# EXPERIMENTAL WIRELESS & The WIRELESS ENGINEER

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# Editorial.

## The "Wave-Band" Theory of Wireless Transmission.

AN amazing article under this title appeared in *Nature* of January 18, written by Sir Ambrose Fleming, F.R.S. It is generally known that the Baird Television Company feel that they have a grievance because of the attitude taken up by the Authorities with regard to the broadcasting of television experiments. In this article Sir Ambrose takes up the cudgels on behalf of the Company and suggests that invention is being retarded by unessential official restrictions. He puts forward a special plea that the television transmissions should not be restricted to a certain limited wave band, and this for a very simple reason. Sir Ambrose, who is the President of the Television Society, has looked into these wave bands, and, like the Cockney who looked at a rhinoceros for the first time, has come to the conclusion that "there ain't no such beast." This will be good news indeed for those charged with the task of sorting out European broadcasting and allocating wavelengths, but somewhat unsettling for those who were under the impression that they were carrying on a transatlantic radio-telephony service by means of one of these non-existent wave bands. The owners of spark transmitters will be cheered by the good news that, so long as their frequency is correct, the mere fact that their amplitude jumps rather suddenly from one value to another is an unimportant detail, and "that sooner or later we shall have to modify our code of wireless laws" because the alleged disturbance caused by the spark transmitter has been due to "a kind of mathematical fiction and does not correspond to any reality in Nature."

When statements of this nature are made by a man whose name is a household word in radio-telegraphy, it naturally upsets the convictions of a large number of people who, while knowing enough about the subject to understand whither the argument leads, do not know quite enough to see wherein lies the fallacy. We have had several letters drawing our attention to this article and suggesting that we should deal with the subject.

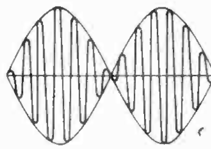


Fig. 1.

To begin with, Sir Ambrose's expression $a = A \cos qt \sin pt$ for a modulated wave is not quite a correct statement of the case; such a wave would be represented by Fig. 1, whereas the wave emitted by a broadcasting station, assuming modulation by a single pure note, is as shown in Figs. 2*a* or 2*b*, the formula for which is $a = (A + B \cos qt) \sin pt$, which may also be written

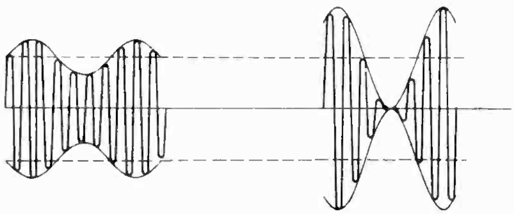
$$A \sin pt + \frac{B}{2}\{\sin (p+q)t + \sin (p-q)t\}.$$

Hence a modulated carrier wave, even when completely modulated, is " equivalent to the simultaneous emission of [three and not of] two carrier waves." This, however, does not affect the argument, and we have only called attention to this point for the sake of accuracy.

The all-important points are these : (i) that if you get a reliable draughtsman to plot the curve $(A + B \cos qt) \sin pt$, and then get another reliable draughtsman to plot the curve

$$A \sin pt + \frac{B}{2}\{\sin(p+q)t + \sin(p-q)t\},$$

giving them the same numerical values for $A$, $B$, $p$ and $q$, you will obtain exactly the same result and will not be able to tell one from the other; (ii) if you set up in one aerial a current of constant frequency and varying amplitude, represented by the formula $i = (A + B \cos qt) \sin pt$, and in another aerial three currents of constant frequencies and amplitudes, represented by the formula



(a) (b)

Fig. 2.

$$i = A \sin pt + \frac{B}{2}\{\sin(p+q)t + \sin(p-q)t\},$$

the actual resultant current in both aerials will be identically the same, and the waves sent out will be identical, as they would also be if the three currents of different frequencies were set up in three separate and adjacent aerials. It is true that the current is produced in the aerial of the broadcasting station in the former manner, and that if one could see the current one would almost certainly describe it as a current of constant frequency and variable amplitude ; but if one could see the resultant wave sent out by the three aerials, one would as certainly describe that as a wave of constant frequency and variable amplitude, although emitted as three separate waves of constant amplitude. In music we have the converse phenomenon when two low notes a semitone apart are played on an organ. Here we certainly send out two waves of constant amplitude but of slightly different frequencies, but the ear detects a combined note of varying intensity. Are we justified in saying that the component waves are a " kind of mathematical fiction," a " mathematical artifice," or an " imaginary wave band " ? Whether the two or three waves of different frequencies ever had a separate existence or not is immaterial, for, as we have seen, the resultant wave is the same. As we pointed out in our January issue in discussing the claims made for the Stenode Radiostat, a transmitter sending out a frequency of 1,000 kc. modulated at a frequency of 1,000, causes exactly the same disturbance in the ether and to receivers, as three transmitters sending out unmodulated frequencies of 999, 1,000 and 1,001 kc. respectively. Fortunately the making of official regulations in this country, so far as wireless telegraphy is concerned, is in the hands of people who know too much about the subject to listen to the suggestion that two of these frequencies are figments of the imagination, invented by scientists, and used by the authorities as the basis of unessential regulations which tend to " throttle and retard invention and progress " or, in plain English, limit the activities of those engaged in promoting television. Sir Ambrose says : " The whole question at issue then is, What range in amplitude is admissible ? This entirely misses the point. The real question is, What rate of change of amplitude is admissible ? Nobody objects to the amplitude of the wave sent out by a spark station, but they do object very strongly to the rapidity with which that amplitude changes ; and the same may be true of the amplitude of the television carrier wave when the scanning spot passes suddenly from dark to light. The depth or degree of modulation is important in that it affects the amplitude of the sidebands and therefore also the disturbance they cause, but this is included in the statement that the disturbing effect of a transmission depends on the rate of change of the amplitude of the carrier, which is only another way of saying that it depends on the spread and strength of the wave band.

Nothing emphasises the fallacy of his arguments more than the example chosen by Sir Ambrose for their illustration. "This," he says, "is merely a mathematical artifice similar to that employed when we resolve a single force or velocity in imagination into two or more component forces. Thus, if we consider a ball rolling down an inclined plane and desire to know how far it will roll in one second, we can resolve the single vertical gravitational force on the ball into two components, one along the plane and one perpendicular to it. But this is merely an ideal division for convenience of solution of the problem; the actual force is one single force acting vertically downwards. Similar reasoning is true with regard to wireless telephony." Now all this is entirely fallacious, for the ball in free space is acted on by a myriad gravitational forces acting in a myriad directions, every particle of the earth exerting its quota to the total, and Sir Ambrose's "one single force acting vertically downwards" is just as much, or as little, a figment of the imagination as the two component forces, one down the plane and the other perpendicular to it. The ball, at any rate, to judge from its movement, believes in the reality of the former component. Apart, however, from the utter fallacy of his argument, does Sir Ambrose suggest that the resolution of the gravitational forces perpendicular to and along the plane ever led to a wrong result, or that regulations or official restrictions based on these imaginary forces ever did anything "to throttle and retard invention and progress"? for this is really the gravamen of his accusation, that, by basing their regulations upon wave bands which are merely figments of the imagination, the Authorities are doing an injustice to those interested in television transmission. To return to the two ways of representing the modulated carrier wave, imagine two super-beings given the task of investigating the nature of the wave radiated from 2LO when the orchestra plays a sustained chord. One, equipped with apparatus for tracing variations in the amplitude of the wave and also for timing the passage of the electric field through zero, would report that the wave had a constant frequency but that its amplitude varied in a complex manner. The other, equipped with a set of highly tuned resonators like the famılar vibration speed indicators, would report that waves of a number of frequencies were sent out covering quite a spectrum, but that the amplitude of each was constant. Sir Ambrose would give the first man one hundred per cent. marks and fail the second—assuming that one dare fail a super-being—whereas modern radio science would give the second man a hundred per cent., but take just a few marks off the first man for speaking of the frequency of something which was not strictly recurrent—and modern science would be right.

We are not here commenting in any way on the claims made by the Baird Television Company, but, in our opinion, attempts to support those claims by arguments such as those put forward by Sir Ambrose Fleming can only be regarded as a disservice to the true interests of television.

G.W.O.H.

# Electrical Wave Filters.*

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

## Introduction.

So far as the present writer knows a good deal of the work that has been done on wave filters in America does not seem to be widely known in this country. It is, therefore, hoped that this article, which is based mainly on the work of Messrs. Campbell, Zobel, Carson, and Johnson, of America, will help to introduce the readers of *E.W. & W.E.*, if such an introduction is necessary, to some of the research which has been carried out in America on the subject of wave filters. In particular the conception of the "Derived Filter" seems, in the opinion of the present writer, to simplify considerably the design of even the most complicated filters, and it is therefore hoped that its introduction into this article will be justified.

As stated above, most of the subject matter in this article has already been published in America, and a complete list of the papers referred to is given on p. 128.

## Contents.

The article is divided into seven sections, the contents of which are outlined below.

### Section A.

In this section the fundamental formulæ for a symmetrical structure are derived, and it is shown how these formulæ may be applied to wave filters.

### Section B.

Here it is shown that it is possible to reduce any complicated filter to a simple filter from which it is said to be "derived," and that it is possible to calculate all the formulæ for the complicated filter by considering the simple filter only.

### Section C.

The analysis of the two previous sections is applied to the design of wave filters in general. As illustrative examples the design of a low-pass and of a band-pass filter is worked out in full.

### Section D.

In this section filters which contain mutual inductance of positive or negative sign are analysed. The design of low-pass and band-pass filters containing mutual inductance is worked out in full.

### Section E.

The unsymmetrical structure is considered, and the formulæ appertaining to the design of composite filters are derived.

### Section F.

In this section the composite filter is discussed and the design of a low-pass composite filter is given as an illustrative example.

### Section G.

Here the question of reflection loss due to incorrect termination of a filter is considered and formulæ are derived to enable this loss to be calculated.

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## Section A. Fundamental Formulæ.

### Symmetrical Structures.

It can be shown that any passive network having one pair of input and one pair of output terminals may, at any frequency, be completely and adequately represented by an equivalent $T$ or $\Pi$ network.† A passive network may be defined as one which has no source of energy within it.

Consider a structure of the form shown in Fig. 1. It will be shown how such a structure can be regarded as being composed of an infinite number of identical $T$ or $\Pi$ networks.

In the first place, consider an infinite length of this structure as made up of an

* MS. received by Editor April, 1928.

† (Campbell, G.A., "Cisoidal Oscillations," *A.I.E.E.*, Vol. 30, pp. 873–909.)

infinite number of symmetrical networks, as shown in Fig. 2.

The impedance $Z_K$, as measured between the terminals $A$ and $B$, is the same as it would be when measured between $C$ and $D$, i.e., if the first section $A$, $B$, $C$, $D$ were omitted, since the structure would still be infinite in length.

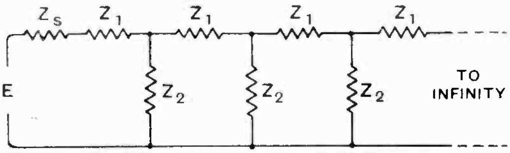


Fig. 1.

Therefore, the value of $Z_K$ at the beginning of the first section must be equal to the impedance $Z_K$ in which it is terminated.

The first section can therefore be represented as in Fig. 3.

It has an input impedance of $Z_K$ and it is terminated in the same value of impedance i.e., $Z_K$.

It is assumed that the currents resulting from the application of the alternating e.m.f. E will be as shown in Fig. 3.

From Fig. 3 it is evident that the impedance measured between $A$ and $B$ is

$$Z_{A-B} = Z_K = Z_1/2 + \frac{Z_2(Z_1/2 + Z_K)}{Z_2 + Z_1/2 + Z_K}$$

or $$Z_K = \sqrt{Z_1 Z_2(1 + 1/4 Z_1/Z_2)} \quad .. \quad (1)$$

The impedance $Z_K$, when measured under the above conditions, is defined as the characteristic impedance of the structure. The particular value of the characteristic impedance obtained in equation (1) is called the "mid-series characteristic impedance," because it is the impedance that is measured in the middle of the series arm $Z_1$.

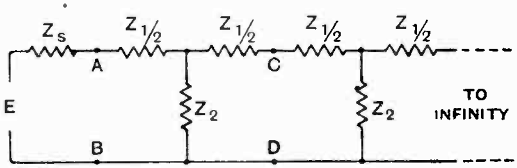


Fig. 2.

It can readily be seen by applying Kirchhoff's law, that the ratio of the current entering the network to that leaving the network is :—

$$I_1/I_2 = \frac{Z_1/2 + Z_2 + Z_K}{Z_2}$$
$$= \frac{Z_1/2 + Z_2 + \sqrt{Z_1 Z_2 + Z_1^2/4}}{Z_2} \quad (2)$$

The natural logarithm of this ratio is called the Propagation Constant $P$ of the structure, that is,

$$P = \log_e I_1/I_2 = \log_e \left[\frac{Z_1/2 + Z_2 + \sqrt{Z_1 Z_2 + Z_1^2/4}}{Z_2}\right] \quad .. \quad (3)$$

In a symmetrical structure, the real part of the propagation constant is called the Attenuation Constant ($A$), while the imaginary part is called the Phase Constant ($B$). Therefore, $P = A + jB$.

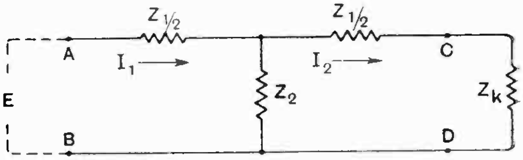


Fig. 3.

If $x = 1 + Z_1/2Z_2$ then (3) becomes :—

$$P = \log_e (x + \sqrt{x^2 - 1}) \; \therefore e^P = x + \sqrt{x^2 - 1} \quad .. \quad .. \quad (4)$$

Now $\cosh P = \frac{1}{2}(e^P + e^{-P}) \; \therefore \cosh^2 P - 1$
$$= \tfrac{1}{4}(e^{2P} - 2 - e^{-2P}) = \tfrac{1}{4}(e^P - e^{-P})^2$$

$$\therefore \cosh P + \sqrt{\cosh^2 P - 1} = \tfrac{1}{2}(e^P + e^{-P}) + \tfrac{1}{2}(e^P - e^{-P}) = e^P \quad .. \quad .. \quad (5)$$

comparing (4) with (5), we have, $x = \cosh P$ or $P = \cosh^{-1} x$ .. .. .. .. (6)

Now $\cosh P = x = \frac{1}{2}(e^P + e^{-P})$

$$\therefore \quad \frac{x - 1}{2} = \tfrac{1}{4}(e^P - 2 + e^{-P})$$

$$\therefore \quad \sqrt{\frac{x - 1}{2}} = \tfrac{1}{2}(e^{P/2} - e^{-P/2}) = \sinh P/2$$

$$\therefore P = 2 \sinh^{-1} \sqrt{\frac{x - 1}{2}} = 2 \sinh^{-1} \tfrac{1}{2}\sqrt{Z_1/Z_2} \quad .. \quad .. \quad (7)$$

Now the structure shown in Fig. 1 can also be considered as being made up of $\Pi$ sections (see Fig. 4).

For the same reasons as those given in the case of the $T$ construction, each section may now be regarded as terminating in a "mid-shunt characteristic impedance" of value $Z_K'$. The value of $Z_K'$ can be derived in exactly the same manner as $Z_K$.* Consider the network of Fig. 5 and let the currents and impedances be as indicated.

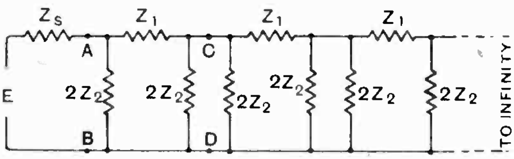


Fig. 4.

In this case

$$Z_{A-B} = Z_K' = \frac{2Z_2\left[Z_1 + \dfrac{2Z_2Z_K'}{2Z_2 + Z_K'}\right]}{2Z_2 + Z_1 + \dfrac{2Z_2Z_K'}{2Z_2 + Z_K'}}$$

$$\therefore \qquad Z_K' = \sqrt{\frac{Z_1Z_2}{1 + Z_1/4Z_2}} \qquad .. \quad (8)$$

$Z_K'$ is defined as the "mid-shunt characteristic impedance" since it is the impedance which would be measured at the division of the shunt impedance $Z_2$.

The ratio of the current entering the first section to the current leaving it is obtained by applying Kirchhoff's law, and it is given by :—

$$I_1/I_2 = \frac{2Z_1Z_2 + 4Z_2^2 + 4Z_2Z_K'(1 + Z_1/4Z_2)}{4Z_2^2}$$

$$= \frac{Z_1/2 + Z_2 + \sqrt{Z_1Z_2 + Z_1^2/4}}{Z_2}$$

Which is identically the same as the expression for the current ratio given by equation (2). The propagation constant, therefore, per section of a recurrent structure will be the same whether the structure is considered to be made up of an infinite number of $T$ networks or of an infinite number of $\Pi$ networks.

## The Attenuation Constant and Phase Constant Per Section of a Symmetrical Structure.

If in equation (5) we put $P = \cosh^{-1} x$ we have :—

$$x + \sqrt{x^2 - 1} = e^P$$

$$\therefore \log_e (x + \sqrt{x^2 - 1}) = \log_e e^P = P = \cosh^{-1} x$$

$$\therefore \qquad P = \cosh^{-1}(1 + Z_1/2Z_2)$$

Now $Z_1/Z_2$ will in general be complex, therefore let

$Z_1/Z_2 = U + jV$, then $|Z_1/Z_2| = \sqrt{U^2 + V^2}$

Further, if we assume the phase angle of $Z_1/Z_2$ to be $\phi$, we have

$$\cos\phi = \frac{U}{\sqrt{U^2 + V^2}} \text{ or } U = \sqrt{U^2 + V^2}\cos\phi$$

Substituting the value of $Z_1/Z_2$ we have that :

$$P = \cosh^{-1}\left(1 + \frac{U}{2} + j\frac{V}{2}\right)$$

From the relationship :—

$$\cosh^{-1}(A + jB) = \cosh^{-1}[\sqrt{B^2 + (1 + A)^2} + \sqrt{B^2 + (1 - A)^2}]\tfrac{1}{2} + j\cos^{-1}[\sqrt{B^2 + (1 + A)^2} - \sqrt{B^2 + (1 - A)^2}]\tfrac{1}{2}$$

we have that :—

$$P = \cosh^{-1}\tfrac{1}{2}[\sqrt{V^2/4 + (2 + U/2)^2} + \sqrt{V^2/4 + U^2/4}] + j\cos^{-1}\tfrac{1}{2}[\sqrt{V^2/4 + (2 + U/2)^2} - \sqrt{V^2/4 + U^2/4}].$$

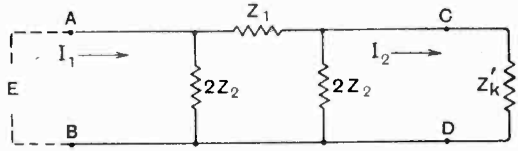


Fig. 5.

If $K$ denotes the absolute magnitude of $Z_1/Z_2$, then $K = |Z_1/Z_2| = \sqrt{U^2 + V^2}$, also $U = \sqrt{U^2 + V^2}\cos\phi = K\cos\phi$.

Then

$$P = \cosh^{-1}(\sqrt{K^2 + 8K\cos\phi + 16} + K)\tfrac{1}{4} + j\cos^{-1}(\sqrt{K^2 + 8K\cos\phi + 16} - K)\tfrac{1}{4}$$

But since $\cos^2\phi/2 = \tfrac{1}{2}(1 + \cos\phi)$

$$\therefore P = \cosh^{-1}\left[\sqrt{\left(\frac{K}{4} - 1\right)^2 + K\cos^2\frac{\phi}{2}} + \frac{K}{4}\right] + j\cos^{-1}\left[\sqrt{\left(\frac{K}{4} - 1\right)^2 + K\cos^2\frac{\phi}{2}} - \frac{K}{4}\right]$$

* In general, the characteristic impedance of any symmetrical structure is the impedance which would be measured between one pair of terminals of the structure, when the other pair are terminated by an impedance equal to the characteristic impedance.

We have already seen that $P = A + jB$, therefore the real and imaginary parts of the above equation give, respectively, the values of the attenuation constant ($A$) and the phase constant ($B$) per section of a

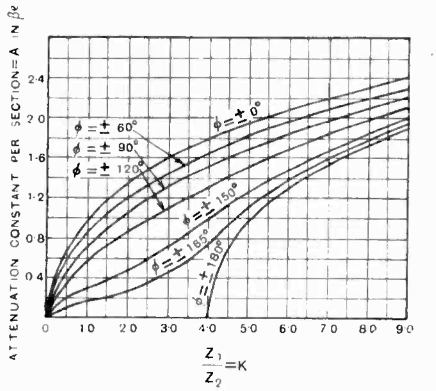


Fig. 6.—*Attenuation constant per section* — $Z_1/Z_2$

symmetrical structure. Figs. 6 and 7 show the curves plotted from the equation for different values of $\phi$.

To use these curves it is necessary to express the ratio $Z_1/Z_2$ in polar co-ordinate form. The modulus and argument will then give, respectively, the corresponding values of $K$ and $\phi$. For example, if the ratio $Z_1/Z_2$ is a real and positive quantity, then $K = Z_1/Z_2$ and $\phi = 0°$. On the other hand, if the ratio $Z_1/Z_2$ is a real and negative quantity, then $K = |Z_1/Z_2|$ and $\phi = 180°$. If $Z_1/Z_2$ is complex and it can be expressed in the form $r|\theta$, then $K = r$ and $\phi = \theta$. Hence the attenuation and phase constant for any value of $Z_1/Z_2$ can be immediately determined.

The units in which the attenuation and phase constant are measured are governed by the following considerations.

We have by definition that

$$P = \log_e I_1/I_2.$$

Now in general the ratio of $Z_1/Z_2$ is a complex number which may be represented by $R|\theta$, where $\theta$ is in radians.

$$\therefore\ P = A + jB = \log_e I_1/I_2 = \log_e R|\theta$$
$$= \log_e R(\cos\theta + j\sin\theta)$$
$$= \log_e (Re^{j\theta}) = \log_e R + j\theta$$
$$\therefore\ A = \log_e R = \log_e |I_1/I_2| \text{ and } B = \theta.$$

The attenuation constant is therefore given by the natural logarithm of the ratio of the absolute values of the two currents. The value of the attenuation per section of a structure is generally represented by $\beta$, therefore in a structure of $l$ sections, the total attenuation would be $\beta l$ units. Hence a structure has an attenuation of $1\beta l$ when the value of $|I_1/I_2|$ is equal to $e$. Also, for any value of the attenuation $\beta l$, the ratio of the absolute values of the currents is given by $|I_1/I_2| = e^{\beta l}$.

It is also seen from the above that the phase constant, in radians, is given by the complex part of the propagation constant.

From Fig. 6 the value of the attenuation in $\beta l$ for any value of $K$ can be obtained and hence the ratio of the absolute values of the currents can be calculated. From Fig. 7 the value of the phase constant in radians can be read off directly for any value of $K$.

## Propagation Characteristics of a Symmetrical Structure.

We have from equation (7) that

$$P = 2\sinh^{-1}\tfrac{1}{2}\sqrt{Z_1/Z_2} = A + jB.$$

Now in the case of an ideal structure $Z_1$* and $Z_2$ would be pure reactances, there-

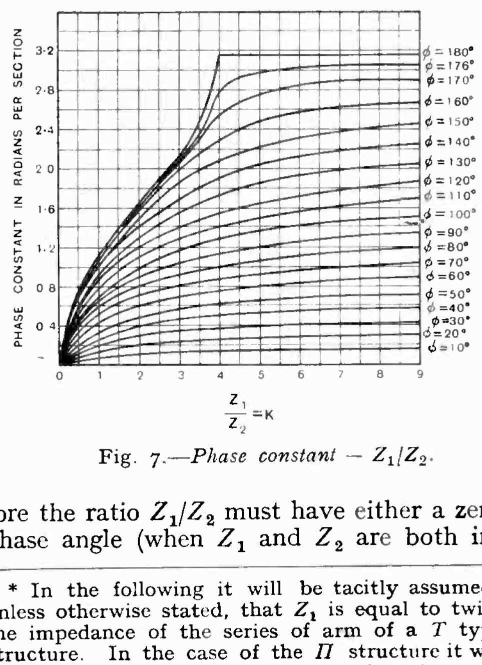


Fig. 7.—*Phase constant* — $Z_1/Z_2$.

fore the ratio $Z_1/Z_2$ must have either a zero phase angle (when $Z_1$ and $Z_2$ are both in-

* In the following it will be tacitly assumed, unless otherwise stated, that $Z_1$ is equal to twice the impedance of the series of arm of a $T$ type structure. In the case of the $\Pi$ structure it will be assumed to represent the total impedance of the series arm.

ductances or both capacities) or a phase angle of 180 degrees (when $Z_1$ is an inductance and $Z_2$ is a capacity, or vice versa). The following cases must be considered.

(1) $Z_1/Z_2$ *is positive.*

In this case

$$P = A + jB = 2 \sinh^{-1} \tfrac{1}{2}\sqrt{Z_1/Z_2} + j0.$$

(2) $Z_1/Z_2$ *is negative.*

We have that

$$P = 2 \sinh^{-1} \tfrac{1}{2}\sqrt{Z_1/Z_2}$$

$$\therefore \quad \sinh P/2 = \tfrac{1}{2}\sqrt{Z_1/Z_2}$$

$$\therefore \quad \sinh \tfrac{1}{2}(A + jB) = \tfrac{1}{2}\sqrt{Z_1/Z_2}$$

$$\therefore \sinh A/2 \cos B/2 + j \cosh A/2 \sin B/2 = \tfrac{1}{2}\sqrt{Z_1/Z_2} \quad \ldots \quad (9)$$

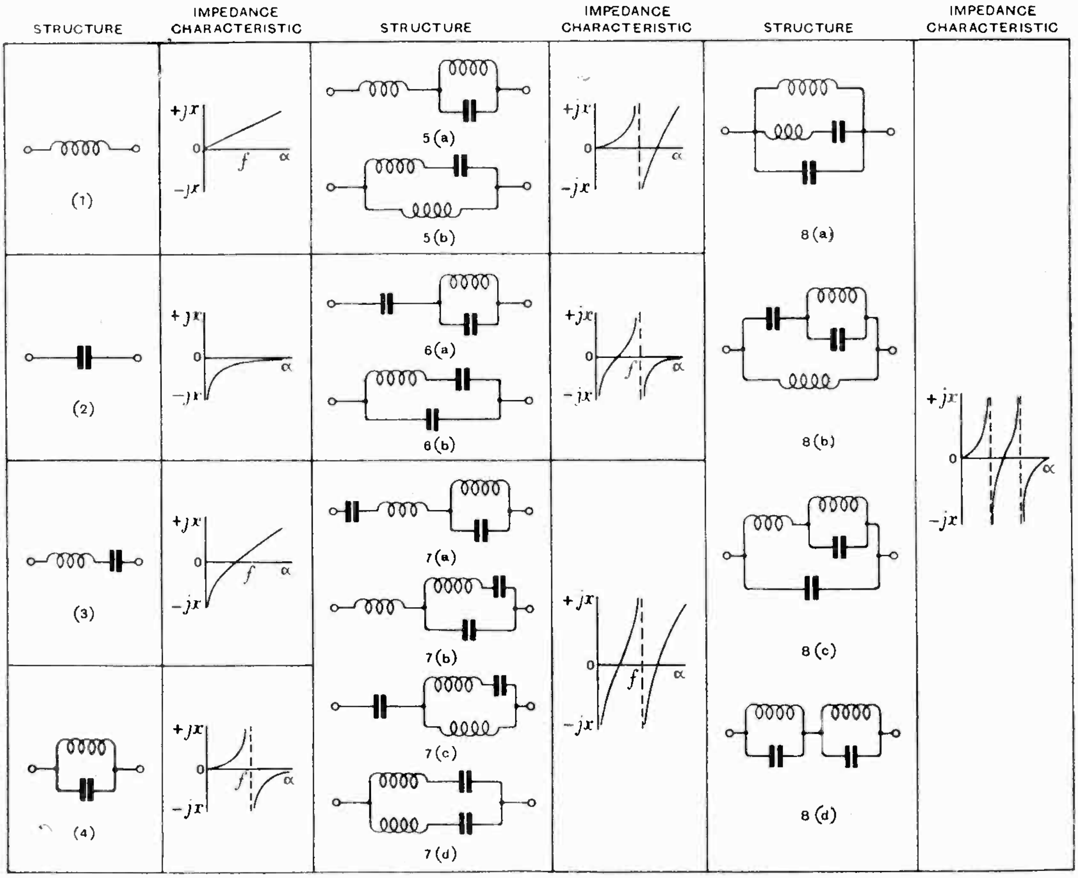


Fig. 8.

Equating real and imaginary quantities, we have

$$A = 2 \sinh^{-1} \tfrac{1}{2}\sqrt{Z_1/Z_2} \text{ and } B = 0.$$

$\therefore$ there will always be attenuation whose value is given by

$$A = 2 \sinh^{-1} \tfrac{1}{2}\sqrt{Z_1/Z_2},$$

provided that the ratio $Z_1/Z_2$ is positive.

Now $Z_1/Z_2$ is negative, hence $\sqrt{Z_1/Z_2}$ is imaginary.

Equating real and imaginaries, we have therefore :—

$$\sinh A/2 \cos B/2 = 0 \quad \ldots \quad (9a)$$

and

$$\cosh A/2 \sin B/2 = \tfrac{1}{2}\sqrt{-Z_1/Z_2}$$

From the relationship

$$\sinh A/2 \cos B/2 = 0,$$

we have that, in general, either

$$\sinh A/2 = 0 \text{ or } \cos B/2 = 0.$$

It follows from the second relationship

$$\cosh A/2 \sin B/2 = \tfrac{1}{2}\sqrt{-Z_1/Z_2}$$

that it is only possible for both $\sinh A/2$ and $\cos B/2$ to be equal to zero when

$$\tfrac{1}{2}\sqrt{-Z_1/Z_2} = \pm 1.$$

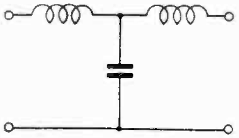

Fig. 9.

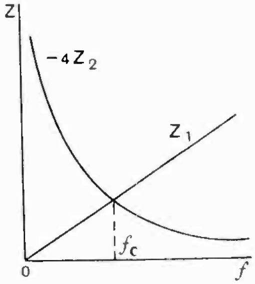


Fig. 10.

It is now necessary to consider two further cases.

(2a) $Z_1/Z_2$ *lies between* 0 *and* $-4$.

Assume in the first place that the solution of equation (9a) is

$\sinh A/2 = 0$, then $A = 0$ and $\cosh A/2 = 1$.

Therefore, from equation (9), we have :—

$$j \sin B/2 = \tfrac{1}{2}\sqrt{Z_1/Z_2}$$

$$\therefore \quad \sin B/2 = \tfrac{1}{2}\sqrt{-Z_1/Z_2}$$

$$\text{or} \quad B = 2 \sin^{-1} \tfrac{1}{2}\sqrt{-Z_1/Z_2} \quad \ldots \quad (9b)$$

Now so long as $0 > Z_1/Z_2 > -4$, the value of $\tfrac{1}{2}\sqrt{-Z_1/Z_2}$ will not be greater than unity. Hence during this interval $B$ will have a real value, and therefore it will be possible for the value of $A$ to be zero, i.e., for the structure to be non-attenuating.

(2b) $Z_1/Z_2$ *lies between* $-4$ *and* $-\infty$.

Assume in this case that the solution of equation (9a) is $\cos B/2 = 0$, then

$$B/2 = (2n - 1)\Pi/2 \text{ or } B = (2n - 1)\Pi$$

where $n$ is an integer.

We have, therefore, that $\sin B/2 = \pm 1$ Equation (9) then reduces to :—

$$\pm j \cosh A/2 = \tfrac{1}{2}\sqrt{Z_1/Z_2}$$

$$\text{or} \quad \cosh A/2 = \tfrac{1}{2}\sqrt{-Z_1/Z_2}$$

therefore,

$$A = 2 \cosh^{-1} \tfrac{1}{2}\sqrt{-Z_1/Z_2}$$

In the range $-\infty < Z_1/Z_2 < -4$, the value of $\tfrac{1}{2}\sqrt{-Z_1/Z_2}$ will be greater than unity, and hence the value of $A$ will be a real quantity. Therefore during this range the structure will have attenuation.

It should be noted that if in condition (2a) we had assumed that $\cos B/2 = 0$, then it follows from the analysis of condition (2b) that $A = 2 \cosh^{-1} \tfrac{1}{2}\sqrt{-Z_1/Z_2}$. It is, however, impossible for the value of

$$\cosh^{-1} \tfrac{1}{2}\sqrt{-Z_1/Z_2}$$

to be real during the range $0 > Z_1/Z_2 > -4$, and hence the only possible solution of equation (9a) during this range is $\sinh A/2 = 0$. Similar considerations will show that the only possible solution for the range

$$-\infty < Z_1/Z_2 < -4 \text{ is } \cos B/2 = 0.$$

We can conclude from cases (1), (2a), and (2b) that a non-dissipative recurrent structure will pass freely only those currents which are of such frequencies that the ratio of the total series impedance to the total shunt impedance lies between zero and $-4$.

### Application to Filter Circuits.

From the above analyses it is seen that any structure will pass freely those currents whose frequencies are such that

$$0 > Z_1/Z_2 > -4.$$

Therefore, if we define the cut-off frequency of a structure as the frequency at which the structure ceases to be non-attenuating, then the cut-off frequency (or frequencies) of a given structure will be obtained by solving the equations :—

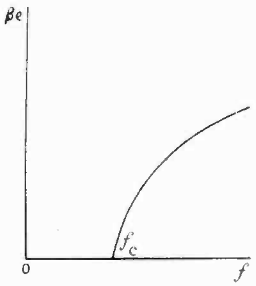


Fig. 11.

$$Z_1/Z_2 = -4 \text{ and } Z_1/Z_2 = 0.$$

The first may be written as $Z_1 = -4Z_2$.

If the curves for $Z_1$ and $-4Z_2$ are plotted against frequency on the same axes then their point (or points) of intersection will give the cut-off frequency (or frequencies). A cut-off frequency will also be given by the point of intersection of $Z_1$ and the frequency axis, for at that point $Z_1 = 0$, and hence the equation $Z_1/Z_2 = 0$ will be satisfied.

From the above we can, therefore, determine, almost by inspection, whether a given structure will attenuate currents of all frequencies, or whether it will pass freely currents of particular frequencies. In other words, we shall have a ready means of determining whether a given structure will behave as a low, high, band, or no pass filter.

In Fig. 8 are given a number of common two terminal reactances with their corresponding reactance-frequency characteristics. Suppose that we combine 1 and 2 in the manner shown in Fig. 9.

Then if we draw the reactance-frequency characteristics of the series and shunt arms in the manner shown in Fig. 10, it is seen that the structure of Fig. 9 will pass freely all currents whose frequencies are less than $f_c$. That is to say, that the structure of Fig. 9 represents a low pass filter. Fig. 11 represents the approximate attenuation-frequency characteristic.

It can readily be seen that if the series and shunt arms are interchanged the resulting structure will represent a high pass filter.

Consider next a combination of 3 and 4, as shown in Fig. 12.

