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How Many Ionised Layers?

MANY of the results obtained from experiments carried out with the object of determining the height to which the refracted waves have attained during their passage from the transmitter to the receiver have been of a nature to indicate either that the waves have undergone multiple reflection between the earth and the ionised layer, or that other ionised layers must exist at heights of two or three hundred kilometres in addition to that at about one hundred kilometres. Professor Appleton has come to the conclusion that the latter is, in many cases, the correct explanation, and he has called the lower and upper regions the *E* and *F* regions respectively. The June number of the *Zeitschrift für Hochfrequenztechnik* contains a very interesting preliminary account of a series of experiments carried out by Goubau and Zenneck between various points in Bavaria. The wavelength employed was 532.9 metres, the normal wavelength of the Munich transmitter, which was employed after broadcasting hours for many of the experiments. Great caution should be exercised in comparing the results with those obtained at other wavelengths, but at this one wavelength a very large number of tests were made at distances varying from 6 to 126 kilometres, and although frequent indications of reflection from ionised layers at heights of 200 and 300 kilometres were obtained, the authors have come to the definite conclusion that these were due in every case to waves which had been reflected two or three times between the 100 km. layer and the earth. The main argument in favour of this conclusion is the fact that the apparent heights of the fictitious layers are, within the errors of observation, always exact multiples of the height of the lowest observed layer. The authors show how irregularities in the level of the ionised layer may be expected to cause slight departures from the exact multiple, and also to give indications of several layers in the neighbourhood of 100 kilometres. Some of the results are so striking that there can be no doubt that this is the correct explanation, as, for example, when a gradual fall of the lower layer from 115 to 100 kilometres, extending over two hours, is accompanied by an equally regular fall in the apparent height of the upper layer from 230 to 200 kilometres. In other cases the agreement is not so striking, but the arguments put forward to explain the discrepancies are fairly convincing, and provide material for careful consideration by other experimenters who may be tempted to come to hasty conclusions as to the undoubted

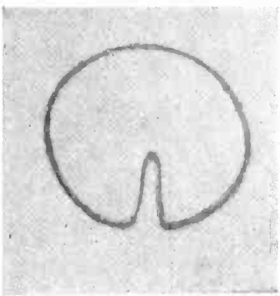

Fig. 1.

existence of several ionised layers before they have exhausted the possibilities of a single layer.

Methods Employed in the Experiments.

The methods employed in these tests are very ingenious and interesting. The transmitter consisted of a master oscillator with several stages of amplification.

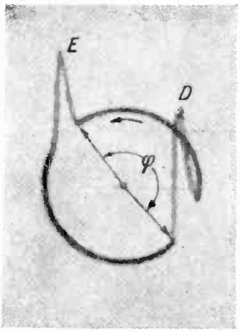

Fig. 2.

The grid of the last valve had such a large negative bias that, under normal conditions, the antenna current was entirely suppressed. In the grid circuit, however, there was a highly saturated choke-coil, which formed part of a condenser circuit, coupled to a 500 cycle alternator. The flux in the core of the choke-coil changed very suddenly 500 times per second in such a direction that the large E.M.F. induced in the coil neutralised the negative bias on the grid of the valve and allowed current to flow in the aerial. In this way a pulse lasting about 10^{-4} second occurred 500 times per second.

At the receiving station a cathode-ray oscillograph had two sets of coils at right angles supplied with current from a valve-oscillator adjusted to a frequency of 500. The current supply to the two sets of coils was arranged to have 90° phase difference, so that the spot on the fluorescent screen described a circle with a frequency of 500 revolutions per second.

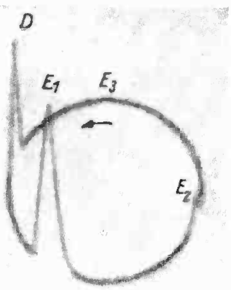

Fig. 3.

The signals were received on a frame, amplified and rectified. A part of the rectified voltage was tapped off, passed through a low-frequency amplifier, and applied to the valve oscillator, adjustments being made until the received signal controlled the frequency of the oscillator. In this way the circle described by the spot of light was maintained in strict synchronism with the emission of pulses from the transmitting station. The rectified voltage of the signal was applied to two deflecting plates of the cathode-ray tube so as to cause a vertical upward movement of the spot. This upward movement was superposed upon the circular movement, and the whole phenomenon was repeated 500 times per second, thus giving a steady picture on the screen, little affected by atmospheric or other disturbances which have not a periodicity of 500.

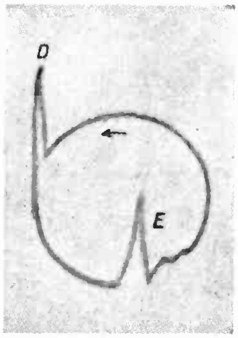

Fig. 4.

Fig. 1 shows the result obtained in the absence of a downcoming wave or echo and Fig. 2 the result obtained with a single echo. *D* denotes the direct or ground signal and *E* the echo signal. The time of the angular displacement ϕ between them is accurately known from the frequency of the 500-cycle generator. It will be seen at once that it is not always an easy matter to determine this angle to a higher degree of accuracy, especially when the signal displacement is approximately tangential to the circle. The method would undoubtedly be greatly improved if the signal voltage could be applied between a central electrode and an external ring electrode, so that the movement of the spot was radial instead of vertical. The article contains no reference to such a possibility, however, and we do not know if it has been considered.

Fig. 3 shows three equally spaced echo signals due to single, double, and triple reflection. Fig. 4 shows a number of echo signals, but all representing single reflection from different parts of the layer.

For a fuller discussion of these and of other interesting photographic results we must refer our readers to the original article, which is, however, only of a preliminary nature. The full description will be published shortly in the *Annalen der Physik*.

G. W. O. H.

A Single-valve Multi-frequency Generator.*

By A. T. Starr, B.A., B.Sc.

Introduction.

IT has long been known that in low-frequency valve oscillators conditions are sometimes met in which a parasitic high-frequency oscillation occurs. So far as the author knows, however, no attempt has been made to produce in a single-valve circuit two or more frequencies of oscillation, the frequencies being arbitrary and of the same order of magnitude, and the amplitudes of the different frequencies of arbitrary ratios. This paper gives methods to achieve this, and an experimental verification of the theory is also given.

Since the tuned-anode oscillator with feed-back resistance has been found highly satisfactory in practice, it formed the starting point of the investigation. Its theory will be given first, as it leads to a generator producing several desired frequencies.

Tuned-anode Oscillator with Feed-back Impedance.

The circuit of a tuned-anode oscillator with feed-back impedance is shown in Fig. 1a. Only a.c. paths are given, and for the sake of generality the feed-back impedance† is a complex impedance $Z = R + j\omega X$. It is assumed that no grid current flows, otherwise the problem is made more complicated. Also inter-electrode capacities are neglected. With these qualifications the equivalent circuit of Fig. 1a is shown in Fig. 1b, since the grid voltage is $j\omega Mi$, i being the current in the primary of the transformer. From Fig. 1b are derived immediately

$$i(j\omega L + r) = i_1/j\omega C,$$

and $\mu j\omega Mi = (i + i_1)(r_p + Z) + i_1/j\omega C$. Elimination of i and i_1 from these equations gives

$$\mu j\omega M = (r_p + Z) + \left(r_p + Z + \frac{1}{j\omega C}\right)(j\omega C)(j\omega L + r)$$
$$= (r_p + R + j\omega X) + \left(r_p + R + j\omega X + \frac{1}{j\omega C}\right)(j\omega C)(j\omega L + r)$$
$$= r_p + R + r + j\omega(X + L) + j\omega C(j\omega L + r)(r_p + R + j\omega X) \quad \ldots \quad (1)$$

Equating real parts we get

$$O = r_p + R + r - \omega C[\omega L(r_p + R) + \omega X r] \quad \ldots \quad \ldots \quad \ldots \quad (1a)$$

If X is of the same order of magnitude as L,

$$\omega X r \ll \omega L(r_p + R),$$

since r is very small compared with $(r_p + R)$ Equation (1a) then gives

$$\omega^2 = \frac{r_p + R + r}{LC(r_p + R)},$$
$$\approx \frac{1}{LC} \quad \ldots \quad \ldots \quad \ldots \quad (2a)$$

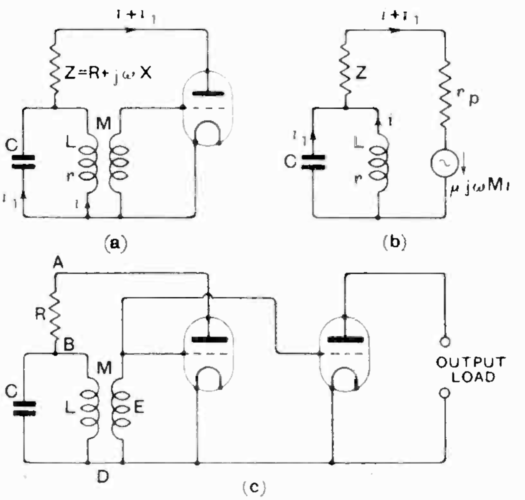

Fig. 1.

A closer degree of approximation is derived from (1a) and is given by

$$\omega^2 = \frac{r_p + R + r}{LC(r_p + R) + XCr}$$
$$\approx \frac{1}{LC}\left[1 + \frac{r}{r_p + R}\left(1 - \frac{X}{L}\right)\right] \quad (2b)$$

* MS. received by the Editor, May, 1931.

† It should be noted that the feed-back impedance (shown as Z in Fig. 1a) is placed in the feed-back circuit and regulates the amount of voltage fed back to the grid, but it is not the voltage across this impedance that is fed back. It might, perhaps, be more correctly termed the "feed-back regulating impedance," but the contraction given is the more usual term, especially in current American literature.

giving $\omega = \frac{1}{\sqrt{LC}}\left[1 + \frac{r}{2(r_p + R)}\left(1 - \frac{X}{L}\right)\right]$ (2c)

If X is zero, as in the ordinary case, this shows that the frequency is greater than the value $(2\pi\sqrt{LC})^{-1}$, but approaches this value as the feed-back resistance is increased. This can be observed when impedance measurements are taken in an a.c. bridge and the feed-back of the oscillator is varied.

If X is not zero, then the frequency may be above or below the value $(2\pi\sqrt{LC})^{-1}$, but approaches this value as R is increased. If r_p varies, as it may do with battery variations, the frequency will vary according to the second term of equation (2c). The variations can be made to vanish by putting $X = L$, *i.e.*, by putting in series with the feed-back resistance a coil of inductance equal to that of the primary winding of the tuning transformer. It should be noticed that this is not an approximation, like (2c), but exact. For putting $X = L$ in equation (1a), we derive at once $\omega = \frac{1}{\sqrt{LC}}$, independent of r_p, R, and r. (This result was discovered independently and earlier by Professor Mallett and published in the proceedings of the Wireless Section of the *I.E.E.*, June, 1930.)

The variations of frequency can be made to decrease by decreasing the resistance of the primary, or by increasing the internal valve impedance and/or the feed-back resistance. If X is negative, *i.e.*, when the reactive part of the feed-back impedance is capacitative, the frequency variations will be diminished, either by increasing the primary inductance of the transformer or by adding inductive reactance of the requisite amount to the feed-back impedance.

Mallett states that grid-plate capacity diminishes the value of X required for non-variation of frequency.

To a first approximation, however, the frequency is independent of the feed-back impedance, as shown by equation (2c).

Equating imaginary parts of equation (1), the condition of oscillation emerges as

$\mu M = X + L + C\,[r(r_p + R) - \omega^2 LX]$ (1b)

It is this equation that determines the amplitude of the oscillation. Substituting for ω from equation (1a), this condition becomes

$$\mu M = L + Cr\,(r_p + R) + X\left[1 - \frac{r_p + R + r}{r + R + \frac{X}{L}r}\right]$$

$$= L + Cr\,(r_p + R) + Xr\left(1 - \frac{X}{L}\right)\Big/\left(r_p + R + \frac{X}{L}r\right) \quad \ldots \quad (3)$$

If X is comparable in magnitude with L, the ratio of the last term to the first is of the order $\frac{r}{r_p + R}$. The condition of oscillation becomes :—

$$\mu M = L + Cr(r_p + R) \quad \ldots \quad (3a)$$

Hence to a first approximation the amplitude of oscillation is independent of the reactive part of the feed-back impedance, provided this latter is comparable with the primary inductive reactance in magnitude.

In practice in most oscillators, one tube is used as an oscillating tube and its grid variations are stepped on to the grid of a tube used as an amplifier, as shown in Fig. 1c.

The advantages of this are the following :

Since no energy is taken from the oscillating circuit, the frequency and amplitude of oscillation are independent of the output load.

There is a reduction of harmonic content in the output. For let the various points in the circuit be designated as in Fig. 1c, and the potential difference between any two points be designated by V with the appropriate letters as suffixes. The anode voltage in the first tube V_{AD} and contains the fundamental and considerable quantities of harmonics, it may be as much as 10 per cent. or even 20 per cent. Let the impedance of the tuned circuit be Z. Then for the case of feed-back impedance,

$$V_{BD} = \frac{Z}{R + Z} V_{AD}$$

The grid-voltage, which is stepped on to the next tube is a constant times this, say

$$V_{DE} = k\frac{Z}{R + Z} V_{AD} \quad \ldots \quad (4)$$

where k is the step-up constant.

At the resonant frequency

$$Z = \frac{L}{Cr}\frac{1 + \dfrac{r}{j\omega L}}{1 - \dfrac{1}{j\omega C(r_p + R)}} \text{ exactly,}$$

$$= \frac{L}{Cr}\frac{1 + \dfrac{r}{j\omega L}}{1 + \dfrac{j\omega L}{r_p + R}} \text{ approx.}$$

In general $\omega L \ll r_p + R$, and $Z \approx \dfrac{L}{Cr}$ (5)

$\omega L \gg r$

At the second harmonic $Z \approx -\frac{1}{3} j\omega L$,
At the third harmonic $Z \approx -\frac{1}{8} j\omega L$, and so on.

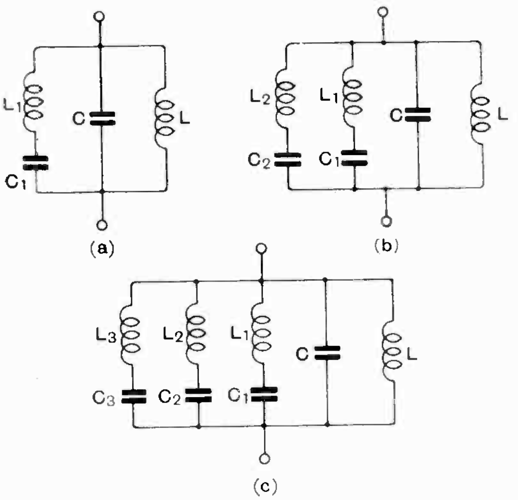

Fig. 2.

The effect of taking a connection from one grid to the next is therefore to discriminate heavily in favour of the fundamental and to cut down the level of the harmonics. For if R be large, as it always is, the magnitude of $\dfrac{Z}{R + Z}$ is small when $\dfrac{Z}{R}$ is small, and this happens when $Z = -\frac{1}{3} j\omega L$ or $-\frac{1}{8} j\omega L$, etc., and somewhere in the neighbourhood of unity (say $\frac{1}{2}$ or $\frac{1}{3}$) where Z is large, say $\dfrac{L}{Cr}$.

The Multi-Frequency Valve Oscillator.

For the sake of simplicity, the simplest type of feed-back oscillator will be taken as the parent- or proto-type of the multi-frequency valve oscillator. Suppose that in Fig. 1a the condenser C is replaced by a general complex impedance Z_t. Then the infinities of the impedance composed of Z_t and L in parallel will give a number of possible frequencies of oscillation. For example, Figs. 2a, 2b, 2c represent the tuning circuit for producing two, three, or four frequencies of oscillation. Z_t in Fig. 2a is the condenser C in parallel with L_1 and C_1 in series, and so on. It is easily seen that the impedance configurations of Figs. 2a, 2b and 2c have, in the ideal case, two, three and four frequencies of infinite impedance respectively. This ensures that phase relationships will be satisfied for oscillation at these frequencies. It now remains to satisfy the conditions for the energy supply at each frequency, so that the oscillations should be possible with the amplifications afforded by the tube at these frequencies. In fact, the relative amplitudes of the frequencies may be arranged by appropriate design.

There are two ways of doing this. One way, which is perhaps more obvious than the other, is to have a feed-back impedance with a given resistance-frequency characteristic.

Another is to include added resistances in the various arms of Z_t.

These methods will be more readily understood if the theory of the multi-frequency valve generator is worked out first.

The Theory of the Multi-Frequency Valve Oscillator.

The a.c. schematic and equivalent circuit are shown in Figs. 3a and 3b, and differ

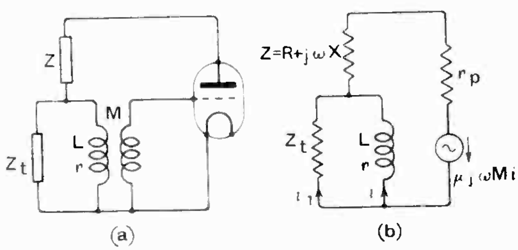

Fig. 3.

from Figs. 1a and 1b only in that the more general impedance Z_t replaces the condenser C.

The equations are seen to be

$$(r + j\omega L)i = Z_t i_1,$$

and $$(i + i_1)(r_p + R + j\omega X) + Z_t i_1 = \mu e_g = \mu j\omega M i$$

Eliminating i and i_1 from these equations one derives

$$\mu j\omega M Z_t = (r_p + R + j\omega X)(Z_t + r + j\omega L) + Z_t(r + j\omega L).$$

This becomes

$$\mu j\omega M = r + j\omega L + r_p + R + j\omega X + \frac{(r + j\omega L)(r_p + R + j\omega X)}{Z_t}$$

Putting $\frac{1}{Z_t} = A + j\omega B$ .. .. (6)

$$\mu j\omega M = r + j\omega L + r_p + R + j\omega X + (r + j\omega L)(r_p + R + j\omega X)(A + j\omega B) \quad (7)$$

Equating real parts,

$$O = r + r_p + R + A(r \,.\, \overline{r_p + R} - \omega^2 LX) - \omega^2 B(L \,.\, \overline{r_p + R} + Xr) \quad (8)$$

The frequencies of oscillation are therefore given by

$$\omega^2 = \frac{r + r_p + R + Ar(r_p + R)}{B(L \,.\, \overline{r_p + R} + Xr) + ALX} \quad (9)$$

Equations (8) or (9) give *frequencies* of oscillation, for B is a function of frequency, and the equations therefore have several roots. It will be shown later how to find the values for the configurations of Figs. 2a and 2b.

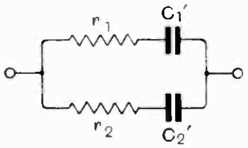

Fig. 4.

Since $r \ll r_p$ or R, and because also A is small near an anti-resonant point of Z_t and L in parallel, equation (9) reduces to

$$\omega^2 = \frac{1}{LB} \quad .. \quad .. \quad .. \quad .. \quad (10)$$

When Z_t is an ordinary condenser C,

$$\frac{1}{Z_t} = j\omega C,$$

so that $A = O$ and $B = C$, equation (10) then reducing to equation (2a).

Equating imaginary parts of (7),

$$\mu M = L + X + A(L \,.\, \overline{r_p + R} + Xr) + B(r \,.\, \overline{r_p + R} - \omega^2 LX)$$

Substituting for the last term in this equation from equation (8), which is exact, the condition of oscillation becomes

$$\mu M = L + Br(r_p + R) + AL(r_p + R) + XAr + \frac{X}{r_p + R + \frac{X}{L}r + \frac{AX}{B}} \left[r\left(1 - \frac{X}{L}\right) + \frac{AX}{B} - Ar(r_p + R)\right] \quad (11)$$

With practical conditions, the last two terms on the right-hand side of equation (10) bear a ratio somewhat like $\frac{r}{r_p + R}$ to the rest. To a first approximation, therefore, the condition of oscillation becomes

$$\mu M = L + Br(r_p + R) + AL(r_p + R) \quad (12)$$

If $Z_t = 1/j\omega C$, so that $A = O$ and $B = C$, this equation reduces to equation (3a).

From equations (9) and (12), both *the frequencies and amplitudes of the oscillation components are independent, to a first approximation, of the reactive part of the feed-back impedance.*

Design of a Multi-frequency Oscillator.

The schematic is shown in Fig. 3a. Suppose four frequencies were required. The tuning-circuit Z_t would be as shown in Fig. 2c.

$$\frac{1}{Z_t} = j\omega C + \frac{j\omega C_1}{1 - \omega^2 L_1 C_1} + \frac{j\omega C_2}{1 - \omega^2 L_2 C_2} + \frac{j\omega C_3}{1 - \omega^2 L_3 C_3} = j\omega B$$

If the frequencies of oscillation are to be ω_1, ω_2, ω_3 and ω_4 then

$$\omega^2 L\left[C + \frac{C_1}{1 - \omega^2 L_1 C_1} + \frac{C_2}{1 - \omega^2 L_2 C_2} + \frac{C_3}{1 - \omega^2 L_3 C_3}\right] = 1 \quad .. \quad (13)$$

for $\omega = \omega_1, \omega_2, \omega_3$, and ω_4.

From the four equations (13), C, C_1, C_2, C_3 could be found fixing L, L_1, L_2, L_3, say. Or any four could be fixed, and the rest will be given by the equations (13). This ensures that the valve will oscillate at the frequencies desired.

If their amplitudes are to be equal,

$$\mu M - L = Br(r_p + R) + AL(r_p + R) \quad (14)$$

must be a constant at each of these frequencies.

There are two ways of doing this. One way is by having a complex feed-back.

Taking μM, L, B, r, A and r_p as given, to make the R.H.S. of (14) have a constant value at the four frequencies, the feed-back impedance must have its real part given by

$$\left.\begin{aligned} R &= \frac{\mu M - L}{Br + AL} - r_p \\ &= \frac{\mu M - L}{AL + \dfrac{r}{\omega^2 L}} - r_p \end{aligned}\right\} \quad \ldots \quad \ldots \quad (15)$$

R is by no means constant, as A, B, and r

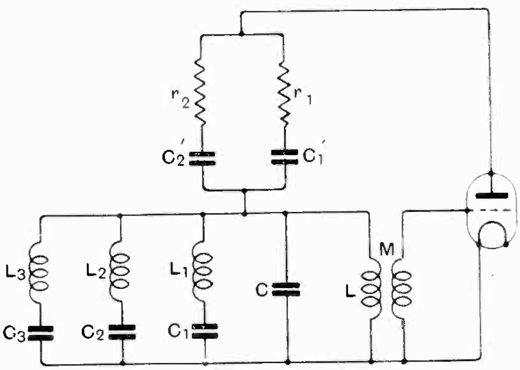

Fig. 5.

vary with frequency. If, as is generally true, R must diminish with frequency, the feed-back impedance may be an impedance configuration, as shown in Fig. 4. By choosing r_1, r_2, C_1', and C_2', the real part of this impedance can be made equal to the value given by equation (15) at the frequencies ω_1, ω_2, ω_3, and ω_4. The reactive part of the feed-back impedance is immaterial, as it does not influence either the frequency or amplitude of the oscillations. The complete schematic is as shown in Fig. 5.

Another way, which is probably more convenient in practice, is by fixing R as a constant, and inserting resistances r_1, r_2, r_3 in series with the arms (L_1C_1), (L_2C_2), (L_3C_3) respectively, these resistances being chosen to satisfy equation (14) at the four frequencies of oscillation. The circuit is as in Fig. 6.

The method of Fig. 5 is not always possible, owing to certain properties of anti-resonant circuits and resistance-capacity networks. The method of Fig. 6 is always possible, and is likely to be more economical than that of Fig. 5, although it needs more work to calculate the elements.

In both cases the calculation of the elements L_1, C_1, L_2, C_2, L_3, C_3 is a matter of some difficulty (and interest).

For the purpose of an experimental test, it was decided to make a valve generator giving two frequencies, and in order to use available apparatus the design was as follows :—

A Two-frequency Valve Generator.

The schematic is shown in Fig. 7. In order to obtain an easily calculated circuit with given frequencies of infinite (*i.e.*, ideally infinite) impedance, two anti-resonant circuits were placed in series The a.c. plate voltage V_{AB} is stepped across with reversed phase and increased magnitude, so that $V_{AC} = -kV_{AB}$, where k is a positive constant. The transformer used had a step-up ratio of 1800 : 10,000, low winding 4.4 H. minimum. The voltage V_{AC} drops off across R and the two anti-resonant circuits, the drop across the latter being fed back to the grid. The frequencies of oscillation are those of anti-resonance of the circuits (LC_1) and (LC_2).

It would seem that the arrangement of Fig. 7 is very different from that of Fig. 3a. It will, therefore, be shown that the differ-

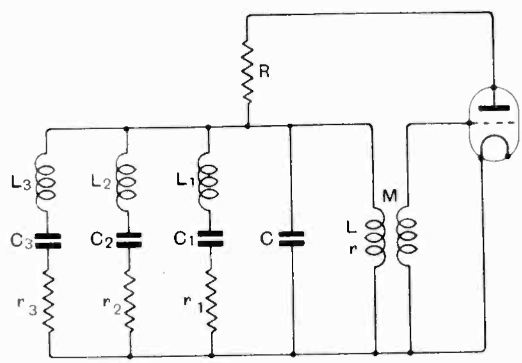

Fig. 6.

ence is not important ; in fact, the mathematics for the two arrangements are identical. For the sake of clearness and brevity, we will assume that the primary winding in Fig. 3a has a very high inductance L and zero resistance, so that $r = 0$, and the mutual inductance M is also very high, comparable with L. This is equivalent to saying that the transformer is ideal. We will then assume that the transformer in Fig. 7 is also ideal, with a turns ratio of k. This is done merely to avoid the complications, which here are inessential, due to practical transformers.

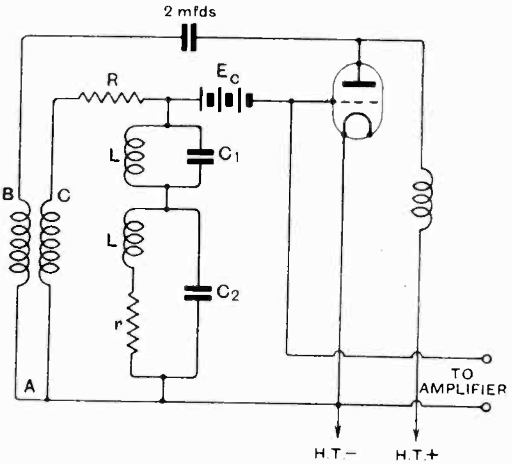

Fig. 7.

In Fig. 7 let the impedance of the two tuned circuits in series be Z_t and the impedance AB in the anode circuit be Z_{AB}.

Then $\quad Z_{AB} = k^2(R + Z_t)$.

If e_g is the a.c. potential of the grid, there is in the anode circuit an e.m.f. μe_g acting through the anode resistance r_p and Z_{AB}. Then

$$V_{AB} = -\mu e_g Z_{AB}/(r_p + Z_{AB}),$$

giving

$$V_{AC} = -kV_{AB} = k\mu e_g Z_{AB}/(r_p + Z_{AB})$$

The grid potential is given by

$$e_g = V_{AC}Z_t/(R + Z_t)$$

$$= e_g \frac{k\mu Z_{AB}Z_t}{(r_p + Z_{AB})\,(R + Z_t)}$$

giving

$$1 = \frac{k^3\mu Z_t}{r_p + k^2(R + Z_t)}$$

This may be rewritten in the form

$$\mu = \frac{1}{k} + \frac{r_p + k^2R}{k^2Z_t} \quad \ldots \quad \ldots \quad (16)$$

This gives the conditions for the oscillation of the circuit of Fig. 7, when the transformer is ideal. Equation (7) gives the conditions for the circuit of Fig. 3a, and, putting $r = 0$ and L and M very high, equation (7) becomes

$$\mu = \frac{L}{M} + \frac{L}{M}\,\frac{r_p + R}{Z_t} \quad \ldots \quad (17)$$

for the case of a real feed-back impedance. It is clear that equations (16) and (17) are identical, provided $\frac{M}{L} = k$, and the anode resistance of the valve in Fig. 7 is k^2 times the anode resistance of the valve in Fig. 3a.

Theoretically, it is no more difficult to treat the cases of complex feed-back impedance and practical dissipative transformers. But the work is tedious and nothing much is to be gained, unless a specific design is required.

The actual values used were $L = .0290$ H, $C_1 = .0350$ μF., and $C = .0545$ μF. In order that the amplitudes of the oscillations be approximately equal, a resistance r of 5 ohms was put in the latter circuit. This was calculated so that the impedance at the anti-resonant frequencies should be equal. Actually, owing to faulty measurements on an Owen's bridge, the 5 ohms was too small and also the frequencies were not accurate. They were sufficiently accurate, however, to show that the method is correct. With a feed-back resistance R of 30,000 ohms, the oscillations were measured with a detector amplifier, and it was found that oscillations of frequencies 3820 pps. and 4720 pps. were simultaneously produced, the latter being 14 db. below the former.

Conclusions.

A single-valve multi-frequency generator can be produced giving frequencies of arbitrarily chosen values, with amplitudes of desired ratios. It would be possible to construct a beat-frequency oscillator with one valve producing two frequencies, one of which could be varied continuously by means of a variable condenser and a rectifying valve. Such an oscillator could be made to have a very good wave form by a suitable choice of the two higher frequencies from which the beat-frequency is obtained, and it would not be necessary to have very large tuning coils and condensers.

Modulation and Side Bands.*

Relation between Amplitude and Frequency Modulation.

By N. F. S. Hecht, M.I.E.E.

Introductory.

THIS article has been written with the object of demonstrating, by physical and graphical methods, the constitution of modulated waves.

It is not meant to be a proof of the reality of side bands, but, it is hoped, it will assist the mind in forming a clear conception of the meaning of the mathematical expressions associated with this subject.

Section 1. Modulation.

The subject which is here dealt with is "modulation" in its two so-called forms; *i.e.*, amplitude and frequency.

The latter has been dealt with mathematically by Van der Pol (*see Proc. I.R.E.*, July, 1930).

The mathematical conclusions will here be worked out from the physical point of view; to this end oscillatory circuits will be completely ignored and the matter reduced to a dynamo-electric treatment, that is, oscillations will be reduced to alternating currents generated by radio-frequency alternators. These will necessarily be of a schematic and idealistic type, but there is no reason why such alternators should not be built if one wished to do so.

Preliminary.

$$a \sin pt \cos nt = \frac{a}{2} \sin (p + n)t + \frac{a}{2} \sin (p - n)t$$

Considering Fig. 1 (*a*) the rotor *R* rotates in a steady and fixed magnetic field *F* at an angular velocity such that it makes $\frac{p}{2\pi}$ complete revolutions in one second. The

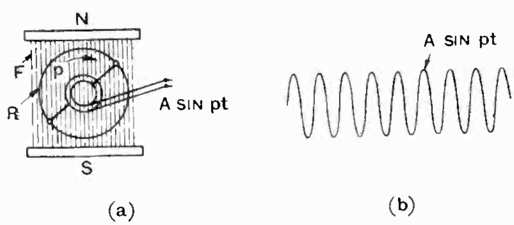

Fig. 1.

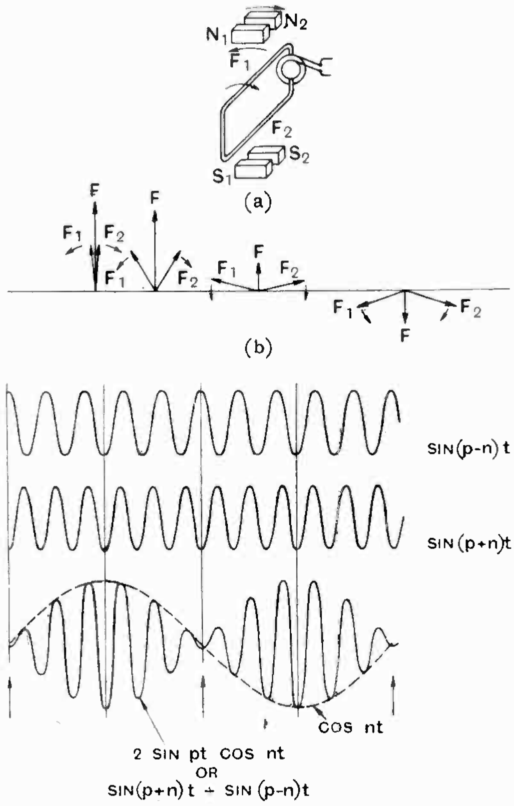

Fig. 2.

frequency of the alternating voltage generated in its windings is therefore $\frac{p}{2\pi}$ and its amplitude is constant; its instantaneous value is: $a = A \sin pt$; *i.e.*, the radiation of such a system would be continuous wave (C.W.). The oscillations are shown in Fig. 1 (*b*).

