as the respective merits of plate and grid leak detection are concerned."

"On the other hand, the theory of the mercury arc power detector has attained a high degree of development, and it seems worth while to apply it to a series of problems arising in radio reception, in order to gain a sound basis for designing rectifier and detector circuits."

Dealing with detection by vacuum valves, he recalls that except for small or negative E, the theoretical relation between E and I is $I = kE^{3/2}$ below the saturation value. "This equation is difficult to handle in the case of rectifiers, and can be replaced in practice by simpler expressions. . . . In many cases a curve $I = \frac{1}{2}TE^2$ (T being a constant) is quite satisfactory, with $I = 0$ for $E < 0$. For somewhat large distances between filament and anode the simple parabolic law represents in some cases the entire characteristic. Finally, for small and negative voltages . . . the current is given by $I = C\epsilon^{E/E_T}$, where E_T corresponds to the thermal energy of the electrons at the temperature of the filament."

Considering this exponential characteristic in detail, he shows that the detection current

$$\Delta I = I[J_0(jE_0/E_T) - 1]$$

is independent of the operating point E. For small values of E_0/E_T the right hand expression reduces to $E_0^2/4E_T^2$, so that the detection current is proportional to the square of the amplitude of the signal voltage, whatever the operating point. It is the larger the lower the velocities of the electrons; the detector is relatively insensitive towards weak signals; it produces amplitude distortion. "The formula is confirmed by the experimental results obtained by different investigators who did not refer to the theoretical basis underlying it."

Dealing next with the parabolic characteristic, the detection curve arrived at $\left(\Delta I = \frac{T}{4} . E_0^2\right)$ shows that here also the detected current is, for sine waves, proportional to the square of the amplitude of the signals. "But the constant of proportionality has a different meaning and value, a point very often overlooked. T varies for different types of tube from 0.03 to 0.3 mA./volt². With a constant value of T, the detection current becomes independent of the operating point E." The straight line characteristic $I = GE$ for $E > 0$, $I = 0$ for $E < 0$, is then considered, and the formation of harmonics for this case and for the square law detector.

For comparison, the rectifying action produced in discharge tube rectifiers containing gases is calculated (characteristics $E = A/I$ and $I = 1/\sqrt{E}$).

"The design of filters for smoothing out the rectified current is treated by making use of the results obtained from telephonic transmission lines. By means of the formulæ given for the different cases, a comparison can be made between the filters with capacitance input, used since 1925, and the type of filter which should be used to prevent temporary overloading of the power tubes. The chief experimental methods for testing the theory, and for examining the rectified current, are indicated; the advantages of the glow discharge tube oscillograph are pointed out, and its use in testing work is proposed in place of the methods hitherto followed."

Zur Theorie der kurzen Siebketten (Contribution to the Theory of Short Wave-Filter Chains).—A. Lurje. (*Archiv. f. Elektrot.*, 15th April, 1930, Vol. 23, No. 5, pp. 485–496.)

Remarks on Feldtkeller's Paper on the "Theory of Neutralised Amplifier Chains": Reply.—C. Hensch: R. Feldtkeller. (*Zeitschr. f. hochf. Tech.*, April, 1930, Vol. 35, pp. 150–151.)

The first writer cites various papers by Forstmann, Schramm, Müller, v. Ardenne, Reppisch and Rukop as anticipating various points in the paper in question (see May Abstracts, p. 271). In his reply, the second writer states that none of these papers recognises the fact and its consequences, that in the leakage resonance of an intermediate transformer, the anode reaction of the preceding valve practically disappears.

Capacity Coupled Filters.—A. L. M. Sowerby. (*Wireless World*, 2nd and 9th April, 1930, Vol. 26, pp. 350–353 and 386–389.)

While inductively coupled filters provide a means of preventing sideband cutting, the author explains why selectivity becomes poor at the lower end of the tuning scale and shows how this disability is combated by capacity coupling. The resonance curves of a filter with a fixed capacity as a coupling element have their two peaks adequately separated at longer wavelengths, but these peaks approach each other at the lower wavelengths and may coalesce at a point depending upon the capacity of the coupling condenser and the inductance and resistance of the tuned circuits concerned. With a carefully chosen value of coupling condenser the disappearance of the peaks can be made to take place at a wavelength where the naturally flat tuning of the individual circuits is in itself enough to take care of the sidebands to an extent sufficient for all but the most critical.

A formula for calculating the value of the coupling condenser is taken from E. A. Uehling's paper in *Proceedings of the Radio Club of America*, November, 1929.

Dispositifs de Condensateurs et Inductances Analogues à celles de Boucherot. (Inductance and Capacity Circuits Analogous to those of Boucherot).— —. Bunet. (*Bull. d.l.Soc. franç. d. Élec.*, No. 98, Vol. 9, pp. 1179–1186.)

In his examination of circuits comprising a condenser C and inductance L in series, in which either the condenser or the inductance was shunted by an impedance Z $(= r + jl\omega)$, Boucherot considered the case when $\omega^2 LC = 1$, the current I being then in quadrature with the voltage. The present writer considers in detail the case when $\omega^2LC = 2$, for the conditions $L = 0$ and $L \neq 0$.

Application of Screen Grid Tubes to Audio-Frequency Amplifiers.—J. J. Glauber: E. D. Cook. (*Rad. Engineering*, February, 1930, Vol. 10, pp. 29–32.)

A paper on the construction of circuits suited to the characteristics of the typical s.g. valve. In a discussion, the second writer describes a "simple trick" which he uses in calculating the amplification of resistance- and impedance-coupled amplifiers:—based on calculating the reciprocal of the percentage amplification (μ_0/μ), it eliminates all rationalisation and results in a relatively simple vector expression whose magnitude may then be evaluated, and inverted for the desired quantity.

WAVE-CHANGE ARRANGEMENTS FOR COUPLED CIRCUITS.—(French Pat. 668898, Pfau, pub. 7th Nov., 1929.)

To avoid change of coils or the short-circuiting of series coils, the inventor connects a coil in parallel with the whole or part of the oscillatory circuit inductance, this coil being coupled neither to that inductance nor to circuit coupled to it.

POTENTIALTHEORETISCHE UNTERSUCHUNGEN ÜBER MAGNETFELDER IN TRANSFORMATOREN UND ÜBER IHRE STREUINDUKTIVITÄT SPEZIELL BEI ZYLINDERWICKLUNG (An Investigation, on Potential Theory Lines, of the Magnetic Fields in Transformers and of their Leakage Inductance, particularly for Cylindrical Windings).—G. Stein. (*Zeitschr. f. angew. Math. u. Mech.*, No. 1, Vol. 9, pp. 23–49.)

DIE GRÖSSE DER GESAMT-WINDUNGSKAPAZITÄT VON SCHUTZDROSSELSPULEN (The Magnitude of the Total Winding Capacity of Protecting Chokes).—R. Klein. (*Elektrot. u. Masch.: bau*, 13th April, 1930, Vol. 48, pp. 337–347.)

TRANSMISSION.

DIE ERZEUGUNG KÜRZESTER ELEKTRISCHER WELLEN MIT ELEKTRONENRÖHREN (The Generation of Ultra-Short Waves by Thermionic Valves). —H. E. Hollmann. (*Zeitschr. f. hochf. Tech.*, Feb., 1930, Vol. 35, pp. 76–80.)

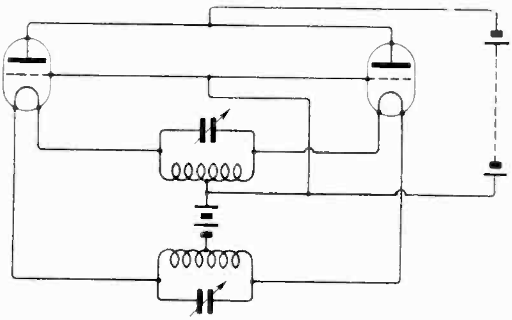
Second and final part of a comprehensive survey (see May Abstracts, p. 273). The new sections deal with the following subjects :—(5) the behaviour of the electronic oscillator in a magnetic field : Forro (1929 Abstracts, p. 269) ; Hollmann (Jan. Abstracts, p. 42) ; Tank and Schiltknecht (1929 Abstracts, p. 389). (6) Magnetron oscillations in diodes : Slutzkin and Steinberg (same, p. 326) ; Okabe (pp. 447–448). (7) Push-pull circuit for electron oscillations : (Hollmann, April Abstracts, p. 211). (8) Practical tests on ultra-short waves ; Kohl, Beauvais, Pierret (various previous abstracts); super-regenerative receiver (Hollmann, Feb. Abstracts, p. 98) ; diode receiver (Okabe, Abstracts, 1929, p. 633 ; 1930, p. 213).

ZUR FRAGE DER ERZEUGUNG KURZER ELEKTRISCHER WELLEN MIT ELEKTRONENRÖHREN (On the Question of the Generation of [Ultra] Short Electric Waves by Thermionic Valves).—L. Bergmann. (*Zeitschr. f. hochf. Tech.*, April, 1930, Vol. 35, pp. 148–149.)

Further tests with the transmitter referred to in 1929 Abstracts, p. 43, have shown the very great importance of a correct value for the h.f. chokes in the leads to the filament : for every wavelength there is a particular optimum value.

To make convenient the desired adjustment, the writer replaces each ordinary choke by a closed rejector circuit with variable condenser. On a 2.41 m. wave, adjustment of one rejector circuit gives a tuning curve with the oscillating current rising from about 0.05A. to 0.66A. and dropping again to 0.2A. ; subsequent adjustment of the second wave-trap increases the maximum to 0.85A. For longer waves the one rejector is all that is needed.

In the Eccles and Jordan push-pull generating circuit, the introduction of the two rejector circuits (as shown below) not only increases the power but



also allows a shorter wavelength to be obtained. The method of connection also prevents h.f. energy flow from one cathode to the other, which would otherwise occur since the h.f. potentials in the two cathodes are displaced 180° in phase.

NKF EXPERIMENTS ABOVE 28 MEGACYCLES : NEW ULTRA HIGH-FREQUENCY TRANSMITTERS AND ANTENNAS AT THE NAVAL RESEARCH LABORATORY.—J. J. Lamb. (*QST*, April, 1930, Vol. 14, pp. 9–18.)

TELEGRAPHIE UND TELEPHONIE MITTELS KURZER WELLEN VON $\frac{1}{2}$ M. WELLENLANGE (Telegraphy and Telephony on [Ultra] Short Waves of $\frac{1}{2}$ Metre Wavelength).—S. Uda. (*Zeitschr. f. hochf. Tech.*, April, 1930, Vol. 35, pp. 129–135.)

An account of tests carried out by the author. (1) Receiver : a triode in the B.-K. connection with reaction, very sharp tuning being accomplished with a variable condenser across the Lecher wires (see April Abstracts, pp. 212–213). In a postscript the writer announces his success in improving very greatly the sensitivity of this receiver by the use of super-regeneration (see Chiba, June Abstracts, p. 334, and Uda, p. 335).

(2) Transmitter : two Cymotron UF 101 valves in parallel, giving 15–20 mA. aerial current ; also 4 or 7 of the same, giving 30 and 50 mA. respectively. The valves are either grouped together and connected to one end of the Lecher wires or are distributed, at distances suited to the wavelength, along these wires, each one with an associated dipole. After trials of various methods, the best results were obtained by modulating the anode voltage, which gave practically distortionless modulation although " pure amplitude modulation is impossible with these ultra-short waves."

(3) Transmitting and receiving aerial systems : wave-directors (40-wire) were used, and also—

to judge by the illustrations—metallic reflectors. Polar diagrams are given of transmitting and receiving systems.

ULTRA-SHORT WAVE TRANSMITTERS.—Pistor. (*See* first part of abstract under "Reception.")

20–40-KILOWATT HIGH-FREQUENCY TRANSMITTER.—I. F. Byrnes and J. B. Coleman. (*Proc. Inst. Rad. Eng.*, March, 1930, Vol. 18, pp. 422–449.)

Illustrated by numerous photographs and a diagram of connections.

Wave range 45–14 m. The set is made up of a crystal-controlled oscillator-amplifier, terminating in an output of 1 kw., and a main power amplifier, using four water-cooled valves, giving 20–40 kw. output. Among special points dealt with are:—the problem of providing a satisfactory artificial load for factory test: the determination of keying characteristics: and the design of the frequency control units.

OBSERVATION AND RECORDING OF PERCENTAGE MODULATION BY THE C.-R. OSCILLOGRAPH.—v. Ardenne. (*See* under "Subsidiary Apparatus.")

A "DISTORTION RECEIVER" AS OVER-CONTROL INDICATOR FOR A BROADCASTING TRANSMITTER.—Walter. (*See* under "Stations, Design and Operation.")

METHOD OF MODULATION BY CONDENSER MICROPHONE OR VARIOMETER MICROPHONE.—(German Pat. 489293, Huth, pub. 16th Jan., 1930.)

This patent dates back to 1924. The detuning produced by the microphone can be either in the grid or in the anode circuit.

THE WAVE-BAND THEORY OF WIRELESS TRANSMISSION.—J. A. Fleming. (*Television*, April, 1930, Vol. 3, pp. 57–58 and 61.)

The writer concludes from the discussion resulting from his *Nature* letter (April Abstracts, p. 212; also May and June) that there is now a very large degree of assent to his original contention that the effect which traverses space between the broadcast transmitter and the receivers is a single modulated wave of one frequency but of varying amplitude.

He testifies to the success of a certain receiver in combining very high selectivity with power to follow the most rapid variations in amplitude required for very perfect reproduction of music.

WHERE ARE THE SIDEBANDS?—R. S. Spreadbury. (*Television*, May, 1930, Vol. 3, pp. 132–133.)

A description of two experiments, carried out by the writer, "which leave no reasonable excuse for the continuance of the sideband theory." In both cases the first results seemed to support the sideband theory to some extent, but were found to be deceptive: when causes of error were eliminated (*e.g.*, when a special modulator was used which gave true amplitude modulation without upsetting the frequency) no traces of sidebands were left.

EXPERIMENTAL PROOF OF THE EXISTENCE OF SIDEBANDS.—F. M. Colebrook. (*Wireless World*, April 30th, 1930, Vol. 26, pp. 451–453.)

"The important point is whether a modulated continuous wave does in fact behave in every respect as if it consisted of a pure carrier frequency associated with sidebands. If it does, then the sidebands do exist physically in the only sense in which the word 'exist' has any intelligible meaning."

The author describes simple experiments to demonstrate the physical existence of sidebands in the above sense. The coupling between a receiving circuit and a valve oscillator was adjusted to a value which gave a sufficiently small e.m.f. for square law rectification in the first valve, and a control experiment was made to ensure that the audio-frequency transformer was effective as a filter, preventing radio-frequency voltages from reaching the measuring valve. The variation of the modulation frequency output with the tuning capacity was then determined, and gave a result showing three peaks in the modulation frequency output.

ON A TYPE OF AUTOMATICALLY INTERRUPTED TRIODE OSCILLATIONS.—Ratcliffe and Vedy. (*See* under "Properties of Circuits.")

THE GENERATION OF MULTIPLE ELECTRICAL OSCILLATIONS WITH CONVENIENT REGULATION OF THE COMMON FREQUENCY AND OF THE RELATIVE PHASE AND AMPLITUDE.—Grösser. (*See* under "Properties of Circuits.")

RECEPTION.

KAMPF GEGEN RUNDFUNKSTÖRUNGEN (The Fight against Interference with Broadcast Reception).—(*E.T.Z.*, 3rd April, 1930, Vol. 51, pp. 514–515.)

Report of a meeting of the Committee formed in Germany to combat these interference troubles. Of 12,000 cases, 7,500 have been cured. About 60 per cent. of all the cases were due to h.f. medical apparatus. Germany has been divided into 1,240 regions, and the Committee has 4,000 workers.

ZÜNDERABSCHIRMUNG FÜR FUNKEMPFANG IM FLUGZEUG (Ignition Screening for Wireless Reception in Aircraft).—L. Hyland. (Summary in *E.T.Z.*, 20th March, 1930, Vol. 51, pp. 438–439; from *Aviation*, Vol. 26, p. 886.)

An account of American researches.

ENGINE-IGNITION SHIELDING FOR RADIO RECEPTION IN AIRCRAFT.—H. Diamond and F. G. Gardner. (*Bur. of Stds. Journ. of Res.*, March, 1930, Vol. 4, pp. 415–424.)

The full paper, profusely illustrated, a summary of which was dealt with in June Abstracts.

INTERFERENCE FROM POWER LINES.—C. L. Farrar. (*Rad. Engineering*, Feb., 1930, Vol. 10, pp. 40–41 and 44.)

CONSIDERATIONS IN SUPERHETERODYNE DESIGN.—E. G. Watts, Jr. (*Proc. Inst. Rad. Eng.*, April, 1930, Vol. 18, pp. 690–694.)

Owing to its inherently uniform selectivity and amplification over a tuning range, the writer considers that the superheterodyne method of selection and amplification approaches the characteristics of an ideal receiver. In spite of the need for valves and components contributing nothing directly to the amplification, a properly designed superheterodyne can be built with less material and in a smaller space than other types of receiver for the same performance.