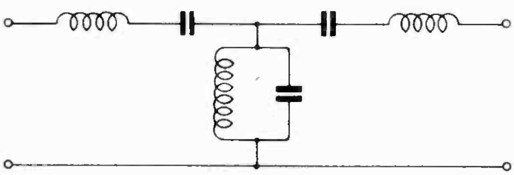

Fig. 12.

The corresponding reactance-frequency and attenuation-frequency curves are shown, drawn in Figs. 13 and 14, respectively. From Fig. 13, it is seen that the structure of Fig. 12 represents a band pass filter, and it will pass freely all currents whose frequencies lie between $f_1$ and $f_2$.

By this method the type of filter that would result from the combination of any of the reactances of Fig. 8 can be determined. The significance of any element of a given structure can also be easily seen from the impedance characteristics. Consider for example the structure of Fig. 9.

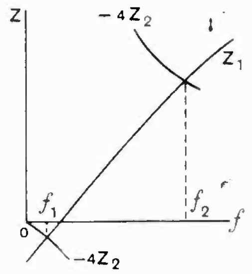


Fig. 13.

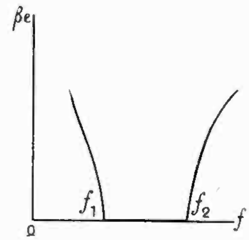


Fig. 14.

From Fig. 10 it is seen that if the reactance of the series arm is increased the slope of $Z_1$ will be greater, and hence the value of the cut-off frequency will be lower. The same effect can be obtained by displacing the curve for $-4Z_2$ downwards, that is, by increasing the capacity of the shunt arm.

(*To be continued.*)

**References.**

The following papers have been referred to in connection with this article :—

1.—Campbell, G. A., "Physical Theory of the Electric Wave Filter," *Bell. Sys. Tech. Jour.*, Nov., 1922.

2.—Zobel, O. J., "Theory and Design of Uniform and Composite Electric Wave Filters," *Bell. Sys. Tech. Jour.*, Nov., 1923.

3.—Zobel, O. J., "Transmission Characteristics of Electric Wave Filters," *Bell. Sys. Tech. Jour.*, Oct., 1924.

4.—Johnson, K. S., and Shea, T. E., "Mutual Inductance in Wave Filters," *Bell. Sys. Tech. Jour.*, Jan., 1925.

5.—Johnson, K. S., "Transmission Circuits for Telephone Communication," Chapters 16 and 17.

# The Balance of Power in Aerial Tuning Circuits.*

*By F. M. Colebrook, B.Sc., D.I.C., A.C.G.I.*

## 1. Object and Scope of the Paper.

THE problem of coupling an aerial to a receiving circuit is not a simple one theoretically or practically, for there are always at least two separate factors to be taken into account, namely, sensitivity and selectivity. The first can be described as the response of the system to some desired signal, the second as the ratio of this response to that due to undesired signals of adjacent frequencies. The conditions most favourable for the one objective may not be and frequently are not those conducive to the other. Furthermore, the relative importance of the two factors will vary considerably with local conditions. For these reasons it is necessary to consider separately the above two factors, and the present paper is devoted almost exclusively to the first, *i.e.*, sensitivity, though the relation of its subject matter to selectivity is touched upon in passing.

The questions to be answered are these. Given an aerial and a receiving set of certain specified characteristics, what is the best way of associating the one with the other so as to obtain the maximum response from a given signal? Is there an optimum adjustment in this respect, and if so, is it critical?

Before answering these questions it will be necessary to state what are the essential characteristics of the aerial and the receiving set from the present point of view.

## 2. The Aerial.

It has been shown theoretically by the present writer† and confirmed experimentally by R. M. Wilmotte‡ that a receiving aerial excited by a sine wave alternating electromagnetic field can be represented, as far as associated receiving apparatus is concerned, by the simple equivalent circuit shown in Fig. 1, where the vector **e** of R.M.S. value $E$ represents an *effective* e.m.f. $\hat{e}\sin\omega t$, and where $\mathbf{Z}_a = R_a + jX_a$ is an effective impedance. For a given aerial and a given exciting field, both **e** and $\mathbf{Z}_a$ will be independent of the characteristics of any apparatus connected to the aerial and earth terminals. Both, however, will depend on the frequency of the field. If the latter is greater than the natural frequency of the aerial, $X_a$ will be negative. If the frequency of the field is much greater (three or four hundred per cent.) than that of the aerial, $X_a$ will be negative and very approximately

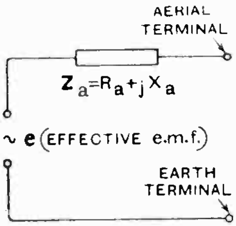


Fig. 1

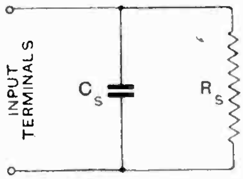


Fig. 2

Fig. 1.—*Circuit analytically equivalent to a receiving aerial.*

Fig. 2.—*Circuit analytically equivalent to a receiving set.*

inversely proportional to the frequency, *i.e.*, the aerial under these conditions will behave as a resistance and a capacity in series with an effective e.m.f.

The resistance component $R_a$ depends mainly on the nature of the earth connection. With an efficient earth screen (*i.e.*, a system of spaced wires, insulated from earth, below the horizontal part of the aerial) it may be as low as a few ohms, but with an ineffective earth connection it may be as high as fifty ohms or more.

To fix ideas, the deductions of the following sections will be illustrated by reference to an aerial for which, at a frequency $\omega/2\pi = 5 \times 10^6/2\pi$, $R_a = 10$ ohms and $X_a = -1/\omega C_a$ where $C_a = 200$ $\mu\mu$F. These numbers correspond roughly to a good 100-foot aerial used for broadcast reception.

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* MS. received by Editor July, 1928.

† "Theory of Receiving Aerials," F. M. Colebrook, *E.W. & W.E.*, Vol. IV. (Nov., 1927), pp. 657–666.

‡ "On the Constants of Receiving and Transmitting Antennæ," R. M. Wilmotte, *Phil. Mag.*, Vol. IV., July, 1927.

### 3. The Receiving System.

For the present purposes, the receiver will be considered simply as an input impedance, which, for analytical convenience, will be represented as in Fig. 2, *i.e.*, a resistance $R_s$, in parallel with a capacity $C_s$. It will be assumed that the signal response increases with $\hat{v}$, the amplitude of the radio-frequency voltage which is maintained across the shunt resistance $R_s$.

This simple representation covers all ordinary types of valve receiving systems, for it is now very generally realised that such systems have a finite input impedance of the above character.

It will be assumed in the following sections that, in the absence of intentional *external* retroaction between the input circuit and some later stage of the receiving set, $R_s$ and $C_s$ are independent of the input circuit. It is perhaps not generally realised that this deduction follows immediately from the usual assumption as to the equivalent network representation of the triode valve. The latter assumption has already received a sufficient degree of experimental verification to justify the above deduction with regard to $C_s$ and $R_s$. Where definite external retroaction exists (apart from and in addition to the inter-electrode capacity couplings on which $C_s$ and $R_s$ mainly depend) the input impedance can still be represented as above, but the components $R_s$ and $C_s$ will not then be independent of the input circuit. The exact analysis of such cases is so complicated as to preclude simple generalisation, and will not therefore be considered here in any detail, except in so far as they are virtually included in the discussion of the effect of the magnitude of $R_s$.

The actual magnitude of $R_s$ will vary greatly with the type of receiving system employed, and is subject to a wide degree of control through positive and negative values by variation of the load in the anode circuit of the first valve. With reactive (capacitative) loads of high impedance, $R_s$ may actually be lower than the internal alternating current resistance of the valve (from anode to filament). Even with reactive loads of comparatively low impedance (*e.g.*, the common case of a 100 $\mu\mu$F. shunt across the primary winding of a low-frequency transformer) $R_s$ may be as low as fifty to a hundred thousand ohms. If, in addition, the input valve is used for grid-circuit rectification, the alternating current grid-filament resistance will be an additional shunt load which will have the effect of further reducing $R_s$.

The value of $C_s$ is subject to almost equally wide variation, but is always positive. It may have any value from a few micro-microfarads to a hundred or more. For the case mentioned above, 10 $\mu\mu$F. would be a fairly representative figure.

### 4. The Balance of Power.

An important generalisation on the subject of aerial coupling can now be put forward.

Let the *effective* e.m.f. induced in the aerial be $\hat{e} \sin \omega t$, represented by the vector $\mathbf{e}$ of magnitude $\hat{e}$ (R.M.S. value $E$). Let the potential difference maintained across the input terminals of the receiving set (*i.e.*, across $R_s$ and $C_s$) be represented similarly by the vector $\mathbf{v}$, of magnitude $\hat{v}$ (R.M.S. value $V$).

Assume for the moment that the coupling and tuning arrangements are of negligible resistance, so that $R_a$ and $R_s$ are the only power-consuming elements to be considered.

It will now be stated and later proved that the most efficient possible tuning and coupling arrangement is such that the reactance of the equivalent aerial circuit is reduced to zero, while at the same time its effective resistance is doubled by suitable control of the load effect of $R_s$. Under these conditions a balance of power is established between the aerial and the receiving system, such that equal power is consumed in each.

Expressed symbolically—let the vector $\mathbf{i}$ of magnitude $\hat{\imath}$ represent the current flowing in the equivalent aerial circuit. Then the above proposition states that the optimum tuning and coupling condition is such that

$$\mathbf{i} = \frac{\mathbf{e}}{2R_a}$$

while the input potential $v$ is such that $V^2/R_s$ is equal to the power consumed in the aerial. The latter is given by

$$P_a = I^2R_a = \frac{E^2}{4R_a^2}R_a = \frac{E^2}{4R_a}$$

The above proposition therefore takes the form

$$\frac{E^2}{4R_a} = \frac{V^2}{R_s}$$

when the optimum condition is established.

One interesting deduction follows immediately. The maximum voltage magnification obtainable under the given conditions is

$$V/E = \tfrac{1}{2}\sqrt{R_s/R_a}.$$

For instance, taking $R_a$ as 10 and $R_s$ as $5 \times 10^4$, the upper limit of $V/E$ is 35.4, and by no means can this figure be exceeded. On the other hand, it is easy to fall considerably below this figure, even with a resistanceless tuning system, if the coupling conditions are ill suited to the given aerial and receiving set.

The twofold function of the tuning and coupling system can now be clearly appreciated. It is required to annul the reactance of the equivalent aerial circuit by introducing an equal reactance of opposite sign, and it is further required to control the voltage applied to the receiving set in such a way that the power balance is established.

In practice, of course, the upper limit given above can never be attained. The components of the coupling and tuning system will themselves introduce further power-consuming elements, parasitic in the sense that they will detract from the over-all efficiency of the system. Such elements will have the effect of increasing $R_a$, or decreasing $R_s$, or perhaps both, giving a correspondingly smaller optimum value for $V/E$. In every case, however, the form of the proposition remains the same and can be completely generalised as follows. If $R_1$, $R_2$, etc., be additional resistances introduced into the system by the coupling and tuning components, a certain adjustment of these components will give an optimum value for $V/E$ such that

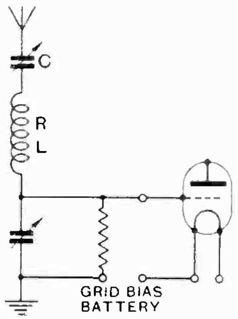


Fig. 3(a).—*Series-tuned receiving circuit.*

$$\text{Lt. } R_1, R_2, \text{etc.} \to 0 \; V/E = \tfrac{1}{2}\sqrt{R_s/R_a}$$

The criterion for the comparison of tuning and coupling systems in respect of the characteristic now being considered (sensitivity), is obviously the comparison of the optimum value of $V/E$ actually obtainable with the limiting value $\frac{1}{2}\sqrt{R_s/R_a}$ theoretically obtainable. Equally it is clear that the establishment of this optimum condition in every case is necessary for a proper comparison.

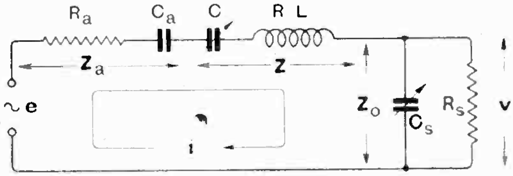


Fig. 3(b).—*Circuit analytically equivalent to Fig.* 3(*a*).

The general proposition will now be illustrated and confirmed by reference to particular tuning and coupling systems.§

## 5. A Series Tuning System.

The first example considered will be one not very generally known, though it has in fact certain features which, when they are appreciated, may commend it to those who have not hitherto made use of it. That, however, is not the reason why it is given this present prominence. It is chosen because it shows more clearly than any other the mechanism of the power balance optimum condition.

The actual circuit is shown in Fig. 3 (*a*), the equivalent circuit for analytical purposes being that of Fig. 3 (*b*). In the equivalent circuit the input shunt capacity $C_s$, being in parallel with the lower variable condenser, is considered as embodied in the latter as an addition to its minimum capacity. Similarly the input shunt resistance $R_s$ is embodied with the "grid leak" shown in Fig. 3 (*a*), to save unnecessary multiplication of symbols. The single symbol $\mathbf{Z}_0$ represents

§ The writer has since renewed his acquaintance with the paper on a somewhat similar subject by Medlam and Oschwald (*E.W. & W.E.*, June and July, 1925). The present article is in effect a generalisation of this paper and confirms some of the conclusions there derived. It is notable, however, that the above-mentioned writers do not seem to have realised the physical significance of their results, at least this is nowhere explicitly stated. The square root of the ratio of two resistances is a mere algebraic formula whereas a balance between utilised and wasted power is a definite physical conception which, moreover, brings the above subject into line with a wide class of related phenomena.

the impedance of $C_s$ and $R_s$ in parallel so that

$$\frac{1}{\mathbf{Z}_0} = \frac{1}{R_0 + jX_0} = \frac{1}{R_s} + j\omega C_s$$

whence $\frac{R_0}{Z_0^2} = \frac{1}{R_s}$ and $-\frac{X_0}{Z_0^2} = \omega C_s$

where

$$Z_0 = \sqrt{R_0^2 + X_0^2} = \text{magnitude of } \mathbf{Z}_0.$$

Note that

$$R_0 = \frac{R_s}{1 + \omega^2 C_s^2 R_s^2}$$

so that the effective resistance component of $R_0$ depends upon $C_s$, by the variation of which it can therefore be controlled. Incidentally, it is easily shown that the variation of $\mathbf{Z}_0$ with $C_s$ is represented by the bottom half of the circular locus

$$\mathbf{Z}_0 = \frac{R_s}{2}(1 + \epsilon^{-2j\phi}) \text{ where } \tan\phi = \omega C_s R_s.$$

It appears already that the function of $C_s$ is the control of the power absorption of the receiving set.

Writing $\mathbf{Z}$ for the impedance of the tuning system ($R$, $L$, $C$) so that

$$\mathbf{Z} = R + j(\omega L - 1/\omega C)$$

then

$$\frac{\mathbf{v}}{\mathbf{e}} = \frac{\mathbf{Z}_0}{\mathbf{Z}_a + \mathbf{Z} + \mathbf{Z}_0}$$

or, inverting this for convenience

$$\frac{\mathbf{e}}{\mathbf{v}} = \frac{1}{\mathbf{Z}_0}(\mathbf{Z}_a + \mathbf{Z} + \mathbf{Z}_0)$$

$$= \frac{1}{\mathbf{Z}_0}\{R_a + R + R_0 + j(x_a + \omega L - 1/\omega C + X_0)\}.$$

For a given constant value of $\mathbf{Z}_0$, the resonance condition, obtained by tuning with the condenser $C$, is

$$1/\omega C = \omega L + X_a + X_0$$

giving

$$\left(\frac{\mathbf{e}}{\mathbf{v}}\right)_{\text{res.}} = \frac{1}{\mathbf{Z}_0}(R_a + R + R_0)$$

Note that in this case the resonance of $\mathbf{v}$ brings $\mathbf{i}$ into phase with $\mathbf{e}$, since at resonance

$$\mathbf{i} = \frac{\mathbf{e}}{R_a + R + R_0}$$

It will be found later that $\mathbf{i}$ is not always in phase with $\mathbf{e}$ when resonance occurs in the above sense.

Considering magnitudes only, we have, at resonance

$$\frac{E}{V} = \frac{1}{Z_0}(R_a + R + R_0)$$

So far no power balance has been established. The means of doing so has already been indicated, *i.e.*, variation of $R_0$ by variation of $C_s$ (resonance being maintained by a corresponding variation of $C$). If the general proposition is valid, $E/V$ should have a critical (minimum) value with respect to $C_s$. It will be convenient to put $E/V$ in the form

$$\frac{E}{V} = \frac{1}{Z_0}\left\{(R_a + R) + \frac{Z_0^2}{R_s}\right\} = \left(\frac{R_a + R}{Z_0} + \frac{Z_0}{R_s}\right)$$

which gives

$$\frac{\partial}{\partial C_s}\left(\frac{E}{V}\right) = \left(-\frac{R_a + R}{Z_0^2} + \frac{1}{R_s}\right)\frac{\partial Z_0}{\partial C_s}$$

Therefore, since $\partial Z_0/\partial C_s$ is not zero, except when $C_s = 0$ or $\infty$, $E/V$ has a critical value, which proves to be a minimum, when

$$R_a + R = \frac{Z_0^2}{R_s} = R_0$$

This, being a minimum of $E/V$ is a maximum for $V/E$, so that this maximum is given by

$$\frac{V}{E} = \frac{1}{2}\frac{Z_0}{R_a + R} = \frac{1}{2}\sqrt{\frac{R_s}{R_a + R}}$$

since

$$Z_0^2 = R_s(R_a + R)$$

Notice that under the same conditions

$$\mathbf{i} = \frac{\mathbf{e}}{2(R_a + R)}$$

so that the effective resistance of the aerial *and* tuning circuit is doubled from $(R_a + R)$ to $2(R_a + R)$.

The power consumed in the aerial and tuning coil is thus $E^2/4(R_a + R)$, and from the above value for $V/E$ we have

$$\frac{E}{2\sqrt{R_a + R}} = \frac{V}{\sqrt{R_s}}$$

*i.e.*,

$$\frac{E^2}{4(R_a + R)} = \frac{V^2}{R_s}$$

which is the equation of the power balance. Note finally that

$$\text{Lt. } R \to 0 \frac{V}{E}$$

$$= \text{Lt. } R \to 0 \tfrac{1}{2}\sqrt{\frac{R_s}{R_a + R}} = \tfrac{1}{2}\sqrt{\frac{R_s}{R_a}}$$

in accordance with the generalised form of the original proposition.

It will be of interest to compare the performance of this system with the ideal described in Section 4.

Assuming the following constants :—

$$R_a = 10 \text{ ohms}$$
$$C_a = 200\ \mu\mu\text{F}.$$
$$R = 12 \text{ ohms}$$
$$R_s = 50{,}000 \text{ ohms}$$
$$\omega = 5 \times 10^6$$

we have

$$\frac{1}{Z_0^2} = \frac{1}{R_s^2} + \omega^2 C_s^2 = \omega^2 C_s^2$$

very approximately, and since at the optimum condition $Z_0^2 = R_s\,(R_a + R)$ the optimum value of $C_s$ can easily be calculated. It is 191 $\mu\mu$F. The optimum value of $V/E$ is

$$\frac{V}{E} = \tfrac{1}{2}\sqrt{\frac{R_s}{R_a + R}} = \tfrac{1}{2}\sqrt{\frac{50{,}000}{22}} = 23.9$$

which can be compared with the ideal upper limiting value 35.4.

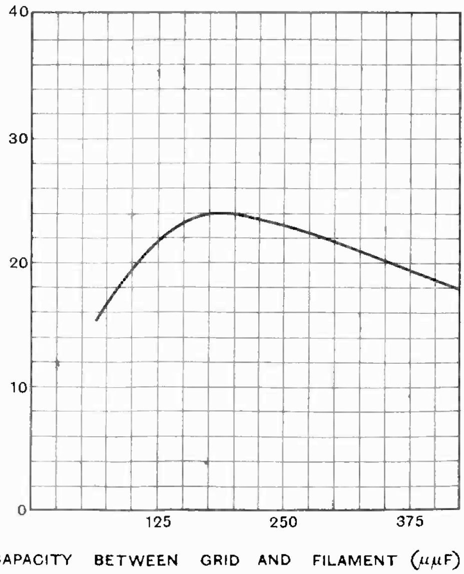



Fig. 4.—*Variation of input voltage with grid-filament capacity.*

The variation of $V/E$ with $C_s$ is illustrated in Fig. 4, which shows that in this case, at least, the optimum condition is not critical. In fact, a 250 per cent. deviation from the best value of $C_s$ only involves about 30 per cent. loss in sensitivity. There is, however, another important aspect of this matter which will be more fully discussed in the next section, which deals with a more widely used form of circuit. As a matter of practical interest some further notes on the above circuit are given in an appendix.

## 6. Parallel Tuning.

The next example to be considered is more representative of general practice. The circuit is shown in practical form in Fig. 5(*a*) and schematically for analytical purposes in Fig. 5(*b*). In the schematic circuit $C_s$ is considered to be embodied in $C$ as an addition to its minimum value. Further, the resistance $R$ of the closed circuit is replaced by the equivalent shunt resistance $S$, given by

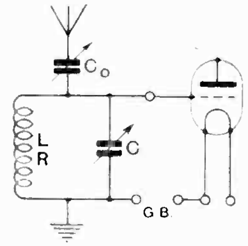



Fig. 5(a).—*Parallel-tuned circuit.*

$$S = \frac{R^2 + \omega^2 L^2}{R} \approx \frac{\omega^2 L^2}{R}$$

(Strictly speaking, if the resistance is represented by the shunt $S$, $L$ should be replaced by $\dfrac{R^2 + \omega^2 L^2}{\omega^2 L}$, but this will not differ appreciably from $L$).

Since $S$ is in parallel with $R_s$ it will be convenient to embody these in a single equivalent shunt resistance $R_s'$ where

$$\frac{1}{R_s'} = \frac{1}{R_s} + \frac{1}{S}$$

The single letter $\mathbf{Z}_1$ is written for the total resultant impedance to the right of the dotted line. Further, the single letter $\mathbf{Z}_a$ will be used for the total equivalent aerial circuit impedance, including that of the series condenser $C_0$. Thus $X_a$ is considered to have a lower limiting value $-1/\omega C_a$ and can be varied to any value greater than this by means of $C_0$. This organisation of the variables gives a desirable compactness to the analysis which follows :

$$\frac{\mathbf{v}}{\mathbf{e}} = \frac{\mathbf{Z}_1}{\mathbf{Z}_1 + \mathbf{Z}_a}$$

Inverting this for convenience, and re-arranging

$$\frac{\mathbf{e}}{\mathbf{v}} = \mathbf{Z}_a\left(\frac{1}{\mathbf{Z}_a} + \frac{1}{\mathbf{Z}_1}\right)$$
$$= \mathbf{Z}_a\left\{\frac{R_a}{Z_a^2} + \frac{1}{R_s'} + j\left(\omega C - \frac{1}{\omega L} - \frac{X_a}{Z_a^2}\right)\right\}$$

Thus the resonance condition, arrived at by tuning with the condenser $C$ is

$$\omega C = \frac{1}{\omega L} + \frac{X_a}{Z_a^2}$$

giving

$$\left(\frac{\mathbf{e}}{\mathbf{v}}\right)_{\text{res.}} = \mathbf{Z}_a\left(\frac{R_a}{Z_a^2} + \frac{1}{R_s'}\right)$$

Considering magnitudes only, at resonance

$$\frac{E}{V} = Z_a\left(\frac{R_a}{Z_a^2} + \frac{1}{R_s'}\right)$$

For the current $\mathbf{i}$ in the aerial circuit

$$\mathbf{i} = \frac{\mathbf{e}}{\mathbf{Z}_a + \mathbf{Z}_1}$$

where

$$\frac{1}{\mathbf{Z}_1} = \frac{1}{R_s'} + j\left(\omega C - \frac{1}{\omega L}\right)$$

At resonance

$$\frac{1}{\mathbf{Z}_1} = \frac{1}{R_s'} + j\frac{X_a}{Z_a^2}$$

giving

$$\mathbf{i} = \frac{\mathbf{e}}{\mathbf{Z}_a + \cfrac{1}{\cfrac{1}{R_s'} + j\cfrac{X_a}{Z_a^2}}}$$

Here then is a case in which $\mathbf{i}$ is not in phase with $\mathbf{e}$ when the system is tuned in the above sense.

It is easy to see that the magnitude of the resonant voltage across $R_s'$ can be varied by variation of $X_a$, *i.e.*, by variation of $C_0$.

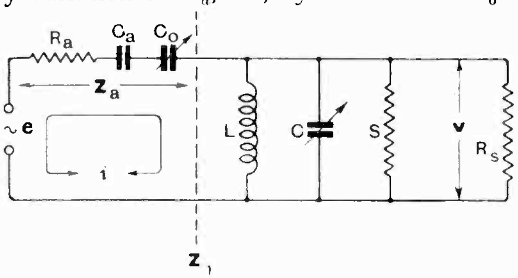



Fig. 5(b).—*Circuit analytically equivalent to Fig.* 5(a).

This then would appear to be the means of attaining the power balance. Putting $E/V$ in the form

$$\frac{E}{V} = \frac{R_a}{Z_a} + \frac{Z_a}{R_s'}$$

it will be found, by differentiation, with respect to $X_a$ that $E/V$ has a critical value with respect to $X_a$ when

$$\frac{R_a}{Z_a^2} = \frac{1}{R_s'}$$

which gives

$$\frac{V}{E} = \tfrac{1}{2}\frac{Z_a}{R_a} = \tfrac{1}{2}\sqrt{\frac{R_s'}{R_a}}$$

since

$$Z_a^2 = R_a R_s'$$

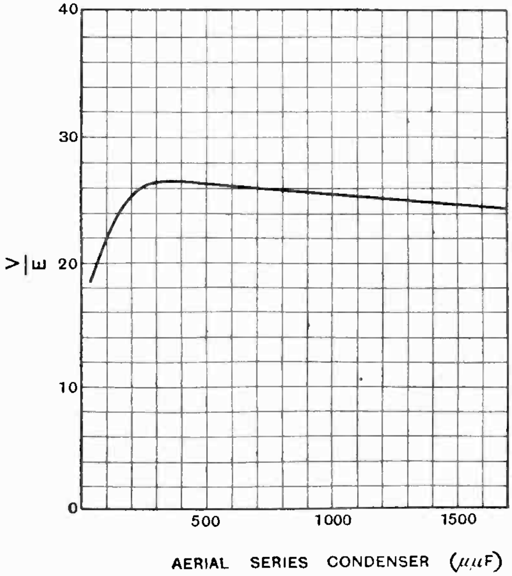



Fig. 6.—*Variation of receiver input voltage with aerial series condenser.*

Notice further that for this value of the coupling capacity

$$\mathbf{i} = \frac{\mathbf{e}}{\mathbf{Z}_a + \cfrac{1}{\cfrac{R_a}{Z_a^2} + j\cfrac{X_a}{Z_a^2}}}$$

$$= \frac{\mathbf{e}}{\mathbf{Z}_a + \cfrac{Z_a^2}{R_a + jX_a}}$$

$$= \frac{\mathbf{e}}{R_a + jX_a + R_a - jX_a}$$

$$= \frac{\mathbf{e}}{2R_a}$$

Here the mechanism is very obvious, for the added reactance $\mathbf{Z}_1$ due to the tuning and receiving system takes the explicit form $R_a - jX_a$ as stated in the general proposition in Section 3. The power consumed in the aerial is $E^2/4R_a$ and, as shown above,

$$\frac{E^2}{4R_a} = \frac{V^2}{R_s'}$$

The maximum value of $V/E$ is clearly less than $\frac{1}{2}\sqrt{R_s/R_a}$ since $R_s'$ is less than $R_s$, but in accordance with the generalised form of the proposition,

$$\text{Lt. } R \to 0 \frac{V}{E} = \frac{1}{2}\sqrt{\frac{R_s}{R_a}}$$

It has been assumed that the coupling condition

$$\frac{R_a}{Z_a^2} = \frac{R_a}{R_a^2 + X_a^2} = \frac{1}{R_s'}$$

can be fulfilled. But if

$$R_a R_s^1 < R_a^2 + 1/\omega^2 C_a^2$$

the condition could only be fulfilled by substituting an inductive coupling for $C_0$, an undesirable expedient since it would increase the parasitic resistance of the system. In such cases it is preferable to use an alternative type of coupling to be described in the next section.

With the values previously used for illustration the condition could not be fulfilled, so the following will be assumed :—

$R_a = 30$ ohms
$C_a = 200\mu\mu$F.
$L = 100$ microhenrys.
$R = 2$ ohms
$R_s = 250{,}000$ ohms
$\omega = 5 \times 10^6$.

These give $340\mu\mu$F. as the optimum series coupling capacity and 26.4 as the optimum voltage magnification, to be compared with the ideal value $\frac{1}{2}\sqrt{250{,}000/30} = 45.6$. The variation of $V/E$ with $C_0$ is shown in Fig. 6. As before, the optimum is exceedingly flat, and it might be thought to be of no account, but, as already pointed out, this is not the whole story. The full merit of the optimum coupling does not appear until the selectivity factor is also taken into consideration. It can be seen from the above analysis that the larger the value of $C_0$ the larger will be the damping effect of the aerial on the closed circuit. A departure from the optimum coupling in the direction of too close a coupling means therefore not only a small decrease in sensitivity but a considerable decrease in selectivity. Too small a coupling capacity on the other hand means a small decrease of sensitivity, but also an increase of selectivity and may therefore be a desirable condition in some circumstances.

The better the coil and the larger the effective value of $R_s'$ the more critical will the optimum coupling condition become. Suppose for instance the input shunt resistance is made negative by means of an inductive load in the anode circuit, *i.e.*, let $R_s = -.143 \times 10^6$.

Then, since $S = .125 \times 10^6$

$$\frac{1}{R_s'} = 8 \times 10^{-6} - 7 \times 10^{-6} = 10^{-6}$$

In this case, the optimum coupling capacity is only about $100\mu\mu$F., and the variation of $V/E$ with $C_0$ is as shown in Fig. 7. Thus, if the best use is to be made of a given degree of retroaction, an appropriately loose coupling to the aerial must be employed. Of course, an inefficient coupling can be compensated by further retroaction, but this is in effect the addition of excessive resistance to the closed circuit, followed by its removal, and there is no object in that.

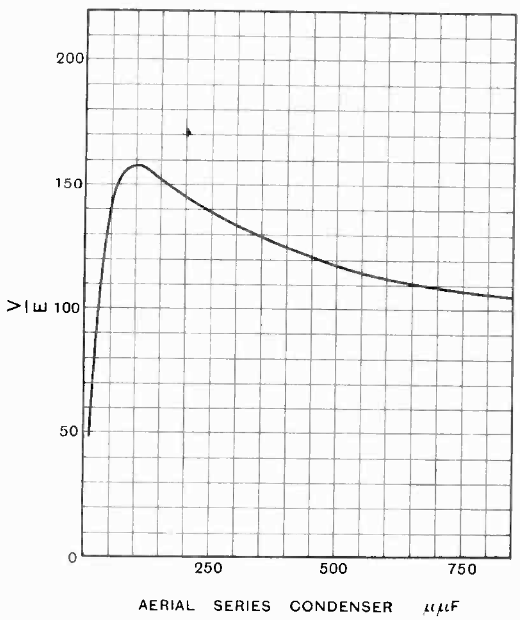



Fig. 7.—*Variation of input voltage with aerial series condenser (negative input resistance).*

If the input resistance is so low that

$$-\frac{1}{R_s'} = \frac{R_a}{Z_a^2}$$

the system will become unstable, the total resultant resistance being zero. Conversely an unstable condition can be avoided, up to a certain limit, by increasing $C_0$ and so decreasing $R_a/Z_a^2$. Thus, a high-frequency

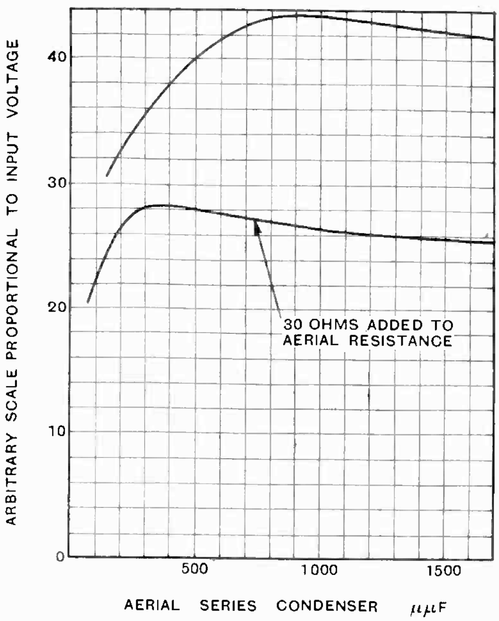



Fig. 8.—*Measured variation of input voltage with aerial series condenser.*

amplifying system which appears to be unstable by itself may be found perfectly stable when connected to the aerial.

## Experimental.

The above analysis involves no new and unproved assumptions and therefore does not require experimental verification. The following actually measured results are put forward, not as evidence in support of Ohm's Law, Kirchhof's Laws and the rules of arithmetic, which would be superfluous, not to say presumptuous, but rather as an illustration to show that the quantities involved are such as may be encountered in practice. The results refer to an aerial approximately 30ft. high and 70ft. long with a very efficient earthing system consisting of buried copper plates. The signal received was the carrier wave of 2LO. The ordinates are proportional to the change in the anode current of a rectifying valve, which changes, for the relatively large input voltages concerned, can be taken as roughly proportional to the input voltages. Two curves, with $C_0$ as abscissæ, are given in Fig. 8. The lower curve was taken with an additional 30 ohms included in the aerial. It will be observed that the shape of the curves is consistent with the theory. The qualitative aspect of the result is more interesting than the quantitative, which would only refer to the particular group of apparatus concerned.

## 7. Capacity Coupling to the Receiver.

When the optimum coupling condition of the previous section cannot be fulfilled, either because the aerial resistance is low, the input shunt resistance low, or alternatively the equivalent reactance of the aerial too high (actually, or made so for the sake of selectivity by means of a small series capacity) then the capacity coupling arrangement shown in Fig. 9 can usefully be employed. Here $C_1$ and the input impedance constitute a potential dividing arrangement whereby the power absorbed in the receiving system can be controlled and adjusted to an efficient balance with that consumed in the remainder of the system.

This type of coupling is particularly well adapted for use with a frame aerial and will be demonstrated in that connection. Its application to an open aerial circuit can then be derived immediately by a simple transformation of the aerial circuit.