In Fig. 2 (*a*) the field *F* has been replaced by two equal fields F_1 and F_2 of the same

* MS. received by the Editor, October, 1930.

type as field F but rotating slowly round the rotor $\left(\text{still rotating at frequency } \frac{p}{2\pi}\right)$ in opposite directions $\frac{n}{2\pi}$ times per second.

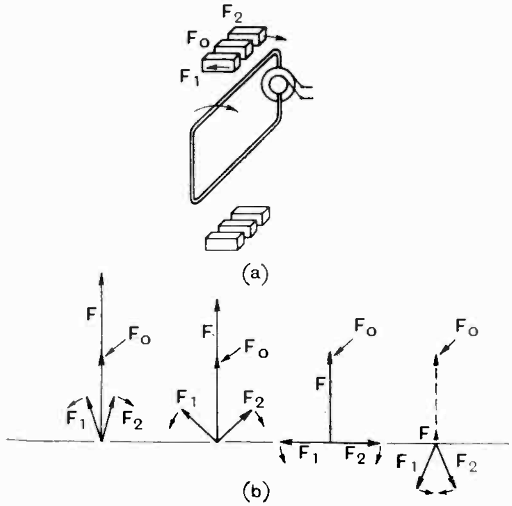

Fig. 3 (*a*) and (*b*).

The frequency due to F_1 will therefore be $\frac{p+n}{2\pi}$ while that due to F_2 will be $\frac{p-n}{2\pi}$. Now the two rotating fields F_1 and F_2 are nothing more than a fixed field F alternating at frequency $\frac{n}{2\pi}$ as can be seen from the vector diagram, Fig. 2 (*b*).

When the two fields are coincident during their rotation they add their effects when of the same sign and neutralise each other when of opposite sign.

The oscillations are shown in Fig. 2 (*c*).

A matter which will be of great importance later is the phenomenon at the points marked with an arrow in Fig. 2 (*c*); here there is a phase reversal of the mean vibration (imaginary term $\sin pt$) due to the action of the phase of $\sin (p+n)$ on that of $\sin (p-n)$. The apparent period $\frac{p}{2\pi}$ is a result of the vector sum of $\sin (p+n)$ and $\sin (p-n)$. There is no pure sine wave of frequency $\frac{p}{2\pi}$ the wave form being more or less distorted throughout the modulation cycle but more obviously near the minimum values of $\cos nt$.

Section 2. Amplitude Modulation.

$$(a \sin pt)(1 + \cos nt) = a \sin pt + \frac{a}{2} \sin (p+n)t + \frac{a}{2} \sin (p-n)t.$$

In Fig. 3 (*a*) the arrangement of Fig. 2 (*a*) has been retained with the addition of a steady double strength field F_0. Three frequencies will thus be generated in the rotor, *viz.*, $\frac{p}{2\pi}$, $\frac{p+n}{2\pi}$ and $\frac{p-n}{2\pi}$. Fig. 3 (*b*) shows the vector sum of the three fields and Fig. 3 (*c*) shows the oscillations obtained when the three pure oscillations of frequencies $\frac{p}{2\pi}$, $\frac{p+n}{2\pi}$ and $\frac{p-n}{2\pi}$ are added together.

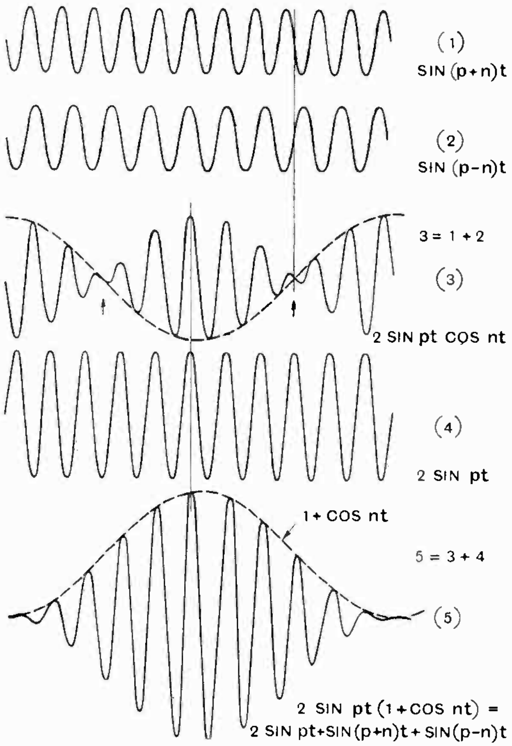

Fig. 3 (*c*).

In Fig. 4 the arrangement of Fig. 3 is used, but the field F_0 is reduced by half, thus being overpowered at times by the sum of the fields F_1 and F_2; this may be referred to as a case of over-modulation, but it is not attainable in the ordinary way;

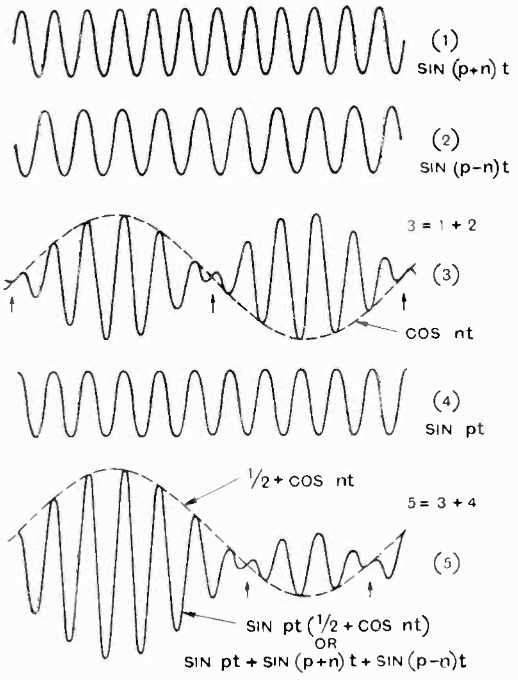

Fig. 4.

it can, however, be produced by double-acting means with valves or by means of alternators.

So far only three oscillations have been considered, but, utilising the same means as before, we can include fields rotating at other frequencies than $\frac{n}{2\pi}$; if frequencies $\frac{2n}{2\pi}$, $\frac{3n}{2\pi}$, $\frac{4n}{2\pi}$, etc., are added to the system described in Fig. 3 there will result modulated waves of the same general type but with complex forms of modulation. In the oscillations of Fig. 5 (*a*) we have the sum of the effects of fields rotating in opposite directions in pairs and with the following values

$$\text{Sin } nt + \frac{1}{6}\sin 3nt + \frac{1}{10}\sin 5nt + \frac{1}{14}\sin 7nt, \text{ etc., etc.,}$$

plus a steady field of value 0.78 approximately.

This would be the effect of interrupting the anode supply to a valve circuit controlled by a master-oscillator.

The constitution of this oscillation train may be better understood by studying Fig. 5 (*b*) in which only the fields of frequency $\frac{n}{2\pi}$ and $\frac{3n}{2\pi}$ have been considered.

By giving appropriate values to the various supplementary fields (harmonic fields) any modulation wave-form may be produced at will.

When the frequencies of the supplementary fields are not commensurable with that of the main pair, wave-forms are produced which are non-recurring or non-periodic; this condition obtains when speech modulation is produced. Although the graphical work becomes very complicated it is of essentially the same nature as that involved in working out periodic modulation.

Section 3. Frequency Modulation.

$$\text{Sin }(pt + b\cos nt) = A\sin pt + A_1\sin(p \pm 2n)t + A_2\sin(p \pm 4n)t + A_3\sin(p \pm 6n)t + \ldots + B_1\cos(p \pm n)t + B_2\cos(p \pm 3n)t + B_3\cos(p \pm 5n)t + \ldots$$

This type of modulation, which will in future be called phase modulation, can be worked out from the same general principles as those employed in amplitude modulation.

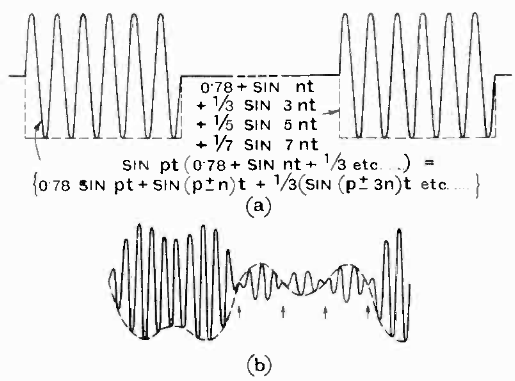

Fig. 5.

Considering Fig. 6 it will be seen that if pendulum swings be given to the otherwise steady field F the frequency generated in the rotor will vary in accordance with the direction and angular velocity of the swing which at its maximum value, *i.e.*, when the field is vertical, will cause a maximum change of frequency, plus or minus. The variation of the frequency will be greater with larger amplitudes of swing and with higher frequencies of the swing cycle. This will now be worked out in detail.

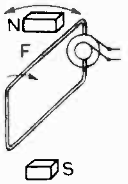

Fig. 6.

Referring to Fig. 7 (*a*) the elements previously used in amplitude modulation are retained without modification, but in this case the rotating fields have been adjusted to be coaxial when passing through a plane at right angles with the plane of the main field F.

The vector diagram of Fig. 7 (*b*) shows the value and angular position of the resultant field which is thus seen to oscillate backwards and forwards with and against the rotation of the rotor. In this first case the fields F_1 and F_2 have each been made equal in value to $\frac{F}{2}$. The result is a field swinging from side to side with varying amplitude. Also the swings are not simple harmonic, being somewhat flattened at the ends of their excursions. To produce simple harmonic swings the combination of F_1 and F_2 would have to be peaky and there would therefore have to be associated with F_1 and F_2 other fields rotating at odd multiples of the rate of rotation of F_1 and F_2. The amplitude is a maximum when the field is at the ends of its swing, while in the middle the frequency generated in the rotor is a maximum or a minimum. The system, consisting of only three components, is thus subject to amplitude variation at a frequency double that of the rotating fields F_1 and F_2. The oscillations are as shown in Fig. 7 (*c*). It will be noted that the variations of amplitude are not sinusoidal, but flattened at the top.

To produce constant amplitude sinusoidal phase modulation we require additional fields odd and even harmonics of F_1 and F_2; the graphical construction to obtain these relations is shown in the Appendix. The odd harmonic fields are phased on F_1F_2, while the even are phased on F. (This is illustrated later in Fig. 10.) That is to say that, in accordance with Section 2, the field F must be modified by two fields F_1^1 and F_2^1 rotating in opposite directions and coincident in the plane of field F, there must also be other fields F_3^1 and F_4^1, F_5^1 and F_6^1, etc. These fields are all even harmonics of the fundamental frequency $\frac{n}{2\pi}$. At the same time the fields F_1 and F_2 must be associated with fields F_3 and F_4, F_5 and F_6, etc., all odd harmonics of the fundamental frequency $\frac{n}{2\pi}$ and

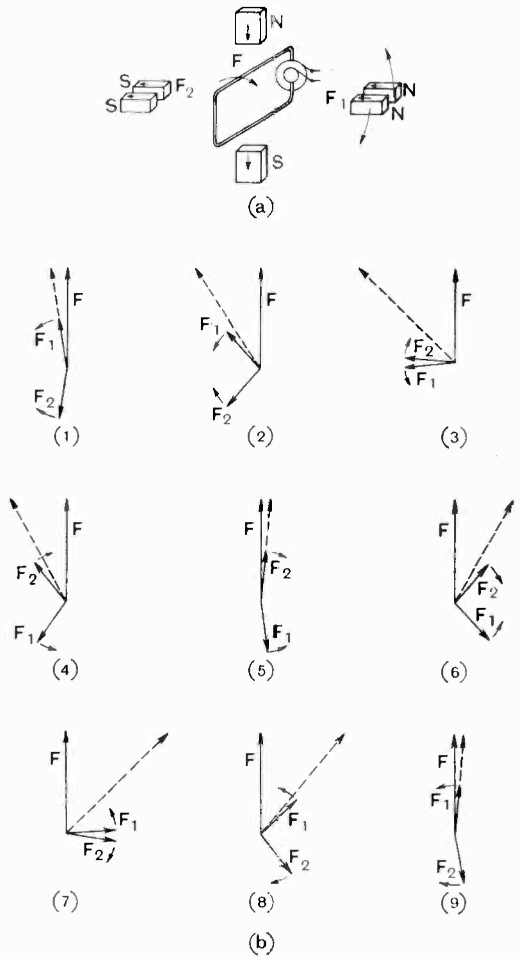

Fig. 7 (*a*) and (*b*).

coincident in the plane of coincidence of the main rotating fields F_1 and F_2. The fields F_1 and F_2 and their associated fields F_3,

F_4, F_5, etc., will hereafter be referred to as the phase shifting group. The fields F, F_1^1, F_2^1, F_3^1, F_4^1, etc., will be referred to as the

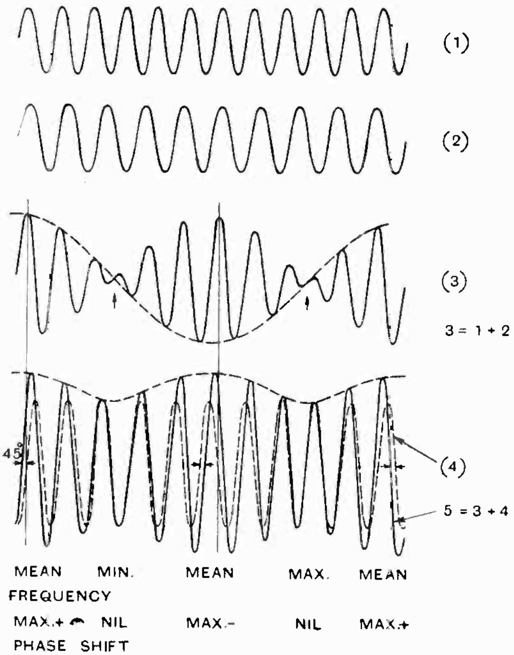

Fig. 7 (c).

carrier group and sometimes as the amplitude group.

Now, as is well known, a symmetrical compound wave-form is composed of a fundamental and odd harmonics only; in special cases the fundamental or any of the components may be missing, but the wave-form contains no even harmonic. When a wave-form is asymmetrical it is composed of a fundamental and odd and even harmonics; as before, any of the harmonics and the fundamental may be missing, but the wave-form contains even harmonics. By the expression symmetrical, one means that the portion in the negative half cycle of the fundamental is an exact replica of the positive half, having due regard to time progress.

An asymmetrical curve is one where the portion lying in the second half cycle of the fundamental is different from that lying in the first half either in shape or in time order.

Now, having previously built up Complex modulation wave-forms from a number of high-frequency components, we can reason backwards from the shape of the modulation wave-form and determine the order of the high-frequency components contained within the complete system. By this means we shall obtain information as to the nature of the auxiliary field systems associated with the carrier and phase shifting groups.

The order of the fields F_1, F_2, F_3, etc., and F_1^1, F_2^1, F_3^1, etc., can be derived from Fig. 8. The modulation of the "carrier" is asymmetrical and is therefore composed of a fundamental and harmonics even and odd. The modulation of the "phase shifting" group is symmetrical and is therefore composed of a fundamental and odd harmonics only. Since the fundamental of the "carrier" modulation is $2n$ where n is the fundamental of the modulation of the "phase shifting" group the arrangement of the components is as follows:—

(*a*) Amplitude group.—p, $p \pm 2n$, $p \pm 4n$,

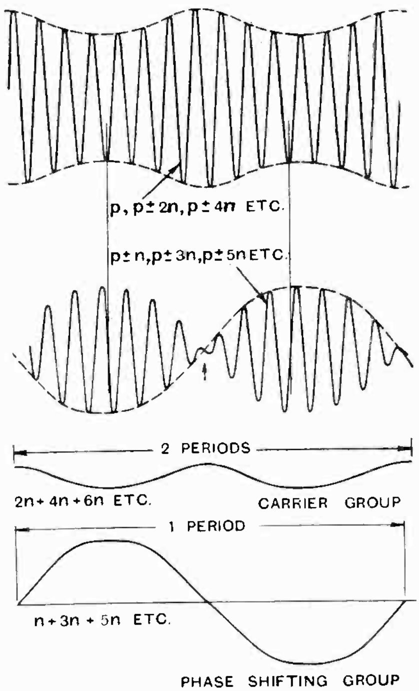

Fig. 8.

$p \pm 6n$, $p \pm 8n$, all in phase at time intervals $\frac{\pi}{n}$.

(*b*) Phase shifting group.—$p \pm n$, $p \pm 3n$,

$p \pm 5n$, $p \pm 7n$, all in phase at time intervals $\frac{2\pi}{n}$ and in quadrature with p.

The oscillations are shown in Fig. 8, and the arrangement of the first few fields to produce these conditions is shown in Fig. 9(*a*).

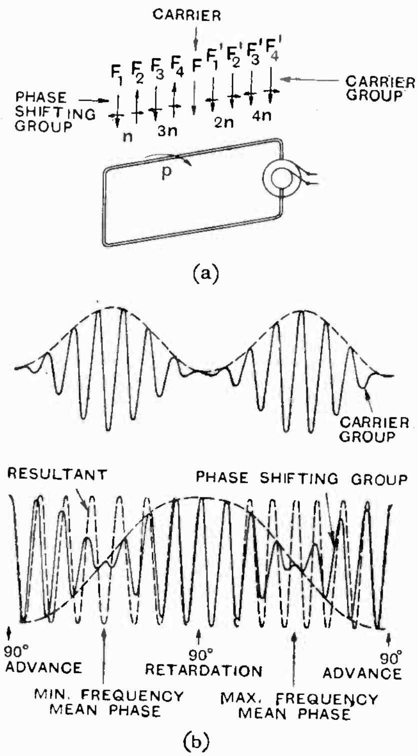

Fig. 9.

For the sake of clearness the field systems are represented by arrows only, the pole pieces having been omitted.

It is thus seen that for simple harmonic modulation of phase at constant amplitude an infinite number of components or side bands* are required; this matter will be referred to later in connection with conversion of phase modulation into amplitude modulation.

In the simple case given above the phase of the resultant oscillation varies about the carrier phase to the extent of 45 degrees only; however rapid or however slow may be the phase shift, *i.e.*, whatever be the frequency of modulation the phase can only be retarded or advanced by 45 degrees so long as the amplitude of the "carrier" is never less than the sum of the amplitudes of the "phase" components. This is the equivalent of 100 per cent. modulation of amplitude. If a three-wave system, phased for amplitude variation only, had its carrier shifted 90 degrees the resultant phase modulation would be limited to 45 degrees, but the phase swings would not be simple harmonic.

In order that the phase may swing through more than 45 degrees either way it is only necessary to reduce in places the amplitude of the "carrier group" so that at its minimum value it is less than that of the "phase shifting group."

To obtain a symmetrical shift of ± 90 degrees it is necessary for the carrier group amplitude to fall to zero at the times when the phase group amplitude is a maximum. This is shown in Fig. 9 (*b*). In the alternator arrangement the modulation of field F is increased to 100 per cent. by increasing the values of its appropriate set of components, *i.e.*, the resultant field strength of the fields rotating at frequencies $\frac{2n}{2\pi}$, $\frac{4n}{2\pi}$, etc., is at certain times equal and opposite to the strength of field F.

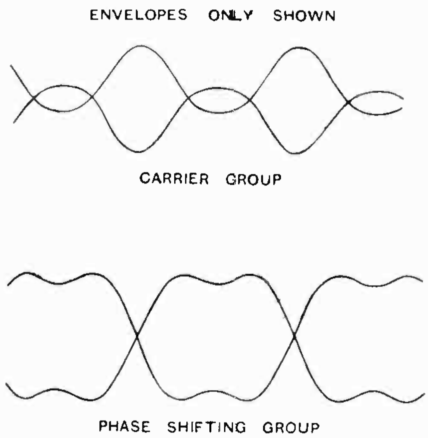

Fig. 10.

The phase can be advanced and retarded beyond 90 degrees by making the amplitude group suffer a temporary reversal of phase; this is obtained when the sum of the "amplitude auxiliary components" is

* The expression "side band" is applied for descriptive convenience to each line of the side-band spectra, although the name really covers the whole of each spectrum above and below the carrier.

greater than the amplitude of the carrier twice in every modulation cycle. This is illustrated in Fig. 10 and is produced by means of more intense harmonics, $2n$, $4n$, $6n$, etc., and a reduced carrier.

Finally, when the third harmonic is sufficiently intense the phase shift is $\pm$ 180 degrees, as shown in Fig. 11.

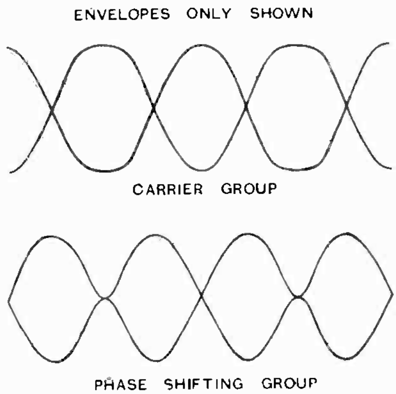

Fig. 11.

For clearness only the harmonics of immediate importance have been included in the wave-form, but it will be seen that an infinite number of harmonics are present and gradually as the higher harmonics assume greater importance the carrier is reduced and the total phase shift increased.

By an extension of the process the phase may be made to advance and retard alternately through one or more radio-frequency cycles.

If the higher harmonics are given a sufficient amplitude the number of cycles (of radio-frequency) gained and lost during each modulation cycle may be considerable; such would be the case if a single field were rotated alternately with and against the rotation of the rotor for a large number of revolutions; or, in the case of an oscillating circuit, if the oscillatory condenser were swung backwards and forwards thus altering the oscillation constant in a periodic manner.

The oscillations are shown in Fig. 12 (*a*) for a periodic advance and retardation of $\pm 3\frac{1}{2}$ cycles. For clearness the less marked harmonics have been left out of the wave-form.

As the number of cycles of radio-frequency gained and lost increases, the higher harmonics assume greater importance, but in all cases the even harmonics belong to the carrier group (*i.e.*, they are sine functions), whereas the odd harmonics belong to the phase shifting group (cosine functions). Fig. 12 (*b*) shows the progressive change of the amplitudes of the two groups as the modulation increases. When we consider large changes of phase produced at a certain rate we have the same type of condition as for small changes of phase at a much slower rate; in each case the modulation harmonics of very high order are most important, while the carrier proper, which has gradually become less important with increased width of modulation, has assumed a very small amplitude. During a form of modulation involving the gain and loss of many cycles of radio-frequency the energy which was expended in the carrier before modulation is expended almost entirely in the amplitude and phase shifting groups. It should also be pointed out that as the frequency sweep increases so the low components of the modulation lose amplitude.

When very large phase swings are produced at a frequency approaching zero the difference of frequency between a cosine and the nearest term in the sine series is nearly zero. In the limit only one pair of terms remains in the cosine and one in the sine series; the original carrier has vanished together with

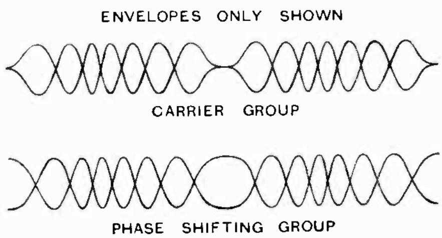

Fig. 12 (*a*).

all the other terms. This is the limiting case where the phase advance is continuous, that is to say, where the frequency is altered once for all to a new value.

The vector diagram in Fig. 13 (*b*) shows how the process has come about. Of the four vectors rotating in pairs in opposite directions one vector is continually opposed to another; they thus neutralise. The remaining two vectors rotate in the same direction and in the same phase and are thus arithmetically additive. The resultant vector is twice the strength of any one vector and rotates with (or against) the direction of rotation of the rotor; the frequency is therefore $\frac{p+n}{2\pi}$ or $\frac{p-n}{2\pi}$, according to the relative phases chosen for

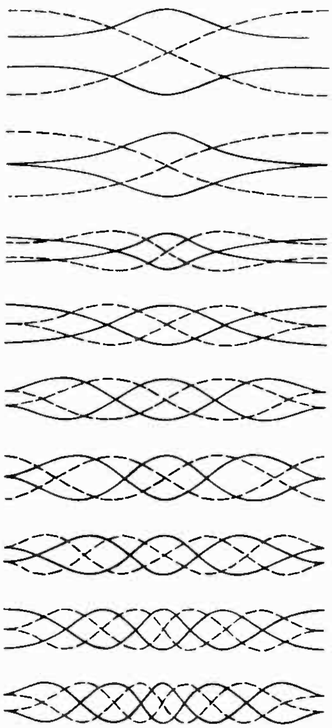

Fig. 12 (*b*).

the arrangement. The frequency is thus different by $\frac{n}{2\pi}$ from the value which would be generated by a fixed and steady field F.

By further elaboration one may produce a frequency varying in any manner required.

Section 4. Conversion of Frequency Modulation into Amplitude Modulation.

Since the difference between phase or frequency modulation and amplitude modulation is purely a question of the number of components and their phase grouping it should be possible to convert one system into the other. There are at least two ways of effecting the conversion and in the simplest case either is readily applied.

First Method: Phase Shift of Carrier.

Considering first a three-component phase-varying wave-train, we have one mean component or carrier and two others: one of higher and one of lower frequency than the carrier. When these two are in phase with each other they are 90 degrees out of phase with the carrier. But, since, in amplitude modulation, all three components are in phase simultaneously it is only necessary to shift the carrier by 90 degrees either forward or backward to convert phase modulation into amplitude modulation. This may be effected in practice by first removing the carrier and then re-inserting it with a phase shift of 90 degrees. There is no difficulty in this, all that is needed is a narrow band pass filter and phase shifting transformer or other circuit. The conversion so effected is complete, no phase variation remains, but it must be pointed out that the original wave was to a certain extent modulated in amplitude (with a frequency $\frac{2n}{2\pi}$ and its harmonics). It was not composed of an infinite series of components and its

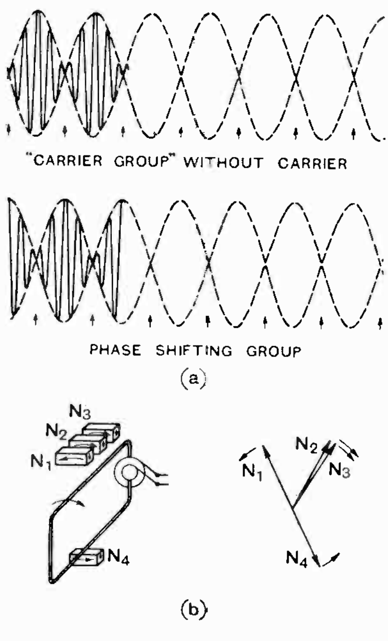

Fig. 13.

phase modulation was not simple harmonic. Thus a wave phase-modulated at frequencies

$\frac{n}{2\pi}, \frac{3n}{2\pi}, \frac{5n}{2\pi}$, etc., and amplitude-modulated at frequencies $\frac{2n}{2\pi}, \frac{4n}{2\pi}, \frac{6n}{2\pi}$, etc., is, after conversion, reduced to a wave modulated in

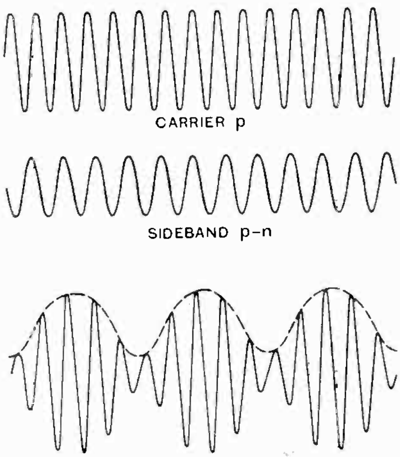

Fig. 14.

amplitude only at frequency $\frac{n}{2\pi}$. The remainder of the terms have been destroyed by the conversion.

From this we would conclude that phase modulation is not convertible to amplitude modulation without distortion or conversely.

Second Method: Suppression of One Side Band.

The second method of effecting the conversion is to remove one member of each component pair causing the phase shift; the remaining member of each pair will now beat with the carrier as any other single component would do; it is a simple case of heterodyne. The wave-form of the amplitude variation is not sinusoidal, however, but is as shown in Fig. 14 for a three-element train. The mathematical expression for this is :—

$$a \sin pt + b \sin qt$$
$$= \sin \frac{p+q}{2} t[c \cos (p-q)t + d \cos 2(p-q)t + e \cos 3(p-q)t + f \cos 4(p-q)t + \ldots].$$

Thus the conversion is obtained with modified distortion of the original phase modulation wave-form. This is reasonable, for one cannot believe that the removal of some or any component produces no change in the properties of the system.

The above result can be obtained in practice, but with further, independent, distortion by tuning the mid-frequency or carrier to the side of the resonance curve of a receiver.

If this be done one modulating component or side band is exaggerated, whereas the other is reduced, but not to nothing, with respect to the carrier. The result, even if the tuning point be suitably selected, is a partial transformation only. Further distortion results. This will be looked into from another angle presently.

If now we consider the shape of the resonance curve required to convert phase modulation to amplitude modulation we find from an examination of Fig. 15 that the frequency width of the sloping side has a lower limit determined by the frequency which has to be reproduced. Consider the case of a wave with ± 45 degrees phase modulation at frequency n; here the carrier p is about equal in amplitude to the sum of the amplitudes of the terms $p+n$ and $p-n$. If $p-n$ is removed then $p+n$ must be doubled in strength with respect to the carrier. Thus on the resonance curve the response to the carrier p and the side-band $p+n$ must be in the ratio of 1 to 2; hence the carrier must be tuned to the mid-point of the slope. If it were tuned to a lower point the side band would over-power it as the ratio would be less than 1 : 2. The resultant amplitude modulation

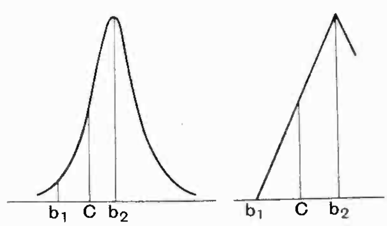

Fig. 15.

would exceed 100 per cent. Idealising the resonance curve we get a width from foot to crest, b_1b_2 (Fig. 15), of $\frac{2n}{2\pi}$. This simply means that the decrement must not fall below a certain value for fair reproduction.

If now we consider an infinite series, as in the case of sinusoidal phase modulation, or the case of telephony, it will be seen that those side bands close to the carrier are less completely converted than those lying farther away (*see* Fig. 16). This means that the fundamental tones (which produce the radio components nearest to the carrier) are partially lost and harmonics are exaggerated.

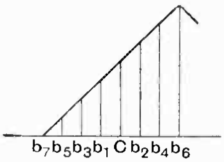

Fig. 16.

Now let us consider the matter from the point of view of *frequency* variation. We find that, as only an infinitely small portion of the side of the curve is straight, the whole curve must, for linear relation between frequency and amplitude, extend to a great distance beyond the maximum excursions of the varying frequency, in other words, the curve must be wide enough to include frequencies well outside the range apparently used. This is shown in Fig. 17; the apparently unused part of the curve is actually made use of by the side bands; these, as previously found, bear little relation to the "frequency sweep," but are directly connected with the frequency *of* the sweeps.

Apart from the distortion due to nonlinearity of the side of the curve there is a further distortion due to the fact that as the frequency increases towards the centre of the resonance curve the time taken for the current to grow sufficiently near to the theoretical value, represented by the appropriate point on the curve, increases due to the effects of resonance. Whereas at the root of the curve oscillations build up quickly to within 1 per cent. of their theoretical final value, at or near the peak the oscillations may not reach in the same time 50 per cent. of their final theoretical value. This produces flattened maxima; the modulation therefore contains exaggerated harmonics or harmonics not present in the pure sinusoidal variation of the frequency; this is equivalent to what was said earlier, *viz.*, the higher tones are exaggerated with respect to the lower ones.

Of course, if the resonance curve is not wide enough to take in the outermost side bands, the latter are weakened and we have then loss of both high and low tones with strong medium tones.