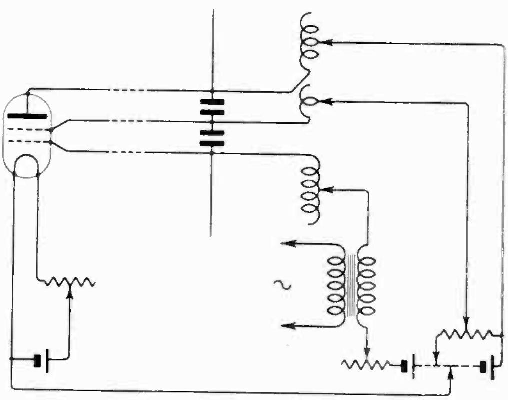
The present paper deals first with the suppression of the double response due to the higher- and lower-frequency beats of signal and oscillator—an obstacle which has, in the past, prevented the superheterodyne from more nearly approaching the ideal. With an intermediate frequency of 150 kc., two tuned circuits before the first detector will provide enough signal-frequency selectivity to reduce the undesired response to a level below that of the component which unavoidably feeds through the circuit capacity to the grid of the first detector. Capacitive and inductive intercircuit coupling must be kept low, and the direct pick-up of the first detector grid circuit must be minimised by thorough shielding (with aerial disconnected, a strong signal should be barely perceptible—this condition is readily obtainable in practice). The remaining heterodyne whistle, produced by the difference of the oscillator beats with the desired and interfering signals, may be shifted by a fine adjustment of the intermediate frequency so as to fall at 5,000 cycles, where the selectivity curve of the intermediate-frequency amplifier drops.

The paper ends by a section on the design of the oscillator. The inherently uniform response of the superheterodyne is spoiled unless the oscillator voltage on the first detector grid remains above a certain value over the frequency range of the oscillator; the oscillator level cannot be raised as a whole to compensate for a deficiency at one end of the range, since this would cause the first detector to be overloaded at the opposite end. The difficulty is overcome by providing the first detector with automatic grid bias, which also improves its efficiency. The oscillator-first detector coupling must be kept below the value at which the tuning of the detector drags the oscillator at the higher frequencies. Some other points are dealt with briefly, including a method of aligning the circuits for single control purposes.

ÜBER DEN EMPFANG ULTRAKURZER ELEKTRISCHER WELLEN MITTELS ELEKTRONENSCHWINGUNGEN (The Reception of Ultra-Short Electric Waves by the use of Electron Oscillations).—W. Pistor. (*Zeitschr. f. hochf. Tech.*, April, 1930, Vol. 35, pp. 135–148.)

The writer considers that transmitters for ultra-short waves [below 1 m.] are likely always to be weak compared with others, so that increased ranges will only be obtained by improving the receivers. Before dealing with his reception experiments at Jena, he describes the transmitter employed (due to Hollmann), giving the diagram of connections of the supply and modulation circuits, which were at some distance from the transmitter. From this it is seen that the anode voltage was taken from a potentiometer across a 120 v. accumulator battery, while the grid voltage was taken from a second potentiometer across 440 v. mains, this being possible because the transmitter was tuned to the maximum intensity for Gill-Morell oscillations, where small fluctuations in grid voltage have no effect.

For wavelengths 100–80 cm. a Schott N type of valve was used, for 80–60 cm. a Schott K. Waves below 60 cm. could only be obtained by overloading the latter valve, so for 60–40 cm. the French TMC type or a similar valve was employed, the power being made more or less equal to that of the Schott type by using two valves in Scheibe's double-valve circuit (one at each end of the Lecher wires). Another type of transmitter used was a very portable one driven by dry batteries, employing a Telefunken space-charge-grid valve (RE 074d), which gave a wave range 150–36 cm. With this valve the shortest waves were obtained by giving a space-charge grid the high positive potential, while the control grid and anode were used together as the anode in the ordinary triode connection. But it was found that greater power could be obtained by connecting the anode separately to a third Lecher wire, as in the diagram given below :—



Finally the writer mentions that higher powers than could be obtained on the electron-oscillation principle were produced by a push-pull transmitter using the TMC valves; successful results were thus obtained on 3 w. using a 100 cm. wave and its first harmonic. A paper by Dennhardt on this subject is promised.

Regarding modulation, it is pointed out that B.-K. oscillations are only susceptible to frequency modulation, since every change in working conditions causes wavelength change: but since Gill-Morell oscillations were here used, amplitude modulation could be obtained both for telephony and tonic train. Tonic train obtained by supplying the anode with a.c. and signalling by interrupting this supply gave bad near-by signals for waves below 60 cm., owing to the building-up processes involved in the G.-M. oscillations. But modulation through a transformer in the d.c.-supplied anode circuit was successful.

Approaching now to the subject of his title, the writer mentions first the failure of many of the usual crystal detectors when applied to these ultra-short waves [*cf.* Esau, June Abstracts, p. 335] but mentions the improvement produced by an auxiliary potential, and also the good detector combination used by Telefunken (pyrites and gold point on a bronze spring) which needs no auxiliary potential. The next section deals with the search for the most suitable valve for reception purposes, with particular reference to keeping the batteries reasonable in size and to obtaining an exact and constant adjustment to that point of sudden increase in sensitivity which is of such value in the Barkhausen-circuit receiver. With few exceptions, the only suitable valves for reception by electron-oscillations have cylindrical electrodes of small diameter: and the presence of residual gas is essential. These facts suggest the use of *modern space-charge-grid valves with oxide-coated filaments ;* these valves in many cases retain the cylindrical electrodes, they have a residue of gas, and the space-charge grid, lying close to the cathode, can be used as the Barkhausen grid.

The next sections, therefore, deal with various characteristic curves taken with such a valve—the RE 074d used in the portable transmitter mentioned earlier.

These lead to the discussion of two different types of reception, called by Cords (1928 Abstracts, p. 286) "oscillating audion reception, first and second types"; in the first, the reaction coupling is just so strong that the incoming wave sets up oscillation; in the second, the reaction is increased so that the receiving circuit is already weakly oscillating just off the tune of the incoming waves; these weak oscillations are carried into synchronism by the signals, and build up to larger amplitudes. Ordinary heterodyne reception is impossible because the necessary constancy of frequency in transmitter and receiver is unattainable.

The first of two receivers now described has a dipole connected to control grid (for the sake of loose coupling with the electron system) and anode; the second receiver has an additional closed circuit in the form *not* of Lecher wires (since these gave too close a coupling with the valve and too violent G.-M. oscillations) but of a small ring and condenser, connected to the space-charge grid. In both receivers the fine adjustment to and past the oscillation threshold is accomplished by means of the filament rheostat, which has practically no effect on the wavelength. Both receivers allow the "first" and "second" types of reception to be used; the more sensitive and better for distant reception is the "first type": at these distances the receiver with the additional circuit was more sensitive than the other. For short ranges the "second type" of reception was preferable. With either receiver, tonic train telegraphy was carried on over 20 km. and the range could have been extended if the stations could have been kept "in view" of each other.

The final section deals with the writer's experiences with a super-regenerative receiver, which gave good results at short ranges but was disappointing at long ranges. He examines this result at some length, attributing it to strong frequency modulation of the electron oscillations by the super-regenerative action. He refers to Hollmann's use of super-regeneration (Feb. Abstracts, p. 98) but maintains that the use of a second valve would be preferable. He ends with a reference to Okabe's results (April Abstracts, p. 213) and concludes that these correspond to reception by one of the two "types" dealt with above.

NOTE ON DAY-TO-DAY VARIATIONS IN SENSITIVITY OF A BROADCAST RECEIVER.—R. P. Glover. (*Proc. Inst. Rad. Eng.*, April, 1930, Vol. 18, pp. 683–689.)

Large variations in the sensitivity of a highly sensitive commercial broadcast receiver, over a period of one month, showed a high degree of correlation with relative humidity of the atmosphere. The decreases of sensitivity were probably due to increased losses in the r.f. transformers during periods of high relative humidity. The effect of humidity changes may be delayed from one to four days, the time-lag being greater at frequencies of relatively low sensitivity. These variations are important in connection with the intercomparison of receiver measuring equipment and the production testing of receivers.

TELEGRAPHY AND TELEPHONY ON [ULTRA] SHORT WAVES OF ½ METRE.—Uda. (*See* under "Transmission.")

THREE POINTS OF INFLECTION ON THE CHARACTERISTIC OF A SCREEN-GRID VALVE.—Kawazoe and Iinuma. (*See* under "Valves and Thermionics.")

DIE FESTELLUNG VON FREQUENZVERZERRUNGEN MIT DEM MILLIAMPEREMETER (The Detection of Frequency Distortion by means of a Milliammeter).—E. Kinne. (*Die Sendung*, 1st Feb., 1930, Vol. 7, p. 80.)

DER SCHALECO-ALL-DX-EMPFANGER (The Schaleco-All-DX Receiver).—(*Zeitschr. f. hochf. Tech.*, Jan., 1930, Vol. 35, pp. 40–41.)

Interchangeable coils gave a wave-range 10–2,000 m. A screen-grid first valve leads to a reaction audion circuit, followed by a transformer-coupled l.f. stage and a resistance-coupled pentode stage. Batteries or mains may be used. A special heating resistance in the screen-grid valve circuit gives volume control.

CASCADED DIRECT-COUPLED TUBE SYSTEMS OPERATED FROM ALTERNATING CURRENT.—E. H. Loftin and S. Young White. (*Proc. Inst. Rad. Eng.*, April, 1930, Vol. 18, pp. 669–682.)

Authors' summary :—An outline is given of the characteristics which are desirable in an audio amplifier or detector-amplifier. A description is given of some direct-coupled cascaded tube systems operating from a.-c. supply. Among the features which are discussed are :—the reduction of current drain on the filter, the elimination of "motor-boating," stabilising against drift of plate current, the elimination of hum and the provision of automatic change of grid bias with change of carrier input. The paper gives circuit constants and amplification-frequency characteristics for certain circuit arrangements.

A REMOTE CONTROL SELECTOR SYSTEM.—E. E. Burns. (*Rad. Engineering*, Feb., 1930, Vol. 10, pp. 42–43.)

A system employing a valve voltmeter circuit to operate the necessary relay. The two connecting wires used can be very small (having to carry only 10 mA. as a maximum) and are both at earth potential.

AERIALS AND AERIAL SYSTEMS.

ENCLOSED FRAME AERIAL.—(German Pat. 489735; Federal Tel. Co., pub. 18th Jan., 1930.)

The metal shield used to protect against weather is here connected to the winding so as to form the centre turn of the latter.

BROADCASTING TRANSMITTING AERIALS TO GIVE DECREASED SPACE WAVE AND INCREASED GROUND WAVE.—Rolf. (*See* last part of Abstract under "Propagation of Waves.")

ANTENNA-MEASURING EQUIPMENT.—J. K. Clapp. (*See* under "Measurements and Standards.")

VALVES AND THERMIONICS.

THERMIONIC PHENOMENA AND THE LAWS WHICH GOVERN THEM.—O. W. Richardson. (Stockholm, 1930. Norstedt & Fils.)

The Nobel Lecture delivered at Stockholm in December, 1929.

ELECTROSTATIC EXTRACTION OF ELECTRONS FROM AN ILLUMINATED METAL SURFACE.—Rosenkewitsch. (*See* under "Gen. Phys. Articles.")

RECTIFIER CHARACTERISTICS OBSERVED BY THE C.-R. OSCILLOGRAPH.—v. Ardenne. (*See* under "Subsidiary Apparatus.")

A PHENOMENON IN A SCREEN-GRID TUBE.—S. Kawazoe and H. Iinuma. (*Journ. I.E.E. Japan*, Supp. Issue No. 490–491, pp. 88–89.)

Three peculiar points of inflection have been noticed on the falling characteristic region of the plate current/plate voltage curve of screen-grid valve Radiotron UX222, when the screen-grid voltage was kept rather high. The points occurred at about 14, 16.5 and 24 v. plate potential, almost regardless of control- and screen-grid voltages; they accordingly produced a noticeable influence on the amplification characteristics when the valve was used as a short-wave r.f. amplifier.

DETERMINATION OF VALVE CAPACITIES C_{ga} AND C_{gc} BY THE AID OF IMPEDANCE MEASUREMENTS.—Bruun: Feldtkeller and Strecker. (*See* under "Measurements and Standards.")

POWER OUTPUT CHARACTERISTICS OF THE PENTODE.—S. Ballantine and H. L. Cobb. (*Proc. Inst. Rad. Eng.*, March, 1930, Vol. 18, pp. 450–470.)

Neglecting what may be called the "space-charge pentode" (a screen-grid tetrode with a space-charge grid inserted between control grid and cathode, for the purpose of increasing the flow of electrons from the latter), the writers investigate mathematically and experimentally the pentode which is a screen-grid tetrode with a third grid, between the screen grid and the plate, connected to the cathode, its object being to prevent the flow of secondary-electron current from the plate.

The writers begin by defining the quantity "power sensitivity" as $S = \sqrt{W}/E_{ce}$, where W is the power delivered to the load and E_{ce} is the r.m.s. value of the a.c. sinusoidal grid voltage. This quantity allows a direct comparison to be made between two output valves in terms of an equivalent amplification, or "gain."

This power-sensitivity is measured for a particular pentode and compared with that of a triode under conditions of equal optimum undistorted output. The pentode was found to be equivalent to the triode *plus a stage of amplification giving a gain of* 3.3. Although this is not intended as a generalisation, virtually the same result has been obtained with other pentodes and triodes.

The mathematical theory of the Carson first- and second-order effects is developed. The production of harmonics by the second-order effect is calculated and is found to depend upon three non-related parameters representing curvature and fanning [non-parallelism] of the characteristics. The possibility of mutual cancellation of the terms involving these parameters when the grid bias is more negative than the point of inflection on the $i_p - e_g$ characteristic is noted. In these circumstances the remaining harmonic distortion is due to higher order terms and is small, so that a maximum of undistorted power is obtained. An expression is obtained for the undistorted power as a function of the load resistance.

Three types of power limitation are classified and discussed; distortion due to (1) curvature of characteristic; (2) plate current cut-off; (3) grid potential becoming positive. The circumstances of their occurrence and their effects are examined qualitatively.

Experimental measurements of the undistorted power output of a low-power pentode are given, and an "improved and simplified technique" is described, using *a special analyser designed to give a rapid null method of indicating the r.m.s. harmonic content.* The harmonics and fundamental are separated by two trains of filters and amplifiers, terminating in two thermocouples which are connected in opposition to a common microammeter. An attenuator, calibrated directly in harmonic percentage, is in the harmonic train and is adjusted until there is no deflection in the microammeter, the percentage being then read off from this setting.

For a fixed plate voltage and a variable grid bias, the highest undistorted power output was obtained at a value of load resistance equal to about *one-quarter of the plate resistance.* The optimum undistorted output increases approximately linearly with the plate voltage.

The paper ends by some notes on the nomenclature and the scheme of symbols used. The term "transconductance" is used as an abbreviation for the "variational transfer conductance" of a tube of n-electrodes, *i.e.*, $\delta i_a^n / \delta e_b^n$ where i_a represents the current in the circuit of electrode *a*, and e_b the potential of electrode *b*, usually with respect to the cathode.

AN AMERICAN PENTODE.—CeCo. Mfg. Company. (*Rad. Engineering*, February, 1930, Vol. 10, p. 33.)

A new a.c. pentode which "performs admirably as a r.f. amplifier using a tuned impedance in the plate circuit. Also, it is a very satisfactory audio amplifier, especially well suited for use in the now famous Lotfin-White direct-coupled circuit." Amplification factor 575–750, plate resistance 100,000–380,000 ohms, mutual conductance 1,930–2,000 micromhos, according to working conditions.

A NEW TYPE FOUR-ELEMENT TUBE.—H. F. Dalpayrat. (*Rad. Engineering*, February, 1930, Vol. 10, pp. 34–35 and 39.)

A valve "employing a screening member out of line with the effective electron path but functioning much the same as the usual screen-grid." This fourth electrode, whose main object is to remove as much as possible of the space charge without obstructing the electron flow, is in the form of a small plate preferably *under* the cathode, following closely the configuration of the latter and as close as possible to it. Apart from its use as a space-charge grid, it may also be used :—to decrease the flow from filament to plate (by giving it a high positive potential) : for modulation : for neutralising purposes : or for opposing audio-frequency resonance in l.f. amplifiers without introducing resistance and consequent loss of volume as is done by the usual cures.

REVISING THE –99 TYPE TUBE : NEW TYPE OF FILAMENT FOR DRY CELL TUBE ELIMINATES USUAL FAULTS.—A. DuMont and V. O. Allen. (*Rad. Engineering*. Feb., 1930, Vol. 10, pp. 42–43.)

AN "ELECTROMETER" THREE-ELECTRODE VALVE WITH A RESISTANCE OF 10^{16} OHMS BETWEEN CONTROL ELEMENT AND THE OTHER ELECTRODES.—Nelson. (*See* under "Measurements and Standards.")

