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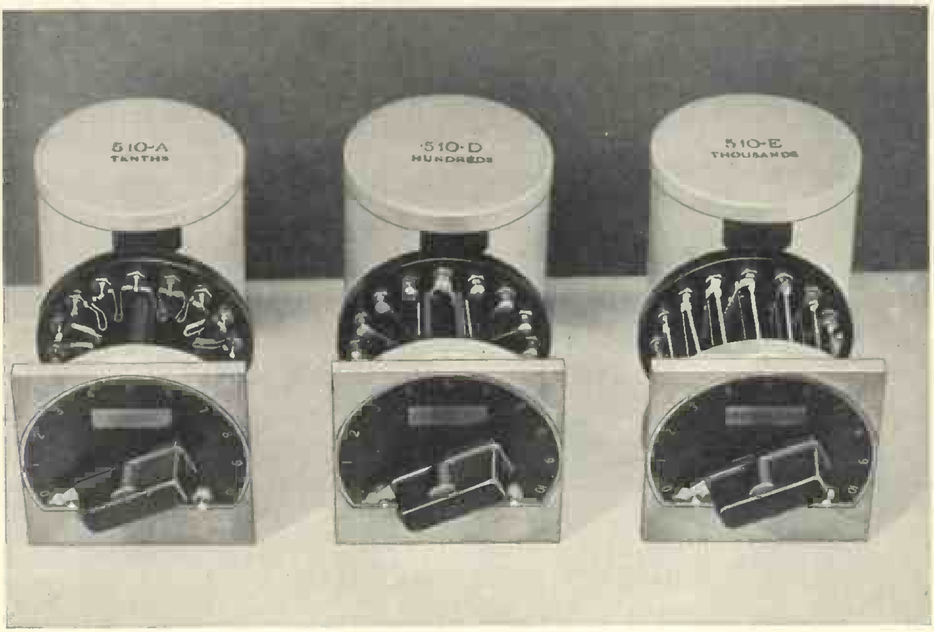

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The

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and EXPERIMENTAL WIRELESS

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THE
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On the Preparation of Articles for "The Wireless Engineer."

WE would like to draw the attention of authors of articles to the importance of paying special attention to the careful preparation of material intended for publication in *The Wireless Engineer*. Some authors appear to be under the impression that so long as the scientific data are correct, the method of their presentation is a matter of little importance. This is certainly not the case and much subsequent trouble would be saved if, after having prepared an article, the author would adopt a critical attitude towards it, and not only consider its general scope and arrangement with a view to improving it, but also read it through, sentence by sentence, to see if the wording could possibly be improved, difficult points made clearer, ambiguities removed and so on. A scientific training and outlook need not necessarily incapacitate anyone from writing good English, nor is a good English style inconsistent with accuracy, conciseness, and freedom from ambiguity.

As an example of the sort of thing which one should seek to avoid we may quote the following sentence from a recent article in the *Proceedings of the Institute of Radio Engineers*: "The sensitiveness of radio transmission to magnetic storms decreases with the wave length." Now what does this mean ? Most people would conclude that sensitiveness and wave length decreased together, and that very short waves would be very insensitive to disturbance, but the next sentence states that "Below sixty metres even slight storms are generally accompanied by radio disturbances," which appears to be quite inconsistent with this interpretation. Apparently then, "decreases with the wave length" is intended to mean that it decreases as the wave length increases, and one reads on in the hope that the point will be cleared up by the subsequent data. We have quoted this as an example of the unnecessary difficulties which are caused by looseness of phraseology.

Another matter of greater importance than many authors seem to realise is the choice of symbols. So far as possible these should conform to internationally agreed usage, but in many cases it is necessary to adopt symbols for which there is little or no precedent and in such cases great care should be taken to choose symbols which will cause a minimum of trouble to the reader. Nothing is more annoying than trying to read a paper which contains a number of unusual symbols which are not suggestive of their meaning and which necessitate a continual reference to a table, or, what is worse, a continual search through the preceding pages to find out what they mean.

"Apparent Demodulation."*

Another Viewpoint.

By E. Mallett, D.Sc., M.I.E.E.

MUCH has been written† on the subject since Dr. Beatty first drew attention to the phenomenon of the "apparent demodulation" of a weak signal by a strong signal. The practical importance of the phenomenon would appear to be considerable, since it leads to a far better performance with regard to selectivity of the average wireless receiving set than would be expected from its actual "resonance curve." It is a pity, therefore, that the presentation of the problem has involved so much mathematics and so little physics that most readers have probably been left without any real insight into what actually happens, whereas the physical explanation of the problem would appear to be delightfully simple.

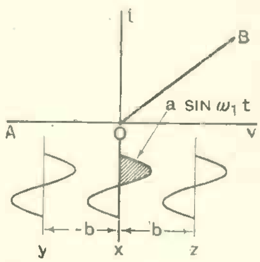

Fig. 1.—*Rectifier thrown completely out of action by bias.*

The phenomenon depends upon what has come to be termed straight line or rectilinear rectification; the rectifier has a characteristic of the form shown by the lines *AO* and *OB* of Fig. 1, in which, as usual, the instantaneous current i flowing through the rectifier is plotted against the instantaneous voltage v established across it. When the voltage is negative there is no current at all; the portion *OA* of the characteristic is involved. When the voltage is positive the current is given by the portion *OB* of the characteristic; let it be $i = \sigma v$. The wave at x indicates a potential $v = a \sin \omega_1 t$ applied to the rectifier under normal circumstances. Since the average value of the shaded half-wave is $2a/\pi$, the area of the shaded half-wave is $2a$, and the mean current flowing over a whole cycle is $\bar{\imath} = \sigma 2a/2\pi = \sigma a/\pi$. In the absence of the signal $a \sin \omega_1 t$ the mean current is nil. Hence the rectified current due to the signal $a \sin \omega_1 t$ is

$$\bar{\imath} = \sigma a/\pi \quad \ldots \quad \ldots \quad (1)$$

Suppose now that the rectifier is given a bias of $-b$ volts, where b is equal to or greater than a. The wave $a \sin \omega_1 t$ is shifted from x to y, and $v = -b + a \sin \omega_1 t$. v is always negative, no current flows at all and there is no rectification. Now suppose that the rectifier is given a bias $+b$ volts, again with b equal to or greater than a. The wave is shifted from x to z, with $v = b + a \sin \omega_1 t$. v is always positive; the current in the absence of the signal is σb and the mean current in the presence of the signal is also σb. Again there is no rectification; the signal has no effect on the mean current flowing. If, therefore, the biassing voltage is periodically altered from $-b$ to $+b$ and back again, so that $b \sin \omega_2 t$ is written instead of b, during that part of the cycle of the biassing

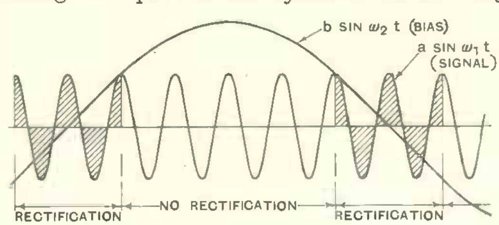

Fig. 2a.—*Low frequency bias. Only shaded portions of signal are rectified.*

voltage when $b \sin \omega_2 t$ is numerically equal to or greater than a the signal $a \sin \omega_1 t$ will have no effect on the mean current flowing; there will be no rectification of the signal at all. It is at once clear that the mean value of the rectified current due to

* MS. received by the Editor, March, 1932.

† For example:

L. T. Beatty, *Experimental Wireless*, vol. 5, p. 300, 1928.

S. Butterworth, *Experimental Wireless*, vol. 6, p. 619, 1929.

F. M. Colebrook, *Wireless World*, May 27th, p. 560, 1931.

Editorial (G. W. O. Howe), *Experimental Wireless*, vol. 8, p. 406, 1931.

E. V. Appleton and D. Boohariwalla, *Experimental Wireless*, vol. 9, p. 136, 1932.

Editorial (G. W. O. Howe), *Experimental Wireless*, February, 1932.

the signal $a \sin \omega_1 t$ must be decreased owing to the presence of the biassing voltage $b \sin \omega_2 t$. The rectifier is thrown completely out of action as far as the signal voltage is concerned during part of the time.

It is only necessary to imagine $a \sin \omega_1 t$ to be the weak signal that is being received and $b \sin \omega_2 t$ to be the strong local carrier superposed, to obtain a broad physical insight into the "demodulation" effect.

The actual frequency ($\omega_2/2\pi$) of the biassing voltage, provided that it is not the same as that of the signal being received, does not alter the argument at all. The fraction of any time (long in comparison with $2\pi/\omega_1$ and $2\pi/\omega_2$) during which the rectifier is out of action to the signal voltage depends only on the relative amplitudes of the signal and biassing voltages. If the biassing frequency is much lower

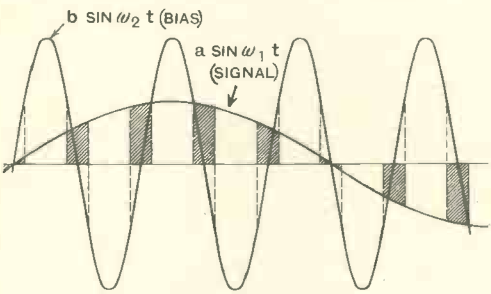

Fig. 2b.—*High frequency bias. Shaded portions are rectified.*

than the signal frequency, there may be rectification during several cycles of the latter at a time, but these periods of rectification occur infrequently. This case is shown in Fig. 2*a*. If the biassing frequency is much greater than the signal frequency, there will be rectification during only a fraction of a cycle at a time, but these rectification periods will be quite numerous, several per signal cycle. This is indicated in Fig. 2*b*. When the signal and the bias frequency are of the same order (and this is the practical case) there will be a rectifying period about twice every cycle as is shown in Fig. 2*c*. It will readily be seen that in all these cases the total time during which rectification of the signal $a \sin \omega_1 t$ takes place is exactly the same.

There are other special cases besides the $\omega_1 = \omega_2$ one. If ω_1 is an even multiple of ω_2 the same portion of the cycle of $a \sin \omega_1 t$ is rectified every time, while if ω_2 is an even multiple of ω_1 the same portions of the cycle of $a \sin \omega_1 t$ are rectified every time. Fig. 2*d* shows the case of $\omega_1 = 2\omega_2$ and 2*e*

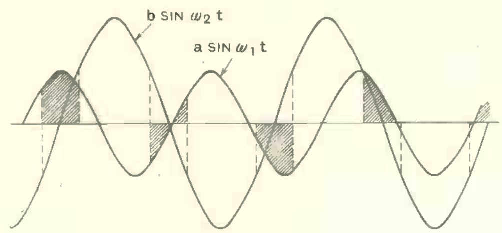

Fig. 2 (*c*).—*Bias frequency of same order as signal frequency. Shaded portions are rectified.*

the case of $\omega_2 = 2\omega_1$. These cases are not of practical importance however; in the practical case, if a sufficiently long time is considered every part of the cycle $a \sin \omega_1 t$ is rectified for the same time.

These considerations still hold if the signal is a modulated wave, that is if the amplitude a varies with time at an acoustic frequency. During the periods when the high-frequency wave is not received, the acoustic signal is also lost.