Assuming a frame aerial system, the schematic diagram will be as shown in Fig. 10. For brevity in analysis the single letters shown will represent the *total* impedances to the right of the dotted lines in the diagram, $R$ and $X$ with corresponding suffixes being

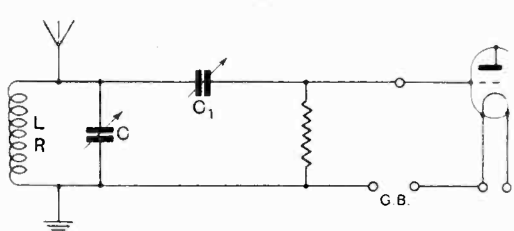



Fig. 9.—*Capacity coupling to input circuit.*

the components of these impedances. The letter **Z** will be written for $R + j\omega L$. This scheme of notation may seem unusual, but will be found very simple and compact in application. The analysis is given very briefly, as it follows the same lines as the examples already given.

$$\frac{\mathbf{v}_2}{\mathbf{e}} = \frac{\mathbf{Z}_2}{\mathbf{Z} + \mathbf{Z}_2}$$

$$\frac{\mathbf{v}}{\mathbf{v}_2} = \frac{\mathbf{Z}_0}{\mathbf{Z}_1}$$

$$\therefore \quad \frac{\mathbf{v}}{\mathbf{e}} = \frac{\mathbf{Z}_0\mathbf{Z}_2}{\mathbf{Z}_1} \quad \frac{1}{\mathbf{Z} + \mathbf{Z}_2}$$

*i.e.*

$$\frac{\mathbf{e}}{\mathbf{v}} = \frac{\mathbf{Z}\mathbf{Z}_1}{\mathbf{Z}_0}\left(\frac{1}{\mathbf{Z}} + \frac{1}{\mathbf{Z}_2}\right)$$

$$= \frac{\mathbf{Z}\mathbf{Z}_1}{\mathbf{Z}_0}\left\{\frac{R}{Z^2} + \frac{R_1}{Z_1^2} + j\left(\omega C - \frac{\omega L}{Z^2} - \frac{X_1}{Z_1^2}\right)\right\}$$

Resonance condition with respect to $C$ :—

$$\omega C = \frac{\omega L}{Z^2} + \frac{X_1}{Z_1^2}$$

giving

$$\left(\frac{\mathbf{e}}{\mathbf{v}}\right)_{\text{res.}} = \frac{\mathbf{Z}\mathbf{Z}_1}{\mathbf{Z}_0}\left(\frac{R}{Z^2} + \frac{R_1}{Z_1^2}\right)$$

Further, at resonance

$$\frac{1}{\mathbf{Z}_2} = \frac{R_1}{Z_1^2} + j\frac{\omega L}{Z_2}$$

Therefore, since

$$\mathbf{i} = \frac{\mathbf{e}}{\mathbf{Z} + \mathbf{Z}_2}$$

$$(\mathbf{i})_{\text{res.}} = \frac{\mathbf{e}}{\mathbf{Z} + \dfrac{1}{\dfrac{R_1}{Z_1^2} + j\dfrac{\omega L}{Z^2}}}$$

so that $\mathbf{i}$ is not in phase with $\mathbf{e}$ when the circuit is tuned.

The power balance is established by variation of $C_1$. Notice that

$$\mathbf{Z}_1 = R_1 + jX_1 = \frac{1}{j\omega C_1} + \frac{1}{R_s} + j\omega C_s$$

so that $R_1$ does not depend on $C_1$. By differentiation of

$$\frac{E}{V} = \frac{ZZ_1}{Z_0}\left(\frac{R}{Z^2} + \frac{R_1}{Z_1^2}\right)$$

with respect to $X_1$, it is easy to show that the critical value of $E/V$ occurs when

$$\frac{R}{Z^2} = \frac{R_1}{Z_1^2}$$

which gives

$$\frac{\mathrm{E}}{V} = 2\frac{Z_1}{Z_0}\frac{R}{Z}$$

This can be put in the form

$$\frac{E}{V} = 2\frac{Z_1}{Z_0}\sqrt{\mathrm{R}\frac{R_1}{Z_1^2}} = 2\sqrt{\frac{R}{R_s}}$$

since

$$\frac{R_1}{Z_0^2} = \frac{R_0}{Z_0^2} = \frac{1}{R_s}$$

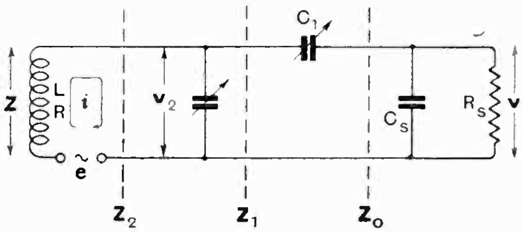



Fig. 10.—*Frame aerial capacity coupled to input circuit.*

Under the same conditions

$$\mathbf{i} = \frac{\mathbf{e}}{\mathbf{Z} + \dfrac{1}{\dfrac{R}{Z^2} + j\dfrac{\omega L}{Z^2}}}$$

$$= \frac{\mathbf{e}}{R + j\omega L + R - j\omega L} = \frac{\mathbf{e}}{2R}$$

Thus, with the optimum value of $C_1$, the power consumed in the frame aerial is $E^2/4R$, and, as above,

$$\frac{E^2}{4R} = \frac{V^2}{R_s}$$

showing that the proposition applies equally to the frame aerial receiving system.

Taking as a numerical example

$L$ = 200 microhenrys.
$R$ = 4 ohms
$C_s$ = 10 $\mu\mu$F.
$R_s$ = 50,000 ohms

it will be found that the optimum coupling capacity is as low as 8.4 $\mu\mu$F., with which coupling

$$\frac{V}{E} = \tfrac{1}{2}\sqrt{\frac{50{,}000}{4}} = 56$$

With a larger coupling capacity—200 $\mu\mu$F. for instance—$V/E$ will be reduced to 43, and the selectivity will be greatly reduced. The comparatively low resistance of a good frame aerial makes it all the more necessary that suitable coupling conditions should be used in order that this characteristic may be utilised to the best advantage.

The application of the above to cases in which the input shunt resistance is negative is sufficiently obvious and need not be elaborated in detail. The instability condition is clearly

$$-\frac{R_1}{Z_1^2} = -\frac{1}{R_s} = \frac{R}{Z^2}$$

Note that variation of $C_1$ is equally effective in controlling the effect of $R_s$ on the closed circuit, whether $R_s$ is positive or negative, and can thus be utilised as a means of obtaining stability. It can, for example, be so employed in association with a tuned high-frequency amplifying system. In such cases, however, $R_s$ may have so low a negative value that the appropriate value of $C_1$ may be inconveniently small. Also, under these conditions, the approach to instability may be rather steep. For these reasons it is preferably utilised as an auxiliary to neutrodyne stabilisation, giving a convenient control of retroaction.

## 8. Application to a Parallel Tuned Aerial Circuit.

The schematic circuit to be considered is shown in Fig. 11. The analysis can be carried out in a straightforward manner, exactly as in Section 7, but there is an alternative transformation which is preferable in the present case as it throws more light on the mechanism of the circuit.

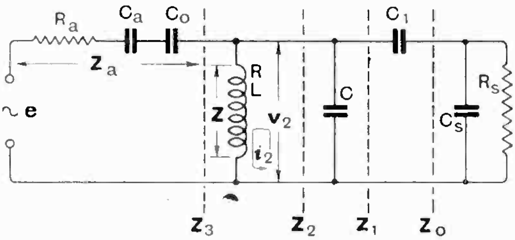



Fig. 11.—*Aerial, capacity coupled to tuned circuit and to input circuit.*

Note first that $C$ and $C_1$ are the only variables, their functions being tuning and coupling respectively. The impedances $\mathbf{Z}_a$ and $\mathbf{Z}$ are constants from the present point of view. The transformation will be stated without proof in order to save space, as the proof is comparatively simple. The circuit shown in Fig. 11 is equivalent, as far as the remainder of the circuit to the right of $\mathbf{Z}_2$ is concerned, to that shown in Fig. 12, where $\mathbf{e}_e$, the effective e.m.f. operating in the closed circuit, is given by

$$\mathbf{e}_e = \frac{\mathbf{Z}}{\mathbf{Z} + \mathbf{Z}_a}\mathbf{e}$$

The arrangement is now essentially the same as that considered in Section 7, and the same

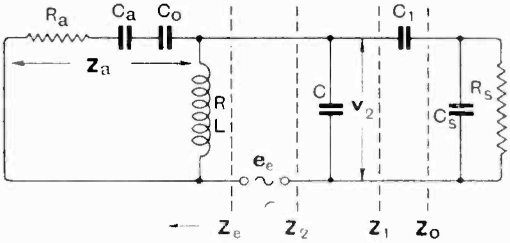



Fig. 12.—*Circuit analytically equivalent to Fig. 11.*

conclusions apply, with the substitution of $\mathbf{Z}_e$ for $\mathbf{Z}$ where

$$\frac{1}{\mathbf{Z}_e} = \frac{1}{\mathbf{Z}} + \frac{1}{\mathbf{Z}_a}$$

The results can therefore be written down directly. They are

$$\left(\frac{\mathbf{e}_e}{v}\right)_{\text{res.}} = \frac{\mathbf{Z}_e\,\mathbf{Z}_1}{\mathbf{Z}_0}\left(\frac{R_e}{Z_e^2} + \frac{R_1}{Z_1^2}\right)$$

$$= \frac{\mathbf{Z}_e\,\mathbf{Z}_1}{\mathbf{Z}_0}\left\{\left(\frac{R}{Z^2} + \frac{R_a}{Z_a^2}\right) + \frac{R_1}{Z_1^2}\right\}$$

or since $\mathbf{e}_e = \dfrac{\mathbf{Z}_e}{\mathbf{Z}_a}\mathbf{e}$

$$\left(\frac{\mathbf{e}}{\mathbf{v}}\right)_{\text{res.}} = \frac{\mathbf{Z}_1\,\mathbf{Z}_a}{\mathbf{Z}_0}\left\{\left(\frac{R}{Z^2} + \frac{R_a}{Z_a^2}\right) + \frac{R_1}{Z_1^2}\right\}$$

The tuning condition is similarly

$$\omega c = \frac{\omega L}{Z^2} + \frac{X_a}{Z_a^2} + \frac{X_1}{Z_1^2}$$

Finally, the optimum coupling condition is

$$\frac{R_e}{Z_e^2} = \frac{R}{Z^2} + \frac{R_a}{Z_a^2} = \frac{R_1}{Z_1^2}$$

giving $\dfrac{E_e}{V} = 2\sqrt{\dfrac{R_e}{R_s}}$ or $\dfrac{V}{E_e} = \tfrac{1}{2}\sqrt{\dfrac{R_s}{R_e}}$

*i.e.*,

$$\frac{E_e^2}{4R_e} = \frac{V^2}{R_s}$$

which is the modified form now taken by the power balance.

(For purposes of calculation, the results are better expressed in terms of the original circuit, *i.e.*,

$$\left(\frac{E}{V}\right)_{\text{res.}} = \frac{Z_1 Z_a}{Z_0}\left\{\frac{R}{Z^2} + \frac{R_a}{Z_a^2} + \frac{R_1}{Z_1^2}\right\}$$

the critical value being

$$\frac{E}{V} = 2\frac{Z_a}{Z_0}\sqrt{R_1\left(\frac{R_a}{Z_a^2} + \frac{R}{Z^2}\right)}$$

$$= 2\sqrt{\frac{R_a + R\,(Z_a^2/Z^2)}{R_s}}$$

since

$$\frac{R_1}{Z_0^2} = \frac{R_0}{Z_0^2} = \frac{1}{R_s}$$

but the equivalent circuit representation is preferable for purposes of interpretation.)

It should be noted that the above arrangement will only give a greater sensitivity than the series aerial coupling condenser circuit of Section 7 in cases where the optimum condition there described cannot be fulfilled. In all other cases the maximum voltage magnification is obtained by direct coupling to the input circuit and control of the aerial load by means of the series capacity. However, as indicated in the beginning of this section, local conditions may be such as to render desirable the greater selectivity obtainable by means of a small series capacity in the aerial. In such cases the above adjustment of the load imposed by the receiver on the closed circuit affords a means of obtaining the maximum sensitivity for a given aerial series capacity, that is for a given degree of selectivity.

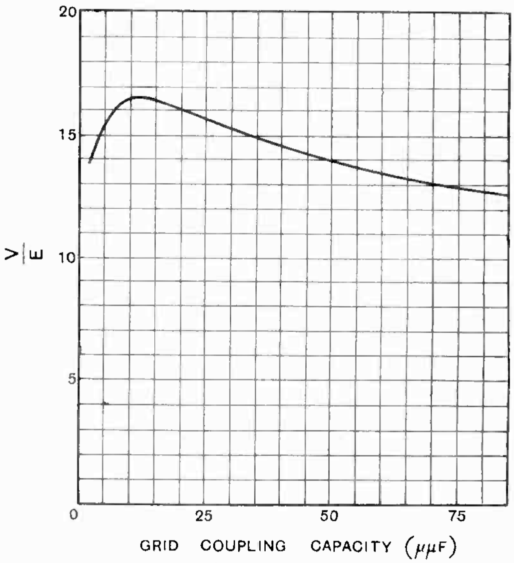



Fig. 13.—*Variation of input voltage with coupling capacity.*

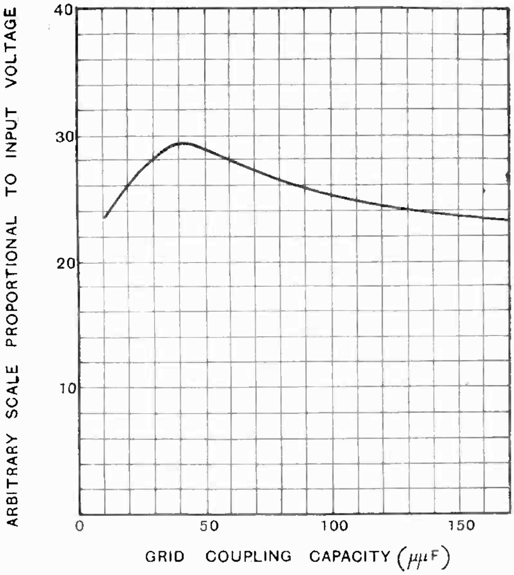



Fig. 14.—*Measured variation of input voltage with grid coupling capacity.*

The function of the aerial series condenser in this respect is shown very clearly in the transformation employed in this section. The e.m.f. **e** in the equivalent aerial circuit is, so to speak, coupled with the closed circuit with a factor $\mathbf{Z}/(\mathbf{Z} + \mathbf{Z}_a)$. The magnitude of this is less than one and decreases as $X_a$ increases, *i.e.*, as the series capacity is reduced. The loading or damping effect of the shunt path $\mathbf{Z}_a$ is, however, also reduced at the same time by increasing $X_a$. Up to a certain point (the optimum condition of Section 7) the decrease in the damping more than compensates for the decrease in the effective coupled e.m.f., and an actual gain in the resonant voltage results. Beyond this point the compensation is not complete and the resultant resonant voltage decreases. The damping effect of the aerial resistance continues to decrease, however, as $X_a$ is increased, so that the selectivity increases continuously. Thus the reduction of the aerial series capacity gives a better selectivity, which, beyond a certain point, involves a small decrease in sensitivity.

The actual variation of $V/E$ with $C_1$ is shown in Fig. 13 for the following case :—

$R_a$ = 10 ohms
$C_a$ = 200 $\mu\mu$F.
$C_0$ = 100 $\mu\mu$F.
$L$ = 200 microhenrys.
$R$ = 4 ohms
$R_s$ = 50,000 ohms
$C_s$ = 10 $\mu\mu$F.
$\omega = 5 \times 10^6$

The maximum value of $V/E$ is 16.5 associated with a coupling capacity of only 10.6 $\mu\mu$F. By short-circuiting the series condenser $C_0$, the optimum value can be increased to 29.9, the best coupling capacity being about 140 $\mu\mu$F. This increase in sensitivity would, however, be gained at the expense of some degree of selectivity.

## Experimental.

The curve of Fig. 13 can be compared as to general shape with that shown in Fig. 14, which was obtained by actual measurement. The tuning circuit was coupled through a fixed 200 $\mu\mu$F. condenser to the aerial and through a variable capacity to a detector valve. A resistance of 50,000 ohms was included in the anode circuit of the latter with a view to producing a comparatively low input shunt resistance in order to accentuate the effect to be demonstrated. The signal was the carrier wave from 2LO, the aerial being as already described. The ordinates of the curve can be taken as roughly proportional to the input voltages, for the reason given in Section 6.

The curve resembles in general shape the calculated curve of Fig. 13, and thus serves as a qualitative illustration of the analysis.

## APPENDIX.

### Practical Applications of the Circuit Described in Section 5.

An alternative form is shown in Fig. 15. In this case a coil of much smaller inductance can be used, with a correspondingly lower resistance. It must be remembered, however, that the effective resistance introduced into the aerial circuit will be larger than the coil resistance, particularly if the remaining capacities of the system are small. The variation of the effective resistance with the tuning capacity greatly complicates the analysis, which is not given for this reason. The conclusions are, however, essentially similar to those of Section 6.

It might be mentioned incidentally that a small variable capacity connected as shown by the dotted lines will give very smooth

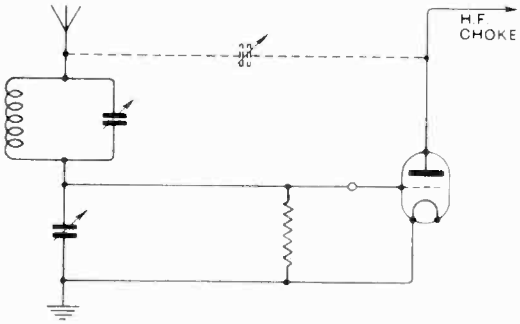



Fig. 15.—*Series tuned circuit.*

reaction control. (It may be found desirable to include a choke in the anode circuit in this connection.) The circuit thus has the advantage of permitting capacity-controlled reaction with a simple two-terminal coil, without centre-tapping or any auxiliary winding.

The circuit is not suitable for use in a region subject to low-frequency interference (mains noises, etc.) owing to the fact that the part of the aerial system included between the grid and filament will have a very high impedance at low frequencies. This objection does not apply to sets in which the first valve is a transformer-coupled high-frequency stage. The circuit is in fact very useful in this connection, for it provides a means of maintaining stability in cases in which the input shunt resistance is negative. This follows from the fact that variation of $C_s$ is equally effective in controlling the resistance added to the aerial circuit by $R_s$ whether the latter is positive or negative. A tuned high-frequency amplifying stage can in fact be used with this type of input circuit without any neutrodyne connection, though in practice it is preferable to use the variation of $C_s$ as an auxiliary stabilising arrangement, affording a certain range of control of retroaction. The writer has used this input circuit in association with a tuned transformer high-frequency amplifying stage and has found it very satisfactory from the point of view of stability and ease of control.

# Correspondence.

*Letters of interest to experimenters are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.*

### "Experimental Transmitting and Receiving Apparatus for Ultra-short Waves."

*To the Editor, E.W. & W.E.*

SIR,—Having read with interest the reply to correspondence upon the above, may I be permitted to trespass again upon your valuable space in order to make one or two further observations upon the subject?

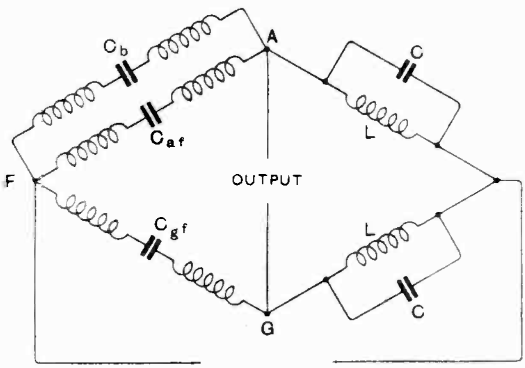
First, with reference to Mr. Megaw's letter, in which he discusses the question of obtaining electrical symmetry in a single-valve oscillator.

In the series of experiments referred to in my original letter, a circuit of similar type to that analysed by Mr. Megaw was used. His experience in regard to the use of this type of circuit seems to have been an exact parallel to my own.

The asymmetry introduced by reason of the fact that $C_{gf} > C_{af}$, was noted, but in the case of the particular arrangement which I used, there was no obvious remedy. The balancing arrangement described by Mr. Megaw was not applicable, in this particular case. (I regret that I am unable to give details of the arrangement referred to, in the present communication.)

Theoretically, there is an obvious alternative (which occurred to me during the course of the work), namely, to increase $C_{af}$ by means of a small adjustable capacity connected between anode and filament terminals of the valve, and use this to balance the "bridge." (See Fig. 2 in Mr. Megaw's letter, and diagram below.)

Though the latter scheme sounds simple and attractive, it is seldom feasible in practice, on the *very* short wavelengths (below about 4 metres). The reason for this will be obvious, upon consideration of the "bridge" diagram shown.




(This is Mr. Megaw's bridge, plus the balancing capacity, *Cb*, re-drawn so as to apply to the very high frequencies (when valves of normal construction are used). The small inductances shown on the left-hand side of the bridge represent the inductances formed by the internal leads to the electrodes of the valve, and the external leads used to connect $C_b$.)

Secondly, with reference to the statement made in my original letter, concerning "feeders" (under (A), (iv), line 21), namely, that "This difference could not be accounted for by . . . resistance losses occurring in the feeder."

I must admit that, in making the above-mentioned statement, I was in error. I was led to form this opinion by a singular train of circumstances occurring during the course of the experiments, in which the question of feeder design was only a subsidiary matter. Convenience was aimed at, rather than the utmost efficiency, so that this phase of the work did not, I am afraid, receive the attention it would otherwise have done.

Since reading Dr. Smith-Rose's reply, I have (experimentally) re-investigated this matter more closely. The result is in entire accordance with his suggestion, namely, that the bulk of the losses is attributable to the presence of the dielectric. For a feeder of the type under discussion, 2.8 metres in length at a frequency of $108 \times 10^6$ (*i.e.*, $l/\lambda = 1$), the loss attributable to this cause amounts to approximately 20 – 25 per cent. (I omitted to state, in my original letter, the length of feeder used; this was, $1.5\lambda$.)

In reply to the remarks concerning the "fourth significant figure," might I be permitted to say that I merely quoted the actual instrument reading, for what it is worth. (I was well aware that this did not necessarily represent the true value of the current or anything like it, but it was quite admissible for purposes of comparison upon a single working frequency.)

C. WHITEHEAD.

S. Farnborough.

### Classification of Radio Subjects.

*To the Editor, E.W. & W.E.*

SIR,—As a student of Radio and Communication Engineering, I have been interested for some time in the classification of literature on radio and allied subjects. A few days ago I got hold of a small book called:

*Manuel de la Classification Decimale a l'usage des ingénieurs electriciens*, by M. E. Beinet, Ingénieur E.S.E. This book was published in 1926 by the Revue Générale de l'Electricité and it is called Publication No. 152 of the Institut International de Bibliographie.

The recommendations of this institute are, it appears, strictly followed by libraries that have adopted the Dewey Decimal system. Turning to 621,384, I was extremely surprised, not to say shocked, to find that the whole of 621,38 was occupied by "Electricité médicale et scientifique." "Radio" is found under 621,394 to 395 headed "Electrical Communications at a distance." Now this would not have mattered much if the subdivisions had been made according to the "Circular 138 of the Bureau of Standards, 1923, A Decimal Classification of Radio Subjects—An Extension of the Dewey System." From first to last there is no resemblance whatever between the two lists. No reference to the "Circular 138" is made, in fact one must suspect the writer of never having heard of it. M. Beinet does however, on pp. 22–23 draw attention to the fact that this rearrangement of 621, 384 is to be regarded purely as a project, but a project subject to the approval of the Institut International de Bibliographie. The Classification according to the "Circular 138" has been widely adopted in the last six years, the *E.W. & W.E.* being one of the first to use it throughout, while the Proceedings of the Institute of Radio Engineers started using it from January this year. The abstracts of radio literature collected by the Bureau of Standards are of course classified according to the "Circular 138." These abstracts are published in the *Proc. I.R.E.* and also in a small publication which constitutes the cheapest source of radio bibliographical information obtainable. I refer to the *Radio Service Bulletin*, issued monthly and costing only 25 cts. a year. This bulletin is obtainable from the Superintendent of Documents, Govt. Printing Office, Washington, D.C., U.S.A.

It would seem quite unnecessary to point out the muddle and extreme inconvenience to all concerned, which will be the result, if the "I.I.B." gives its approval to the proposals of M. Beinet.

For all I know it may already have done so. But one thing seems quite certain: That librarians all over the world will adhere to the "Manuel" "because it is the latest." It appears to me that rapid action on the part of those whose interests are at stake, is the one thing required.

*Adhere to the "Circular 138."*

KAYE E. WEEDON.

Norges Tekniske Høiskole,
Trondhjem, Norway.

## Frequency Variations of Valve Oscillators.

*To the Editor, E.W. & W.E.*

SIR,—I was much interested in Dr. Martyn's paper in your January issue. I note that in Section 10, p. 13, an equation of mine is quoted in which $C$, $C_0$ are wrongly described as plate-filament capacities. The only inter-electrode capacities to which the equation is intended to apply are *grid-filament* capacities. It must not be thought that space charge in a thermionic system necessarily raises the effective capacity. The inertia of the electrons themselves, though small, can be shown to endow the electron atmosphere in a diode with inductance, bringing a theoretical figure of the capacity down from $4/3\ C_0$ to $3/5\ C_0$. That the effective specific inductive capacity in a diode is less than 1 can be confirmed experimentally, with suitable precautions as to the paralleling effect of the valve resistance on the capacity. This last result agrees with those of Larmor and Eccles on the dielectric constant of a layer of electrons (*cf.* Larmor, *Phil. Mag.*, 48, 1025, 1924).

The fact that $C/C_0$ is greater than unity when measurements are made using a negative grid as one plate (as in my experiments), receives explanation on the consideration that the inertial effect of the electrons only comes in when a current is flowing, the negative grid being, so to speak, unaware of any inertial effects. The question will be more fully discussed in Part II of my Paper (Ref. 10, Dr. Martyn's Paper), to appear shortly.

In the first equation on p. 14, the term in round brackets is wrongly given as

$$1 + \frac{13}{600}\,\omega^2 T^2$$

The error arises from confusion as to the dual nature of the current, though this is clearly pointed out on p. 13 ($b$, $b^1$). This term should actually read

$$1 - \frac{11}{1800}\,\omega^2 T^2$$

Dr. Martyn's equation applies to the total (alternating) current $j$, inclusive of capacitative current, and not to the current $i$. Also $\hat{\imath}_0$ should read $\hat{\imath}p$, as current values at the anode are not by any means the same as those at the cathode, this being so only in the case of the total current $\hat{\jmath}$. The fact which emerges from the distinction in the results for $i$ and $j$ is that the time lag of the electrons causes a slight *decrease* in the useful conductance, the increase indicated by the equation for $j$ being entirely due to the increase with frequency of capacitative current, which also varies in a very marked manner as we go from cathode to anode of any valve, being least where the field is least.

W. E. BENHAM.

21st January, 1930.

*To the Editor, E.W. & W.E.*

SIR,—Let me point out that I published what was probably the first theoretical study of the valve oscillator (see *La Lumière Électrique*, 18th December, 1916, p. 225).

This paper took account of grid current, and the formulæ established later on by Vallauri and others are only a peculiar case of my own investigations.

10th January, 1930. J. BETHENOD.

# Book Reviews.

TELEGRAPHY AND TELEPHONY, INCLUDING WIRELESS COMMUNICATION. By E. Mallett, D.Sc. Pp. ix + 413 with 287 Figs. (Chapman & Hall, 21/–.)

For many years lectures and laboratory work in Telegraphy and Telephony have occupied an important place in the curriculum at the City and Guilds Engineering College. The tradition originally established by Professor Ayrton is now ably carried on by Professors Fortescue and Mallett. And in addition to the undergraduates taking this subject in their degree course, there have been for many years a number of post-graduate students at the College carrying out research work in telegraphy and telephony. As the references show, the results of much of this advanced work are embodied in the book under review. Every teacher of the subject in our Universities and Colleges has been conscious of the lack of a suitable text book; as the author says in his preface, "there appears to be no single book containing an outline exposition of the application of scientific principles to the whole art of electro-communications, which serves as an introduction to the specialised books, and does not deal largely with the teaching of electricity and magnetism, which is better done elsewhere. It is this apparently well-defined gap in the literature of the subject that the author has attempted to fill." We have no hesitation in saying that the author has succeeded in his attempt. The book assumes a second-year standard of knowledge of electricity and magnetism on the one hand, and on the other it makes no attempt to give detailed descriptions of practical apparatus. The principles underlying every branch of electro-communication are developed with the exceptional clarity which would be expected by those who are familiar with Prof. Mallett's articles and papers. The division of the book into sections, the type, the illustrations, the mathematical appendices, the references for further reading on each branch of the subject, all conspire to add to the attractiveness of the volume and make it an admirable text-book. The book is divided into 14 chapters and 11 appendices. The first five chapters constitute Part I on Line Telegraphy; the next five constitute Part II on Line Telephony, whilst the last four chapters deal with Wireless Telegraphy and Telephony. Simple telegraphy apparatus and systems are considered in Chapter I, Short lines and equivalent networks in Chapter II, transients, including the effects of line capacity in duplex, etc., in Chapter III, long lines, repeaters, loading, etc., in Chapter IV, and high-speed systems in Chapter V. Gulstad is wrongly spelt in Fig. 56, although correctly spelt in the text. In Part II, Chapter VI is devoted to the nature of sound, and to vector algebra and resonance curves; Chapter VII to simple telephone apparatus and circuits, Chapter VIII to lines, filters, loading, etc.; Chapter IX to thermionic valves and Chapter X to exchange apparatus. We are not clear as to the *raison d'être* of Fig. 166 which shows a "circuit for taking valve characteristics," but which shows no filament current ammeter and no grid or anode voltmeter. In Part III, Chapter XI deals with electromagnetic waves, Chapter XII with oscillatory circuits, a subject to which the author has devoted much attention, which is reflected in the clear treatment in this chapter. The production of high-frequency currents is dealt with in Chapter XIII, a few pages even being devoted to such ancient subjects as sparks and arcs. The final chapter is devoted to methods of reception. We need not enumerate the appendices which deal with various mathematical problems which it was considered undesirable to embody in the text.

An error has crept into the statement of the fundamental laws of electromagnetism on page 286. On line 11 it is stated that "the total electric flux through a closed surface is equal to $4\pi$ times the total charge within the surface." Now, electric flux may mean one of two different things, viz.: the surface integral of the displacement $D$ or the surface integral of the electric force $E$. If the former, then the total flux is equal to the charge $Q$ and not to $4\pi Q$; if the latter, then the total flux is equal to $\frac{4\pi Q}{k}$. Although we always use the term "electric flux" in the former sense, we thought at first that the author was using it in the latter sense and omitting the dielectric constant as he only intended it to refer to a vacuum—a very undesirable limitation to adopt in any statement of fundamental laws. Three lines from the bottom of the same page, however, we read "If $D$ is the electric flux per square centimetre (called by Maxwell the displacement) then $D = kE/4\pi$." With this we entirely agree, but if $D$ is the electric flux density, the total electric flux through a closed surface is equal to $Q$ and not to $4\pi Q$. This is seen at once for a charge at the centre of a sphere, since the total flux is then

$$4\pi r^2 D = r^2 kE = kr^2 \times \frac{Q}{kr^2} = Q.$$

The mistake could be rectified by re-wording Gauss's Law as follows: The surface integral of the normal electric force taken over any closed surface is equal to $4\pi/k$ times the total charge within the surface; or more simply, the integral of the normal displacement taken over any closed surface is equal to the total charge within the surface.

We have gone into this point in such detail because it is a matter of ever increasing importance in connection with the nomenclature of dielectric phenomena and because it is a matter on which much confusion of thought exists, and not because it detracts to any appreciable extent from the general excellence of the book under review.

We congratulate the author on producing a book which will be indispensable to all serious students of telegraphy and telephony.

G. W. O. H.

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ELEMENTS OF RADIO COMMUNICATION. By J. H. Morecroft. (Chapman & Hall, 1929, pp. 269. 15s. net.)

This treatise has been written as an elementary text-book containing the essential matter of Professor Morecroft's larger book, "Principles of Radio Communication" and the same lucidity of style and ease of treatment is apparent in both these volumes. The present volume is by no means a series of extracts from the larger one, but is a self-contained presentation of the science and art of wireless telegraphy and telephony.

The first few chapters treat in a general way of the theory of alternating currents as far as this can be done by elementary mathematics without the use of the calculus. The more difficult parts of the subject such as those relating to high-frequency resistance are given as numerical results in the form of graphs and tables. These figures are adequate for the purpose of giving the student an idea of the magnitudes of the quantities with which he has to deal in actual practice.

The remaining chapters offer an up-to-date presentation of the art of wireless transmission and reception, in which the results of the most recent research are incorporated, such as the distribution of energy in speech and the conditions which determine intelligibility of the spoken word.

The last chapter treats of receiving sets from crystal receivers to all-mains' sets. The advantages of different types are discussed in a helpful way, and it is clearly shown that though the varieties in design are innumerable the guiding principles are few.

R. T. B.

# A Symposium of Wireless Papers.

## Meeting of Institute of Electrical Engineers at City and Guilds College, South Kensington.

The monthly meeting of the I.E.E. Wireless Section was held on 5th February at the City and Guilds (Engineering) College, South Kensington. Five papers, abstracts of which are given below, were read and the apparatus described in the papers was demonstrated in the laboratories. Apart from this demonstration there was no formal discussion of the papers.

ABSTRACTS OF PAPERS READ.

### I.—AN AMMETER FOR VERY HIGH FREQUENCIES.

(By Prof. C. L. Fortescue, O.B.E., M.A., and Mr. L. A. Moxon.)

Reference is made to the difficulties of measuring currents at frequencies of $10^7$ or $10^8$ cycles per second, due to (a) capacity effects, (b) the inductive reactance of even very short conductors,

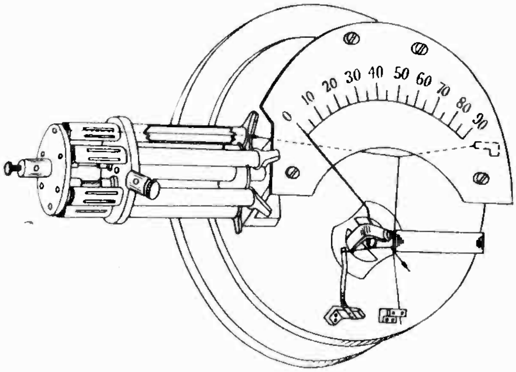


Fig. 1.

and (c) the disturbance of the circuit under measurement by the impedance of the measuring device.

The simplest case for which all corrections can be applied with certainty is that of a wire of small diameter mounted coaxially with a cylindrical screen.

The construction of the instrument described is shown in Fig. 1*. Provision is made for six parallel wires, each carrying a maximum direct current up to 1.2 amp. at full scale. Each wire is kept in its central position on the axis of a screening tube by means of a flat spiral at the end. One of these wires is directly attached to what is normally the heated wire of an ordinary hot wire ammeter. A symmetrical arrangement of the terminal connections ensures uniform distribution of current between the heated wires. Calibration is by d.c. in the ordinary way, and the scale marked from this. The capacity between terminal blocks and screen is measured before insertion of the wires. This, along with the dimensions, enables corrections to be made and plotted as a correction curve, or, alternatively, curved scale divisions may be used.

Notes are given in the paper for the calculation of the corrections. Corrections are small, below $10^7$ cycles per second. Above that they increase rapidly. Further research on the subject is still in progress under the auspices of the Department of Scientific and Industrial Research.

*The authors' original figure numbers are adhered to throughout these abstracts.

### II.—A METHOD OF MEASURING MECHANICAL IMPEDANCE.

(By Prof. E. Mallett, D.Sc., and Mr. R. C. G. Williams, B.Sc.)