Incidentally, the phase of the side bands is altered, by the above process, to a larger extent for the distant side bands than for the near ones. This will, in a measure, affect the final reproduction, but whether to its advantage or not it is not easy to tell; with sufficient patience this point might be cleared up. In any case the conversion is an approximation only.

It would appear that the best that can be done is to utilise a curve of the form given in Fig. 18, which is not a low decrement curve but a filter characteristic covering much more than the "frequencies swept through" during the modulation.

Finally, conversion of pure phase modulation to pure amplitude modulation by shifting the phase of the carrier is *not* attainable in practice. Of the whole of the carrier group, *i.e.*, p, $p \pm 2n$, $p \pm 4n$, only p requires to be shifted. The odd harmonics of n, *i.e.*, $3n$, $5n$, $7n$, must also shift with the carrier so as to remain in quadrature with it at the proper times; when this is done the phasing of $\cos (p \pm n)t$ with respect to $\sin pt$ is correct for undistorted amplitude effects, $\sin pt$ having become $\cos pt$, whereas the phasing of $\sin (p \pm 2n)t$, $\sin (p \pm 3n)t$, $\sin (p \pm 4n)t$, etc., makes these components a phase shifting group with little or no

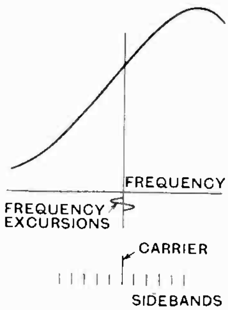

Fig. 17.

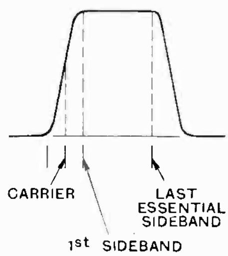

Fig. 18.

effect on the amplitude. To obtain even this approximation the apparatus would be far too elaborate to be practical.

In view of the above considerations it appears that frequency modulation causes the generation of side bands as in the case of amplitude modulation. The number of side bands may be far in excess of that occurring in the case of amplitude modulation and their range may occupy a much greater frequency band. This depends on the frequency of the modulation and on the "frequencies swept through" during modulation.

Thus under the best possible conditions the frequency band occupied by a telephony transmission must be at least as wide for frequency modulation as for amplitude modulation. It will generally be a great deal wider and cause interference over a wider spectrum.

Appendix.

The shapes of the envelopes of the phase shifting and of the amplitude groups may be obtained graphically as follows :—

Draw a number of vectors of equal lengths representing the direction of the stator field at various times. These vectors should cover an arc equal to the total phase shift under consideration and should be spaced out with a sine distribution, *see* Fig. 19 (*a*).

The vertical components of the vectors represent the instantaneous values of the carrier group, whereas the amplitudes of the phase shifting group are represented by the horizontal components of the vectors.

The amplitude group envelope is obtained by plotting on a linear time scale the values of the vertical components of the vectors taken progressively from one end to the other and back again.

The phase shifting group envelope is obtained in the same way by taking their horizontal values. These values are shown plotted in Fig. 19 (*b*) and (*c*).

A swing of ± 90 degrees has been chosen in order to show the distortion of the two envelopes.

In the case of ± 45 degrees phase shift there is too little distortion in the carrier group to show up satisfactorily, but for

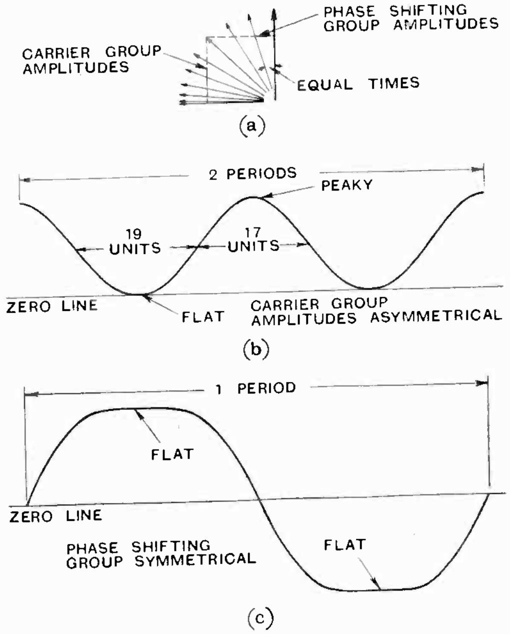

Fig. 19.

± 180 degrees the distortion of the carrier group is obvious.

This method is not recommended for phase shifts exceeding ± 360 degrees owing to overlapping of the two ends. In such cases it is better to resort to calculation.

Coil Resistance Shunts.*

A Simple Graphical Construction.

By W. A. Barclay, M.A.

THE graphical combination of impedances in parallel is, in general, a good deal more complicated than the evaluation of their series resultant. In particular cases, however, notably when one of the component impedances is a pure resistance or a pure reactance, comparatively simple graphical constructions exist which deserve to be better known. One of these, *viz.*, the case of a resistive inductance shunted by a pure capacity, was described by the writer some time ago in this journal.†

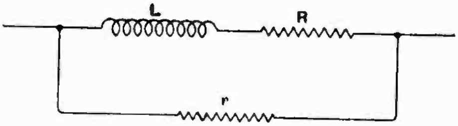

Fig. 1.

It is now proposed to describe very briefly the analogous construction for an inductive coil shunted by a pure resistance, and to show how the procedure may be still further modified to meet the practical requirements of frequency variation. The general proof is omitted for reasons of space; it follows substantially the same line of reasoning as that given in the previous article, to which readers are referred.

If L and R be the inductance and resistance of the coil of Fig. 1, and r a shunting resistance, we may write z for the impedance of the coil itself at impressed frequency $\frac{\omega}{2\pi}$, and Z for the impedance to line current of the parallel combination. Then, as is known,

$$z^2 = \omega^2L^2 + R^2$$

If, now, we consider Z as due to an effective inductance L_0 in series with an effective resistance R_0, we shall have

$$Z^2 = \omega^2{L_0}^2 + {R_0}^2$$

where

$$\omega L_0 = \frac{\omega L \cdot r^2}{\omega^2L^2 + (r + R)^2}$$

$$R_0 = \frac{r \cdot \omega^2L^2 + r^2R + rR^2}{\omega^2L^2 + (r + R)^2}$$

It is required to make a simple graphical construction whereby the values of ωL_0 and R_0 may be determined from those of ωL and R.

In Fig. 2 let the point A have cartesian co-ordinates $(-R, \omega L)$ and let AOC be the circle through A which is tangent to the horizontal axis at the origin.

Then if B be taken in the positive direction along OX to represent r, the straight line AB will cut the circle in a second point C, the co-ordinates of which will represent the desired values of R_0 and ωL_0. That is, if CN be drawn perpendicular to OX, $ON = R_0$ and $NC = \omega L_0$.

As the value of shunting resistance r increases, the line AC tends to become horizontal, and when r is infinite the point C will take up the position A', the image of A in OY, so that (as is otherwise obvious)

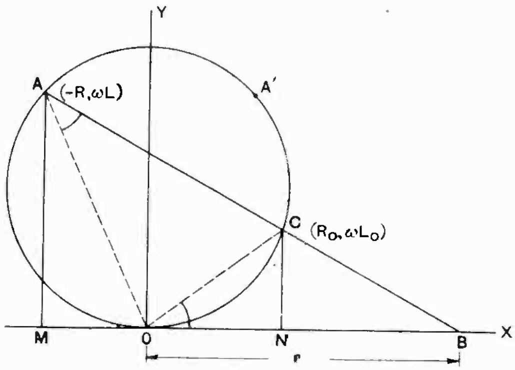

Fig. 2.

the resulting values of R_0 and ωL_0 in the limit are the same as those of R and ωL for the original coil. It may be noted as a slight disadvantage of this method that the points A and C, which both represent values

* Received by the Editor, Dec., 1930.

† *E.W. & W.E.*, Feb., 1927, "Some New Coil Impedance Diagrams."

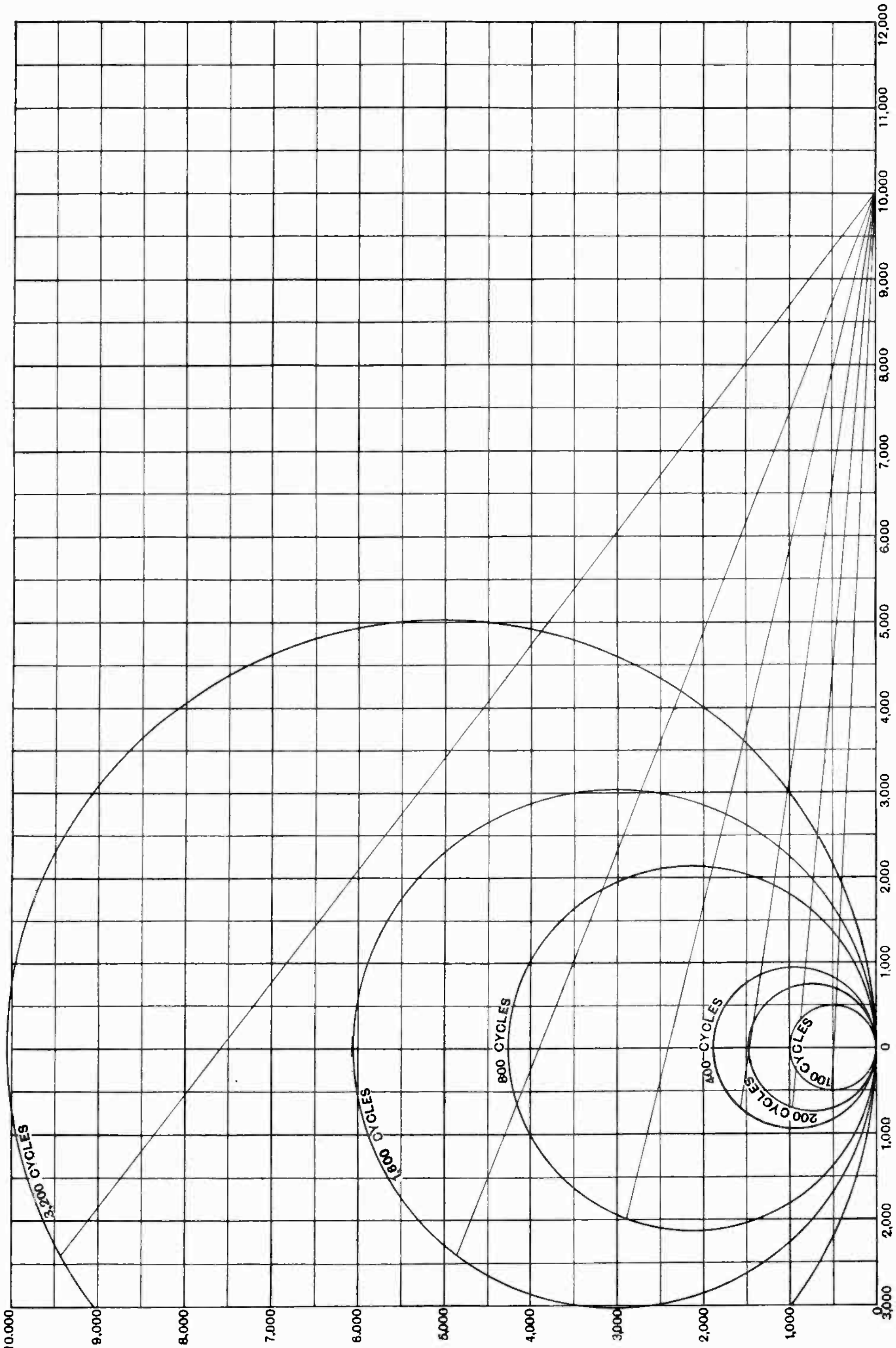

Fig. 3.—*Showing derivation of effective resistance and reactance of given loud speaker in parallel with resistance of* 10,000 *ohms.*

of inductive impedance, should appear in different quadrants.

It has been seen that the circle employed in the above construction depends on the location of the point A, whose ordinate, MA, represents the inductive reactance ωL of the coil alone. As the frequency varies, the coil resistance being assumed constant, the position of A will move along the line MA, and hence a different circle will be necessary for each frequency. Indeed, the process is equally available in cases where, as with the inductive loud speaker, the effective resistance itself varies with frequency, the centres of the circles, of course, being always situated on OY.

TABLE I.

f (cycles).	z (ohms).	R (ohms).	X (ohms).
100	720	500	510
200	1,200	700	970
400	1,720	700	1,570
800	3,510	2,000	2,880
1,600	5,430	2,400	4,870
3,200	9,740	2,400	9,440

To illustrate the method, the above approximate data relative to a certain loud speaker were ascertained from the impedance-frequency characteristic by the process described by the writer in *The Wireless World*.*

* *The Wireless World*, 3rd and 10th December, 1930, "Loud Speaker Impedance."

Owing to the well-known irregularities of loud-speaker response curves, the corresponding points when plotted on Fig. 3 do not lie on a smooth curve. The coil-frequency circles having been drawn as shown, the points corresponding to the same speaker in conjunction with a shunt resistance of 10,000 ohms are readily derived, the values being as under:

TABLE II.

f (cycles).	R_0 (ohms).	X_0 (ohms).
100	470	490
200	720	840
400	850	1,340
800	2,120	1,900
1,600	3,010	2,730
3,200	4,890	3,880

A modification of the above procedure, by means of which the necessity for drawing the circles is eliminated, is suggested by reference to Fig. 2. Here let O be joined to A and C. Then, since OB is a tangent and OC a chord, the angle COB will equal angle OAB. Hence, if A and B are given, the point C may be found on AB by taking angle COB equal to angle OAB.

In conclusion, it may be said that the above method is easily extended to the general case of two impedances in parallel, which it is hoped may be made the subject of a future communication.

Books Received.

EXPERIMENTAL RADIO ENGINEERING. By John H. Morecroft, E.E., D.Sc.

A text-book of Laboratory experiments and testing. Pp. 345, with 250 diagrams and illustrations. Published by John Wiley & Sons, Inc., New York, and by Chapman & Hall, Ltd., London. Price, 17s. 6d. net.

PRACTICAL RADIO, INCLUDING TELEVISION. By James A. Moyer, S.B., A.M., and John F. Worstrell. (Fourth Edition).

A text-book for students, including chapters on Common Troubles and their remedies, Television—General Applications of Radio, and Important Events in Wireless History. Pp. 410, with 235 illustrations and diagrams. Published by McGraw Hill Publishing Co., Ltd., London. Price, 12s. 6d. net.

ADMIRALTY LIST OF WIRELESS SIGNALS 1931.

This new edition of the well-known list is issued in two separate volumes. Vol. I (which will be revised annually) contains Particulars of Coast and D.F. Stations, Fog-signals and Beacons, Stations transmitting Weather Bulletins, Storm Signals, Navigational Warnings, Time Signals, etc., with notes concerning individual stations. Vol II (which will be re-published at intervals of approximately five years) contains general information and regulations affecting the various sections, Details of Codes, Lists of Observation Stations, Time-signal Codes, Extracts from the Washington Convention, and other matters of a semi-permanent nature hitherto included in the Appendices. Published by H.M. Stationery Office and sold by J. D. Potter, 145, Minories, E.C.3. Price, Vol. I, 6s. net. Vol. II, 5s. net.

Transients and Telephony.

By T. S. E. Thomas, B.Sc.

IN the investigation of the mechanical and electrical properties of the apparatus used in telephony it is nearly always assumed that speech and music can be represented by combinations of simple harmonic vibrations of various frequencies and that these vibrations continue long enough for the initial transient terms added by the apparatus to die out, so that only its response to the forced vibrations need be determined.

This last assumption is justified by some experimental work done at the Bell Telephone Laboratories.* In this research the minimum time that a pure tone must excite the ear in order that it may be sensed as a tone having definite pitch was investigated. This time was found to be approximately independent of the frequency and to be about 1/20th second.

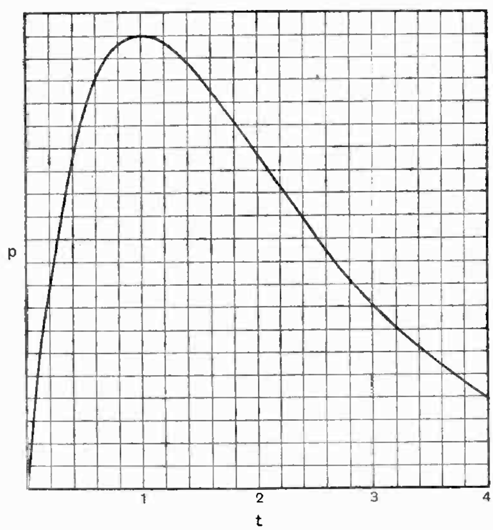

Fig. 1.—$p = Pte^{-t}$.

It is well known, however, that there are many sounds such as the report of a gun and the initial part of the sound produced in uttering such constants as p, t which have a duration of much less than 1/20 second and, in investigating the reproduction of these sounds, usually called transients, it is best to start from first principles. The exact pressure time relation for such sounds is not known but it consists essentially of a rapid

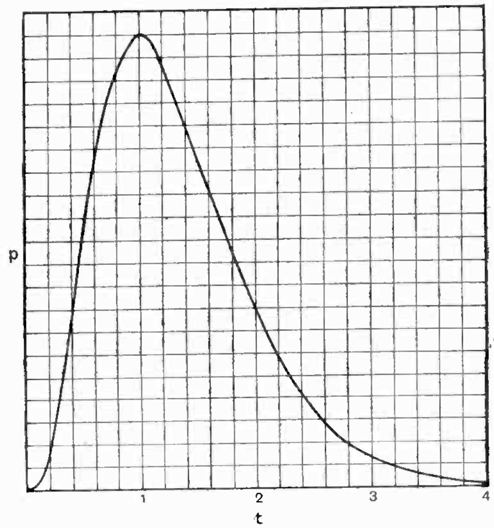

Fig. 2.—$p = Pt^3e^{-3t}$.

pressure rise followed by a rapid fall. A simple mathematical function which undergoes this kind of variation is

$$p = Pt^ne^{-kt}.$$

This function reaches its maximum value in $t = n/k$ seconds. If n is kept constant and k varied then the form of the pressure time curve is unchanged although the time to the maximum pressure varies as $1/k$. If k is constant and n varied then the form of the curve as well as the time to the maximum pressure will be changed. In Figs. 1 and 2 the curves are shown for $n = 1$, $k = 1$ and $n = 3$, $k = 3$ respectively.

Some examples will now be given of the mathematical analysis of the distortion produced by amplifiers and loud speakers. The

* *Speech and Hearing*, H. Fletcher, Macmillan, 1929, page 152.

function taken to represent the transient is Pte^{-kt}. In passing, it may be remarked that this transient may easily be reproduced experimentally. If a condenser C is discharged through an inductance L and resistance R in series, then, if $R = 2\sqrt{L/C}$, the potential difference across the resistance is $RdQ/dt = -Rp^2Q_0te^{-pt}$ where $p^2 = 1/LC$. This potential could be applied to the grid of a valve and the corresponding current pulse obtained.

1. Resistance Capacity Amplification.

In the resistance capacity amplifier the varying potential across the anode resistance is applied to a condenser in series with a resistance and the potential across this grid resistance is applied to the next valve. The equivalent circuit is shown in Fig. 3, and,

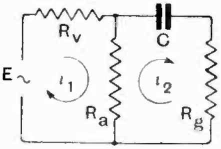

Fig. 3.—*Equivalent circuit of resistance capacity amplifier.*

applying Kirchhoff's Laws, the following equations are obtained :

$$(R_v + R_a)i_1 - R_ai_2 = \mu E \quad \ldots \quad \ldots \quad (1)$$

$$(R_a + R_g)i_2 + \frac{\int i_2 \,.\, dt}{C} - R_ai_1 = 0 \quad \ldots \quad (2)$$

where

R_v is the differential resistance of the valve,

R_a is the anode resistance,

R_g is the grid resistance,

E is the voltage applied to the grid of the first valve, and

μ is the amplification factor of the valve.

Eliminating i_1 we get

$$\left(R_g + \frac{R_vR_a}{R_v + R_a}\right)i_2 + \frac{\int i_2 dt}{C} = \frac{R_a}{R_v + R_a}\mu E \quad (3)$$

Now $\frac{R_vR_a}{R_v + R_a} < R_a$ and in practice R_g is at least ten times R_a so that $\frac{R_vR_a}{R_v + R_a}$ may be omitted without much error. If C and R were absent the potential across the anode resistance would be $\frac{R_a\mu E}{R_v + R_a}$ and, since $R_a\mu/R_v + R_a$ is constant, we may put this equal to the transient Pte^{-kt}. Equation (3) then becomes

$$R_gi_2 + \frac{\int i_2 \,.\, dt}{C} = Pte^{-kt} \quad \ldots \quad \ldots \quad (4)$$

The solution of equation (4) with the initial condition $i_2 = 0$ when $t = 0$ is

$$R_gi_2 = \frac{PCR_g}{kCR_g - 1}\left\{e^{-kt}\left(kt + \frac{1}{kCR_g - 1}\right) - \frac{e^{-t/CR_g}}{kCR_g - 1}\right\} \quad \ldots \quad (5)$$

giving the potential difference R_gi_2 across the grid resistance.

In Fig. 4 the variation of R_gi_2 with t is shown for the case $k = 1000$ (unit time 1/1000th second) and $CR_g = .005$ (*e.g.* $R_g = 10^6$ ohms, $C = .005$ microfarad).

The broken line shows the initial pulse for comparison.

2. Choke Capacity Amplification.

In choke capacity amplification the potential Ldi/dt across the choke is applied to a condenser and resistance as in resistance capacity amplification. If the equations

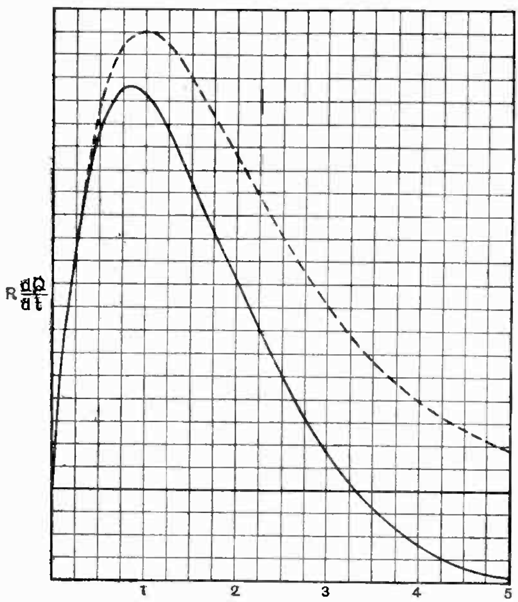

Fig. 4.—*Transient, Pte^{-1000t} as reproduced by resistance capacity amplifier* ($CR = .005$).

for the equivalent circuit are written out it will be found that they are not easily solved. The distortion caused by the choke alone, neglecting the effect of the condenser and grid resistance in parallel with it, can however be found. The equation is

$$L\frac{di}{dt} + Ri = Pte^{-kt} \quad \ldots \quad \ldots \quad (6)$$

where R is the differential resistance of the valve. This equation is of exactly the same type as (4). By substituting $i = \int i_2 \, . \, dt$, $L = R_g$, $R = 1/C$ in (5) the solution is obtained and the potential across the choke will be

$$Ldi/dt = \frac{PL}{kL-R}\left\{e^{-kt}\left(kt + \frac{R}{kL-R}\right) - \frac{Re^{-Rt/L}}{kL-R}\right\} \quad \ldots \quad (7)$$

The curve in Fig. 4 will represent the above solution for the case $k = 1{,}000$, $L/R = .005$ (*e.g.*, $L = 100$ Henry, $R = 20{,}000$ ohms).

Further distortion will be effected by the coupling condenser and resistance so that comparing a resistance capacity amplifier with a choke capacity amplifier which has the same condenser and resistance it will be seen that the resistance capacity amplifier will give less distortion of transients.

3. Cone Loud Speakers.

In its ideal form the cone loud speaker consists of a rigid piston, held in position by some elastic support, which can be made to move by the action of varying electro-magnetic forces. We may suppose that all the forces act at the centre of the piston and that the mass is concentrated there. The forces acting are (*a*) the electromagnetic force proportional to the original transient, (*b*) the restoring force $-sx$, where x is the displacement, (*c*) a resisting force $-rdx/dt$ due to viscous friction, eddy currents, etc. By Newton's First Law the product of the mass and the acceleration is equal to the resultant of these forces, so the dynamical equation for the system is

$$md^2x/dt^2 = Pte^{-kt} - sx - rdx/dt$$

or

$$md^2x/dt^2 + rdx/dt + sx = Pte^{-kt} \quad \ldots \quad (8)$$

The question of the relation between the movement of the piston and the pressure in the wave produced by the movement is complicated. If the piston moves in a tube so that a plane wave is produced then the pressure will vary as the velocity of the piston. If a spherical wave is produced by a small vibrating source, then, at a point some distance from the source, the pressure will vary as the acceleration of the source.

Now a piston moving in a baffle may be regarded as being equivalent to a large number of small sources, and at a distant point on the axis of the piston the waves from all parts of the piston will arrive at the same time, so that the pressure here will vary as the acceleration of the piston.

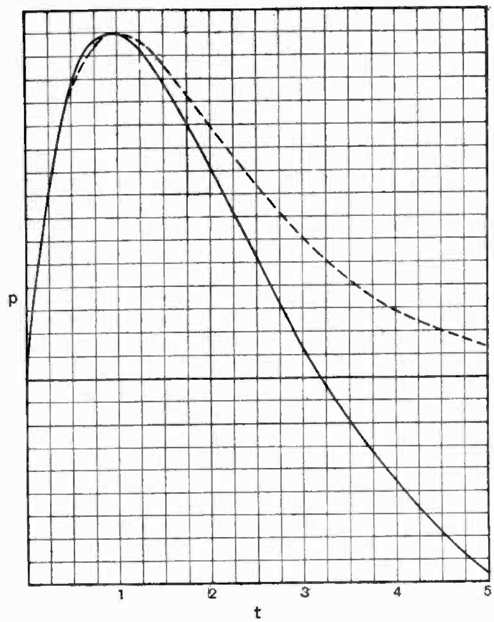

Fig. 5.—*Transient* $p = P.e^{-1000t}$ *as reproduced by undamped cone loud speaker (frequency 50).*

The solution of equation (6), though straightforward, involves much algebraical labour and only two special cases will be considered here.

In the first the damping will be neglected, *i.e.*, $r = 0$. With the initial condition $dx^2/dt^2 = 0$ the acceleration will be :—

$$\frac{d^2x}{dt^2} = \frac{P}{s(1 + k^2/n^2)}\left[ke^{-kt}\left(kt - \frac{2n^2}{k^2+n^2}\right) + \frac{2k\cos nt + n(1 - k^2/n^2)\sin nt}{1 + k^2/n^2}\right] \quad \ldots \quad (7)$$

where $n^2 = s/m$. It will be noted that the last term represents a vibration of the piston at its natural frequency, and unless this is outside the limits of audition it will be heard in addition to the transient. In most moving coil loud speakers the natural frequency is fairly low. Fig. 5 shows the solution for the particular case $n = 100\pi$ (frequency $= 50$) and $k = 1{,}000$. The broken line shows the original transient. It will be seen that the transient is reproduced very well but the curve only shows the beginning of the free vibration which follows. In this example the amplitude of the free vibration is 0.8 times that of the transient.

The obvious way to extinguish the free vibration is to increase the damping forces acting on the piston. The minimum amount of damping required is given by the equation $r^2 = 4sm$, and with this amount the system is said to be "critically damped." The solution of equation (6) for this case is

$$\frac{d^2x}{dt^2} = \frac{Pe^{-kt}}{s(1 - k/n)^2}\left\{ke^{-kt}\left(kt - \frac{2}{1 - k/n}\right) + ne^{-nt}\left(nt + \frac{2k}{n(1 - k/n)}\right)\right\} \quad (8)$$

This solution, with the same values of n and k as before, is shown in Fig. 6. It will be seen that the transient is not reproduced as faithfully as before, but this is compensated for by the absence of the free vibrations.

In conclusion it may be pointed out that, although the distortion of a transient by a single stage amplifier may be imperceptible to the ear, the transient in its progress from the broadcast studio to the ear has to pass through many stages of amplification, not to mention the landlines, and the cumulative effect of all these may cause the reproduced transient to have no resemblance to the original.

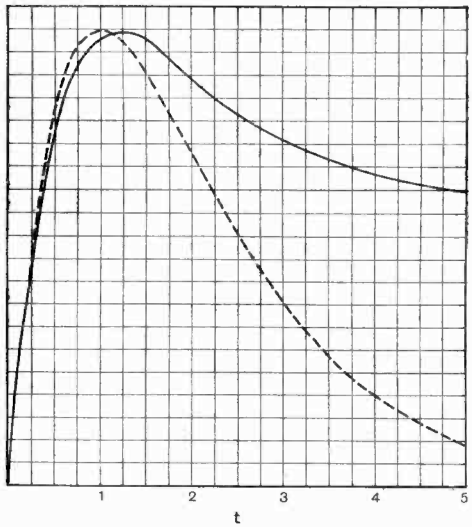

Fig. 6.—*Transient $p = Pte^{-1000t}$ as reproduced by critically damped cone loud speaker (undamped frequency 50).*

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.

The Variation of the Resistances and Inter-electrode Capacities of Thermionic Valves with Frequency.

To the Editor, The Wireless Engineer.

SIR, At the risk of occupying much of your space I would like to point out to Dr. Hartshorn and to readers of his paper in the August issue, that the above problem can on no account be solved if the time of transit of electrons is not taken into consideration. The neglect of the time of transit cannot be regarded even as a first approximation in any calculations connected with the frequency dependence of valve parameters.

It is therefore not surprising that Figs. 2 and 3 do not bear a trace of resemblance to the true frequency variation of the quantities represented. Actually the valve parameters are functions of the product ωT (T = time of transit of electrons). Exact calculation shows these functions to be highly complicated in general. It is therefore not possible here even to write them down. Curves of conductance and ratio of "hot" to "cold" capacity as a function of ωT may be found by referring to the Supplementary Number of *Phil. Mag.*, February, 1931, pp. 470 and 473. It will be noticed that the low frequency value of the ratio $\frac{\bar{c}}{c_1}$ as given in this paper is $\frac{3}{5}$ and not $\frac{48}{45}$ as given by Dr. Hartshorn. This difference is a very subtle one and I shall attempt to explain it at a later stage. The value $\frac{c}{c_1} = \frac{3}{5}$ was first published in a letter to the March, 1930, number of this Journal, commenting on a paper by Dr. Martyn.

Before leaving the subject of frequency variation, I will attempt to show in the simplest possible manner how it comes about that valve parameters are functions of ωT.

It is well known that the electric intensity in a valve is different at different points. This fact was, of course, made clear in Dr. Hartshorn's paper. If ρ represents the space charge density at the point (x, y, z) and if X, Y, Z are components of the electric intensity at this point, the space variation of electric intensity is related to the density of distribution of electrons by Poisson's equation :—

$$\frac{\partial X}{\partial x} + \frac{\partial Y}{\partial y} + \frac{\partial Z}{\partial z} = 4\pi\rho$$

If we consider the valve to be a parallel plane diode with the x-direction parallel to the lines of force, the value of Y and Z is zero and X becomes equal to the electric intensity F. We thus have

$$\frac{\partial F}{\partial x} = 4\pi\rho \quad \ldots \quad \ldots \quad (1)$$

The current between the plates is partly the conduction current (or electron convection current as named by Dr. Hartshorn) and partly displacement current. If j denote the sum of these two currents, and u the velocity of electrons

$$j = \rho u + \frac{1}{4\pi}\frac{\partial F}{\partial t} \quad \ldots \quad \ldots \quad (2)$$

in which the first term on the right-hand side represents the conduction current, the second term being the displacement current.