The reception of the acoustic frequency signal is therefore intermittent, there must be distortion, and the distortion probably does depend upon the frequency of the biassing voltage. It seems likely that a very low frequency would lead to greater

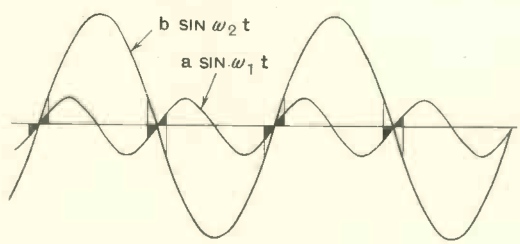

Fig. 2 (*d*).—*Bias frequency half signal frequency.*

distortion than a frequency in the neighbourhood of the signal frequency or a higher frequency. That the "demodulation" has been accompanied by distortion has been observed.

Reverting to the reception of the unmodulated signal $a \sin \omega_1 t$, the rectifier is in action to the signal when $b \sin \omega_2 t < a$. The fraction of the time during which rectification takes place is given, therefore, by $\gamma = 4\omega_2 t'/2\pi$, where $\sin \omega_2 t' = a/b$, or writing $\omega_2 t' = \theta$,

$$\left.\begin{aligned} \gamma &= \frac{2\theta}{\pi} \\ \text{where } \theta \text{ is determined from } \sin\theta &= \frac{a}{b} \end{aligned}\right\} \quad \ldots (2)$$

If full rectification were obtained directly the biassing voltage fell below a, the ratio

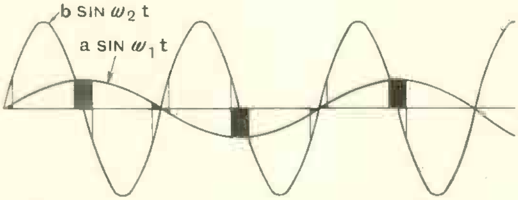

Fig. 2 (*e*).—*Bias frequency twice signal frequency.*

of the mean rectified signal in the presence of the biassing voltage to the rectified signal in the absence of the biassing voltage would clearly be equal to the ratio of the times of rectification in the two cases, *i.e.*, would be γ as defined by (2).

But actually full rectification is only obtained when the biassing voltage is zero; *any* biassing voltage results in a reduction of the rectification. This is made clear in Fig. 3, where normal rectification is shown at x, rectification with a negative bias g volts at y and with a positive bias g volts at z (g being less than a). The rectified current in the three cases is proportional to the shaded areas; to the area of the half-wave at x, and to the area of the tip of the wave at y and z.

Hence on this account also the rectified current from a given signal will be smaller in the presence of a biassing wave than in its absence; even during the periods when rectification of the signal is taking place, the rectifier is put partly out of action to the signal by the biassing wave.

The magnitude of this effect may be estimated as follows. The area of the shaded tip of the wave (at y or z, Fig. 3) is

$$2\left\{\int_{\phi_1}^{\pi/2} a \sin\phi d\phi - g\left(\frac{\pi}{2} - \phi_1\right)\right\}$$

$$= 2a\cos\phi_1 - 2g\left(\frac{\pi}{2} - \phi_1\right)$$

where $a \sin\phi_1 = g$, and ϕ is written for $\omega_1 t$.

The rectified current i_r is this area divided by 2π and multiplied by σ, *i.e.*,

$$i_r = \frac{\sigma}{\pi}\left\{a\cos\phi_1 - g\left(\frac{\pi}{2} - \phi_1\right)\right\}$$

In the absence of the biassing voltage the rectified current is from (1) $\sigma a/\pi$. Hence, if γ' is written for the ratio of the rectified current in the presence of a biassing voltage $g \leqslant a$ to the rectified current with no biassing voltage,

$$\gamma' = \cos\phi_1 - \frac{g}{a}\left(\frac{\pi}{2} - \phi_1\right)$$

$$\text{where} \qquad \sin\phi_1 = \frac{g}{a} \qquad \ldots \quad \ldots (3)$$

The values of γ' for various values of g/a are obtained in the following table:—

TABLE I.

$\frac{g}{a}$	ϕ_1 (radians)	$\frac{\pi}{2} - \phi_1$	$\frac{g}{a}\left(\frac{\pi}{2} - \phi_1\right)$	$\cos\phi_1$	γ'
0	0	—	0	1	1
0.1	0.1	1.47	0.147	0.997	0.85
0.3	0.302	1.27	0.381	0.951	0.57
0.5	0.52	1.05	0.525	0.866	0.34
0.7	0.78	0.79	0.550	0.707	0.15
0.9	1.13	0.44	0.396	0.420	0.02
1.0	—	—	—	—	0

It is next necessary to find the mean value of γ' during the time the rectifier is in action, *i.e.*, while g varies from $-a$ to $+a$. In Fig. 4 the curve OAB is the biassing wave $b \sin\theta$ plotted against θ or the time. A horizontal at a height a cuts the curve at A and AT is drawn vertically, so that OT is the time during which rectification takes place. The variation of g with time is given by the curve OA. Each ordinate gives a value of g/a for which the corresponding value of γ' can be found from Table I or formula (3). The values of γ' so found give the curve RET, and the area of this curve divided by OT gives the required mean value of γ', say, $\overline{\gamma'}$.

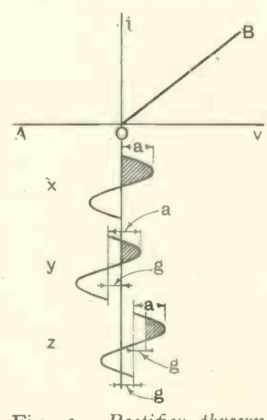

Fig. 3.—*Rectifier thrown partly out of action by bias.*

The actual ratio x of rectified signal in the presence of the biassing voltage to the rectified signal in the absence of the biassing voltage is

$$x = \gamma\overline{\gamma'} \quad \ldots \quad \ldots \quad (4)$$

γ from (2) taking account of the time the rectifier is completely out of action to the signal and $\overline{\gamma'}$ taking account of the partial

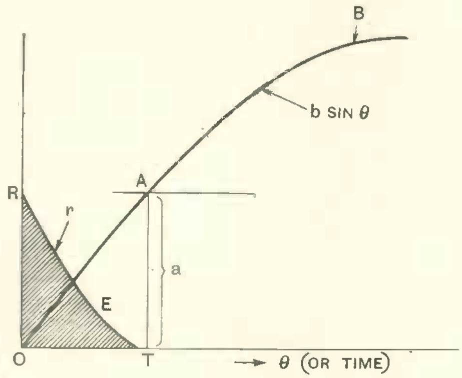

Fig. 4.—*Determination of mean value of* γ^1.

putting out of action of the rectifier to the signal. Both γ and $\overline{\gamma'}$ depend upon the ratio a/b. But if b is much greater than a, say, twice as great or more, the part OA of the biassing wave is nearly a straight line, *i.e.*, the variations of g with time are practically linear, and the mean value of γ' can be found directly from Table I and is independent of the ratio a/b. In this case $\overline{\gamma'}$ is found to be approximately 0.39.

The values of x for various values of the ratio a/b are found in Table II below, using (2) and the value 0.39 for $\overline{\gamma'}$.

TABLE II.

$\frac{a}{b} = \sin\theta$	θ°	$\gamma = \frac{\theta^\circ}{90}$	$x = \gamma \times \overline{\gamma'}$	$4x$
0.50	30.0	0.333	0.13	0.52
0.33	19.5	0.216	0.0842	0.337
0.25	14.5	0.161	0.0627	0.251
0.20	11.5	0.127	0.0495	0.198
0.10	5.7	0.064	0.025	0.10

The values of $4x$ are entered in the last column and it is seen that very nearly

$$\frac{a}{b} = 4x \quad \text{or} \quad x = \frac{a}{4b} \quad \ldots \quad (5)$$

Thus since the rectified current in the absence of the biassing voltage is

$$\bar{i}_1 = \sigma a/\pi \quad \ldots \quad \ldots \quad (6)$$

the rectified current in the presence of the biassing voltage is

$$\bar{i}_2 = \sigma a^2/4\pi b \quad \ldots \quad \ldots \quad (7)$$

It is necessary finally to estimate the effect of this on the acoustic signal produced from a modulated wave. Let $a(1 + \kappa \sin pt)$ be written instead of a, where κ is the factor of modulation and $p/2\pi$ an acoustic frequency. Equation (7) becomes

$$\bar{i}_2 = \frac{\sigma a^2}{4\pi b}(1 + 2\kappa \sin pt + \kappa^2 \sin^2 pt)$$

and here the only term in the brackets that represents a useful rectified current of the frequency transmitted is the second. The first and third terms indicate a steady rectified current and a rectified current of double frequency. The last is small if κ is small but leads to distortion. In any case the useful rectified current is

$${}_2i_p = \frac{\sigma a^2}{2\pi b}\kappa \sin pt \quad \ldots \quad \ldots \quad (7a)$$

Similarly from (6) the useful rectified current in the absence of the biassing wave is

$${}_1i_p = \frac{\sigma}{\pi} a\kappa \sin pt \quad \ldots \quad \ldots \quad (6a)$$

The ratio R of the audible signal in the presence of the biassing wave to the audible signal in the absence of the biassing wave will be from (7a) and (6a).

$$R = {}_2i_p/{}_1i_p$$
$$= \frac{a}{2b} \quad \ldots \quad \ldots \quad (8)$$

in agreement with the results obtained for this case ($b > 2a$) by other writers.

The effect of the weak signal on the strong one can be obtained from the expression for γ' equation (3), if g is replaced by a and a by b, giving

$$\gamma' = \cos\phi - \frac{a}{b}\left(\frac{\pi}{2} - \phi\right), \text{ where } \sin\phi = \frac{a}{b} \quad \ldots \quad (9)$$

Rectification of the wave $b \sin \omega_2 t$ takes place during the whole cycle; γ in equation (2) is one, and the mean value of γ' is required with ϕ varying from 0 to 2π.

If a/b is small, $\phi \doteq a/b$, $\cos\phi \doteq 1 - \frac{1}{2}\left(\frac{a}{b}\right)^2$ and (9) becomes

$$\gamma' = 1 + \frac{1}{2}\left(\frac{a}{b}\right)^2 - \frac{\pi}{2}\frac{a}{b}$$

Since a varies sinusoidally the mean value of $(a/b)^2$ is $a^2/2b^2$ and the mean value of a/b is zero. Thus

$$\bar{\gamma}' = 1 + \tfrac{1}{4}\left(\frac{a}{b}\right)^2$$

In the absence of the wave $a \sin \omega_1 t$ the wave $b \sin \omega_2 t$ gives a rectified current

$$\bar{i}_1 = \frac{\sigma}{\pi} . b \quad \ldots \quad \ldots \quad (10)$$

In the presence of the wave $a \sin \omega_1 t$ the rectified current is

$$\bar{i}_2 = \bar{\gamma}' \, \bar{i}_1 = \frac{\sigma}{\pi}\left(b + \frac{a^2}{4b}\right) \quad \ldots \quad (11)$$

Suppose now that the strong signal is modulated and $b(1 + \kappa \sin pt)$ is written instead of b. Equation (11) becomes

$$\bar{i}_2 = \frac{\sigma}{\pi}\left\{b(1 + \kappa \sin pt) + \frac{a^2}{4b(1 + \kappa \sin pt)}\right\}$$
$$= \frac{\sigma}{\pi}\left\{b(1 + \kappa \sin pt) + \frac{a^2}{4b}(1 - \kappa \sin pt + \kappa^2 \sin^2 pb - \kappa^3 \sin^3 pt \ldots)\right\}$$

and the required acoustic signal is given very nearly by

$$_2i_p = \frac{\sigma}{\pi}\left\{b\kappa \sin pt - \frac{a^2}{4b} \kappa \sin pt\right\}$$
$$= \frac{\sigma b}{\pi}\left\{1 - \frac{a^2}{4b^2}\right\}\kappa \sin pt \quad \ldots \quad \ldots \quad (12)$$

In the absence of the weak signal (now regarded as the biassing wave) the acoustic signal is from (10)

$$_1i_p = \frac{\sigma}{\pi} \, b\kappa \sin pt \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

and the ratio of the acoustic signals in the two cases is from (12) and (13)

$$R = {_2i_p}/{_1i_p} = 1 - \tfrac{1}{4}\frac{a^2}{b^2} \quad \ldots \quad \ldots \quad (14)$$

in agreement with Appleton and Boohariwalla.