The method described in the paper uses a tuning fork, one prong of which drives the device whose mechanical impedance is to be measured. The other prong is loaded to restore balance, the condition of balance being indicated by absence of vibration of the fork support. The load required to effect the balance is the mechanical impedance required. The mechanical equations of the fork are first discussed, and the methods of measurement are described. The principle of the arrangement is shown in Fig. 1. The vibration detector found most useful was a set of 22 single reeds clamped into two brass blocks, and of various lengths to cover the range of 80 to 100 cycles. The fork was driven by an oscillator supplying its maintaining coil. A "pick-up" was driven from the fork by fixing a small piece of gramophone record to the

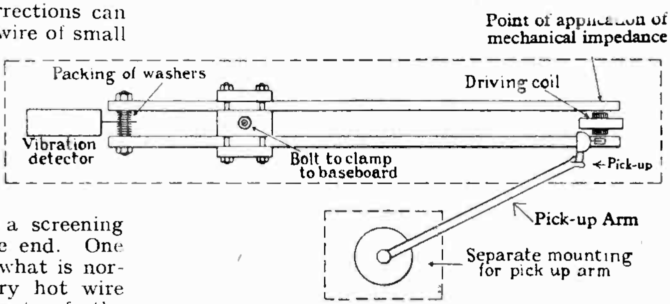


Fig. 1.

top of one prong and resting the needle of the pick-up on the record. This very nearly reproduces the forces between needle and record under ordinary conditions.

It was found that resistive out-of-balance between the two prongs of the fork produced an inappreciable vibration of the fork support. If, therefore, the prongs are balanced for mass, the total resistance can be found from a decay-factor determination, or by a single measurement of amplitude with a known current.

Details are given of an experimental determination of the impedance of a certain gramophone pick-up, and results are shown. So far the method has only been used at about 100 cycles, but no difficulty is anticipated in obtaining results at frequencies up to 500 cycles per second.

Appendices deal with (a) Increase of Mechanical Resistance with mass out of balance, (b) Constancy of Fork Resistance with unbalanced resistive load, (c) Force Factor, (d) Constancy of force factor with unbalanced resistive loads.

## III.—SOME NOTES ON THE DESIGN OF A GRAMOPHONE PICK-UP.

**(By Mr. G. W. Sutton, B.Sc.)**

The work described in this paper was begun some 18 months ago and finished about nine months ago, the author mentioning that in the interim considerable improvement had been effected in commercial pick-ups.

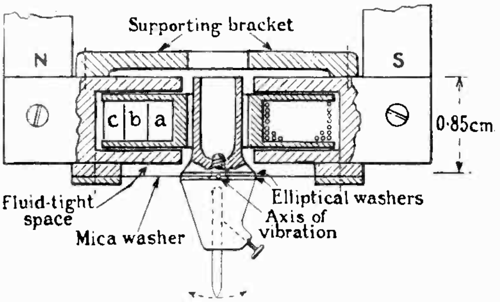


Fig. 9.

The author reviews the types of pick-up, and favours the "balanced-armature" pattern for use with the usual radio-gramophone apparatus. Preliminary tests were made of commercial types, and various experiments are described on the mode of vibration, laminating and annealing the armature and pole-shoes, etc.

In a résumé of the theory of operation, the author concludes that the position on the frequency scale of the chief resonance is governed by the inertia of the armature and the stiffness of the armature suspension and needle. The only means available to the designer in order to move the principal resonance point to a higher position, is to reduce armature inertia. The minimising of inertia is an essential feature, and it is also necessary to have adequate damping. Reference is made in the paper to attempts at reducing damping by rubber rings and blocks, but these are considered

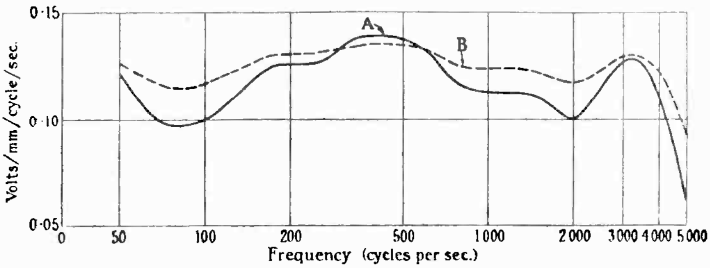


Fig. 12.—*Voltage characteristic of experimental model used with a 6 : 1 step-up transformer. A to a scale of volts (measured at secondary of transformer). B to a scale of log (volts).*

generally unsatisfactory, and the use of oil immersion is suggested. An experimental design embodying this principle is described and illustrated in Fig. 9, and its voltage characteristics given in Fig. 12. The use of a tapped transformer is recommended for regulation of voltage output.

Notes and appendices are given on experimental measurements and on the theory and methods of design.

## IV.—FREQUENCY STABILISATION OF VALVE OSCILLATORS.

**(By Prof. E. Mallett, D.Sc.)**

The type of oscillator considered is the ordinary coupled circuit arrangement, with the anode circuit tuner. One kind of frequency variation may be due to changes in the L.C. value of the circuit. Another group of variations may be due to the constants of the valve itself, including alterations due to operating voltages and to emission. The main effect of these is through alteration of the internal resistance $R_a$ of the valve, since

$$\omega = \sqrt{\frac{1}{CL}\left(1 + \frac{R}{R_a}\right)}$$

The phase relations in the system are then considered by means of circle diagrams, and the author concludes that the inclusion of a suitable inductance in the anode circuit (between the tuned circuit and the anode itself) will keep the grid and anode voltages in exact phase opposition. This results in the frequency of the maintained oscillations being that of the free undamped oscillations of the oscillatory circuit.

Experimental results are described from which it is seen that in the case given, 63 $\mu$H. so inserted would have caused no frequency change over a 10 per cent. change of anode voltage. This value of inductance was less than suggested by theory, according to which the added inductance should be equal to that of the tuned circuit. The discrepancy may be due to the effect of the capacity between anode and grid, and between anode coil and grid coil, or to the effect of resistance in the capacity arm of the oscillatory circuit. The value of the added inductance depends on frequency, and stray capacities may be such as to give it a negative value—*i.e.*, capacity must be added. Intermediately, it may just happen that the circuit is already stabilised at the particular frequency employed.

Experiments are being continued to ascertain if the modified circuit can take the place of tuning fork or quartz crystal as master oscillator control.

## V.—AN INSTRUMENT FOR PROJECTING AND RECORDING THE RESPONSE CURVES OF ELECTRICAL CIRCUITS.

(By Prof. C. L. Fortescue, O.B.E., M.A., and Mr. F. Ralph.)

The instrument described is intended to give direct projection of response curves—*e.g.*, of an ordinary wireless receiver over some pre-determined range of frequency. It uses a specially designed amplifier and a projection type Duddell oscillograph. The horizontal deflection is dependent on the frequency change and the vertical upon the amplitude of the output of the circuits under test. The curve is repeated 10 or 15 times per second, so that, when projected, normal persistence gives the impression of a continuous curve.

A variable-frequency screened oscillator is used, with motor-driven condenser to give capacity

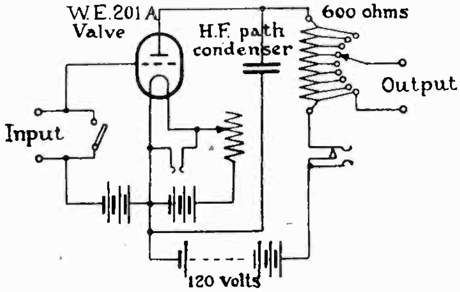


Fig. 1.

changes such as to cover the desired range of frequency. An extension of the condenser spindle carries a cam operating the rocking mirror of the oscillograph. By this means the spot of light is deflected horizontally in proportion to the change of capacity above and below the mean value. This may be made to approximate very closely to the frequency change.

The output of the apparatus under test is applied to the rectifying system of Fig. 1. The anode circuit has resistance and capacity, so proportioned that no more than 1 per cent. of the h.f. component passes through the resistance and no more than 1 per cent. of the rectified current passes through the

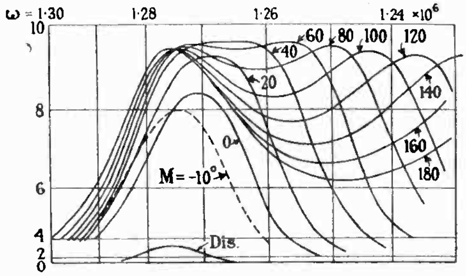


Fig. 6.—*Test No. 9. Record of output from capacity-coupled circuits.*

capacity. This is necessary to keep the h.f. components out of the amplifier, where they would upset the proportionality of the response to the rectified component. The output of the rectifier unit is applied to a resistance/battery-coupled amplifier of variable gain, this system being used so as to be responsive at zero frequency.

Various examples of the curves obtainable from the instrument are shown in the paper. One such is reproduced here in Fig. 6, which shows the record of output from capacity-coupled circuits.

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After the reading of the papers, the meeting visited the various laboratories of the college connected with wireless, acoustics and electrical communication generally.

All the apparatus described in the papers was demonstrated in operation. The response curve apparatus (Paper V) was particularly interesting, and was demonstrated in operation on the response of a circuit to an unmodulated and to a modulated input. In the case of no modulation, the trace was of the usual resonance curve pattern. The addition of modulation introduced two bumps corresponding to the side frequencies and these were shown moving nearer to and farther from the carrier with change of modulating frequency.

The constant-frequency oscillator (Paper IV) was also a very interesting exhibit. The demonstration included the experimental adjustment of the added inductance to such value that no change of frequency occurred when, by movement of a key, a 20 per cent. change of H.T. voltage was effected.

# 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.*

## GRAMOPHONE PICK-UPS.

*Application date, 26th June, 1928. No. 319717.*

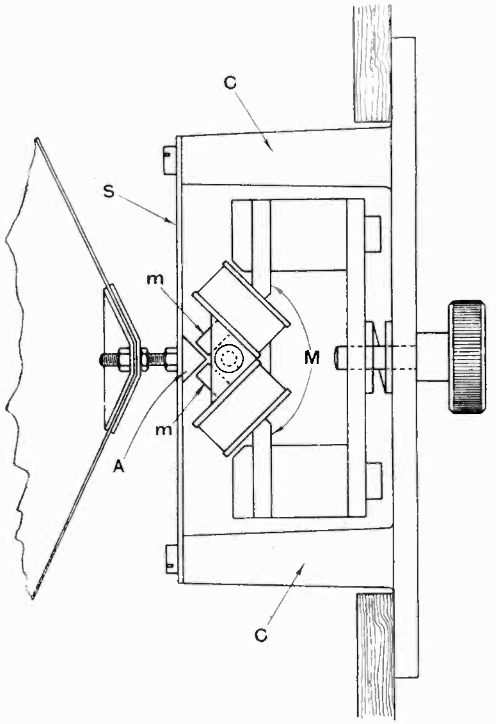
Mechanical damping of the armature or vibrating part of the pick-up is effected by arranging pieces of rubber on the armature so that the damping surfaces lie in planes parallel with that in which the armature vibrates. When for instance the armature is pivoted at its centre and moves inside a central hole in the bobbin carrying the windings, the damping-material is placed between the surfaces of the armature and the surrounding walls of the hole.

Patent issued to P. D. Tyers.

## LOUD SPEAKERS.

*Application date, 28th June, 1928. No. 320081.*

The gaps between the armature *A* and the pole pieces *m* of the magnetic drive *M* are disposed obliquely and at a substantially large angle to the direction of movement of the armature. It will be seen from the Figure that the armature *A* overlaps the polepieces; that is to say the sloping faces of the armature extend over and beyond the co-operating faces of the polepieces. Instead of being rectangular the gap between the poles and the armature may be curved or arcuate. The armature is supported by a stop *S* of phosphor bronze secured at each end to the standards *C*.



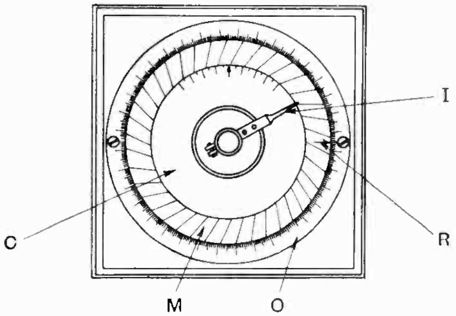

No. 320081.

Patent issued to S. G. Brown.

## DIRECTION-FINDING.

*Convention date (France), 22nd June, 1928. No. 314039.*

In order to apply conveniently the necessary corrections in ascertaining the bearings of a transmitting station by means of a ship's *DF* equipment, the indicator I fixed to the spindle of the frame aerial (not shown) co-operates with three graduated dials *C*, *M*, *O*. The outer ring *O* is adjusted so that an arrow *R* is in line with "zero" and lies along the lubber-line of the ship. An intermediate ring *M* is fixed, and carries a series of deflection curves, corresponding to the distortion set up in the incoming wave-front by adjacent metallic parts on the ship. A centre disc *C* carries arbitrary markings arranged on each side of an arrow (*See* Fig.). The disc *C* is rotated by means of a control knob until the arrow marks the centre point of the swing of the frame aerial when receiving signals. The curved correction mark on the disc *C* then opposite to the arrow on disc *C* will point at its outer end to the correct bearing on the scale O.




No. 314039.

Patent issued to Société Maritime Nationale.

## GRID-LEAK UNITS.

*Application date, 12th October, 1928. No. 320235.*

The condenser and grid-leak resistance are combined in the form of a spool, which is adapted to be mounted on a panel between two side spring-clips. The condenser consists of a hollow cylinder of metal on which wire is wound in a layer, with an intervening dielectric, to form the condenser. The leak resistance is of the cartridge type and is accommodated inside the hollow cylinder.

Patent issued to Brandes, Ltd., and T. D. Ward-Miller.

## AMPLIFYING CIRCUITS.

*Application date, 7th August, 1928. No. 317221.*

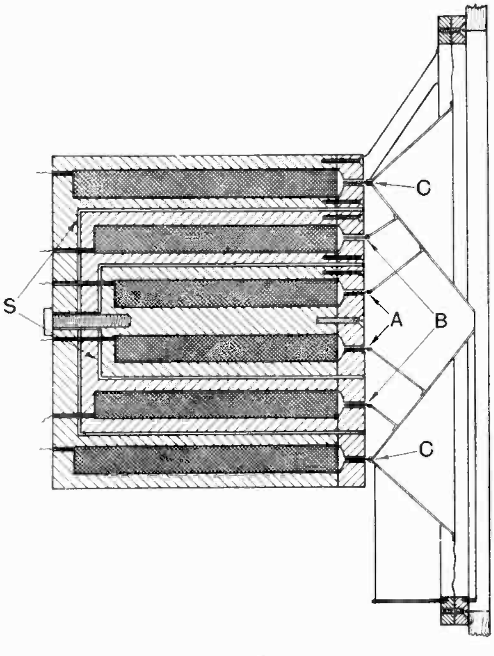
The response of an amplifier is balanced and selected frequencies are emphasised or diminished, by means of a network of impedances shunted across the output transformer, or across the input to the grid. The complex shunt or "leak" may comprise a condenser passing all currents except those of the lower audio-frequencies, a choke shunted by a small condenser and a resistance to impede the medium frequencies, and a choke to block the higher frequencies.

Patent issued to A. F. and D. A. Pollock.

## MOVING COIL SPEAKERS.

*Application date, 7th January, 1929. No. 317134.*

The drive of a moving coil system is distributed more evenly over the diaphragm by using a plurality of moving coils, *A*, *B*, *C*, each connected separately to the diaphragm and each excited by a separate magnet. Preferably the moving coils and magnets are arranged concentrically, as shown, the different magnets being separated by screens *S* of copper



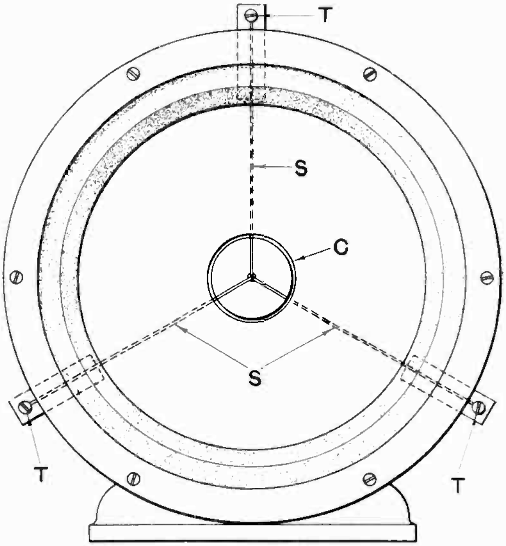

No. 317134.

or aluminium. The coils *A*, *B*, *C* may be connected in series or parallel with the amplifier.

Patent issued to W. R. Westhead.

*Convention date (U.S.A.), 8th October, 1927, No. 298482.*

In order to lessen the difficulty of centring the coil windings *C* in the magnetic gap between the poles, three cords *S* are knotted together at the centre of the collar carrying the windings, and, after being given one turn around an anchorage winding glued on the narrow end of the cone, are




No. 298482.

brought around to screws *T* accessible from the front of the instrument. By turning the screws the position of the moving-coil can be accurately adjusted.

Patent issued to British Thomson-Houston Co., Ltd.

*Convention date (U.S.A.), 6th December, 1927. No. 301840.*

For a similar purpose, the moving coil is supported by a cruciform spider, and an adjusting-cord is secured to each of the four ends of the spider and is then brought out to an accessible position on the surface of the casing. The tension of the cords is controlled by means of a screw nut and an interposed spiral spring.

Patent issued to British Thomson-Houston Co., Ltd.

## PREPARING COATED FILAMENTS.

*Application date, 28th June, 1928. No. 319823.*

When forming a cæsium-coated tungsten core or filament, it is advantageous to ensure an atomic bombardment of the heated filaments by certain gases so as to form a film of atomic thickness which is strongly adherent. According to the invention quantities of barium or manganese dioxide, of an alkali metal or compound such as cæsium or rubidium, and of a cleaning-up agent such as Misch metal, are arranged inside the glass bulb. These are consecutively heated to temperatures at which they vaporise or decompose, to yield first electro-negative and then electropositive elements, which form an activated layer of alkali-metal on the electrode.

Patent issued to A. S. Cachemaille.

## TRANSMITTING VALVES.

*Convention date (Germany), 17th October, 1927. No. 298959.*

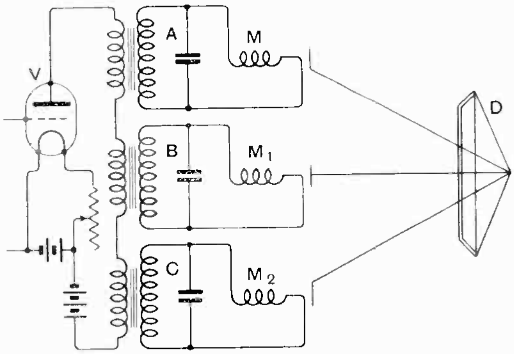
An auxiliary valve is shunted across the power supply to a high-powered transmitter, and is so arranged as to compensate automatically for the varying load thrown on to the supply during keying. When the signalling key is down, the increase in the grid current of the transmitting valve applies a negative bias to the auxiliary valve, thus increasing the latter's resistance. When the key is up, the resistance of the auxiliary valve is correspondingly decreased, so that it takes more current, thereby keeping the effective load constant.

Patent issued to Telefunken Ges. für drahtlose Telegraphie.

## AMPLIFIER OUTPUT CIRCUITS.

*Application date, 25th June, 1928. No. 319639.*

To ensure an overall uniformity in reproduction, the output of the last amplifier valve *V* comprises three separate circuits *A*, *B*, *C*, the inductances and capacities of which are so selected as to be resonant at points equally spaced apart over the total audible range, say from 50 to 5,000 cycles. Each circuit energises separate magnets $M$, $M_1$, $M_2$, which act in combination upon the aperiodic conical diaphragm *D* of a loud-speaker. Instead of the separate transformer couplings shown, a similar




No. 319639.

number of tuned acceptor circuits may be shunted in parallel across a common choke in the output of the valve *V*.

Patent issued to Brandes, Ltd.

## SCREENED GRID VALVES.

*Application date, 17th July, 1928. No. 317610.*

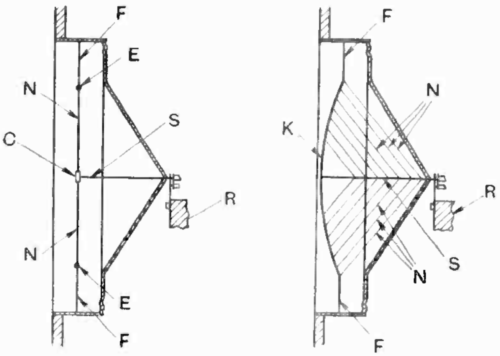
A choke coil, anode resistance, transformer, condenser, or the like is arranged as a unitary structure and is mounted on the top portion of the glass bulb of the valve, being clamped in position by the usual nipple and screw top of the screening-grid terminal.

Patent issued to Igranic Electric Co., Ltd., and D. Sinclair.

## LOUD SPEAKERS.

*Application date, 31st July, 1928. No. 319874.*

There is a tendency for reed-driven cone diaphragms to "rattle," particularly on the higher notes, owing to the production of frequencies in the




(A) No. 319874. (B)

material of the cone which have no relation to the applied audible currents. In order to absorb such undesirable frequencies, a network of wires is stretched across the open mouth of the diaphragm. As shown in Fig. A, a light spindle *S* extends forward from the point where the cone is impulsed by the reed *R*. A radial series of wires *N* is stretched across from a small collar *C* to the circumference of a ring *E* suspended by cords *F* from the framework. As shown in Fig. B, the ring *E* is replaced by a vertical wire *K* to which the wires *N* are connected from different points along the axis of the spindle *S*.

Patent issued to F. Charles.

## FRAME AERIALS.

*Application date, 31st July, 1928. No. 317215.*

The frame aerial of a portable set is wound in three separate sections, the ends of the various windings being brought out to a switch so that, for short-wave reception, only one section is in circuit, the other two windings being connected in opposition. For long-wave reception all three sections are connected in series so that the induced magnetic flux is additive.

Patent issued to D. and S. Montague.

## PICTURE TRANSMISSION SYSTEMS.

*Convention date (Germany), 8th February, 1928. No. 305625.*

The scattered rays of light coming from each point of the picture, as it is successively swept over by the exploring ray, are concentrated by a surrounding hollow reflector of elliptical cross-section. The point under illumination is situated at one focus of the elliptical reflector, so that the diffused rays converge, by internal reflection, at the conjugate focus. The light-sensitive cell is located at this second focal point.

Patent issued to Telefunken Ges. für drahtlose Telegraphie.

## SECRET WIRELESS SYSTEMS.

*Application date, 4th July,* 1928. *No.* 320091.

In order to ensure secrecy without unduly broadening the width of the sidebands, the signalling frequencies are subdivided and relatively transposed. The width of each separate division is varied, but the total or overall width of the entire band of frequencies is maintained constant. The speech currents, for instance, are applied to modulate two high-frequency waves so selected that the resulting upper sidebands are contiguous. This double band is then caused to modulate a variable-frequency carrier wave. The carrier is suppressed, and the upper sideband is a " wobbling " wave such that its width in the frequency scale is twice the width of the speech frequency band at each instant, whilst its position in the frequency scale varies in synchronism with variations in the frequency of the carrier wave. Double demodulation and filter circuits are necessary to secure intelligible speech in reception.

Patent issued to Standard Telephones & Cables, Ltd.

## PREPARING COATED FILAMENTS.

*Convention date (Germany), 9th July,* 1927. *No.* 293694.

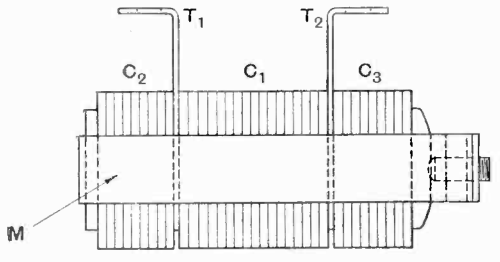
Substances of high emissivity, such as metal oxides, sulphides, or carbonates are sprayed in colloidal form over an assembly of wire cores arranged around a circular rotating holder. A stationary case, fitted with one or more slots is brought down over the rotating holder, and the colloidal material is then sprayed on to the naked wire cores through the slots, so as to produce an even coating.

Patent issued to S. Loewe.

## ELECTRIC CONDENSERS.

*Application date, 12th July,* 1928. *No.* 320405.

A fixed condenser, particularly suitable for high-frequency working, in situations where both poles of the device are insulated from earth, is built up of three or more groups of elements $C_1$, $C_2$, $C_3$ connected to the two poles or terminals $T_1$, $T_2$ in such




No. 320405.

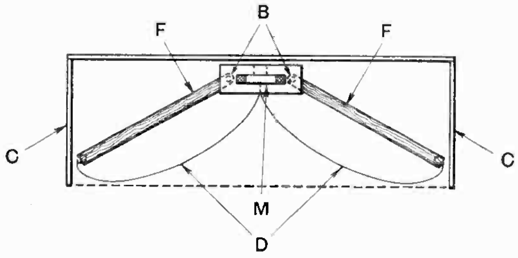
a way that the high-frequency flow is subdivided into two parts. One part flows directly through the group $C_1$ from pole to pole. The other part flows from pole $T_1$ through condenser element $C_2$, then through the metal clamp $M$ to condenser element $C_3$, and finally to pole $T_2$. The clamping-band $M$ can, if necessary, be kept free from contact with the containing case.

Patent issued to P. R. Coursey and The Dubilier Condenser Co., Ltd.

## LOUD SPEAKERS.

*Application date, 1st September,* 1928. *No.* 320198.

The diaphragm $D$ consists of two sheets of cartridge paper, each mounted in a rectangular wooden




No. 320198.

frame (shown in cross-section) and connected together along one edge in a manner similar to the two leaves of an open book. The frames $F$ are pivoted to swing about the axes $B$. Four operating magnets $M$ are disposed along the length of the joined edges of the diaphragm. For high-powered reproduction, six square feet of diaphragm area can be operated by each magnet $M$. The diaphragm is enclosed in a separate frame $C$ which forms an acoustic reflector.

Patent issued to C. M. de C. de la Bourdonnais (Prince de Mahe).

## REMOTE HIGH-SPEED KEYING.

*Convention date (U.S.A.), 2nd November,* 1927. *No.* 299856.

In order to overcome the time-lag characteristics of the land line between a central keying-station and a distant transmitter, which impose a limit to the speed of signalling when direct current impulses are used, the latter impulses are used only for low-speed signalling. For high-speed working, the " rate of change " of current is utilised by coupling the line to the transmitter control through a choke or other reaction coupling. This is found to permit a keying speed of from 250 to 500 words a minute as compared with a normal maximum rate of 75.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

## GANGED CONDENSERS.

*Application date, 10th January,* 1929. *No.* 320001.

In order to allow independent adjustment of the capacity value of one or more of a number of ganged condensers, a separate adjusting-screw is provided, in addition to the master-control knob, for the purpose of varying the spacing between the fixed and moving vanes of the selected condenser. By moving one set of vanes axially with respect to the other, the effective capacity is altered without changing the relative overlap or rotary setting of the condenser.

Patent issued to S. Moss.

# Abstracts and References.

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## PROPAGATION OF WAVES.

RECHERCHES RELATIVES À LA PROPAGATION DES ONDES RADIOÉLECTRIQUES EFFECTUÉES À L'OCCASION DE L'ÉCLIPSE DU 9 MAI, 1929 (Researches on the Propagation of Radio-electric Waves, on the Occasion of the Eclipse of 9th May, 1929).—J. B. Galle and G. Talon: G. Ferrié. (*Comptes Rendus*, 6th Jan., 1930, Vol. 190, pp. 48–52.)

A report of the results obtained by the Indo-China expedition (*cf.* 1929 Abstracts: Stôrmer, pp. 565 and 623).

The entrance of the phase of totality produced:—considerable diminution of the field strengths due to short-wave stations more or less distant: sudden variations in their d.f. bearings: and diminution of local atmospherics. A remarkable point was the almost simultaneous occurrence of these results at the moment of totality; as if the instant the upper atmosphere is deprived of the solar radiation, the modifications which it undergoes from this radiation disappear. The variation, at the same moment, of the bearings of stations outside the shadow "implies an increase of the index in the eclipse region and consequently a decrease in ionisation of the upper atmosphere." Half an hour after the cessation of the total eclipse, radiotelegraphic conditions had returned to normal.

Other results related to the long-time echoes; these (from a 25 m. station 3 km. distant) were very frequent on the days preceding the eclipse and on the day itself. The delays ranged from 5 to 25 secs. Between 12 and 16 h. (local time) practically every signal (each half minute) was followed by an echo, the delays being usually the same for several consecutive signals. Some echoes were weak (about 1/100th of the signal intensity) and often multiple; often the echo gave a distorted reproduction of the 2-dot signal. Others were strong (1/3rd to 1/10th of signal intensity). Between 12 h. and 16 h., the proportion of strong to weak echoes was about 1 to 5. On one occasion a strong echo was multiple, consisting of a series of very clear double dots. As the sun approached the horizon the number of echoes decreased, reaching zero at about 18 h. *On the day of the eclipse they disappeared about two minutes before totality and reappeared a little before the end of totality.*

The last two and a half pages are occupied by a note by Ferrié on the above observations. He points out that while the large number of long-time echoes on the dates in question seems to support Stôrmer's theory (see previous references), the last result (in italics) is contradictory; since the toroidal reflecting space is far beyond the moon, the occultation of the sun by the latter could hardly be expected to affect the echoes. The results seem to agree with the second theory (van der Pol, Appleton and others) in attributing the long delays to travels in the uppermost atmosphere, but they do not help this theory over the difficulty which Pedersen pointed out as to the resulting dissipation of energy. The writer therefore suggests a third possibility; he describes Gutton's "quasi-elastically" oscillating ions (1929 Abstracts, pp. 146—also *cf.* Rybner—204 and 385, twice), dealt with also by Tonks and Langmuir, and then concentrates on the last two writers' discovery of similar oscillations of positive ions (Abstracts, 1928, p. 687; 1929, pp. 273, 576) which they label "electro-sonorous" as possessing the attributes of elastic vibrations, and in particular a velocity of propagation of the order of only a km. per sec. As nowadays it is necessary to admit the presence in the upper atmosphere of positive ions in numbers almost equal to those of electrons, he suggests that these "electro-sonorous" oscillations may play a part in producing the long-time echoes, their slow velocity of propagation accounting for the delay.

FURTHER OBSERVATIONS OF RADIO TRANSMISSION AND THE HEIGHTS OF THE KENNELLY-HEAVISIDE LAYER.—G. W. Kenrick and C. K. Jen. (*Proc. Inst. Rad. Eng.*, Nov., 1929, Vol. 17, pp. 2034–2052.)

"The results of further [*cf.* 1929 Abstracts, p. 441] observations on radio transmission phenomena associated with the reflections of radio pulse and spark signals are outlined, and a brief theoretical consideration of the form of index of refraction variation best adapted to explain the observed phenomena is given. The discussion considers the relation of this index of refraction variation to that discussed in a previous paper [*loc. cit.*] and that recently considered by Breit [January Abstracts, p. 32: exponential distribution, $n = \epsilon^{-y/a}$. The present writers have found that a hybrid form, in which the exponential type is used for small values of $n$ and the types previously employed ($n^2 = 1 - ry$) for larger values, is successful in describing at least qualitatively the major phenomena observed]. The results of long-wave [18.35 kc.] field strength observations are also presented. Evidence for a considerable diurnal layer movement is found from the short-wave [4435 kc.] observations of layer height."

Echo signal phenomena on 390 kc. (only during sunrise and sunset periods) are also dealt with: the oscillograms may be used for determining the virtual heights of the layer. Here also, considerable evidence is to be found of a cyclical change in height (though the shortness of the time intervals, etc., makes these observations somewhat unreliable). Heights of the order of 100 km. are indicated, in accord with the results of Hollingworth and others by other methods. The oscillograms exhibit another point of interest—the importance of absorption at this frequency (390 kc.).

A winter run ("short days and low electron densities") on the 4435 kc. wave indicates that this frequency is close to, if not above, the "critical" frequency for zero skip distance at periods during night and dawn at this season, and provides interesting evidence of long-time retardations and blurred pulse-groups.

DER EINFLUSS DER ERDATMOSPHÄRE AUF DIE AUSBREITUNG DER RADIOWELLEN (The Influence of the Earth's Atmosphere on the Propagation of Radio Waves).—J. Fuchs. (*Funkmagazin*, Nov. and Dec., 1929, Vol. 2, pp. 1021–1027 and 1091–1099.)

A general survey of our present knowledge, ending with a reference to the writer's own work on the correlation of atmospheric pressures with propagation conditions (*see* 1929 Abstracts, p. 40). "All variations in the audibility of over-sea stations correspond definitely, and only, with the variations of the atmospheric pressure along the intervening path; lower pressure increases the silence zone, higher pressure decreases it. No connection was found with the temperature." The writer now suggests that the correlation between size of silence zone and atmospheric pressure can be explained as follows:—decrease of pressure diminishes the ionic density—this increases the refractive index—increase of refractive index (as he has already pointed out) brings increase of extent of silence zone.

THE REFRACTIVE INDEX OF SPACES WITH FREE ELECTRONS: A MECHANICAL MODEL.—P. O. Pedersen. (*E.W. & W.E.*, January, 1930, Vol. 7, pp. 16–21.)

The writer shows by simple reasoning how the presence of $N$ free electrons per cm.³ changes the dielectric constant $\epsilon$ from unity to $1 - N \cdot \frac{4\pi e^2}{\omega^2 m}$, where $e$ and $m$ are the charge and mass of the electrons; a unit condenser, of capacity $C = \frac{1}{4\pi}$ before the electrons are introduced, on the introduction of the $N$ electrons behaves as if it were shunted by an inductance $L = m/Ne^2$. If $\omega^2 LC = 1$ or $N \cdot \frac{4\pi e^2}{\omega^2 m} = 1$, the equivalent dielectric constant is zero; if $\omega^2 LC < 1$ or $N \cdot \frac{4\pi e^2}{\omega^2 m} > 1$, it is negative—in which case the condenser with its free electrons is equivalent to a self inductance $L' = \dfrac{\frac{4\pi}{\omega^2}}{N \cdot \frac{4\pi e^2}{\omega^2 m} - 1}$.

The relation between the dielectric constant and the refractive index is discussed: this is

$$n = \sqrt{\frac{\epsilon}{2} + \sqrt{\frac{\epsilon^2}{4}}}$$

for a medium of zero conductivity. If $\epsilon < 0$, $n = 0$. Considering a space made up of unit condensers with free electrons, all rays in a medium where $n_0 > 0$, on meeting the transition layer between it and such a space, will be totally reflected if $n = 0$, *i.e.* if $\epsilon$ is negative.

The rest of the paper deals with a mechanical model by which the various effects of a negative, a positive and a zero dielectric constant can be demonstrated.

ÜBER DIE VERÄNDERUNG DER DIELEKTRIZITÄTSKONSTANTE EINES SEHR VERDÜNNTEN GASES DURCH ELEKTRONEN (The Alteration of the Dielectric Constant of a Very Rarified Gas by Electrons).—Sven Benner. (*Ann. der Phys.*, 18th Dec., 1929, Series 5, Vol. 3, No. 7, pp. 993–996.)

Referring to the experimental work of Bergmann and During (1929 Abstracts, p. 440) who compared their results with the formulæ derived by Salpeter, the writer points out that Salpeter assumed the electrons to be set into oscillation by an a.c. field, these oscillations being broken off each time the electron collided with a gas molecule and having to be started again. This condition did not hold in B. and D.'s experiment, and Salpeter's formulæ do not apply. The writer derives other formulæ to take their place, on the assumption that the condenser plates are so close together that edge effect can be neglected. For conductivity $\sigma$ and alteration of dielectric constant $\triangle\epsilon$ he obtains

$$\sigma = \frac{Ne^2}{m\omega^2 T}(1 - \cos \omega T)$$

and

$$\triangle\epsilon = -\frac{4\pi Ne^2}{m\omega^2}\left(1 - \frac{\sin \omega T}{\omega T}\right),$$

where $T$ is the time spent by each electron in the condenser. He also points out certain likely errors in the tests in question.