NEW G.E.C. VALVES : LS.6A AND P.2.—Gen. Elec. Co. (*Electrician*, 16th May, 1930, Vol. 104, p. 623.)

The LS.6A resembles the LS.5A, but has an output equal to that given by two of this type paralleled. Anode dissipation can reach 25 w. ; normal slope is 2.3 MA./V. ; impedance at 100 V. with zero grid volts is 1,300 ohms, and amplification factor 3.0. The P.2 is especially suitable for portable sets, giving super-power valve results with least possible increase in h.t. current.

STANDARDISATION IN THE RADIO VACUUM-TUBE FIELD.—W. C. White. (*Proc. Inst. Rad. Eng.*, March, 1930, Vol. 18, pp. 373–390.)

"In vacuum-tube engineering the base dimensions, the filament voltage, plate voltage, and grid-bias voltage are the features that require standardisation to the greatest degree. The history and present status of standardisation of these features are given. Only tube types commonly used [in the U.S.A.] for broadcast reception and transmission are included."

DIRECTIONAL WIRELESS.

UNILATERALES PEILWINKELZEIGERGERÄT MIT ROTIERENDER GONIOMETER-ANKOPPLUNGSPULE (A Unilateral Direct-reading Direction Finder with Rotating Goniometer Coupling Coil).—F. Berndorfer and M. Dieckmann. (*Zeitschr. f. hochf. Tech.*, March, 1930, Vol. 35, pp. 98–105.)

For previous types of direct-reading d.f.s in which the second writer is concerned, see March Abstracts, p. 161. In the type now described, the search coil of a goniometer (whose field coils are connected to two crossed loops) is rotated continuously and is coupled with a definite gear ratio to a 3-phase generator. The r.f. currents derived from the aerial loops, and modulated by the rotation of the search coil, are taken to a receiver through slip-rings and brushes. Signals from a vertical aerial are superposed on these currents on their way to the receiver. After amplification, rectification, filtering and l.f. amplification, the signals are led to the moving system of a phase-meter, which is of the "power factor meter with 360° scale" type and which has its rotating field supplied by the 3-phase generator geared to the rotating search coil.

Since the phase of the currents led to the moving system varies with the bearing of the in-coming signals, this arrangement gives a direct indication of the bearing over a 360° scale. Tests described in the paper indicate that provided the speed of rotation is kept constant and the signal currents kept at a fixed value (by observing an anode current meter in the rectifier circuit and adjusting accordingly) such an apparatus gives good results even with weak signals from distant broadcasting stations.

INTERLOCKED-SIGNAL DIRECTION FINDER IN A ROTATING FORM. (German Pat. 489944, Lorenz, pub. 23rd Jan., 1930.)

The objection that the ordinary equi-signal beacon requires the guided craft always to travel in the course given by the beacon is here avoided by rotating the two beams. The interval is measured which occurs between a starting signal and the merging of the two interlocked signals into a long dash.

RECENT DEVELOPMENTS IN DIRECTION-FINDING APPARATUS.—R. H. Barfield. (*E.W. & W.E.*, May, 1930, Vol. 7, pp. 262–265.)

Long abstract of the I.E.E. (Wireless Section) paper. Part I deals with recent developments for medium waves, in connection with the Adcock aerial system, now working at ground level. Part II deals with 12–60 m. waves and begins with a description of a rotating-loop d.f. for these waves; continues with a description of a rotating Adcock d.f. for a similar wave-range, and compares the results obtained with these two outfits—the latter showing a marked superiority. See also *Elec. Review*, 11th April, 1930, pp. 711–712.

SOME EXPERIMENTS ON NIGHT ERRORS FOR LONG WAVES.—I. Tanimura. (*Proc. Inst. Rad. Eng.*, April, 1930, Vol. 18, pp. 718–722.)

When the transpacific station, JAA (λ = 15,250 m.) is received near Tokio (148 km. away), the bearing begins to shift towards east 3 or 4 hours before sunset, the shift increasing gradually to a maximum, then reversing gradually to pass through the true bearing to a maximum on the west; it then reverses again and returns to the true bearing. Another similar cycle generally follows at once, and then night sets in; during this, irregular variations occur until sunrise, when the regular cycles begin again but in the reverse direction: the true bearing returns 3 or 4 hours after sunrise. These night errors reach maxima of nearly 30°.

The minimum point, as observed on a frame aerial rotating about a vertical axis, is sometimes very sharp (zero) but generally rather flat: *the sharp minima are mostly found when the shift in bearing is at a maximum.* Records of bearing variations and of broadness of bearing are given. Field intensity variations, as received on a horizontal loop, are also recorded, and the form of this record almost exactly corresponds with that of the variations of bearing (comparison with results on a vertical aerial seems to show that these horizontal-loop variations are a result of the polarization of the space waves). It appears from a comparison of the curves, and from theory, that both surface and space waves were in phase when the values of bearing error reached the E. maxima—where the bearings were sharp—while they were in opposite phase when the bearing error was at its W. maxima, where again the bearings were sharp.

The paper ends with the comparison of curves of bearing error and of broadness of bearing, calculated along the lines of T. L. Eckersley's 1921 paper, with the curves based on these actual observations. Theoretical and observed values are "in fair coincidence, though not quite exactly on account of the several assumptions made."

AN INTERPRETATION FOR VARIATIONS IN APPARENT DIRECTION OF LONG-WAVE RECEPTION.—I. Tanimura. (*Res. Electrot. Lab.*, Tokyo, No. 271, 1929, 36 p.p.)

Summary in English. Covers the same ground as the I.R.E. paper dealt with above.

DEVELOPMENT OF THE VISUAL TYPE AIRWAY RADIO-BEACON SYSTEM.—J. H. Dellinger, H. Diamond and F. W. Dunmore. (*Bur. of Stds. Journ. of Res.*, March, 1930, Vol. 4, pp. 425–459.)

After dealing with the aural radiobeacon system, the paper describes the development of the double-modulation system and its use with the tuned-reed indicator; the adaptation to four independent courses; the station course-shift indicator. It then deals with the triple-modulation system, capable of serving 12 courses simultaneously; special three-reed indicators; adjusting the courses to airways at arbitrary angles.

The next section considers aeroplane receiving equipment; antennæ; engine ignition shielding. Section 6 is devoted to Marker Beacons; Section 7 to Fog Landing:—field localizers, landing altimeters. The remaining sections deal with tests of the systems, the comparison of various types of "radio aids to air navigation," and a bibliography of 33 items.

A 12-COURSE RADIO RANGE FOR GUIDING AIRCRAFT WITH TUNED REED VISUAL INDICATION.—H. Diamond and F. G. Kear. (*Bur. of Stds. Journ. of Res.*, March, 1930, Vol. 4, pp. 351–369.)

A description of the Triple Modulation system referred to in the preceding abstract, used to provide radio-marked courses at air terminals where more than four airways converge.

In order to prevent coupling between amplifier branches, special means are employed to supply them successively rather than simultaneously. These are described in detail [automatic switching using (*a*) 3-phase audio-frequency grid biasing, and (*b*) 3-phase radio-frequency switching]; the stability of the resulting system is shown to be excellent. Three-phase r.f. supply, received from a single-phase oscillator by means of a phase divider, is used to excite the amplifier trains. A goniometer with three primary coils at 120° transfers the energy to the two crossed aerials through two secondary coils at 90°. This allows the two aerials to establish a space pattern from three amplifier branches. Means for aligning this resultant space pattern with the airways are discussed, and examples given.

A TUNED-REED INDICATOR FOR THE 4 AND 12 COURSE AIRCRAFT RADIO RANGE.—F. W. Dunmore. (*Bur. of Stds. Journ. of Res.*, April, 1930, Vol. 4, pp. 461–474.)

Very complete descriptions of the three-reed indicator for use with the 12-course radiobeacon referred to above, and of the two-reed indicator for use with the 4-course beacon with double modulation (see Diamond, March Abstracts, p. 162).

SCREENING OF REED INDICATOR. (*Journ. Franklin Inst.*, Jan., 1930, Vol. 209, p. 112.)

Preliminary tests show that if sheet iron is used for the external mounting of the indicator, the latter may be located within 3 inches of the magnetic compass without affecting the compass readings—instead of being spaced at least 18 inches as is otherwise necessary.

ACOUSTICS AND AUDIO-FREQUENCIES.

REFLECTION MEASUREMENTS ON SOUND WAVES: THE REFLECTING PROPERTIES OF AN OPENING.—M. J. O. Strutt. (*See* Abstract under "Propagation of Waves.")

The writer applies his methods (developed for ultra-short electromagnetic waves) to sound waves. Curves are obtained showing the received strength of sound as a function of the height of the loud speaker (sound emitter) above the reflecting medium, the receiver being kept at a fixed height; maxima and minima are here found, as they were in the electromagnetic case, produced by the interaction of the direct and the once-reflected rays: the presence of a harmonic in the note is shown clearly by irregularities in the curve, pure notes giving regular curves. It is shown that apertures of dimensions comparable with the wavelength behave as apertures only to an extent (in the case in point) of 90 per cent., owing to diffraction effects.

TRANSMISSION CHARACTERISTICS OF SHORT-WAVE TELEPHONE CIRCUIT.—R. K. Potter. (*Proc. Inst. Rad. Eng.*, April, 1930, Vol. 18, pp. 581–648.)

The considerable technique which has been developed for wire circuits, for the measurement of the audio-frequency transmission characteristics, is inadequate to disclose the true nature of the distortion which may exist in a radiotelephone circuit (especially short-wave) because of the large changes which may take place in as little as a fraction of a second. A method must be used which permits taking an entire characteristic "as quickly as a snapshot record" and allows a rapid succession of such records to be taken, as in moving-picture photography. For this purpose the measuring frequencies are sent simultaneously and continuously rather than individually and consecutively, as in wire-line testing: the circuit is thus subjected to a steady state and complications due to transients are avoided.

The paper gives a very full account of the methods and results of transmission ("Multitone") measurements over the short-wave circuit between Deal (N.J.) and New Southgate, England. Most of these were on 13 and 18 megacycles, but occasional observations were made on 6, 9, and 21 megacycles also. The "Multitone" transmitter at Deal gave a spectrum of 12 frequencies from 425 to 2,295 cycles; these tones were monitored at a near-by receiver and their amplitudes adjusted to equality, so that any variations received in England would be due to effects of the radio transmission path. For the successive recording of the individual tones thus sent out simultaneously, a rotating commutator at New Southgate selected the outputs of the different filters in rapid succession. Most of the recording was by moving element oscillograph on sensitised paper, but the cathode-ray oscillograph was also used.

From the many results of these tests, the following conclusions may be selected:—(1) The cause of fading on a short-wave, long-distance circuit appears to be of a more or less orderly nature when the fading is observed on a band of frequencies rather than upon one alone. The relative simplicity of the selective fading patterns suggests that the contributing factors are limited in number. Diurnal and seasonal variations in the amplitude and character of selective fading are quite as orderly as field-strength variations. The patterns are in general most simple for the higher radio frequencies, indicating that a smaller number of components are involved as the frequency increases; the average fading rate is correspondingly lower for the higher frequencies.

(2) The presence of distortion on both single and double side-band signals indicates that the cause cannot be assigned to side-band asymmetry. Patterns of such signals, obtained at times when patterns were simple, suggest that much of the distortion is due to wave interference between signals arriving over paths of different group length (the normal difference appearing to be between 50 km. or less and 300 km. for the different components). Except in unusual cases it is necessary to assume three or more paths to account for the pattern shapes and sequence of changes observed, *particularly for the lower frequencies*. This does not seem to agree with the idea that the paths are through different levels of the refracting medium where the rate of change of ionisation with height is effectively the same—since the lower frequencies would be less inclined to penetrate to the higher layers. On the other hand, it does agree with the idea that the number of paths may be the result of "earth" reflections. The fact that the selective fading patterns were practically the same on a vertical aerial and on an array directive within some 10° in the horizontal plane apparently precludes any possibility of widely divergent paths in this plane.

(3) The distortion appearing in the audio-frequency signal is due to intermodulation of the side-bands as the carrier is suppressed ("harmonic distortion"—the voice becoming high-pitched, seeming to slide an octave up the scale when the signal falls into a fade), and to a selective suppression or exaggeration of fundamental audio-frequencies ("fundamental distortion"). The former may be reduced by a decrease in percentage modulation at the transmitter when using double side-band, or eliminated by the use of single side-band. The latter cannot be corrected by either of these methods.

(4) The use of an automatic gain control depending on carrier amplitude changes apparently emphasizes the distortion due to selective fading, since the maximum distortion occurs during the fades.

RECHERCHES SUR LES PLAQUES TÉLÉPHONIQUES (Researches on Telephonic Diaphragms).—H. C. Huizing. (*Archives Néerland. d. Phon. Exp.*, Vol. 5, 1930, 12 pp.)

The method used by the writer to observe and record the vibrations of a diaphragm is to fix a small piece of aluminium foil (supported by a mica backing) perpendicularly to the face of the diaphragm. On illuminating this foil and observing the other side through a microscope, a number of very small holes are seen; when the diaphragm vibrates, each illuminated point becomes a streak of light.

To obtain better illumination for photographic recording, a small slit is found in the foil, parallel to the plane of the diaphragm. By means of a cylindrical lens, this slit is focused so that its length is diminished to a point. The image is recorded on a photographic plate carried in a holder which falls past the lens in 0.1 to 0.2 sec.

By visual observation in front of the lens it may be seen whether the vibration is simple or contains harmonics. In the former case the brightness of the vibrating slot diminishes regularly from the ends to the middle ; in the latter, the distribution of light may be of any form. A time base is provided by a tuning fork arrangement. The writer, with this apparatus, has studied the movements of telephone diaphragms under the influence of currents of varying intensity, varying frequencies, with varying air-gaps, etc. He points out the influence of the particular point of attachment of the aluminium indicator, particularly when resonant frequencies are used—owing to the formation of nodes and antinodes on the diaphragm. These he shows, for third and fourth harmonics, by photographs of the diaphragm scattered-over with sand.

The paper then deals with the examination, by the photographic method, of the MacGregor Morris and Mallet question of whether a telephone diaphragm should be regarded as a plate or as a membrane. The results, at any rate for the diaphragm tested, seem very much in favour of the *plate*—contrary to those of the former workers. The last section deals with the use of the method for the examination of distortion.

AN ELECTRICAL FREQUENCY ANALYZER.—M. Kobayashi. (*Elec. Communication*, April, 1930, Vol. 8, pp. 315–319.)

The full paper, a summary of which was dealt with in June Abstracts, p. 341.

FREQUENZUNABHÄNGIGE SCHWÄCHUNG BEI DER LAUTSTÄRKEREGULIERUNG (Volume Control Independent of Frequency).—E. Asch. (*Zeitschr. f. tech. Phys.*, April, 1930, Vol. 11, No. 4, pp. 121–125.)

The theory of frequency-independent volume control obtained by the adjustment of three resistances between " generator " and " indicator " (*e.g.*, loud speaker) is here investigated. The three resistances may be connected in the T-form or the Π-form. Simple formulæ are evolved for the calculations of the values. The results are applied to the designs of a control giving approximate logarithmic decrease, and of a simple volume-meter which " appears to fill a gap in the average laboratory " : its accuracy is great enough for many cases and it consists only of an output transformer with tapped primary, a volume control and a hot wire meter calibrated in watts. It is shortly to be put on the market.

ÜBER DIE KOMBINIERENDE TÄTIGKEIT BEIM HÖREN VON SILBEN UND TEXTEN (On the Combining Activity in the hearing of Syllables and Sentences).—V. Englehardt and E. Gehrcke (*Zeitschr. f. Psychol.*, Special Number, Vol. 111, 1929, pp. 257–272 ; also *Wiss. Abh.d.Phys.-Tech. Reichaust.*, No. 1, Vol. 13, pp. 127–142.)

Statistics are given of the errors (mistakes and omissions) in hearing gramophone records with (1) meaningless syllables (consonant + vowel), (2) a consecutive sensible sentence, and (3) a meaningless series of syllables, some of them sensible. Vowels were far less often mistaken than consonants, except that in (1) U was repeatedly taken as being O (but not vice versa). (2) gave only 2 per cent. errors ; in (3) the sensible syllables gave 27 per cent., the meaningless ones gave 43 per cent. ; the latter were often mis-heard as sensible syllables.

EFFECTS OF DISTORTION ON THE RECOGNITION OF SPEECH SOUNDS.—J. C. Steinberg. (*Journ. Acoustical Soc. Am.*, Oct., 1929, pp. 121–137 : *Bell Tel. Lab. Reprint B.*445, Jan., 1930.)

Effect of changing the level of the received speech ; of removing portions of the speech frequency range : general effects of distortion : effect of an extraneous noise ; of the resonance type of frequency distortion ; of reverberation : other types of distortion.

ELECTROMAGNETIC PICK-UPS. — E. W. D'Arcy. (*Rad. Engineering*, Feb., 1930, Vol. 10, pp. 49–52.)