It is evident from equations (8) and (14) that the present writer's point of view of the problem leads to exactly the same results that have been obtained by other writers in the case of $b > 2a$ considered, although the method of attack has been entirely different. It seems probable, therefore, that the present point of view is justified, and it has certainly enabled the present writer to obtain a clearer insight into the problem than he had before.

The description " Apparent Demodulation " used by previous writers would appear to be quite misleading. In the presence of a strong signal, for a part of the time a weak signal is not detected at all, since it has no effect whatever on the rectified current: during the rest of the time the detection is not as strong as it should be, since the effect of the weak signal on the rectified current is less than it would be in the absence of the strong signal. It may be stated, therefore, that there is no question of " demodulation " (meaning a loss of modulation). The modulation of the weak wave is unaltered by the presence of the strong wave; the reduced acoustic signal is simply due to the fact that the modulated high-frequency signal is not " received " at all during a part of the time, and during the rest of the time it is not " received " at its normal strength. The rectifier is put more or less completely out of action to the weak signal by the presence of the strong signal acting as a biassing wave.

Multiples & Sub-multiples of Ten.

THE Committee of the Verband Deutscher Elektrotechniker, which, through a number of sub-committees, has been engaged for some years on the definition of units and symbols, has recently published the following table of suggested names and abbreviations for multiples and sub-multiples of the units. Some of these are well known and universally employed, but others are quite new and must appear somewhat strange on a first acquaintance.

$T = 10^{12}$ Tera.	$d = 10^{-1}$ Dezi.
$G = 10^{9}$ Giga.	$c = 10^{-2}$ Zenti.
$M = 10^{6}$ Mega.	$m = 10^{-3}$ Milli.
$k = 10^{3}$ Kilo.	$\mu = 10^{-6}$ Mikro.
$h = 10^{2}$ Hekto.	$n = 10^{-9}$ Nano.
$D = 10^{1}$ Deka.	$p = 10^{-12}$ Pico.

We have given the actual spelling as it appears in the German original; in English we write hecto, deca, deci, centi and micro.

The suggested Tera comes from the Greek τέρας, which may be translated " monster." The distance from the sun to Saturn is about 1.4 *Tm*, to Uranas 2.8 *Tm* and to Neptune 4.5 *Tm*. The origin of " Giga " is fairly obvious. " Nano " is presumably from the Greek " nanos," a dwarf. " Pico " —associated with the Italian " piccolo "—is a British suggestion, adopted by the German Committee from the B.E.S.A. Glossary; they favour, however, the abbreviation " p " in preference to the more cumbersome " $\mu\mu$."

G.W.O.H.

The Graphical Solution of Detector Problems.

By G. S. C. Lucas, A.M.I.E.E.
(B.T.H. Co., Engineering Laboratory.)

(Concluded from page 207 of last issue.)

ANODE BEND.

THE graphical solution of problems in anode bend detection requires a new characteristic known as the $E_p/m - I_p$ characteristic. As far as the writer is aware, this characteristic was first explained by Mr. L. J. Davies, in a lecture given before the Rugby Engineering Society in 1928, and has not been mentioned in any publication other than the proceedings of the Rugby Engineering Society. The following description is taken in full from Mr. Davies' lecture.

$E_p/m - I_p$ Characteristic.

"A valve has the following data specified :—

Amplification factor (m)

Anode resistance (Ra)

Slope or mutual conductance $= \frac{m}{Ra}$

Max. working anode voltage (E_p)

Max. anode current (I_p)

Max. plate watts dissipation ($E_p \times I_p$)

" In addition to this data, there will usually be supplied with a valve a set of characteristic curves. These curves show the varia-

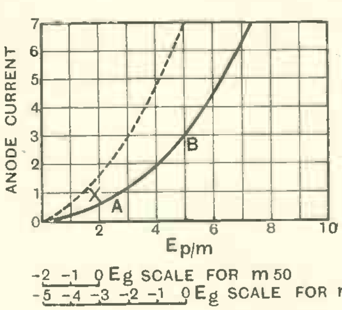

Fig. 6.—*$I_a/E_p/m$ curves for triode valves.*

tion of anode current with grid volts for different values of anode voltage. A better realisation of the meaning of valve constants can be obtained by considering the type of curve shown in Fig. 6. Here are shown curves of anode current plotted against the voltage E_p/m, the grid voltage being kept constant at zero by connecting the grid to the filament. From the single curve given, providing the constructional constants K and l/r grid* are kept constant, the anode current under any conditions of m factor, anode or grid voltage can be obtained. For example, suppose that a valve has constructional constants that give the curve shown by the full line, then if the m factor is 50 and the anode voltage 100, the anode current will be given by the point A. The voltage axis can now represent the grid volts, these being zero, by definition, at the point A, and negative to the left of A and positive to the right. The curve OXA represents the ordinary valve characteristic of the valve with 100 volts on the anode. If the grid mesh is changed so that the m factor becomes 20, then for the same anode voltage —*i.e.*, 100—the anode current will be given by the point B, since

$$\frac{E_p}{m} = \frac{100}{20} = 5$$

and, similarly, the voltage scale can be made the grid voltage scale, and the curve OAB becomes the usual grid voltage/anode current characteristic curve for a valve with m factor of 20. It will be observed that whatever the m factor, this curve is but part of a general curve provided that the constructional constants of the valve are not altered. It will follow, also, that the available grid swing from a negative value at which the current is zero to $E_g = 0$ depends upon the m factor and the anode voltage.

If the construction of the valve is altered, the assembly remaining the same, but the ratio filament length/grid radius altered,

*K = Assembly constant for valve.
r = Grid radius.

a new curve will be traced having a different slope. *E.G.*, if the filament length is doubled the curve will be that shown by the broken line. It will also be seen that the slope will vary along the curve, getting steeper as the anode volts are increased or the *m* factor is lowered."

It will be seen, therefore, that this single curve represents the whole family of $E_g - I_p$ curves not only for a valve of given "*m*" factor, but for all valves of the same general construction. Since the whole family of curves can be constructed from one $E_p/m - I_p$ curve, this curve can be reconstructed from any set of $E_p - I_p$ curves, or $I_p - E_g$ curves.

General Principle of Anode Bend Detection.

Following on the method adopted for grid detection, the general principle of anode bend detection will be discussed leading to a description of the graphical method and a worked example.

Consider first a thermionic valve as shown in Fig. 7, with an alternating voltage applied

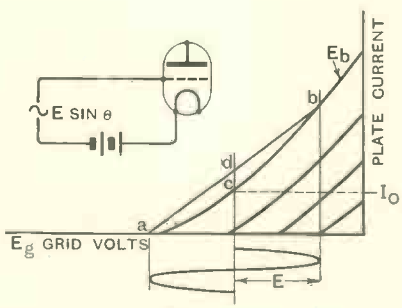

Fig. 7.

to the grid. The operation of the valve under such conditions can be completely studied with the aid of the $E_g - I_p$ curves. With a battery voltage E_b and a bias voltage E_g the steady plate current is given by I_0 and if an alternating signal E volts (max.) is injected into the grid circuit the steady plate current is increased. As in the case of grid detection the increase in current can be determined graphically by joining the points *ab* by a straight line, and taking $\frac{1}{2}cd$ as the change in plate current. By repeating the construction for a number of different values of E the relation between the change in amplitude of the A.C. signal on the grid and the change in plate current, can be determined.

The usual arrangement for anode bend detection is shown in Fig. 8, where a resistance R_x is connected in the anode circuit and shunted with a condenser "*C*," the impedance of which, compared with R_x and

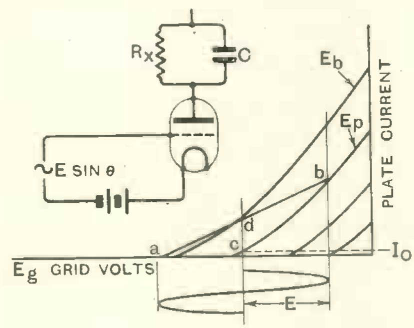

Fig. 8.

the valve resistance R_a, is negligible at the frequency of the A.C. signal.

The resistance R_x drops the plate voltage from E_b to E_p, and since the impedance of C is small the A.C. resistance of the valve is unaltered and the valve operates on an $I_p - E_g$ for a plate voltage E_p.

With no signal on the grid the plate current is I_0, but with a signal E volts the D.C. plate current is increased by an amount $i = \frac{1}{2}cd$, and this current flowing through the resistance R drops the plate volts by an amount iR. Thus, if the amplitude of E is slowly changed, the mean D.C. current changes and therefore the plate voltage on the valve, and if the change in amplitude of E is effected by modulating E with a low frequency voltage, the value of the low frequency voltage appearing across R is iR where i is the change in plate current.

When the plate voltage has increased or decreased due to the change in plate current flowing through the resistance R_x, the valve operates on a new $I_p - E_g$ curve corresponding to the new plate voltage and for every change in plate voltage, rectification takes place along a different curve. It will be apparent, therefore, that since the instantaneous plate voltage depends upon the current, and the current depends upon the particular characteristic on which the valve is rectifying, the final steady value of plate voltage when a signal is applied to the grid, can only be determined by a trial and error method, and although the $I_p - E_g$ curves assist us in a qualitative analysis, they are not very useful for quantitative measurements.

By using the $I_p - E_p/m$ characteristic instead of the $I_p - E_g$ curves, it is possible to take this change from one curve of the family to another into account and so obtain a complete solution.

Application of $I_p - E_p/m$ Curves.

Fig. 9 shows an $I_p - E_p/m$ characteristic for valves of the 407 class and if m is fixed the abscissae can be rescaled in terms of E_p and E_g.

In the simplest case where R_x and $C = 0$ if the bias is fixed at E_g, the amplitude of the rectified current, when a signal "E" volts is applied to the grid, can be determined in exactly the same way as with the $I_p - E_g$ curves.

Considering the second case where a resistance R_x shunted by a condenser C, is connected in the plate circuit as shown in Fig. 8, let the bias volts be fixed at E_g volts (see Fig. 9) so that with no signal on the grid the plate current is I_0. On injecting an A.C. signal into the grid circuit the plate current is increased and the plate voltage decreased by amounts depending upon the amplitude of the A.C. signal.