ON THE DAYLIGHT TRANSMISSION CHARACTERISTICS OF HORIZONTALLY AND VERTICALLY POLARIZED WAVES FROM AIRPLANES.—F. H. Drake and R. M. Wilmotte. (*Proc. Inst. Rad. Eng.*, Dec., 1929, Vol. 17, pp. 2242–2258.)

Authors' summary:—The investigation described below was carried out for the purpose of comparing the transmission characteristics from an airplane of horizontally and vertically polarized waves in daytime. A frequency of about 6 megacycles was arbitrarily chosen. In view of the fact that modern practice is tending towards the elimination of the trailing wire antenna, an antenna producing vertically polarized waves must of necessity be of small dimensions. The transmissions were therefore compared using a doublet antenna, each arm of which stretched from wing tip to tail for the horizontally polarized wave, and a rigid antenna six feet high for the vertically polarized wave. It was found that the sky ray began to be appreciable with the horizontally polarized wave at a distance of 20 miles, while on the vertically polarized wave it became important at a distance of 50 miles. The signal from the sky ray for distances of the order of 150 miles was always stronger with horizontal polarization than with vertical. The result with the direct ray was different. The signal from the vertically polarized wave was stronger than that from the horizontally polarized wave over highly conducting ground, while the reverse was the case over badly conducting ground. For this reason, the signal from the vertically polarized wave sometimes became very weak at a distance of 40 to 50 miles, before the sky ray was able to arrive with sufficient strength. This occurred particularly on badly conducting ground and when the airplane was flying low. From the horizontally polarized wave, strong signals were received in all conditions continuously for distances up to 600 miles, and there did not appear to be any tendency for the signal to decrease in intensity as this distance was approached.

A very effective ground antenna was investigated, which possesses the property, when used horizontally, that the signal received is little affected by the height of the antenna above the ground. This permits the use of a very low antenna.

The effect of the conductivity of the ground was considered and, in the appendix, a method is described by which it is possible to deduce the transmission characteristics for flights at any altitude, when those at given altitude are known. The results of the experiments are qualitatively explained on the basis of the present knowledge of transmission phenomena.

DIE BEUGUNG GEDÄMPFTER ELEKTRISCHER WELLEN AN EINEM DIELEKTRISCHEN ZYLINDER (The Refraction of Damped Electric Waves at a Dielectric Cylinder).—I. Kobayashi. (*Ann. der Phys.*, 4th Dec., 1929, Series 5, Vol. 3, No. 6, pp. 721–736.)

A theoretical treatment. Author's summary :—The theory is more free from objections than the former ones. A plane wave train is taken as the incident wave, beginning suddenly with damped sinusoidal waves. The effect of the non-simultaneous arrival of the head of the wave at various parts of the cylinder is obtained in integral form. Further, the intensity beyond the cylinder is calculated, since the difference between undamped and damped incident waves is most clearly noticed in this case. If the incident waves are damped, the $\frac{I(\rho)}{I(0)}$ curve shows (as the experiment of Schaefer and Grossman proved) no sharp bend such as must otherwise occur. This is because $\frac{I(\rho)}{I(0)}$ is a definite mean value of $\left\{\frac{I(\rho')}{I(0)}\right\}_{k=0}$, so that the function $\frac{k}{\rho\left\{\nu^2\left(\frac{\rho'}{\rho}-1\right)^2+k^2\right\}}$, in the case where $k/\nu$ is not very small (about 1/10), is slowly variable with increasing $\rho$; with the result that a sharp increase or decrease of $\left\{\frac{I(\rho')}{I(0)}\right\}_{k=0}$, if this takes place not very close to $\rho = 0$, can have no great influence on $\frac{I(\rho)}{I(0)}$.

SHORT WAVE RANGES.—(*Telefunken Zeit.*, Sept., 1929, Vol. 10, No. 52, p. 74.)

The steamship "Resolute" maintained communication with "Reliance" for 10 days, on 36 m. The distance (Sumatra–Curaçao) was about 10,200 nautical miles. The "Resolute" when off Sumatra had good communication with San Francisco—12,500 naut. miles. The air-ship "Graf Zeppelin" was well received from the Mediterranean at the Radiomarine Corp. of America's station at Chatham (Mass.).

DIE THEORETISCHE ERKLÄRUNG DES KURZWELLEN-PHÄNOMENS (The Theoretical Explanation of the Behaviour of Short Waves).—H. Rukop. (*Telefunken Zeit.*, Sept., 1929, Vol. 10, No. 52, pp. 15–26.)

A general survey of the various phenomena and theories, ending with the recommendation of the use of picture telegraphy as a tool in the investigation of these waves.

THE PENETRATION OF ROCK BY ELECTROMAGNETIC WAVES AND AUDIO FREQUENCIES.—A. S. Eve, D. A. Keys, and F. W. Lee. (*Proc. Inst. Rad. Eng.*, Nov., 1929, Vol. 17, pp. 2072–2074.)

See 1929 Abstracts, p. 565.

DISSIPATION DE L'ÉNERGIE TRANSPORTÉE PAR UNE ONDE AERIENNE (Dissipation of the Energy Transported by an Air Wave).—Th. Vautier. (*Comptes Rendus*, 30th December, 1929, Vol. 189, pp. 1253–1255.)

In this work (a continuation of that published in 1924 and 1926) two classes of wave are distinguished and compared: short (produced by caps or pistol) and long (black powder, gun-cotton).

ÜBER DIE STRAHLENBRECHUNG AN DER GRENZE VON BEWEGTEN MEDIEN (The Refraction of Rays at the Surface of Separation of Moving Media).—D. J. Eropkin. (*Zeitschr. f. Phys.*, 24th Oct., 1929, Vol. 58, No. 3/4, pp. 268–272.)

DIE ENERGIESTRÖMUNG BEI DER TOTALREFLEXION (The Energy Flow in Total Reflection).—J. Picht. (*Physik. Zeitschr.*, 1st Dec., 1929, Vol. 30, pp. 905–907.)

## ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

SUR LA VARIATION DIURNE DES PARASITES ATMOSPHÉRIQUES: MOYENNES MENSUELLES, VARIATION ANNUELLE, INFLUENCES MÉTÉOROLOGIQUES (On the Daily Variation of Atmospherics: Monthly Averages, Annual Variation, and Meteorological Influences).—R. Bureau. (*Comptes Rendus*, 30th December, 1929, Vol. 189, pp. 1293–1295.)

Curves are given representing the mean diurnal variation, at Saint-Cyr, of the number of atmospherics during seventeen months for a wavelength of the order of 6,000 m. Referring to the night and afternoon maxima, the writer says that an examination of the daily diagrams shows that these are due to the independent appearance of "anticyclone" and "stagnant" atmospherics respectively (*cf.* same writer, 1929 Abstracts, p. 443): the "migratory" type naturally appear very little on the mean curves. The "stagnant" type disappear completely during the winter: during the summer they are very accentuated on some days, but almost disappear on others. The "anticyclone" type can be observed throughout the year. However weak they may be, they can always be found by increasing the sensitivity of the receiver; the amplitude of their maximum suffers, however, very great variations, sometimes even from one night to another.

The writer has already pointed out (*loc. cit.*) that during the winter this amplitude is closely connected with the meteorological situation; it is greater in the presence of a mass of unstable polar air: the arrival of a high mass of warm air decreases both intensity and number of these night atmospherics, the minimum coinciding with the passage of the warm sector. It appears that this property applies to all seasons provided that care is taken *not* to include the prolongation into the night hours of the stagnant type on very stormy summer days. A first comparison of records at points several hundred kilometres apart (Saint-Cyr, Zurich, Slough and Sarrebrück) appears to confirm these views. In a period of stagnant atmospherics, the curves at the various stations are very often similar, thus showing an almost perfect simultaneity of the atmospherics; whereas there are great differences between the amplitudes of the night atmospherics at the various stations, each time that these are not in one and the same mass of air.

Notes on the Atmospherics Experienced in a North Atlantic Depression.—D. G. Mackenzie. (*Journ. Inst. Wireless Tech.*, Nov., 1929, Vol. 2, pp. 77–81.)

A record of observations taken on a voyage from England to the Panama Canal. One graph shows the barometric pressure curve, inverted, for three days, together with the corresponding curve showing the number of "static crashes" per minute. The two curves are very similar in shape, but the static curve is always ahead of the pressure curve. "This latter fact should be of great assistance in forecasting weather."

À Propos de la Relation entre les Orages et les Parasites (The Relation between Storms and Atmospherics).—R. de Ballore. (*L'Onde Élec.*, October, 1929, Vol. 8, pp. 463–464.)

Applying his statistical procedure (1929 Abstracts, p. 466) to the storm data given by Maurain (same, p. 443), the writer gives here a table of the monthly calculated and observed frequencies of storms: agreement is fairly good, except for the month of May when there is a marked anomaly, the storm frequency being 25 per cent. greater than calculated. On applying the same treatment to the mean temperatures (period 1851–1900) the agreement is altogether better, and there is no anomaly in May. Thus the May anomaly in storm frequency has no connection with the temperature: "it is the result of some special cause: what? We cannot say. Perhaps these details may help towards the study of the influence of storms on atmospherics."

Suggested Correlation of Solar Radiation, Weather and Varved Clay.—C. A. Reeds. (Summary in *Science*, 13th Dec., 1929, Vol. 70, p. 587.)

Sul Calcolo della Turbolenza nei bassi Strati atmosferici (The Calculation of the Turbulence in the Lower Atmospheric Strata).—M. Lombardini. (*Lincei Rend.*, No. 10, Vol. 9, 1929, pp. 898–902.)

Arctic Flight of the "Graf Zeppelin."—(*Science*, 27th December, 1929, Vol. 70, p. X.)

Included in the apparatus used by the Graf Zeppelin on its North-Polar flight will be small balloons carrying automatic recording instruments for the measurement of atmospheric pressure, temperature and humidity. In order that these records should not be lost (as in the event of the non-return of the balloon) it is arranged that the balloons be equipped with small transmitters whereby they will automatically "radio" their observations to the airship. *Cf.* Bureau, 1929 Abstracts, p. 445.

Théorie de la Formation des gros Ions et Gouttelettes (Theory of the Formation of the "Large Ions" and Droplets).—A. Veronnet. (*Comptes Rendus*, 30th December, 1929, Vol. 189, pp. 1249–1251.)

Further development of the electronic theory of the ether (1929 Abstracts, p. 646). It is here applied to explain the agglomeration of hundreds of thousands of molecules or atoms, giving the "large ions" of Langevin and de Broglie. Various atmospheric and cosmic phenomena are explained in the light of the enormous electric force of attraction (varying inversely with the 4th power of the distance) which the theory envisages: the "large ions" would be particularly stable and numerous in the rarified upper atmosphere of earth and sun; the writer suggests that they form Deslandres' "solid dust" of the solar corona, the "solid nitrogen" which Végard postulates for the production of the auroral green ray, the particles in the tails of comets, and those responsible for the zodiacal light.

Sur la Formation des Charges électriques dans les Nuages (On the Formation of the Electric Charges in Clouds).—C. Dauzère. (*Comptes Rendus*, 9th December, 1929, Vol. 189, pp. 1092–1094.)

Simpson's explanation of the prevailing positive charge in rain, snow and hail depends on the splitting-up of large drops: the present writer explains how the occurrence of these large drops can be accounted for along the lines of his own theory of the formation of hail (1929 Abstracts, p. 41).

Anormali Dispersioni elettriche dell'Atmosfera (Abnormal Electrical Dispersion in the Atmosphere).—G. Petrucci. (*Nuovo Cim.*, July, 1929, Vol. 6, pp. 305–309.)

The writer's measurements of the diffusion (at a constant potential of 150 v.) measured by a La Rosa electroscope show high and irregular peaks from hour to hour between about $11^h$ and $19^h$. He considers that they completely confirm Brillouin's words "An electrical distribution, in perfectly insulating air, may be in equilibrium under the combined action of electric force, pressure and gravity. But this equilibrium can be stable only rarely (I think 'never' but have no general proof as yet). The very localised modifications will be unstable, the more so the narrower they are. It seems probable that the result will be jets of electrified air rapid enough to produce an electromagnetic action (Wireless parasites). . . ."

THE ELECTRIC CHARGE ON RAIN.—T. C. Marwick. (*Nature*, 30th Nov., 1929, Vol. 124, p. 861.)

Summary of a Roy. Met. Soc. paper. Thunderstorm rain showed a high positive charge per c.c. Of the total quantity observed, 94.6 per cent. was positively charged, compared with 79.5 per cent. for non-thunderstorm rain (which had a lower charge per c.c.). Hail and rain mixed had only 39.4 per cent. of positively charged drops, the charge per c.c. being about the same as for non-thunderstorm rain.

INFRA-RED PHOTOGRAPHS : CARBON IN THE SUN.—(*Science*, 20th Dec., 1929, Vol. 70, pp. X and XII.)

"Because movie producers wanted a film that would give night effects to pictures taken in the daytime," a new dye (neocyanin) has been produced which renders a film sensitive to infra-red light (and photographs taken by this light give a black sky). The use of this dye has led to the definite proof of the presence of carbon in the sun.

ÜBER DAS NÄCHTLICHE LEUCHTEN DER HOHEN ATMOSPHÄRE ÜBER GÖTTINGEN (The Night Glow of the Upper Atmosphere over Göttingen).—L. A. Sommer. (*Zeitschr. f. Phys.*, 3rd October, 1929, Vol. 57, No. 9/10, pp. 582–600.)

The writer's latest results, in photographing and measuring numerous hitherto undetected bands corresponding with those in the aurora borealis, weaken Rayleigh's argument that the night glow and the aurora are two physically different phenomena.

THE ZODIACAL LIGHT.—H. T. Stetson. (*Science*, 27th December, 1929, Vol. 70, pp. 634–635.)

"The rapidity of the fluctuation ['a fluctuation in its brightness over a period of two or three minutes'] suggests that we may be dealing with an atmospheric or gaseous affair excited by solar activity."

THEORY OF MAGNETIC FIELD ASSOCIATED WITH SUN-SPOTS.—R. Gunn. (*Astrophys. Journ.*, May, 1929, Vol. 69, pp. 287–292.)

WAVES AND TIDES IN THE ATMOSPHERE.—G. I. Taylor. (*Proc. Roy. Soc.*, 2nd December, 1929, Vol. 126 A, pp. 169–183.)

AMERICAN RESULTS WITH THE KLYDONOGRAPH.—H. Neuhaus. (*Siemens Zeitschr.*, May–June, 1929, Vol. 9, pp. 368–375.)

A survey with a complete bibliography.

## PROPERTIES OF CIRCUITS.

THÉORIE GÉNÉRALE DE LA SYNCHRONISATION (The General Theory of Synchronisation).—J. Haag. (*Comptes Rendus*, 30th Dec., 1929, Vol. 189, pp. 1244–1246.)

(1) Elementary theory in the case of instantaneous impulses.—If the natural periods of oscillator and synchronising force be $2T$ and $2T'$ respectively, $D$ the logarithmic decrement and $I$ the moment of inertia of the oscillator, and $If\frac{\pi^2}{T^2}$ the constant frictional couple, then to maintain an oscillation of amplitude $\theta_0$ the following equation must be satisfied, where $u$ is the increase of angular velocity produced by each impulse (assumed to be at each half-period) :—

$$u^2 = \frac{\pi^2}{T^2}\left[(2f + \theta_0 D)^2 + \pi^2\theta_0^2\left(\frac{\Delta T}{T}\right)^2\right],\ \Delta T$$

being $T' - T$. This formula allows the ready discussion of the influence of $f$, $D$ and $\Delta T$ on the amplitude resulting from any given impulse : thus for synchronisation to be possible it is necessary that $u > \frac{2f\pi}{T}$. Formulæ are also given for $\phi$ (phase angle between impulse and end of oscillation) and for energy furnished by each impulse.

(2) Case where the synchronising force is not instantaneous : it is shown that the law governing the synchronising force during a period is of no importance, the more general case reverting to (1). The note then deals with (3) a synchronising force depending on elongation and velocity, (4) influence of the counter-electromotive force created by the movement of the oscillator, and (5) the influence of a disturbing force, independent of time, adding itself to the synchronising force (*e.g.*, the effect of intermittent friction due to a counting mechanism).

FREQUENCY VARIATIONS OF VALVE OSCILLATORS.—D. F. Martyn. (*E.W. & W.E.*, Jan., 1930, Vol. 7, pp. 3–15.)

An experimental and theoretical investigation, leading to the description of a constant frequency oscillator in which all grid current is eliminated by means of grid bias. When properly adjusted "it was found that the frequency remained constant to one part in a million over a period of hours." The adjustments must be carefully made or the oscillations will cease before the grid current is reduced to zero. The H.T. voltage should be as large as the valve can take without damage, the filament current as low as possible (reduced bit by bit with appropriate re-adjustment of grid bias) ; the negative grid bias should be large. Inductance of grid coil should be small, the coupling to anode coil not too loose.

The outline of the paper is as follows : I.—Experimental : (1) Effect of filament current : increase of current produces decrease of frequency, the total change being greater for high than for low plate voltages—except with large positive grid bias, when the largest change is for low plate voltages. The variation depends in extent "almost entirely" [but other factors of importance are mentioned] on the ratio $L_1/C_1$ (in tuned plate circuit) : if this ratio is large, variation of several octaves is possible : if small, variations are reduced to, say, 1 per cent. (2) Effect of plate voltage, (3) of grid bias, (4) of coupling, (5) of resistance in series with $L_1$ and in series with $C_1$.

II.—Theory. Treatment of Eccles and of Appleton and Greaves: the variation accounted for is very much smaller than that observed practically. (1) Theory of Generation of Oscillations taking account of Grid Current (*cf.* same writer, 1928 Abstracts, pp. 33 and 520). "When the resistances present are not large, and the frequency is not too high, it is permissible to say that grid current is the sole cause of observed frequency variations. At very high frequencies two other causes come into action. The first of these causes is the inter-electrode capacities in the valve, and the second is the finite time taken by the electrons from the filament to reach the electrodes." (2) Condition of maintenance; (3 and 4) Conditions for the occurrence of greatest frequency changes and of the smallest; (5–9) the theory applied to explain the effects of factors I. 1–5; (10 and 11) the two factors mentioned above, viz., inter-electrode capacity (expansion of electrodes: the effect of increased electron clouds in the dielectric—"the effect is small, and it decreases as the frequency increases. At high frequencies it is entirely negligible") and the effect of electron motions (negligible except at very high frequencies combined with large filament current and low plate voltages).

DIE RÜCKWIRKUNG FLÄCHENHAFTER LEITER AUF DAS MAGNETISCHE FELD VON SPULEN (The Reaction of Conducting Sheets on the Magnetic Field of Coils).—F. Ollendorff. (*E.N.T.*, Dec., 1929, Vol. 6, pp. 479–500.)

In this mathematical investigation the coil is replaced by a magnetic dipole; for its primary field an integral representation is given, which gives the field radially as Bessel functions and axially as exponential. The secondary field of the eddy currents in the plate can be represented by similar field components. The combination of the primary and secondary fields, by means of the border conditions holding at the plate, leads to an integral representation of the whole field which gives the formal solution of the problem. From this the writer proceeds further, dealing with the supplementary losses; the influence on these of the shape of the coil (a complex correction factor is derived to correct for the difference between the coil and the ideal magnetic dipole); the screening action of the plate; the quasi-stationary eddy current field—allowance for the fact that the plate is finite in extent. A numerical example is given of the application of the results obtained.

P.D. AND E.M.F.—E. A. Biedermann. (*E.W. & W.E.*, January, 1930, Vol. 7, pp. 21–22.)

Continuation of the discussion referred to in January Abstracts, p. 40.

THE DEFINITION OF SELECTIVITY.—F. M. Colebrook: E. A. Biedermann. (*E.W. & W.E.*, Oct. and Nov., 1929, Vol. 6, pp. 552–553 and 622.)

A discussion on Colebrook's paper referred to in 1929 Abstracts, pp. 629–630. It is there proposed that, given an impedance $Z$ which is a function of frequency ($\omega/2\pi$), resonance should be defined by $\frac{\delta Z}{\delta \omega_r} = 0$ and selectivity by

$$\omega_r \sqrt{\frac{1}{Z_r}\left|\frac{\delta^2 Z}{\delta \omega_r^2}\right|}.$$

Biedermann traces the derivation of this formula and shows that it is based on the coefficient of $\left(\frac{\delta\omega}{\omega}\right)^2$ in the expansion of $Z^2(\omega + \delta\omega)$ in terms of $Z^2(\omega)$ and $\delta\omega$. In the many cases where the series is rapidly converging, for a given value of $\frac{\delta\omega}{\omega_r}$ the selectivity is practically dependent only on this coefficient of $\left(\frac{\delta\omega}{\omega_r}\right)^2$, and it is the square root of this coefficient which Colebrook proposes as the definition of selectivity. Biedermann, however, stresses the importance of the cases where the remaining terms of the series are *not* negligible. He further suggests that *if* selectivity is to be defined in terms of one coefficient it should be in terms of the coefficient of $\delta\omega^2$ rather than that of $\left(\frac{\delta\omega}{\omega}\right)^2$, since in practice we judge of the selectivity of the circuit by the ratio

$$\frac{I}{I'}\left(= \sqrt{1 + 4 \cdot \frac{L^2}{R^2}\delta\omega^2}\right)$$

at some frequency difference, and are not primarily concerned with the *ratio* of this frequency difference to the resonant frequency. According to Colebrook's definition, he says, the selectivity of a tuned anode circuit is greater the smaller the capacity—for a given frequency; whereas it is generally recognised that the opposite is the case.

As, however, no definition in terms of any one such coefficient can cover all cases, he suggests finally that selectivity should be defined as the ratio of the quantity concerned at the resonant frequency to that existing at a frequency differing by some specified amount (say 10 kc.) from the resonant frequency (*cf.* Hull, 1929 Abstracts, p. 632). In his reply, Colebrook agrees that this definition may have advantages from a practical and technical point of view, but points out that a definition based on a proportional change in frequency (*cf.* resolving power in optics) is free from any arbitrary element and is thus more satisfactory from a logical and scientific viewpoint. He defends his proposed formula, the form of which is equivalent to introducing the limiting condition $\delta\omega \rightarrow 0$, in which case (assuming the convergency of the series) all the terms vanish except that on which his definition is based.

ÉTUDE SUR UN FILTRE ÉLECTRIQUE (An Electric Filter).—G. Fayard. (*Bull. Soc. Franç. Radioélec.*, June, 1929, pp. 103–110.)

This special design of filter consists of a series of amplifying stages in each of which the anode impedances have the selective properties of a band-pass filter; each stage gives a cupped curve approaching the ideal rectangular form.

A series of these stages, similar in all respects except for the choice of the middle and edge frequencies of their bands, gives "remarkable efficiency and regularity."

High-pass and low-pass filters can be made on the same principle. A diagram and curves, together with explanatory text, will be found in *L'Onde Élec.*, October, 1929, p. 59A, while a theoretical treatment by the same writer is referred to in 1929 Abstracts, p. 149.

A PHENOMENON OF THE OSCILLATING ARC.—W. Cramp and A. P. Jarvis. (*Nature*, 14th Dec., 1929, Vol. 124, p. 913.)

". . . it does not appear to have been noticed that such an arc [carbon arc fed with d.c.] will oscillate violently when the shunt circuit contains no inductance whatever." The writers, using both a carbon arc in air and a Poulsen arc in coal gas, have obtained such oscillations, dependent for frequency (for given capacity and supply voltage) on the resistance in series on the d.c. side, just as in the case of a neon lamp. In the table of results given, the frequency varies from 940 to 2,520. The ratio r.m.s. high frequency/d.c. feed ranges between 3.92 and 5.37. Oscillograph tests are described. An arc 1 mm. long, with $C = 216$ μF., $R = 31.6$ ohms, d.c. volts 215, gave a condenser-charging current averaging 1.76 A. and lasting for $40 \times 10^{-4}$ sec. The maximum discharge current was 126 A., and the time of discharge about $5 \times 10^{-4}$ sec. The writers point out that besides the scientific interest of these results, they show how a cable on any system (having considerable capacity and little inductance) may cause violent disruptive effects if the insulation gives way at any point.

PHASE RELATIONS IN A MULTI-VALVE OSCILLATOR.—A. P. Stvolin. (*See* under "Transmission").

FREQUENCY CHARACTERISTICS OF AUDIO-FREQUENCY TRANSFORMERS.—S. Takamura. (*Res. Electrot. Lab. Tokyo*, April, 1929, No. 256, 47 pp.)

In English. Author's abstract:—The author obtains a simplified equivalent circuit deduced from a series of experiments, and derives an equation which can be used conveniently for calculating the frequency characteristics of the transformer with the circuit. The effects of the transformer and the valve constants on the frequency characteristics are investigated both theoretically and experimentally, and the conclusions are: (1) all stray capacities of the several parts of the transformer affect the second peak of its frequency characteristic in a similar manner, whereas resistances, as a whole, lower the amplification; (2) the primary shunt resistance flattens the characteristic curve in the lower frequency band, while the secondary shunt resistance lowers the second peak; (3) it is due to the series resonance effect of the plate circuit that the value of the amplification near the second resonance frequency exceeds considerably the product of the turn ratio of the transformer and the amplification constant of the valve.

## TRANSMISSION.

ZUR THEORIE DER BARKHAUSENSCHWINGUNGEN (On the Theory of the B.-K. Oscillations).—H. G. Möller. (*Zeitschr. f. Hochf. Tech.*, December, 1929, Vol. 34, pp. 201–207.)

Barkhausen's explanation of these oscillations leaves the following point unexplained:—if an alternating current is to be produced in the Lecher wire system, the space charge *as a whole* must oscillate from the filament, through the grid, to the anode and back again, and in such a way that during one half-period it dwells predominantly in the filament-grid space and during the other half-period in the anode-grid space. Barkhausen's theory only explains the pendulum action of *individual* electrons. Since in each element of time an equal number of electrons emerge from the filament to take up their pendulum-motion, there must continually be a space charge returning in front of the anode and another in front of the filament. How this (at first) unsystematic medley of electrons swinging past and between each other becomes organised into a combined manœuvre is, in this paper, investigated and explained, the theory evolved being represented both mathematically and graphically. It is based on the "sorting out" of electrons on arrival at the anode, the process being controlled by the a.c. potential impressed on the grid.

Some implications of the theory are as follows:—(1) A condenser between whose plates a space charge swings with frequency $\omega$ behaves exactly as an oscillatory inductance tuned to $\omega$. Such an equivalent inductance forms, in the B.-K. oscillations, the oscillatory circuit: the Lecher wire system merely forms a coupled secondary circuit.

(2) The anode potential most favourable to the production of B.-K. oscillations is that for which the electrons ordinarily can *just reach* the anode; owing to their deflection, by the grid wires, from their radial paths, this potential is slightly positive. Either an increase or a decrease will diminish the activity of the valve.

(3) If the path time between filament and grid is greater than that between grid and anode, no oscillations take place; if it is smaller, oscillations are set up. This is readily tested: if the grid potential is arranged to be less than the saturation potential, the electron reaches its full velocity only when close to the grid and takes too long reaching it—no oscillations: if now the filament heating is *decreased* so that the grid potential passes the saturation potential, the slope of the potential curve changes (from parabolic to linear or upward-bent curve), the electron reaches its full velocity quickly, and oscillations set in.

ÜBER DIE ULTRAKURZEN ELEKTRISCHEN WELLEN, DIE NACH DEM BARKHAUSENSCHEN SCHEMA ERZEUGT SEIN KÖNNEN (On the Ultra-short Waves obtainable by the Barkhausen Method).—G. Potapenko. (*Zeitschr. f. tech. Phys.*, Nov., 1929, Vol. 10, pp. 542–548.)

The writer records his results in the form of a three-dimensional plastic model, representing the relations between amplitude of oscillation, grid-potential, and the natural frequency of the anode and grid circuits. An investigation of these models, for a number of types of valve, shows that in addition to the waves of normal length, conforming approximately to the Barkhausen law $\lambda^2 E_g =$ const. (C), a number of other waves can be generated ("pigmy" waves) of length 2, 3, 4 . . . times shorter. With a Russian valve 10 cm. waves were obtained; with a German TKD 49, waves down to 3.5 cm.

The formation of the "pigmy" waves of the 1st, 2nd . . . order is explained as follows:—Kapzov (1929 Abstracts, p. 154) showed by integration of the electron motion equations, assuming oscillating circuit natural period $T$ to equal $2t$ ($t$ = electron time from filament to anode) or $\tau$, that those electrons leaving the filament between the times $\omega t = \pm 70$ deg. approx. could swing to and fro at the grid, the remainder reaching the anode. This gives the "normal" Barkhausen waves. Further integration (by the Runge-Kutta method) now shows that this effect can also happen for $T' = \tau/2$, $T'' = \tau/3$ . . . thus giving the "pigmy" waves of 1st, 2nd . . . order; for these, $\lambda^2 E_g = C/4$, $C/9$, $C/16$ . . . .

As regards energy, in general this decreases as the "order" increases. Success was, however, finally obtained in constructing a special valve containing a movable internal bridge across the prolonged ends of the grid spiral: with this, it was possible to increase several times the energy of any particular pigmy wave by decreasing the energy of the other orders. An abstract in *E.N.T.* (Nov. issue) gives the following powers:— $\lambda > 30$ cm., several watts; $\lambda = 30 - 10$ cm., about one watt; $\lambda = 10$ cm., 0.1 w.

RASPREDELENIE FAZ V SLOJNOM LAMPOVOM GENERATORE NEZATUHAUSCHIH KOLEBANII (Phase Relations in a Multi-valve Oscillator).—A. P. Stvolin. (*T.i T.b.p., Leningrad*, October, 1929, Vol. 10, pp. 526–534.)

In Russian. A report on experiments carried out at the Moscow Research Institute with a multi-valve oscillator designed by Prof. Romanov for wavelengths less than one metre. The oscillator consists of several valves connected in parallel by copper tubes sliding on bus bars, the distance between the valves thus being variable. Radiating antennæ are connected to the plate and grid bus bars. The plates are kept at zero potential and a high positive voltage is applied to the grids.

The phase relations in the oscillator are determined. The way in which they are affected by varying the angles between the "anode" and "grid" antennæ is also discussed. The connection between the energy radiated and the plate currents of the oscillating valves is briefly indicated.

RAZBOR SKEM RADIOTELEFONIH PEREDATCHIKOV S MODULIACIEI NA SETKU (Discussion of Different Systems of Grid Modulation).—N. D. Smirnov. (*T.i T.b.p., Leningrad*, October, 1929, Vol. 10, pp. 447–457.)

In Russian. A detailed theoretical discussion is given on the following systems of modulation: (*a*) Grid voltage modulation, (*b*) Grid leak modulation, (*c*) Grid modulation on the first of two valves in cascade.

Modulation on valves with plate and grid circuits coupled is also considered. Theoretical modulation curves for the above systems are constructed. Some curves obtained at the Moscow Radio Station are also shown. It is indicated that (1) systems (*c*) and (*a*) are more efficient than system (*b*), (2) A bias battery should be used in preference to a grid leak; and (3) The plate and grid circuits of the modulated valve should not be coupled.

MESSUNGEN IN DEM GEBIETE DER ULTRAHERTZSCHEN UND DER WÄRMEWELLEN (Measurements in the Region of the Ultra-Hertzian and Heat Waves).—A. Glagolewa-Arkadiewa. (*Zeitschr. f. Phys.*, 14th Oct., 1929, Vol. 58, No. 1/2, pp. 134–138.)

The selective absorption shown by a thermo-element to the radiation from the writer's "Massenstrahler" (1929 Abstracts, p. 508), *e.g.* at $\lambda = 340\,\mu$, is repeated with the long heat waves of the quartz mercury vapour lamp.

## RECEPTION.

ÜBER KURZWELLENEMPFANG IN BEWEGLICHEN STATIONEN (On Short Wave Reception at Mobile Stations).—K. Krüger. (*Zeitschr. f. tech. Phys.*, Nov., 1929, Vol. 10, pp. 528–532.)

A paper on the difficulties of short wave reception in travelling craft (motor-lorries, motor-boats, aircraft, etc.), leading the writer to the use of quartz-controlled receivers: the most satisfactory arrangement proved to be a short wave audion circuit and a quartz-controlled heterodyne oscillator, giving an intermediate frequency (250–487 m.). The intermediate frequency audion circuit gave autodyne reception in the form of a note whose pitch could be adjusted to the best value. For a longer abstract of a similar paper, *see* 1929 Abstracts, p. 573.

SEPARATION OF BROOKMAN'S PARK TWIN PROGRAMMES. (*Engineer*, 3rd Jan., 1930, Vol. 149, p. 15.)

A paragraph on tests designed to discover how near to Brookman's Park it is possible to get and still be able to separate the two programmes which, according to numerous complaints, "came over confused and clashing with each other." A four-valve portable was used, and the test ended actually at the gates of the station, where "not only were the two programmes separated and heard clearly, but several continental stations, including Berlin and the Eiffel Tower, were received."

THE PARALLEL-FED L.F. AMPLIFIER.—F. Aughtie and W. F. Cope. (*Wireless World*, December 11th, 1929, Vol. 25, p. 644.)

Discussing the advantages of deflecting anode current from the primary windings of the l.f. transformer by means of a suitable resistance capacity filter. The lower "cut-off" frequency is reduced in value (the d.c. feed current of the valve flowing only through the resistance and not the primary of the transformer), and the condenser reduces the impedance of the circuit, thereby permitting a larger current and a consequent increased voltage across the transformer.

To facilitate design, a number of curves are given showing the correct coupling condenser for various primary inductances and valve resistances.

H.F. AMPLIFICATION WITHOUT DISTORTION.—
—. Kofes. (*Funkbastler*, 2nd August, 1929, Vol. 31, pp. 481–484.)

Comparing fidelity curves of l.f. transformers and loud-speakers with the selectivity curves of the tuned stages of receivers, the writer concludes that the chief cause of distortion in commercial receivers is too great r.f. selectivity. A systematic de-tuning of the successive circuits improves matters, but the writer recommends particularly the use of filters with nearly rectangular resonance curves as coupling between valve and valve. A diagram of his proposed arrangement is given in *L'Onde Élec.*, October, 1929, p. 58A.

METALLIC RESISTANCES OF $10^{10}$ TO $10^{11}$ OHMS.—
(*See* Perucca, under "Subsidiary Apparatus.")

For the use of resistances of this order as grid resistances in amplifiers, see Mulder and Razek, and Teegan, in 1929 Abstracts, p. 516, and Feb. Abst., p. 110.

"STENODE RADIOSTAT."—G.W.O.H. (*E.W. & W.E.*, Jan., 1930, Vol. 7, pp. 1–2.)

Editorial on the apparatus or system recently announced in the daily Press. "Although, therefore [owing to insufficient published details] we cannot criticise the threatened revolution, we can discuss the constitution of the state which is to be revolutionised, and thus get a clear idea of what the inventor is up against."

ELIMINATION OF FADING.—(*Amer. Pat.*, 1719845, Martin, pub. 9th July, 1929.)