The fourth instalment of the series on Public Address and Centralised Radio Systems referred to in May Abstracts, p. 291, deals with pick-ups :—damping, magnet life, the electro-mechanics of various types—linear output, wear on bottom of record groove, maximum effective coupling of needle point with record groove, allowable maximum variation from right angles of the reproducer with respect to groove, maximum effective inertia of reproducer head with respect to amplitudes reproduced. A diagram is given of the apparatus used for measuring the linear output of a pick-up.

THE SECTOR-MEMBRANE LOUD SPEAKER : THE " SEKTORPHON."—Grass and Worff. (*Zeitschr. f. hochf. Tech.*, Jan., 1930, Vol. 35, pp. 41–42.)

The frequency curves of this special diaphragm and of an ordinary cone are compared.

NEW MOVING COIL LOUD SPEAKER.—R. W. Paul AND B. S. COHEN. (*Wireless World*, 9th April, 1930, Vol. 26, pp. 374–375.)

Description of an instrument employing a flat rigid piston of Balsa wood, 11½ inches in diameter. An entire freedom from " booming " is claimed and response curves indicate exceptionally good results at the lower and the upper ends of the audio range. For a criticism of its performance by N. W. McLachlan, and a reply by R. W. Paul, see issues for 14th and 28th May, pp. 520 and 569.

IMPROVED MOVEMENT FOR M.C. LOUD-SPEAKER.—(French Pat. 667357, Bethenod, pub. 16th October, 1929.)

A special re-entrant form of pot magnet is used, and a straight-line movement of the moving coil is assured by a spindle passing clear through a central channel in the inner pole ; the end of this spindle is supported at the back of the pot magnet by a corrugated circular membrane—or this membrane may be dispensed with and the channel lined with velvet, etc., on which the spindle rests.

MEASUREMENT OF THE PERFORMANCE OF LOUD SPEAKERS.—E. J. Barnes. (*E.W. & W.E.*, May, 1930, Vol. 7, pp. 248–255.)

First part of a paper published by permission of the G.P.O. Diagrams of connection are given for the heterodyne oscillator used as the source of testing current; for the circuit for wave-form measurement; and for the amplifier for the condenser microphone used as the sound detector.

ACOUSTICS OF RADIO BROADCASTING STUDIOS.—L. E. Voorhees. (*Journ. Am.I.E.E.*, March, 1930, Vol. 49, pp. 210–217.)

THE LAW OF STIFLING OF SOUND BY CURTAINS OR CUSHIONS.—J. Larmor. (*Proc. Camb. Phil. Soc.*, April, 1930, Vol. 26, Part II, pp. 231–235.)

A theoretical examination of an experimental conclusion arrived at by Heyl, Chrisler and Snyder (June Abstracts, pp. 340–341). "The intensity of stifling is estimated. Under ideal conditions the absorption should vary as the secant of the angle of incidence of the sound."

SCHALLDRUCKMESSUNGEN AN MIKROPHONEN, TELEPHONEN UND IM FREIEN SCHALLFELD (Measurements of Sound Pressure in Microphones, Telephones and in the Free Acoustic Field). —C. A. Hartmann. (*E.N.T.*, March, 1930, Vol. 7, No. 3, pp. 100–107.)

See March Abstracts, p. 162.

METHODS AND APPARATUS FOR MEASURING THE NOISE AUDIOGRAM.—R. H. Galt. (*Journ. Acoust. Soc. Am.*, October, 1929, Vol. 1, pp. 147–157.)

A discussion of the methods and apparatus for measuring the deafening effect of noises on the human ear. The paper is reprinted in *Bell Telephone Lab. Reprint B*.446 of Jan., 1930.

EINE SCHALTUNGSANORDNUNG ZUR ABHALTUNG VON SAMMELFERNGESPRÄCHEN (A Circuit Arrangement allowing of Long-Distance Telephone Conversations with Several Participants).—H. Decker. (*E.N.T.*, Feb., 1930, Vol. 7, No. 2, pp. 49–64.)

SCHWINGUNGEN VON MEMBRANEN IN EINER PULSIERENDEN FLÜSSIGKEIT. EIN BEITRAG ZUR RESONANZTHEORIE DES HÖRENS (Oscillations of Membranes in a Pulsating Fluid. A Contribution to the Resonance Theory of Hearing).—W. Kucharski. (*Physik. Zeitschr.*, 15th March, 1930, Vol. 31, No. 6, pp. 264–280.)

CALCULATION OF THE ARTICULATION OF A TELEPHONE CIRCUIT FROM THE CIRCUIT CONSTANTS.—J. Collard. (*World Engineering Congress Abstracts*, 1929, Paper 659.)

"A detailed study of speech and hearing has been carried out, and as a result a complete and rigid theory has been built up in connection with the transmission of sounds over a telephone circuit. From this theory a series of algebraic formulæ have been worked out which enable the articulation of the circuit to be calculated from a knowledge of such factors as the attenuation of the circuit and the amount of noise present in it." Its practical application to any given case requires only about half an hour, as compared with about 50 hours for direct measurement.

UNTERSUCHUNGEN AN SCHEIBEN, DIE IN EINER TÖNENDEN LUFTSÄULE ROTIEREN (Investigations of Discs rotating in a Sounding Air-Column).—A. Schmidt. (*Zeitschr. f. Phys.*, 14th Feb., 1930, Vol. 60, No. 3/4, pp. 196–209.)

A STUDY OF GROUND NOISE IN THE REPRODUCTION OF SOUND BY PHOTOGRAPHIC METHODS.—O. Sandvik. (*Kodak Scient. Pub.*, Vol. 12, 1928, pp. 260–265.)

PHOTOTELEGRAPHY AND TELEVISION.

CONTROL OF LIGHT BY PIEZOELECTRIC CRYSTALS.—(German Pats. 484462 and 485317, Siemens and Halske, pub. 16th Oct., 1929, and Telefunken, pub. 29th Oct., 1929.)

Methods of light control depending on the marked effects produced on the optical properties of anisotropic crystals when they are set into vibration. For diagrams of the various circuits covered see *Zeitschr. f. hochf. Tech.*, Jan., 1930, p. 32.

LIGHT CONTROL BY PIEZOELECTRIC ACTION ON NON-CRYSTALLINE SUBSTANCES SUCH AS GLASS.—(German Pat. 489465, Telefunken, pub. 21st Jan., 1930.)

The optically polarising effects of piezoelectric action, on glass which has been put into an electrically polarised state by means of an applied d.c. potential, is here made use of. A special application is for the scanning of pictures: a number of layers of glass, each with its own natural frequency of vibration, are excited in turn by h.f. passing cyclically through these frequencies, and thus become in turn transparent to a polarised beam.

THE PHOTOELECTRIC EFFECT IN GLASS PLATES, AND ITS DEPENDENCE ON THE ANGLE OF INCIDENCE.—A. Wehnelt and G. Schmerwitz. (*Zeitschr. f. Phys.*, No. 7/8, Vol. 57, pp. 533–538.)

PHOTO-CELLS AND RELAYS.—Isenthal and Co. (*Elec. Review*, 28th March, 1930, Vol. 106, pp. 611–612.)

Some notes on the "Carola" photoelectric cells (three types) and the glow-tube relay referred to in April Abstracts, p. 229.

TWO-WAY SOUND AND SIGHT TELEPHONE COMMUNICATION: THE IKONOPHONE.—(*Engineer*, 2nd May, 1930, Vol. 149, p. 489.)

Paragraph on a recent demonstration by the A.T. and T. between a New York call office and another office $1\frac{1}{2}$ miles away. Each person stood in front of a 7×5 in. picture of the other: both sound and visual reproduction were good, and synchronised perfectly. No details are given of the apparatus.

TWO-WAY TELEVISION: BELL TELEPHONE SYSTEM DEMONSTRATED.—(*Wireless World*, 14th May, 1930, Vol. 26, pp. 514–515.)

An illustrated article on the "Ikonophone" equipment referred to in the above abstract.

PHOTOELECTRIC TUBE AS TELEVISION TRANSMITTER.—C. E. C. Roberts. (*Television*, May, 1930, Vol. 3, p. 113.)

In an article on the recent exhibition held by the Television Society, this transmitter is mentioned. The image is thrown on to a photoelectric surface, where it gives rise to streams of electrons directly proportional to the light values. This electron stream is "scanned" by magnets placed outside the tube and so fed as to cause every part of the stream in turn to pass through the centre hole in a screen: electrons passing through fall on a "grid" and give rise to electrical variations which can be amplified in the ordinary way.

TELEVISION EXHIBITION.—(*Electrician*, 18th April, 1930, Vol. 104, p. 500.)

A short survey of the 2nd annual exhibition of the Television Society recently held in London (see also above).

ÜBER DEN EINFLUSS DES RASTERS BEI DER BILDTELEGRAPHIE (On the Influence of the Screen Mesh in Phototelegraphy).—P. Arendt. (*E.N.T.*, Feb., 1930, Vol. 7, No. 2, pp. 72–78.)

A paper based on a series of tests, on Siemens-Karolus-Telefunken apparatus, using screen-meshes of 5, 4 and 3 lines to the mm., and applying various enlargements and reductions; with particular reference to the requirements of pictures which are to be copied by some printing process—where the transmitting mesh must always be finer than that used for the printing, in order to avoid the "moiré" effect.

It is concluded that a mesh of 5 lines per mm., for a picture 18 × 26 cm., is nearly always satisfactory. This gives 1 million elements, and the resulting picture can be reproduced full size or even, in many cases, can be enlarged to twice full size: or, using the same 5 lines per mm. mesh, the original can be reduced to half size (13 × 18 cm.) before transmission, giving only 5×10^5 elements. It does not seem advisable, however, to go still lower and use 2.5×10^5 elements for Press services.

A SYSTEM OF ELECTRICAL TRANSMISSION OF PICTURES.—Y. Niwa. (*Elec. Communication*, April, 1930, Vol. 8, pp. 283–295.)

A paper on the N.E. [Nippon Electric] System referred to in April Abstracts, p. 220. Reception is by means of an electromagnetic vibrator and screen forming a "translator," and the paper discusses two types of translator, "central-screened" and "side-screened," and their characteristics. Thus for a negative-to-positive transmission, the former type is used; by suitable adjustment of the shape of the screen opening, an over- or under-exposed negative can be corrected. For positive-to-positive transmission the side-screened translator is used. The paper then discusses the reflection method as compared with the transmitted light method of transmission, and the question of the speed of transmission and the choice of carrier frequency.

PICTURE OR HIGH SPEED TELEGRAPHY.—(German Pat. 499464, Telefunken, pub. 18th Jan., 1930.)

Valve frequency-multiplying methods to enable the carrier wave to be filtered out in cases where, for the purposes of transmission over cables, a carrier frequency is chosen only twice the modulation frequency.

ELECTROSTATIC EXTRACTION OF ELECTRONS FROM AN ILLUMINATED METAL SURFACE.—Rosenkewitsch. (*See* under "Gen. Phys. Articles.")

MEASUREMENTS AND STANDARDS.

ANTENNA-MEASURING EQUIPMENT.—J. K. Clapp. (*Proc. Inst. Rad. Eng.*, April, 1930, Vol. 18, pp. 571–580.)

Description of a portable equipment. The substitution method is used, the calibrated phantom aerial being adjusted to maintain constant frequency and amplitude of oscillation in the driving oscillator circuit as the oscillator is switched from the physical to the phantom aerial. For measuring the natural frequency of the aerial the classic method is used of added series inductances and the extrapolation of the resulting curve.

THE MEASUREMENT OF CAPACITANCE AND INDUCTANCE IN TERMS OF FREQUENCY AND RESISTANCE AT RADIO FREQUENCIES.—C. P. Boner. (*Review Scient. Instr.*, April, 1930, Vol. 1, pp. 243–259.)

The precision method described measures capacitances of the order of 500 $\mu\mu$F. or larger, at intermediate and radio frequencies. Author's abstract:—"A method of measuring capacitance and inductance is described, in which the product LC is found in terms of frequency by adjusting a circuit which contains the capacitance and an inductance to resonance, the ratio L/C is found in terms of resistance by a high frequency bridge, and the value of C is finally calculated by solving the two equations for LC and L/C simultaneously. A method of eliminating the effect of condenser leads is described. The bridge equations are derived and the effects of residuals in the arms are discussed. Details are given concerning the construction of the bridge, the oscillators, and the heterodyne detector, and concerning essentials of the operating technique. Numerical results are given for a sample condenser calibration."

SENSITIVITY MEASUREMENTS AND PERFORMANCE TESTS ON RADIO RECEIVERS IN PRODUCTION.—N. E. Wunderlich and W. R. Dohan. (*Rad. Engineering*, Jan., 1930, Vol. 10, pp. 31–37.)

A discussion of the test methods used in building the Victor sets.

PERFORMANCE REQUIREMENTS OF QUARTZ OSCILLATORS AND THEIR STANDARDISATION.—Bureau of Standards. (*Commercial Stds. Monthly*, January, 1930, Vol. 6, p. 217.)

Paragraph on a conference "attended by more than 50 representatives of radio-manufacturing companies and interested governmental departments," and by engineers and physicists. Various recommendations were made as to standard terminology, sizes and shapes of plates, and the adoption of general specifications outlining performance requirements.

METHOD AND APPARATUS USED AT THE BUREAU OF STANDARDS IN TESTING PIEZO OSCILLATORS FOR BROADCAST STATIONS.—E. L. Hall. (*Proc. Inst. Rad. Eng.*, March, 1930, Vol. 18, pp. 490–509.)

See April Abstracts, p. 223.

COMPOSITE PIEZOELECTRIC PLATES. (German Pat. 490085, Telefunken, pub. 23rd Jan., 1930.)

Quartz plates often present more than one natural frequency owing to lack of homogeneity in the crystal. According to the invention, this is avoided by using quite thin piezoelectric layers, made of powder and a binding material, on a plate of some suitable [homogeneous] material. The vibration excited in the piezoelectric layer is passed on to the adjoining plate, which then vibrates in its own natural period.

THE MAGNETOSTRICTION CONSTANT FOR ALTERNATING MAGNETIC FIELDS.—F. D. Smith. (*Proc. Physical Soc.*, 15th April, 1930, Vol. 42, Part 3, pp. 181–191.)

Author's abstract :—A magnetostriction constant K for the Joule effect is defined by the equation $p = KH$ where p is the alternating mechanical stress produced by a small alternating field H superposed on a steady magnetic field H_0. It is shown that the alternating intensity of magnetisation I produced by an alternating strain $\delta l/l$ is given by the equation $I = K \cdot \delta l/l$, K being the same constant in both equations. These equations are used to calculate the motional impedance of a laminated ring toroidally wound and vibrating in its fundamental radial mode.

K has been measured for various values of H_0 with a ring of the alloy Fe 60%, Ni 40%. It is shown that the magnetostriction effect for steady magnetising fields can be inferred from the measurements with alternating magnetic fields, if the reversible permeability and the differential permeability of the alloy are known.

A PIEZOELECTRIC WAVEMETER. (German Pat. 489661, Schäffer, pub. 18th Jan., 1930.)

Two crystals of differing frequencies are switched alternately into a bridge circuit in the wavemeter, the rectifier and indicator being in the diagonal of the bridge. The wave to be measured is in tune if it corresponds to the point of intersection of the two resonance curves of the crystals ; any slight departure from this point is indicated by a change in deflection on switching from one crystal to the other.

PIEZOELECTRIC PATENTS. (American, 1735808, Taylor, pub. 12th Nov., 1929 ; French, 668771, Belin-Holweck, pub. 6th Nov., 1929.)

(1) A crystal-controlled oscillator using a two-grid valve, several [3] crystals of the same frequency being connected between the two grids and the cathode, and between grid and grid. A higher output can be reached in one stage owing to the decreased load on each crystal.

(2) Two small crystal plates lie between metal electrodes which themselves lie between two large crystal plates ; these appear to form only a screen, and have no electrical connections. The arrangement is said to have great independence of temperature-changes.

MODES OF VIBRATION OF A ROUND PLATE CUT FROM A QUARTZ CRYSTAL.—A. M. Skellett. (*Journ. Opt. Soc. Am.*, May, 1930, Vol. 20, pp. 293–302.)

Author's abstract :—A large number of modes of vibration of a round quartz crystal plate of the "Curie" cut were photographed by means of the ionized gas appearing at the antinodal regions when the plate was mounted in an atmosphere of neon or argon at a few mm. pressure and thrown into vibration piezo-electrically by a radio frequency oscillator.

Two general types of vibration of the plate were found. In the first kind the plate was symmetrically divided up into nodal and anti-nodal regions forming patterns peculiar to the exciting frequencies. In the second kind of which less evidence was found the vibration consisted of standing waves along chords or diameters of the plate with reflection at the edges. The crystal rested on a round brass plate which served as the lower electrode. Two different top electrodes were used, a point and a screen, the same pattern being photographed with each for the more prominent modes of vibration and from this it was concluded that the patterns were independent of the electrode arrangement. Evidence of vibration along axes oblique to the surfaces of the crystal plate was found. All vibrations observed were believed to be compressional in nature.