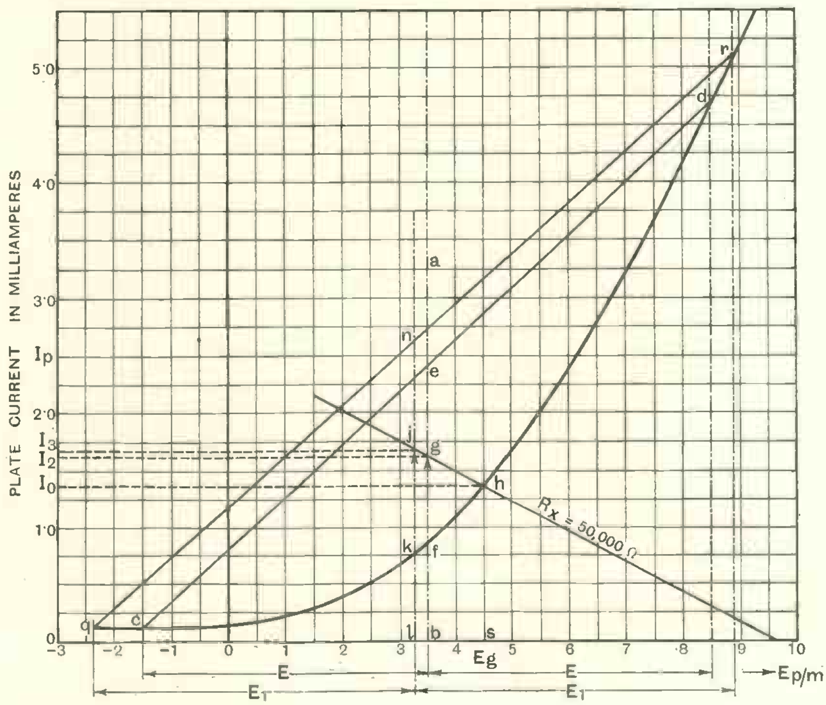

Fig. 9.—*$I_p - E_p/m$ curve for valves of the 407 class.*

The relation between the decrease in plate voltage and increase in current can be shown graphically by drawing a line hg through the point h such that the slope of the line is equal to the external resistance R_x. Then if the plate current changes from I_0 to I_2 the change in plate voltage is given by $sb \times$ "m" factor of the valve. The amplitude of the signal E on the grid necessary to produce this change in plate current is determined in the following way :—

Extend the line fg to e so that $fg = ge$ and draw the line ced to meet the curve, so that $ce = ed$, then the amplitude of the signal E on the grid is given by reading along the grid volts scale. By repeating this construction for a number of different values of plate current the relation between rectified current and amplitude of the signal on the grid can be found.

In practice, the amplitude of the signal E is altered by modulating it with a low frequency voltage, and if the amplitude of the carrier and the depth of modulation are known, the amplitude of the low frequency voltage appearing across the anode resistance R can be determined as follows :—

Determination of Efficiency of Anode Bend Rectification.

For the present it is assumed that the condenser C shunting the resistance R_x has infinite reactance at the frequencies of the modulating voltages and zero reactance at the frequency of the carrier. The choice of the condenser is discussed on Appendix 1. Then given

(*a*) $I_p - E_p/m$ characteristic of valve.

(*b*) m factor of valve.

(*c*) Amplitude of carrier signal " E."

(*d*) Anode load resistance " R_x."

find the efficiency of the valve as an anode bend detector.

Fig. 9 shows the $I_p - E_p/m$ characteristic of the 407 class of valve, and in order to obtain maximum efficiency it is necessary to work on the point of the curve where the rate of change of slope is greatest. Through this point draw the line *ab* and step off on either side a grid voltage equal to the maximum amplitude of the carrier signal " E." Join the points *cd* by a straight line. Then the amplitude of the rectified current is $\frac{1}{2}ef = gf$ and the steady plate current is equal to *gb*.

Through the point *g* draw the line *gh* with a slope equal to the resistance R_x in the anode circuit.

Take another point *j* and find the increase in amplitude of the carrier signal E necessary to produce an increase in the plate current from I_2 to I_3 as follows. Extend the line *kj* to *n* and draw the line *qnr* to meet the curve so that $qn = nr$. Then the increase in grid signal is $(E_1 - E)$ volts and the change in plate voltage is given by $lb \times$ " m " volts.

The efficiency of rectification, therefore, is

$$\frac{lb \times \text{“} m \text{”}}{(E_1 - E)} \times 100\ \%$$

where " m " is the amplification factor of the valve.

The *DC* plate current when $E = O$ is given by the intersection of the curve and the resistance line *gh* (*i.e.* point I_0).

The bias voltage is determined by the maximum value of " E " (*i.e.* max. value of carrier + max. value of modulating voltage) since the valve must be so biased that the grid is never at a positive potential with respect to the cathode. Then having fixed the bias the plate voltage is given by

$$E_p = (OS + E_{\text{bias}}) \times \text{“} m \text{”}$$

where *OS* is the value of E_p/m at the point *h*. The battery voltage is then

$$E_b = E_p + I_0 R_x$$

where I_0 is the steady plate current at point *h* and R_x is the resistance in the anode circuit.

Choice of Anode Resistance and " *m* " Factor.

The choice of anode resistance " R_x " and " m " factor of the valve is very important where the maximum efficiency of rectification is required. It can be shown that the higher the values of m and R_x the greater is the efficiency, always assuming that there is no limit to the battery voltage available and that the limits of m and R_x are not already fixed by consideration of stray capacity, etc. In practice, the battery voltage available is usually the limiting feature, and then it is better to use a medium value of " m " factor and a fairly low value of resistance. The optimum working conditions can be fairly readily determined from the graphical construction.

Example.

Below is given a worked example of the graphical method of solution applied to a particular valve. It is required to know the efficiency and best values of plate and battery voltage, grid bias and shunting capacity when given,

Highest frequency of audio signal	$= 5 \times 10^3$ cycles
Frequency of carrier	$= 4 \times 10^5$ cycles
Anode resistance	= 50,000 ohms
Max. value of carrier voltage	= 5 volts
Using a G.P. 407 valve " m " factor	= 13.4

The $I_p - E_p/m$ curve for 407 class of valves is given in Fig. 9.

Determine the point of max. rate of change of slope and then draw line *ab* through this point. Step off 5 volts on either side of line *ab* (*i.e.*, 5 div. of E_p/m) and join the points *cd* by a straight line.

Halve *ef* and through point *g* draw the line *jgh*, the slope of which is equal to 50,000 ohms.

Take a second point *j* and extend *kj* to *n* such that $kj = nj$ and draw the line *qnr* to meet the curve such that $qn = nr$. Measure E_1.

Then efficiency =

$$\frac{lb \times m}{E_1 - E} = \frac{.25 \times 13.4}{5.625 - 5.0} = \frac{3.35}{.625} = 5.4$$

Assuming a depth of modulation of 50 per cent. max., the voltage on the grid is $5 \times 1.5 = 7.5$ volts. The bias voltage must be at least equal to this and allowing a small margin make the bias voltage − 9 volts.

Then mean plate voltage with no signal in the grid

$$(4.5 + 9) \times 13.4 = \text{volts } 181$$

and from the curve the mean plate current with no signal on grid = 1.3 mA.
Therefore battery volts

$$= 181 + [1.3 \times 50 \times 10^{-3} \times 10^3] = \text{volts } 246$$

Shunting Condenser.

R_x = 50,000 ohms

$\omega_1 = 3.1 \times 10^4$

ω_2 2.5×10^6

R_a = 20,000 ohms (average value given by slope of line *ced*).

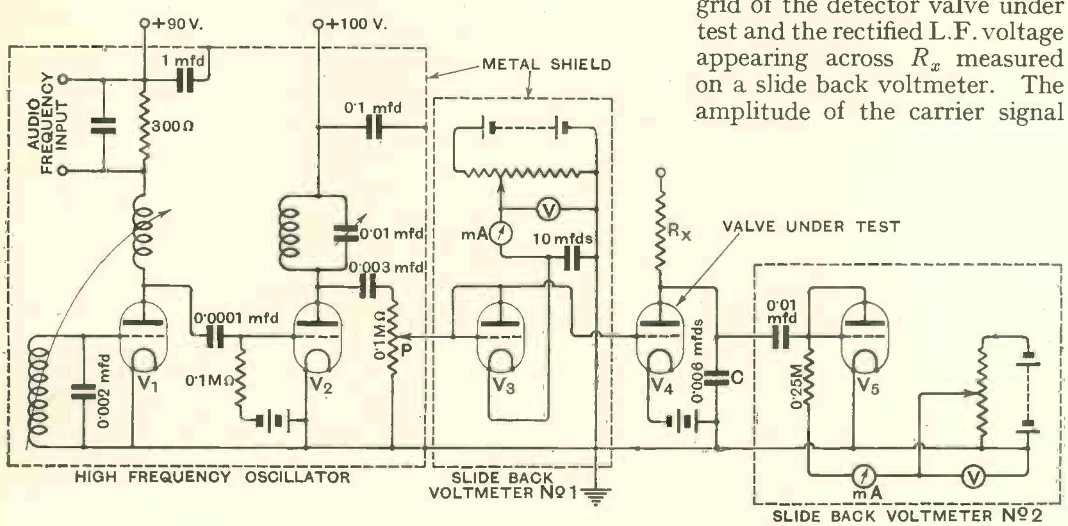

Fig. 10.—*Diagram of connections of test apparatus.*

Substituting these values in

$$p_1 = 1 - \frac{1}{\sqrt{1 + \frac{(\omega_1 C R_x R_a)^2}{(R_x + R_a)}}} = 1 - \frac{1}{\sqrt{1 + (4.4 \times 10^2 C)^2}}$$

and

$$p_2 = \frac{1}{\sqrt{1 + \frac{(\omega_2 C R_x R_a)^2}{(R_x + R_a)}}} = \frac{1}{\sqrt{1 + (3.5 \times 10^4 C)^2}}$$

and substituting for values of C and tabulating

$C \times 10^{-4} \mu F$	2	4	6	8	10
p_2	0.14	0.07	0.046	0.036	0.028
p_1			0.032	0.06	

and the correct value of *C* is between 6 and 8×10^{-4} μF.

The drop in voltage at 5000 cycles due to the condenser *C* is about 4 per cent. and the radio frequency voltage drop across *C* is also about 4 per cent. of the maximum value.

Measurement of Efficiency.

The accuracy of the graphical method was checked by actual measurement. A modulated carrier signal was applied to the grid of the detector valve under test and the rectified L.F. voltage appearing across R_x measured on a slide back voltmeter. The amplitude of the carrier signal and the depth of modulation were measured on a second voltmeter.

A diagram of connections of the apparatus is shown on Fig. 10.

Valve V_1 is the master oscillator, oscillating at 4×10^5 cycles and modulated by a low frequency voltage (500 cycles), from an audio-frequency oscillator, injected into the anode circuit. The modulated output from V_1 is amplified by V_2 which is loaded on to a potentiometer of 10,000 ohms forming the output circuit of the oscillator. V_3 is a slide back voltmeter measuring the peak values of the H.F. output from V_2. The modulated H.F. voltage is applied to the grid and plate of V_3 and to the grid of the detector valve under test V_4. The valve V_5 is part of a second slide back voltmeter reading the A.C. voltage across the anode resistance.

The master oscillator was set to oscillate at 4×10^5 cycles and the output adjusted on the potentiometer P, the voltage being measured on the slide back voltmeter V_3. A low frequency voltage (500 cycles), was injected into the anode of V_1, and the peak voltage again measured on V_3. The difference of the two readings gave the depth of modulation.

The performance and wave form of the oscillator and the output from the detector were checked on a cathode ray oscillograph.

Tests Made with the Apparatus.

The tests consisted of measuring the efficiency of a standard valve as a detector with various values of R_x and checking the measured against the calculated values. The effect of changing the "*m*" factor of the valve was also checked by measuring the efficiency of a number of valves with different "*m*" factors but having the same $I_p - E_p/m$ curve, and keeping the anode resistance R_x constant.

The results of the tests are given below, and it will be seen that they agree fairly well with the calculated figures. Some differences are to be expected owing to the difficulty of making exact measurements.