Two spaced aerials each have a separate receiver but a common heterodyne. The two l.f. outputs are passed on by separate transformers to a common receiver: a grid-circuit variable resistance in the first valve of this adjusts the strength, while a polarising winding on one of the two transformers mentioned above is used to adjust the phase.

RADIO TELEGRAPH RECEIVERS.—A. J. Gill and G. H. Farnes. (*P.O. Elec. Eng. Journ.*, Jan., 1930, Vol. 22, pp. 303–305.)

A brief illustrated description of two receivers recently constructed at the P.O. Experimental Station, furnishing an indication of the present trend of development in such apparatus. One is a group of four monitoring long-wave receivers for the Central Radio Office, London; the other is of a more sensitive type, with a wave-range of 300–20,000 m.

EIN KURZWELLEN-EMPFÄNGER FÜR TRANSOZEANISCHEN SCHREIBBETRIEB (A Short Wave Receiver for Trans-oceanic Recording).—
W. Runge. (*Telefunken Zeit.*, Sept., 1929, Vol. 10, No. 52, pp. 43–54.)

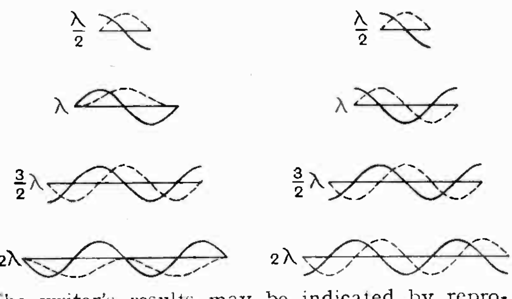
## AERIALS AND AERIAL SYSTEMS.

ÜBER DIE SCHWINGUNGEN EINES OSZILLATORS IM STRAHLUNGSFELDE (On the Vibrations of an Oscillator in a Radiation Field).—N. v. Korshenewsky. (*Zeitschr. f. tech. Phys.*, Dec., 1929, Vol. 10, pp. 604–608.)

A paper dealing with current and potential distribution in a linear (symmetrical) oscillator excited uniformly along its whole length by a plane wave arriving normally to it (*e.g.*, a receiving aerial in free space). The case first considered is where the length of the aerial bears a simple relation to the wavelength: then the detuned aerial is dealt with.

The well-known distribution curves (*e.g.*, current distribution curves) of an aerial excited to its fundamental or harmonic frequency ($l = \lambda/2$, $\lambda$, $3\lambda/2$, $2\lambda$ . . .) by shock or by the supply of energy at a definite point, seem often to be assumed true for the case of a receiving aerial. If this were so, what would happen if the $\lambda/2$ aerial were slightly increased in length? It would probably be assumed that the current distribution would maintain the typical $\lambda/2$ shape but that the amplitude would decrease somewhat for lack of resonance. But an aerial longer than $\lambda/2$ is also shorter than $\lambda$, so that the typical $\lambda$ shape might also be expected, with decreased amplitude as before: while—still more confusing—if the aerial were lengthened gradually from $\lambda/2$ towards $\lambda$, a sudden change-over from the $\lambda/2$ shape to the $\lambda$ shape might be expected. This is obviously wrong, and the writer investigates what actually happens.

An application of the mathematical treatment of the propagation of waves along wires, with the special condition that the current at both ends shall be zero, leads to a formula *which is symmetrical as regards the two ends* and is independent of the length of the aerial: *i.e.*, whether tuned or untuned, the aerial must have the same current distribution at equal distances from its two ends. The usual $\lambda$ and $2\lambda$ curves are therefore impossible. The usual $\lambda/2$ and $3\lambda/2$ curves, on the other hand, are possible since they conform with this condition.




The writer's results may be indicated by reproducing the above curves, comparing both current- and voltage-distribution for an aerial as specified (left) with those of an aerial excited as a transmitter (right).

Of particular interest is the case $l = \lambda$, where the receiving aerial shows a current loop at the mid-point, against a node in the transmitting aerial, and potential nodes at the free ends against potential loops in the transmitting aerial [for $l = \lambda$ or $2\lambda$, the receiving aerial thus has nodes of current *and* of potential at the free ends].

From these curves it can be gathered how, as the length of the aerial is gradually increased, the distribution gradually alters without any sudden change. This is shown more clearly in a series of curves $l = \lambda/2, 3\lambda/4, \lambda, 5\lambda/4 \ldots$, which also shows how nodes occur which are *not* a distance $\lambda/2$ apart —the spacing varying between 0 and $\lambda$. The rest of the paper describes a graphic method of determining, without calculation, the current and potential distribution in a given aerial.

THE CONSTANTS OF AIRCRAFT TRAILING ANTENNAS.—L. A. Hyland. (*Proc. Inst. Rad. Eng.*, Dec., 1929, Vol. 17, pp. 2230–2241.)

A short description of the measuring apparatus and methods is given. The tests were on several types of aircraft, including the dirigible "Los Angeles." Curves for a typical aeroplane and dirigible are compared, and conclusions drawn as to the centre of radiation and as to the relation between this and the aerial resistance. If $l/\lambda_0$ is plotted against aerial resistance, both on a logarithmic scale, the result is a series of points along a straight line, from the slope of which an empirical formula may be developed to show resistance in terms of frequency and aerial length. The uniformity of aerial constants of heavier-than-air craft is noticed: also the negligible effect of structural differences, speed and weight on the characteristics of the aerial.

AERIAL DESIGN FOR SHORT WAVE TRANSMISSION.—G. L. Morrow. (*Journ. Inst. Wireless Tech.*, Nov., 1929, Vol. 2, pp. 89–116.)

The author considers the radiation from vertical aerials of length of half and three-quarters of the wavelength, which is of the order of 10 to 30 metres. The angle of maximum radiation in the vertical plane is calculated for a number of typical cases, neglecting the effect of the earth. The results have been compared with some experimental measurements, and the conditions for obtaining maximum radiation at any specific angle, with or without the radiation of a ground wave, are detailed.

DIE BÜNDELUNG DER ENERGIE KURZER WELLEN (Beam-Concentration of the Energy of Short Waves).—O. Böhm. (*Telefunken Zeit.*, Sept., 1929, Vol. 10, No. 52, pp. 27–34.)

*See* 1929 Abstracts, pp. 104–105.

## VALVES AND THERMIONICS.

UNTERSUCHUNGEN ÜBER SEKUNDÄREMISSION (Investigations on Secondary Emission).—K. Sixtus. (*Ann. der Phys.*, 23rd Dec., 1929, Series 5, Vol. 3, No. 8, pp. 1017–1054.)

Author's summary :—Secondary emission at the anode, in commercial valves with various cathode-materials (tungsten, thoriated tungsten, oxide-coated cathode), is discussed in the light of measured results. The differences displayed in the amounts of secondary emission are attributed to the nature of the anodic surface-layer, which may consist of vaporised cathodic material.

Irregularities of the characteristic in the case of Siemens BE. valve are attributed to the special geometrical arrangement of electrodes.

In valves with equi-potential oxide-coated filament, the grid- and anode-characteristics both show striking irregularities between 0 and 10 v. These are shown to be due, probably, to selective absorption and reflection at the electrode surfaces.

The contact P.D. (Volta-potential) between tungsten and thoriated tungsten is about 10 per cent. smaller than the difference between the emergence-work of the two materials. The amount of the secondary emission in the temperature range 300–1000°K. is independent of the temperature of the emitting body. While the primary emission of a tungsten wire is increased 100,000 times by its being thoriated, the secondary emission is increased at most by 20 per cent. This fact is due to the high intrinsic velocity of the secondary electrons, in view of which a small decrease of emergence-work has little effect.

On the assumption of Maxwell's velocity distribution for the secondary electrons (this appears from the test results to be approximately correct) the mean velocity of the secondary electrons in the metal can be calculated. Measurements on oxide-coated filaments show no regular connection between the amount of secondary emission and the emergence-work.

GRID BIAS VALUES.—W. I. G. Page. (*Wireless World*, 18th December, 1929, Vol. 25, p. 666.)

The author urges valve manufacturers to publish anode current-anode voltage curves in preference to the more usual grid voltage-anode current characteristics. It is contended that only with such curves is it possible for the grid potential to be properly adjusted to give the minimum distortion with the greatest possible amplification.

Notes are included with regard to the effect on grid bias of the early flow of grid current with indirectly heated valves, and the alteration from normal bias which becomes necessary when the filaments of power valves are directly fed with raw a.c.

THE PENTODE UNDER WORKING CONDITIONS.—Research Dept. of the G.E.C. (*Wireless World*, 4th December, 1929, Vol. 25, pp. 630–633.)

Operating notes regarding the correct conditions of load necessary to obtain the maximum undistorted output. Attention is drawn to excessive voltages developed when the pentode is used incorrectly.

VALVE DATA.—(*Wireless World*, 4th December, 1929, Vol. 25, pp. 614–617.)

An article explaining how to take the utmost advantage of valve characteristics with particular reference to the valve data chart published with *The Wireless World* of 4th December. Sections are devoted to screen-grid valves, miscellaneous valves (with a.c. resistances greater than 13,000, certain anode and grid detectors and early l.f. types), output valves, pentodes and rectifiers. The undistorted a.c. watts output for 5 per cent. second harmonic in respect of some 85 output valves is given. This valuable constant should render the design of the output stage considerably easier.

PRESERVATION OF ANODES.—(German Patent 482531, Seibt, pub. 16th September, 1929.)

To avoid the deterioration of anodes by sputtering, they should be enriched with manganese or similar material by tempering.

SCHOTTKY EFFECT AND CONTACT POTENTIALS OF THORIATED TUNGSTEN FILAMENTS.—N. B. Reynolds. (*Phys. Review*, No. 6, 1929, Vol. 33, p. 1083.)

CURRENT DISTRIBUTION NEAR EDGES OF DISCHARGE-TUBE CATHODES.—P. B. Moon and M. L. Oliphant. (*Proc. Camb. Phil. Soc.*, Oct., 1929, Vol. 25, Part 4, pp. 461–468.)

An investigation and explanation of the observed fact that the disintegration of a plane cathode in a gas discharge was not uniform, but showed a maximum at a small distance from the edge.

A NEW METHOD OF PRODUCING AND CONTROLLING THE EMISSION OF (POTASSIUM) POSITIVE IONS.—F. G. Cottrell, C. H. Kunsman and R. A. Nelson. (Supp<sup>t</sup>. to *Journ. Opt. Soc. Am.*, Oct., 1929, Vol. 19, No. 4, Part 2, pp. 9–10.)

Abstract only.

L'ÉMISSION ÉLECTRIQUE DU TUNGSTÈNE INCANDESCENT DANS UNE ATMOSPHÈRE D'IODE (The Electric Emission from Incandescent Tungsten in an Atmosphere of Iodine).—S. Kalandyk. (*Journ. de Phys. et le Rad.*, September, 1929, Vol. 10, p. 377.)

An atmosphere of iodine diminishes the positive emission of the fresh surface, but has no effect on the positive emission of a previously heated filament. It increases the negative emission of tungsten, particularly at low incandescent temperatures. It diminishes the emission of thoriated tungsten, but has no effect on the emission of oxidised tungsten.

DIE BESTIMMUNG DER GESCHWINDIGKEIT DER GASSTRÖMUNG IN GASGEFÜLLTEN GLÜHLAMPEN (The Determination of the Velocity of Gas Currents in Gas-filled Incandescent Lamps).—E. Lax and M. Pirani. (*Zeitschr. f. Phys.*, 14th Oct., 1929, Vol. 58, No. 1/2, pp. 7–10.)

## DIRECTIONAL WIRELESS.

ZUR FRAGE DER STANDORTSBESTIMMUNG VON SENDERN MITTELS FUNKPEILUNG (On the Determination of the Bearings of Transmitting Stations by Wireless D.F.).—P. Duckert. (*Mitt. Aeron. Obs. Lindenberg*, 1929, pp. 193–197.)

*Cf.* 1929 Abstracts, pp. 214 and 636, same writer. Here he refutes the idea that the size of the triangle of error is a measure of the accuracy of the direction finding. He considers the ordinary procedure (method of smallest [quadrate] square) to be inapplicable, since the systematic errors due to the weather conditions are considerably greater than the casual errors. These systematic errors are, he suggests, of such a kind that the "bearing rays" within the North Sea network are all simultaneously deflected in the same sense and by the same amount. On this hypothesis he proposes that for any determination of bearing, the three bearing rays should be swung so as to obtain the smallest possible triangle.

DIRECT-READING D.F.—(German Patents 481703 and 482281, Dieckmann and Hell, pub. 31st August and 11th September, 1929.)

Patents concerning the arrangements referred to in 1929 Abstracts, pp. 393 and 394.

RANGE OF RADIOBEACONS: RADIO MARKER BEACONS.—(*Bur. of Stds. Tech. News Bull.* Nov., 1929, No. 151, pp. 107–108.)

"This type of radiobeacon can furnish 12 courses for guiding airplanes along any desired courses regardless of the angles between them. Small changes in electrical characteristics occur during normal operation, but a study of the phase relations of the amplifier trains used in the transmitter showed that under conditions of practical operation the direction of courses was not affected by these changes. Another result of the special study of the design . . . was a 60 per cent. increase in power output." The 3-reed indicator, for receiving any one of the 12 courses, was also improved; in particular, a switching arrangement, automatically operated by a shutter on the indicator front, was devised whereby the pair of driving coils controlling the reed not in use are switched out of circuit. "The sensitivity of the reed indicator is thus increased by about 15 per cent." The magnetic properties of the elinvar used for the reeds is improved by cold-rolling.

Regarding the marker beacons, recent tests indicate that a loop aerial may be better than an open one because of the sudden drop of deflection when the aeroplane is directly over the loop aerial: this is of special importance in fog-landing. Other improvements are mentioned.

APPLYING THE RADIO RANGE [EQUI-SIGNAL ZONE RADIO-BEACON] TO THE AIRWAYS.—F. G. Kear and W. E. Jackson. (*Proc. Inst. Rad. Eng.*, Dec., 1929, Vol. 17, pp. 2268–2282.)

The aural type (the only type to be put into routine daily operation at present) is discussed, particularly with regard to methods of adjusting the space pattern of the beacon system so that the courses may align with the fixed airways. By using a vertical wire aerial in addition to the loops, and varying the relative power in the latter, practically any array of courses desired is possible.

PAPERS ON WIRELESS FOR AIRCRAFT.—H. J. Walls: F. Eisner and H. Fassbender: L. D. Seymour: E. H. Furnival. (*See* under "Stations, Design and Operation"; for another paper by Fassbender, *see* under "Miscellaneous.")

APPLYING THE VISUAL DOUBLE-MODULATION TYPE RADIO RANGE TO THE AIRWAYS.—H. Diamond. (*Proc. Inst. Rad. Eng.*, Dec., 1929, Vol. 17, pp. 2158–2184.)

Author's summary :—This paper deals with methods for aligning the courses of the visual radio range with the fixed airways. It has previously been shown that the courses of the aural radio range may be shifted by the use of a vertical wire antenna in conjunction with the transmitting loop antennas or by varying the relative power in the two antennas. These methods are, in part, applicable to the visual system. In the aural system the goniometer primaries are excited alternately. This permits independent consideration of the field patterns due to the primaries. In the visual system this is not the case as both goniometer primaries are excited all the time. Two cases present themselves, the condition when the currents in the primaries are in time phase and the condition when they are in quadrature time phase. The former condition results in two beacon courses which are 180 deg. apart and cannot be shifted from this relationship. The latter condition yields four beacon courses. A mathematical analysis is made of this case and the amounts of angular variation possible using several methods of attack are tabulated.

A method of obtaining small amounts of shift by an adjustment of the receiving equipment aboard the airplanes is also described ; one of the reeds is shunted by a suitable resistance in order that the reeds will vibrate equally when on one side of the equi-signal zone. This method permits a great flexibility in securing a desired course and is suitable only for employment with the visual system. Sample calculations are made for actual airway routes to demonstrate the several methods of attack.

## ACOUSTICS AND AUDIO-FREQUENCIES.

SCHALLDRUCKMESSUNGEN AN MIKROPHONEN, TELEPHONEN UND IM FREIEN SCHALLFELD (Sound Pressure Measurements on Microphones, Telephones and in an Open Sound Field).—C. A. Hartmann. (*Zeitschr. f. tech. Phys.*, Nov., 1929, Vol. 10, pp. 553–558.)

The advantages of a compensation method are detailed. Since the accuracy of such a method depends on the sensitivity of the apparatus as a sound-receiver, the writer has abandoned the older electrodynamic compensation arrangements and uses an electrostatic pressure-measurer on the principle of the Riegger and Trendelenburg condenser microphone, which is distinguished by its sensitivity. A double generator circuit (the prime mover of which is a valve-driven hummer) gives two a.c. supplies, independent of one another in amplitude and adjustable in phase. The latter property is obtained by the use of a bridge circuit, amplifiers and a 3-winding transformer, which together produce a rotating field. One a.c. supply is used for the production of the sound, while the other produces the compensating potential.

The numerical connection between the compensating potential and the sound pressure is obtained by a calibration of the pressure-meter by Meyer's frequency-independent method of glass tubes containing xylol. Examples of the use of the whole apparatus are given in connection with a condenser microphone, a submarine receiver, and the effect of an ear-piece on the frequency curve of a telephone.

SRAVNENIE DVUH METODOV OPREDELENIA ZVUKOVIH AMPLITUD (Comparison of Two Methods for Measuring the Amplitude of Sound Waves).—N. N. Riabinin. (*T.i. T.b.p., Leningrad,* October, 1929, Vol. 10, pp. 543-547).

In Russian. A report on tests made at the State Laboratory of Physics in order to compare two methods of measuring the amplitude of vibration of a telephone diaphragm. The two methods are as follows:—(1) A particle of glass is placed on the diaphragm and observed through a magnifying glass. The value of the current flowing through the electro-magnet is noted when the particle becomes detached from the diaphragm. (2) The value of the current in the electro-magnet is noted when contact is broken between the vibrating diaphragm and a light contact piece held against it by a small spring. From each of these observations, the amplitude of vibration at any current strength can be calculated. It was found that when due precautions were taken, the two methods gave practically identical results.

UNTERSUCHUNG EINES SCHALLEMPFÄNGERS (Investigation of a Sound Receiver).—N. N. Andreyev. (*Physik. Berichte*, 15th Dec., 1929, Vol. 10, p. 2276.)

Abstract of a Russian article (1927) on the full investigation of a receiver in which a sensitive membrane has at its middle point a contact hammer ; on the arrival of the sound wave the contact is broken. *Cf.* Riabinin, above.

KLANGANALYSE MIT EINEM EINFADENELEKTROMETER (Musical Sound Analysis with a Single Thread Electrometer).—M. Grützmacher. (*Zeitschr. f. tech. Phys.*, November, 1929, Vol. 10, pp. 572–573.)

A simple and reliable analysing process using a symmetrical circuit which introduces an exploring potential, together with the mixed sound under analysis, to the electrometer. The force on the thread is then proportional to the product of these two alternating potentials. If the thread is so tuned that it can only vibrate at low frequencies, when the exploring potential passes through the frequency of a partial tone, the thread will vibrate to the difference frequency : if the exploring potential is kept constant in magnitude throughout the whole frequency range, the amplitude of the thread vibrations will be directly proportional to the amplitude of the partial tone.

SUR L'ANALYSE SCIENTIFIQUE DES SONS MUSICAUX (The Scientific Analysis of Musical Sounds).—J. F. Cellerier. (*Comptes Rendus*, 6th Jan., 1930, Vol. 190, pp. 45–47.)

A piezoelectric quartz microphone is used, combined with electric filter circuits for selecting the various harmonics, etc., for study in turn. The pitch is determined by comparing the oscillographic record with that of a calibrated oscillator; the *relative* intensity is judged by comparing the magnitude of the current with that of the current of equal frequency required to produce the same volume in the calibrated oscillator; the *effective* intensity is measured by the effective pressure produced at the microphone (by calibrating the quartz by Wente's method, using a gold leaf thermophone). A record is shown of the sound from a motor car horn, showing why this sound gives a high, disagreeable, and comparatively feeble effect. The research is directed particularly in this direction, in view of future legislation on the subject.

ZUR ANALYSE VON GERÄUSCHEN (The Analysis of Noises).—M. Grützmacher. (*Zeitschr. f. tech. Phys.*, November, 1929, Vol. 10, pp. 570–572.)

The writer's exploring-voltage method for the analysis of a musical sound (1928 Abstracts, p. 168) presents difficulties when applied to noises, the recording instrument showing a permanent deflection completely independent of the exploring-voltage. The trouble is cured by the use of a push-pull circuit for the rectifier; this avoids the quadratic terms and their corresponding deep difference frequencies, which (by passing through the filter) caused the permanent deflection. Examples of the method given include the spectrum curves of a Bunsen burner and of a vacuum cleaner.

PICK-UP VOLUME CONTROL.—F. L. Devereux. (*Wireless World*, December 25th, 1929, Vol. 25, p. 695.)

The potentiometer and variable shunt resistance methods are compared. From actual measurements, curves show that the high note loss with a shunt resistance of 10,000 ohms increases from 20 per cent. at 500 cycles to at least 50 per cent. at 5,000 cycles. On the other hand, in the potentiometer scheme the high note loss is negligible provided that the total resistance of the potentiometer exceeds 100,000 ohms.

ZUR FRAGE DES WIRKUNGSGRADES ELEKTRODYNAMISCHER LAUTSPRECHER (On the Efficiency of the Electrodynamic Loudspeaker).—H. Neumann. (*Zeitschr. f. tech. Phys.*, Nov., 1929, Vol. 10, pp. 548–553.)

The dependence of the electro-acoustic efficiency on the four factors :—membrane surface, membrane mass, specific resistance of coil material and magnetic energy in the volume of this, is discussed, Riegger's formula being brought into a more convenient form. Methods of improving the efficiency by treatment of each of these factors are considered and lead to a description of the writer's method of obtaining a very much stronger magnetic field, giving an important increase of efficiency. In the largest "Blatthaller" type, the maximum air-gap field is only about 9,000 gauss, being limited by considerations of overheating of coils, of magnetic leakage, and of pole-point saturation. In the writer's design, the field can reach 20,000 gauss, or 10 per cent. more if an iron-cobalt alloy (Preuss and Weiss) is used instead of iron for the pole-points. The special point of the design is the use of a number of flat magnetising coils, one encompassing each air-gap and at the same time enclosing the membrane. The shape of the coils gives plenty of cooling surface, and the magnetomotive force is concentrated on just those parts of the magnetic circuit where the reluctance is greatest. The leakage is thus decreased from the usual 90 per cent. to 52: the exciting power, for 20,000 gauss, is reduced by 56 per cent. The radiation of sound is not noticeably affected by the presence of the coils.

EFFECT OF FLIGHT ON HEARING.—C. B. Mirick. (*Proc. Inst. Rad. Eng.*, Dec., 1929, Vol. 17, pp. 2283–2296.)

Author's summary :—The unusual conditions imposed by flight on the sense of hearing are stated, showing the need of audiometric study. After brief review of the theory of the audiometer, data are submitted covering: (*a*) fatigue as indicated by measurements before and after flight, (*b*) fatigue as indicated by measurements taken during flight, (*c*) initial impairment coincident with flight, (*d*) group measurements of fliers and non-fliers as a test for permanent impairment. The results are discussed with particular view to their bearing on aircraft radio operation.

ÜBER DEN KLIRRFAKTOR LANGER FERNKABELLEITUNGEN (On the Non-linear Distortion Factor of Long Distance Telephone Cables).—M. Grützmacher. (*T.F.T.*, May, 1929, Vol. 18, pp. 143–148.)

The non-linear distortion is measured by a sound-analysis method using exploring notes. The "klirr" factor is here defined as the ratio of the effective value of the sum of all the combination tones to the effective value of the sum of all fundamental tones and combination tones. It is determined in dependence on various parameters, such as input voltage, length and nature of the conductors. The net attenuation curve is also plotted for comparison.

FREQUENCY CHARACTERISTICS OF AUDIO-FREQUENCY TRANSFORMERS.—S. Takamura. (*See* under "Properties of Circuits.")

KONSTRUCTIVNII RASCHET MEJDULAMPOVOGO TRANSFORMATORA NIZKOI CHASTOTI (Design of an Audio-frequency Inter-stage Transformer).—V. Listov. (*T.i T.b.p., Leningrad*, October, 1929, Vol. 10, pp. 458–469.)

In Russian. The method presented is based on Willans' paper (*Journ. I.E.E.*, 1926) and on the assumption that in a well-designed audio-frequency transformer the leakage inductance and effective capacity of the secondary winding should be small. Different types of transformers are discussed from this point of view. Transformer losses neglected by Willans are taken into account. A complete design of an audio-frequency transformer is given, together with an experimental check on its calculated frequency characteristic.

## PHOTOTELEGRAPHY AND TELEVISION.

Die physiologischen und die psychologischen Grundlagen des Fernsehens (The Physiological and Psychological Principles of Television).—E. Roessler. (*Zeitschr. f. tech. Phys.*, Nov., 1929, Vol. 10, pp. 519–525.)

"Latest investigations have shown that as a result of various physiological and psychological phenomena, whose importance had not been fully recognised, television is not so difficult to carry out as was anticipated [*cf.* 1929 Abstracts, pp. 156–157]; so that a primitive television on broadcasting lines is not beyond the bounds of present possibility."

Thus the writer points out that a good photograph 9×12 cm., viewed from 20 cm. distance, shows details 0.05 mm. long, or say 0.0025 sq. mm. in area. To reproduce properly, such a picture would require over 4 million elements: for an animated picture, taking the usual film rate of 20 per sec., this would involve 80 million elements per sec. Such an argument when applied to television leads to fantastic results, even if allowance is made for a much poorer quality of reproduction.

The writer shows how, thanks to certain psychological and physiological effects, such reasoning does not apply to television, though it does—to some extent—to picture telegraphy (where a grating of 0.2 to 0.3 mm. is, however, made to suffice, compared with the 0.05 mm. detail mentioned above). For example, of the four million elements of the 9×12 cm. photograph only one hundredth part is seen simultaneously, owing to the manner in which the resolving power of the retina falls off away from the visual axis (a curve of this is given). The rest of the four million are only seen by a succession of impressions, and in television there is no time for the eye-movements necessary to obtain these.

The writer deals first with a comparison between ear and eye, beginning by showing how a 2,500 cycle band is enough for intelligible speech whereas an analogous argument would demand an 8,000 cycle band: he discusses the effects of memory and imagination, and passes on to analyse the eye's perception of size and shape, and (later) of light and shade. Finally, he admits that on broadcast wavelengths "good" television is impossible: shorter waves and technical improvements should however lead to this.

Television Reception Tests.—F. H. Haynes. (*Wireless World*, 18th December, 1929, Vol. 25, p. 669.)

An account of reception of the experimental Baird transmissions from 2LO on receiving apparatus of the kind which should be within the constructive abilities of the average layman. "A slow-speed motor with ball-race bearing having an armature and commutator of the smallest permissible diameter was selected after making several tests. As to the scanning disc itself, which measured 11$\frac{5}{16}$ in. in diameter, sheet aluminium was adopted, a little more than $\frac{1}{16}$ in. in thickness, after tests had been made with another and much lighter material.

"Instead of the iron-toothed wheel, as recommended by Baird, one of fibre was constructed slightly larger in diameter than was indicated, so as to provide a more critical control and yet possessing quite moderate weight. To avoid the windage of projecting teeth, which it was quickly realised was appreciable at the normal running speed, small iron bars were pressed into a fibre disc, and their ends turned down flush with the faces.

"The next step was to arrange a generous output power stage, and the arrangement finally set up consisted of no fewer than three of the new LS6A valves with fully loaded grids, as revealed by microammeter and milliammeter, and working with the maximum rated anode voltage of 400. Even so generous an output stage as this proved insufficient to produce stable and automatic synchronising.

"As to the results obtained it may be stated that pictures were received within the first ten minutes of using the apparatus, but the synchronising was not automatic and success depended upon the very careful manipulation of the field regulating switch, combined with frequent frictioning of the disc. For the most part the successive pictures appeared as parallelograms rising and falling before the aperture. With the rising or falling string of pictures one soon learns how to speed up or retard the disc, yet an apparatus demanding such a procedure possesses no commercial merit. The neon tube functioned well, and after critically adjusting the threshold and signal voltages the contrast of the image was brought down from the harshness which it possessed at the commencement of the tests. Detail was poor, due, perhaps, in some measure to small inaccuracies in the location of the holes and to the continuously changing position of the picture."

La Phototélégraphie d'Amateur (Amateur Phototelegraphy).—R. Mesny. (*L'Onde Élec.*, October, 1929, Vol. 8, pp. 449–462.)

The paper read at the Joint Meeting of the Soc. des Amis de la T.S.F. and the Soc. des Électriciens in March, 1929. A previous reference was given in 1929 Abstracts, p. 456.

Light-ray Interruption, for Photoelectric Cells, without Perforated Disc.—(German Pat. 482798, Lorenz, pub. 20th September, 1929.)

To avoid the use of the large discs necessary to give high frequency of interruption, their function is performed by a string galvanometer, oscillograph or the like, working on high frequency a.c.

Über die Abhängigkeit einiger elektrischer und elektrooptischer Konstanten von Nitrobenzol und Nitrotoluol vom Reinheitsgrade (On the Dependence of some Electrical and Electro-optical Constants of Nitrobenzol and Nitrotoluol on the Degree of Purity).—F. Hehlgans. (*Physik Zeitschr.*, 15th Dec., 1929, Vol. 30, pp. 942–946; *Zeitschr. f. tech. Phys.*, Dec., 1929, Vol. 10, pp. 634–637.)

A special cleaning process, made up of filtration, treatment with basic oxides, distillation, and electrochemical treatment in the electrostatic field, led to marked increase in specific resistance, dielectric strength, dielectric constant and Kerr constant.

PICTURE ANALYSIS DEVICE.—(German Pat. 482562, Seibt, pub. 16th Sept., 1929.)

A mirror-wheel arrangement in which the horizontal axis is displaced up and down (keeping practically parallel to itself) once during the passage of each mirror surface. This is accomplished by a heart-shaped cam driven by step-up gearing from the axis.

OPERATING CHARACTERISTICS IN PHOTOELECTRIC TUBES.—G. F. Metcalf. (*Proc. Inst. Rad. Eng.*, Nov. 1929, Vol. 17, pp. 2064–2071.)

Definitions of photometric terms are given, together with the introduction of a few special terms essential to photoelectric cell work. Curves are given showing both the static and dynamic characteristics of a typical cell. A simple mathematical analysis is given of the elementary photoelectric cell circuit. An appendix of photometric formulæ and conversion factors ends the paper.

ÜBER ROTEMPFINDLICHE NATRIUM-PHOTOKATHODEN (On Red-sensitive Sodium Photocathodes).—P. Selényi. (*Physik. Zeitschr.*, 15th December, 1929, Vol. 30, pp. 933–935.)

A paper on the Tungsram-" NAVA " photoelectric cell, made by the electrolytic process evolved by Márton and Rostás (1929 Abstracts, p. 277) and utilising the special properties of very thin (ultimately monomolecular) alkali metal films (Ives: N. Campbell, 1928 Abstracts, p. 692, and Feb. Abstracts, p. 109). The special activating processes, improving the sensitivity and extending its range over the red limit of the visible spectrum, are (1) the depositing of a thin layer of a photoelectrically inert metal such as nickel on the surface of the sodium mirror, or (2) a surface oxidation of the latter by a reversed electrolysis of the glass. The second method is the more convenient. The resulting cell is sensitive throughout the whole of the visible spectrum, and is capable of many applications.

PERSISTENT GLOW FOR TELEVISION RECEPTION.—(German Pat. 482800, Telefunken, pub. 20th Sept., 1929.)

In receivers where each element is formed by a separate glow lamp, the light intensity is increased by making the glow persist (*e.g.*, 1/15 sec. for a 15 per sec. scanning). This is accomplished by providing such a bias potential that a discharge is produced by each incoming impulse; some device such as a switching arrangement interrupts the discharge at the proper moment.

VERGLEICH VON SELEN- UND PHOTOZELLEN (A Comparison between Selenium and Photoelectric Cells).—F. Schröter and W. Ilberg. (*Physik. Zeitschr.*, 15th Nov., 1929, Vol. 30, pp. 801–804.)

It is often assumed that the essential inertia of the selenium cell is to a certain extent compensated for by a sensitivity greater than that of a photoelectric cell, so that the former cell requires less amplification. The writers investigate this point, using for each type of cell a customary resistance coupling to an amplifier. A light ray of average strength $L$ is assumed, varied by fluctuations $dL$. The maximum obtainable input voltage to the amplifier, at the coupling resistance $R_a$, is sought.

For the selenium cell there is an optimum when $R_a = R_i$, the resistance of the cell under light $L$. Under these conditions $\frac{dE_g}{dL} = \frac{E}{L} \times 0.125$ where $dE_g$ is the change in grid potential and $E$ is the voltage of the battery in the cell circuit. The corresponding equation for the photoelectric cell is $\frac{dE_g}{dL} = \frac{E}{L} \times 0.172$, so that the maximum control-sensitivity of a photoelectric cell somewhat *exceeds* that of a selenium cell. The theoretical result obtained shows the surprising fact that this maximum control-sensitivity of the selenium cell $\left(\text{measured by } \frac{dE_g}{dL}\right)$ is entirely independent of the constant " $k$ " which gives a measure of the absolute current output *under a given illumination*; so that as regards control-sensitivity a " bad " selenium cell gives the same result as a " good " one.

NACHWEIS DES LICHTELEKTRISCHEN PRIMÄRSTROMES IN ANTIMONGLANZ (Proof of the Photoelectric Primary Current in Antimony Blend—Stibium).—K. H. Voigt. (*Zeitschr. f. Phys.*, No. 3/4, Vol. 57, 1929, pp. 154–162.)

The first demonstration of the characteristic phenomena of primary photoelectric current in a semi-conductor.

BEZIEHUNGEN ZWISCHEN DEM NORMALEN LICHTELEKTRISCHEN EFFEKT UND ELEKTRISCHEN OBERFLÄCHENEIGENSCHAFTEN VERSCHIEDENER METALLE (Relations between the Normal Photoelectric Effect and Electrical Surface Properties of Various Metals).—R. Suhrmann. (*Physik. Zeitschr.*, 15th Dec., 1929, Vol. 30, pp. 939–942.)

LOCATION OF THE ELECTROMOTIVE FORCE IN A PHOTO-VOLTAIC CELL.—W. N. Lowry. (*Phys. Review*, No. 6, 1929, Vol. 33, p. 1081.)

An investigation of the e.m.f. of electrolytic photo-electric cells by a method based on Murdoch's principle (*Proc. Nat. Acad. Sci.*, 1926).

L'EFFETTO MAY-SMITH NELLO SOLFO PURO NELLA GRAFITE E NELLE MISCELE SOLFO-GRAFITE (The May-Smith Effect in Pure Sulphur, in Pure Graphite and in a Sulphur-Graphite Mixture).—L. Amaduzzi and C. Zanchi. (Summary in *Physik. Berichte*, 15th Dec., 1929, p. 2378.)

ÉTUDE DU COURANT PHOTOÉLECTRIQUE DANS L'AIR À LA PRESSION ORDINAIRE (A Study of the Photoelectric Current in Air at Ordinary Pressure).—A. Blanc. (*Journ. de Phys. et le Rad.*, May, 1929, Vol. 10, pp. 187–197.)