NEW PIEZO OSCILLATIONS WITH QUARTZ CYLINDERS CUT ALONG THE OPTICAL AXIS.—A. Hund and R. B. Wright. (*Bur. of Stds. Journ. of Res.*, March, 1930, Vol. 4, pp. 383–394.)

The experiments of Röntgen (1890) and the later ones of Tawil (1929 Abstracts, pp. 159, 335 and 581) on the effect of torsion about the optical axis of a quartz cylinder cut along that axis, all dealt with *static* torsional forces. One of the purposes of the present paper is to show that *dynamic* torsional forces can produce electric effects, and vice versa. A second purpose is the demonstration of new oscillations produced with crystals cut along the optical axis, which embody true piezoelectric action and which may be explained without conflicting with Voigt's theory.

The large number of photographs shown were taken by means of the glow discharges occurring when the quartz was enclosed in an atmosphere of helium (sometimes neon or neon and helium, or nitrogen) at pressures of several mm. of mercury. New adaptations of regenerative circuits were used as the driving circuit.

THE PIEZO-ELECTRIC RESONATOR IN HIGH-FREQUENCY OSCILLATION CIRCUITS.—Y. Watanabe. (*Proc. Inst. Rad. Eng.*, April, 1930, Vol. 18, pp. 695–717.)

Part I. Motional Impedance of the Piezo-Electric Resonator. This is a translation of a 1927 paper in Japanese, and deals with the experimental verification of Cady's theoretical considerations regarding motional admittance. Part II, which will appear in the May issue, will deal with the oscillation conductivity, the properties of the crystal coupling, the piezoelectric oscillation generator and the crystal frequency stabiliser. For a German version, *see* 1928 Abstracts, p. 289.

DESIGN OF A PORTABLE TEMPERATURE-CONTROLLED PIEZO OSCILLATOR.—V. E. Heaton and W. H. Brattain. (*Bur. of Stds. Journ. of Res.*, March, 1930, Vol. 4, pp. 345–350.)

A paper describing the essential details of a design to which the Bureau has made several portable oscillators which on preliminary tests have shown a constancy of 1 part in 100,000. The quartz is placed in the grid-filament connection [*cf.* and contrast Vigoureux, June Abstracts, p. 343], a grid resistance of several megohms being in parallel with the quartz to maintain a constant grid voltage on the oscillator valve. The inductance in the anode circuit has low distributed capacity (in order to emphasise the harmonics) and needs no shunting capacity. The output from the piezo-oscillator is not used directly (since a variable load at the output would affect the frequency) but through a constant, very loose coupling and one or more (screen-grid) stages of r.f. amplification. The quartz plate is mounted between two metal electrodes separated by a pyrex ring of such diameter as to fit the cylindrical plate to within one-hundredth of an inch, and of such thickness that the top electrode leaves an air-space approximately one-quarter of the wavelength of the supersonic waves generated by the quartz (*see* Dye, *Proc. Phys. Soc.*, Aug., 1926, and Hund, *Proc. I.R.E.*, Aug., 1928). The plate holder is mounted in a thermal attenuating chamber consisting of a copper cylinder and layers of asbestos contained in a wooden box, the copper cylinder being mounted on heavy bronze coil springs and carrying in a slot in its side a sensitive mercury thermostat.

REGISTRATION OF PENDULUM SWINGS BY VALVE METHOD NOT INVOLVING PHOTOELECTRIC CELLS.—G. Ferrié. (*Month. Not. R. Astron. Soc.*, October, 1929, Vol. 89, pp. 713–718.)

A method depending on the difference of plate current when the circuit is, and is not, oscillating. A detailed description of the apparatus is given.

DIE RADIOTECHNIK IM DIENSTE DER ZEITMESSUNG (Radio Technique in the Service of Chronometry).—J. Baltzer. (*Zeitschr. f. Fernmeld.*, 30th April, 1930, Vol. 11, pp. 58–62.)

The Nauen "Onogo" signal and its production and reception; coincidence signals; the use of short waves for avoiding electrical contacts in precise time-recording (Lejay, Mahnkopf—the latter simplifies the former's method by abolishing the local oscillator and making the pendulum change the retroaction of the receiver itself); Wireless clock setting. *Cf.* same writer, 1929 Abstracts, p. 518.

ABAQUE POUR LE CALCUL DES RÉSISTANCES OHMIQUES À TOUTES FRÉQUENCES (Abac for the Calculation of Ohmic Resistances at All Frequencies).—M. Mathieu. (*L'Onde Élec.*, March, 1930, Vol. 9, pp. 139–140.)

An abac for copper conductors at normal temperature, based on Levasseur's formula (*see* April and June Abstracts, pp. 224 and 342.)

DIE BERECHNUNG VON EISENLOSEN DROSSELSPULEN (The Calculation of Air-Cored Choking Coils).—K. Faye-Hansen. (*E.T.Z.*, 20th March, 1930, Vol. 51, pp. 427–429.)

The graphical work of Hak (Abstracts, 1929, p. 280, and 1930, p. 112) has led the writer to derive a number of empirical formulæ for circular coils of rectangular section and for other shapes, such as rounded oblong coils of rectangular section or rounded section. They are based on the simplest formula, *i.e.*, that for the first case mentioned, which is

$$L = n^2\pi^2 D \cdot \frac{1 - \frac{2}{3}\rho + \frac{1}{3}\rho^2}{a} \cdot 10^{-9} \text{ henry.}$$

ON A DOUBLE HUMP PHENOMENON OF CURRENT THROUGH A BRIDGE ACROSS PARALLEL LINES [LECHER WIRES].—E. Takagishi. (*Proc. Inst. Rad. Eng.*, March, 1930, Vol. 18, pp. 513–532.)

A theoretical and experimental investigation from which it is concluded that the "double hump" of bridge-current occurs necessarily (quite apart from the well-known absorption effect produced when the coupling between generating set and the system is too close) under certain circumstances which are detailed. The phenomenon stands on the same theoretical basis as the writer's method of producing 3-phase oscillations (*see* Jan. Abstracts, pp. 46–47).

A METHOD OF MEASURING THE RADIO-FREQUENCY RESISTANCE OF AN OSCILLATORY CIRCUIT.—H. Iinuma. (*Proc. Inst. Rad. Eng.*, March, 1930, Vol. 18, pp. 537–543.)

A "dynatron oscillator" method based on the fact that in an ordinary screen-grid valve the anode has a negative resistance characteristic at certain operating voltages, and the amount of this negative resistance can be varied over a wide range by adjusting the control-grid voltage. If an oscillatory circuit consisting of an inductance and a capacity in parallel is inserted in series with such an anode circuit and the negative resistance gradually increased, oscillation will take place suddenly when the negative resistance becomes just equal to the resonance impedance of the oscillatory circuit. The negative resistance value at which oscillation starts or stops is obtained from the static characteristics, and the resonance impedance may accordingly be determined.

Results obtained by this method at frequencies from 600 to 1,250 kc. per sec. agree within 2.5% with those obtained by the usual resistance variation method. The method has special advantages for short wave measurements, where the introduction of measuring instruments may cause unfavourable effects; it requires, moreover, no r.f. standard resistances and no r.f. oscillator.

WIDERSTANDSVERGLEICHUNG MIT WECHSELSTROM UNTER VERWENDUNG VON VERSTARKERRÖHREN (Alternating Current Resistance Comparison Using Valve Amplifiers).—E. Wiegand. (*Ann. der Phys.*, Series 5, 1930, Vol. 4, No. 6, pp. 781–822.)

A paper on a null method, using Pfeiffer's improved form of the Bellati dynamometer combined with different forms of Wheatstone bridge, the sensitivity of the dynamometer being increased by its being preceded by one, three or five stages of amplification.

A SET OF CURVES FOR SKIN EFFECT IN ISOLATED TUBULAR CONDUCTORS.—A. W. Ewan. (*Gen. Elec. Review*, April, 1930, Vol. 33, pp. 249–251.)

MODIFICATION DU PONT DE KOHLRAUSCH POUR LA MESURE DES RÉSISTANCES EN COURANT ALTERNATIF (Modification of the Kohlrausch Bridge for the Measurement of Resistances for A.C.).—E. Denina. (*Rev. Gén. de l'Élec.*, 10th May, 1930, Vol. 27, pp. 737–738.)

Summary of an Italian article.

CALCULATION OF INDUCED VOLTAGES [NOT INCLUDING RADIATION EFFECTS] IN METALLIC CONDUCTORS.—H. B. Dwight. (*Journ. Am. I.E.E.*, April, 1930, Vol. 49, pp. 289–292.)

SIMPLIFIED CALCULATION OF AMPLIFICATION OF RESISTANCE- AND CAPACITY-COUPLED AMPLIFIERS.—E. D. Cook. (*See* Glauber abstract under "Properties of Circuits.")

BESTIMMUNG DER ROHRENKAPAZITÄTEN C_{ga} UND C_{gk} MIT HILFE VON SCHEINWIDERSTANDSMESSUNGEN (Determination of Valve Capacities C_{ga} and C_{gc} by the Aid of Impedance Measurements).—H. Bruun: Feldtkeller and Strecker. (*Zeitschr. f. hochf. Tech.*, March, 1930, Vol. 35, pp. 105–108.)

A theoretical and practical investigation of the method used by the last two workers. The process is as follows:—the slope of the valve for a normal working point is determined from the static characteristic. The valve is then loaded with an anode resistance about twice as great as the valve internal resistance, and the phase angle of the combination is measured (by the Franke machine or otherwise) for a constant frequency of about 800 p.p.s. and for various values of grid leak.

From the values of resistance and phase-angle thus obtained, the impedance circle is constructed. From the points of intersection of this circle and the true axes R and R_0, the ratio C_{gc}/C_{ga} can be obtained and by geometrical construction C_{ga}, and hence C_{gc}, can be measured.

RÖHRENVOLTMETER ZUR VERLUSTFREIEN MESSUNG HÖHERER SPANNUNGEN BEI GLEICHSTROM UND WECHSELSTROM (Valve Voltmeter for Measurement without Loss of High Voltages with Direct and Alternating Current).—J. Welikin. (*E.N.T.*, February, 1930, Vol. 7, No. 2, pp. 78–79.)

An adaptation of Weisglass' voltmeter circuit (where the voltage to be measured is applied with its negative pole to the anode of the valve, and the change in grid current measured—1928 Abstracts, p. 644) to make it applicable to a.c. The simplest way of doing this is to interpose a condenser in the anode lead: *e.g.*, for $C = 3{,}000$ cm. and $f = 50$ p.p.s, the internal resistance (which would otherwise fall to some ten thousands of ohms during the positive half-period) is raised by about a megohm. But the writer prefers an arrangement applicable to d.c. as well as a.c., and uses therefore either a two-valve circuit or a two-grid valve: in the latter case the voltage to be measured is applied to the anode and the inner grid.

RADIO MEASURING INSTRUMENTS.—E. H. W. Banner. (*Wireless World*, 23rd and 30th April, 1930, Vol. 26, pp. 432–436 and 466–468.)

Points in the design and the working principles of the four general types of instruments usually met in radio work, *viz.*:—moving coil, moving iron, thermal and electrostatic.

WAVEMETER SCALES.—W. H. F. Griffiths. (*Wireless World*, 9th April, 1930, Vol. 26, pp. 381–383.)

Choosing a suitable condenser scale for an accurate wavemeter. Thickly engraved scales make fine reading difficult. Many wavemeters have scales so small that their overall accuracy is much less than that which should be expected from the design of their resonant circuits.

VIBRATIONSGALVANOMETER MIT WEITGEHENDER FREQUENZUNABHANGIGKEIT (A Vibration Galvanometer with Extensive Independence of Frequency).—W. Meissner and U. Adelsberger. (*Zeitschr. f. tech. Phys.*, April, 1930, Vol. 11, No. 4, pp. 102–107.)

An ordinary vibration galvanometer may have its deflection altered by more than 100 per cent. by a variation of 1 per cent. in the frequency of the current affecting it. This effect can be reduced by increasing the damping, but only at the cost of loss of sensitivity.

The first part of this paper deals with the writers' plan of rendering the galvanometer independent of frequency by combining its own (mechanical) resonance curve with the (electrical) resonance curve of an LC circuit formed by introducing a condenser of suitable value in series with the inductance of the windings. The damping of this circuit can be adjusted by a series resistance. Such a mechanical-electrical combination has already been used in sound generators for submarine signalling (Du Bois-Reymond, Hahnemann and Hecht—*ibid.*, 1921, Vol. 2, p. 37).

A thorough mathematical investigation of the system leads to a determination of the best conditions, and thus to the design of a special galvanometer particularly suitable for such use. This design involves a needle of special steel to give as high a magnetisation as possible, and an electromagnet core of 2×2 cm.^{2} cross section with an air-gap of only 1.4 mm. between conical pole-tips of 0.4×0.4 cm.^{2} cross section. For frequencies above 100 p.p.s. the air-gap can be made still smaller. At the value given, the standard sensitivity is some 100 times greater than that of a Du Bois Rubens shielded galvanometer.

The paper is continued in the May issue (pp. 143–147), where the results of tests are given and compared with the theoretical results.

A Vacuum Tube Electrometer.—H. Nelson. (*Rev. of Scient. Instr.*, May, 1930, Vol. 1, pp. 281–284.)

Circuits hitherto used for measuring small d.c. currents by a three-electrode valve have been complicated and not altogether satisfactory because of the difficulties involved in securing steady conditions and because of factors such as electrical leakage between the elements of the valve. The paper describes how a specially constructed triode may be used in a simple circuit to measure accurately currents as small as 10^{-14} A.

This special "electrometer" valve has a resistance of 10^{16} ohms between the control element and the other electrodes under normal working conditions, as compared with less than 10^7 ohms for ordinary triodes. The anode is in the form of a cylindrical nickel grid; the oxide-coated filament is supported in the centre of the anode by a piece of mica fastened to the latter. A nickel cylinder supported by a lead brought out at the top of the valve is used as a control grid. A larger nickel cylinder serves as an electrostatic shield.

The chief advantages claimed for the apparatus using this valve are:—simplicity and cheapness: low capacity: no delicate adjustments: portability: practical independence of vibrations.

Dimensional Analysis.—B. L. Robertson. (*Gen. Elec. Review*, April, 1930, Vol. 33, pp. 207–221.)

Fundamentals and Applications: Changing Units: Checking Equations: Deriving Formulas: Predicting the Operation of Machines from Behaviour of Models: Determining the Flow of Liquids and Gases.

The "N-Diagram."—W. A. Barclay. (*Wireless World*, 9th and 16th April, 1930, Vol. 26, pp. 376–378 and 418–421.)

A form of alignment diagram for ascertaining the proportion of some available magnitude required for a specific purpose. The diagonal of the "N" carries the percentage scale, the extremities of the diagonal cutting vertical parallel lines at zero. The vertical lines are graduated in equal divisions. Where, for example, it is required to find the e.m.f. across a resistance r_1 in the case of resistances r_1 and r_2 in series, the graduations represent ohms. The percentage of total e.m.f. across r_1 is shown at the point where the diagonal is cut by a line through the respective values of the resistances marked on the vertical lines.

The "N-diagram" can be applied to many other problems, including the calculation of stage gain in a l.f. amplifier.

Note on a Modified Randall Universal Calibration Curve for Ballastic Galvanometers.—R. H. Frazier. (*Rev. of Scient. Instr.*, May, 1930, Vol. 1, pp. 227–280.)

A Method of Comparing Small Magnetic Susceptibilities.—R. A. Fereday. (*Proc. Physical Soc.*, 15th April, 1930, Vol. 42, Part 3, pp. 251–263.)

A method of the non-uniform field type which is greeted in the subsequent discussion as a "definite advance on previous methods."

Methods of Impedance Measurement of Coils with Superposed Direct Current.—M. Kobayashi. (*Journ. I.E.E. Japan*, Supp. Issue, No. 490–491, pp. 65–67.)

A bridge method is described, also a "fall of potential" method; for high frequencies the use of a cathode ray oscillograph to give vectorial measurement of voltages in the latter method is recommended.

SUBSIDIARY APPARATUS AND MATERIALS.

Bestimmung von Modulationsgraden und Gleichrichterkennlinien mit der Braunschen Röhre (Determination of Degree of Modulation and Rectifier Characteristics with the C.-R. Oscillograph).—M. von Ardenne. (*E.N.T.*, Feb., 1930, Vol. 7, No. 2, pp. 80–84.)

A. Observation and recording of the degree of modulation. If the modulation is constant, a standing image can be obtained by demodulating the signal and using the resulting l.f. to give the ordinate deflection, while the r.f. gives the abscissæ. From the trapezoidal diagram thus formed, the percentage modulation k can be obtained by measuring the lengths a and b of the parallel sides; then $k = \frac{a - b}{a + b}$. The true trapezoidal diagram is only given if the l.f. potentials at the oscillograph reproduce without phase displacement the course of the l.f. modulation of the transmitter: the conditions necessary for this are difficult to fulfil in a transformer-coupled amplifier, but can be fulfilled, up to frequencies of 10,000 p.p.s., in a resistance-coupled amplifier, as an example (taken with a triple valve for demodulation and amplification) shows.