In conclusion, the writer wishes to acknowledge his indebtedness to the Chief of the Engineering Laboratory and the B.T.H. Company for permission to publish this paper, and to thank the members of the Engineering Laboratory staff who have made so many helpful suggestions and assisted in checking the results.

Test Results in Anode Rectification.

(1) *Efficiency of Rectification for various values of Resistance in the anode circuit.*

Valve G.P. 407, Frequency of H.F. voltage 4×10^5 cycles, Frequency of L.F. modulating voltage 500 cycles, Shunting condenser .0006 μF.

Resis. in Anode (R_x) (ohms). A.	Max. Amp. of H.F. Volts Unmodulated. B.	Max. Amp. of H.F. Volts Modulated. C.	L.F. Voltage Across R_x. D.	Efficiency.	
				Measured $\frac{D}{C - B}$	Calculated.
60,000	5.0	6.3	8.1	6.4	6.45
50,000	5.0	6.3	7.7	5.9	5.4
40,000	5.0	6.3	7.1	5.4	5.0
30,000	5.0	6.3	6.0	4.6	4.5
20,000	5.0	6.3	4.8	3.7	3.35
10,000	5.0	6.3	3.1	2.4	1.7

(2) *Efficiency of Rectification for various "m" factors.*

Valves H.F. 407, G.P. 407, L.F. 407, and P. 415 anode resistance, 50,000 ohms.

Valve.	"*m*."	Max. Amp. of H.F. Volts.	Max. Amp. of H.F. Volts Modulated.	L.F. Voltage Across R_x.	Efficiency.	
					Measured.	Calculated.
HF.407 ..	23.0	5.0	6.4	13.6	9.7	9.0
GP.407 ..	13.5	5.0	6.4	8.5	6.05	5.4
LF.407 ..	6.8	5.0	6.3	5.0	3.85	4.0
P.415 ..	5.1	5.0	6.3	3.8	2.9	2.5

The Analysis and Design of a Chain of Resonant Circuits.*

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

SUMMARY.—This article is divided into two parts. The first contains an analysis of a chain of resonant circuits consisting of two, three, and four links, respectively. The second part will be concerned with the factors which influence the design of the above systems. It is shown that the design of chains consisting of an odd number of links must be treated differently from those which contain an even number of links.

Part I.

CONSIDER a chain of resonant links as shown in Fig. 1, where each link has total resistance R, inductance L, and capacity C, and adjacent links are coupled with mutual inductance M.

If Z is the impedance of a link at frequency f given by $f = \frac{\omega}{2\pi}$, then

$$Z = R + j\left(\omega L - \frac{1}{\omega c}\right) = p + jq \quad .. \quad (1)$$

Therefore $\frac{q}{p} = \frac{\omega L}{R}\left(1 - \frac{1}{\omega^2 LC}\right)$

If we put $\omega_0 = \frac{1}{LC}$ and $\frac{{\omega_0}^2}{\omega^2} = x$, we have

$$\frac{q}{p} = \frac{\omega L}{R}(1 - x).$$

Now the ratio $\frac{\omega L}{R}$, expressed as m, is

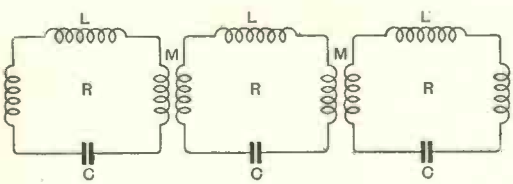

Fig. 1.

known as the amplification factor of the coil, and it may generally be assumed to remain constant over the frequency band for which a resonance curve is of practical interest.

The above equation may therefore be written

$$\frac{q}{p} = m(1 - x) \quad .. \quad .. \quad (2)$$

Hence for any given circuit, the above equation provides a ready means for obtaining the value of x from the ratio q/p. Also this ratio can be used as a measure of the magnitude of x. In practice, the value of q is generally varied by altering the value of the condensers. Below, we shall assume that the condensers of all the links are ganged, so that the change in the value of q will be the same for all links.

In the first instance, the case where there are only two links will be analysed. This circuit has already been investigated quite fully elsewhere,† but for the sake of completeness and also to illustrate the treatment employed to analyse the other cases, it is also considered here.

1. Two Links.

If we assume that E is the voltage applied in series with the first link and that I_2 is the current in the second link, then Prof. E. Mallett has shown‡ that

$$Z_{12} = \frac{E}{I_2} = \frac{1}{j\omega M}(\omega^2 M^2 + Z^2) \quad .. \quad (3)$$

We have, therefore, from equations (1) and (3) that

$$|Z_{12}|^2 = \omega^2 M^2\left(1 + \frac{2p^2}{\omega^2 M^2} + \frac{p^4}{\omega^4 M^4} - \frac{2q^2}{\omega^2 M^2} + \frac{q^4}{\omega^4 M^4} + \frac{2p^2 q^2}{\omega^4 M^4}\right) \quad .. \quad (4)$$

If we put $|Z_{12}|^2 = t$, then

$$\frac{dt}{dq} = 4q\left(\frac{q^2}{\omega^2 M^2} + \frac{p^2}{\omega^2 M^2} - 1\right) \quad .. \quad (5)$$

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

† "A Vector Loci Method of Treating Coupled Circuits," by Prof. E. Mallett, *Proc. of the Royal Society*, A, Vol. 117, 1928.

‡ "Chains of Resonant Circuits," *J.I.E.E.*, Sept., 1928, page 971.

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and $$\frac{d^2t}{dq^2} = 4\left(\frac{3q^2}{\omega^2M^2} + \frac{p^2}{\omega^2M^2} - 1\right) \quad \ldots \quad (6)$$

Putting $$r = q^2/\omega^2M^2 \quad \ldots \quad \ldots \quad (7)$$

$$\text{and } s = \frac{p^2}{\omega^2M^2} = \frac{1}{m^2k^2} \quad \ldots \quad (8)$$

where k is equal to the value of the coupling factor, enables equations (4), (5), and (6), respectively, to be written

$$\frac{|Z_{12}|^2}{p^2} = \frac{(r+s)^2 + 2(s-r) + 1}{s} \quad \ldots \quad (9)$$

$$\frac{dt}{dq} = 4q(r + s - 1) \quad \ldots \quad \ldots \quad (10)$$

$$\frac{d^2t}{dq^2} = 4(3r + s - 1) \quad \ldots \quad \ldots \quad (11)$$

Now for a given input voltage E, the value of I_2 will be inversely proportional to the value of $|Z_{12}|$. In a given system, the ratio $\left|\frac{p}{Z_{12}}\right|$ can therefore be used as a measure of the magnitude of the secondary current, and a curve plotted between the ratios $|p/Z_{12}|$ and q/p will correspond to the resonance curve of the system.

The maxima and minima of equation (9) are obtained by equating $\frac{dt}{dq}$ to zero. We have therefore that the values of x at which these occur are given by

$$q = 0 \quad \ldots \quad \ldots \quad (12)$$

$$\text{and} \quad r + s - 1 = 0 \quad \ldots \quad \ldots \quad (13)$$

From equation (12) we have that one value is obtained at resonance, and from equations (7), (8), and (13), that the other values are given by

$$r = \frac{q^2}{p^2} \cdot s = 1 - s \quad \ldots \quad \ldots \quad (14)$$

$$\text{or} \quad \frac{q}{p} = \pm\sqrt{\frac{1-s}{s}} \quad \ldots \quad \ldots \quad \ldots \quad (15)$$

Equation (15) demonstrates that the resonance curve will only have the well-known double peak if $s < 1$. For values of s greater than unity, the resonance curve will have only one peak, namely, at resonance. The critical value of the coupling is therefore given by $s = 1$ or $k^2 = 1/m^2$ (from equation (8)).

When $s = 1$, equation (11) shows that $\frac{d^2t}{dq^2}$ is zero when $r = 0$, thus indicating that a point of inflexion is obtained at resonance for this value of s. Investigation of the sign of $\frac{d^2t}{dq^2}$ for values of s above and below unity shows that this is due to the fact that at this point

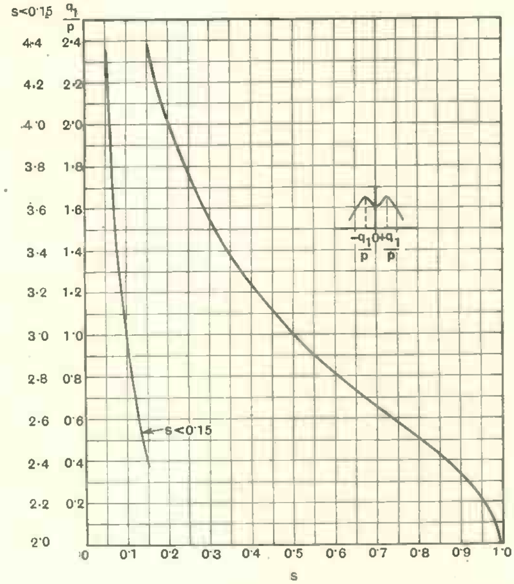


Fig. 2.—*Links* = 2. *Position of peaks.*

we go from a trough to a crest on the resonance curve. The sign of $\frac{d^2t}{dq^2}$ for the values of r given in equation (14) and for the condition $s < 1$, shows that the values given by equation (15) correspond to peaks on the resonance curve.

Fig. 2 gives a curve plotted between q/p and s, for convenience, only the upper sign of (15) is taken. From this curve it is seen that as the coupling is reduced so the peaks come closer together, and they occur nearer to the resonance point. At the critical coupling the peaks coincide.

At resonance, $r = 0$, therefore we have from equation (9) that

$$\left|\frac{p}{Z_{12}}\right|_{q=0} = \sqrt{\frac{s}{(s+1)^2}}$$

This is a maximum when $s = 1$, hence

$$\left(\left|\frac{p}{Z_{12}}\right|_{q=0}\right)_{\max.} = \tfrac{1}{2} \quad \ldots \quad \ldots \quad (17)$$

From equations (9) and (14) we deduce

that at the peaks

$$\left|\frac{p}{Z_{12}}\right|_{q=\pm q_1} = \tfrac{1}{2} \quad .. \qquad .. \ (18)$$

which shows that increase of coupling beyond the critical value produces no alteration in the secondary current maximum. Fig. 3, plotted from equation (14), shows how the value of the secondary current at resonance is influenced by the coupling.

The properties of the simple coupled circuits are summarised below.

Summary.

1. If $s < 1$, then the resonance curve has two peaks, the points at which these peaks occur, for different values of the coupling, are given by Fig. 2.
2. Increase of coupling above the critical values does not alter the magnitude of the secondary current at these peaks.
3. This current is equal in magnitude to the value obtained at resonance when the coupling has the critical value. For other values of the coupling, the magnitude of the secondary current at resonance is shown in Fig. 3.
4. The value of the coupling which gives maximum current at resonance is the same as the value at which the resonance curves cease to have two peaks.
5. The resonance curve is symmetrical about the resonance position.