If we multiply (1) by u we get $4\pi\rho u$ on the right-hand side. By (2) we find

$$4\pi\rho u = 4\pi j - \frac{\partial F}{\partial t}$$

Hence
$$u\frac{\partial F}{\partial x} = 4\pi j - \frac{\partial F}{\partial t}$$

which may be written

$$\frac{\partial F}{\partial t} + u\frac{\partial F}{\partial x} = 4\pi j$$

Since $u = \frac{dx}{dt}$, where $\frac{d}{dt}$ denotes differentiation following the motion of the electrons, we may write

$$\frac{dF}{dt} = \frac{\partial F}{\partial t} + \frac{\partial F}{\partial x}\frac{dx}{dt} = \frac{\partial F}{\partial t} + u\frac{\partial F}{\partial x}$$

We thus obtain

$$\frac{dF}{dt} = 4\pi j \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

We now introduce the Newtonian equation of motion

$$m\frac{d^2x}{dt^2} = eF \quad \ldots \quad \ldots \quad (4)$$

Differentiating (4) once with respect to t and substituting for $\frac{dF}{dt}$ from (3) yields the relation

$$\frac{d^3x}{dt^3} = 4\pi\frac{e}{m}j \quad \ldots \quad \ldots \quad (5)$$

Equation (5) is very important as it contains within itself the whole Physics of the situation. So far we have not introduced the time of transit. Let us suppose

$$4\pi\frac{e}{m}j = B + b\sin\omega t \quad \ldots \quad \ldots \quad (5a)$$

and let t refer to electrons which started with zero acceleration and velocity from the cathode at the instant θ. Then we can integrate (5) subject to $\frac{d^2x}{dt^2} = 0$ when $t = \theta$. Thus

$$\frac{d^2x}{dt^2} = B(t-\theta) + \frac{b}{\omega}(\cos\omega\theta - \cos\omega t)$$

Similarly

$$\frac{dx}{dt} = \frac{B}{2}(t-\theta)^2 + \frac{b}{\omega}(t-\theta)\cos\omega\theta - \frac{b}{\omega^2}\sin\omega t + \frac{b}{\omega^2}\sin\omega\theta$$

We have now obtained the velocity $u\left(= \frac{dx}{dt}\right)$ and it is to be noted that $(t - \theta)$ represents the time taken to travel a distance x from the cathode. If we take the principal term $B(t-\theta)^2$ outside the bracket, we obtain

$$\frac{dx}{dt} = \frac{B}{2}(t-\theta)^2\left[1 + \frac{2b}{B}\left\{\frac{\cos\omega\theta}{\omega(t-\theta)} - \frac{\sin\omega t}{\omega^2(t-\theta)^2} + \frac{\sin\omega\theta}{\omega^2(t-\theta)^2}\right\}\right]$$

We need not proceed any further, as all that was attempted was to arrive at an expression which would bring out the importance of the product $\omega(t-\theta)$. It must necessarily follow that this product enters into all the parameters of practical utility, since all these are dependent on either $\frac{d^2x}{dt^2}$ or $\frac{dx}{dt}$. The analysis given above leads eventually to precisely the same results as those given in the *Phil. Mag.* paper referred to above, and the values of the valve parameters there given may be considered thoroughly established.

With regard to the difference between Hartshorn's value $\left(\frac{48}{45}\right)$ and my value $\left(\frac{3}{5}\right)$ for the ratio hot to cold capacity at low frequencies, this appears to be due to the very pardonable error on Dr. Hartshorn's part of equating the W_0 of his equation (3) to the W_0 of his equation (7). Equation (7) may be taken as correct for the energy stored in the whole current path, though since the integration is a path integration a single integral sign would surely have sufficed: also, on the concepts of the electron theory ϵ should be unity in this expression. Owing to the inertia of the electrons the storage of energy per quarter cycle (not half cycle as stated by Hartshorn) is only 9/16 W_0. It is most surprising that the inertia of the electrons is of such importance at low frequencies. No one who had not investigated the subject would have suspected it in advance.

W. E. Benham.

Abstracts and References.

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PROPAGATION OF WAVES.

THE HIGH FREQUENCY BEHAVIOUR OF A PLASMA.—L. Tonks. (*Phys. Review*, 1st June, 1931, Series 2, Vol. 37, No. 11, pp. 1458–1483.)

Author's abstract :—An analogue for a uniformly ionised gas on the basis of the known formula $K_p = 1 - \omega_0^2/\omega^2$ for its specific inductive capacity is found in a shunt-tuned circuit. In that formula $\omega_0^2 = 4\pi Ne^2/m$ and ω is the impressed angular frequency. This formula is extended to two simple cases of non-uniform ionization, with the conclusion that non-uniformity may be indistinguishable from large energy dissipation in so far as reactive effects are concerned. Formulas have been derived for calculating the *conductivity and specific inductive capacity of a cylindrical plasma* (positive column of an arc) between parallel condenser plates from the measured impedance of this condenser by using a modification of Mossotti's Theory. The natural period of such a condenser occurs very nearly when $K_p = -1$. For a fixed frequency the reactance of such a composite condenser was followed for varying arc current by observing the length of Lecher system connected to the condenser plates which was required to cause circuit resonance. Two and sometimes three resonances were found. They occurred in the neighbourhood of the calculated plasma-electron resonance as determined from electron density measurements, and varied with impressed frequency according to theory.

The theoretical variation of K_p was checked in the range $\omega_0^2 > 2\omega^2$ by the hyperbolic relation between change in condenser reactance and arc current there. Resistance measurements on the Lecher system, used in connection with a more detailed analysis, allowed *calculation of relative electron density* in the range from one-half to five times that giving resonance, checking the actual values. In the same range, the *resistance to electron motion* varied considerably. The maximum value occurred near resonance and checked, roughly, the value calculated from free path considerations. The alternating fields in the plasma varied from 0.17 to 1.2 v.cm^{-1} and the maximum amplitude of electron motion was 2.1×10^{-3} cm.

A transverse magnetic field was found to double the resonance as H. Gutton has found. The separation of resonances accords with theory.

ON THE CHANGE OF THE DIELECTRIC CONSTANT PRODUCED BY FREE ELECTRONS.—S. Benner. (*Phil. Mag.*, June, 1931, Series 7, Vol. 11, No. 74, pp. 1252–1253.)

An answer to criticisms by W. E. Benham (April Abstracts, p. 212) of a paper by the author (1930 Abstracts, p. 152).

POLARIZATION PHENOMENA OF LOW-FREQUENCY WAVES: PART I.—MEASUREMENTS ON POLARIZATION. PART II.—A NOTE ON POLARIZATION ERROR IN DIRECTION FINDING—S. Namba. (*Electrot. Lab., Ministry of Communications, Tokyo :* pub. by National Research Council of Japan, Tokyo, 1931 : 21 pp.)

An investigation into the state of polarisation of 19.8 and 17.4 kc. waves from two high power stations, 145 and 358 km. distant respectively, receiving on a pair of horizontal dipoles (one along the line to the transmitter and the other at right angles) and a cathode ray oscillograph. To avoid having to use two independent amplifier sets with the same characteristics as to amplification and phase relation, as would be necessary if the two dipoles were in action simultaneously, each dipole is used in turn and its amplified signals combined in the oscillograph with those from a subsidiary vertical aerial connected to a receiver of its own. The procedure is divided into two parts : first the elliptical figure representing the state of polarisation is determined, and then the sense of rotation is obtained by watching the effect of a phase-shifting circuit as this is adjusted. Thus the state of polarisation is completely determined.

The 19.8 kc. station located N. of the receiving station gave a wave which in day-time was plane-polarised, slightly inclined in the counter-clockwise direction, and at night changed into a state of elliptical polarisation of *small* eccentricity, the sense of rotation being always left-handed. The 17.4 kc. station, situated to the W.S.W., gave a wave which throughout day and night was nearly plane-polarised (elliptical polarisation of *very great* eccentricity) and slightly inclined in the clockwise direction. The sense of rotation was irregular, sometimes right- and sometimes left-handed. At sunset and sunrise a quick change occurred. At sunset several results show a double transition phenomenon. Seasonal variations in polarisation were not noticed.

The writer is disposed to attribute the predominant night-time elliptical polarisation of the 19.8 kc. station (as compared with that hardly noticeable in the case of the 17.4 kc. station) to the much shorter distance of the former ; and the regular left-handed rotation of the former (as compared with the irregular rotation of the latter) to the difference in the direction of propagation with respect to the magnetic meridian. He is as yet uncertain whether the *cause* of the production of an elliptically polarised wave is to be attributed to terrestrial magnetism or not.

In Part II the writer prefers to use the term "polarisation error" in place of the more usual "night error." In these tests a loop direction finder was carried about at various distances and directions from the same two stations. It is concluded that there are two main causes for the polarisation error, the change of polarisation of the downcoming wave itself and the interference between ground and downcoming waves. On the long waves here dealt with, the errors due to these two causes are of the same order at a distance between 100 and 250 km., and the error curve at these distances is complicated by the superposition of the two effects. Direction finding is unstable and erratic at night.

At a distance somewhat over 300 km. the latter cause predominates and the polarisation of the downcoming wave becomes less effective owing to the fact that the wave becomes nearly plane polarised with its electric force in the vertical plane. Thus except for typical cyclic errors at sunrise and sunset, d.f. is practically reliable and scarcely at all erratic throughout day and night.

The relation between direction of transmission and magnetic meridian, as regards the polarisation error, is not clear. The main factor is the distance of transmission; the error is large when the amount of elliptical polarisation is great, while the sense of rotation of the ellipse does not play an important rôle in determining the amount of the directional error.

SHORT-DISTANCE OBSERVATIONS ON LONG-WAVE PHENOMENA.—R. Naismith. (*Journ. I.E.E.*, July 1931, Vol. 69, pp. 875–880.)

The full paper, with Discussion (pp. 885–890), a long summary of which was dealt with in July Abstracts, pp. 375–376.

FIELD-STRENGTH MEASUREMENTS ON DAVENTRY 5XX.—R. Naismith: Reyner. (*Journ. I.E.E.*, July 1931, Vol. 69, pp. 881–885.)

The full paper, with Discussion (pp. 885–890), a long summary of which was dealt with in July Abstracts, p. 376. Mention is made in the Discussion of an investigation by Chapman and Franklin to develop a method of geophysical prospecting based on the observed variation of signal strength in the area under investigation.

POLARIZATION OF HIGH-FREQUENCY WAVES AND THEIR DIRECTION FINDING.—S. Namba, E. Iso and S. Ueno. (*Electrot. Lab., Ministry of Communications, Tokyo*: pub. by National Research Council of Japan, Tokyo, 1931: 26 pp.)

Authors' conclusions:—1. Measurements on polarisation of a downcoming high-frequency wave present great difficulty as our knowledge on the electrical property of the earth is very much limited. However, if the electrical constants theoreof hitherto known are adopted, it is possible to eliminate the influence of the ground and to estimate the probable state of polarisation from the results of measurements. The waves are, in general, elliptically polarised, the state of polarisation being (*a*) mostly horizontal, that is, an ellipse with its major axis parallel to the ground as shown in Fig. 26, when the distance of transmission is short; (*b*) mostly vertical, that is, an ellipse with its major axis perpendicular to the ground as seen in Fig. 26, when the distance is long; and (*c*) within a certain distance, the measurement is impossible as the scattering phenomena are predominant.

2. Electric force measured at a receiving point which is at a small height above the ground, as in common practice, is in general somewhat greater in Y-component that in Z, the reason being due to the dielectric properties of the earth for the high-frequency waves. Thus a horizontal doublet is generally preferable as a receiving aerial although the downcoming wave itself is not so predominant in horizontal force. The most suitable height of the horizontal aerial to be mounted above the ground depends on the properties of the earth, frequency of the wave and its angle of incidence. If attention be directed to this point, a receiving sensitivity which is several times greater than that in a usual case might be obtained. As for a vertical aerial, it must be placed as close to the ground as possible to obtain its maximum sensitivity.

3. From Item 1, it will easily be seen that the use of a loop aerial for short-wave direction finding is sometimes meaningless. Although the results measured by a loop may be approximately correct for a distant station where the vertical electric force fortunately predominates, the results will not turn out true for a nearer station where the horizontal force predominates. An Adcock-type aerial works satisfactorily for either of the above two cases. However, at a certain distance where the scattering phenomena are predominant, the bearing can hardly be obtained even with the Adcock-type aerial as the waves actually come in from many directions.

The possible range of direction finding both by Adcock and usual loop aerials with reference to the probable state of polarisation of the wave is as shown in Fig. 26.

4. If a transmitter be situated slightly apart from the exact antipode of the receiver, a fair amount of lateral deviation of the wave may be observed. In the case of a 30 m.-wave transmission the wave does not always propagate along the great circle plane, but chooses a path on which the sunlit portion is minimum. The bearing thus shows marked diurnal variations as shown in Fig. 24.

FIELD STRENGTH MEASUREMENTS OF SHORT WAVE TRANSMISSIONS.—T. L. Eckersley. (*Marconi Review*, May–June, 1931, No. 30, pp. 1–12.)

This paper contains an analysis of the results of a series of systematic measurements of short-wave ($\lambda = 14.5$ to 44.41 metres) signal intensities made at Chelmsford during the period October, 1930, to January, 1931, with the type 205 Marconi signal-measuring apparatus (1929 and 1930 Abstracts, pp. 517 and 51). The stations observed were chiefly those with well defined c.w. carriers, *i.e.*, telephone stations and multiplex beam stations.

Much of the discussion is based on the shadow charts already described (Eckersley and Tremellen, 1930 Abstracts, p. 329).

Comparing the results here obtained with those obtained qualitatively in the same months of 1927, the striking difference in the behaviour of the 30 m. night transmissions over the transatlantic route indicates a cyclic change associated with the eleven year sunspot or magnetic cycle.

In discussion of attenuation, which largely controls day transmission, a formula recently found by the author for long-distance short-wave transmission is applied to find the value of the "equivalent attenuation coefficient" by comparison with experimental results. Comparing 16 m. and 32 m. stations on the transatlantic route, it is found that the attenuation coefficient does not vary with λ^2 in the manner expected. This may be due to magnetic storm disturbances.

Field intensity measurements made on the voyages of the *Homeric* enable the attenuation constant to be determined from the "distance/field intensity" curve; it is found to be greater for small distances than for large ones, "suggesting that the intensity is the sum of a number of components, the more absorbable of which are rapidly attenuated in the initial stages, leaving the less rapidly absorbed components to traverse the greater distances."

The overall attenuation is predicted theoretically, assuming that the distribution of ionic density and collision frequency in the lower 100 km. attenuating layer are known from the results of Appleton (1930 Abstracts, p. 500) and Chapman (1929 Abstracts, p. 204) respectively, the rays being assumed totally reflected from a layer at height 340 km. The results obtained agree as nearly as expected with the values given by experiment.

The paper closes with short preliminary remarks on night transmission.

HEIGHT OF KENNELLY-HEAVISIDE LAYER.—Bureau of Standards. (*Journ. Franklin Inst.*, June, 1931, Vol. 211, No. 6, pp. 793–794.)

A note on the Bureau's proposed programme of studies of the height of the Kennelly-Heaviside layer by the echo method. "Beginning June 1, the Bureau will issue a weekly bulletin giving KHL heights. This will be broadcast by radio telegraphy from the Arlington naval radio station, as a part of the Ursigram bulletins of cosmic data."

A SIMPLE METHOD OF INVESTIGATING WIRELESS ECHOES OF SHORT DELAY.—E. V. Appleton and G. Builder. (*Nature*, 27th June, 1931, Vol. 127, p. 970.)

In development of the pulse method for determining the equivalent height of the Kennelly-Heaviside layer, the writers have found that no special modulating system is necessary to produce the short pulses required; "if the grid leak of an ordinary triode oscillator is increased to a relatively high value, the generator itself produces suitable short pulses of radio-frequency energy alternating between uniform periods of quiescence. By adjusting the grid circuit constants, both the duration of the pulse and the duration of the interval between successive pulses may be controlled." The same circuit is used to provide a uni-directional time scale for cathode ray oscillography.

Specimen records are illustrated showing echoes received three miles from the transmitter, which worked on a wavelength of 80 metres, emitting pulses of about 0.0003 sec. in duration, spaced 0.02 sec. apart. A dual observational system is used, consisting of a cathode-ray oscillograph and a high-speed Duddell recording oscillograph. The received pulses are normally watched on the cathode-ray oscillograph and, when desired, photographed on the Duddell oscillograph. The echoes obtained indicate reflections from two regions at different heights in the upper atmosphere, confirming results previously obtained by the frequency-change method.

THE MULTIPLE REFRACTION AND REFLECTION OF SHORT WAVES.—N. H. Edes. (*Proc. Inst. Rad. Eng.*, June, 1931, Vol. 19, pp. 1024–1032.)

Author's summary:—This paper discusses the theory that normal long-distance short-wave communication is brought about by a series of refractions and reflections. It shows how, if we know the "range/best-wavelength" characteristic for ranges which entail only one "hop" of the rays, we can predict the best wavelength for any larger range necessitating a number of hops, it being assumed that propagation conditions, such as ionic distribution, remain the same throughout all those ranges.

Single-hop characteristics given by the author in a previous paper (March Abstracts, p. 145) are used in this way to derive the characteristic for longer ranges in daylight. The result is in close accord with a curve given by Lloyd Espenschied (1928 Abstracts, pp. 518–519) which shows the result of actual experiment over long ranges. For conditions of darkness the present theory cannot be fully tested owing to incompleteness of the data over short ranges, but general agreement is indicated. It is shown that the theory helps to account for the phenomenon of "fading," and for dissimilarities in reception at stations situated a few miles apart, but both receiving from the same sending station. Suggestions are made as to future research.

It is thought that multiple refraction and reflection is the most satisfactory explanation of the effects met with in the course of ordinary short-wave communication at long ranges.

QUELQUES RÉSULTATS DE LA MISSION RADIO-MÉTÉOROLOGIQUE SUISSE AU SAHARA EN 1929 (Some Results of the Swiss Radio-meteorological Mission to the Sahara in 1929 ["Sounding" of the Atmosphere by Atmospherics and Short Waves]).—J. Lugeon. (*Arch. sc. phys. et nat.*, Sept.-Oct., 1930, Series 5, Vol. 12, pp. 319–339.)

Covering much the same ground as the papers dealt with in January Abstracts, p. 29 (two abstracts). *See* also June Abstracts, p. 318.

RANGE RESULTS ON 5-METRE WAVES.—Lamb: Hull. (*QST*, July, 1931, Vol. 15, pp. 18, 19: 25, 42.)

In their two papers (*see* under "Transmission," "Reception" and "Aerials") the writers describe their range tests. The greatest range observed was about 35 miles, but this was obviously not the limit. "The signals are often found in the most unexpected places and then again are lost entirely in spots where good reception would appear likely. How the signals get over and around such apparently insurmountable obstructions as high hills and show up in the valley on the other side without the assistance of reflection or refraction in the atmosphere is just one of the things that intrigues us." "Very little difference was noted in the strength of signals from the low powered (20 watts oscillator input), and the higher powered transmitter (200 watts input)" [the receiver was super-regenerative]. "At occasional locations a form of distortion, similar in effect to that of 'selective fading' on the broadcast band, was noted. It did not interfere with the intelligibility of speech, however." The poorest signals were usually when the receiver was close under the shadow of an intervening hill; at more than a mile or so from the receiver the presence of such a hill did not appear to have much influence. The best signals at any appreciable distance were heard on the far side of a large lake, where the approach to the receiver was across a mile or two of water.

BIBLIOGRAPHY ON RADIO WAVE PHENOMENA AND MEASUREMENT OF RADIO FIELD INTENSITY.—Bureau of Standards. (*Proc. Inst. Rad. Eng.*, June 1931, Vol. 19, pp. 1034–1089.)

A useful collection of 620 references and short abstracts drawn from some 60 journals and ranging from about 1900 to 1930.

CONSIDÉRATIONS ÉLECTRONIQUES SUR L'ÉMISSION RADIOÉLECTRIQUE (Radioelectric Emission from the Electronic Standpoint).—M. Boll. (*L'Onde Élec.*, June 1931, Vol. 10, pp. 251–258.)

Author's summary:—"The 'microscopic' idea of the *oscillating electron* replaces with great advantage the classic consideration of the doublet; it allows an easy calculation of the electric and magnetic fields at any distance from a transmitter (or from the primary of a transformer), as well as of the radiation resistance. Radioelectric emission at the 'critical distance' [*see* below] is the intermediate case between distant emission and the action of a static transformer."

The author deals first with the e.m.f. produced in a loop aerial by the oscillation of an electron in a second circuit, and then with the power radiated by an aerial and with the radiation resistance of the aerial, arriving by electronic treatment at the classic formula $R_r = 80\pi^2\left(\frac{L}{\lambda}\right)^2$ ohms. He sums up:—

"(*a*) The action of a transformer presents certain analogies with radioelectric reception on a frame. In particular, the only useful electric field is that of Maxwell, which varies inversely with the distance. (*b*) The intermediate case between a transformer and distant emission is realised in reception at the *critical distance, i.e.*, a distance equal to the wavelength divided by 2π [elsewhere defined as the distance at which the Maxwellian magnetic field and that of Laplace have the same amplitude, or at which the e.m.f. is due half to the distance term and half to the phase term of the electric field]. (*c*) But the disparity in frequency (between radioelectric emission and transformer action) brings in a practical consequence: that whereas the aerial *always* radiates energy, whatever the total resistance of the receivers may be, the primary [of a transformer] only passes energy to its secondary when the resistance of the latter is sufficiently small.

"(*d*) We will end by a little-known remark: there are two types of electromagnetic induction: *dynamic* induction (produced by the motion of conductors in magnetic fields) and *static* (produced by a varying current in a fixed circuit). And finally there is a greater analogy between the action of a transformer (static induction) and a radioelectric communication (Hertzian radiation) than between the action of a transformer (static induction) and that of a dynamo (dynamic induction)."

OVER DE IONISATIE BIJ DE ONTBINDUNG VAN OZON (Ionisation in the Breaking-up of Ozone).—R. Ruyssen. (*Natuurwetensch. Tijdschr.*, No. 3, Vol. 12, pp. 86–90.)

Contrary to previous opinion, the writer maintains that the decomposition of ozone is accompanied by transitory ionisation: $2O_3 = 2O_2 + O^{=} + O^{++}$.

ÜBER DIE "GLASHAUSWIRKUNG" DER ERDATMOSPHÄRE UND DAS ZUSTANDEKOMMEN DER TROPOSPHÄRE (The "Greenhouse" Effect of the Earth's Atmosphere, and the Formation of the Troposphere).—F. Albrecht. (*Meteorol. Zeitschr.*, No. 2, Vol. 48, 1931, pp. 57–68.)

BEUGUNG EINER EBENEN WELLE AN EINEM SPALT VON ENDLICHER BREITE (Diffraction of a Plane Wave at a Slit of Finite Breadth).—M. J. O. Strutt. (*Zeitschr. f. Phys.*, 1931, Vol. 69, No. 9/10, pp. 597–617.)

A theoretical investigation, using Mathieu functions, of the diffraction of a plane electromagnetic or acoustic wave with any angle of incidence at a straight slit in a plane screen of infinite extent. A bibliography of Mathieu functions is appended.

DAMPING IN BODILY SEISMIC WAVES [THEORETICAL INVESTIGATION OF THE VELOCITY OF DAMPED SEISMIC WAVES].—H. Jeffreys. (*Monthly Not., Roy. Astron. Soc.*, No. 7, Vol. 2, 1931, pp. 318–323.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

"SOUNDING" THE ATMOSPHERE BY ATMOSPHERICS AND SHORT WAVES (SWISS MISSION TO SAHARA).—Lugeon. (*See* abstract under "Propagation of Waves.")

SUR LA PORTÉE DES PARASITES ATMOSPHÉRIQUES D'APRÈS LES ENREGISTREMENTS SIMULTANÉS DE PARIS-ZURICH-EL GOLÉA (SAHARA) ET ROCHERS-DE-NAYE (SUISSE)-VARSOVIE (The Range of Atmospherics, according to Simultaneous Records at Paris-Zurich-El Goléa [Sahara] and Rochers-de-Naye [Switzerland]-Warsaw).—J. Lugeon and E. Nicola. (*Arch. sc. phys. et nat.*, Nov.–Dec., 1930, Series 5, Vol. 12, pp. 403–404.)

The records of the first-named system have already been dealt with (Jan. Abstracts, p. 29, and above). With regard to the simultaneous observations on a peak in Switzerland and in Warsaw (1,200 km. apart), about 40 % of the atmospherics were found to correspond.

THE NATURE AND ORIGIN OF ULTRA-PENETRATING RAYS.—Discussion at the Royal Society. (*Nature*, 6th June, 1931, Vol. 127, pp. 859–861.)

A short account of a discussion opened by H. Geiger and continued by F. A. Lindemann, G. M. B. Dobson, F. Regener, A. Eddington, Rutherford, and C. T. R. Wilson. No satisfactory hypothesis has yet been framed to account for phenomena exhibited by radiation of 1,000 million volts energy.

ÜBER EXAKTE INTENSITÄTSMESSUNGEN DER HESSSCHEN ULTRASTRAHLUNG (On Exact Intensity Measurements of Cosmic Radiation). —G. Hoffmann. (*Zeitschr. f. Phys.*, 1931, Vol. 69, No. 11/12, pp. 703–718.)

In this account of accurate measurements on cosmic radiation by the ionisation method it is shown that the soft radiation is subject to a strong meteorological influence, while in the case of the hard radiation a direct or indirect solar influence is detectable in addition to variation with air pressure. The great difficulties attached to the problem of a decisive determination of any sidereal time period which may be present are discussed.

OBSERVATIONS ON THE PENETRATING RADIATION IN THE ANTARCTIC.—K. Grant. (*Nature*, 20th June, 1931, Vol. 127, p. 924.)

Observations over a range of geographical latitude from 43° S. to 68° S. tend to confirm the results of experiments by other workers in various parts of the world in showing that the intensity of the penetrating radiation does not vary to any considerable extent with magnetic latitude even within 250 miles of a magnetic pole.

DER ABSORPTIONSKOEFFIZIENT DER HÖHENSTRAHLUNG ZWISCHEN 2,000 UND 9,000 M. HÖHE ÜBER MEER (The Absorption Coefficient of Cosmic Radiation between 2,000 and 9,000 m. above Sea-Level).—W. Kolhörster. (*Naturwiss.*, 26th June, 1931, Vol. 19, No. 26, pp. 574–575.)

The author's balloon observations of 1914 show the variation of the absorption coefficient of cosmic radiation with height; the mass absorption coefficient increases as the height decreases from 9 km., reaching a maximum at about 6.5 km. above sea-level. The decrease of the absorption coefficient from 6 km. to sea-level demonstrates the inhomogeneity of the radiation. The results obtained by Millikan and Cameron give qualitative agreement with those of the author.

THE AURORA BOREALIS.—J. C. McLennan, H. Wynne-Roberts and H. J. C. Ireton. (*Science*, 29th May, 1931, Vol. 73, Supplement p. 10.)

A note on the determination of the height of the aurora in Canada. The aurora was observed from two separate stations, linked by telephone, and photographs of the same portion of it were taken simultaneously. The plates were compared and the height determined by triangulation ; 50 to 75 miles from the ground was the value finally arrived at, though occasional flashes occurred 155 miles up.

THE LOW ALTITUDE AURORA OF NOV. 16, 1929.—A. Corlin. (*Nature*, 20th June, 1931, Vol. 127, p. 928.)

A letter upholding the conclusion of the writer (June Abstracts, p. 319) that the aurora observed by him on November 16th, 1929, really was one of low altitude, against the arguments of G. C. Simpson (July Abstracts, p. 377) that this effect was an illusion.

AURORA GLOW REPRODUCED IN LABORATORY.—J. Kaplan. (*Sci. News Letter*, 4th July, 1931, Vol. 20, p. 14.)

The evacuation of the borosilicate tube was continued intermittently for weeks, during which time much of the remaining nitrogen and oxygen disappeared and was replaced from the outside: finally the residual gas, largely nitrogen, gave the ruddy auroral glow including the characteristic lines in the red and green. It is suspected that some chemical change has occurred on the inside walls of the tube which " makes the discharge act as though the tube were not there " ; and that it was the presence of the unnatural glass wall which had interfered with previous artificial aurora experiments.

16,000,000 VOLTS FROM SKIES TO PRODUCE SUPER X-RAYS [MONTE GENEROSO EXPERIMENTS]. —F. Lange and A. Brasch. (*Sci. News Letter*, 27th June, 1931, Vol. 19, p. 403.)

An article on the Monte Generoso experiments (1929 Abstracts, pp. 567–568). Sparks 55 feet long (16 million volts) were obtained. A new type of X-ray tube built of alternate rings of paper, rubber, and aluminium has been tested at 2,600,000 volts for a millionth of a second. It is less than 12 feet long, the layers having different internal diameters so as to make the surface crooked and decrease surface leakage. The cathode is a small porcelain tube, and " plain water " is used for insulating. The X-rays already produced penetrate a yard of lead. When a tube now being built is used on the thunderstorm voltages, the rays produced should equal the cosmic rays in penetration.

ÉTUDE DE L'INFLUENCE DE QUELQUES FACTEURS GÉOPHYSIQUES SUR LES POINTS DE CHUTE DE LA FOUDRE (On the Influence of Certain Geophysical Factors on the Points of Incidence of Lightning Strokes).—L. N. Bogoïavlensky. (*Journ. de Phys. et le Rad.*, April, 1931, Series 7, Vol. 2, pp. 101–113.)

An account of Russian tests prompted by the work of Dauzère and Bouget (1930 Abstracts, p. 503).

EXPERIENCE WITH LIGHTNING.—P. Sporn. (*Elec. World*, No. 5, Vol. 97, 1931, pp. 227–228.)

Among other results, it was found that the probability of two lines run parallel being simultaneously put out of action is very slight: that the protective action of earth wires is very great (3.6 failures per 100 miles for a conductor with 2 earth wires, compared with 76 for a conductor without earth wire): and that in 70 % of the cases one wire alone is affected; next come the cases affecting the upper (or lower) and middle wires, while only 5 % affect all three wires. *From the fact that the upper and lower wires are affected equally, it is concluded that direct and indirect lightning effects are equally dangerous.*

DIELECTRIC PHENOMENA AT HIGH VOLTAGES.—Goodlet, Edwards and Perry. (*See* under "Subsidiary Apparatus and Materials.")

OVER-VOLTAGE PROBLEMS.—A. H. von Altmann. (*Engineer*, 5th June, 1931, Vol. 151, pp. 634–636.)

EFFECT OF SUNRISE ON POWER TRANSMISSION.—(*Electrical World*, 27th June, 1931, Vol. 97, p. 1210.)

An editorial on interruptions to power line transmission apparently due to sunrise effects. George and Brownlee have drawn attention to these interruptions not due to lightning, 70 % of which occur at or near sunrise.

PROPERTIES OF CIRCUITS.

DIE ANPASSUNG DER RUNDFUNKGERÄTE AN DIE ANTENNE (Matching the Broadcast Receiver with Its Aerial [Theoretical Investigation of Inductive and Capacitive Couplings]).—W. Kautter. (*E.N.T.*, June, 1931, Vol. 8, pp. 245–256.)

The writer sets out to investigate the various types of inductive and capacitive couplings between aerial and first grid, and their influence on the potential step-up to that grid and on the selectivity; attention is also paid to the calculation (so important for multi-circuit receivers) of the de-tuning effect of the aerial on the input circuit. The mathematical analysis is shortened by the application of the generalised equivalent circuits for transformers, and Section (1) is devoted to a recapitulation of these. Section (2) deals with the difference between purely inductive coupling (two separate windings) and "inductive-galvanic" coupling (auto-transformer), and Fig. 7 gives the various curves representing the relations—coupling coefficient, leakage coefficient and inductance, etc. —in a cylindrical auto-transformer for various positions of the tapping point. The mathematical relation between the leakage in these two varieties of inductive coupling is derived: "thus—and also on the ground of economy—the inductive-galvanic coupling should be employed." Section (3) defines the properties of an aerial, showing how, above its natural wavelength (usually lying at the bottom of the Broadcast band), the real component of the effective resistance keeps practically constant over a wide wave-range while the imaginary (wattless) component increases nearly linearly (Fig. 8); below the natural wavelength the damping increases sharply, while the phase becomes inductive: the aerial is here in a bad condition for reception.