If these conditions are not fulfilled, the oscillogram displays—joining the ends of its two parallel horizontal sides—two more or less irregular ellipses; the deviations from the true (theoretical) ellipse being due to frequency multiplication (rectification- and iron-distortion). But the percentage modulation can nevertheless be found from such a diagram by drawing the rectangles enclosing the ellipses and then measuring the lengths *a* and *b* thus obtained.

For varying modulation the standing diagram, of course, fails, but the contour of the modulated wave can be observed by the use of a mirror rotating on a horizontal axis: or the degree of modulation can be gauged by direct observation of the brightness at the middle of the horizontal (r.f.) streak. For recording, a vertically moving film can register directly the time-curve of the r.f. fluctuations. For all these purposes, the cathode-ray oscillograph must give powerful optical effects combined with great r.f. sensitivity, and the writer points out the suitability of his own tube (*see* March Abstracts, pp. 169—right-hand column—and 228) combined with the resistance-coupled amplifier (with linear amplification up to 10,000) referred to on the same page 169, left-hand column.

B. The observation and recording of detector valve characteristics. Of the two possible methods described, the one finally recommended presents the characteristic as the outside edge of a luminous area To obtain this dynamic representation of the function $\delta i_a(t) = f(\mid e_g \mid)$, where δi_a represents the rectifying action and $\mid e_g \mid$ the input high-frequency amplitude, the input potential is allowed to swing between zero and its maximum value (quickly in comparison with the inertia of the eye) and the direct current coming through the detector is applied to the vertically deflecting plates of the oscillograph. The input potential (radio-frequency) is applied to the horizontally deflecting plates.

The photograph of a characteristic thus obtained refers actually to a rectifier valve (RE 134, 200 v. on the anode, −20 v. grid bias) which was able to control the oscillograph directly with an anode load of 20,000 ohms. But in the case of weaker detectors, l.f. amplifiers may be interposed, provided that they are suitably designed to give absolute linearity, etc.

Die Spannungsteilung beim Kathodenoszillographen (Voltage Division in the Cathode Ray Oscillograph).—W. Rogowski, O. Wolff and H. Klemperer. (*Archiv. f. Elektrot.*, 15th April, 1930, Vol. 23, No. 5, pp. 579–588.)

Authors' summary:—Potentiometers constructed of high ohmic resistances or of series connections of condensers and resistances are useless for phenomena of short duration, on account of the capacity of the plates of the cathode-ray oscillograph. For such work voltage division can only be attained by means of a condenser method.

A Cathode Ray Oscillograph with Norinder Relay.—O. Ackermann. (*Journ. Am. I.E.E.*, April, 1930, Vol. 49, pp. 285–289.)

Abridgment of a paper describing the original Norinder oscillograph and a new model developed in 1929 for field and laboratory tests. A simple and concise formula is developed for the sensitivity of a C.-R. oscillograph (L. R. Smith). This takes into account the change of the mass of the electron at speeds approaching that of light: at 60 kv. this phenomenon causes a deviation of 5 per cent. from the value which would be expected otherwise. A bibliography of 19 items is added.

Sur la Théorie des Appareils Indicateurs (On the Theory of Indicators).—N. Kryloff and N. Bogoliuboff. (*Journ. de Phys. et le Rad.*, March, 1930, Series 7, Vol. 1, pp. 77–92.)

This theoretical investigation of the Indicator Diagram refers specially to oscillographs, but its reasoning can be applied to other indicators such as the ordinary (steam) indicator, seismographs, vibrographs, etc.

Stabilized Oscilloscope with Amplified Stabilization.—F. Bedell and J. G. Kuhn. (*Review Scient. Instr.*, April, 1930, Vol. 1, pp. 227–236.)

Authors' abstract:—One stage of amplification included in the stabilizing circuit of the Bedell-Reich oscilloscope, which comprises a cathode-ray tube with linear time-axis for observation of periodically varying quantities, extends the frequency range of the instrument and permits stabilization without disturbance to the circuit under test. Although not primarily intended for use beyond the audio range, the instrument has in this way been stabilized above 100,000 cycles. Curves are given showing the use of the instrument for the study of non-electrical quantities (as sound and light) as well as of electrical quantities (as in the study of modulation and rectification).

Ein Sprungschaltung für Sperr- und Zeitkreise für Kathodenstrahl-Oszillographen (A Very Rapid Starting Arrangement for Blocking- and Time-Base Circuits of the C.-R. Oscillograph).—W. Krug. (*E.T.Z.*, 24th April, 1930, Vol. 51, pp. 605–609.)

A full description of the arrangement referred to in 1929 Abstracts, p. 460. It can be applied to the recording of uncontrolled phenomena. Time lag is of the order of 10^{-8} sec.

High Vacuum: the Problems attached to its Production and Maintenance.—H. V. Cadwell. (*Rad. Engineering*, Jan., 1930, Vol. 10, pp. 38–41.)

Protective Resistances for Electrostatic Oscillograph Elements.—A. N. Arman. (*Journ. Scient. Instr.*, April, 1930, Vol. 7, p. 137.)

The use of high resistances, cheaply made from strips of carbon paper clamped between ebonite plates, is recommended. A value of about 5 megohms has been found suitable.

A Tangent Meter for Graphical Differentiation.—O. W. Richards and P. M. Roope. (*Science*, 14th March, 1930, Vol. 71, pp. 290–291.)

Description of a simple device for the direct measurement of the tangent to a curve at any point. The derivative curve may then be rapidly and easily obtained by plotting the tangents. Maxima, minima and points of inflection may be found without reference to the rest of the curve.

PRECISION INDUSTRIAL RECORDERS AND CONTROLLERS.—I. M. Stein. (*Journ. Franklin Inst.*, February, 1930, Vol. 209, No. 2, pp. 201–228.)

CHARACTERISTICS OF [NEON] DISCHARGE TUBES UNDER "FLASHING" CONDITIONS AS DETERMINED BY MEANS OF THE CATHODE RAY OSCILLOGRAPH.—W. A. Leyshon. (*Proc. Physical Soc.*, 15th April, 1930, Vol. 42, Part 3, pp. 157–169.)

Current/time and Voltage/time curves are derived from the oscillograph records.

THE USE OF THE GRID GLOW TUBE IN A THERMO-REGULATOR.—J. H. Hibben. (*Rev. of Scient. Instr.*, May, 1930, Vol. 1, pp. 285–288.)

GRUNDSÄTZLICHES ÜBER DIE VERWENDUNG GEMEINSAMER STROMQUELLEN FÜR MEHRERE VERSTÄRKER (Principles concerning the Use of a Common Source of Current for a Number of Amplifiers).—G. Lubszynski. (*E.N.T.*, Jan., 1930, Vol. 7, No. 1, p. 14.)

Addendum to the paper referred to in March Abstracts, 1930, p. 170. The use of valves with indirectly heated cathodes is recommended as a means of avoiding "crosstalk" between amplifiers supplied from a common source.

COLLOIDAL RECTIFIERS.—(German Pat. 489955, André, pub. 24th Jan., 1930.)

DAS TE-KA-DE SELENVENTIL (The Te-ka-De Selenium Rectifier).—(*Rad., B., F.f. Alle*, March, 1930, p. 132.)

A new dry-plate rectifier using selenium as the active layer in place of copper oxide. The selenium is spread on discs of nickel-plated iron, and against each layer is pressed a sheet of lead backed with copper, uniform pressure being obtained by rubber separators. Output is up to 1 A. at about 4 v.; full-wave rectification is arranged for and the input voltage is about 8 v. The rectifier is particularly suitable for combination with an electrolytic condenser for direct filament supply. A special advantage claimed is the positive temperature co-efficient; in prolonged service, with its attendant heating-up, the reverse current *decreases* instead of increasing.

EIN NEUARTIGER SPANNUNGSTEILER: DER GLIMMLICHTSPANNUNGSTEILER (A New Potential-Divider: the Glow-Discharge Potential-Divider).—F. Noack: L. Körös. (*Zeitschr. V.D.I.*, 26th April, 1930, Vol. 74, pp. 548–549.)

In 1929 Abstracts, p. 460, a paper by Körös is dealt with which points out the disadvantages of Schröter's method of avoiding voltage fluctuation, oscillation and distortion caused by ohmic resistances in eliminators by using a glow-discharge tube in a parallel connection (see also Pearson, same Abstracts, p. 642); it goes on to describe Körös' own method in which a number of such tubes actually *replace* the ohmic resistances and provide the various tappings of voltage.

The present article describes a multiple glow-discharge tube, made by the Lorenz A.G. and the Osram Company to Körös' suggestion. The neon-filled glass container encloses a number of bell-shaped electrodes of different diameter, one inside the other, each connected to a pin of the container-base. In the sample illustrated, there are five pins, labelled + 210, + 140, + 70, 0, and − 70 v., the + 210 v. being the pin connected to the innermost electrode; the various voltages are arranged for by the size of the various gaps. The current/voltage curve shows that between 3 and 60 mA. the voltage drops are independent of the load.

The internal resistance is very low, and reaction effects—such as are only too liable to occur with ohmic resistances—can be avoided without the additional cost of shunting condensers.

A VOLTAGE REGULATOR FOR MAINS SUPPLY OF RECEIVERS.—(*Rad., B., F.f. Alle*, March, 1930, pp. 130–132.)

Description of a device, including a voltmeter and regulating switch, to protect mains-driven sets from damage and inconvenience by fluctuations in mains voltage. An automatic version is also made, but this is only suitable (on account of its cost) for large installations.

ACCUMULATEURS PLOMB-ZINC POUCHAIN (The Pouchain Lead-Zinc Accumulator).— —. Antoine. (*Bull. d.l. Soc. franç. d. Élec.*, April, 1930, Vol. 10, pp. 427–448.)

A LABORATORY B-VOLTAGE SUPPLY.—F. Bedell and J. G. Kuhn. (*Review Scient. Instr.*, April, 1930, Vol. 1, pp. 237–242.)

Authors' abstract:—An eliminator for full-wave rectification (600 v.) or half-wave rectification (1,200 v.) with adjustable taps for all intermediate voltages, while introducing no new principle, gives a desirable flexibility for laboratory purposes. Ripple voltage, determined by the Bedell-Reich Stabilized Oscilloscope, is found to be unusually small.

THE FOUR-ELECTRODE VACUUM TUBE AS BEAT-FREQUENCY OSCILLATOR.—S. R. Warren. (*Proc. Inst. Rad. Eng.*, March, 1930, Vol. 18, pp. 544–547.)

One UX-222 tetrode is used as a double oscillator and detector. Audio-frequency output is obtained in the beat note between the fundamental of the oscillation due to one grid and the second harmonic of that due to the other. Oscillograms are shown: changes in plate voltage have little influence on wave form and amplitude, while changes in screen-grid potential provide great changes in these characteristics.

THE CURRENT IMPULSE TRANSFORMER.—A. B. Hendricks, Jr., and S. T. Maunder. (*Gen. Elec. Review*, April, 1930, Vol. 33, pp. 241–248.)

A paper on the design and calculation of these special transformers for the production of very large currents lasting very short times—for the magnetisation of permanent magnets, etc.

Über das Auftreten von anharmonischen Schwingungen bei dynamischen Materialuntersuchungen nach dem Zug-Druckverfahren (The Occurrence of Anharmonic Oscillations in the Dynamic Investigation of Materials by the Compression-Extension Process).—A. Esau and E. Voigt. (*Zeitschr. f. tech. Phys.*, April, 1930, Vol. 11, No. 4, pp. 113–114.)

These anharmonic vibrations resemble those found by Hartmann-Kempf in tuning forks, by Martin in stretched strings, and also those obtained under certain conditions in electrical circuits with iron-cored coils. For another paper on steel under these tests see same authors, *ibid.*, March, 1930, pp. 78–81.

Les Alliages à haute Perméabilité (High Permeability Alloys).— —. Chauchat. (*Bull. d.l. Soc. franç. d. Élec.*, No. 98, Vol. 9, pp. 1091–1106.)

Dielectric Properties of Insulators.—W. H. F. Griffiths. (*Wireless World*, Vol. 26, 16th April, 1930.)

An article discussing the relative merits of a large number of insulating materials, both natural and synthetic, and the methods by which their properties can be determined.

Varieties and Uses of Mica: I.—Value as an Electrical Insulator—Few Sources of Large Sheets—Possibility of Utilising More Finely Divided Mica.—A. R. Dunton and A. W. Muir. (*Electrician*, 9th May, 1930, Vol. 104, pp. 576–578.)

Zur Theorie des Verlustfaktors technischer Isolierstoffe (On the Theory of Loss Factor in Commercial Insulating Materials).—P. Boning. (*Zeitschr. f. tech. Phys.*, March, 1930, Vol. 11, pp. 81–87.)

The dependence of loss factor on temperature, voltage and frequency is investigated theoretically and the results confirmed by tests.

Insulating Oils.—A. Monkhouse. (*Electrician*, 29th Nov., 1929, Vol. 103, pp. 666–670.)

Steatite and Porcelain Insulators.—(*Electrician*, 16th May, 1930, Vol. 104, pp. 605–606.)

Radio Control of Airport Lights.—B. F. Gostin. (*QST*, April, 1930, Vol. 14, pp. 19–22 and 80.)

A Method of Examining Stereoscopic Photographs.—J. M. Nuttall and E. J. Williams. (*Proc. Physical Soc.*, 15th April, 1930, Vol. 42, Part 3, pp. 212–217.)

A Harmonic Analyser.—J. Harvey. (*Proc. Physical Soc.*, 15th April, 1930, Vol. 42, Part 3, pp. 245–250.)

A device for finding a given number of the Fourier components of a function by means of successive weighings.

A Portable Geiger Tube Counter.—L. F. Curtiss. (*Bur. of Stds. Journ. of Res.*, April, 1930, Vol. 4, p. 593.)

Accumulator Testing by the "Signaldrop" Method.—A. E. Bawtree. (*Electrician*, 2nd May, 1930, Vol. 104, p. 560.)

Two battery testing devices are described, depending on the use of test paper which gives different colours, when moistened with electrolyte, according to the state of charge of the battery.

Photography of Dielectric Fields.—L. L. Carter. (*Elec. World*, 22nd Feb., 1930, p. 397.)

A test tank for observing and photographing electric fields about insulators is filled half full of high-grade kerosene or eocene: carbon tetrachloride is then introduced below it, by a tube, till the tank is full. Very finely cut artificial silk fibres are sprinkled uniformly over the surface, and sink till they meet the dividing plane between the liquids, where they float. The insulator is so placed that the fibres lie in the plane in which it is desired to observe the field.

Glyptal Lacquers.—L. E. Barringer. (*Rad. Engineering*, Jan., 1930, Vol. 10, p. 37.)

The synthetic (phthalic anhydride or alkyd) resins known as Glyptal now find extensive use in lacquers as well as in the production of a flexible form of mica insulation (April Abstracts, p. 229). Their tenacious adhesion is of special importance for aluminium, galvanised iron and other surfaces usually difficult to coat. They withstand temperatures above 600 deg. F., weak acids and alkalis, etc., and have a higher dielectric strength than many commonly used paints.

Ein vielseitiges selbstschreibendes Kontroll- und Alarmgerät (A Self-recording Control and Alarm Device with Many Applications).—Leeds and Northrup Co. (*E.T.Z.*, 20th March, 1930, Vol. 51, pp. 430–431.)

A device recently put on the market for use with all kinds of circuits in which the null method is employed, the moving coil galvanometer actuating mechanism in such a way as to adjust the circuit to a constant balance, while at the same time recording the changes.

Les Appareils "Auto-Alarm" (Distress Signal Apparatus).— —. Chauveau. (*QST Franç.*, Jan., 1930, Vol. 11, pp. 9–16.)

An article on the 1929 Conference in London. The systems described are those of the Marconi, Siemens, Radio Communication, S.F.R. (Chauveau) and Telefunken Companies.

STATIONS, DESIGN AND OPERATION.

The Madrid-Buenos Ayres Short Wave Service.—(*Elec. Communication*, Feb., 1930, Vol. 8, pp. 207–249.)

Various papers on the service inaugurated in October, 1929, and its transmitting and receiving plants, aerial systems, etc.

LA NOUVELLE STATION D'ÉMISSION À ONDES COURTES DE SAINTE-ASSISE (The New Short Wave Transmitting Station at Ste. Assise).—R. Villem. (*L'Onde Élec.*, March, 1930, Vol. 9, pp. 115–138.)

A description of the station which has now been in successful use for 8 months for high-speed telegraph service Paris—New York. The first model was put into operation a year ago on the telephonic service to Buenos Ayres.

LA LIAISON RADIOTÉLÉPHONIQUE PARIS BUENOS-AYRES PAR ONDES COURTES PROJETÉES (The Paris Buenos Ayres Short-Wave Beam Service).—R. Villem. (*Bull. d.l. Soc. franç. d. Élec.*, No. 98, Vol. 9, pp. 1107–1145.)