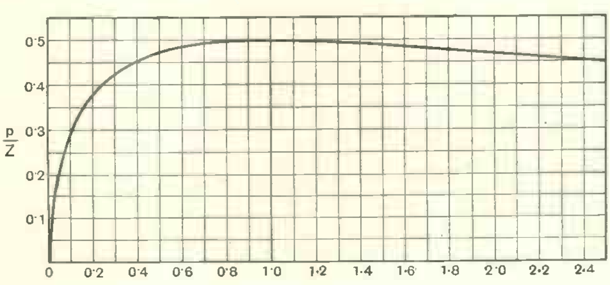


Fig. 3.—*Links* = 2. *Amplitude at resonance.*

2. Three Links.

In this case we have that*

$$Z_{13} = -Z\left(2 + \frac{Z^2}{\omega^2M^2}\right) \quad .. \ (19)$$

Substituting from equation (1), this reduces to

$$|Z_{13}|^2 = \omega^2M^2\left(\frac{p^6}{\omega^6M^6} + \frac{4p^4}{\omega^4M^4} + \frac{4p^2}{\omega^2M^2} + \frac{3p^4q^2}{\omega^6M^6} + \frac{3p^2q^4}{\omega^6M^6} + \frac{4q^2}{\omega^2M^2} - \frac{4q^4}{\omega^4M^4} + \frac{q^6}{\omega^6M^6}\right) \quad (20)$$

Putting $|Z_{13}|^2 = t$, we obtain

$$\frac{dt}{dq} = q\left\{\frac{6q^4}{\omega^4M^4} - \frac{4q^2}{\omega^2M^2}\left(4 - \frac{p^2}{\omega^2M^2}\right) + 2\left(4 + \frac{3p^4}{\omega^4M^4}\right)\right\} \quad .. \ (21)$$

After substituting from equations (7) and (8), the above may be written

$$\frac{|Z_{13}|^2}{p^2} = \frac{(s+r)^3 + 4(s+r)(1+s-r)}{s} \quad (22)$$

and

$$\frac{dt}{dq} = 2q\{3r^2 - 2r(4-3s) + (4+3s^2)\} \quad (23)$$

If we equate $\frac{dt}{dq}$ to zero, then it is possible for equation (23) to have five roots, one of which will always be zero.

If the equation is to have only one root, namely $q = 0$, then it is necessary that the equation

$$3r^2 - 2r(4-3s) + 4 + 3s^2 = 0 \quad (24)$$

should have no real roots.

For this condition the resonance curve will have only one peak, *i.e.*, at resonance, and we shall thus obtain the value of the critical coupling.

The condition that equation (24) should have no real roots is

$$3(4+3s^2)^2 > (4-3s)^2$$

The critical value for the coupling is therefore given by

$$s = \tfrac{1}{6} \quad .. \qquad .. \qquad .. \ (25)$$

For values of s less than this, the roots of equation (24) will be given by

$$r = \frac{(4-3s) \pm \sqrt{(4-3s)^2 - 3(4+3s^2)}}{3}$$

$$= \frac{(4-3s) \pm 2\sqrt{1-6s}}{3}$$

* *Loc. Cit.*, p. 972.

Hence $\frac{q}{p} = \pm \sqrt{\frac{(4 - 3s) \pm 2\sqrt{1 - 6s}}{3s}}$ (26)

thus giving four values for q.

For convenience only the positive values of q/p will be considered.

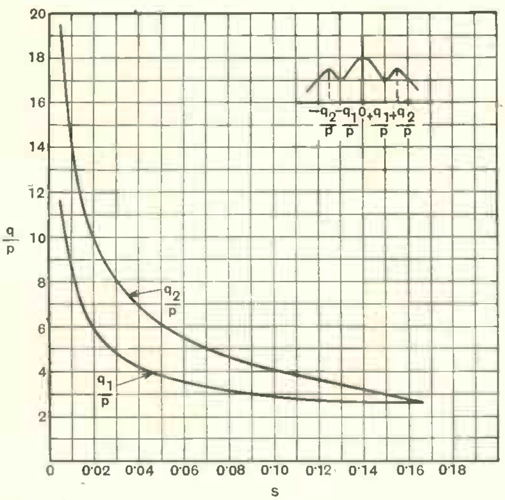


Fig. 4.—*Links* = 3. *Position of crests and troughs.*

Equation (26) gives a ready means for obtaining the relationship between the coupling, and the values of x at which the crests and troughs of the resonance curve will occur. Fig. 4 shows a curve plotted between s and the ratio q/p From this curve it is seen that when the coupling has the critical value, the outside peaks and troughs coincide. Increase of coupling above this value causes these peaks and troughs to move further away from each other and from the resonance point.

Consider now the amplitude of the current in the final link, at the different peaks and troughs.

At resonance, when $r = 0$, we obtain from equation (22) that

$$\left|\frac{p}{Z_{13}}\right|_{q=0} = \frac{1}{s + 2} \quad \ldots \quad (27)$$

It is seen from this equation that at resonance the value of the current in the last link increases so long as the coupling is increased. This case therefore differs from the previous one in that there is no optimum coupling.

From equation (27) it is seen that

$$\frac{d^2}{ds^2}\left(\left|\frac{p}{Z_{13}}\right|_{q=0}\right)$$

is negative for all values of s, hence resonance always occurs on a peak of the resonance curve.

From equation (26) we have that

$$\sqrt{r_1} = \frac{q_1\sqrt{s}}{p} = \sqrt{\frac{(4 - 3s) - 2\sqrt{1 - 6s}}{3}}$$

Substituting this value for r_1 in equation (22) we finally deduce that

$$\left|\frac{p}{Z_{13}}\right|_{q=\pm q_1} = \frac{1}{4}\sqrt{\frac{27s}{1 + 18s - \sqrt{(1 - 6s)}(6s - 1)}} \quad \ldots \quad (28)$$

From equation (26) we also have that

$$\sqrt{r_2} = \frac{q_2\sqrt{s}}{p} = \sqrt{\frac{(4 - 3s) + 2\sqrt{1 - 6s}}{3}}$$

For this value of r_2 we also deduce from

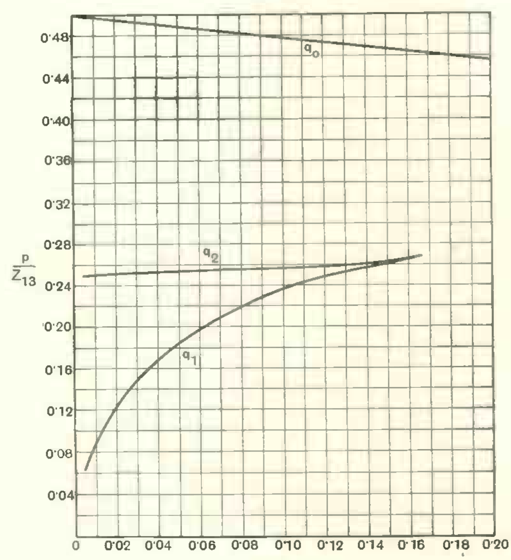


Fig. 5.—*Links* = 3. *Amplitude at crests and troughs.*

equation (22) that

$$\left|\frac{p}{Z_{13}}\right|_{q=\pm q_2} = \frac{1}{4}\sqrt{\frac{27s}{1 + 18s + \sqrt{(1 - 6s)}(6s - 1)}} \quad (29)$$

Fig. 5 shows the above three amplitudes plotted for different values of s. From this figure it is seen that :—

(a) The amplitude at q_2 is greater than that at q_1 for all values of the coupling (*i.e.*, for values greater than the critical coupling), thus showing that the value of x given by the former, corresponds to a crest on the resonance curve.

(b) Whereas the amplitude at the troughs increases quite rapidly as the coupling is reduced, the amplitude at the crests, given by the ratio q_2/p, remains practically constant for all values of the coupling above the critical value. When the coupling is critical, the amplitude at the troughs and at these crests is the same.

(c) For couplings greater than the critical value, the amplitude at resonance is always greater than that at the other peaks, thus showing that maximum current is always obtained at resonance.

The properties of a resonant chain with three links are summarised below

(1) The critical value of the coupling is given by $s = \frac{1}{6}$, for values of s less than this, the resonance curve will have three peaks.

(2) Maximum current is always obtained at resonance. Increase of coupling increases the current at resonance, there being no optimum value for the coupling.

(3) Increase of coupling beyond the critical value does not cause very much change in the value of the current obtained at the two outside peaks, but it causes a decrease in the current obtained at the troughs.

(4) The resonance curve is symmetrical about the resonance position.

3. Four Links.

In this case we have that*

$$Z_{14} = j\omega M\left\{1 + \frac{Z^2}{\omega^2M^2}\left(3 + \frac{Z^2}{\omega^2M^2}\right)\right\} \quad .. \quad (30)$$

Substituting from equation (1) this reduces to

$$|Z_{14}|^2 = \omega^2M^2\left\{1 + \frac{6}{\omega^2M^2}(p^2 - q^2) + \frac{1}{\omega^4M^4}(11p^4 + 6p^2q^2 + 11q^4) + \frac{6}{\omega^6M^6}(p^6 + p^4q^2 - p^2q^4 - q^6) + \frac{1}{\omega^8M^8}(p^8 + 4p^6q^2 + 6p^4q^4 + 4p^2q^6 + q^8)\right\} \quad .. \quad (31)$$

Putting $|Z_{14}|^2 = t$, we have

$$\frac{dt}{dq} = q\left\{-12 + \frac{4}{\omega^2M^2}(11q^2 + 3p^2) + \frac{12}{\omega^4M^4}(-3q^2 - 2q^2p^2 + p^4) + \frac{8}{\omega^6M^6}(q^6 + 3q^4p^2 + 3q^2p^4 + p^6)\right\} \quad (32)$$

and

$$\frac{d^2t}{dq^2} = \left\{-12 + \frac{12}{\omega^2M^2}(11q^2 + p^2) - \frac{12}{\omega^4M^4}(15q^4 + 6q^2p^2 - p^4) + \frac{8}{\omega^6M^6}(7q^6 + 15q^4p^2 + 9q^2p^4 + p^6)\right\} \quad (33)$$

After substituting from equations (7) and (8), the above equations may be written, respectively

$$\left|\frac{p}{Z_{14}}\right|^2 = \frac{s}{(r+s)^4 - 6(r^3 - s^3) + 11(r^2 + s^2) + 6rs(1 - r + s) - 6(r - s) + 1} \quad .. \quad .. \quad (34)$$

$$\frac{dt}{dq} = 4q\{2r^3 + 3r^2(2s - 3) + r(6s^2 - 6s + 11) + (2s^3 + 3s^2 + 3s - 3)\} \quad .. \quad (35)$$

and

$$\frac{d^2t}{dq^2} = 4\{14r^3 + 15r^2(2s - 3) + 3r(6s^2 - 6s + 11) + (2s^3 + 3s^2 + 3s - 3)\} \quad .. \quad (36)$$

From equation (35) it is seen that putting $\frac{dt}{dq} = 0$ makes it possible to obtain seven roots for this equation, one of which is always $q = 0$.

If we put $q = 0$ (*i.e.*, $r = 0$) in equation (36) we obtain

$$\frac{d^2t}{dq^2} = 2s^3 + 3s^2 + 3s - 3$$

hence $\frac{d^2t}{dq^2} = 0$ when $s = 0.56$ .. (37)

For this value of s we have a point of inflexion, and investigation of the sign of $\frac{d^2t}{dq^2}$ shows that the resonance point will lie

* *Loc. cit.*, p. 972.

on a trough of the resonance curve for couplings greater than the value given by equation (37), and on a crest for lower values of the coupling.

Before investigating the other roots given by equation (35), it would perhaps be best to consider the general equation of a cubic.

Suppose we have a cubic equation of the form

$$ar^3 + 3br^2 + 3cr + d = 0 \quad \ldots \quad (38)$$

then if we put $y = ar + b$ .. .. (39)

$$A = b^2 - ac \quad \ldots \quad (40)$$

and $$B = a^2d - 3abc + 2b^3 \quad (41)$$

equation (38) becomes

$$y^3 - 3Ay + B = 0 \quad \ldots \quad (42)$$

The nature of the roots of this equation depends upon the algebraic sign of A and the relative numerical magnitudes of A and B.