After the above preliminaries, Section (4) concentrates on inductive coupling, and in (*a*) the formula 9 is derived for the percentage re-tuning which must be applied to the oscillatory circuit when the aerial is coupled-up, in order to bring the whole into tune with the incoming wave. This formula does not hold in the neighbourhood of the natural frequency of the "aerial branch" $\left(\frac{1}{\omega^2{}_a} = \sigma L_1 C_A\right.$, where σ is the transformer leakage$\left.\right)$, which, however, with a normal aerial and proper design of the circuits does not fall in the Broadcast range. In (*b*) the writer deals with the voltage step-up at resonance, and obtains formula 12 for the highest possible step-up from aerial to first grid $\left(v = \frac{1}{2\omega C_0 \sqrt{RR_A}}\right)$. Thus with an aerial of $R_A = 60$ ohms and an oscillatory circuit with reduced damping in which $\frac{1}{\omega C_0} = 1500$ ohms and $R = 3$ ohms, $v = \frac{1500}{2\sqrt{3 \times 60}} = 56$. This value is reached with the optimum coupling α_0 given by formula 11. As a result of the above, it is possible to calculate the step-up for any other value of coupling (formula 13, illustrated by Fig. 15). Combining formula 11 for the optimum coupling with formula 9 for the de-tuning effect (see 4*a* above), an important formula is arrived at giving the de-tuning at optimum coupling, namely

$$\delta_0 = \frac{C_0}{C_A} \cdot \frac{R}{R_A}\left(1 - \frac{\omega^2}{\omega^2{}_a}\right) \quad \ldots \quad \ldots (14)$$

Thus the greater the damping of the oscillatory circuit, the greater must be the coupling to the aerial, and consequently the greater is the de-tuning. For any other coupling α the de-tuning is given by

$$\frac{\delta}{\delta_0} = \frac{\alpha^2}{\alpha^2{}_0} \quad \ldots \quad \ldots \quad \ldots (15)$$

Sub-section 4*c* deals with the selectivity with inductive coupling: here the selectivity ψ for any particular coupling α is linked with the maximum selectivity ψ_0 by the approximate formula

$$\frac{\psi}{\psi_0} = \frac{1}{1 + \frac{\alpha^2}{\alpha_0{}^2}},$$

where α_0 is the coupling for maximum potential step-up as given in formula 11.

This approximation (formula 20), which only holds when the selectivity is sufficiently great, is illustrated by Fig. 17, which shows how the selectivity increases as the coupling is decreased to the point of maximum step-up $\left(\frac{\alpha}{\alpha_0} = 1\right)$ and beyond that point *still* increases while, however, the potential step-up (and consequently the amplification) decreases from its maximum. As compensation for this loss of amplification, the increase of selectivity only amounts to 0.7 Neper, *so that it is best to adjust to the coupling value* α_0. Fig. 18 shows the relation between selectivity and amplification: this can be used in practice to identify under- and over-coupling. Sub-section

(4*d*) deals with the existence of two wavelengths for which the inductively coupled combination is in resonance.

In section (5) the writer deals similarly with capacitive coupling, obtaining formula 25 (for the maximum step-up) which is identical with formula 12 in the inductive case; formulae 26 and 27 (de-tuning effect) which are the capacitive equivalents to 14 and 15; and so on. Section (6) gives a comparison between the two types of coupling based on the foregoing: both, suitably designed, give exactly the same amplification and selectivity; *as regards de-tuning, however, capacitive coupling produces a much greater effect.* In an example given, the detuning by formula 14 is only 0.04, while by 26 it is 0.316. This fact causes difficulties in the design calculations for capacitive couplings. The paper ends by a denunciation of the meaningless term "aperiodic aerial coupling."

THE DESIGN OF HIGH-FREQUENCY TRANSFORMERS.—M. Reed. (*E.W. & W.E.*, July, 1931, Vol. 8, pp. 349–355.)

"In radio receiver design the high-frequency transformer is employed to couple the antenna to the receiver and also to couple the valves which provide the high-frequency amplification. This article shows that the same considerations govern the design of transformers for either of these purposes, and it also gives an analysis of the factors which influence the design of high-frequency transformers."

SUR L'ÉXISTENCE D'UN FLUX MAGNÉTIQUE ANORMAL (On the Existence of an "Anomalous" Magnetic Flux). P. Fourmarier: Mitkevitch. (*Comptes Rendus*, No. 8, Vol. 192, 1931, pp. 486–487.)

A criticism of Mitkevitch's results according to which the e.m.f. induced in a circuit by a current i is given by $e = -M \cdot \frac{di}{dt} + M_a \cdot \frac{d^2i}{dt^2}$, where M_a is the "anomalous" counter-induction coefficient. Fourmarier concludes that the results are due to experimental errors.

THE THEORY OF VOLUME EQUALISATION AND OPTIMUM MATCHING OF RECEIVERS ON A DELAY NETWORK.—Fischer. (*See* under "Acoustics and Audio-frequencies.")

MAXIMUM AMPLIFICATION IN CAPACITY-COUPLED CIRCUITS.—W. van B. Roberts. (*Electronics*, July, 1931, pp. 20 and 42.)

THE VARIATION OF MAGNIFICATION WITH PITCH IN RESISTANCE-CAPACITY COUPLED AMPLIFIERS.—Barclay. (*See* under "Acoustics and Audio-frequencies.")

TRANSMISSION.

THE SUPPRESSION OF RADIO-FREQUENCY HARMONICS IN TRANSMITTERS.—J. W Labus and H. Roder. (*Proc. Inst. Rad. Eng.* June, 1931, Vol. 19, pp. 949–962.)

Authors' summary:—"In the present paper the harmonic components of the antenna current are determined in terms of the corresponding components of the plate current of the power amplifier of transmitters. After investigating the cause of harmonic currents and pointing out the difficulties arising in connection with an exact calculation of the harmonics of the field strength, the discussion is confined to the effect of the circuits inserted between plate and antenna circuit on the suppression of harmonics. Several types of circuits are considered and the current ratios of the harmonic antenna currents with respect to the fundamental are given. For better comparison the results are tabulated.

"It has been found that, in general, the suppression of harmonics as given by the above ratio is proportional to the product of the volt-amperes in each individual circuit of the network and to a power of the order of the respective harmonic. Moreover, a general law has been derived, according to which for a given total volt-amperes of the whole filter network the optimum number of individual circuits can be determined. Finally, the advantage of the push-pull amplifier and another circuit which inherently compensates harmonics has been discussed and also the detrimental effect of the distributed capacity of the coupling device which provides an undesired path for the harmonics has been described."

The "other" circuit referred to is a Telefunken patent (DRP 448060) shown in Fig. 10; the harmonics pass through the "tank" condenser to an adjustable tapping near the middle of a primary winding, and divide themselves here in the two directions open to them so that the harmonic voltage induced in the secondary (coupling) winding can be reduced to zero by adjusting the tapping point or the position of the coupling coil. "This is true for one harmonic frequency; since, however, the adequate adjustments leading to the suppression of the rest of the harmonics differ very little, it follows that in the average a good over-all suppression of harmonics can be achieved. In opposition to the push-pull amplifier, this arrangement reduces both even and odd harmonics equally well."

ELIMINATION OF HARMONICS IN VALVE TRANSMITTERS.—Y. Kusunose. (*Electrot. Lab., Ministry of Communications, Tokyo*: pub. by National Research Council of Japan, Tokyo, 1931: 5 pp.)

English version of the paper dealt with in February Abstracts, p. 95.

FREQUENCY STABILISATION OF RADIO TRANSMITTERS.—Y. Kusunose and S. Ishikawa. (*Electrot. Lab., Ministry of Communications, Tokyo*: pub. by National Research Council of Japan, Tokyo, 1931: 27 pp.)

Where the highest precision is necessary (0.001 %) quartz control with thermostatic temperature regulation should be utilised. This is expensive, complex and inflexible; for frequency control of a precision round 0.01 %, therefore, the writers recommend the use of a master-oscillator controlled by one of the following methods:—(*a*) constant frequency oscillator with effects of supply voltage variations minimised by resistance-stabilisation or phase-compensation stabilisation; (*b*) quartz crystal very loosely coupled to the oscillator; (*c*) mechanically stabilised oscillator, a vernier condenser (mechanically driven and controlled by a relay) being governed by the beat frequency of the oscillator wave heterodyning with that of a low-power quartz-oscillator frequency standard; and (*d*) valve-stabilised oscillator, in which a valve is coupled to the oscillator in such a manner that it acts as a pure capacity whose effective value is controlled by the grid bias voltage, this being itself controlled by a quartz resonator acting as the frequency standard. All these methods are described and discussed.

SENDER FÜR ULTRAKURZE WELLEN (An Ultra-Short-Wave Transmitter [for 10–20 cm. Waves]).—W. Kroebel. (*Zeitschr. f. Physik*, No. 11/12, Vol. 65, 1930, pp. 726–729.)

Improvements to the transmitter used in the tests dealt with in 1930 Abstracts, p. 505. The original arrangement, in which the telescopic grid and plate wires led straight to the two halves of an adjustable dipole split at the centre by a condenser, did not always oscillate with a potential node exactly at the condenser, owing to the grid and plate leads joining the dipole a few millimetres from the condenser plates. The system, therefore, was inclined not to give its maximum power. This was particularly true for the shorter waves, when the "few millimetres" formed a larger proportion of the dipole length. Better results, therefore, were obtained when the grid lead and one half dipole were made all in one piece and the anode lead and the other half dipole similarly treated, the half dipoles being made by turning up the ends of the leads, while the condenser was dispensed with entirely and the battery leads with their chokes were transferred from each side of the condenser and inserted in small holes in the grid and anode leads. fine wire being used so as to cause as little reflection as possible. This arrangement oscillated with a potential node exactly at the corners where each half dipole turned in towards the valve, but it had the disadvantage of not being adjustable, so that a fresh system had to be made for each wavelength.

In the final arrangement the grid and anode leads were again made telescopic and their ends soldered to two metal discs. Part (half ?) of each disc was bent out at right angles, the bent-out portions being brought to within 0.05 to 0.1 mm. of each other so as to form an air condenser, the leads being soldered on the other portion near each bend. Thus the disc-leads combination formed a Lecher wire system closed by reflector discs. By slightly sloping the leads towards each other as they approached the discs, potential nodes were arranged to lie in the Lecher wires at opposite points, and a half dipole was mounted to slide on each wire. In this case the battery leads were transferred back to the condenser, being soldered to the back of the bent-out half discs.

DEVELOPMENTS IN ULTRA-HIGH FREQUENCY OSCILLATORS.—J. J. Lamb. (*QST*, July, 1931, Vol. 15, pp. 9–20.)

A practical paper by the Technical Editor. He deals first with the range 1.5 metres and under (electronic oscillators) on lines based on the *Proc. I.R.E.* papers by Hollmann and Uda, mentioning a few commercially available (American) valves which are suitable. This part of the paper ends with a section on the receiver used by Uda. He then turns to the longer waves, particularly the 56-megacycle band, giving here his own experiences and describing the transmitting circuit finally adopted—a push-pull Armstrong ("TNT") circuit with fixed grid coil. He gives useful advice regarding the choice of valves and their treatment: "it must be remembered that . . . the limit on what a tube can handle becomes not what it can dissipate on the plate but what the dielectric breakdown in its stem may be." Valves with oxide-coated filaments may give trouble if the plate voltage is high (350 v.), their grids being inclined to emit electrons and to become positively charged after a few minutes' operation. Tuning and calibrating the transmitter with the help of a dynatron wavemeter intended for the short wave band is described on p. 17. The last part of the paper deals with aerial systems and communication tests: the super-regenerative receiver employed is described by Hull (*see* under "Reception").

SYSTÈMES POLYPHASÉS À AUTO-EXCITATION (Self-Exciting Polyphase Valve Systems).—A. Arenberg. (*L'Onde Élec.*, June, 1931, Vol. 10, pp. 259–274.)

Author's summary:—"By combining a number of ordinary one-valve oscillators, circuits may be obtained giving polyphase currents. The fundamental frequency does not circulate in the feeders; in this respect such circuits have the same advantages as the push-pull circuit. The oscillatory régime is little affected by asymmetries in the different phases.

"The facility with which polyphase currents of high frequency can be obtained, and the stability of their frequencies, makes their employment of interest in various domains of radio technique, especially in communication by ultra-short waves. The feeding circuits are traversed by intense currents of frequency $qn\omega$ (n being the number of phases, ω the fundamental frequency, $q = 1, 2, 3 \ldots$). This fact gives a new method of stabilising ultra-short waves: it is only necessary to apply to the grid of a neutrodyned oscillator a potential taken from the feeders of an n-phased generator whose fundamental frequency is low enough to be stabilised by quartz. The production of rotating magnetic fields of high frequency allows a number of physical experiments to be carried out."

The paper deals with the theory of such polyphase generators, with inductive coupling, in the case where each valve is connected on one side to the neutral point of the combination, and on the other side either to the neighbouring valves only or to all the valves of the combination. At the end, the writer mentions that the radiation from a combination of symmetrical aerials forming a plane system fed by polyphase current "gives an interesting picture of electromagnetic fields, depending on the position of the point considered with regard to the system" (for experimental work on the transmission from such a system, *see* Takagishi and Iso, 1930 Abstracts, pp. 46–47).

For a Russian paper by the same writer covering much of the same ground, *see* August Abstracts, p. 438.

STABILISATION OF ULTRA-SHORT-WAVE GENERATOR BY A POLYPHASE OSCILLATOR.—Arenberg. (*See* preceding abstract.)

A METER FOR INDICATING 100 PER CENT. MODULATION.—G. F. Lampkin. (*Electronics*, July, 1931, p. 26.)

TELEPHONE TRANSMITTING EQUIPMENT ON BOARD THE "HOMERIC." (*Marconi Review*, May–June, 1931, No. 30, pp. 23–28.)

THE OSCILLATING ARC: ELEMENTS OF GROUP VI.—Stowell. (*See* under "Miscellaneous.")

RECEPTION.

"FIVE METER" RECEIVER PROGRESS: DESCRIBING A SUCCESSFUL SUPER-REGENERATIVE RECEIVER FOR THE ULTRA-HIGH FREQUENCIES.—R. A. Hull. (*QST*, July, 1931, Vol. 15, pp. 21–25 and 42.)

Full description of the 3-valve receiver with indirectly heated valves (the audio-amplifier valve being a pentode) used in the Lamb-Hull tests referred to under "Transmission," "Aerials," and "Propagation of Waves."

CALIBRATING ULTRA-SHORT-WAVE RECEIVERS EMPLOYING SUPER-REGENERATION.—C. Whitehead. (*E.W. & W.E.*, July, 1931, Vol. 8, pp. 370–371.)

Using a Lecher wire system, the "mush" caused by the super-regeneration being employed as an aperiodic artificial signal which is observed on a rectifier-microammeter combination.

FUNDAMENTAL POINTS FOR ULTRA-SHORT-WAVE RECEIVERS.—Liebau. (*Funk*, 1st May, 1931; Summary in *Electronics*, June, 1931, p. 697.)

The need for excellent shielding and r.f. choking, especially to avoid "fringe howl"; reaction control by variation of plate resistance rather than by the more usual methods; disadvantages of super-reaction; full description of two receivers built at the Heinrich Hertz Institute, one using super-reaction with a separate valve, the other using a single valve for both purposes; both receivers can readily be used as ordinary regenerative receivers.

ADAPTORS FOR ULTRA-SHORT-WAVE RECEPTION, SUPER-REGENERATIVE AND OTHERWISE.—Schröter: Leithäuser. (*See* abstract under "Stations, Design and Operation.")

ADAPTOR FOR ULTRA-SHORT WAVES.—(*Funk*, 1st May, 1931.)

Constructional details of an attachment including a detector with reaction, for use with the audio-frequency portion of an ordinary receiver (cf. July Abstracts, p. 384). A further article will deal with the addition of a second valve for super-regeneration.

TUNING BY PERMEABILITY VARIATION.—R. H. Langley: W. J. Polydoroff. (*Electronics*, July, 1931, pp. 8–9 and 17.)

Tuning of r.f. transformers by the gradual introduction of magnetic cores. "As long ago as 1890, patents were issued on compressed iron dust cores, and cores of this type have been successfully used in telephone work, and at frequencies as high as 40,000 cycles. But the losses increased more rapidly than the square of the frequency, and such cores were useless above 200 kc. The secret of the Polydoroff cores lies not only in the fact that a method of producing a much finer powder has been developed, but also in the method of completely insulating the particles . . . Careful measurements indicate that the performance [over the Broadcast frequency range] is even better than can be obtained with the conventional variable air condenser method of tuning." The grain size of the powdered iron (produced by condensing the vapour of iron carbonyl or by reducing the sulphate) is chosen to be 10 microns, although grain sizes down to 1 micron can be obtained by these processes. Over each grain a 1 micron film of a "specially developed insulator" is deposited; this prevents the powder from burning on contact with air. The mixing medium is phenol resin. The moulded material has a resistance 5 million times that of pure iron, and an initial permeability of 10 as compared with 50.

RECEIVER DESIGN FOR MINIMUM FLUCTUATION NOISE.—N. P. Case. (*Proc. Inst. Rad. Eng.*, June, 1931, Vol. 19, pp. 963–970.)

It is shown that the limitation of sensitivity set by "fluctuation noise" depends primarily on the efficiency of the coupling aerial—first grid, which should therefore be as efficient as possible; and secondarily on the plate-circuit load impedance if this is low; it should therefore be high enough to give a gain of at least 5 for the first r.f. valve apart from the aerial coupling circuit. The noise also depends on the gas pressure, if this is excessive; it should therefore be less than 10^{-4} mm. of mercury. Ordinarily, the noise is independent of heater or filament voltage, but when this is reduced too far, or when the valve is near the end of its useful life, the noise increases sharply: the space charge is beginning to disappear and its "cushion" action on the shot-effect fluctuation is removed. Cathode emission, therefore, should always be high enough for the valve to be operating under dense space-charge conditions. A useful bibliography of 20 items ends the paper.

HIGH LEVEL AUTOMATIC OR SELF-BIAS DETECTION.—J. R. Nelson. (*Electronics*, July, 1931, pp. 14–15.)

AMPLITUDE MODULATION VERSUS FREQUENCY MODULATION [AND THE STENODE RADIOSTAT].—V. V. Gunsolley. (*Rad. Engineering*, June, 1931, Vol. 11, pp. 33–35.)

The writer sums up his analysis as follows:—"It is quite probable that transmission and reception on the frequency modulation principle from beginning to end will become a reality. It awaits only a detector that will operate on frequency modulation instead of amplitude modulation. In such event, the sideband theory will apply at no point along the transmission. Thus far it has been developed in the Stenode to the point where the sideband theory does not apply between sender and receiver and thus can cause no station interference, but it does apply just at the point of conversion and thus causes audio suppression in the higher frequencies in accordance with the sideband theory. . . . If it were not true that reception on the Stenode is independent of sidebands up to the crystal, then the compensation in the audio amplifier would also compensate the interference, and in the same manner as it restores the suppressed frequencies it would also restore the interference. This it does not do, thereby demonstrating the truth of the analyses made in this article."

A Radio Receiver for Police [Motor Car] Service.—V. M. Graham. (*Rad. Engineering*, June, 1931, Vol. II, pp. 31–32.)

The German Super-Midget Receiver.—R. Raven-Hart. (*Electronics*, June, 1931, p. 674.)

Diagrams are given of two models selling at about £5 complete with valves; mains operated, with built-in loud speaker, provision for gramophone pick-up, and wave-band switching for long and normal bands; there are several others at slightly higher prices, and others are promised.

D.C. Mains Three.—H. B. Dent. (*Wireless World*, 24th June, 1931, Vol. 28, pp. 670–674; 1st July, Vol. 29, pp. 9–13.)

Constructional details of a receiver embodying the Mazda indirectly heated d.c. valves, types DC/SG, DC/HL and DC/PEN.

The Lightweight Portable.—H. F. Smith. (*Wireless World*, 8th July, 1931, Vol. 29, pp. 26–29.)

A "headphone" portable designed to fit into a gramophone record holder. A regenerative detector valve is connected in a throttle-controlled "Hartley" circuit and is followed by one transformer-coupled a.f. stage. The centre-tapped frame aerial acts as a combined tuned grid coil and reaction winding.

Super-Selective Five.—W. T. Cocking. (*Wireless World*, 15th and 22nd July, 1931, Vol. 29, pp. 59–64 and 80–84.)

A battery-operated five-valve superheterodyne with six tuned circuits. Although the basic circuit and much of the component lay-out are the same as in the "Super-Selective Six" a.c. model (August Abstracts, p. 440), modification of the set has involved the virtual re-design of the whole apparatus. Two limitations are imposed by battery operation: the valves themselves are less efficient than the mains types, and the power supply is strictly limited by considerations of economy. Five valves are employed, and the filament current from a 2-volt accumulator is 0.8 ampère; the load upon the h.t. battery is 28 mA. when this has a potential of 160 volts.

Interference from Electrical Machinery and Appliances, and the Shielding of the Aerial Down-Lead.—Rechnitzer: A.E.G. (*Funk*, 24th April, 1931; Summary in *Electronics*, June, 1931, p. 696.)

Results of tests at the A.E.G. showrooms in Berlin, where interference is unusually strong owing to the demonstration of all kinds of electrical appliances and machinery. *Cf.* Asch, below.

Installation of Radio Receivers in the Home [Importance of Shielded Lead-In, etc.]—M. Asch. (*Rad. Engineering*, June, 1931, Vol. 11, p. 36.)

"Shielded antenna lead-ins prevent much of the disturbing noises complained of," particularly lift "clicks." The outside shield must be earthed in more than one place: usually the best results are obtained by using the shield as the earth of the set and earthing the outside end near the window.

Radio Program Distribution over Lighting Circuits [in Hotels, etc.].—T. D. MacCoun: Satterlee. (*Electronics*, June, 1931, pp. 682–683 and 706.)

In a 1,200 room hotel a saving of about £6,000 is estimated as a result of using the Satterlee "guided radio" method in place of re-wiring the building for audio-frequency circuits. Individual one-valve receivers are installed in a standard bedside table in each room.

Remote Tuning Control Systems.—A. Dinsdale. (*Wireless World*, 17th June, 1931, Vol. 28, pp. 646–650.)

New American devices for the synchronous-motor control of volume and tuning. The author deals with the types manufactured by the Westinghouse, R.C.A., and the National Companies.

Microphonic Difficulties in the Superheterodyne [Regeneration due to Vibration of Air Condenser Plates].—R. de Cola. (*Rad. Engineering*, June, 1931, Vol. 11, pp. 45–46.)

Testing Wireless Receivers.—Smith-Rose. (*See* under "Measurements and Standards.")

AERIALS AND AERIAL SYSTEMS.

New Broadcasting Aerial System for Large Ground Wave and Small Space Wave Radiation.—Lorenz Company. (*Rad., B., F.f. Alle*, July, 1931, pp. 289–290.)

Preliminary tests are reported of an aerial system designed to give the same results as Eckersley's suggested aerial, but without the need for high masts. The new system has a "quite unusual horizontal extension close to the ground—surfaces of a square kilometre are spoken of. . . ." Results so far appear to be promising, and inspire the writer to see in such a system the solution of the "congestion" problem.

A Graphical Method for Determining the Magnitude and Phase of the Electric Field in the Neighbourhood of an Antenna carrying a Known Distribution of Current: Discussion.—R. M. Wilmotte: J. S. McPetrie. (*Journ. I.E.E.*, May, 1931, Vol. 69, p. 636.)

Discussion on McPetrie's paper dealt with in April Abstracts, pp. 211–212. Wilmotte has recently somewhat changed his views as to the effect of the image in the ground. "The waves emitted from a vertical antenna are simply vertically polarized, and, in order to change this state of polarization into the steady elliptically polarized condition, currents are set up in the ground which produce a comparatively local field. It is this field which completely upsets the simple reflection theory when applied in the neighbourhood of the antenna. If the antenna were designed to radiate horizontally waves having the same polarization as that corresponding to a steady state of polarization, I believe it would be found that the simple reflection theory would hold even at small distances from the antenna. Such a design would have important practical applications because it would decrease the currents in the ground that are required to produce the change in the polarization of the ray propagated horizontally, and thus reduce the ground losses in the neighbourhood of the antenna. . . ." McPetrie disagrees.

The Effective Height of Closed [Loop] Aerials.—V. I. Bashenoff and N. A. Mjasoedoff. (*Proc. Inst. Rad. Eng.*, June, 1931, Vol. 19, pp. 984–1018.)

Authors' summary:—In this article formulas are given for the calculation of the effective height of coil aerials with non-quasi stationary distribution of current. Aerials of triangular, rhombical, rectangular, and pentagonal forms, suitable for use in radio beacons, are treated, and the method of taking account of the distribution of current along the aerial found by experiment discussed.

Graphs for facilitating numerical calculations using the formulas are given, together with examples illustrating their use. Special attention is given to the determination of those forms of aerials in which the wire is most advantageously placed for obtaining a maximum of effective height.

Aerial Systems for Ultra-Short (5 Metre) Waves and their Effect on the Formation of Interference Patterns at a Distance.—Lamb. (*QST*, July, 1931, Vol. 15, pp. 18–19.)

In his paper dealt with under "Transmission," the writer describes how in his car receiving tests the signals at distances up to 5 miles changed from *R*9 to zero in a few feet. On changing the transmitting aerial from a vertical-horizontal combination, giving high-angle radiation with both vertical and horizontal polarisation, to a vertical dipole, almost all the standing waves producing this effect disappeared. Such as remained were probably due to accidental phase-shifts resulting from re-radiation from smoke-stack guys, power and telephone lines, etc.; perhaps even from rocks and trees. The addition of reflectors is briefly mentioned: there was a marked reduction in radiation in the backward direction "and perhaps a slight gain" in the forward.

Dipoles Buried in Snow on the Pic du Midi.—Garrigue.

(*See* abstract under "Stations, Design and Operation.")

The Efficacy of Shielding the Down-Lead to prevent Interference.—Asch: Rechnitzer.

(*See* abstracts under "Reception.")

VALVES AND THERMIONICS.

A Note on the Time Required to Set up Conduction in an FG-17 Thyratron as Determined by a Study of a Linear Time Axis Circuit for an Oscillograph.—W. B. Nottingham. (*Journ. Franklin Inst.*, June, 1931, Vol. 211, No. 6, pp. 751–755.)

In a study of small thyratrons recently published by the author (May Abstracts, p. 269) certain results seemed to indicate that 1,000 microseconds were required to set up conduction. In the present investigation the thyratron is used in connection with a cathode-ray oscillograph to produce a linear time-axis, and it is definitely shown that good conduction can be set up in 10–20 microseconds. An explanation of the earlier result, suggested by O.W.Livingston, is that the condenser used in the "phase shifting" circuit charged up with grid current the half cycle in which the plate potential was negative and the grid potential positive with respect to the cathode. The grid was therefore more negative than it should have been during the negative half of the grid potential cycle. The *effective* phase difference between grid and anode was therefore greater than the *calculated* one.

Tubes for Generating 18-Centimetre Waves.—I.T. & T. Company: I. J. Saxl. (*Electronics*, July, 1931, p. 4 and cover.)

Photograph, drawing and brief description of the transmitting valve used in the Dover-Calais demonstrations (June Abstracts, p. 339). Worked as a Barkhausen oscillator, the plate and grid voltages were −40 and +250 respectively; "since the wavelength is a function only of the size and mutual position of the electrodes within the tube and the voltages thereon, the tube is designed in such a way that all parts which act as coupling devices are exact ratios (in size and spacing) of the desired wavelength. A shield about one inch square protects the radiating parts of the tube from the field of the antenna." Only the filament leads go out through the stem, the plate and grid being taken out separately at two points at the top of the bulb. The grid is a self-supporting spiral: "there are no connections between windings of the grid so that any short-circuiting with the oscillating system is avoided. The lead-in wire to the grid is made at the exact centre of the grid": in the diagram the ends of the spiral are short-circuited by a thicker bow, to the mid-point of which the lead-in wire is connected. "With such tubes a lower limit of 2.5 centimetres wavelength has been reached."

THE PHILIPS ELECTROMETER VALVE IN AN AMPLIFIER FOR DETECTION OF A CHARGE OF 10^{-16} COULOMB.—Leprince-Ringuet. (*See* last abstract under "Subsidiary Apparatus.")

THE VARIABLE-MU TUBE AND DISTORTION IN RADIO RECEIVERS.—A. G. CAMPBELL. (*Rad. Engineering*, June, 1931, Vol. 11, pp. 29–30 and 44.)

From the Arcturus laboratories. The principles on which the advantages of these valves depend are analysed.

TUBES ÉLECTRONIQUES AMPLIFICATEURS À GRANDE PENTE (Steep-Slope Amplifier Waves).—R. Boussard. (*Journ. de Phys. et le Rad.*, March, 1931, Series 7, Vol. 2, pp. 40S–41S.)

A discussion on the various ways in which manufacturers try to increase the slope, with particular reference to the "Radio-Fotos" valves. In one type mentioned a slope of 5 to 6 MA./volt has been obtained with filament supply of 0.5 A. at 4 V. *Cf.* Abèles, Aug. Abstracts, p. 456.

GERMAN VALVES OF 1931.—E. Schwandt. (*Electronics*, June, 1931, p. 696.)

Summary of an article in *Funk* for 20th February.

NEW SIX-VOLT D.C. TUBES.—G. Grammer. (*QST*, July, 1931, Vol. 15, pp. 45–46.)

Including a series of "automobile radio" valves with indirectly heated cathodes working off 6 volts.

ANALYSIS OF VACUUM TUBE PRODUCTION COSTS.—(*Electronics*, June, 1931, pp. 664–665.)

REACTIONS AT THE SURFACE OF HOT METALLIC FILAMENTS. PART V.—THERMIONIC EMISSION AND CATALYTIC ACTIVITY AT THE SURFACE OF HOT METALLIC WIRES.—B. S. Srikantan. (*Indian Journ. Physics*, No. 7, Vol. 5, 1931 pp. 685–698.)

OXYGEN FILMS ON TUNGSTEN. I.—A STUDY OF STABILITY BY MEANS OF ELECTRON EMISSION IN PRESENCE OF CESIUM VAPOR.—I. Langmuir and D. S. Villars. (*Journ. Am. Chem. Soc.*, No. 2, Vol. 53, 1931, pp. 486–497.)

When a tungsten cathode is heated, the emission first follows the Richardson formula, then reaches a maximum and falls considerably, finally increasing again according to the Richardson formula. The decreasing zone is due to the vaporisation of caesium deposited on the tungsten; the subsequent increase corresponds to the emission from the pure tungsten. The effect of the presence of oxygen, in addition to a comparatively slight influence on the constants, lies above all in a very strong binding effect on the caesium atom to the tungsten surface, with the result that the above-mentioned maximum is displaced towards higher temperatures. The validity of the Richardson formula for the first rise is in this way extended to higher temperatures, and thus the presence of oxygen produces an emission up to 10^6 times greater than that in its absence. The measured values are so reproducible and consistent that they can be used to detect the presence of oxygen in a gas.

THERMIONIC EMISSION IN CAESIUM-OXIDE PHOTO-CELLS AT ROOM TEMPERATURES.—Kingsbury and Stilwell. (*See* under "Phototelegraphy and Television.")

ZUR THEORIE DES SCHROTEFFEKTES (On the Theory of the Shot Effect).—H. J. de Boer. (*Physik. Zeitschr.*, 15th June, 1931, Vol. 32, No. 12, pp. 482–483.)

Calculations supplementing the simple theory of the shot effect given by Fürth (*Physik. Zeitschr.*, Vol. 23, 1922, p. 354).

BEITRAG ZUM AUSBRENNVORGANG DER IM VAKUUM GEGLÜHTEN (WOLFRAM-) DRÄHTE (Contribution to the Burn-Out Process of Tungsten Wires Heated *in Vacuo*).—L. Prásnik. (*Zeitschr. f. Phys.*, 1931, Vol. 69, No. 11/12, pp. 832–834.)

"The phenomenon found by G. A. Fonda for tungsten wires heated in a gaseous atmosphere, that the proportion of the filament which evaporates during the whole time of heating increases with the temperature, is deduced [theoretically] for wires heated *in vacuo*. The reason for the increase is that the sensitivity of the filament life to faults in the wire decreases with increase of temperature."

DIRECTIONAL WIRELESS.

LES PROCÉDÉS LOTH POUR LE GUIDAGE DES AVIONS PAR ONDES HERTZIENNES (The Loth Systems for Guiding Aeroplanes by Wireless).—A. Verdurand: Blancard. (*Génie Civil*, 9th May, 1931, Vol. 108, pp. 473–475.)

Summary of a discussion published in *l'Aeronautique*, Oct. 1930, between Verdurand, director of the Compagnie Air-Union, and Blancard, engineer of the Sociétés des Procédés Loth, on the practical application of Loth methods.