The current/field curve, in air at ordinary pressure, shows no saturation. The writer explains this by supposing that the average number of ions produced by each electron emitted increases with the field, to a degree dependent on the particular metal; if this is so, no saturation can occur; the shape of the curve must be in very close relation to the distribution of velocities and must change with this. Consequently, fatigue of the metal, which changes the shape of the curve, must modify the distribution of velocities.

SUR L'EFFET PHOTOÉLECTRIQUE DES RAYONS ULTRA-VIOLETS SUR LES GAZ (The Photo-electric Effect of Ultra-Violet Rays on Gases).—R. Dantinne and P. Lenaerts. (*Arch. Sci. Phys. et Nat.*, Jan./Feb., 1929, Vol. 11, pp. 5–14.)

The writers conclude from their researches (carried out at pressures of 50–100 atmospheres) that the photoelectric effect in solid bodies, especially metals, depends on an ionisation of the adsorbed gas layers.

PICTURE TELEGRAPHY TO BERLIN.—(*Electrician*, 10th Jan., 1930, Vol. 104, pp. 31–33.)

An illustrated description of the apparatus employed in the new public picture telegraphy service between Great Britain and Germany (1,000 miles of cable).

REFLECTION SCANNING FOR PICTURE TELEGRAPHY—ELLIPSOIDAL REFLECTORS.—(German Patent 482842, Telefunken, pub. 21st September, 1929.)

The use of a reflector of the form of an ellipsoid of revolution to collect the rays diffused from the scanning point and concentrate them on the photo-electric cell. The scanning beam is brought in at the side and bent down to the drum by a totally reflecting prism. *See* Schröter, 1929 Abstracts, p. 580.

SYNCHRONISATION BY SUPERIMPOSED ALTERNATING CURRENTS.—(German Patent 482797, Lorenz, pub. 20th September, 1929.)

The synchronising a.c. from *A*. is transmitted to *B*. and a similar "auxiliary" current there superimposed on it. The two currents are taken to a rotating commutator which commutates once for every period of the auxiliary current. The resultant current is led to the grid circuit of a valve, in whose anode circuit is the winding of an eddy-current brake. Synchrony results in the two currents annulling each other: lag and lead of the synchronising current produces a negative and a positive resultant respectively in the grid circuit.

THÉORIE GÉNÉRALE DE LA SYNCHRONISATION (The General theory of Synchronisation).—J. Haag. (*See* under "Properties of Circuits.")

SYNCHRONISATION.—(German Pat. 484088, Karolus, pub. 9th Oct., 1929.)

In synchronising by driving off a common main, at the high speeds necessary for television and facsimile telegraphy the small possible fluctuations of frequency may cause hunting in the motors, and consequent trouble. The invention describes the use of higher harmonic frequencies of the system frequency: *e.g.*, the main motor may be driven by the fundamental frequency, while an auxiliary (synchronising) motor on the same shaft is driven by a harmonic supplied by an iron frequency transformer.

## MEASUREMENTS AND STANDARDS.

EXAKTE FREQUENZMESSUNG KURZER WELLEN (The Exact Frequency Measurement of Short Waves).—H. Mögel. (*Telefunken Zeit.*, Sept., 1929, Vol. 10, No. 52, pp. 54–58.)

The method described measures short waves (12–50 m.) entirely by their lower overtones. For the whole range, a single measuring circuit of about 2,000 m. wavelength is used, with a range of adjustment of only 2—3 per cent., so that only a single calibration curve has to be worked on. As reference standards, Giebe and Scheibe luminous quartz resonators are used. An accuracy of $\pm$ 0.1 per thousand is readily attained (up to the present) without the use of thermostatic control.

MESSUNG ELEKTRISCHER WIRKWIDERSTÄNDE MIT HILFE NEGATIVER WIDERSTÄNDE (The Measurement of A.C. Ohmic Resistances with the help of Negative Resistances).—H. Pauli. (*Zeitschr. f. tech. Phys.*, Dec., 1929, Vol. 10, pp. 592–595.)

The frequency-dependent ohmic resistance to alternating current is balanced by a frequency-independent negative resistance, whose value can be determined at some convenient frequency or by d.c. (according to its nature). The damping of the composite circuit is determined by an adjustment of the energy supply. The paper describes the application of the principle to the measurement of the ohmic resistance of a coil using a dynatron circuit, a Numans-Roosenstein circuit [Negadyne], and an amplifier- or a transmitter-valve circuit. The method provides a convenient substitute for the older bridge arrangement or the coupled circuit method, and is applicable even to wavelengths below 100 m.

MEASURING THE INTER-ELECTRODE CAPACITY OF SCREEN-GRID VALVES.—T. H. Kinman. (*Wireless World*, December 4th, 1929, Vol. 25, pp. 610–613.)

Describing a system of measuring inter-electrode capacity based on the substitution method outlined by A. W. Hull and N. H. Williams in the *Physical Review*, Vol. 27, April, 1926. The valve capacity is determined by observing the capacity change required in a standard condenser connected in parallel with the valve capacity, when coupled between an r.f. source and amplifier, to obtain the same amplifier output reading when the valve capacity is removed.

ANWENDUNG DER SILBENVERSTÄNDLICHKEITSMESSUNGEN IN DER DRAHTLOSEN TELEPHONIE (The Application of Syllable-Intelligibility Measurements to Wireless Telephony).—F. Eisner. (*Zeitschr. f. tech. Phys.*, Nov., 1929, Vol. 10, pp. 532–542.)

The writer describes in detail the application of the well-known Fletcher system to Wireless telephony, with special reference to the testing of receiving gear in conditions of severe external interference—*e.g.*, in aeroplanes. A number of results are given with regard to aeroplane receivers: the maximum syllable intelligibility of those tested lies round 80 per cent. (compared with 96 per cent. for a low-frequency music-transmitting system) but is much lower if external noises are present: additional l.f. amplification decreases the percentage if noises are absent, increases it if they are present: for very high input voltages a decided fall of intelligibility takes place.

TEMPS, FRÉQUENCE, MESURES DES FRÉQUENCES (Time and Frequency: the Measurement of Frequencies).—R. Jouaust. (*L'Onde Élec.*, Oct., 1929, Vol. 8, pp. 421–435.)

(1) The measurement of time. Among the points made, secondary standards (such as marine chronometers) are said to have their frequency known hardly to one hundred thousandth, even when they are checked frequently against the astronomical pendulums. Regarding these last, they are checked once a day at the Observatories, but even so all that is known is the number of swings in 24 hours; there is no proof that each swing has the same period: as a matter of fact, they have not: the apparent constancy is due to the variations compensating in the aggregate. (2) The irregularities of pendulums. Various devices (photoelectric cells, effect on short wave circuit, etc.) have only partially suppressed these irregularities: "up to now we have only considered the effect of the irregularities in the seconds-indicating mechanism, but the mechanism for maintaining the swings produces identical effects. Only a pendulum maintained without material connections can have a rigorously constant frequency: attempts on these lines have been made with encouraging results,* but at present in the best pendulums in general use the seconds may vary among themselves by as much as one hundredth part." (3) Secondary standards of frequency: valve-maintained forks: magnetostriction: quartz — variations in supply voltage which according to Dye would produce variations of the order of 1 in 10,000, with forks, are shown by Namba and Matsumura to produce with quartz changes only of the order of 1 in 100,000 (1929 Abstracts, p. 397). Marrison and Lack (1929 Abstracts, p. 518) have obtained piezoelectric standards without temperature coefficient. (4) Calibration of secondary standards: general rules (for details see Decaux, Jan. Abstracts, p. 52): demultiplication by relaxation oscillations: deterioration of tuning forks owing to elasticity changes: possible changes in quartz-controlled frequencies by wearing away of the quartz and consequent change in thickness? (5) The use of secondary oscillators for the measurement of radio frequencies. (6) Conclusion: CCIR recommendation of special transmissions to be measured at various points: would it not be better to compare the secondary standards more directly, *e.g.*, by getting the various Laboratories to modulate a r.f. transmission by their audio-frequency standards, the various notes being compared by the very accurate beat method? Ultimate accuracy attainable—perhaps the variation of the sidereal day, or of gravity, will impose a limit? The paper ends with a bibliography.

* *Cf.* Planiol, 1929 Abstracts, p. 110, who suggests using the pressure of light to maintain his very lightly damped torsion pendulum: also Holweck and Lejay, 1929 Abstracts, p. 457, who propose the same idea for their quartz tuning fork.

LA RADIOTÉLÉGRAPHIE ET LA MESURE PRÉCISE DES DURÉES (Radiotelegraphy and the Accurate Measurement of Times).—P. Lejay. (*L'Onde Élec.*, October, 1929, Vol. 8, pp. 436–448.)

Accuracy of existing standards of Time: researches undertaken to improve these: pendulums without contacts (photoelectric; r.f. condenser) —the abolition of contacts makes a gain of about two decimal points in accuracy: methods of measurement—chronographs; the writer's special chronograph referred to in 1929 Abstracts, p. 398—capable of recording times down to one ten-thousandth of a second (a full, illustrated description is given of this combination of valve-maintained fork, Blondel oscillograph and revolving photographic drum with special provision for regularity of motion, including a stroboscopic control): irregularities of the pendulum controlling the French time-signals (small variations, approx. 1/1,000 sec., about a larger periodic variation of 6/1,000 sec. with a period of 12 seconds). The paper ends with a reference to the promising results obtained by the writer and Holweck with the vibrating quartz fibre referred to in 1929 Abstracts, p. 457.

DIE FEHLER UNSERER ZEITMESSUNG UND EIN VORSCHLAG ZUR VERBESSERUNG DER ASTRONOMISCHEN UHREN (Errors in our Measurement of Time, and a Suggestion for Improving Astronomical Clocks).—M. Schüler. (*Physik. Zeitschr.*, 1st Dec., 1929, Vol. 30, pp. 884–887.)

Records of the Shortt clocks at Greenwich ("the best clocks Astronomy at present possesses") show that in 20 months these varied twice to the extent of 13 secs. (the curve of the variation is approximately parabolic, indicating a regular, quadratic error). To trace any possible variations in the speed of rotation of the earth, an accuracy of 1 sec. per year is necessary, so that these clocks are not accurate enough for such observations. The writer goes on to describe his balanced-pendulum clock (Jan. Abstracts, p. 52).

REGISTERING THE OSCILLATIONS OF A PENDULUM WITHOUT TOUCHING IT.—F. Hope-Jones. (*Journ. Scient. Instr.*, December, 1929, Vol. 6, pp. 394–396.)

". . . . General Ferrié states the case against clicks, ratchet wheels and their contacts clearly and forcibly, but he also states that the problem has not been solved, and proceeds to discuss photoelectric cells and triode valves as substitutes." The writer goes on to describe and illustrate his mechanism (1906), which is so completely satisfactory that the Loomis spark chronograph, dividing each second into a thousand separate cells, places the spark from this mechanism into the same cell every time. The same mechanism is used at Greenwich and elsewhere: it is used for the Rugby Time Signals, and its time-spacing is correct to within ± os.001. "I look upon photoelectric cells and triode valves as but ineffectual substitutes for substantial switches." A roller carried on a gravity arm falls off the end of the pendulum pallet after imparting its impulse to the pendulum, and alights on the armature, thus making contact: "consequently the moment of contact corresponds with the identical instant of the period of the pendulum. The precise point of time at which the contact occurs is dependent solely upon the pendulum and upon gravity, and it is therefore identical at each operation."

Die angenäherte Theorie des magnetostriktiven Generators (The Approximate Theory of the Magnetostrictive Generator).—L. S. Freimann. (*Zeitschr. f. Hochf. Tech.*, Dec., 1929, Vol. 34, pp. 219–223.)

From Pierce's equations for the motion of a magnetostrictive rod the writer arrives at the equivalent circuit of such a rod and hence of a complete magnetostrictive generator (oscillator) circuit; from this he determines the conditions for self-excitation. The equation for the generator being

$$\frac{j\omega M + aZ}{D} = R_i + (Z_1 + Z)\left(1 + \frac{R_i}{Z_c}\right),$$

he considers various cases: *e.g.*, if $M$ (mutual induction between grid and anode circuits) = 0; this occurs when the rod swings to its 3rd harmonic, for then its two halves produce cancelling induced e.m.f.s. The equation becomes $\frac{Z}{D} = R_i + Z_1 + Z$, which corresponds exactly with Watanabe's equation for the tuning-fork oscillator (1929 Abstracts, p. 48).

Measurement of Frequency.—S. Jimbo. (*Proc. Inst. Rad. Eng.*, Nov., 1929, Vol. 17, pp. 2011–2033.)

A full summary of this paper was given in 1928 Abstracts, p. 345, when it appeared in its Japanese version.

Measurement of Currents down to $10^{-14}$ Ampere by Bronson's Method, using Gold Film Resistances of $10^{10}$–$10^{11}$ Ohms.—(*See* Perucca, under "Subsidiary Apparatus.")

For the use of resistances of this order in the grid circuits of amplifiers, see Mulder and Razek, and Teegan, in 1929 Abstracts, p. 516; also Feb. Abstracts, p. 110.

[Calorimetric Measurement of] Dielectric Losses at High Frequencies.—G. E. Owen. (*Phys. Review*, 1st October, 1929, Vol. 34, pp. 1035–1039.)

The power loss in very small pieces of dielectrics in h.f. fields was measured by a calorimetric method which, unlike most methods, demands no assumptions about any electrical property of the circuit. *Cf.* Scott, Bousmann and Benedict, *Journ. Am. I.E.E.*, Vol. 47, p. 361. Results of measurements on various dielectrics are given and discussed.

The Measurement of Magnetic Quantities.—L. W. McKeehan. (*Journ. Opt. Soc. Am.*, Oct., 1929, Vol. 19, No. 4, pp. 213–242.)

A discussion of methods for the measurement of magnetic quantities, under the following headings:—(*a*) ponderomotive forces on currents: on magnets; (*b*) electromotive forces in fixed coils: in moving coils: in alternating fields; (*c*) secondary effects on conduction of electricity: on propagation of light. References to the originators and developers of the various methods are given in a bibliography of 202 items.

Amplification of Currents from Thermo-elements.—E. Madelung. (*E.N.T.*, Nov., 1929, Vol. 6, p. 461.)

The writer converts the small thermo-electric d.c. potentials into a.c. potentials by means of a rotating condenser. These can be amplified conveniently, rectified and measured.

Note on the Theory of Screened Impedances in A. C. Bridges with the Wagner Earth.—A. C. Bartlett. (*Journ. Scient. Instr.*, September, 1929, Vol. 6, pp. 277–280.)

"This note is based on an important paper by Hartshorn and Wilmotte (*ibid.*, November, 1926; see also Wilmotte, 1929 Abstracts, p. 49) and puts forward a simple explanation of the action of shielded impedances."

Mitteilungen aus der Praxis. Nadir-Netzanschluss-Röhrenvoltmeter (Report after testing the Nadir Mains-supplied Valve voltmeter).—H. Reibedanz. (*Zeitschr. f. Hochf. Tech.*, Oct., 1929, Vol. 34, pp. 145–146.)

Description, with illustrations, of an improved quick-reading instrument (two types, for high and medium sensitivity respectively). Inconstancy need not be feared since, by a high anode-resistance of the anode rectifier, the circuits and valves are quite under-loaded. On the input side there is only the static grid capacity which, without leads, amounts to about 5 cm. A special arrangement compensates for any change in mains voltage, so that the calibration is always correct. The instrument is so convenient to use that it may well be employed not only for high and low frequency measurements, but also in conjunction with thermo-elements, etc.

A New Precision Variable Air Condenser.—W. H. F. Griffiths. (*Journ. Scient. Instr.*, Sept., 1929, Vol. 6, pp. 297–302.)

See 1929 Abstracts, p. 111.

Precise Measurements with an A.C. Potentiometer of the Larsen Type.—E. R. Wigan. (*Electrician*, Nov. 8th, 1929, Vol. 103, pp. 561–563.)

The Cambridge Scientific Instrument Company have produced an a.c. potentiometer for speech frequencies containing the elements of Larsen's original design but with various ingenious additions which make the instrument a precision one. Larsen himself suggested the use of his instrument for measuring the efficiency of transformers and the attenuation of telephone lines, but at the time its employment was handicapped by the lack of suitable oscillators and by difficulties due to leakage currents. These objections are now overcome, and the new instrument will, for example, measure the ratio of two potentials, and their phase difference, with very great accuracy. It is here described in detail, with diagrams.

EIN INTERESSANTER SPRUNG IN EINEM PIEZOQUARZ (An Interesting Crack in Piezoelectric Quartz).—F. Seidl. (*Naturwiss.*, 4th October, 1929, Vol. 17, pp. 781–782.)

Finding that quartz plates were the more easily set into oscillation the more carefully they were cleaned, the writer washed them with potassium bichromate and benzine. While drying over a flame a plate cut from a rock-crystal, a zig-zag crack developed, which the writer illustrates. It appears to be an example of what Voigt found—that a rock-crystal heated and suddenly cooled developed cleavages in such planes as to produce rhomboidal forms from the original trapezoidal class of the trigonal system.

PIEZOELECTRIC CONTROL OF OSCILLATORS. (American Pat. 1,722,196, Byrnes, pub. 23rd July, 1929. American Re. Pat. 17,245/7 to 1,450,246 and 1,472,583, Cady, pub. 26th March, 1929. German Pat. 481489, Lorenz, pub. 24th August, 1929.)

(1) The use of the piezoelectric crystal in a push-pull circuit, thus reducing the capacity effect; (2) Cady's patents for coupling methods for piezoelectric crystals with more than two electrodes to each crystal; (3) increasing the possible load by using two or more crystals in series.

THE DIELECTRIC CONSTANT OF AIR AT VARIOUS RADIO FREQUENCIES.—F. L. Talbott. (*Phys. Review*, No. 4, 1929, Vol. 33, p. 641.)

A heterodyne null method was used, the capacity change due to the admission of air being compensated for by adjustment of the standard precision condenser. Frequencies ranged from 28 to 1100 kc. No change of the dielectric constant with frequency was found. The mean value was 1.000547.

DER APERIODISCHE VERSTÄRKER IN DER MESSTECHNIK (The Use of the Aperiodic Amplifier in Testing).—M. v. Ardenne. (*E.T.Z.*, 7th Nov., 1929, Vol. 50, pp. 1617–1620.)

An illustrated article on the use of these amplifiers (using multiple valves) for measuring very small alternating or oscillating voltages. They are used in conjunction with thermionic voltmeters or with oscillographs.

## SUBSIDIARY APPARATUS AND MATERIALS.

DER DRAHTLOSE WECKANRUF FÜR EINZEL- UND SAMMELRUF (The Wireless Call for Selective and Collective Calls).—A. Ristow. (*Zeitschr. f. Hochf. Tech.*, Nov., 1929, Vol. 34, pp. 169–173.)

After an introduction dealing with the general difficulties of an automatic wireless alarm or call apparatus—variation of signal strength from the same station day by day, interference, etc.—the writer examines the possibilities of certain methods and then describes the apparatus of the Tefag-Ristow system (Berliner Company). A simple input relay $I$ (10 mA. "make," 6 mA. "break") has in series with its windings the contacts of an "amplitude control" which works in such a way that signals of any value between 10 and 6 mA. can have no effect on $I$, so that interference of this strength is ignored. Interference of troublesome strength is dealt with, not by a multiplicity of different relays (some "calls" contain as many as 20 relays) but by two time-relays, one with a delay at "make" and the other with a delay at "break," combined with a step by step signal selector which finally rings the bell only after the reception of a complete call-sign. A typical call resembles the letter $X$, the dots and spaces being 1 sec. and 0.8 sec. respectively. Prolonged interference is countered by a "current-impulse pendulum" which, when brought into action, returns the mechanism to its starting point. A test installation has worked well, under trying conditions, for six months: calls were sent 10 times a day from a 40 w. (radiated) station 350 km. away, and various sources of interference were at hand. A few "exceptional cases" of missed calls were traced to faulty service at the transmitter, and practically ceased as the personnel became practised.

EN TRÅDLÖS LYSTRINGSSIGNAL FÖR ENSTAKA OCH GRUPPANROP (A Wireless Alarm-Signal for Separate and Group Calls).—A. Salmony. (*Teknisk Tidskrift*, 11th Jan., 1930, Vol. 2, pp. 21–23.)

A description with illustrations of the Tefag-Ristow alarm-signal device (*see* also above).

EINE NEUE BRAUN'SCHE RÖHRE (A New Type of Braun Tube—C.-R. Oscillograph).—H. v. Hartel. (*Zeitschr. f. Hochf. Tech.*, Dec., 1929, Vol. 34, pp. 227–228.)

Description of the new von Ardenne-von Hartel tube. It is of the hot cathode type, with a sensitivity of about 1 mm. per v.; the anode voltage lies between 800 and 3,000 v., according to whether visual observation or photographic recording is required. Since only a fraction of a milliampere is used, ordinary anode batteries can provide this voltage. The filament (0.8 A. at 0.5 v.) is hardly visibly luminous, and is shielded by a cylinder, co-axial with the tube, which is kept at a negative potential (about one-tenth that of the anode) and thus concentrates the electrons into a beam. Residual gas is left in the tube: this gives a sharper focus and diminishes wall-charge effects.

ZEITPROPORTIONALE, SYNCHRON LAUFENDE ZEITABLENKUNGEN FÜR DIE BRAUN'SCHE RÖHRE (Time-proportional, Synchronous Time Base for C.-R. Oscillographs).—E. Hudec. (*Zeitschr. f. Hochf. Tech.*, December, 1929, Vol. 34, pp. 207–219.)

A detailed investigation of the use of relaxation oscillations, generated by special valve circuits, to provide (1) electrostatic, and (2) magnetic, time bases. For an electrostatic time base, the auxiliary potential required ranges from 100 v. (for a 400 v. hot cathode tube) to 1,000 v. (for a 10–20 kv. tube 1 m. long). The circuit used for this purpose is a "current" relaxation oscillation generator circuit (*see* same writer, January Abstracts, pp. 37–38) combined with a two-valve controlling circuit for synchronising by the current or potential under investigation. For high frequencies ($10^5$–$10^6$ p.p.s) the relaxation times must be decreased by the use of smaller resistances and higher anode current, and a special circuit is given for this purpose: here a single two-grid valve is used for control.

For a magnetic time base, a current of about 50 mA. is needed, combined with a large number of turns on the deflecting coil (inductance of the order of 0.1 henry). For this purpose the circuit used is a "potential" relaxation oscillation circuit (*loc. cit.*). Good results are obtained up to frequencies of 10,000 p.p.s.; they can be improved by designing the coil to have small self-capacity, winding it on a rectangular iron ring broken only at the tube.

The writer ends by pointing out that if the time base is controlled always by the same voltage, while the main deflecting plates are subjected to various voltages one after the other, and the curves on the screen photographed in succession, they will be recorded in their correct relative positions. Or by a rotating commutator they can be observed side by side on the screen.

New H.F. Oscillograph (Duddell Type).—Cambridge Instrument Co. (*Electrician*, 12th July, 1929, Vol. 103, pp. 47–48.)

A 3-element instrument, each element independent and mounted in an oil bath. For adjustment, a screen is used: a trigger then transfers the image to the photographic paper. Undamped nat. period 0.00008 sec.; d.c. sensitivity in oil 20 mm. (at 60 cm.) for 60 mA.

Résistance métallique de $10^{10}$ à $10^{11}$ ohms. Nouvelle Mise au Point de la Méthode de Bronson (Metallic Resistance of $10^{10}$ to $10^{11}$ ohms. The Latest Version of Bronson's Method).—E. Perucca. (*Comptes Rendus*, 7th Oct., 1929, Vol. 189, pp. 527–529.)

Bronson's method of measuring very small currents requires a sensitive electrometer and a known and constant resistance of the order named: this resistance is difficult to obtain, as it must have no polarisation e.m.f. and a small temperature coefficient. The writer has obtained entirely satisfactory resistances by using cathode-sputtered films of gold on quartz threads. Various workers have experimented with such films: Féry reached a resistance of $8 \times 10^6$ ohms, but the writer has gone $10^4$ times farther, reaching with gold and platinum a thickness estimated at 5–10 m$\mu$. His results are as follows:—once past the critical thickness the resistance decreases regularly, so that the action can be stopped at the right point to give a value of $10^{10}$–$10^{12}$ ohms. Although the resistance varies 100 or 200 per cent. with time, either *in vacuo* or in air, it takes on a permanent value ($\pm$ 0.5 per cent.) after several days' ageing. Conductivity obeys Ohm's law perfectly; there is no trace of polarisation e.m.f. Although only designed to support a voltage of about 1 v., they are not injured by 72 v. [For gold films as fuses, *see* 1929 Abstracts, p. 340.]

The above applies both to gold and to platinum films, but as regards temperature coefficient the gold film stands out as much superior: while the value for platinum is about 0.01, for gold it is less than 0.0005. A much greater purity, however, is needed for gold in order to get a regular deposit (transparent green).

As regards the electrometer, the writer does not approve of valve methods; thread electrometers, of Lindeman's or preferably his own design are his choice. The latter will give a reading for 0.001 volt in about 1 second. With this apparatus he has been able to detect rapid changes in the photoelectric properties of fresh metal surfaces, especially in the case of mercury.

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.*, December, 1929, Vol. 6, pp. 500–504.)

The writer obtains a formula for the cross-talk ratio $\eta$ in the case of amplifiers supplied from a common source. The permissible value for $\eta$ in Broadcasting is taken as $\eta = 10^{-4}$. Numerical examples show that for central anode- or heating-batteries this value cannot be reached without special steps. He then discusses the use of various devices—choke coils in the anode leads, in filament leads for parallel filaments, in the common lead for series filaments. The technical and economic advantages and disadvantages of the common source are discussed: in considering a decision in any particular case, the necessary subsidiary apparatus can be worked out from the writer's equations and its cost estimated.

A Seal for Electrodes.—S. Munday. (*Journ. Scient. Instr.*, November, 1929, Vol. 6, pp. 360–361.)

A small egg-shaped, drilled bead is soldered to the wire and a thin rubber tube (bicycle valve tubing) slipped over bead and wire. The wall of the vessel is drilled with a tapered hole, big end on the "pressure" side. To assemble, the rubber tube is stretched, the whole pulled into the hole and then, when the bead is wedged, the rubber tube at the big end of the whole is allowed to spring back.

Constant Voltage High-Tension Generators.—G. E. Bell. (*Brit. Journ. of Radiol.*, Vol. 2, pp. 156–173: *Discovery*, April, 1929, pp. 173–174.)

A review of methods, ending with a description of the National Physical Laboratory apparatus consisting of a four-valve Gratz connection with condenser and choke filter: the regulating device is described. The output is 30 mA. at 100 kv.

Cartridge Wet H.T. Battery.—(*Electrician*, 20th December, 1929, Vol. 103, p. 770.)

Paragraph on the new type produced by the Standard Wet Battery Company. The cartridge now comprises both sac and zinc, ready to be placed in the jar.

TEMPERATURE RATING OF WIND-DRIVEN AIRCRAFT RADIO GENERATORS.—C. B. Mirick. (*Proc. Inst. Rad. Eng.*, Dec., 1929, Vol. 17, pp. 2259–2267.)

Author's summary :—Measurements of temperature rise of generator under load are given for still air and in flight. Theory of heat emission is briefly reviewed, constants of emissivity are given from which rising and final temperatures of generators can be approximated. Conditions governing the rating of wind-driven aircraft radio generators are discussed.

EIN KOMPLEXER WECHSELSTROMKOMPENSATOR FÜR MITTLERE FREQUENZEN (A Complex A.C. Compensator for Medium Frequencies).—W. Geyger. (*Zeitschr. f. Hochf. Tech.*, Dec., 1929, Vol. 34, pp. 223–227.)

The frequency range is 500–5,000 cycles. The apparatus is used in the complex compensation method of measuring amplitude and phase of a.c. potential, and has been applied by the writer (Feb. Abstracts, p. 118) to geo-electric exploration. *See* also the writer's survey of geo-electric exploration methods using a.c., same *Zeitschrift*, pp. 228–233.

EINE ANORDNUNG ZUR EINSTELLUNG BELIEBIGER, DIREKT ABLESBARER PHASENVERSCHIEBUNGEN (An Arrangement for Producing any desired, directly-readable Phase-Displacement).—W. Geyger. (Long summary in *Physik. Berichte*, 1st October, 1929, Vol. 10, No. 19, p. 1843.)

A VACUUM-TUBE VOLTAGE REGULATOR FOR LARGE POWER UNITS.—L. C. Verman and H. J. Reich. (*Proc. Inst. Rad. Eng.*, Nov., 1929, Vol. 17, pp. 2075–2081 ; and *Journ. Opt. Soc. Am.*, Oct., 1929, Vol. 19, No. 4, pp. 243–249.)

The writers believe the regulator here described to be the first valve regulator which can be applied to any standard d.c. machine or, with a slight modification, to an a.c. machine. A gradual change from no-load to a little above full-load causes less than 0.1 per cent. voltage variation. The cycle of operation is as follows :—a small decrease of line voltage produces a corresponding increase of negative grid bias on an amplifier valve, thereby decreasing its plate current, which flows in a coupling resistance. The consequent decrease in voltage drop across this decreases the negative bias of a power valve, whose plate current increases and boosts the exciter voltage and, through this, the line voltage. *Cf.* Stoller and Power, 1929 Abstracts, p. 339 ; Turner, p. 340 ; van Voorhoeve, p. 162.

LEERLAUFSTROM UND MAGNETISIERUNGSSTROM DES LUFTTRANSFORMATORS (No-load Current and Magnetising Current of the Air-Core Transformer).—G. Hauffe. (*Zeitschr. f. tech. Phys.*, Oct., 1929, Vol. 10, No. 10, pp. 472–473.)

A continuation of the work referred to in 1929 Abstracts, p. 341. The two quantities are not identical in air-core transformers, except in the case of a toroidal type where a constant e.m.f. is applied to the inner winding.

HIGH RESISTANCES. (German Patent 482363, Siemens and Halske, pub. 12th September, 1929.)

The use of resistance layers, composed partially of zirconium or titanium, deposited on porcelain, steatite, etc.

A " SPINNING TARGET X-RAY GENERATOR " AND ITS INPUT LIMIT.—A. Müller. (*Proc. Roy. Soc.*, 1st Oct., 1929, Vol. 125 A, pp. 507–516.).

A theoretical investigation of the possibility of increasing the input limit by keeping the target moving so as to carry the heat away from the spot where it is produced. Details and results with a generator built on this principle are promised later.

A PORTABLE ELECTRIC HARMONIC ANALYSER.—R. T. Coe. (*Journ. I.E.E.*, Oct., 1929, Vol. 67, pp. 1249–1259.)

*See* 1929 Abstracts, p. 164. The special feature of the present method is the production of the " analysing current " by means of a synchronously-driven contact disc of special design and a valve circuit. The paper describes in detail the operation of the analyser and establishes its accuracy. Examples of its use are given.

FREQUENZERNIEDRIGUNG DURCH EISENWANDLER (Frequency-Reduction by Iron Frequency-Transformers).—W. Janovsky. (*Zeitschr. f. Hochf. Tech.*, Sept., 1929, Vol. 34, pp. 81–87.)

The possibility of frequency-reduction by the use of coils with saturated iron cores has been recognised for some years (Heegner, 1924, and others). The present paper deals with experiments with the apparatus used by Kramar (1928 Abstracts, pp. 590 and 650) as a frequency-multiplier, using it this time as a frequency-reducer, changing the generator frequency to one-third of its value. Cathode-ray oscillograms are used to examine the processes, and the latter are dealt with theoretically by Kramar's method of assuming the transformer to act as a switch. Once a permanent condition is reached, the frequency-reduction processes are similar to the multiplication processes ; but whereas the introduction of the permanent condition is straightforward in the case of multiplication, in reduction the reaction of the secondary circuit is an essential factor and special arrangements have to be made to ensure this. For a correction to this paper *see* same journal, Nov., 1929, p. 184.

LOW EXPANSION NICKEL STEELS.—T. F. Russell. (*Engineering*, 27th Sept., 1929 ; summary in *Nature*, 12th October, 1929, p. 598.)

DURCHSCHLAG VON FESTEN ISOLATOREN IN HOMOGENEN UND NICHTHOMOGENEN ELEKTRISCHEN FELDERN BEI BEANSPRUCHUNGEN VON LANGER UND KURZER DAUER (Breakdown of Solid Insulators in Homogeneous and Inhomogeneous Elastic Fields for Long and Short Test Periods).—L. Inge and A. Walther. (*Arch. f. Elektrot.*, 1st Aug., 1929, Vol. 22, No. 4/5, pp. 410–442.)

Among the results obtained, it was found that in an inhomogeneous field the breakdown voltage for glass was independent of the duration of the test for a time-interval of $10^{-7}$ to 1,000 sec. Here an ionisation process must be involved. In a homogeneous field it was also independent for times $10^{-7}$ to 1 sec., but for longer times it decreased considerably for an increased test period. Here probably thermal action is involved. No signs of fatigue in the glass were found. Mica, rubber and ebonite were also tested.

DIE PERMEABILITÄT DES EISENS BEI GLEICHSTROM-VORMAGNETISIERUNG (The Permeability of Iron with D.C. Polarising Current).—E. Höller. (Summary in *E.T.Z.*, 3rd Oct., 1929, Vol. 50, pp. 1450–1451.)

Spooner's formula is checked experimentally and corrected and extended to apply to the latest silicon alloys, etc.

ÜBER DAS STROBOSKOPISCHE NONIUSVERFAHREN (The stroboscopic "Nonius" Method).—H. E. Linckh and R. Vieweg. (*Arch. f. Elektrot.*, 5th Nov., 1929, Vol. 23, No. 1, pp. 77–83.)

Contrary to ordinary stroboscopic methods, the one here described is used to accelerate slowly-moving processes. It is shown that a simultaneous combination of the two methods can be used to bring the angle of lead between two rotating bodies to an apparent standstill, and at the same time to magnify it. Tests on a synchronous motor, whose angle of lead is plotted in dependence on the load, are described as an example.

SIMPLIFYING "STRAIGHT LINE" CONDENSER DESIGN.—O. C. Roos. (*Rad. Engineering*, October, 1929, Vol. 9, pp. 46–50 and 67.)

EXPERIMENTELLE ERMITTLUNG DER SPANNUNGSVERTEILUNG IN ISOLIERSTOFFEN BEI GLEICHSPANNUNG (Experimental Determination of the Potential Distribution in Insulating Materials, for Direct Current).—P. Böning. (*Elektrot. u. Masch:bau*, 21st July, 1929, Vol. 47, pp. 613–620.)

ZUR NATUR DES ELEKTRISCHEN DURCHSCHLAGS FESTER KÖRPER (On the Nature of the Electrical Breakdown of Solid Bodies).—P. Böning. (*Zeitschr. f. Phys.*, 29th July, 1929, Vol. 56, No. 7/8, pp. 446–457.)

DIELECTRIC CONSTANTS AND ABSORPTION INDICES OF SEVERAL ALCOHOLS FOR SHORT ELECTRIC WAVES.—S. Mizushima. (*Proc. Imp. Acad. Tokyo*, Jan., 1929, Vol. 5, pp. 15–16.)

THE PROPERTIES OF DIELECTRICS: PART II.—THE DIELECTRIC CONSTANT.—F. M. Clark. (*Journ. Franklin Inst.*, July, 1929, Vol. 208, pp. 17–44.)

The effect of temperature on the dielectric constant of gases: molecular polarity: the effect of pressure: of frequency: of voltage: of magnetic fields: of changing state (gas to liquid to solid). The same series as regards liquids: dielectric constant of mixtures: of liquid-liquid solutions: of solids in liquid solutions: effect of molecular structure. The dielectric constant/resistivity relation.