Case 1.—A positive and $B < 2A\sqrt{A}$ (B may be either positive or negative). Put

$$\phi = \tfrac{1}{3}\sin^{-1}\left[\frac{B}{2A\sqrt{A}}\right]$$

Then the three roots of equation (42) are

$$y_1 = 2\sqrt{A}\sin\phi \quad \ldots \quad (43)$$

$$y_2 = 2\sqrt{A}\sin(\phi + 120°) \quad \ldots \quad (44)$$

$$y_3 = 2\sqrt{A}\sin(\phi - 120°) \quad \ldots \quad (45)$$

and all three roots are real.

Case 2.—A positive and $B > 2A\sqrt{A}$, B is also positive.

Put $$u = \tfrac{1}{3}\cosh^{-1}\left[\frac{B}{2A\sqrt{A}}\right]$$

Then the three roots of equation (42) are

$$y_1 = -2\sqrt{A}\cosh u \quad \ldots \quad (46)$$

$$y_2 = \sqrt{A}\cosh u + \sqrt{-3A}\sinh u$$

$$y_3 = \sqrt{A}\cosh u - \sqrt{-3A}\sinh u$$

In this case the first root is real and the other two are complex quantities.

Case 3.—A negative and B any positive value.

Put $$u = \tfrac{1}{3}\sinh^{-1}\left[\frac{-B}{2A\sqrt{-A}}\right]$$

Then the three roots of equation (42) are

$$y_1 = -2\sqrt{-A}\sinh u \quad \ldots \quad (47)$$

$$y_2 = \sqrt{-A}\sinh u + \sqrt{3A}\cosh u$$

$$y_3 = \sqrt{-A}\sinh u - \sqrt{3A}\cosh u$$

Therefore in this case, the first root is real and the other roots are complex quantities.

From equation (35) we have that the equation whose roots have to be investigated is given by

$$2r^3 + 3r^2(2s - 3) + 3r\left(\frac{6s^2 - 6s + 11}{3}\right) + 2s^3 + 3s^2 + 3s - 3 = 0 \quad \ldots \quad (48)$$

comparing this equation with equation (38), we have that

$$a = 2$$

$$b = (2s - 3)$$

$$c = \frac{6s^2 - 6s + 11}{3}$$

and $$d = 2s^3 + 3s^2 + 3s - 3$$

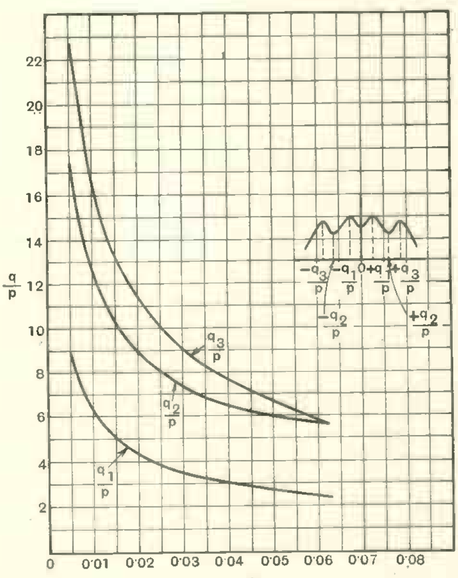


Fig. 6.—*Links* = 4. *Position of crests and troughs.* $s < 0.0625$.

For the above values we obtain from equation (40) that

$$A = \tfrac{5}{3} - 8s \quad \ldots \quad (49)$$

and from equation (41) that

$$B = 40s \quad \ldots \quad (50)$$

From equation (39) we obtain also that

$$y = 2r + 2s - 3$$

or $$r = \frac{y + (3 - 2s)}{2} \quad \ldots \quad \ldots \quad (51)$$

From equations (49) and (50) we can obtain the following information regarding the signs and relative magnitudes of A and B.

1. $s \leqq 0.0625$. A and B are positive and $B < 2A\sqrt{A}$.

2. $0.0625 < s < 0.208$. A and B are positive and $B > 2A\sqrt{A}$.

3. $s \geqq 0.208$. A is negative, B is positive, and $B > 2A\sqrt{A}$.

There is one further factor to be considered. Since r must be positive $\left(\text{to give real values for } \frac{q}{p}\right)$, we have from equation (51) that

$$y + 3 - 2s > 0 \quad \ldots \quad \ldots \quad \ldots \quad (52)$$

Hence we are restricted to those roots which satisfy the above condition.

Investigation shows that the condition is satisfied by all the roots which are obtained when s lies between zero and 0.56. For values of s greater than this, there is no positive value of r which will satisfy equation (48), hence equation (32) will have only one real value of q (namely, $q = 0$) when $\frac{dt}{dq} = 0$. We can therefore deduce that for values of the coupling smaller than that given by $s = 0.56$, the resonance curve will have only one peak, *i.e.*, at resonance. Equation (37) shows that this value of s also gives a point of inflexion.

We can also deduce that the resonance curve will have four peaks for values of the coupling greater than that given by $s = 0.0625$, and that it will have two peaks for couplings greater than that given by $s = 0.56$. There are therefore two critical values of the coupling, the first given by

$$s_1 = 0.0625 \quad \ldots \quad \ldots \quad \ldots \quad (53)$$

and the second by $s_2 = 0.56 \quad \ldots \quad \ldots \quad (54)$

For values of s less than 0.0625, the roots of equation (48) are obtained by calculating the values of A and B from equations (49) and (50), respectively, and substituting these values in equations (43), (44), and (45), respectively. The values of y thus obtained are then substituted in equation (51), and the respective values of q/p are obtained as before. Fig. 6 shows curves relating the values of q/p and of s. From these curves it is seen that as we approach the first critical coupling, the point at which the

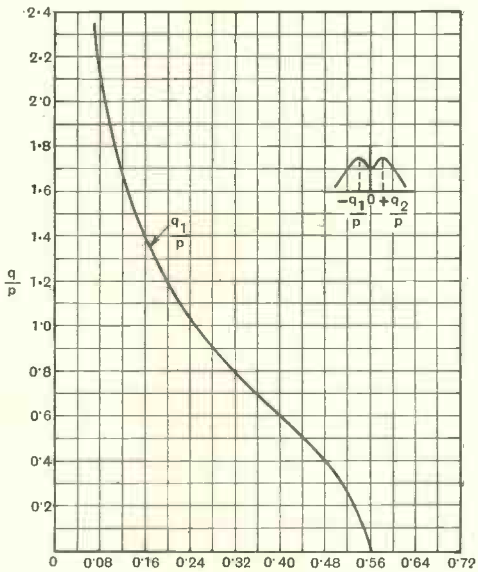


Fig. 7.—*Links* = 4. *Position of crests.* $0.0625 < s < 0.56$.

last crests occur approaches the point at which the last troughs occur. When the coupling is equal to the first critical value these two points coincide. It is also seen that as the coupling is decreased from maximum to the first critical value, the points at which the troughs and crests occur move towards the resonance position.

For values of s greater than 0.0625 and less than 0.208, equation (48) has only one real root, and this is obtained from equations (46) and (51) after substituting the appropriate values of A and B.

For values of s greater than 0.208 and less than 0.56, equation (48) also has only one real root, and this is obtained from equations (47) and (51).

Fig. 7 shows the values of q/p corresponding to values of s which lie between 0.0625 and 0.56. It is seen that this curve is a continuation of the curve shown as q_1 in Fig. 6, and that the points at which the peaks occur approach the resonance position as the coupling is reduced towards the second critical value. These points finally coincide with the resonance position when the value of the coupling is equal to the second critical value.

The values of the current at the crests and troughs will now be considered. As indicated above, these can be obtained from the ratio p/Z_{14} which can be calculated, for any given values of s and r, from equation (34).

In the first place, we shall consider the amplitude at resonance. Here $r = 0$, hence we have from equation (34) that

$$\left|\frac{p}{Z_{14}}\right|_{q=0} = \frac{s}{s^4 + 6s^3 + 11s^2 + 6s + 1} \quad \ldots (55)$$

which has a maximum value when the coupling is given by

$$s_0 = 0.264 \quad \ldots \quad \ldots (56)$$

It is seen that this value differs from the second critical coupling given by equation (54), and it seems to be very nearly equal

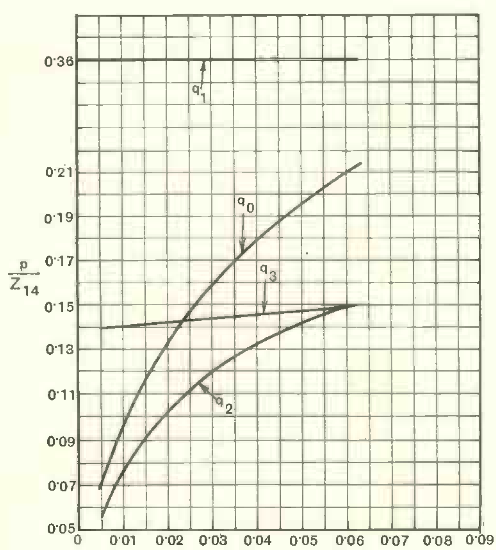


Fig. 8.—*Links = 4. Amplitude of crests and troughs.* $s < 0.0625$.

in value to the arithmetical mean of the two critical couplings.

Consider next the range $0 < s < 0.0625$. The amplitudes of the different crests and troughs are calculated by substituting the appropriate values of r and s obtained from Fig. 6, in equation (34). Fig. 8 shows a curve relating these amplitudes and the value of s. The amplitude at resonance for this range is also shown on this figure. This curve was obtained from equation (55).

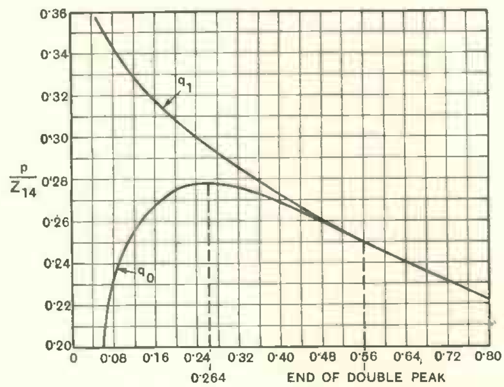


Fig. 9.—*Links = 4. Amplitude at resonance and at peaks.* $s > 0.0625$.

From Fig. 8 it is seen that increase of the coupling beyond the first critical value does not increase the value of the current obtained at the first crests. It is also seen that the current obtained at the outside troughs decreases fairly rapidly as the coupling is increased from the critical value; at the critical value it coincides with the value obtained at the second crests. The current at these crests only decreases by quite a small amount as the coupling is increased from the critical value. Finally, the current obtained at resonance is always greater than the value obtained at the outside troughs, and it is also greater than the value obtained at the second crests for values of the coupling less than that given by $s = 0.023$.

For the range $0.0625 < s < 0.56$, we have seen that there are only two peaks. The amplitude at these peaks, and also the corresponding amplitude at resonance for different values of s, are shown in Fig. 9. From this figure it is seen that decrease of coupling from the first to the second critical value causes the peak and the resonance amplitudes to come closer together until they finally coincide when the coupling is equal to the second critical value. It is also seen that the amplitude at resonance is a maximum at the calculated figure of $s = 0.264$.

The properties of a resonant chain with four tuned circuits are summarised below :—

(1) There are two critical couplings, the first occurring when the resonance curve changes from one having four peaks to one having two peaks, and the second when the curve changes from one of two peaks to one having only one peak. These couplings are given by $s = 0.0625$ and $s = 0.56$, respectively.