The first part dealt with the method of guiding an aeroplane on a course by means of two rotating beacons whose beams intersect along the required route (*see* 1930 Abstracts, p. 217). Verdurand criticised the method for its alleged inaccuracies, short range obtained (300–400 km.), bad night effects, and the impossibility of maintaining a large number of air routes by it. He considered that the experiments so far made did not justify the adoption of Loth methods. According to Blancard, the sectors of silence are well defined (10°–12° average) thanks partly to the Marrec filter. It is on the intersection of the axes of these silent zones that the Loth system depends, *not* on equi-signal zones: Verdurand's radiation diagram does not therefore apply.

The Loth electromagnetic system for the blind landing of aeroplanes in fog or darkness was then discussed. Verdurand suggested that the guiding zones were not precisely defined except dangerously near to the wires, and that the pilot had only a short time in which to interpret the signals.

Blancard refuted this; as regards the danger in having wires suspended round the aerodrome, a method had been developed in which the transmitting wires were completely undergound, and which not only defined the shape and position of the aerodrome but also indicated one or more levels of height.

Finally, the Marrec filter was outlined. The principle consists in equalising the intensities of the signal and the interference so that after selective resonance the latter will not be troublesome. A triode with a vertical characteristic is used, the aerial circuit being inserted between filament and grid, and the resonance circuit between filament and plate.

Direct Reading Radio Compass for Aircraft.—Gerhard Fisher and G. Kruesi. (*Electronics*, June, 1931, p. 685.)

"Two comparatively strong signals are received which are matched against each other in a specially designed tube circuit. Depending on their individual values, they influence an indicator which is installed on the instrument board in front of the pilot . . ."

A Note on Polarisation Error in Direction Finding [Long Waves].—Namba. (*See* abstract under "Propagation of Waves.")

Polarisation of High-Frequency Waves and Their Direction Finding.—Namba, Iso and Ueno. (*See* under "Propagation of Waves.")

The Practical Correction of a Wireless Direction-Finder for Deviations Due to the Metal Work of a Ship.—C. E. Horton. (*Journ. I.E.E.*, May, 1931, Vol. 69, pp. 623–636.)

The full paper, with Discussion, a long summary of which was dealt with in June Abstracts, p. 328.

The Effective Height of Closed [Loop] Aerials.—Bashenoff and Mjasoedoff. (*See* under "Aerials and Aerial Systems.")

Photoelectric Receiver and Neon Beacon for Fog Landing.—General Electric Company, (*Electronics*, June, 1931, p. 695.)

Picture only. *Cf.* July Abstracts, p. 388.

Prevention of Collision between Aircraft.—Bureau of Standards. (*See* under "Miscellaneous.")

Indicator for Visual Type Beacon.—Bureau of Standards. (*Ibid.*)

ACOUSTICS AND AUDIO-FREQUENCIES.

Measurement of the Accession to Inertia of a Vibrating Diaphragm [Application to Loud-Speaker Action].—N. W. McLachlan. (*Phil. Mag.*, June, 1931, Series 7, Vol. 11, No. 74, pp. 1137–1152.)

Author's abstract :—The paper is concerned with methods of measuring the accession to inertia of vibrating diaphragms.

Five methods are described, each necessitating the measurement of the inductance of a coil situated in a magnetic field. The diaphragm is driven by virtue of the reaction between this field and that of an alternating current in the coil. The inductance is measured with the coil fixed (L_0) and free to move in air (L_1) and *in vacuo* (L_v). In the free condition the value of inductance depends upon the effective mass of the moving system. Knowing L_0, L_1, L_v, and m, the natural mass of the system, the accession to inertia M can be calculated. The results obtained for a conical diaphragm are in good agreement with those computed from Rayleigh's formula for a rigid disk. It is shown that with a limited size of baffle the accession to inertia decreases with the frequency. Numerous precautions to attain experimental accuracy are given, and experiments showing the necessity for the diaphragm to move as a whole are quoted.

On the Amplitude of Driven Loud Speaker Cones.—Strutt: McLachlan: Warren. (*E.W. & W.E.*, June, 1931, Vol. 8, pp. 312–314.)

Correspondence on Strutt's paper dealt with in July Abstracts, p. 388. McLachlan compares the method and results with those of Sowter and himself (Abstracts, March, p. 158; July, p. 389; and elsewhere) and contests the statement that radial modes should have no effect on the emission of sound provided that the wavelength is many times the diaphragm radius. Warren remarks that "the use of Bragg's method for other than a rigid body appears so daring that further details of the method by which it was successfully accomplished would be of value," and goes on to show by calculation the seriousness of one difficulty which he has in mind.

Some Measurements on a Loud-Speaker *In Vacuo*.—P. K. Turner. (*Journ. I.E.E.*, May, 1931, Vol. 69, pp. 591–622.)

The full paper, with Discussion, summaries of which have been dealt with previously (May Abstracts, p. 273.)

A Loud Speaker Good for Twelve Thousand Cycles.—L. G. Bostwick. (*Bell Lab. Record*, May, 1931, Vol. 9, No. 9, pp. 433–436.)

From about 3,000 c.p.s. To cover the whole scale, this moving coil loud speaker (which has a small horn) is suspended in the mouth of the horn of a loud speaker designed for the low frequency range, the two instruments being connected to the electrical input through a simple network which delivers most of the power above 3,000 cycles to the small loud speaker and most of that below 3,000 to the big loud speaker.

Free Field Current.—F. H. Haynes. (*Wireless World*, 15th July, 1931, Vol. 29, pp. 54–57.)

A less expensive alternative to the use of the permanent magnet for the loud speaker field is a small electro-magnet with a winding forming part of the smoothing or grid-biasing circuits. A voltage loss is inevitable in a smoothing choke and deliberate in the biasing circuit of an all-mains set. As a loud speaker field winding possesses both resistance and considerable inductance it can replace either biasing resistance, smoothing choke, or both, and the watts that would thus be normally thrown away may be used to energise the magnet. In addition to giving circuit arrangements for free field excitation, the article gives reference data for the automatic grid biasing of output valves.

SOUND FILM DEVELOPMENTS.—T. Thorne Baker. (*Electrical Review*, 24th April, 1931, Vol. 108, p. 732.)

A review of recent progress in sound film production, and some side developments. The tendency is towards wider films on which both sound and picture can be recorded. A portable sound film camera is described in which the sound equipment is fixed on top of the camera and portability is mainly secured by the use of a special small type of mirror galvanometer which throws the varying light beam on to a narrow film track in the form of a band of light of varying width. Improvements in the silent running of cameras are indicated.

The Vitaphone Corporation has designed a portable apparatus for detecting the acoustical defects of theatres by oscillograph records, which are developed on the spot, and R.C.A. Victor Company has carried out new work on the mixing of microphone outputs.

A method has been recently patented by G. Seeber for "incorporating a magnetic alloy of nickel, cobalt and iron divided into colloidal particles in the celluloid 'kine-film' base. The amplified currents of the microphone will impress such a magnetically susceptible base with a permanent 'strain' which, on the subsequent passing of the film between the poles of a sensitive telephone, will reproduce the original sounds." This is an elaboration of the Poulsen magnetised-wire and of the Stille recorders now being used by the B.B.C. (1930 Abstracts, p. 457).

The process of Sémat and Champillon for "transmitting electrically a motion picture film complete with sound record" is also referred to.

SOUND RECORDING ON FILM INCORPORATING COLLOIDAL MAGNETIC PARTICLES.—Seeber. (*See* preceding abstract.)

SOUND PICTURES: FUNDAMENTAL PRINCIPLES AND FACTORS WHICH AFFECT QUALITY.—F. L. Hunt. (*Journ. Acous. Soc. Am.*, April, 1931, Vol. 2, pp. 476–484: *Bell Tel. Sys. Reprint*, Monog. B. 564, 9 pp.)

A TYPE OF ACOUSTIC DISTORTION IN THE TAKING OF SOUND FILMS.—R. L. Hanson. (*Journ. Soc. Motion Pic. Eng.*, Oct., 1930, Vol. 15, pp. 460–470: *Bell Tel. Sys. Reprint*, Monog. B. 517.)

Interference by reflection from a wall, or even from a piece of furniture such as a table, can produce an appreciable distortion and must be avoided in placing the microphone.

PHOTOTUBE CIRCUIT DESIGN FOR SOUND-PICTURES.—C. A. Wyeth. (*Electronics*, July, 1931, pp. 22–23 and 44.)

GLOW LAMP SOUND-ON-FILM RECORDING.—V. T. Braman. (*Electronics*, June, 1931, pp. 679–681.)

RECENT EUROPEAN DEVELOPMENTS IN ELECTRONIC MUSICAL INSTRUMENTS.—R. Raven-Hart: Trautwein. (*Electronics*, July, 1931, pp. 18–19 and 42.)

Devoted chiefly to the "Trautonium" and the "tone-former" theory (Feb. Abstracts, p. 101). In connection with the latter, it is suggested that the resonance peaks in loud speakers are in reality not offensive *as such* (the ear hearing logarithmically) but by acting as tone-formers and giving false qualities; and that the striking distortion which occurs when a gramophone record is run at an incorrect speed is due to the change in pitch of the tone-formers. A bibliography of twelve items is given.

A DISTORTIONLESS VOLUME CONTROL. (*Zeitschr. f. hochf. Tech.*, June, 1931, Vol. 37, p. 238.)

Illustrated description of the "Preferato" Control in which a potentiometer is combined with a series resistance in order to avoid the effect on the damping of the input l.f. circuit produced by either separately—an effect which spoils the frequency characteristic of the amplifier.

A LABORATORY [AUDIO-FREQUENCY] OSCILLATOR FOR RECEIVER TESTING.—C. J. Franks. (*Electronics*, June, 1931, pp. 668–670.)

The standard model is provided with 11 frequencies from 40 to 700 c.p.s., the adjustment being performed with a single control provided with a click system so that the correct point is apparent to the sense of touch. Power output available is always greater than half a watt (about 3 % total harmonics): the oscillator will maintain a voltage of 80 v. across a load of 10,000 ohms. Output can be adjusted with great accuracy. One valve acts as oscillator (Hartley circuit), two others in push-pull as amplifiers.

A DIRECT READING AUDIO-FREQUENCY PHASE METER [USING A C.-R. OSCILLOGRAPH].—W. R. MacLean and L. J. Sivian. (*Journ. Acous. Soc. Am.*, April, 1931, Vol. 2, pp. 419–433: *Bell Tel. Syst. Reprint*, Monog. B. 566, 15 pp.)

LE FILTRE D'AMPLITUDES, DISPOSITIF POUR EFFECTUER LES STATISTIQUES CONCERNANT LES AMPLITUDES DES GRANDEURS À VARIATIONS IRRÉGULIÈRES (The Amplitude Filter, an Appliance for obtaining Amplitude Statistics of Irregular Processes).—H. G. Baerwald. (*Ann. des P.T.T.*, June, 1931, Vol. 20, pp. 493–507.)

French version of the German paper dealt with in Jan. Abstracts, p. 44.

GERÄUSCHVERHÜTUNG AN LUFTBEWEGENDEN MASCHINEN (Noise [Analysis and] Prevention in Air-disturbing Machinery).—R. G. Berthold. (*Siemens-Zeitschr.*, No. 2, Vol. 11, 1931, pp. 90–95.)

A NEW USE FOR "TALKIES" [CATHODE-RAY OSCILLOSCOPE AND MICROPHONE FOR LANGUAGE TEACHING].—Westinghouse Electric Co. (*Electrician*, 19th June, 1931, Vol. 106, p. 917.)

SUPPRESSION OF NOISE. (*Electrical World*, 20th June, 1931, Vol. 97, pp. 1171–1172.)

Summary of an Am. I.E.E. meeting held to discuss noise mitigation. The discussion seemed to favour the adoption of the decibel scale, and of some appropriate pressure (*e.g.* .001 dynes/sq. cm.) as representing the arbitrary threshold value of noise for the average ear at 1,000 cycles/sec. Various meters for measurement of sounds and noises were described and demonstrated; prevention of noise by insulation and isolation of machinery was discussed.

CHART OF SOUND FREQUENCIES.—(*Electronics*, June, 1931, p. 677.)

Including frequencies of string and wind instruments, television wire circuit (20–18,000), wire lines for broadcasting (highest class 50–8,000, ordinary 50–5,000), modern broadcasting transmitter (30–7,500), broadcasting station transmitting chain programme (90–5,000), m.c. loud speaker (40–5,500), highest type electrical transcriptions for radio—"hill and dale" cut (30–10,000), modern electrically-recorded home phonograph (60–5,000), etc., etc.

SUR LA TRADUCTION DES INTENSITÉS LUMINEUSES EN INTENSITÉS SONORES (The Translation of Luminous Intensities into Sound Intensities [for the Blind]).—G. Fournier: Auger. (*Comptes Rendus*, 15th June, 1931, Vol. 192, pp. 1547–1548.)

The Auger copper-oxide photoelectric cell is robust and so sensitive that it can actuate a telephone receiver without the use of amplifiers; for a potential of a fraction of a volt it gives a current proportional to the illumination and exceeding 0.6 mA. for an active surface less than 3 cm.^{2} in full sunlight. The writer describes how such a cell, combined with a "ticker" arrangement and telephones, has enabled a war-blinded man to detect the direction of the windows of a room, the position on a table of a piece of white paper, etc. The writer and Auger are working at an apparatus with colour filters for the analysis of colours by the blind, and also on another apparatus to enable the blind to "read" ordinarily printed pictures and text [presumably somewhat on the lines of the Fournier d'Albe "Optophone"].

THE VARIATION OF MAGNIFICATION WITH PITCH IN RESISTANCE-CAPACITY COUPLED AMPLIFIERS.—W. A. Barclay. (*E.W. & W.E.*, July, 1931, Vol. 8, pp. 362–369.)

". . . there is a certain middle frequency at which the amplification obtainable is optimum; on either side of this frequency the note-losses progessively increase. To show that this 'middle' frequency is readily calculable, and that the losses entailed on other frequencies no less easily ascertainable, is one of the chief objectives of this article." The treatment derives from the analysis given by Hartshorn (*ibid.*, Aug., 1928), uses the alignment principle, and includes sections on the effect upon the response curve of altering the amplifier constants—grid leak and condenser, anode resistance, and stray capacity.

PERCENTAGE HARMONIC DISTORTION.—M. G. Scroggie: G.W.O.H. (*E.W. & W.E.*, July, 1931, Vol. 8, pp. 372: 347–348.)

A letter maintaining that the usual formula for estimating the second harmonic distortion from the characteristic curve of an output valve gives results only half as great as those given by what the writer considers the correct formula. The editorial points out that the usual formula is correct.

THE "PARAFEED" TRANSFORMER, AN INTERESTING DEVELOPMENT IN TRANSFORMER DESIGN.—(*Electrician*, 12th June, 1931, Vol. 106, p. 859.)

The core has a much higher percentage of nickel than has been previously employed, and a correspondingly higher permeability; the core area and weight of copper are both reduced. Test curves show that the amplification is practically constant over a frequency range of 25–8,000 cycles, with a rising characteristic at the upper end of the scale.

MAKING THE MOST OF THE L.F. TRANSFORMER.—W. A. Barclay. (*Wireless World*, 8th and 15th July, 1931, Vol. 29, pp. 30–33 and 72–74.)

"The performance of the coupling unit as a whole depends as much upon the amplifying valve as upon the transformer, and it is impossible to study the action of the two apart." Two alignment charts are given which illustrate usefully the effect of each of these factors upon the total magnification realised by the stage. The first chart—an example of "four variable" alignment—deals with an "ideal" transformer: the second takes "practical politics" into account and includes the effect of primary no-load reactance.

THE DISTORTIONLESS AMPLIFICATION OF ELECTRICAL TRANSIENTS. PART II.—C. W. Oatley. (*E.W. & W.E.*, June, 1931, Vol. 8, pp. 307–309.)

The continuation referred to at the end of the previous abstract (August, pp. 442–443). Only resistance-coupled amplifiers are considered.

BEMERKUNGEN ZUR THEORIE DER GÜNSTIGSTEN NACHHALLDAUER VON RÄUMEN (Remarks on the Theory of the Optimum Reverberation Time for Rooms).—G. v. Békésy. (*Ann. der Physik*, No. 7, Vol. 8, Series 5, 1931 pp. 851–873.)

THE MEASUREMENT OF THE COEFFICIENTS OF SOUND INSULATION OF BUILDING MATERIALS.—R. Moens. (*Génie Civil*, 23rd May, 1931, Vol. 98, pp. 526–527.)

MEASUREMENTS ON THE ACOUSTIC EFFICIENCY OF SPECIALLY DESIGNED SOUND REFLECTORS.—A. D. Fokker and M. J. O. Strutt. (Summary in *Physik. Ber.*, 15th May, 1931, Vol. 12, p. 1068.)

ACOUSTIC DELAY CIRCUITS.—W. P. Mason. (*Bell Lab. Record*, May, 1931, Vol. 9, No. 9, pp. 430–432.)

THEORIE DES LAUTSTÄRKENABGLEICHES UND DER GÜNSTIGSTEN EMPFÄNGERANPASSUNG BEI VERZÖGERUNGSKETTEN (The Theory of Volume Equalisation and Optimum Matching of Receivers on a Delay Network).—F. A. Fischer. (*Zeitschr. f. tech. Phys.*, June, 1931, Vol. 12, pp. 292–298.)

FORTSCHRITTE DER AKUSTIK UNTER BESONDERER BERÜCKSICHTIGUNG DER ARBEITEN DER ANGEWANDTEN AKUSTIK (Recent Developments in Acoustics, particularly Applied Acoustics).—F. Trendelenburg. (*Zeitschr. f. hochf. Tech.*, March and June, 1931, Vol. 37, pp. 105–112 and 235–237.)

First two parts of a comprehensive survey. The March instalment deals with methods of measurement, including sound analysis; compensation methods for the exact amplitude and phase determination of periodic pressure variations; measurement of sound field strengths, of the output of a sound generator, and of the acoustics of rooms. The June instalment deals with sound receivers (condenser microphones, band microphones, Reiss microphone, and the Cathodophon); the field distortion due to the receiver itself; and the work of Obata and Yosida on the directional receiving properties of the condenser microphone with a horn or at the focus of a concave mirror.

VITESSE DE PROPAGATION DES ONDES AÉRIENNES ULTRA-SONORES (Velocity of Propagation of Ultrasonic Waves in Air).—P. Tcheng Kao. (*Comptes Rendus*, 6th July, 1931, Vol. 193, pp. 21–22.)

Certain apparent anomalies found by other workers are discussed: the writer's work is stated to account for them, and the velocity is given as 331.85 m./sec. for frequencies from 40 thousand to one million cycles per second, with an accuracy of at least 1 in a thousand. No dispersion was found.

VELOCITY OF SOUND IN TUBES: ULTRASONIC METHOD.—G. S. Field. (*Nature*, 18th July, 1931, Vol. 128, p. 117.)

A preliminary account of results of theoretical and experimental investigations on the velocity of ultrasonic waves in liquids contained in tubes. A frequency/velocity curve is given which shows that for a range of frequencies just above the absorbing frequency the velocity tends to have two different values, one high and the other low.

NOTES ON THE EFFECT OF DISTANCE FROM THE SOURCE ON THE VELOCITY OF SOUND AT ULTRASONIC FREQUENCIES.—C. D. Reid. (*Phys. Review*, 1st May, 1931, Series 2, Vol. 37, pp. 1147–1148.)

A CONCAVE ULTRASONIC DIFFRACTION GRATING.—G. E. Thompson.—(*Review Scient. Instr.*, June, 1931, Vol. 2, pp. 332–335.)

For measuring ultrasonic wavelengths between one and three millimetres. The results agree quite well with those obtained by the Pierce interferometer.

EINIGE VERSUCHE MIT ULTRASCHALL (Some Experiments with Ultrasonic Waves).—H. Straubel. (*Physik. Zeitschr.*, 1st May, 1931, Vol. 32, pp. 379–381.)

The ultrasonic waves used in these experiments for demonstration of interference phenomena were generated by the free end of an oscillating quartz crystal and made visible by means of lycopodium powder.

THE METHOD OF FORMATION OF SAND FIGURES ON A VIBRATING PLATE.—E. N. da C. Andrade and D. H. Smith. (*Proc. Phys. Soc.*, 1st July, 1931, Vol. 43, Part 4, pp. 405–411.)

As regards loud-speaker testing this paper is of interest in connection with Bragg's method of measuring small amplitudes (*see* 1929 Abstracts, p. 519, and Strutt, July Abstracts, p. 388).

EDGE TONES [FROM A JET OF FLUID].—E. G. Richardson. (*Proc. Phys. Soc.*, 1st July, 1931, Vol. 43, Part 4, pp. 394–404.)

THE FORMATION OF STRIAE IN A KUNDT'S TUBE.—R. V. Cook. (*Phys. Review*, 1st May, 1931, Series 2, Vol. 37, pp. 1189–1190.)

AN EXPERIMENTAL STUDY OF KUNDT'S TUBE DUST FIGURES.—E. Hutchisson and F. B. Morgan. (*Phys. Review*, 1st May, 1931, Series 2, Vol. 37, pp. 1155–1163.)

GERÄUSCH UND LÄRM (Noise and Hubbub).—K. W. Wagner. (*Sitzungsber. preuss. Akad. der Wissenschaften, phys.-math. Klasse*, 1931, No. 9.)

A general account of the effect of loud, continuous noise on those subjected to it and of the different kinds of noise and their intensity, with a calculation of the sound isolating properties of a partition wall from its mass and elastic properties.

PHOTOTELEGRAPHY AND TELEVISION.

LE SECRET DES TRANSMISSIONS TÉLÉGRAPHIQUES ET RADIOTÉLÉGRAPHIQUES (Secrecy in [Facsimile] Telegraphic and Radiotelegraphic Transmissions).—E. Belin. (*Comptes Rendus*, 6th July, 1931, Vol. 193, pp. 25–27.)

"Secrecy . . . can easily be assured if the messages are transmitted in their original form (telephotography and teleautography)." The writer considers two methods: (i) in which 3 successive operations are needed, the first of which is that a ciphering machine transforms the original document into a meaningless version, which is then transmitted by any ordinary facsimile process, received in the meaningless form, and then re-composed by a corresponding deciphering machine; and (ii) in which only one operation is necessary, a special ciphering form of facsimile transmitter (which, by a simple setting of an adjustment, can function for ordinary facsimile work) being employed at one end and a corresponding deciphering receiver at the other.

The rest of the Note deals with this second method. For complete secrecy it is essential that there should be no control transmission between the two ends, and that it should be impossible for a listener to detect, by *any* means, a periodicity in the succession of mechanical actions. Thus provision is made of a "dummy" document (preferably written by the same hand) which is automatically transmitted during the intermittent periods of silence, and which in this way makes the transmission appear continuous to the "spying" station. The ciphering and deciphering is accomplished by means of an electromagnetic clutch. In order to prevent the re-composition of the meaningless received document either by receiving it on an endless band which is then cut in parts equal to the cylinder circumference and adjusted, or by the use of a number of receivers, the two cylinders (transmitter and receiver) are given a varying speed, the variations *not* necessarily beginning at the commencement of a turn.

Marconi Portable Picture Apparatus.—(*Marconi Review*, May-June, 1931, No. 30, pp. 13–22.)

For the transmission and reception of rough sketches, maps, weather charts, etc., "from the air to ground or between two ground stations." Among the special requirements which the apparatus fulfils are the following:—(*a*) The transmitting operator must be able to make a rough sketch, etc., and transmit it straight away without delay or preparation: he uses a fountain pen containing a graphite solution which impregnates and renders conductive a thin tissue coating a very thin metallic foil with a stout paper backing: or an alternative type of "form," rendered conductive by marking with an ordinary pencil, can be used. The useful area is nearly 9.4 × 5 inches. (*b*) The scanning time must not be greater than 5 minutes. (*c*) At the receiving end it should be possible to observe the picture continuously as it is received, so that the cylinder must not revolve and the record must be immediately visible without any processing: in both transmitter and receiver it is the stylus (in the form of a ribbon of equal width to the picture mesh, fed out of its housing as required to compensate for wear) which revolves: the recording is by the ferricyanide method. (*d*) Synchronism must be independent of any transmitted signal, so that jamming does not upset it: a tuning fork is used at the transmitter, and a 1000-cycle oscillator, adjustable, at the receiver. It is possible to remove and replace the cylinders without stopping the scanning mechanism with consequent loss of phasing and synchronism.

Fernsehen mit Kathodenstrahlen (Cathode Ray Television [particularly the Farnsworth System]).—H. Günther: P. T. Farnsworth. (*Rad., B., F. f. Alle*, July, 1931, pp. 298–304.)

After dealing with the original Campbell Swinton system and (very briefly) with Zworykin's developments, the writer gives a good outline of the Farnsworth apparatus. He refers to Farnsworth's recent announcement of a "picture compressor" which is said to reduce the previously necessary 300 kilocycles (minimum) to 7 kilocycles: "how this 'compressor' functions is not yet known." It is said that towards the end of 1931 the receiving apparatus will be on the market at about 250–300 dollars. "Experts who have seen tests of the Farnsworth apparatus state that it gives better pictures than the hitherto best system—the two-way Bell Telephone Company's system." The paper ends with a reference to von Ardenne's latest work.

The Sanabria System of Television.—Sanabria: Taylor. (*Electronics*, July, 1931, p. 7.)

In an article "Technical Trends Seen at RMA Trade Show," favourable mention is made of this system, which is "marked by intense illumination (due to the Taylor lamp) over a six-foot screen." No description is given: a paragraph in the *Daily Mail* mentions that the good performance of the neon lamp depends on the temperature of the gas being raised by a heater.

Technical Problems in Connection with Television.—I.E.E. Wireless Section Discussion. (*E.W. & W.E.*, June, 1931, Vol. 8, pp. 310–311.)

Die Abbildung beim Fernsehen (Image Synthesis in Television [Suggested Cyclical Line-Shift Method]).—E. Hudec. (*E.N.T.*, June, 1931, Vol. 8, pp. 229–245.)

(1) The re-composed image in a television receiver is compared with the "grid" into which the original is converted by line scanning: definition of "element" and formulation of its area ($s = \frac{Sp}{2f}$, where p is the framing frequency—*e.g.*, 12.5 pictures per sec.—and f the modulation frequency—*e.g.*, 7500 c.p.s.): a *stationary* picture of 3000 elements is barely recognisable, but a television image of even fewer elements is distinctly better, partly on physiological grounds (Roessler, 1930 Abstracts, p. 164) and partly because the synthesis takes place in a different fashion, as has been pointed out by Kirschstein, who has described a method by which the image as it would be seen by television may easily be produced experimentally: defects of ordinary line scanning—Figs. 2*a* and *b* show how two parallel lines are differently re-composed *because of the difference of their positions relative to the mesh.*

(2) Derivation of formulae for the image synthesis in a receiver.—(*a*) in the ordinary process where the lines are not displaced in the direction of their width, including Thun's proposed method of constant light strength and varying speed. Equations for the brightness along each line are obtained (7*a* and 7*b*) and show that in this direction the

reproduction of light values is quite good. It is in the other direction (at right angles to the length of the lines) that conditions are unfavourable. The sudden jump from line to line has a bad effect, which is illustrated by the unnatural, sharp-cornered rendering of a straight sloping line in Fig. 16*a* on page 240. *Such defects can be avoided if the movement in this direction is gradual and continuous, as is the motion along the lines (giving equation* 8 *and Fig.* 16*b*).

(2*b*) This result can be approximated to in practice by shifting the position of the lines in the direction of their width in successive pictures; *e.g.*, by shifting the whole system of lines by one-third of the line-width after each picture, in such a way that the lines regain their position relative to the picture after the formation of three pictures (Fig. 5). Assuming that the eye integrates over ⅑ sec., a particularly favourable arrangement for a framing frequency of 20 per sec. would be a displacement equal to half the line width. The practical methods for obtaining such a process of line shifting are discussed in (7) for scanning-disc and cathode-ray systems. In connection with the latter the process is stated to have special importance in combating disfiguring streaks due to the fluorescent spot not being of square form.

In sections (3) to (5) the writer examines mathematically the recomposition of various figures, *e.g.*, very bright or dark figures smaller than element, large figures, strips in various directions, etc.; results for the fixed-line and the line-shifting systems are compared. Section (6) deals with the shape and size of the aperture, hitherto assumed equal in size to the picture element. A diminution of size has both advantages and disadvantages: in any case it is found desirable that the dimensions in the two directions should be equal.

RADIAL SYSTEM OF SCANNING.—(French Pat. 700088, pub. 24th February, 1931, Cie Thomson-Houston.)

For a long summary of this patent see *Rev. Gén. de l'Élec.*, 30th May, 1931, Vol. 29, pp. 195-196D. This is another system by which greatest detail is obtained at the middle of the picture (*cf.* Codelli, March Abstracts, p. 160, and Harries, same page).

THE CONDUCTION OF LIGHT AND X-RAYS THROUGH TUBES.—Jentzsch and Nähring. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 12, 1931, pp. 185–189.)

TELEVISION ON ULTRA-SHORT WAVES: MINIMUM DECREMENT ALLOWABLE IN RECEPTION.—F. Schröter. (*Rad., B., F.f. Alle*, July, 1931, pp. 291–292.)

In a recent lecture by Schröter (*ibid.*, p. 330), it is stated that his calculations show that for reasonably sharp contours (5,000–10,000 elements) even with waves shorter than 10 metres the least logarithmic decrement allowable is 0.01. This—in view of the high absorption in the buildings of a city—implies the need for several kilowatts' power at the transmitter.

DOUBLE MODULATION OF HIGH-FREQUENCY GENERATORS: A THEORETICAL SUGGESTION FOR TRANSMITTING SIMULTANEOUSLY SOUND AND VISION WITH ONE CARRIER WAVE.—H. Peters and H. Biskamp. (*Television*, May and July, 1931, Vol. 4, pp. 109–111 and 174–175.)

"Summarising . . . for sound the usual type of modulation is employed, but there is a refinement in that the amplitude modulated carrier wave is utilised to propagate sound and also synchronising signals. Secondly, by means of frequency modulation it is possible to transmit the picture on the same carrier wave." A possible scheme of connections for the frequency-modulation receiver is shown (Br. patent 291740).

EXPERIMENTS ON TIME-LAG IN GAS-FILLED PHOTOELECTRIC CELLS.—E. L. E. Wheatcroft. (*Phil. Mag.*, July, 1931, Series 7, Vol. 12, No. 75, pp. 162–173.)

Experiments are described which confirm an oscillogram published by Campbell and Stoodley ("Time-Lag in Gas-filled Cells," June Abstracts, p. 332) and establish, within limits, certain simple differential equations as representing the behaviour of the cell.

PHOTOCELL THEORY AND PRACTICE.—V. K. Zworykin. (*Journ. Franklin Inst.*, July, 1931, Vol. 212, No. 1, pp. 1–41.)

A general account of the development and uses of photocells; the history of the photoelectric effect, the methods of preparation of the photocell and of photo-conductive and photovoltaic cells, and various applications of the photocell, are all discussed, reference being made, amongst other things, to the production of audible motion pictures, the transmission of pictures and television.

THE PHOTO CELL.—H. R. Ruff. (*Wireless World*, 1st and 8th July, 1931, Vol. 29, pp. 2–4 and 39–42.)

A description of its properties and construction. For the construction of photoelectric cells sensitive to visible light with cathodes of pure metal, the choice is limited to the alkali metals, lithium, sodium, potassium, rubidium, and calcium, together with the alkaline earth metals, barium and strontium. A number of curves are given showing the relative emission from the cathodes for equal energy of light of different wavelengths.

LATEST FORMS OF PHOTO-ELECTRIC CELLS.—F. Schröter. (*Television*, July, 1931, Vol. 4, pp. 177–179.)

First instalment.

LICHTELEKTRISCHE ZELLEN UND IHRE ANWENDUNGEN (Photoelectric Cells and Their Use).—H. Simon and W. Kluge. (*AEG-Mitteil.*, No. 3, 1931, pp. 190–195.)

PHOTO CELLS AND THYRATRONS.—L. J. Davies. (*Electrician*, 26th June, 1931, Vol. 106, pp. 936–938.)

PHOTOTUBE CIRCUIT DESIGN FOR SOUND-PICTURES.—C. A. Wyeth. (*Electronics*, July, 1931, pp. 22–23 and 44.)

THE USE OF THE COPPER-OXIDE PHOTOELECTRIC CELL FOR THE TRANSLATION OF LIGHT INTO SOUND FOR THE BLIND.—Fournier: Auger. (*See* abstract under "Acoustics.")

THE PHOTOELECTRIC EMISSION OF THIN FILMS.—N. R. Campbell. (*Phil. Mag.*, July, 1931, Series 7, Vol. 12, No. 75, pp. 173–185.)