INSULATION BREAKDOWN OF PAPER IMPREGNATED WITH OIL AND ROSIN.—G. A. Dmitriew and A. Walther. (*Arch. f. Elektrot.*, 15th Feb., 1929, Vol. 22, pp. 488–497.)

ÜBER POLARISATIONSSPANNUNG IN GLAS, GLIMMER UND GIPS (Polarisation Voltages in Glass, Mica and Gypsum).—G. Gullner. (*Arch. f. Elektrot.*, 15th June, 1929, Vol. 22, No. 2, pp. 141–144.)

MECHANISM OF DIELECTRIC BREAKDOWN IN THIN LAYERS (Impregnated Papers).—F. E. Null and J. B. Edwards, *and* THE EFFECT OF TEMPERATURE, PRESSURE AND FREQUENCY ON THE ELECTRICAL PROPERTIES OF RUBBER.—H. L. Curtis, A. T. MacPherson and A. H. Scott. (Summaries in *Phys. Review*, June, 1929, Vol. 33, pp. 1076 and 1080.)

OSZILLOGRAPHIC DIELEKTRISCHER VERLUSTE (Dielectric Losses measured by Oscillograph).—A. Gyemant. (*Naturwiss.*, 6th Sept., 1929, Vol. 17, p. 710.)

It has recently been established that at high voltages dielectric losses can be divided into two parts—the fluid or solid phase (somewhat according to the Wagner or Debye mechanism) and the gaseous (ionisation) phase. The latter takes place in a non-sinusoidal manner, i.e. the wave contains several harmonics. The usual bridge method of measuring loss-angle misses these harmonics. The writer describes a method combining a Schering bridge with an oscillograph, which allows all the components to be measured, even when the loss is of the order of 1 per cent.

BEWEGUNGSERSCHEINUNGEN AN DIELEKTRIKEN UNTER HOHEN FELDERN (Motion Effects in Dielectrics in High Fields).—A. Gyemant. (*E.T.Z.*, 22nd Aug., 1929, Vol. 50, pp. 1225–1227.)

The effects are divided into four classes, according to the causes:—dielectric action (e.g., the deposit of dirt particles on an insulator); displacement of the double layer (e.g., endosmosis, kataphoresis); space charges (e.g., in methods of deposition using a "spray" electrode yielding ions which form a space charge); and mechanical forces (e.g., electric wind for gases, surface bubbles in the oil of oil-switches). These are dealt with separately, and the diagnosis of any particular case is discussed.

THE INTERCONNECTED INTEGRAPH.—R. E. Glover and H. H. Plumb. (*Journ. Am. I.E.E.*, Sept., 1929, Vol. 48, pp. 695–697.)

Authors' summary:—A machine for solving differential equations in two variables is described. The equations may be linear or non-linear and may have variable or constant coefficients. The machine draws out the solution in the form of a curve, together with its derivatives. By altering the connections in various ways, a wide variety of equations may be solved with a limited number of integrating and reflexing elements.

ÜBER DIE VERWENDUNGSMÖGLICHKEITEN VON KUPFERPANZERSTAHL IN DER ELEKTROTECHNIK (Concerning Possible Applications for Copper-coated Steel in Electrical Engineering).—G. Dettmar. (*E.T.Z.*, 31st October, 1929, Vol. 50, pp. 1580–1585.)

MYCALEX: THE PROPERTIES AND APPLICATIONS OF A NEW INSULATING MEDIUM. (*Electrician*, 11th Oct., 1929, Vol. 103, p. 422.)

Mycalex (see 1929 Abstracts, p. 462) is now to be made in England. A table of physical properties is given here.

DIE URSACHE DER DRUCKABHÄNGIGKEIT DER DURCHSCHLAGSSPANNUNG VON DIELEKTRISCHEN FLÜSSIGKEITEN (The Cause of the Dependence on Pressure of the Breakdown Potential of Liquid Dielectrics).—H. Edler and C. A. Knorr: H. Edler. (*Naturwiss.*, 15th Nov., 1929, Vol. 17, pp. 894–895.)

The writers have shown that this dependence is entirely due to the presence of dissolved gases and volatile impurities: a well-purified and out-gassed oil shows practically no dependence.

THE REACTION OF CONDUCTING SHEETS ON THE MAGNETIC FIELD OF COILS.—F. Ollendorff. (*See* under " Properties of Circuits.")

## STATIONS, DESIGN & OPERATION.

NEUES ZUR GLEICHWELLENTELEFONIE (New Developments in Common Wave Telephony).—E. Kramar. (*Zeitschr. f. tech. Phys.*, Nov., 1929, Vol. 10, pp. 525–528.)

Description of the latest methods of frequency multiplication by valves, working since last September at the E. Berlin station and controlling the Stettin and Magdeburg transmitters. It is described as " the first practical application of a very high-frequency multiplication by valves for common wave telephony "; whereas in England the system of frequency doubling requires 10 stages, here—just as with the previous saturated-iron method—a multiplication to the 730th harmonic is necessary, but is accomplished in 3 stages only. This makes the plant far easier to control, and also allows an almost complete suppression of unwanted frequencies by simple filtering arrangements.

The sequence of processes is as follows:—a stabilised valve oscillator 1 generates the fundamental frequency between 1,500 and 2,500 p.p.s. [since overhead lines were found to be " too subject to disturbances," the original Telefunken control-frequency of 30,000 p.p.s. has had to be reduced to this value so as to make possible the use of cable]. It is provided with extremely accurate frequency adjustment. The control frequency is passed on, through a very loosely coupled amplifier 2, to a distributor 3, which feeds the outlying stations through valves and a toroidal repeating coil. These units are only present once for each common wave system: the remaining units are essential at every station.

The incoming oscillations, measured by a valve-voltmeter 4 (1/10–1/100 v.) are led to a 2-stage fundamental frequency amplifier 5, 6, which acts elastically so as to compensate automatically for input-voltage fluctuations of ± 25 per cent. At a potential of about 100 v. the fundamental oscillations enter the first multiplying stage 7–11; this is made up of 7, frequency multiplier; 8, ante-circuit (unpurified frequency): 9, suppression filter: 10, post-circuit (purified frequency): 11, amplifier. These units are for a wave between 13 and 22 km. The next stage (12–16) is similar but for a wave 1,800–2,800 m.; the last stage (17–21) for a wave 200–550 m. The final 70 w. stage of the output amplifier feeds the main oscillator, of 0.8 kw. power.

DER TELEFUNKEN-GROSS-KURZWELLENSENDER (The Telefunken High-power Short-wave Transmitter).—W. Buschbeck. (*Telefunken Zeit.*, Sept., 1929, Vol. 10, No. 52, pp. 35–43.)

The present paper gives the general considerations: details of construction will follow later. Sections deal with the crystal stage, the r.f. amplifier, grid compensation, anode compensation, the double-bridge circuit (compensated " push-pull " instead of parallel working), frequency multiplication. A photograph of the Zeesen " World Broadcasting Transmitter " is given.

COMMERCIAL SHORT WAVE WIRELESS COMMUNICATIONS. PART III. FOREIGN SHORT WAVE SERVICES.—H. M. Dowsett. (*Marconi Review*, Dec., 1929, pp. 1–17.)

This third instalment (of the Radio Society paper referred to in February Abstracts, p. 115) deals with the Radio Corporation of America services (particular attention being given to the " R.C.A." Broadside Projector Antenna and the " Diversity system " of receiving aerials), the French " S.F.R." services, and the German " Transradio " services.

INTRODUCTION TO THE SYMPOSIUM ON TECHNICAL ACHIEVEMENTS IN BROADCASTING (prepared for World Engineering Congress, Tokio, Oct., 1929).—A. N. Goldsmith. (*Proc. Inst. Rad. Eng.*, Nov., 1929, Vol. 17, pp. 1940–1948.)

As examples of the contents of this paper, these two section-headings may be quoted:—(5) General technical aspects of transmitter service area, of receiver selectivity, of network distribution, and of receiver fidelity. (9) General classification of programmes and their national aspects.

The following five abstracts deal with the papers included in the Symposium.

RADIO BROADCASTING TRANSMITTERS AND RELATED TRANSMISSION PHENOMENA.—E. L. Nelson. (*Proc. Inst. Rad. Eng.*, Nov., 1929, Vol. 17, pp. 1949–1968.)

Among points mentioned are:—(1) Recent public acceptance of, and demand for, field intensities which a few years ago would have been considered objectionably high. Thus in spite of increased modulation and increased sensitivity of receivers, stations giving 10–15 mv. per m. have recently been greatly handicapped in competing with others capable of producing 30–50 mv. per m. (2) A definite tendency towards the use of higher aerials (300 ft. towers in place of 150–225 ft.), "The effect is to concentrate the radiated power along the ground plane and to increase materially the field intensity in the local service area" (*cf.* Eckersleys and Kirke, 1929 Abstracts, pp. 211 and 329).

THE NATIONAL BROADCASTING COMPANY, A TECHNICAL ORGANISATION FOR BROADCASTING.—J. Weinberger. (*Proc. Inst. Rad. Eng.*, Nov., 1929, Vol. 17, pp. 1969–1985.)

The paper ends: "These programmes, received regularly in millions of homes, are rationally and consistently extending and improving the culture of the nation. The effect is bound to be truly magnificent as the art progresses and evolves, since radio combines the functions of both amusement and education."

SPEECH INPUT EQUIPMENT.—D. G. Little. (*Proc. Inst. Rad. Eng.*, Nov., 1929, Vol. 17, pp. 1986–1997.)

WIRE LINE SYSTEMS FOR NATIONAL BROADCASTING.—A. B. Clark. (*Proc. Inst. Rad. Eng.*, Nov., 1929, Vol. 17, pp. 1998–2005.)

RADIO BROADCASTING REGULATION AND LEGISLATION.—J. H. Dellinger. (*Proc. Inst. Rad. Eng.*, Nov., 1929, Vol. 17, pp. 2006–2010.)

RADIO IN AERONAUTICS—ITS TECHNICAL STATUS AND THE ORGANISATION FOR ITS APPLICATION IN GERMANY.—F. Eisner and H. Fassbender. (*Proc. Inst. Rad. Eng.*, Dec., 1929, Vol. 17, pp. 2185–2229.)

The apparatus used now in German aircraft communications is described, and the results of measurements on the fundamentals of radio in aeronautics, made by the German Research Institute for Aircraft, are given. The trend that German aircraft radio will probably follow in the next few years is indicated. The paper deals in succession with long-wave apparatus, short-wave apparatus, the use of ultra-short waves, direction-finding apparatus, airship sets (long-wave sets, short-wave sets, radio-compass), and operating organisation.

RADIO FOR THE AIR TRANSPORT OPERATOR.—L. D. Seymour. (*Proc. Inst. Rad. Eng.*, Dec., 1929, Vol. 17, pp. 2137–2140.)

Long-wave receiving equipment on the aeroplane, and the additional use of a short-wave aeroplane transmitter, are discussed. The tendency is noted towards the establishment of short-wave two-way communication systems by the operators themselves: requirements for apparatus under these conditions are considered.

THE CIVIL AIRWAYS AND THEIR RADIO FACILITIES.—H. J. Walls. (*Proc. Inst. Rad. Eng.*, Dec., 1929, Vol. 17, pp. 2141–2157.)

The legislation which created the Aeronautics Branch of the Department of Commerce and its organisation is discussed: radio-telephone and -telegraph equipment used in the collection and broadcasting of weather information to aircraft is described. Radio-beacons and their distribution ("radio ranges" as the well-known "equi-signal zone" beacons are now called, and "marker beacons" of about 5 w. power) are dealt with: the regulations proposed for the installation of radio equipment on aircraft are given briefly.

TYPICAL WIRELESS APPARATUS USED ON BRITISH AND EUROPEAN AIRWAYS.—F. H. Furnival. (*Proc. Inst. Rad. Eng.*, Dec., 1929, Vol. 17, pp. 2123–2136.)

HÖRBARKEITSGRENZEN UND GÜNSTIGSTE VERKEHRSZEITEN BEI KURZWELLEN AUF DEN EINZELNEN ÜBERSEELINIEN (Limits of Audibility and Most Favourable Traffic Times for Short Waves over various Trans-oceanic Routes).—E. Quäck and H. Mögel. (*Telefunken Zeit.*, Sept., 1929, Vol. 10, No. 52, pp. 58–65.)

*See* 1929 Abstracts, p. 165.

PROJET DE LOI SUR LE RÉGIME DE LA RADIODIFFUSION (Proposed Broadcasting Regulations in France).—(*L'Onde Élec.*, Oct., 1929, Vol. 8, pp. I–IV.)

Previous instalments were in the July and August issues.

TELEPHONE CIRCUITS FOR BROADCAST PROGRAMME TRANSMISSION.—F. A. Cowan. (Abstract in *Journ. Am. I.E.E.*, July, 1929, Vol. 48, pp. 538–541.)

NAVAL WIRELESS TELEGRAPH COMMUNICATIONS.—G. Shearing and J. W. S. Dorling. (*E.W. & W.E.*, January, 1930, Vol. 7, pp. 23–25.)

Abstract of paper read before the I.E.E. Wireless Section, 4th December, 1929.

SEPARATION OF BROOKMAN'S PARK TWIN PROGRAMMES.—(*See* under "Reception.")

## GENERAL PHYSICAL ARTICLES.

SUR LES MACHINES QUI FONCTIONNENT ENTRE DEUX SOURCES RADIANTES (On Engines Working between Two Sources of Radiation).—T. Takéuchi. (*Comptes Rendus*, 9th Dec., 1929, Vol. 189, pp. 1067–1068.)

A reversible engine is considered which works between two sources of radiation of frequencies $\nu_1$ and $\nu_2$, the working substance being any oscillator whose energy E depends only on $\nu^2 l$, where $l$ is a variable parameter. The engine is supposed to describe a closed, reversible "Carnot's cycle." Its efficiency is deduced and it is found that the number of energy quanta taken in by the body from the source is equal to the number it yields to the condenser.

THE SCATTERING OF BETA-PARTICLES BY LIGHT GASES, AND THE MAGNETIC MOMENT OF THE ELECTRON.—M. C. Henderson. (*Phil. Mag.* Dec., 1929, Suppy. No. 53, Vol. 8, pp. 847–857.)

Research to test Uhlenbeck and Goudsmit's suggestion that the electron possesses an angular momentum of $\frac{1}{2} \cdot \frac{h}{2\pi}$ due to its own rotation and a magnetic moment equal to one Bohr magneton. Results suggest that the electron does possess a field of force in addition to the normal electrostatic field, but that it is unlikely that it can have a magnetic moment as large as one Bohr magneton.

CONTRIBUTION À L'ÉTUDE DU CHAMP CYLINDRIQUE DANS L'AIR IONISÉ À LA PRESSION ORDINAIRE (The Cylindrical Field in Ionised Air at Atmospheric Pressure).—Pauthenier and Mallard. (*Comptes Rendus*, 21st Oct. and 18th Nov., 1929, Vol. 189, pp. 635–637 and 843–845.)

PHOTOIONIZATION OF SOME ALKALI VAPOURS.—F. L. Mohler and C. Boeckner. (*Bur. of Stds. Journ. of Res.*, Aug., 1929, Vol. 3, pp. 303–314.)

THE THEORY OF RECOMBINATION OF GASEOUS IONS.—L. B. Loeb and L. C. Marshall. (*Journ. Franklin Inst.*, Sept., 1929, Vol. 208, pp. 371–388.)

THE DISTRIBUTION OF MOBILITIES OF IONS IN MOIST AIR.—J. Zeleny. (*Phys. Review*, 15th July, 1929, Vol. 34, No. 2, pp. 310–334.)

A search was made in undried air for groups of ions having different mobilities and no such distinct groups were found among ions two or more seconds after their formation. A critical study was made of the effects of diffusion upon the distribution of ions moving in an electric field.

CALCIUM CLOUDS SPREAD THROUGH SPACE.—J. S. Plaskett and J. A. Pearce. (*Sci. News-Letter*, 14th September, 1929, Vol. 16, p. 159.)

The authors' results confirm Eddington's theory that these clouds permeate the inter-stellar space in the Milky Way and do not, as maintained by other authorities, merely surround the individual stars.

INFLUENCE DE LA TEMPÉRATURE SUR LES FORCES ÉLECTROMOTRICES PHOTOVOLTAÏQUES (The Effect of Temperature on Photo-voltaic E.M.F.s).—G. Athanasiu. (*Comptes Rendus*, 23rd Sept., 1929, Vol. 189, pp. 460–462.)

The writer's experiments, succeeding those of Rigollot and others on the increase of the photo-voltaic e.m.f. of various voltaic piles as the temperature decreases, lead to the conclusion that the photo-voltaic currents cannot be explained by the ordinary external photo-electric emission but must be due to photo-chemical transformations; he supposes the *direct* action to be little influenced by temperature, while the *reverse* action (leading to re-combination) would be a thermal one favoured by a rise in temperature.

SOME FACTORS GOVERNING THE MAGNITUDE OF FRICTIONAL ELECTRIC CHARGES.—P. A. Mainstone. (*Phil. Mag.*, Nov., 1929, Vol. 8, No. 52, pp. 733–749.)

DIE ÄNDERUNG DER ELEKTRISCHEN LEITFÄHIGKEIT IN STARKEN MAGNETFELDERN (The Alteration of Electrical Conductivity in Strong Magnetic Fields).—O. v. Auwers. (*Naturwiss.*, 8th Nov., 1929, Vol. 17, pp. 867–873.)

LA COHÉSION DIÉLECTRIQUE DES GAZ RARES (Dielectric Cohesion of Rare Gases).—M. Curie and A. Lepape. (*Journ. de Phys. et le Rad.*, August, 1929, Vol. 10, pp. 294–298.)

A development of the work of Bouty, who introduced the idea of dielectric cohesion as a constant characteristic of a gas.

PROPERTIES OF THE ELECTRON.—R. D. Kleeman. (*Nature*, 9th Nov., 1929, Vol. 124, p. 728.)

Further development of the work referred to in 1929 Abstracts, p. 400, on the hypothesis that the electron possesses the property of absorbing radiant energy during its motion, which induces a decrease of its electrical field; and of ejecting again, under certain conditions, this energy in the form of radiation. See also *Science*, 15th Nov., 1929, p. 479.

DISCONTINUITIES OF MAGNETISATION IN IRON AND NICKEL.—C. W. Heaps and J. Taylor. (*Phys. Review*, 15th September, 1929, Vol. 34, pp. 937–944.)

Investigation into the Barkhausen effect. The length of the portion of material associated with each discontinuity is estimated to be 2 or 3 mm.; the volume is of the order of $10^{-7}$ cm³. It is suggested that in different portions of the material different magnetostrictive effects may occur—strains being set up which, when relieved discontinuously, produce the jumps of induction. See also Bozorth, *ibid.*, 1st September, 1929, pp. 772–784.

A GENERAL THEORY OF THE PLASMA OF AN ARC.—L. Tonks and I. Langmuir. (*Phys. Review*, 15th Sept., 1929, Vol. 34, pp. 876–922.)

BEMERKUNGEN ZUM ABSORPTIONSGESETZ DER DURCHDRINGENDEN HÖHENSTRAHLUNG (Remarks on the Absorption Law of the Cosmic Radiations).—H. Kulenkampff. (*Physik. Zeitschr.*, 15th September, 1929, Vol. 30, pp. 561–567.) Also NEW RECORDS OF THE COSMIC "ULTRA-RADIATION" ON THE SONNBLICK (3,100 M.).—V. F. Hess and O. Mathias. And NEW RESEARCHES ON THE PENETRATING HESS RADIATIONS.—E. Steinke. (*Ibid.*, 1st November, 1929, Vol. 30, pp. 766–767 and 767–771.)

DIE HÖHENSTRAHLUNG BEI POLARLICHT (Cosmic Rays and their Connection with Polar Light).—E. A. Smith. (*Zeitschr. V.D.I.*, 4th Jan., 1930, Vol. 74, pp. 20–21.)

Last year's observations showed a regular correlation between the strength of the two phenomena. The writer concludes, therefore, that the cosmic rays must proceed from the sun and not, as hitherto believed, from the distant nebulæ.

ON NEW MEASUREMENTS ON THE INTENSITY OF COSMIC RAYS AS A FUNCTION OF DEPTH BENEATH THE SURFACE OF THE ATMOSPHERE.—R. A. Millikan and G. H. Cameron. (Summary in *Science*, 13th Dec., 1929, Vol. 70 p. 588.)

These new measurements lead to the following results :—the existence of very considerable homogeneity in the penetrating power of the rays responsible for the bulk of the ionization in the upper atmosphere ; the existence of an exceedingly hard component in the cosmic rays, in excellent agreement with the recent findings of Regener (1929 Abstracts, p. 463) ; and the fact, hitherto ignored in all theories, that the nucleus plays an important rôle in the absorption of cosmic rays.

ELECTRON SCATTERING AND HIGH FREQUENCY RADIATION.—J. A. C. Teegan. (*Phil. Mag.*, November, 1929, Vol. 8, No. 52, pp. 664–667.)

An extension of the de Broglie wave hypothesis of the electron to the question of the absorption of high speed electrons in matter leads to the result that the absorption coefficient of electrons (or electron waves) of very high velocity should differ only very slightly from that of a gamma radiation of the same energy. Thus, since electrons corresponding to 940 million volts might be expected to behave in their absorption by matter in a manner almost identical with that of a gamma radiation of corresponding wavelength ($.013 \times 10^{-11}$ cm.), it would not appear possible to predict, from a study of its absorption, whether the most penetrating of the cosmic radiations is of a corpuscular or gamma-ray nature. *Cf.* Kar, 1929 Abstracts, pp. 644–645.

ON THE DETERMINATION OF THE RANGE OF FREQUENCIES WITHIN THE GROUP OF MECHANICAL WAVES OF AN ELECTRON.—H. T. Flint. (*Proc. Roy. Soc.*, 2nd December, 1929, Vol. 126 A., pp. 40–43.)

". . . We deduce that for high velocities the electron behaves more and more like a monochromatic set of waves as $v$ approaches $c$, and actually becomes monochromatic at $v = c$. If we extend this reasoning to include the photon we shall deduce that the photon is associated with a single frequency $\nu$, as is in fact generally assumed. But the formula suggests that the electron and the photon are indistinguishable when the electron has the velocity $c$. We may perhaps tentatively assume the same limiting condition in the case when $v$ is small, and so derive a general upper limit to the extended group. It is then interesting to note that when $v = 0$ there is still an upper limit, viz., $m_0c^2/h$, and this is equal to the wave frequency itself.

INTRODUCTION À UNE THÉORIE DES PHÉNOMÈNES MAGNÉTO-OPTIQUES DANS LES CRISTAUX (Introduction to a Theory of the Magneto-optical Phenomena in Crystals).—J. Becquerel. (*Journ. de Phys. et le Rad.*, Sept., 1929, Vol. 10, pp. 313–320.)

PROOF AND EXTENSION OF HEAVISIDE'S OPERATIONAL CALCULUS FOR INVARIABLE SYSTEMS.—B. van der Pol. (*Phil. Mag.*, June, 1929, Vol. 7, pp. 1153–1162.)

## MISCELLANEOUS.

ÜBER EINE ANWENDUNG DER QUANTENTHEORIE ZUR LEUCHTENERSCHEINUNG AM KARBORUNDUM-DETEKTOR (The Application of the Quantum Theory to the Glow Phenomenon in the Carborundum Detector).—O. W. Lossew. (*Physik. Zeitschr.*, 1st Dec., 1929, Vol. 30, pp. 920–923.)

*See* 1929 Abstracts, pp. 53 and 588. It is now shown that the glow "type I" may be regarded as Röntgen radiation of a continuous spectrum; the direct connection between the process of radiation-production and the possibility of rectifying action is pointed out by quantum mechanics.

SUR L'EMPLOI D'UN DÉTECTEUR À GALÈNE DANS LES MESURES OPÉRÉES PAR COURANT VARIABLE (The Use of a Galena Detector in Measuring Processes depending on a Variable Current).—A. Guillet. (*Comptes Rendus*, 9th Dec., 1929, Vol. 189, pp. 1070–1072.)

Inductometer measurements, on a.c. from the mains, show that for a given inducing a.c. the currents rectified by the galena (in the second circuit) are proportional to the square of the coefficients of mutual induction between the two circuits. Among other uses, the writer has employed this method for determining the elongation of metal wires loaded from 50 gm. to 6 kgm.

ZUR UMKEHR DES DETEKTORSTROMES BEI HOHEN FREQUENZEN (On the Detector Current Reversal at High Frequencies).—G. G. Reissaus. (*Naturwiss.*, 8th Nov., 1929, Vol. 17, pp. 877–878.)

The writer considers that his theory readily explains Hollmann's results (1929 Abstracts, p. 647), which he himself has often encountered with medium frequencies. Electrostatic attraction between crystal and point is enough to cause mechanical damage to the crystal surface.

TERMINAL APPARATUS FOR TRANSOCEANIC SUBMARINE CABLE TELEPHONY.—N. W. McLachlan. (*Electrician*, 6th and 13th December, 1929, pp. 703–705 and 735–736.)

"Technical details of transmitting and receiving amplifiers devised to compensate for attenuation of long submarine telephone cables."

NEUE ANWENDUNGEN ULTRAKURZER WELLEN (New Uses for Ultra-Short Waves) : Discussion.—Esau : Schliephake : Meissner : Kohl : Fassbender. (*E.N.T.*, Sept., 1929, Vol. 6, pp. 371–373.)

Esau's paper itself has not yet been published, but the discussion contains several points of interest. Schliephake amplifies Esau's treatment of the medical side of their 3 and 5 m. tests (*cf.* 1929 Abstracts, p. 347). The liver, kidneys, and other deep-lying organs can be warmed almost as much as the skin and near-lying layers, and flushed with blood—which is often synonymous with healing action.

The speaker and Haase have studied the action of the electric field (apart from the heating effect) on bacilli and have found a distinct damaging effect on bacteria: even tubercle bacilli (which can survive a high temperature for a long time) were considerably checked in their development. Experiments on the human body being at first undesirable (injuries by X-ray radiation being too fresh in the memory), they made tests with animals: it can be said now that tuberculous infection in animals (*not* mice, as has been stated in certain journals—for these animals are almost unsusceptible to tuberculosis; but guinea-pigs and other animals) definitely recedes under treatment; in particular, the tuberculosis takes on far more harmless forms. Subsequent tests on his own person and on others are in progress: all he can say at present is that calming [misprint for disturbing ?] effects on the nervous system and favourable effects on infectious illnesses have been noted. He himself suffered a severe determination of blood to the head and a curious nervous irritability: sleep was very bad and loss of appetite and a kind of depression were noticeable: a suspension of the work caused these symptoms to decrease.

His co-workers suffered in similar ways, and a certain dependence on wavelength seemed to show itself: the human body appears to oscillate as a dipole, and a few centimetres difference in height seems to have an effect on the susceptibility to a certain wavelength: there is even a difference between a person sitting and standing.

Esau, on the other hand, attributes the injurious results on the sight (reported from various sources) to exposure of "too weak eyes too close to the bright valves." Results on the effect of these waves on the optic nerves were entirely negative. In reply to Fassbender, who asks whether the comparison between ordinary currents used in diathermy and the short waves was carried out with similar electrodes and similar magnitudes (in which case, unless there is a skin effect on the human body, the "doses" would be equal) Esau replies that the comparison was made as exact as possible and the results were clearly different as regards the deep working. There can be no appreciable skin effect or (at these frequencies) the waves would hardly penetrate at all.

Schliephake describes tests on cubes of bread (which forms a good representation of animal substance), introducing pieces of celluloid to represent muscle and tendons and channels to represent organs filled with air. The diathermic currents are strongly deflected by the insulating layers, whereas the r.f. field goes practically straight through.

Meissner maintains that the effects of these waves are not due only to ordinary diathermy, but also to electrolytic effects: he refers to American results, and quotes the discovery that the resonance wave for solutions of the constitution of human blood lies in the neighbourhood of 6 metres. Kohl stresses the importance of investigating the absorption index of numerous kinds of electrolytes, organic substances, etc.

EFFICACITÉ DE LA D'ARSONVALISATION MÉDICAMENTEUSE DANS LE LUPUS ÉRYTHÉMATEUX (Efficacy of "medicamental" d'Arsonvalisation—H.F. Treatment—in Erythematic Lupus).—H. Bordier. (*Comptes Rendus*, 6th Jan., 1930, Vol. 190, pp. 87–88.)

MÉCANISME D'ACTION DU BISTOURI ÉLECTRIQUE À HAUTE FRÉQUENCE (The Mechanism of the Action of the High Frequency Electric Scalpel).—Ch. Champy and M. Heitz-Boyer. (*Comptes Rendus*, 30th Dec., 1929, Vol. 189, pp. 1328–1330, with a number of plates.)

A study of the mechanical (as distinct from the thermal) effects produced by h.f. currents, applied by fine electrodes, on living matter; cellular elongation and disruption, and hæmostatic action on the blood vessels. For a comparison between the use of damped and undamped waves ("the h.f. bistoury working diathermically [damped oscillations] cuts badly and destroys much: the h.f. bistoury without diathermic action [undamped oscillations] cuts well and destroys only a minimum") see same writers, *ibid.*, 2nd Dec., 1929, pp. 1039–1040.

SUR L'INTERPRÉTATION DES ACTIONS BIOLOGIQUES À DISTANCE (The Interpretation of Biological Actions at a Distance [Mitogenetic or "Vital" Rays]).—J. Magrou. (*Comptes Rendus*, 6th Jan., 1930, Vol. 190, pp. 84–87.)

More on the subject referred to in 1929 Abstracts, pp. 524–525.

THE ACTION OF THE MITOGENETIC RAYS THROUGH A QUARTZ SCREEN.—A. Naville. (Short abstract in *Nature*, 12th October, 1929, Vol. 124, p. 602.)

The author finds that onion roots, placed behind a quartz filter, are capable of producing about 40 per cent. more kineses in the cornea of a frog than would occur otherwise.

SUR L'HYPOTHÈSE DU RAYONNEMENT MITOGÉNÉTIQUE (On the Hypothesis of Mitogenetic Radiation).— —. Choucroun. (*Comptes Rendus*, 4th November, 1929, Vol. 189, pp. 782–784.)

Tests throwing doubt on the existence of the "vital rays" referred to in 1929 Abstracts, p. 524, and above.

ULTRAROTE STRAHLEN ZUR SIGNALGEBUNG UND ORIENTIERUNG IM NEBEL (Ultra-Red Rays for Signalling and Direction Finding in Fog).—Wolff, Koppe, Müller, Voege, and others. (*Zeitschr. V.D.I.*, 28th Dec., 1929, Vol. 73, pp. 1859–1860.)

A number of papers on various aspects of the problem, including "Ultra-red d.f. using the Thalofide Cell" ('Case' cell, thallium-oxygen-sulphur combination); "Practical experiences with ultra-red signalling in the War." "A torpedo-boat, obscured by fog at 4 km., remained audible and was easily spotted." The French used in the War the quenching effect of ultra-red radiation on phosphorescence, for Morse signalling (range 10 km. with 100 cm. diameter mirror); the Americans, using a 36 cm. parabolic mirror, revealed the presence of troops at 180 metres. "The reports about the latest successes of the English, in reliably receiving the heat rays thrown back from the side of a ship, sound most improbable." The subsequent discussion showed how great an importance was attached to the subject by naval and other authorities in Germany. See also Fassbender, Jan. Abstracts, p. 47.

SUR UN PROCÉDÉ D'ACTIVATION DE LA MATIÈRE (A Process for the Activation of Matter).—G. Reboul. (*Comptes Rendus*, 30th Dec., 1929, Vol. 189, pp. 1256–1257.)

The writer has previously [no reference given] described how to produce a very absorbable radiation by the use of "resistance cells" traversed by 1 or 2 mA. at "some tens of thousands of volts." Bodies exposed to the action of these cells acquire the property of affecting a photographic plate and of discharging an electroscope, retaining this property often for several hours.

PROTECTION AUTOMATIQUE DES TRAINS, SYSTÈME BÄSELER, PAR RÉPÉTITION OPTIQUE DES SIGNAUX (Automatic Train Protection, Bäseler System, by Optical Repetition of Signals).—(*Génie Civil*, 14th December, 1929, Vol. 95, pp. 597–598.)

An illustrated description of the system referred to in February Abstracts, pp. 116–117.

PHOTOELECTRIC CELLS FOR TESTING ELECTRICITY METERS.—S. Aronoff and D. A. Young. (*Elect. Journ.*, June, 1929, Vol. 26, pp. 255–257.)

For precision tests the photoelectric cell can actuate relays controlling a timing device, but for commercial tests it can work in conjunction with a neon lamp to give a stroboscopic test, the meter error being determined by observing the apparent creep of its disc.

THE OPACIMETER: PHOTOELECTRIC METHODS IN PAPER TESTING.—F. A. Pearson. (*Scient. American*, Nov., 1929, pp. 416–418.)

This apparatus is used to "weigh" moving paper in process of manufacture, making use of the dependence of opacity on weight. It is so sensitive that the recorder pen moves for a change in the photoelectric cell circuit of four billionths of an ampere, and other applications are suggested —*e.g.*, X-ray examinations or cathode-ray analysis.

LE "CAROTTAGE ÉLECTRIQUE" DES SONDAGES (Geological Sounding by Electrical "Carrotting").—Schlumberger. (*Génie Civil*, 12th Oct., 1929, Vol. 95, pp. 361–362.)

An article on the Schlumberger method of making use of an un-tubed boring to test the electrical conductivity of the rocks, etc., through which it passes: obtaining in this way information as to their nature. In the example described, three cables of different lengths are hung down the water-filled boring, each ending in an electrode which is in contact with the water. The deepest electrode carries current to the walls of the boring, while the other two are connected to a potentiometer instrument.

A NOTE ON A STATIC MACHINE WITH PYREX INSULATION.—A. W. Simon. (*Journ. Opt. Soc. Am.*, Dec., 1929, Vol. 19, pp. 407–408.)

A small Wimshurst machine thus constructed gave a very heavy spark with a voltage of about 75 kv.; its action was *very little* influenced by atmospheric conditions.

AU 6E SALON DE LA T.S.F. (The 6th French Radio Exhibition).—P. Maginot. (*L'Onde Élec.*, October, 1929, Vol. 8, pp. 465–467.)

THIS YEAR'S PROGRESS IN COMMERCIAL WIRELESS.—Chetwode Crawley. (*Wireless World*, December 25th, 1929, Vol. 25, p. 706.)

A review of 1929, dealing with the Government cable and wireless merger, progress in international wireless telephony, the coming into force of the International Radio Telegraph Convention, developments in ship wireless and the wavelength decisions of the Hague Conference.

ARBEITEN DER DEUTSCHEN VERSUCHSANSTALT FÜR LUFTFAHRT E.V. IM JAHRE 1928/29 (Work of the German Research Establishment for Aircraft in the year 1928/29).—H. Fassbender. (*Zeitschr. V.D.I.*, 21st December, 1929, Vol. 73, pp. 1823–1825.)

A section on p. 1825 deals with the Wireless Division. The various pieces of work mentioned have been dealt with in these Abstracts from time to time.

TEFAG-RISTOW WIRELESS AUTOMATIC CALL.—A. Ristow. (*See* under "Subsidiary Apparatus").

INFRA-RED PHOTOGRAPHY: NEOCYANIN.—(*See* under "Atmospherics.")