ITALIAN BROADCASTING: NEW SHORT-WAVE TRANSMITTER FOR LONG DISTANCE WORK.—(*Electrician*, 25th April, 1930, Vol. 104, p. 528.)

A GERMAN COMMON FREQUENCY BROADCAST SYSTEM.—F. Gerth. (*Proc. Inst. Rad. Eng.*, March, 1930, Vol. 18, pp. 510–512.)

A very brief outline of the system used in the Berlin-Stettin-Magdeburg group (see 1929 Abstracts, p. 400). No overhead lines being available, two cables were used—the modulation cable, which can be replaced by re-broadcasting, and the operation and carrier frequency cable. A paper on the operating experiences since January, 1930, is promised.

THE RADIO PLANT OF R.C.A. COMMUNICATIONS, INC.—H. E. Hallborg. (*Proc. Inst. Rad. Eng.*, March, 1930, Vol. 18, pp. 403–421.)

WIRELESS TELEPHONE DEVELOPMENTS BETWEEN NORTH AND SOUTH AMERICA.—(*Engineer*, 18th April, 1930, Vol. 149, pp. 436–437.)

SHIP AND SHORE TELEGRAPHY.—T. F. Purves. (*Electrician*, 25th April, 1930, Vol. 104, pp. 516–517.)

First part of an abstract of a recent address by the President of the I.E.E. to the Students' and Graduates' section. Among the various aerial systems briefly dealt with are the Marconi, Koomans, Sterba, Bruce and "T.W." arrays. "In general, the field strength due to a single-plane array increases with the area enclosed by the boundary radiators, but the 'T.W.' aerial effects a considerable improvement as compared with other arrays occupying the same space." Part 2 (*ibid.*, 2nd May, 1930, pp. 553–555) deals with the Rugby transmitter, the maintenance of constant frequency, modulation, and the connection to land lines.

TRANSOCEANIC TELEPHONE SERVICE SHORT-WAVE EQUIPMENT.—A. A. Oswald. (*Journ. Am. I.E.E.*, April, 1930, Vol. 49, pp. 267–272.)

Abridgment of a paper on the technical features of the Lawrenceville and Netcong stations.

HAND-DRIVEN PORTABLE SET FOR TELEGRAPHY AND TELEPHONY ON 30–80 M. WAVES.—Marconi Co. (*Electrician*, 16th May, 1930, Vol. 104, p. 623.)

POSTE MILITAIRE TYPE T POUR FONCTIONNEMENT DUPLEX (Type T Military Set for Duplex Working).—(*Bull. d.l. S.F.R.*, March–April, 1930, Vol. 4, pp. 31–41.)

Transmitter, receiver and aerial equipment weigh 52 kg. Ranges are 15 km. telegraph and 5 km. telephone; wavelength 30–60 m. The transmitter is crystal-controlled. The receiver has 3 valves; the duplex working is obtained by the use of separate aerials, each formed by insulated duralumin masts 5.5 m. high, and by the introduction of a resonating circuit shunting the receiving aerial inductance.

AIRCRAFT RADIO: RECEIVING AND TRANSMITTING APPARATUS FOR LARGE MULTI-MOTORED AND SMALL PLANES.—C. W. Thomas. (*Rad. Engineering*, Jan., 1930, Vol. 10, pp. 49–52.)

This paper includes a description of a remote control, cheaper, lighter, and more free from backlash, etc., than previous designs. A small motor is used to drive the condensers in either direction, so that control is effected by operating a reversing switch and watching a hydraulically-operated indicator (using castor oil mixed with alcohol). Three wires control the condensers, volume, and filaments.

RADIO-TELEPHONY ON TRAINS, "SOCIÉTÉ RADIO-FER" SYSTEM.—(*See* under "Miscellaneous.")

VERZERRUNGSEMPFÄNGER ALS ÜBERSTEUERUNGSANZEIGER BEIM RUNDFUNKSENDER (A "Distortion Receiver" as Over-control Indicator for a Broadcasting Transmitter).—R. Walter. (*Zeitschr. f. hochf. Tech.*, April, 1930, Vol. 35, pp. 149–150.)

The distortion produced by over-control consists of a series of harmonic and combination frequencies, some audible when the station itself is being received, others (of higher orders) which are inaudible in such reception but cause disturbances in the reception of other stations on neighbouring frequencies. The Riga station successfully uses these latter, high-order overtones (which, the writer says, can be detected earlier than the former) as a warning of over-control; using for the purpose a receiver with a frequency-sensitivity curve which has a steep-sided trough (to zero) of a width of 16 kc.

The device needs no calibration; it indicates the presence of over-control, independently of the power or method of modulation of the station, by giving "surprisingly loud" sudden scratching sounds: proper control gives almost complete silence. An ordinary 4-valve receiver is used with an external aerial and a rejector circuit which is very free from losses and accurately adjustable; it is made more effective by excitation from a second aerial or from another branch of the first.

GENERAL PHYSICAL ARTICLES.

PRESSURE POTENTIAL IN A FLUID.—W. H. Pielemeier. (*Science*, 25th April, 1930, Vol. 71, p. 438.)

"The above title is intended to designate a concept in connection with a fluid pressure field similar to the concept of electric and gravitational potential. . . . The difference in potential between two points is defined as it is for the electric field. Such a potential might be thought of as a condition of stress existing in the fluid, whereby a pressure (vector quantity) is caused to act on a surface in contact with the fluid if there is a difference in pressure potential between the two sides of this surface. . . . The treatment of sound is materially aided by such a concept. The pressure potential gradient in a sound field gives a pressure field intensity and an acceleration similar to the gravitational field intensity and acceleration in connection with the gravitational potential gradient. The analogue might also be carried over to electromagnetic waves."

THE EQUATIONS OF MOTION OF A VISCOUS FLUID IN TENSOR NOTATION.—C. N. H. Lock. (*Proc. Physical Soc.*, 15th April, 1930, Vol. 42, Part 3, pp. 264–288.)

"The tensor notation, which is probably best known in its application in Einstein's four-dimensional theory of gravitation, can be used in its three-dimensional form in obtaining the general equations in many branches of mathematical physics. In the present paper the various steps in the proof of the equations of motion of a viscous fluid are translated into tensor form . . ."

THE DEFLECTION OF LIGHT AS OBSERVED AT TOTAL SOLAR ECLIPSES.—C. L. Poor. (*Journ. Opt. Soc. Am.*, April, 1930, Vol. 20, pp. 173–211.)

The various eclipse expeditions are here said to study only "selected" data, which is then reduced by methods and formulæ which "assume with Einstein" the existence of the predicted radial displacements and of the Einstein law of decrease with distance from the sun. "No attempt has yet been made to test the validity of these basic assumptions. There is not the slightest observational evidence to support" them. "The actual stellar displacements, when freed from all assumptions, do not show the slightest resemblance to the predicted Einstein deflections"; if real, they can best be explained by some refractive effect of the earth's atmosphere: by a combination of the Courvoisier effect, of daylight refraction, and of temperature effects caused by the passing of the eclipse shadow. *See also* K. Burns, *ibid.*, pp. 212–224, and H. R. Morgan, pp. 225–229.

ÜBER DIE ELEKTROSTATISCHE ELEKTRONENEXTRAKTION BEI BELEUCHTUNG DER METALLOBERFLÄCHE (On Electrostatic Extraction of Electrons from an Illuminated Metal Surface).—L. Rosenkewitsch. (*Naturwiss.*, 7th March, 1930, Vol. 18, No. 10, pp. 226–227.)

A note recording the order of magnitude of the electronic current extracted from a metal by an electrostatic field, when the metallic surface is illuminated by light of insufficient strength to produce the external photo-effect.

BEMERKUNG ZUR FRAGE DES ELEKTRISCHEN WIDERSTANDES DÜNNER METALLSCHICHTEN (Remark on the Question of the Electrical Resistance of Thin Metallic Layers).—W. Braunbek. (*Zeitschr. f. Phys.*, 2nd January, 1930, Vol. 59, No. 3/4, pp. 191–197.)

DURCHGANG EINES HOCHFREQUENZSTROMES DURCH EINE ENTLADUNG IN GASEN (The Passage of a H.F. Current through a Discharge in Gases).—B. Klarfeld. (*Zeitschr. f. Phys.*, 19th Feb., 1930, Vol. 60, No. 5/6, pp. 379–386.)

The h.f. current passing through a discharge in various gases was recorded by a C.-R. oscillograph. This current lags in phase behind the voltage at the electrodes; increase in frequency increases the resistance of the discharge path.

DER ELEKTRISCHE DURCHSCHLAG BEI GASEN (Electrical Breakdown in Gases).—W. Rogowski. (*Naturwiss.*, 7th March, 1930, Vol. 18, No. 11, pp. 246–247.)

A preliminary account of new investigations on electrical breakdown in gases. For breakdown at atmospheric pressures it is necessary that the field strength should reach a high value locally, so that the positive ions can excite, lower the ionising potential and ionise; these high local values of field strength can be originally produced by a single shower of electrons. The development of space charge is also the decisive factor in breakdown at low pressures.

ÜBER GASDURCHSCHLAG UND RAUMLADUNG (On Discharge through Gases, and Space Charge).—W. O. Schumann. (*Zeitschr. f. tech. Phys.*, May, 1930, Vol. 11, pp. 131–143.)

An investigation of the influence of space charge on the Townsend discharge equations, for the steady state and for shock.

ÜBER DURCHSCHLAG UND RAUMLADUNG (Dielectric Breakdown and Space Charge).—W. O. Schumann. (*Zeitschr. f. tech. Phys.*, Feb., 1930, Vol. 11, pp. 58–59.)

THE EFFECT OF A PERMANENT ELECTRICAL DIPOLE ON THE INTERNAL LATENT HEAT OF VAPORIZATION OF A LIQUID.—A. R. Martin. (*Phil. Mag.*, March, 1930, Vol. 9, No. 57, pp. 422–425.)

ON AN EXTENSION OF THE FOURIER THEOREM GIVING RAPID METHODS FOR CALCULATING THE CONSTANT PART AND THE COEFFICIENT OF ANY PERIODIC TERM IN THE DISTURBING FUNCTION.—E. W. Brown. (*Proc. Nat. Acad. Sci.*, Feb., 1930, Vol. 16, pp. 150–156.)

OPERATIONAL CALCULUS IN QUANTUM MECHANICS. SOME CRITICAL COMMENTS AND THE SOLUTION OF SPECIAL PROBLEMS.—R. B. Lindsay and R. J. Seeger. (*Proc. Nat. Acad. Sci.*, March, 1930, Vol. 16, pp. 196–205.)

ON THE EARLY STAGES OF ELECTRIC SPARKS.—E. O. Lawrence and F. G. Dunnington. (*Phys. Review*, 15th Feb., 1930, Series 2, Vol. 35, No. 4, pp. 396–407.)

A study of phenomena in the early stages of sparks between electrodes of zinc, cadmium and magnesium, using the Kerr-cell electro-optical shutter of Abraham-Lemoine and Beams.

PHYSICAL PROBLEMS WITH DISCONTINUOUS INITIAL CONDITIONS.—H. Bateman. (*Proc. Nat. Acad. Sci.*, March, 1930, Vol. 16, pp. 205–211.)

THE GROWING IMPORTANCE OF FREQUENCY.—A. S. Eve. (Supplement to *Nature*, 22nd March, 1930, Vol. 125, pp. 454–455.)

A note urging a scientific status for frequency comparable with those of energy, mass and heat. A conservation of energy has its counterpart in a conservation of frequency; in place of the linkages of Nature such as $e = mc^2 = hf = Jq$, we can, by adopting what the author calls "superunits," write down $E = M = F = Q$, wherein energy, mass, frequency and heat appear all expressed with the same abstract number. Also, the Einstein-Bohr equation $h\nu = W_1 - W_2$ can be written $\nu = f_1 - f_2$. The linkage between energy and time suggests a close relationship between energy and frequency.

SUR LA DÉFINITION DES CAPACITÉS (The Definition of Capacities).— —. Iliovici. (*Bull. d.l. Soc. franç. d. Élec.*, No. 98, Vol. 9, pp. 1158–1167.)

ENREGISTREMENTS DE L'ULTRA-RAYONNEMENT COSMIQUE À MUOTTAS-MURAIGL (Cosmic Radiation Records at Muottas-Muraigl).—F. Lindholm. (*Arch. sc. phys. et nat.*, Sept./Oct., 1929, Vol. 11, pp. 271–272.)

THE VARIATIONS WITH SIDEREAL TIME IN THE INTENSITY OF HIGHLY PENETRATING COSMIC RADIATION.—A. Corlin. (Abstract in *Physik. Berichte*, 1st April, 1930, Vol. 11, p. 709.)

RECENT REACTIONS BETWEEN THEORY AND EXPERIMENT: THE RAMAN EFFECT: THE CONSTITUTION OF HYDROGEN GAS.—E. Rutherford. (*Nature*, 7th Dec., 1929, Vol. 124, pp. 878–880.)

ZUM ELEKTRISCHEN WIDERSTANDSGESETZ BEI TIEFEN TEMPERATUREN (The Electrical Resistance Law at Low Temperatures).—F. Bloch. (*Zeitschr. f. Phys.*, 2nd January, 1930, Vol. 59, No. 3/4, pp. 208–214.)

LA RÉFLEXION DES RAYONS X DE GRANDE LONGEUR D'ONDE SUR UN MIROIR PLAN (The Reflection of Very Long X-Rays at a Plane Mirror).—J. Thibaud. (*Journ. de Phys. et le Rad.*, January, 1930, Vol. 1, Series 7, pp. 37–48.)

THE PASSAGE OF IONISING ELECTRONS THROUGH HELIUM.—T. Osgood. (*Phys. Review*, Nov., 1929, Vol. 34, pp. 1234–1238.)

MISCELLANEOUS.

STARKSTROMLEITUNGEN UND FERNMELDEANLAGEN (Power Lines and Telephony Systems).—H. Klewe. (*Zeitschr. V.D.I.*, 22nd March, 1930, Vol. 74, pp. 361–365.)

PROTECTION OF TELEGRAPH AND TELEPHONE SYSTEMS AGAINST DISTURBING EFFECTS OF POWER LINES OF ANY DESCRIPTION IN THEIR VICINITY.—P. Jager and H. Klewe. (*World Engineering Congress Abstracts*, 1929, Paper 207.)

THE TRANSMISSION SYSTEM AND INDUCTIVE INTERFERENCE PROBLEMS ON COMMUNICATION LINES IN JAPAN.—M. Shibusawa. (*World Engineering Congress Abstracts*, 1929, Paper 609.)

LA RADIOPHONIE DANS LES TRAINS (Radio-Telephony on Trains).—(*Génie Civil*, 1st March, 1930, Vol. 96, pp. 213–215.)

An illustrated description of the system just installed by the "Société Radio-Fer" on the State railway from Paris to Havre. Broadcast programmes are received on a frame aerial and heard in telephone head-gear; at times when there are no such programmes, the operator on board the train provides gramophone music and information as to the country passed through, particulars as to the journey, latest telegrams handed in at certain stations, etc. Special precautions are taken to silence interference caused by the train's dynamos. Telegrams can be sent and received by means of a short wave equipment working on about 47 m., a small overhead transmitting aerial being carried on the Wireless coach.

ICEBERG DETECTION.—(*Engineer*, 7th March, 1930, Vol. 149, p. 271.)

"Following experiments, it has been proved that icebergs melting in the sea water make a peculiar noise, and a special microphone device to 'tune in' the bergs is to be tested by the United States line. By means of a physician's stethoscope, attached by a length of rubber hose to a funnel immersed in the sea, the melting noise can be heard at a distance of 6 miles. . . . Other experiments made recently have been with an infra-red ray apparatus, which will reveal the outline of icebergs through dense fog."

CONDENSER-MICROMETER DEVICES AND THEIR USE FOR MEASURING TORQUES, LATHE CUTTING PRESSURES, ETC.—Gerdien: Mauksch: v. Auwers. (*Wiss. Veröff. Siemens-Konz.*, Vol. 8 [2], 1929, pp. 126–129, 130–136, and 137–143; also *Zeitschr. V.D.I.*, 22nd Feb., 1930, Vol. 74, p. 243.)

PHOTOGRAPHIC PLATES AND THEIR SENSITIZATION TO INFRA-RED LIGHT.—P. Lueg. (*Zeitschr. f. Phys.*, 10th Feb., 1930, Vol. 60, No. 1/2, pp. 13–19.)

A paper on some researches in connection with Neocyanin (*see* March Abstracts, p. 155.)

A General Electromagnetic Theory of [Rotating] Electric Machines.—F. Dahlgren. (*Ingen. Vetenskaps Akad., Handling.* No. 99, 1930, pp. 79.)

On the Theory of Polysymmetric Static Machines of the Toepler-Holtz Type.—A. W. Simon. (*Rev. of Scient. Instr.*, Feb., 1930, Vol. 1, pp. 57–64.)