Author's summary:—The thin films studied are those found by heating oxidized silver (and some other metals) in caesium vapour. Apparatus is described for the gradual introduction of known quantities of caesium into the cell. The changes in the emission during such introduction are described. They indicate that the caesium undergoes a chemical reaction with the oxidized silver and that the final cathode is a thin film of caesium on the products of the reaction. From the ratio of oxygen absorbed to caesium reacting with it, it is concluded that the reaction is, as might be expected, $2Cs + Ag_2O = Cs_2O + 2Ag$. It is impossible, however, that the support for the thin film should be simply a mixture of Cs_2O and Ag, for the cathode does not resemble thin films deposited on either of these substances in the absence of the other. Evidence is presented that excess of Cs may alloy with the Ag and thus bring about the production of a substance in which Cs_2O and Ag are intermingled on the molecular scale. This substance is sometimes, if not always, the support of the thin caesium film. Measurements of the thermionic emission indicate that cathodes of this nature have nearly all the same b but widely different A [Richardson formula]. Those with the highest A (and therefore the largest photoelectric emission) have in general the lowest mean photoelectric emission. This result is consistent with Fowler's theory of selective emission. The value of b determined thermionically does not accord with the photoelectric threshold.

THERMIONIC EMISSION IN CAESIUM-OXIDE PHOTOCELLS AT ROOM TEMPERATURES.—E. F. Kingsbury and G. R. Stilwell. (*Phys. Review*, 1st June, 1931, Series 2, Vol. 37, No. 11, pp. 1549–1550.)

A letter giving measurements of a large, unidirectional leakage of thermionic origin occurring in total darkness in some caesium oxide on silver photoelectric cells.

ÜBER DIE NEGATIVE WIRKUNG BEI INNEREM PHOTOEFFEKT AM BROMSILBER (The Negative Action in the Internal Photoelectric Effect on Silver Bromide).—E. A. Kirillow. (*Zeitschr. f. wiss. Photogr.*, No. 12, Vol. 28, 1931, pp. 367–373.)

The negative effect first found by Ries in selenium (decrease of conductivity on illumination) is considered in connection with the writer's earlier results with silver bromide: as a result, these are attributed to a true decrease in conductivity, probably due to an impoverishment in ions (formation of neutral *Ag-Br* molecules).

RICHTUNGSVERTEILUNG DER VON POLARISIERTEM LICHT IM KALIUMDAMPF AUSGELÖSTEN ELEKTRONEN (Directional Distribution of the Electrons Emitted from Potassium Vapour under the Action of Polarised Light).—A. Kraus. (*Naturwiss.*, 10th July, 1931, Vol. 19, No. 28, pp. 617–618.)

ÜBER DEN SPERRSCHICHT-PHOTOEFFEKT DER RÖNTGENSTRAHLUNG — VORLÄUFIGE MITTEILUNG (On the Attenuating Layer Photoelectric Effect of X-Radiation—Preliminary Communication).—B. Lange and P. Selényi. (*Naturwiss.*, 17th July, 1931, Vol. 19, No. 29, p. 639.)

An attenuating-layer photoelectric effect of X-radiation has been found in copper oxide photoelectric cells and also in the attenuating photoelectric cell developed by B. Lange, whose light-sensitive material consists mainly of selenium.

NEBENERSCHEINUNGEN BEI DER ELEKTROLYSE VON NATRIUM DURCH GLAS (Secondary Effects in the Electrolysis of Sodium through Glass).—J. H. de Boer and W. de Groot. (*Zeitschr. f. tech. Phys.*, June, 1931, Vol. 12, pp. 303–305.)

The presence of a layer of salt in the electrolysis of sodium through glass may give rise to certain streaky shadows which are formed by the electron rays leaving the cathode and consist of adsorbed sodium. The sodium may even cross the bulb and cause streaks on the opposite wall. The shadows observed by Márton and Rostás (1929 Abstracts, p. 277) under different conditions (in the absence of adsorbed layers) are also to be attributed to positive ions formed in the neighbourhood of the negative filament. The "catching-up" of positive sodium ions in an electron beam by Henriot, Goche and Dony-Hénault is referred to (June Abstracts, p. 341.)

NEON TUBES: PHOTOELECTRIC EFFECT. EXTINGUISHING VOLTAGE, ETC.—Ryall. (*See* abstract under "Measurements and Standards.")

TAYLOR NEON LAMP IN SANABRIA SYSTEM OF TELEVISION. (*See* fourth abstract in this Section.)

ÜBER DIE TEMPERATURABHÄNGIGKEIT DER ELEKTRISCHEN DOPPELBRECHUNG IN ORGANISCHEN FLÜSSIGKEITEN (The Variation with Temperature of the Electrical Double Refraction in Organic Liquids).—A. Kürten. (*Physik. Zeitschr.*, 15th March, 1931, Vol. 32, pp. 251–252.)

A new method of measuring the Kerr effect is described: the polarised ray passes through two similar cells one after the other; the planes of the electric fields are at right angles. Both cells are filled with the liquid under test, one being subjected to temperature change. The potential across this cell is adjusted at each temperature till the ray is again obscured, the Kerr constant being inversely proportional to the square of the necessary potential.

MEASUREMENTS AND STANDARDS.

BERECHNUNG DER IMPEDANZ ZYLINDRISCHER LEITER VON BELIEBIGER QUERSCHNITTFORM (Calculation of the Impedance of Cylindrical Conductors of Any Shape of Cross Section).—M. J. O. Strutt. (*E.N.T.*, June, 1931, Vol. 8, pp. 269–276.)

To determine the impedance it is necessary to know the current distribution. The calculation of this is easy in the two extreme cases—low and high frequency. The writer sets out to extend the results of Kelvin and Rayleigh in such a way as to link up these two extremes, so that the impedance of a cylindrical conductor may be calculated within a small percentage for practically *any* frequency. He arrives at the following result (expressed in words) :—The ratio of the a.c. resistance to the d.c. resistance plotted as a function of $\sqrt{\omega}$ begins at unity, increases in proportion to ω^2 and then proceeds in a straight line with the equation $F\sqrt{\omega} + f$. The ratio of internal self-induction times angular frequency (reactance) to d.c. resistance plotted as a function of $\sqrt{\omega}$ begins at zero increases first in proportion to ω and then follows a straight line with the equation $F\sqrt{\omega} + g$.

These results are shown in Figs. 2 and 3. The straight portion of these curves corresponds to the general equation 8 in Section III, for any shape of cross section ; namely

$$Z = A\sqrt{\omega} + B + j(a\sqrt{\omega} + b),$$

and thus it is possible to obtain the value of impedance or reactance with only a small percentage error, provided $F\sqrt{\omega} + f > 1$; and with the help of the initial (ω^2) part of the curve the impedance for *any* frequency is covered. A comparison between the exactly calculated values (full lines) and those obtained by the above approximate method (broken lines) is shown in Fig. 7, which refers to a cylindrical conductor of circular section isolated far from its return lead. The paper ends with an application of the theory to two parallel cylindrical conductors of circular cross section, carrying equal currents in opposite directions. The ratio of impedance to d.c. resistance is given by equation 14 ; in this, the expression

$$\left[(1 + j) \cdot \tfrac{1}{2} \sqrt{\frac{2\omega}{R_0}} + \tfrac{1}{4} \right]$$

represents the dependence of the impedance on frequency : this factor can be applied unchanged to all cylinders of circular section, however many in parallel they may be and at whatever distances (not too small).

IL CONDENSATORE ELETTRICO FORMATO DA UN FILO RETTILINEO FRA DUE PIANI PARALLELI (The Electrical Condenser formed of a Straight Wire between Two Parallel Plates [Theoretical Investigation]).—A. Masotti. (*Lincei Rendic.*, No. 10, Vol. 12, Series 6, pp. 519–522.)

A CAPACITY, INDUCTANCE AND IMPEDANCE CONVERSION CHART.—H. W. Anderson. (*Rad. Engineering*, June, 1931, Vol. 11, p. 32.)

For example, to find the capacity necessary to resonate at 4,000 c.p.s. with 85 millihenries inductance, follow the 4,000 cycle line to where it intersects the 85 millihenry line : the corresponding capacity line indicates 0.02 microfarad. The chart covers 10–1,000 c.p.s., 5 mH.–200 H., and 0.005–10 μF.

DIE MESSUNG DES DÄMPFUNGSWIDERSTANDES VON HOCHFREQUENZSCHWINGUNGSKREISEN MIT HILFE DER DYNATRONSCHALTUNG (The Measurement of the Damping Resistance of High Frequency Oscillatory Circuits by the Use of the Dynatron Circuit).—H. Frühauf. (*Zeitschr. f. hochf. Tech.*, June, 1931, Vol. 37, pp. 229–234.)

The added resistance method and the resonance curve method both have their own disadvantages : the writer describes a method depending on the introduction of enough negative resistance (in the form of a dynatron circuit whose slope is varied by adjusting the negative bias of a second grid) to cause the setting-in of oscillation. *Cf.* Green, June Abstracts, p. 334 ; also Iinuma, 2 abstracts, same page.

THE CONSTRUCTION AND OPERATION OF A SIMPLE NEON-TUBE HIGH TENSION CREST VOLTMETER.—L. E. Ryall. (*Journ. I.E.E.*, July, 1931, Vol. 69, pp. 891–897 and 922–928.)

NOTE ON THE PIEZO-ELECTRIC QUARTZ OSCILLATING CRYSTAL REGARDED FROM THE PRINCIPLE OF SIMILITUDE.—I. Koga. (*Proc. Inst. Rad. Eng.*, June, 1931, Vol. 19, pp. 1022–1023.)

The principle that " if the configurations of the two homogeneous aeolotropic [subject to change of physical qualities on change of position] elastic bodies of a certain substance be geometrically similar when their crystallographic axes are faced in the same orientations, the ratio of the vibrating periods of the two bodies for a certain mode of vibration is equal to the ratio of their linear dimensions " is here applied to the case of X-waves in X-cut quartz plates. Thus if two X-cut crystals are similar in their geometrical configurations, the periods of X, Y and Z vibrations are all proportional to their linear dimensions. Practical applications of this fact are given.

BEMERKUNGEN ZU MEINER ARBEIT " DIE SCHWINGUNGEN DER QUARZLAMELLE " (Remarks on My Paper " The Oscillations of a Quartz Lamina ").—A. Lissütin. (*Zeitschr. f. Phys.*, 1931, Vol. 69, No. 11/12, pp. 850–852.)

Cf. 1930 Abstracts, p. 343. The theoretical investigation is here extended to laminae of various shapes.

FREQUENCY STABILISATION OF RADIO TRANSMITTERS.—Kusunose and Ishikawa. (*See* under " Transmission ".)

UN FRÉQUENCEMÈTRE À QUARTZ PIÉZOÉLECTRIQUE AVEC MODULATION SYNCHRONE (A Quartz-Controlled Frequency Meter with Synchronous Modulation).—B. Decaux. (*Comptes Rendus*, 29th June, 1931, Vol. 192, pp. 1713–1715.)

A little time ago the precision of laboratory measurements was no greater than 1 in 100 thousand ; this accuracy is now necessary in everyday transmissions. An accuracy of 1 in a million is therefore needed now in standard frequency meters, and as the greatest accuracy is required in the short-wave range (where tuning forks are difficult to use) recourse is made to quartz oscillators of fundamental frequency of the order of several hundred thousands per second. In a previous note (1929 Abstracts, p. 279) the writer has shown the necessity for artificially sub-dividing the intervals between successive harmonics of such oscillators (these harmonics being too far apart for accurate results from interpolation) and has described a method of subdivision consisting in modulating the oscillator by a current of lower adjustable frequency f, giving—in addition to the harmonics nF—currents of frequencies $nF \pm f$. The precision of these frequencies, however, depends on that of f, and in general decreases as f increases; moreover, it would be much more convenient to have at one's disposal simultaneously, without adjustment, the numerous frequencies $nF \pm pf$. The following method has therefore been evolved :—

The modulation frequency f, instead of being arbitrary, *bears a simple ratio to F, and the source of f is made rich in harmonics.* In these conditions the various resultant frequencies corresponding to the consecutive harmonics of F and f form a regular spectrum; thus if $F = 100{,}000$ and $f = \frac{F}{10}$, the frequencies obtained include 1,000,000, 1,010,000, 1,020,000, . . . 1,090,000, 1,100,000, 1,110,000, etc. The scheme has been carried out by using as modulator an Abraham-Bloch multivibrator Type B (plate-circuit resistances replaced by inductances) made adjustable by the addition of a variable condenser; this is synchronised on a sub-harmonic frequency by the quartz-controlled oscillator which it, in its turn, modulates. Synchronisation and modulation are effected simultaneously by one screen-grid valve; the screen grid is connected to one of the multivibrator anode circuits, the control grid is coupled to the oscillator, and the plate circuit goes to the output.

In this way the screen grid acts as an anode with regard to the control grid and synchronises the multivibrator, while at the same time it acts as a grid with regard to the anode and modulates the anode current.

The quartz-controlled frequency is compared, by de-multiplication, with an Observatory pendulum, with a relative accuracy of the order of one-millionth. Since the modulation is synchronised, all the frequencies are known with the same precision. It is easy to interpolate between two of them by a note-frequency frequency meter, particularly if the ratio $f : F$ is changed. The whole apparatus is readily transportable and forms a high-accuracy portable frequency meter: it can also be used as a heterodyne for the stable reception of signals, or (by separating and amplifying one frequency) as a transmitter with a large number of perfectly constant alternative wavelengths.

A Device for the Precise Measurement of High Frequencies.—F. A. Polkinghorn and A. A. Roetken: Farrington and Ports. (*Proc. Inst. Rad. Eng.*, June, 1931, Vol. 19, pp. 937–948.)

Authors' summary :—" A description is given of equipment which has been constructed for the measurement of radio frequencies between 5000 and 30,000 kc. The equipment consists of a million-cycle quartz-crystal oscillator as a standard of frequency, means for producing harmonics and subharmonics of this frequency, and means for combining voltages of these known frequencies with a voltage whose frequency it is desired to measure so as to produce beat frequencies in successive stages, the beat frequency produced in each stage having one less digit than that in the preceding stage. A calibrated electric oscillator is used to measure the frequency of the last stage. An indicator gives the frequency of the unknown after a series of dial adjustments. The precision of a completed measurement is estimated at better than three parts in a million."

The quartz-crystal oscillator working at 1 megacycle controls a multivibrator whose fundamental is 100,000 cycles. From this stage, frequencies of 500, 600 . . . 1000 kilocycles may be obtained. This multivibrator controls a 10,000-cycle multivibrator which in turn controls a 1000-cycle multivibrator. From each of these multivibrators the 5th, 6th . . . 10th harmonics are available. In addition, the 1-megacycle quartz oscillator supplies two harmonic generators (negative-bias generators using screen-grid valves) covering the ranges 5, 6, 7 . . . 10 and 10, 20 and 30 megacycles. For every multivibrator and harmonic generator there is a corresponding amplifier-detector whose function is to pick out the required known frequency and beat it with the signal (or beat frequency from the preceding stage) to produce a beat frequency which will be passed by the succeeding stage. Each amplifier-detector unit is equipped with an input filter so that only frequencies beginning with a 5, 6, 7, 8 or 9 followed by the proper number of zeros are passed. The final stage produces a beat frequency between 500 and 1000 cycles, which is measured by a visual and audible comparison with a calibrated l.f. oscillator.

A Laboratory [Audio-frequency] Oscillator for Receiver Testing.—Franks. (*See* under " Acoustics and Audio-frequencies.")

Standard Signal Generators.—Franks and Ferris: David: Brueske. (*See* abstracts under " Subsidiary Apparatus and Materials.")

Testing Wireless Receivers.—R. L. Smith-Rose. (*Wireless World*, 10th and 17th June, 1931, Vol. 28, pp. 636–638 and 653–655.)

A description of modifications in the apparatus which has been set up at the National Physical Laboratory for carrying out a comprehensive series of tests on wireless receivers of all types. The apparatus was originally described by Thomas (*see* 1930 Abstracts, p. 464). The modifications are chiefly concerned with the testing of broadcast receivers, which are examined for sensitivity, selectivity and fidelity.

Bibliography on Radio Wave Phenomena and Measurement of Radio Field Intensity.—Bureau of Standards. (*See* under " Propagation of Waves.")

ÜBER DIE MESSUNG SEHR KLEINER FREQUENZEN UND IHRE ANWENDUNG FÜR FERNMESSUNG (The Measurement of Very Low Frequencies [of the order of 10 Cycles per Sec.] and Its Application to Telemetering).—E. Hudec. (*E.T.Z.*, No. 12, Vol. 52, 1931, pp. 380–385.)

ÉTUDE DES SIGNAUX HORAIRES INTERNATIONAUX (An Investigation of the International Time Signals).—P. Lejay. (*L'Onde Élec.*, June, 1931, Vol. 10, p. 47A.)

Abstract of an article which appears to cover some of the same ground as the paper dealt with in 1930 Abstracts, p. 167. In addition to the Eiffel Tower Signals, those from Rugby, Nauen, Annapolis and Saigon are examined. *Cf.* Andersen, Jouaust, both in August Abstracts, p. 448.

THE SHORTT CLOCKS AT GREENWICH IN 1930.—J. Jackson and W. Bowyer. (*Monthly Not., Roy. Astron. Soc.*, No. 3, Vol. 91, 1931, pp. 291–293.)

STANDARDS OF MEASUREMENT, THEIR HISTORY AND DEVELOPMENT.—R. T. Glazebrook. (*Proc. Phys. Soc.*, 1st July, 1931, Vol. 43, Part 4, pp. 412–457.)

ÜBER DIE MASSEINHEITEN DER STRAHLUNG (On the Units of Radiation).—F. Kiebitz. (*Zeitschr. f. hochf. Tech.*, April, 1931, Vol. 37, pp. 136–139.)

A critical examination of the units generally regarded as measures of the radiation from antennae and of the connection of these units with one another, including units of radiation efficiency, radiation resistance, metre-ampères or "magnetic charge," density of energy flow; the general conclusion reached is that, in giving numerical data of absorption and fluctuation of received signals, the formulae used to calculate the numbers given from the actual readings taken should always be stated.

STANDARD FREQUENCY SERVICE HAS WORLD-WIDE COVERAGE.—(*QST*, July, 1931, Vol. 15, pp. 43–44.)

SUBSIDIARY APPARATUS AND MATERIALS.

ENREGISTREMENTS D'ONDES MOBILES, À HAUTE TENSION ET À FRONT RAIDE, PAR L'OSCILLOGRAPHE À RAYONS CATHODIQUES, TYPE DUFOUR, À UN SEUL DEGRÉ DE VIDE (The Recording of High Tension, Steep-Fronted Surges by the Dufour Type C.-R. Oscillograph with Only One Stage of Vacuum).—S. Teszner: Gondet. (*Comptes Rendus*, 15th June, 1931, Vol. 192, pp. 1541–1543.)

Modifications to the Dufour oscillograph, chiefly to increase the stability of the ray and the brightness of the spot. The most important points are:—the addition of a metallic "protecting" tube surmounting the anode and concentric with the glass cathode tube, to protect the ray from outside electrostatic influences and to prevent electron collisions against the glass; water cooling for anode and cathode to prevent the setting free of gas which is a chief cause of ray instability; concentration of the spot by means of a flat coil surrounding the deviating tube, which allows the hole in the anode to be enlarged considerably and thus increases the number of electrons which can pass through it.

Other important modifications are in connection with the time base, which hitherto was according to a sine law, and with the starting and stopping arrangements. The well-known condenser-discharge method is employed, started by the "starting spark" of the arriving surge. But the ordinary method of carrying this out leads to a rather feeble deflection owing to the impossibility of applying an adequate voltage to the deflecting plates in a tube with only a low vacuum. The writer therefore uses an artifice based on the principle that if the maximum charging potential admissible without danger of producing a luminous discharge between the plates is V, the discharge potential producing a deflection *in the reverse sense* can with impunity reach the value $2V$. This principle is carried out by means of suitably proportioned capacities and resistances forming a potential divider so that the potential reduction by resistance (charging potential) is up to twice as great as the potential reduction by capacities (discharge potential).

The ordinary condenser discharge system gives an exponential scale, but this has been made almost linear for a large portion of the deflection by graduating the condenser discharge-curve. This is accomplished by means of the potential-dividing capacities.

As a result of all these modifications, recording speeds have been regularly obtained up to several thousand kilometres per second, perfectly readable and consistent curves being formed. The time-scale is of several—up to 5—centimetres per microsecond, and can if desired be increased still further.

EIN ABGESCHMOLZENES BRAUNSCHES ROHR HOHER LEISTUNG (A Sealed Braun [Cathode-Ray] Tube of High Efficiency).—W. Rogowski and K. Szeghö. (*Archiv f. Elektrot.*, 30th Dec., 1930, Vol. 24, No. 6, pp. 899–900.)

A description of a cathode-ray tune containing several new devices for increased efficiency; the cathode can be displaced, so that new surfaces are available as the source of electrons, and a diaphragm may be used before the cathode to define the point of origin of the ray. Such a tube has given 800 hours working without diminution of effectiveness and may be used with frequencies of the order of a megacycle per sec. The tube is particularly suited for registration of high voltages. A double vacuum may occasionally prove useful and this may be attained by using one or two diffusion pumps in parallel with the tube. Several interchangeable fluorescent screens can also be provided.

THYRATRON FOR TIME-BASE OF C.-R. OSCILLOGRAPH: TIME REQUIRED TO SET UP CONDUCTION.—Nottingham. (*See* abstract under "Valves and Thermionics.")

EINE AUTOMATISCHE ALARMVORRICHTUNG BEI AUSFRIERGEFÄSSEN VON HOCHVAKUUMAPPARATUREN (An Automatic Alarm Device for Cooling Chambers of High Vacuum Apparatus).—J. Obrist. (*Zeitschr. f. tech. Phys.*, June, 1931, Vol. 12, pp. 305–307.)

Giving a warning when the liquid air or other refrigerating substance is becoming exhausted.

MÉTHODE POUR LA COMPENSATION AUTOMATIQUE DES VARIATIONS DE RÉSISTANCE DES CIRCUITS ÉLECTRIQUES, PRODUITES PAR LES VARIATIONS DE LA TEMPÉRATURE AMBIANTE.—APPLICATION À LA COMPENSATION D'UN GALVANOMÈTRE (A Method for the Automatic Compensation of Resistance Changes in Electrical Circuits due to Variations in the Temperature of the Surrounding Air.—Application to the Compensation of a Galvanometer).—A. Arnulf. (*Journ. de Phys. et le Rad.*, No. 3, Vol. 2, Series 7, 1931, pp. 27S–28S.)

Using a constantin wire dipping into the mercury of an open thermometer.

EIN NEUER THERMOREGULATOR FÜR DEN BETRIEB VON ADIABATISCHEN KALORIMETERN (A New Thermo-Regulator for the Control of Adiabatic Calorimeters).—H. Rieche and R. Grau. (*Zeitschr. f. tech. Phys.*, June, 1931, Vol. 12, pp. 284–286.)

A mirror galvanometer, controlled by a resistance thermometer in a bridge connection, reflects a pulsating light ray (coming through a rotating perforated disc) on to a special optical wedge in such a way that the intensity of light falling on a selenium cell varies with the deflection of the galvanometer. The a.c. flowing through this cell is amplified and passed through a heating winding either directly or through an intensity relay.

A THERMOSTAT REGULATOR.—E. Q. Adams. (*Review Scient. Instr.*, March, 1931, Vol. 2, pp. 187–188.)

Using a tungsten-mercury contact in hydrogen, permanently enclosed in glass, with adjustment by a mercury-tight tungsten plunger.

THE GENERATION OF [LARGE] CURRENT PULSES OF RECTANGULAR WAVE-FORM [BY THE USE OF THYRATRONS AND AN OSCILLATORY TIMING CIRCUIT].—A. J. Maddock. (*Proc. Phys. Soc.*, 1st July, 1931, Vol. 43, Part 4, pp. 371–382.)

A DEVICE FOR OBTAINING VERY SMALL ELECTRIC CURRENTS OF KNOWN MAGNITUDE.—L. P. Smith. (*Review Scient. Instr.*, April, 1931, Vol. 2, pp. 237–241.)

A vacuum tube which will provide very small currents of known magnitude and of either sign, over a large current range. Its capacity is only 2 $\mu\mu$F.

THE DESIGN AND CONSTRUCTION OF STANDARD SIGNAL GENERATORS.—C. J. Franks and M. Ferris. (*Rad. Engineering*, June, 1931, Vol. 11, pp. 37–44.)

Properties and requirements of a standard signal generator (*cf.* Farnham and Barber, 1930 Abstracts, p. 639): The Shielding Problem: Practical examples of design: Modulation system: Output and attenuator system: Checking accuracy: Filters: Miniature portable generator.

GÉNÉRATEUR DE F.E.M. ÉTALONNÉES SUR ONDES COURTES (Calibrated Source of High Frequency Potentials on Short Wavelengths).—P. David. (*L'Onde Élec.*, June, 1931, Vol. 10, pp. 233–250.)

For providing known voltages adjustable from 1 volt to 1 microvolt or less, on frequencies corresponding to wavelengths from 10 to 100 metres. The generating circuit is a symmetrical arrangement of two triodes (Fig. 8, in which the symmetrically tapped-off leads *a*, *b*, go to the attenuator). In its meticulously screened case are included two or more low-pass filters, each forming a carefully screened unit (Fig. 9), which allow the generator to be fed from external sources instead of having to have batteries built into the set. The care with which the two main units (generator and attenuator) are screened is shown by Figs. 3 (double Faraday cages), 5 (method of fitting on the lids), 6 (spindles of adjustment knobs), and 7 (method of leading-out the screened leads).

The attenuator (Fig. 12; that shown in Figs. 2–4 was too widely spaced and had too long connections to go down to 10 m.) comprises three "sinusoidal transformers" [variable couplings] based on Mesny's work but provided with special measures against parasitic capacity effects, in the form of "screen grids" of fine parallel wires stretched on cardboard formers (*see* Fig. 10). Each "transformer" is individually screened by a metal pot.

In the long section on the calibration of the equipment, it is mentioned that the thermionic voltmeter finally adopted used a symmetrical arrangement of two horned valves (to reduce the parasitic capacities): a shunted condenser was in each grid lead, of such a value that it could be halved or doubled without altering the reading on any frequency. A section on the accuracy to be obtained with the equipment leads to an estimate of about 5 %; or better, of course, when only a comparison between two potentials of the same order is concerned. Other models on the same lines have been made for 100–2500 metre and 2500–16,000 metre wave-ranges. The paper ends with a bibliography of 26 items.

DESIGN NOTES ON BEAT FREQUENCY OSCILLATORS [FOR AUDIO- OR LOW RADIO-FREQUENCIES].—G. A. Brueske. (*Rad. Engineering*, June, 1931, Vol. 11, pp. 56 and 58.)

DIELECTRIC PHENOMENA AT HIGH VOLTAGES.—B. L. Goodlet, F. S. Edwards and F. R. Perry. (*Journ. I.E.E.*, June, 1931, Vol. 69, pp. 695–738.)

" The paper discusses the breakdown of air, oil and solid dielectrics by normal-frequency, impulsive, and high-frequency voltages. A large amount of original numerical data is given, covering the entire range of voltage up to 1 million volts."

The impulse generator employed gives a wave which on open circuit rises to maximum voltage in about 0.1 microsecond, the decline to half value taking 35 microseconds.

ÉTAT ACTUEL DE NOS CONNAISSANCES SUR L'ARC À MERCURE À BASSE PRESSION (Present Knowledge of the Low Pressure Mercury Arc [as in Rectifiers]).—M. Leblanc and M. Demontvignier. (*Rev. Gén. de l'Élec.*, 6th and 13th June, 1931, Vol. 29, pp. 891–904 and 935–950.)

ON THE ATTENUATING LAYER PHOTOELECTRIC EFFECT OF X-RADIATION.—Lange and Selényi. (*See* under " Phototelegraphy and Television.")

ZUR WIRKUNG DER GLEICHRICHTER (On the Action of Rectifiers).—W. Ch. van Geel. (*Zeitschr. f. Phys.*, 1931, Vol. 69, No. 11/12, pp. 765–785.)

" The current/voltage curves for various dry and electrolytic rectifiers are measured and analysed. In both pass and attenuation directions, these curves may be represented by the equations

$$i = AF^2e^{-\frac{B}{F}} \text{ and } i = CF$$

The currents are therefore due to cold electron emission. Calculations are given of the fields occurring in a rectifier, the effective surfaces, and of the ratio of the currents in forward and backward directions. It is shown that a decisive part is played not only by the " work function " (Richardson's ϕ) but also by the " internal work function " (Sommerfeld's W_i).

AUTOMATIC TIME-DELAY RELAY [FOR PLATE VOLTAGE OF MERCURY RECTIFIERS, ETC.]—C. Huff. (*Proc. Inst. Rad. Eng.*, June, 1931, Vol. 19, pp. 1019–1021.)

Author's summary :—" The design of an automatic time-delay relay is described. For certain types of mercury-rectifier tubes no plate voltage should be applied for at least one-half minute after the filament current is turned on if the peak inverse potential exceeds 2100 volts. During a six-months' test of this relay on a special radio transmitter it has not failed to function at any time." The device consists of a combination of relays and a " Telechron " clock motor.

KONSTRUKTION DES ERSATZWIDERSTANDES PARALLEL GESCHALTETER WIDERSTÄNDE (Graphical Construction for the Equivalent Value of Paralleled Resistances).—H. Kind. (*E.T.Z.*, No. 15, Vol 52, 1931, pp. 477–478.)

STROMREGELUNGEN BEI LABORATORIUMSMESSUNGEN (The Regulation of Current in Laboratory Measurements [by Parallel Resistances for Coarse and Fine Adjustments]).—G. Hauffe. (*E.T.Z.*, 12th March, 1931, Vol. 52, pp. 340–341.)

THEORY OF A COMBINED SERIES AND POTENTIOMETER RHEOSTAT.—J. R. Nielsen : –. Dodge. (*Review Scient. Instr.*, March, 1931, Vol. 2, pp. 184–186.)

AN IMPROVED FEUSSNER TYPE POTENTIOMETER.—M. Eppley and W. R. Gray. (*Review Scient. Instr.*, April, 1931, Vol. 2, pp. 242–249.)

L'AMPLIFICATEUR À LAMPES ET LA DÉTECTION DES RAYONS CORPUSCULAIRES ISOLÉS (The Valve Amplifier and the Detection of Isolated Corpuscular Rays).—L. Leprince-Ringuet. (*Ann. des P.T.T.*, June, 1931, Vol. 20, pp. 480–492.)

Description of a resistance-capacity amplifier by which the arrival may be detected of a charge of 10^{-16} coulomb., collected on the input grid in a time varying from $\frac{1}{100}$ to $\frac{1}{1000}$ second. When preceded by a suitable ionisation chamber, it will detect the ionisation produced by one proton in one cubic centimetre of air. The input valve is a Philips electrometer triode, with grid and plate on opposite sides of the filament (March Abstracts, p. 157).

STATIONS, DESIGN AND OPERATION.

LES LIAISONS RÉGULIÈRES RADIOTÉLÉPHONIQUES ENTRE L'OBSERVATOIRE MÉTÉOROLOGIQUE DU PIC DU MIDI ET LA PLAINE (The Establishment of Constant Radio-telephonic Communication between the Pic du Midi Meteorological Observatory and the Plain [Short and Ultra-Short Waves]).—H. Garrigue. (*L'Onde Élec.*, June, 1931, Vol. 10, pp. 275–280.)

The old aerial at the Observatory was 50 m. long and 25 m. high and gave excellent transmission on the Broadcast band, telephony with 20 watts in the aerial being heard at Bordeaux, Casablanca, in Spain, etc. But it was hopeless for a regular service to the Plain, for it could stand up neither to the glazed frost which formed on it nor to the hurricanes, and, moreover, during snow storms it took up potentials to earth of over 50,000 volts ; an earth current of 2 milliampères would flow for 24 consecutive hours.

The writer describes how he set to work, therefore, to establish constant communication with the Plain by transmitting on an 80-metre wave and receiving (on a military super-regenerative receiver) on a 6.5-metre wave. It was impossible to use the ultra-short wave for transmission owing to the great absorption caused by the snow—*the transmitting dipole being buried in the snow* at depths varying from a few centimetres to one and a half metres, to protect it from the glazed frost and hurricanes. The height of the snow above the ground is about 5 metres. For the 80-metre wave, the dipole consists of two 13-metre lengths of insulated wire. It is protected electrostatically by a steel cable stretched between two metal pylons 25 metres high, earthed by wires running to a lake 700 metres below.

The ultra-short-wave receiving apparatus had to be established 50 metres from the transmitter in a snow dug-out just outside the " shadow " thrown by the north crest of the Pic du Midi. This dipole also is buried : each horizontal arm is 1.50 metres long.

The 80-metre transmission is on 20 watts to the aerial. The ultra-short-wave transmitters at the stations in the Plain use two receiving valves working on 160 volts. Regular duplex telephonic communication is maintained in all weathers.

BROADCASTING BY HIGH POWER STATIONS WITH AERIALS GIVING NO SPACE WAVE.—Lorenz Company. (*See* abstract under " Aerials and Aerial Systems.")

RE-DIFFUSED RADIO.—P. P. Eckersley : Re-diffusion, Ltd. (*Electrician*, 29th May, 1931, Vol. 106, p. 786.)

The ultimate scheme is as follows :—at the main receiving station a large number of [foreign ?] programmes will be received, rectified and transmitted by land lines at audio frequencies to the main centres of distribution in town and country. Here they will be reconverted into radio frequencies, a different band for each programme, and will then pass over the electric light wires to the public. " With regard to the re-diffusion of British programmes, Captain Eckersley gave me the impression that he would prefer to take them directly from the B.B.C. by land line."

VORARBEITEN FÜR DEN KÜNFTIGEN ULTRAKURZWELLEN-RUNDFUNK (Development Work for Future Ultra-Short-Wave Broadcasting). —E. Schwandt : Schröter : Leithäuser. (*Rad., B., F. f. Alle*, July, 1931, pp. 328–334.)

An article by the first-named based on recent lectures by the other two, dealing with the part played by the Telefunken Company and the Heinrich Hertz Institute. Diagrams include a simple Telefunken adaptor (leaky-grid detector with reaction) and two Leithäuser super-regenerative adaptors, one with two valves and the other with a single valve which acts as detector and also generates the " quench " frequency.

BERLIN ULTRA-SHORT-WAVE TRANSMISSIONS SUSPENDED.—Telefunken Company. (*Rad., B., F. f. Alle*, July, 1931, pp. 335–336.)

In an announcement to the trade of the Company's views on ultra-short wave results and possibilities, it is mentioned that the 7.05-metre transmissions are being suspended while the transmitter is having its power increased. New times will be arranged when this is ready. An editorial note mentions that the Company is shortly putting into action a transmitter with 8 kw. in the aerial, to be used chiefly in television tests.

ULTRA-SHORT WAVES FOR BROADCASTING.—G. Leithäuser. (*Funk*, 1st May, 1931 ; summary in *Electronics*, June, 1931, p. 697.)

" Important general discussion of the uses of these waves for broadcasting. Some points not brought out by other authors are the difficulties in the transmitter building (capacity effects in r.f. chokes and reistances ; glass or quartz insulation for condensers) ; avoidance of interference on normal broadcast wavelengths by not grounding the sender and by the use of effectual r.f chokes in all leads to the (grounded) accumulators and dynamos, these measures having made possible DX reception on the normal waves in the same room as the ultra-short-wave sender at the Heinrich Hertz Institute ; use of quarter wavelength doublet at considerable heights above surrounding buildings, etc. ; use of Armstrong super-regenerative and Flewelling circuits in receivers ; avoidance of ground connections in receivers, a two-metre rod antenna and a similar counterpoise being preferable ; . . . television and sound film possibilities."

LOW-FREQUENCY HIGH POWER BROADCASTING AS APPLIED TO NATIONAL COVERAGE IN THE UNITED STATES.—W. H. Wenstrom. (*Proc. Inst. Rad. Eng.*, June, 1931, Vol. 19, pp. 971–983.)

Author's summary :—" With P. P. Eckersley's general theory derived from north European practice as a starting point, the possibilities of broadcasting in the United States on frequencies around 200 kc. are examined from the viewpoint of national coverage. It is shown that Eckersley's curves can be applied approximately to the American terrain, and that as a first approximation seven low-frequency transmitters radiating at maximum power levels between 1,000 kw and 10,000 kw. may be expected to cover practically the entire country with true broadcast service. Objections to and advantages of such a structure operated as a supplement to existing broadcast facilities are discussed."

Among the advantages, it is thought (Hoyt Taylor) that serious night fading will not occur very frequently inside of 500 miles, assuming automatic receiver volume control ; actual broadcast transmission in the U.S. on 200 kc. has shown no pronounced fading ring within 300 to 350 miles, the limit of effective signal strength at the power employed (20 kw.). Differential side-band fading will be relatively less severe, and 200-kc. fading will be *slower* than that on present broadcasting frequencies. Some of the present enormous differences in signal strength between near-by points, such as a hill-top and a valley bottom, should be smoothed out somewhat by the greater ability to bend round obstructions.

Among the disadvantages, atmospherics are worse at 200 than at 600 kc. Austin estimates that the ratio is probably greater than 2 : 1 and less than 4 : 1. The writer deduces from this and other estimates that a signal intensity of 3 to 10 millivolts per metre should probably be sufficiently above the interference level, the lower value being probably good enough for most of the U.S. except certain parts of the South.

FIELD-STRENGTH MEASUREMENTS ON DAVENTRY 5XX.—Naismith : Reyner. (*See* under " Propagation of Waves ".)

A METER FOR INDICATING 100 PER CENT. MODULATION.—G. F. Lampkin. (*Electronics*, July, 1931, p. 26.)

TELEPHONE TRANSMITTING EQUIPMENT ON BOARD THE "HOMERIC."—(*See* under "Transmission".)

WIRELESS COMMUNICATION IN AFRICA. (*Electrical Review*, 24th April, 1931, Vol. 108, p. 700.)

A summary of the system of radio communication to be established in S. and E. Africa, with special reference to short-wave and aircraft systems.

GENERAL PHYSICAL ARTICLES.

NON EXISTENCE D'UN SPIN DES PHOTONS (The Non-Existence of Photon-Spin).—A. Kastler. (*Journs. de Phys. et le Rad.*, May, 1931, Series 7, Vol. 2, pp. 159–164.)

THE "INFINITE ENERGY OF RADIATION AT THE ABSOLUTE ZERO" DIFFICULTY IN THE QUANTUM THEORY, AND ITS SOLUTION. L. Rosenfeld and J. Solomon. (*Journ. de Phys. et le Rad.*, May, 1931, Series 7, Vol. 2, pp. 139–147.)

RELATION ENTRE LE PARCOURS D'UN PROTON RAPIDE DANS L'AIR ET L'IONISATION QU'IL PRODUCT. APPLICATION A L'ÉTUDE DE LA DÉSINTÉGRATION ARTIFICIELLE DES ÉLÉMENTS (Relation between the Path of a Rapid Proton in Air and the Ionisation It Produces. Application to the Study of the Artificial Disintegration of the Elements).—L. Leprince-Ringuet. (*Comptes Rendus*, 15th June, 1931, Vol. 192, pp. 1543–1545.)

THE ANNIHILATION OF MATTER.—J. H. Jeans. (*Nature*, 18th July, 1931, Vol. 128, pp. 103–110—Supplement, 3,220.)

The substance of lectures on the evidence as to the annihilation of matter yielded by experiments on cosmic radiation.

PRÜFUNG ZWEIER VERFAHREN ZUR BESTIMMUNG VON KONTAKTSPANNUNGEN AN HALBLEITERN (Test of Two Methods for the Determination of Contact Voltages at Semi-Conductors).—G. Mönch. (*Zeitschr. f. Phys.*, 1931, Vol. 68, No. 3/4, pp. 244–256.)

"It is shown that the contact potentials determined by Thomson's method between a metal and various semi-conductors (CuO, Cu_2O, AgI, Ag_2S, Se) have values equal in magnitude to those found from the parallel displacement of emission characteristics."

ZUR THEORIE DES ELEKTRISCHEN KONTAKTES (On the Theory of Electric Contact).—W. Ehrenberg and H. Hönl. (*Zeitschr. f. Phys.*, 1931, Vol. 68, No. 5/6, pp. 289–308.)

UNTERSUCHUNGEN ÜBER KONTAKTPOTENTIALE. III.—ZUR THEORIE DER KONTAKTPOTENTIALE (Investigations on Contact Potentials. III.—On the Theory of Contact Potentials). —R. Fürth. (*Zeitschr. f. Phys.*, 1931, Vol. 68, No. 11/12, pp. 735–757.)

THE DISTRIBUTION OF ELECTRICITY NEAR THE SURFACE OF CONTACT OF TWO CONDUCTORS [THEORETICAL INVESTIGATION]. — A. T. Waterman. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, p. 1018.)

Abstract only.

NEUE UNTERSUCHUNGEN ÜBER DIE ELEKTROLYTISCHE VENTILWIRKUNG. I. DIE OXYDSCHICHT DES TANTALS (Recent Investigations of the Electrolytic Valve Effect. I. The Oxide Layer of Tantalum).—A. Güntherschulze and H. Betz. (*Zeitschr. f. Phys.*, 1931, Vol. 68, No. 3/4, pp. 145–161.)

INTENSITIES OF THE MAGNETIC AND ELECTRIC ILLUMINATION COMPONENTS IN THE ELECTRODELESS DISCHARGE.—C. T. Knipp. (*Phys. Review*, 15th April, 1931, Series, 2, Vol. 37, No. 8, p. 1020.)

Abstract only.

SUR LA THÉORIE DE LA DÉCHARGE SANS ÉLECTRODE (On the Theory of the Electrodeless Discharge.—F. Esclangon. (*Comptes Rendus*, 18th May, 1931, Vol. 192, pp. 1211–1212.)

THE ELECTRODELESS DISCHARGE IN MERCURY VAPOR.—H. Smith, W. A. Lynch and N. Hilberry. (*Phys. Review*, 1st May, 1931, Series 2, Vol. 37, pp. 1091–1101.)

RELATIVE INTENSITIES OF THE MAGNETIC AND ELECTROSTATIC ILLUMINATION COMPONENTS IN THE ELECTRODELESS DISCHARGE.—C. T. Knipp. (*Phys. Review*, 15th March, 1931, Series 2, Vol. 37, No. 6, pp. 756–759.)

MISCELLANEOUS.

APPLICATION OF SPINOR ANALYSIS TO THE MAXWELL AND DIRAC EQUATIONS.—O. Laporte and G. E. Uhlenbeck. (*Phys. Review*, 1st June, 1931, Series 2, Vol. 37, No. 11, pp. 1380–1397.)

ON THE SUMMABILITY OF FOURIER SERIES. FOURTH NOTE.—E. Hill and J. D. Tamarkin. (*Proc. Nat. Ac. Sci.*, June, 1931, Vol. 17, pp. 376–380.)

THE APPLICATION OF VISIBLE AND INVISIBLE—PARTICULARLY INFRA-RED—RAYS FOR TRANSMISSION OF NEWS AND SAFEGUARDING OF TRAFFIC: ERRATA.—G. Gresky. (*Physik. Zeitschr.*, 1st April, 1931, Vol. 32, No. 7, p. 304.)

Corrections to the paper dealt with in June Abstracts, p. 341.

PROGRESS IN AERONAUTIC RADIO RESEARCH.—Note from the U.S. Bureau of Standards. (*Journ. Franklin Inst.*, May, 1931, Vol. 211, pp. 662–664.)

Notes on performance tests of the recently developed simultaneous radio telephone and range-beacon transmitter, on a radio system to aid the prevention of collision between aircraft in flight under conditions of poor visibility, and on a new indicator for the visual type radio range beacon.

NEW DEVELOPMENTS IN WIRELESS COMMUNICATION.—Chetwode Crawley. (*Discovery*, May, 1931, Vol. 12, pp. 161–163.)

COMMUNICATION ENGINEERING IN AUSTRALIA.—J. M. Crawford. (*Journ. of the Inst. of Engineers, Australia*, February, 1931, Vol. 3, pp. 41–53.)

A summary of communication work in Australia, including radio, broadcasting and picture transmission services.

THE ELECTRICAL STATE OF THE SUN.—R. Gunn. (*Phys. Review*, 15th April, 1931, Series 2, Vol. 37, No. 8, pp. 983–989.)

ELECTROMAGNETIC REACTIONS BETWEEN CONDUCTING AND MAGNETIC MATERIAL, AND AN ALTERNATING CURRENT [MATHEMATICAL INVESTIGATION].—S. Whitehead. (*Phil. Mag.*, April, 1931, Series 7, Vol. 11, No. 72, pp. 897–914.)

Author's summary :—The present paper is mainly mathematical in nature. It deals with the eddy currents and secondary magnetic fields due to the presence of a cylinder or plate of conducting and magnetic material in the neighbourhood of a current. Solutions are deduced for certain particular cases, such as the magnetic effect alone, eddy currents alone, and the effect of material of infinite thickness. A number of solutions of particular cases by different authors are shown to form part of a general scheme and to be deducible from a general solution.

The present report furnishes a basis for deducing solutions for further particular cases which may arise, since the analysis is of wide application. Among these applications may be mentioned the following :—Sheath losses in cables ; the effect of metal work in the neighbourhood of cables upon the impedance and loading ; proximity effects between conductors ; the heating of flanges in transformer bushings ; the forces on an arc drawn near metallic bodies ; and earth currents, including fault impedance and telephone interference.

THE ELECTRICAL POLARIZATION OF ELECTRETS.—M. Ewing. (*Phys. Review*, No. 4, Vol. 37, Series 2, 1931, p. 463.)

The polarisation of the electret tested was 2.0 $\pm$ 0.2 e.s.u./cm^2. Adam's theory (*Journ. Franklin Inst.*, 1927, p. 469) seems to require that it should be of the order of 10^5 e.s.u./cm^2. For other references to electrets *see* March Abstracts, p. 168 (Eguchi).

THE OSCILLATING ARC : ELEMENTS OF GROUP VI.—E. Z. Stowell. (*Phys. Review*, 1st June, 1931, Series 2, Vol. 37, No. 11, pp. 1452–1457.)

From the author's abstract :—" A study of the behaviour of sulphur, selenium, tellurium, chromium, molybdenum, tungsten and uranium as cathodes in an arc in hydrogen reveals that all of them permit radio-frequency oscillations to occur in a tuned circuit across the arc. No magnetic field is required for these oscillations."

ZUR FRAGE DER BESEITIGUNG VON RUNDFUNKSTÖRUNGEN DURCH KONDENSATOREN (The Use of Condensers in Stopping the Production of Interference with Broadcast Reception).—A. Dennhardt. (*E.T.Z.*, No. 11, Vol. 52, 1931, pp. 347–348.)

In arranging the customary pair of symmetrically connected condensers, two possibilities of danger must be considered : the breakdown of one condenser, and the connection of too large a capacity across the mains. The writer concludes that a maximum value of about 0.01 microfarad may be used, provided that the frame of the apparatus is not earthed. The dielectric must be designed to allow for the additional strain due to surge and high-frequency potentials.

PHOTOELECTRIC APPARATUS FOR TESTING ELECTRICITY METERS.—R. Laurent. (*Journ. de Phys. et le Rad.*, May, 1931, Series 7, Vol. 2, p. 90S.)

A very steep-slope valve (*see* Boussard, under " Valves and Thermionics ") in the third stage of the amplifier enables the photoelectric cell to work a recorder directly. *See* also 1930 Abstracts, p. 178, Aronoff and Young.

DETECTION OF OXYGEN IN A GAS THROUGH ITS EFFECT ON THE EMISSION FROM A TUNGSTEN FILAMENT.—Langmuir and Villars. (*See* abstract under " Valves and Thermionics.")

THE CONDUCTION OF LIGHT AND X-RAYS THROUGH TUBES.—F. Jentzsch and E. Nähring. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 12, 1931, pp. 185–189.)

GEOPHYSICAL PROSPECTING USING OBSERVED VARIATION OF SIGNAL STRENGTH.—Chapman and Franklin. (*See* abstract under " Propagation of Waves "—Naismith : Reyner.)

IS A RADIO PATENT POOL THE WAY OUT ?—(*Electronics*, July, 1931, pp. 2–3.)

" Present economic situation points to importance of eliminating costly litigation between manufacturers. Interests of all parties, independents as well as RCA group, declared protected by open interchange." *See* also August Abstracts, p. 456.

FINDING THE EXPEDITIONS.—(*QST*, July, 1931, Vol. 15, p. 50.)

A list of nine expeditions (including the Wilkins-Ellsworth Transarctic Submarine Expedition) signals from which should be reported to the American Radio Relay League.

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.

D.F. AERIALS.

Application date, 3rd December, 1929. No. 344783.

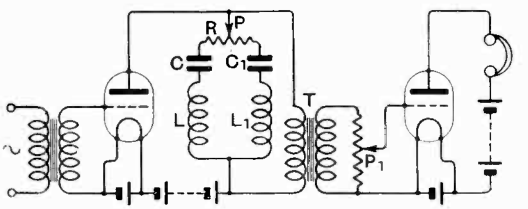
In a direction-finding aerial system of the Adcock type, assymmetry between the upper and lower halves of the aerial is compensated by the provision of a condenser in the earth lead of each aerial. Alternatively, or in addition, the horizontal conductors coupling the two main aerials are divided up into several closed circuits, which are insulated from each other. The object is to eliminate error, due to the proximity of the earth, and to the effect of currents induced by the horizontal electric component of the received wave.

Patent issued to R. H. Barfield.

TONE CONTROL.

Application date, 30th September, 1929. No. 344373.

The output primary of the intervalve transformer T is shunted by a tone-control network comprising a resistance R and two series-tuned circuits C, L and C_1, L_1. The values of C and L are chosen to resonate to a frequency in the higher



No. 344373.

part of the audible range, while the circuit containing C_1 and L_1 is tuned to a frequency towards the lower end of the scale. By adjusting the movable tapping P, the quality of the output can be regulated to a desired timbre, or the clearness of speech controlled. Volume is regulated by a potentiometer tapping P_1 across the secondary winding of the transformer.

Patent issued to S. G. S. Dicker.

PIEZO-ELECTRIC OSCILLATORS.

Application date, 10th April, 1930. No. 344694.

A piezo-electric crystal is ground so that its natural frequency along one axis is different from that along another axis. The crystal is then fed with oscillations corresponding to the beat frequency between the two natural or inherent frequencies, and this beat frequency is sustained in a tuned circuit connected to the input of a thermionic amplifier. Alternatively the crystal may be ground in " stepped " formation to produce two different oscillatory periods, which in turn give the required beat frequency.

Patent issued to Kolster-Brandes, Ltd.

INDIRECTLY-HEATED VALVES.

Convention date (Holland), 13th April, 1929. No. 346096.

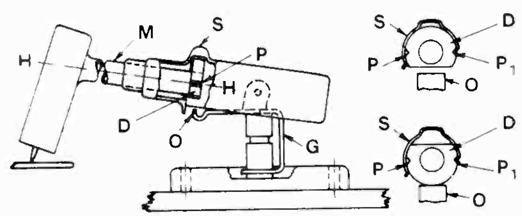
The cathode, which is formed as a tube containing a heating-element, is so mounted inside the valve that one end is free to move longitudinally through a guide on the supporting member. This allows the cathode to expand freely when heated, and prevents any warping or deformation likely either to vary the working characteristics of the valve, or to cause a short-circuit between the cathode and grid.

Patent issued to N. V. Philips, Gloeilampenfabrieken.

GRAMOPHONE PICK-UPS.

Convention date (Germany), 29th October, 1929. No. 345721.

In order to facilitate needle-changing, a cam disc D is mounted at the end of the pick-up arm M, and is provided with a resilient stirrup S and two notches P, P_1, so that when the pick-up is rotated around its horizontal axis H H, the curved portion of the disc D comes into contact with the flat surface O of a supporting-member G. The stirrup S locks the pick-up in this position, where it is lifted up away from the surface of the record. Should the pick-up arm be rocked away laterally about a vertical axis, the flat portion of the disc D can rest against the flat part O of the member G.



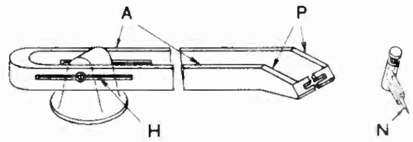
No. 345721.

This holds the pick-up at such a height that the needle cannot come into contact with the cabinet, etc.

Patent issued to Ideal Werke Akt für Drahtlose Telephonie.

Application date 12th February, 1930. No. 348575.

The pick-up arm itself constitutes the magnet supplying flux to the pole-pieces. It may be a permanent magnet, or an electro-magnet with a variable resistance in the energising-winding to regulate the field-strength and the output from the pick-up. As shown, the arm A consists of a



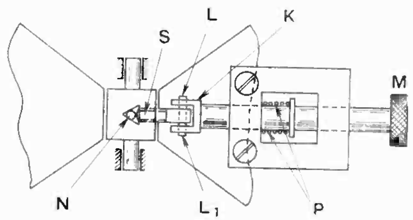
No. 348575.

U-shaped permanent magnet adjustably mounted on a pivot support H to ensure correct length and balance. The pole-pieces P are sloped to give the needle N the proper tracking angle on the record.

Patent issued to R. L. Aspden.

Convention date (Holland), 17th September, 1929.
No. 348483.

The head of the screw used for clamping the needle to the armature must necessarily be of sufficient size to be conveniently adjusted by hand. Its comparatively large moment of inertia is then found to prejudice the desirable freedom of movement of the armature. To avoid this objection the head of the screw is replaced by small lugs which are manipulated by a key, which is permanently mounted on one of the job pieces so that it cannot be lost. As shown in plan, the



No. 348483.

needle N is clamped by a screw S with lugs L, L_1 engaged by the forked end of a key K. The key is pressed into contact with the fixing-screw S by a knob M, and is automatically retracted by a spring P.

Patent issued to N. V. Philips Gloeilampenfabrieken.

DISTRIBUTING H.F. BROADCAST PROGRAMMES.

Convention date (U.S.A.), 29th March, 1929,
No. 347431.

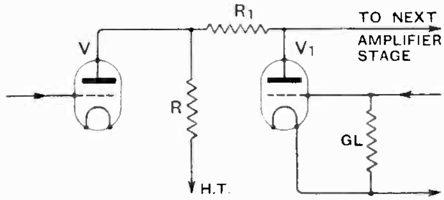
Different broadcast programmes are received on the same aperiodic aerial and are there distributed, in high-frequency form, to the various rooms of an apartment house or hotel, etc. The distributing lines are also substantially aperiodic, and each is terminated by a resistance equal to the surge impedance of the line. The whole of the pick-up energy from the aerial is amplified and distributed without frequency discrimination. A tuner is installed at each terminal point to allow a listener to select any desired programme from the complex currents fed to that point.

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

PREVENTING FADING.

Convention date (France), 26th January, 1929,
No. 347629.

The input valve V is coupled to the next stage of amplification, or to a rectifier valve, by a complex impedance comprising a resistance R shunted by a second resistance R_1 in series with the plate-filament path of an auxiliary valve V_1. A part of the incoming carrier-wave is diverted through a separate rectifier valve (not shown), the output from which is fed to a grid-resistance GL so as to



No. 347629.

vary the internal resistance of the auxiliary valve V_1 automatically in accordance with fluctuations in the strength of the incoming wave. The resistances R, R_1 also vary the potential applied to the plate of the valve V_1, so that during a period of extreme fading the amplification factor of the stage is at a maximum, whilst during normal reception the sensitivity is decreased.

Patent issued to Société Française Radio-Electrique.

SHORT-WAVE BROADCASTING.

Convention date (Germany), 24th April, 1929.
No. 348784.

A number of di-pole oscillators, radiating wave-lengths of the order of a few decimetres, are arranged circularly around the top of a supporting mast so as to cover the entire cone bounded by the visible horizon. Each pair of oscillators is backed by a curved reflecting surface, and several "rings" of oscillators may be mounted in tiers one above the other. The disposition of the reflectors is such that the density of the radiated field is not uniform, but consists of "bundles" of energy formed by the overlapping edges of the beams or cones from adjacent reflectors. The oscillators are also slightly displaced from the true focus of the reflectors in such a way as to ensure that the "bundles" of radiation which strike the earth at more distant points have a greater energy content than those falling nearer to the transmitter.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie m.b.H.

"VISUAL" HETERODYNE RECEPTION.

Convention date (Germany), 8th June, 1929.
No. 344738.

When receiving unmodulated C.W. signals, difficulty is often experienced, especially on the shorter waves, in maintaining the local heterodyne receiver at a sufficiently constant frequency to render the incoming signals audible. According to this invention, the output circuit of the detector valve is shunted by a glow-lamp in series with a pair of telephones. The lamp is adjusted by means of a potentiometer to the threshold point, and the received signals are then utilized to produce a glow discharge. This response is recorded on a light-sensitive film, in addition to the audible effect produced in the phones.

Patent issued to Telefunken Gesell. für Drahtlose Telegraphie m.b.H.

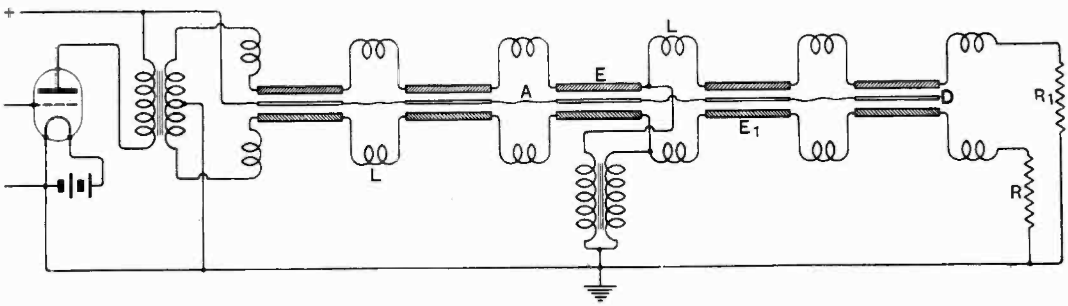
ELECTROSTATIC SPEAKERS.

Convention date (U.S.A.), 27th September, 1929.
No. 346646.

An electrostatic speaker constitutes a capacity load on the output circuit of an amplifier, the actual power converted into sound being small compared with the wattless voltamperes required for charging the electrodes to the required varying potentials. This is particularly the case on the higher frequencies, where the capacity reactance of the speaker practically forms a short-circuit or bypass. According to the invention the speaker is divided into several sections, which are connected by inductances, so as to form, in effect, an artificial transmission line or wave filter with a constant impedance characteristic at all frequencies within the working range.

As shown applied to a push-pull operated speaker, the centre diaphragm D may consist of one continuous sheet or of separate sections connected by conductors A. The stationary electrodes E, E_1 are connected through inductances L. The speaker "line" is terminated by damping resistances R, R_1.

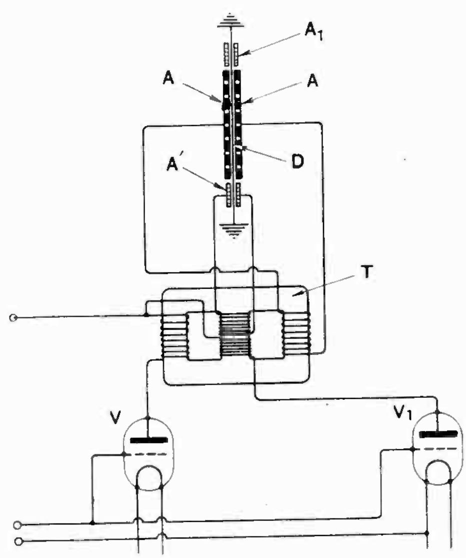
Patent issued to British Thomson-Houston Co., Ltd.



No. 346646.

Convention date (Germany), 4th July, 1929.
No. 345342.

In order to secure an even overall response, two or more electrostatic loud speakers are driven from the same source, each being designed to produce a distinctive tone characteristic. As shown in the figure the stationary plates A, A_1, A' are divided into two separate zones, and each is spaced a different distance from the common diaphragm D. The plates A, and A', A_1, are connected to different secondary windings on a common transformer T, the primary windings being in the anode circuits of two amplifiers V, V_1. The speaker element handling the lower-frequency notes is fed at a voltage approximately ten times higher than that supplied to the higher-frequency element. This is ensured either by suitably selecting the type of amplifier valves V, V_1, or by using separate transformers.



No. 345342

Patent issued to H. Vogt.

Application date 12th February, 1930.
No. 348573.

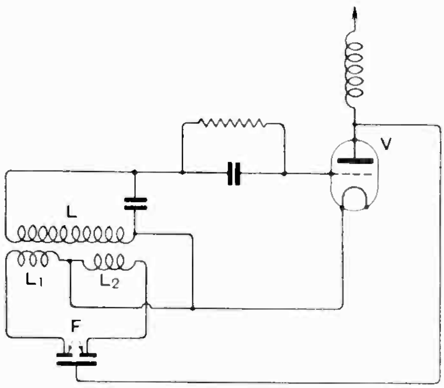
Instead of using an auxiliary source of rectified current to supply the biasing-voltage for an electrostatic speaker diaphragm, the latter is made from "electret" material, which has the property of absorbing a high electrical charge and maintaining it indefinitely. For instance, the diaphragm may consist of one or more stretched layers of fine films of resinous products, such as rubber, gutta-percha, balata, etc., either alone or in combination with an insulating and supporting fabric of very fine texture.

Patent issued to A. Rauser and W. Steuer.

REACTION CONTROL.

Application date 18th February, 1930.
No. 348233.

It is sometimes desirable, in reception, to be able to apply either positive or negative reaction to a



No. 348233.

tuned circuit. The usual method of doing so is to rotate a reaction coil through 180°, so that the current flowing therein is either in phase with or in opposition to that flowing in the circuit to be controlled. The drawing illustrates an arrangement for securing the same effect by means of a variable condenser. The plate circuit comprises two coils L_1, L_2 which are oppositely wound. The outer ends of each coil are connected to the fixed plates of a differential condenser, whilst the inner ends are both connected to the cathode of the valve V. The coils, L_1, L_2 are fixed relatively to the grid coil L. As the moving plates of the condenser are rotated, a point is reached where the current through the coils L_1, L_2 balances out, giving no reaction. On one side of this point reaction is positive, and on the other negative.

Patent issued to British Thomson-Houston Co., Ltd., and T. H. Kinman.

SHORT-WAVE RECEIVERS.

Convention date (Germany), 9th July, 1929.
No. 348453.

When using a valve oscillator according to the Barkhausen-Kurz method, *i.e.*, with a high positive potential on the grid, for the super-regenerative reception of short-wave signals, trouble may be experienced in controlling the amplitude of the locally-generated oscillations without at the same time varying their frequency. According to the invention this difficulty is avoided by utilising a magnetic field perpendicular to a plane passing through the longitudinal axis of symmetry of the electrodes of the oscillator. The intensity of the field is varied in any known manner at superaudible frequency, to produce the desired quenching effect.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie m.b.H.

BROADCAST TRANSMITTING AERIALS.

Convention date (Germany), 11th June, 1929,
No. 347525.

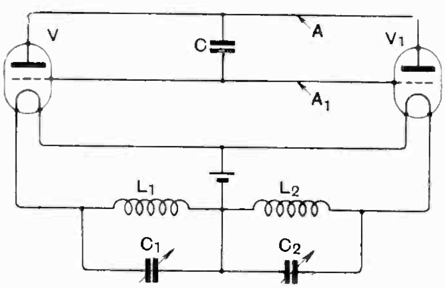
In broadcast transmission it is desirable to radiate a uniformly-distributed field of energy having as small a vertical component as possible, in order to minimise fading at the receiving end. With this object in view a central transmitting aerial is combined with a series of auxiliary aerials which form a closed circle around the main aerial at a radius of one-quarter the working wavelength. For instance, the main aerial is a quarter wavelength in height, and is surrounded by eight outer aerials of the same size. Each outer aerial is energised with current which is 180° out of phase with that fed to the main aerial and of one-eighth its value.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie m.b.H.

SHORT-WAVE OSCILLATORS.

Convention date (Germany), 25th July, 1929.
No. 348461.

Two valves V, V_1 are connected to the main oscillation circuit A, C, A_1 in push-pull, and one or more tuned circuits L_1, C_1 and L_2, C_2 are inserted symmetrically and in series between the cathodes, where they are entirely independent of the grid-anode oscillatory circuit. By means of this arrange-



No. 348461.

ment it is stated that the power-output can be increased to five times its normal value.

Patent issued to Dr. A. Esau.