Über Anodengleichrichtung (Anode Rectification).—G. Ulbricht. (*Verh. d. Deut. Phys. Ges.*, No. 2, 1929, Vol. 10, p. 31.)

A brief account of the various rectification processes using X-ray tubes and the bend in their characteristics.

Sur un Procédé d'Activation de la Matière (A Process for the Activation of Matter).—G. Reboul. (*Comptes Rendus*, 10th Feb., 1930, Vol. 190, pp. 374–375.)

More on the subject dealt with in March Abstracts, p. 178.

Effects of Electric Shock.—W. B. Kouwenhoven and O. R. Langworthy. (*Journ. Am. I.E.E.*, Jan., 1930, Vol. 49, pp. 25–29.)

An investigation into the effects of electric shock on the central nervous system: the tests were made on a large number of rats.

Widerstand des menschlichen Körpers bei hochfrequenten elektrischen Strömen (The Resistance of the Human Body to H.F. Currents).—N. N. Malov and S. N. Rschevkin. (*Journ. App. Phys.*, Moscow, No. 5, Vol. 6, 1929, pp. 39–74.)

In Russian, with summary in German.

The Difference in Biological Action produced in Cultures by Various Radiations: Energy Study of the Biological Action of Various Radiations.—A. Lacassagne: F. Holweck. (*Comptes Rendus*, 24th February, 1930, Vol. 190, pp. 524–526 and 527–529.)

The Beneficial Effect of 2–3 m. Waves on the Germination of Seeds and the Growth of Plants.—G. Mezzadroli and E. Vareton. (Summary in *Nature*, 10th and 17th May, 1930, Vol. 125, pp. 731 and 767.)

Nat. Acad. Lincei papers (5th and 19th Jan.). Interposition of a Lakhovsky oscillating circuit (1929 Abstracts, p. 286) over the germinator or plants enhances the effects, which are always favourable. Even greater effects are produced by placing the germinators " between the coils of the receiving oscillating circuit."

The Laws of Electrical Excitability by Very Short Discharges, in Rapidly Responding Muscles.—P. Fabre. (*Comptes Rendus*, 3rd March, 1930, Vol. 190, pp. 595–597.)

Certain apparent anomalies are explained by considering that the nerve, owing to its internal protoplasmic discontinuities, acts as a series of condensers with imperfect dielectric and converts the very short impulses into prolonged impulses. High frequency c.w. currents have no exciting effect, since one half-wave cancels the next; but h.f. damped currents (d'Arsonvalisation) may excite because the first half-wave is stronger than the next.

Oscillations in Drops of Mercury produced by the Johnson-Rahbek Effect.—M. Katalinić. (*Zeitschr. f. Phys.*, 18th March, 1930, Vol. 60, pp. 795–824.)

Evidence that Natural Radioactivity is Inadequate to Explain the Frequency of " Natural " Mutations.—H. J. Muller and L. M. Mott-Smith. (*Proc. Nat. Ac. Sci.*, April, 1930, Vol. 16, pp. 277–285.)

See Babcock and Collins, 1929 Abstracts, pp. 589 and 650; also Hanson and Heys, April Abstracts, p. 233.

The Electric Field of the Human Body.—W. E. Boyd. (*Brit. Journ. Radiology*, March, 1930, Vol. 3, pp. 128–135.)

A description of the writer's researches on static electrical phenomena of the human body. They were carried out in a laboratory completely protected against external static fields: records were made by an Einthoven galvanometer. Conclusions reached were:—(1) The skin surface of the body shows the presence of static charges of varying potential relative to earth. (2) Amongst these charges there is a recurrent static potential with a periodicity approximating to the heart beat. (3) Surrounding the body, and originating from it, there is an electrical field of force of static origin, which varies continually.

The writer concludes by mentioning that by the use of an aerial arrangement, effects similar to those of Sauerbruch and Schumann (Abstracts, 1928, pp. 349, 649: 1929, pp. 464–465) can be obtained.

Elektrostatische Ladungen von Personen und ihre Messung (The Electrostatic Charges on Human Beings, and their Measurement).—A. Flad. (*Siemens-Zeitschr.* No. 8, Vol. 9, pp. 499–501.)

The Magnoscope, our Electrical Stethoscope.—A. Sato and H. Nukiyama. (*World Engineering Congress Abstracts*, 1929, Paper 701.)

The equipment consists of a contact piece, a mechanical band-pass filter, a mechanical-electrical transformer of the moving coil type, a 3-stage transformer amplifier, various filters, a balanced type band-pass receiver, and acoustic tubes.

Untersuchungen über Herzgeräusche (Investigations into Heart Sounds).—K. Posener and F. Trendelenburg. (*Wiss. Veröff. Siemens-Konz.*, Vol. 8 [2], pp. 228–241.)

The use of a condenser-microphone, amplifier and oscillograph combination for auscultation (*see* various previous abstracts). A particular point was that the amplifier was designed so as to have a similar frequency curve to that of the human ear, so that the results could easily be compared with those of ordinary auscultation.

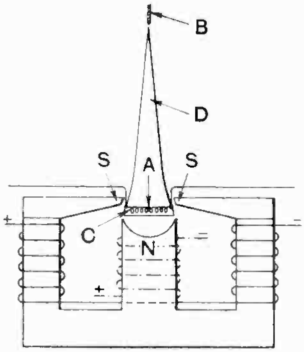
Some Recent Patents.

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.

LOUD SPEAKERS.

Application date, 21st November, 1928. No. 325543.

Instead of the usual plunger movement, the moving-coil and attached diaphragm are vibrated angularly about a fixed axis. As shown the moving-coil *C* is pivoted about an axis *A* and extends



No. 325543.

between two like poles *S* coacting with a lower pole *N*. The diaphragm *D* extends upwards to a baffle-plate *B*. The effect of applied speech currents is to vibrate the coil *C* between the *N* and *S* poles about the axis *A*, flexing the diaphragm correspondingly. A number of moving coils may be arranged in parallel between the two *S* poles, and may be tensioned by a pair of torsion wires.

Patent issued to A. F. and D. A. Pollock.

VARIABLE CONDENSERS.

Application date, 26th November, 1928. No. 325802.

Two concentric metallic cylinders form a condenser the capacity of which is a function of the eccentricity of the two parallel axes. For an applied alternating current, the electric and magnetic lines are confined to the air space between the cylinders, and the apparent capacity at any frequency can be calculated by the mathematical analysis used for a telephone cable. Variation in capacity is secured by pivoting the inner cylinder on an axis parallel to, but eccentric with its own axis, which in turn is eccentric with the axis of the outer cylinder.

Patent issued to E. B. Moullin.

MODULATING SYSTEMS.

Conversion date (U.S.A.), 12th April, 1928. No. 309557.

Modulation is so effected that either the sum or difference side-band frequencies are obtained alone, but not both. To do this, both the carrier and modulating currents are supplied as, or converted into three-phase form, and each phase of the carrier is modulated by the corresponding phase of the lower frequency. When the modulation outputs are combined, not only are the initial frequencies neutralised, but also one of the two side-bands. The method is analogous to the operation of an induction-motor frequency-changer, where the output from the rotor will have a frequency equal to the sum or difference of the frequency supplied to the field and the frequency of rotation of the rotor according as the rotor is driven in the same or opposite direction to that in which the field flux is rotating.

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

BATTERY-CHARGING CONNECTIONS.

Application date, 14th December, 1928. No. 325632.

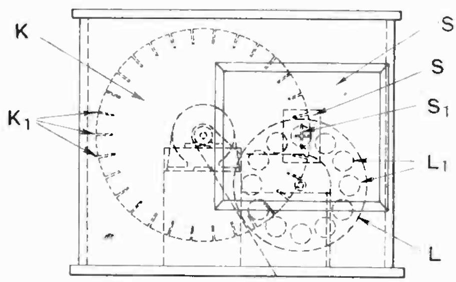
The leads between the set and a supply battery are combined into a single cord, which is broken at an intermediate point, the two ends being normally joined together by a plug and socket connection. When it is desired to recharge the battery from the mains, the plug and socket are disconnected, and the former is inserted directly into a socket formed in the casing of the mains rectifying-unit.

Patent issued to Oldham & Son, Ltd., and R. S. Miller.

WIRELESS PICTURE RECEPTION.

Application date, 24th October, 1928. No. 325790.

In receiving photographic or television signals, the light from a neon lamp passes first through a vertical slit S_1 in an opaque screen *S*. It is then divided into a series of spots travelling in a vertical



No. 325790.

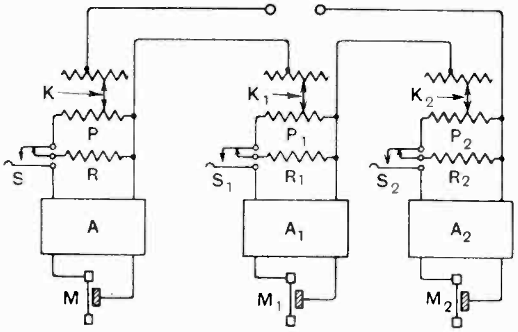
line by means of a rotating disc *K* formed with radial slots K_1 around its periphery. Finally a series of lenses L_1 carried by a rotating disc *L* move at right-angles to but in a plane parallel to the disc *K*, and focus the spots of light upon a ground-glass viewing screen *VS*.

Patent issued to L. P. Todd.

MICROPHONE CIRCUITS.

Convention date (U.S.A.), 21st October, 1927. No. 299041.

Where a number of differently-spaced microphones are connected up to a common amplifier, it is desirable to maintain balanced impedance relations throughout the chain. At the same time



No. 299041.

it may be necessary to control the volume delivered by each microphone individually. As shown in the figure, potentiometers P, P_1, P_2 control the volume output from amplifiers A, A_1, A_2 fed from microphones M, M_1, M_2. Resistances R, R_1, R_2 take the place of the amplifier output impedances if one or other of the microphones is switched out of circuit at S, S_1 or S_2. Volume-control sliders K, K_1, K_2 vary the potential in the output circuit, but move along upper and lower resistances in such a manner as to maintain the effective output impedance substantially constant at all settings.

Patent issued to Electrical Research Products Inc.

PREVENTING FADING.

Convention date (Germany), 18th February, 1928. No. 306418.

In order to compensate for fading due to rotation of the plane of polarisation of the signal wave at the Heaviside layer, two aerials are used in reception, one being vertical, and the other a loop aerial set at right angles to and surrounding the first. Both aerials are coupled to a common receiver, but a phase difference of 90° is introduced in one of the coupling lines. The resulting amplitude in the receiving circuit is thus made independent of variations in the polarisation angle of the incoming signal field.

Patent issued to Telefunken Ges. Fur Drahtlose Telegraphie.

GRAMOPHONE PICK-UPS.

Application date, 25th May, 1928. No. 321967.

In order to prevent undue wear on the record it is usual to counterbalance the weight borne by the needle so that it is limited to some three or four ounces. For the lower frequencies this is an insufficient anchorage, the movements of the pick-up system tending to vitiate the full amplitudes impressed upon the needle by the record. In order to readjust matters a ballast weight is mounted on the tone arm so that it has a small moment of inertia about the arm, but applies the necessary load to the needle to prevent "surging."

Patent issued to F. W. Lanchester.

SHORT-WAVE SIGNALLING.

Application date, 27th September, 1928. No. 323237.

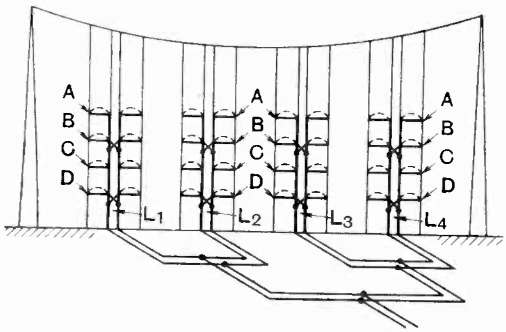
When receiving short-wave beam signals of the order of 10 metres or less, serious interference may be caused by the ignition systems of motor-cars or tram-cars passing, say, along a road fronting the aerial system. According to the invention this interference is cut out by erecting a screen of rod conductors, extending in the form of an arch roughly transverse to the road and at such a height as not to interfere with passing traffic. Preferably the screen members are tuned to the working wavelength and are earthed at each end. They appear to operate as a reflecting system diverting or absorbing any local interfering radiation produced along the road.

Patent issued to G. Marconi.

SHORT-WAVE AERIALS.

Convention date (Germany), 3rd March, 1928. No. 307060.

A short-wave beam aerial consists of a number of horizontal Hertzian oscillators A, B, C, D arranged one above the other. The system is energised through branched conductors feeding vertical uprights L_1, L_2, L_3, L_4, from which the horizontal radiators are taken off in pairs as shown. Preferably both "pairs" are excited each in a half-wave of the same phase so as to increase the directional effect. The aerial system may be slightly inclined as a whole to the horizontal.



No. 307060.

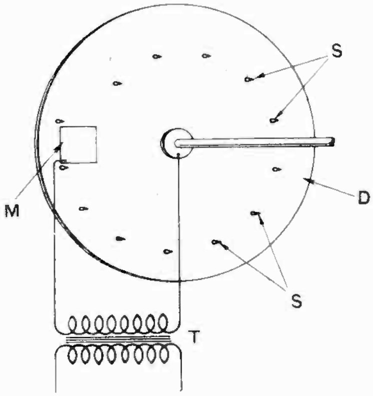
The energy transmission is stated to be more favourable than that obtained from known vertical networks.

Patent issued to Telefunken Ges. Fur Drahtlose Telegraphie.

TELEVISION SYSTEMS.

Application date, 10th October, 1928. No. 323817.

The received signals are rendered visible by creating a succession of arcs between projecting spikes on a rotating disc and a viewing-screen of thin metallic foil. The arcs heat the screen to varying degrees of incandescence. The incoming signals



No. 323817.

are fed to a transformer *T* the secondary winding of which is connected across the disc *D* (fitted with a spiral series of spikes *S*) and the viewing screen *M*. The discharges between the spikes *S* and screen *M* create a series of luminous or incandescent bands which reproduce the picture in transient or semi-permanent form.

Application date, 20th June, 1928. No. 321961.

The light-sensitive cell is carried on a movable support fitted with a rack and pinion by means of which the cell is moved towards or from the image-projecting device, so as to maintain the cell always in focus, as the object whose image is to be projected moves relatively to the projector.

Application date, 20th June, 1928. No. 321930.

A glow-discharge lamp, such as a Neon tube, is fitted with a flat plate electrode of a size not less than that of the image to be viewed. The plate is provided with a mica backing so as to concentrate the glow on the front surface.

Patents issued to J. L. Baird and Television Ltd.

MAINS SUPPLY SYSTEMS.

Convention date (France), 6th March, 1928. No. 307393.

In a mains-supply system to a receiving set in which a buffer battery is connected across the low-tension supply, for smoothing purposes, a relay is arranged so that when either the mains-supply unit or the buffer battery circuit is opened or closed, the relay automatically opens or closes the other. The battery ceases to deliver current to the set as soon as the eliminator is cut out, but comes automatically into circuit when the mains current is restored.

Patent issued to J. Dieux.

PREPARING MAGNETIC MATERIALS.

Application date, 22nd August, 1928. No. 321957.

In manufacturing "dust" magnet cores of high permeability, the constituent materials, nickel and iron, after being welded in a high-frequency furnace, are worked by rolling at a temperature exceeding that of crystallisation, and are then allowed to cool in air. The granular material is in this way split up into a brittle fine-grained mass, small enough to pass through a 200 mesh sieve.

Patent issued to Standard Telephones and Cables Ltd.

GLOW-DISCHARGE TUBES.

Application date, 13th July, 1928. No. 321915.

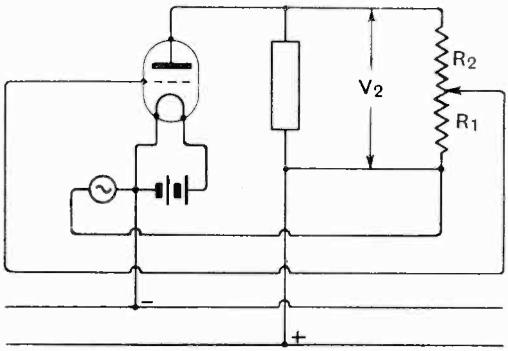
Relates to cathode glow-discharge tubes containing mercury or other metal vapour. In order to cause the metal vapour to take part more intensively in the discharge, a heating-element is inserted near the electrodes, or alternatively in a separate re-entrant part of the glass bulb. By increasing the heating current a sufficiently high vapour pressure can always be ensured, particularly in the case of positive-column discharges.

Patent issued to S. G. S. Dicker.

AMPLIFIER CIRCUITS.

Application date, 18th October, 1928. No. 323823.

In order to correct for distortion introduced by the inherent capacity and curved characteristic of the amplifier tube, as well as by the resonance effects of associated circuits, a predetermined fraction of



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the output voltage is fed back from a shunt resistance to the input circuit as shown. When the amplification factor of the valve is 100, a suitable value for the resistance R_2 will be a megohm and for R_1 100,000 ohms.

Patent issued to S. G. S. Dicker.