(2) This system differs from the one having only two links in that, at resonance, the coupling which gives the point of inflexion, namely, the second critical coupling, is not the same as the value of the coupling which gives maximum secondary current. The latter coupling is given by $s = 0.264$.

(3) Increase of coupling beyond the first critical value does not increase the value of the secondary current obtained at the first peaks.

(4) The resonance curve is symmetrical about the resonance position.

General Conclusion.

From the cases considered above, it seems that for any given number of links, the number of peaks obtained on the resonance curve will decrease, two at the time, as the value of the coupling factor is gradually decreased from unity to zero. The number of critical couplings thus obtained will therefore depend on the maximum number of peaks it is possible to obtain for the given system, *i.e.*, it will depend on the number of links. The relationship indicated seems to be as follows :—

If N = number of critical couplings

and n = number of links,

then for an even number of links

$$N = \frac{n}{2} \qquad \ldots \quad (57)$$

and for an odd number of links

$$N = \frac{n - 1}{2} \qquad \ldots \quad (58)$$

Illustrative Example.

Suppose we have a system which has the following constants :—

$$L = 1000\mu\text{H}.$$

$$R = 10 \text{ ohms}.$$

$$M = 44.6\ \mu\text{H}.$$

Also $\omega_0 = 10^6$

Therefore

$$m = \text{amplification factor} = \frac{\omega_0 L}{R} = 100$$

and

$$s = \frac{p^2}{\omega_0^2 M^2} = 0.05$$

Each of the three cases will now be considered.

a.—Two Links

From Fig. 2 we have for the above value of s that $\frac{q_1}{p} = \pm 4.35$

Hence from equation (2) we deduce that

$$\pm 4.35 = 100(1 - x)$$

Therefore $x = \frac{\omega_0^2}{\omega^2} = 1.0435$ and 0.9565

Now $\omega_0^2 = \frac{1}{LC} = \frac{10^3}{C}$, hence the values of the condenser at which the peaks will appear are given by

$$C_1 = \frac{1000}{1.0435}\ \mu\mu\text{F.} = 960\ \mu\mu\text{F.}$$

and $$C_2 = \frac{1000}{0.9565}\ \mu\mu\text{F.} = 1045\ \mu\mu\text{F.}$$

From Fig. 3 we have that

$$\left|\frac{p}{Z_{12}}\right|_{q=0} = 0.21.$$

Therefore $$\frac{1}{Z_{12}} = \frac{I_2}{E} = \frac{0.21}{10} = 0.021$$

Hence the secondary current at resonance for one volt input is equal to 21 milliamps.

From equation (18) we have that at the peaks

$$\left|\frac{p}{Z_{12}}\right|_{q=\pm q_1} = \tfrac{1}{2}$$

Hence the secondary current at each of the peaks, per volt input, is equal to 50 milliamps.

b.—Three Links.

From Fig. 4 we obtain

$$\frac{q_1}{p} = \pm 3.8 \text{ and } \frac{q_2}{p} = \pm 6.1$$

Substitution in equation (2) shows that for the troughs

$$x_1 = 1.038 \text{ and } 0.962$$

Hence the condenser values at which the troughs will appear are given by

$$C_{t_1} = \frac{1000}{1.038} = 964 \ \mu\mu\text{F}.$$

$$C_{t_2} = \frac{1000}{0.962} = 1040 \ \mu\mu\text{F}.$$

For the peaks

$$x_2 = 1.061 \text{ and } 0.939$$

hence the condenser values for the peaks are given by

$$C_{p_1} = \frac{1000}{1.061} = 943 \ \mu\mu\text{F}.$$

$$C_{p_2} = \frac{1000}{0.939} = 1055 \ \mu\mu\text{F}.$$

From Fig. 5 we obtain

$$\left|\frac{p}{Z_{13}}\right|_{q=0} = 0.488$$

$$\left|\frac{p}{Z_{13}}\right|_{q=\pm q_1} = 0.183$$

and $$\left|\frac{p}{Z_{13}}\right|_{q=\pm q_2} = 0.254$$

The amplitudes, per volt input, are therefore given by

At resonance = 48.8 milliamps.

At troughs = 18.3 milliamps.

At peaks = 25.4 milliamps.

c.—Four Links.

From Fig. 6 we obtain

$$\frac{q_1}{p} = \pm 2.7, \frac{q_2}{p} = \pm 6, \text{ and } \frac{q_3}{p} = 6.7$$

We have therefore at the first peaks that

$$x_1 = 1.027 \text{ and } 0.973$$

hence the condenser values at which these appear are given by

$$C_{p_1} = \frac{1000}{1.027} = 974 \ \mu\mu\text{F}.$$

$$C_{p_2} = \frac{1000}{0.973} = 1027 \ \mu\mu\text{F}.$$

Also at the troughs we have that

$$x_2 = 1.06 \text{ and } 0.94$$

Therefore the condenser values are

$$C_{t_1} = \frac{1000}{1.06} = 945 \ \mu\mu\text{F}.$$

and $$C_{t_2} = \frac{1000}{0.94} = 1065 \ \mu\mu\text{F}.$$

At the second peaks we have that

$$x_3 = 1.067 \text{ and } 0.933$$

Therefore the condenser values are

$$C_{p'_1} = \frac{1000}{1.067} = 938 \ \mu\mu\text{F}.$$

$$C_{p'_2} = \frac{1000}{0.933} = 1070 \ \mu\mu\text{F}.$$

From Fig. 8 we obtain

$$\left|\frac{p}{Z_{14}}\right|_{q=0} = 0.1955, \quad \left|\frac{p}{Z_{14}}\right|_{q=\pm q_1} = 0.36$$

$$\left|\frac{p}{Z_{14}}\right|_{q=\pm q_2} = 0.142$$

and $$\left|\frac{p}{Z_{14}}\right|_{q=\pm q_3} = 0.1465$$

Therefore the currents in the last link, per volt input, are given by

At resonance = 19.55 milliamps.

At first peaks = 36.0 milliamps.

At troughs = 14.2 milliamps.

At second peaks = 14.65 milliamps.

NOTE.—In practice, the frequency range over which the resonance curve is of interest is generally quite small, and at any given point the frequency to which the system is tuned will not differ by very much from the resonance frequency. Therefore, if we assume that the system remains fixed and that the frequency of the input voltage is varied, the values of q/p given above can be used to calculate the frequencies at which the different crests and troughs occur. The example shows that these can be readily calculated, for a given value of q/p, from equation (2).

END OF PART I.

Developments in the Testing of Radio Receivers.

Paper by H. A. Thomas, M.Sc., A.M.I.E.E., read before the Wireless Section, I.E.E., on 2nd March, 1931.

ABSTRACT.

Part 1.—Developments in Technique.

THE paper first describes the improvements in the apparatus installed at the National Physical Laboratory for testing the performance of radio receivers. The general arrangement of the apparatus has been described in a

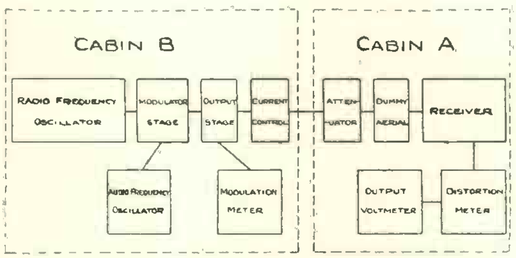


Fig. 1.—*Schematic arrangement of testing apparatus.*

previous paper,* but considerable modifications have been made, particularly in the method of obtaining and measuring the modulated e.m.f. applied to the receiver under test.

The present arrangement is schematically illustrated in Fig. 1.† The generating apparatus is housed in the screened cabin *B*, which consists essentially of a completely shielded room with a mercury trap-door seal. The radio-frequency oscillator gives a good sine-wave form over the range of 10 to 50,000 kc/s. The audio-frequency oscillator is of heterodyne-beat type with a range of 20 c/s to 10 kc/s, the output containing less than 1 per cent. of harmonics. The modulator stage is capable of giving a correct modulation envelope up to a depth of 100 per cent. The general circuit arrangement is shown in Fig. 2. The small-power master oscillator is shown at (1), *b* being the main tuning condenser, *c* a fixed loading condenser to give good wave form, while *a* is a small variable condenser of 15 $\mu\mu$F. giving small changes of frequency, *e.g.*, as for selectivity determinations. This outputs to the modulator (2), whose main tuning is ganged with that of the oscillator. Modulation is effected by applying the audio-frequency voltage in series with the modulator h.t. It has been found possible, by suitable adjustment of the value of the radio-frequency input e.m.f. and of the bias voltage, to obtain a linear relationship between the h.f. current in the tuned-anode circuit and the voltage-supply to the anode. The modulating e.m.f., injected as shown, then gives a modulated output free from frequency-distortion, since the amplitude of the master oscillator remains sensibly unchanged. The output from the modulator stage is taken to a large power-output stage (3) with an aperiodic load circuit which can deliver about 150 milliwatts to the current-control circuit.

Owing to the selective properties of the tuned-anode circuit in the modulator stage, it is necessary to measure the modulation percentage of the current in the output circuit at the actual frequency of modulation then being used. A separate modulation-meter is used for this purpose, the input to it being taken from the outgoing line circuit. The instrument used is of the type due to K. W. Jarvis,‡ consisting essentially of two anode-bend valve-voltmeters, one recording the d.c. component and the other the a.c. component of the rectified current.

The arrangement of the attenuator applying known injection to the dummy aerial is shown at Fig. 4. The leads from the generating equipment

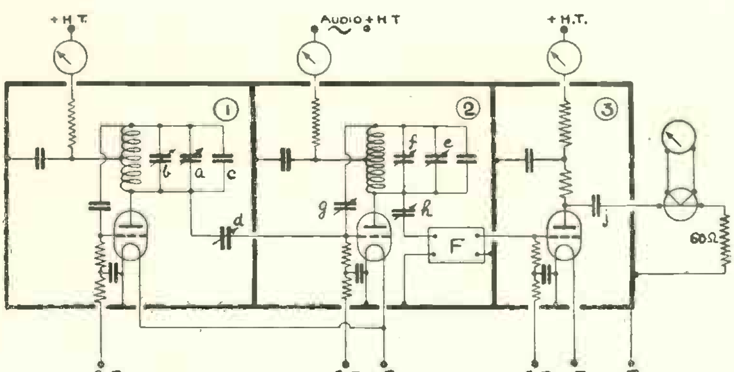


Fig. 2.—*Circuit arrangement of modulated radio-frequency generator.*

are taken to the current divider, consisting of the series and shunt resistances R_1 and R_2. These are in the form of two parallel circles of studs, the two contact-arms being connected mechanically.

* Journal *I.E.E.*, 1930, vol. 68, p. 475; also *E.W. & W.E.*

† The author's original figure numbers have been adhered to throughout this abstract.

‡ *Proc. I.R.E.*, 1929, vol. 17, p. 664.

The values of the steps are arranged so that the division-ratio I_2/I_1 is proportional to the number of studs, 100 in all, while the resistance load is kept constant at 60 ohms. The current I_2 is passed through a special screened resistance R, the voltage across which may be used to supply the dummy aerial or may be further reduced by the potential divider P. Voltages between 1v. and 1μv. can thus be applied to the dummy aerial. This aerial is made up as a small screened unit having, for broadcast receivers, the values recommended by I.R.E. Standardising Committee, *i.e.*, capacity 200 μμF., inductance 20 μH. and resistance 25 ohms. These values are considered typical of an aerial of 4m. effective height.

It is usual to measure the receiver output across a specified non-inductive resistance, which readily gives the power output. This is usually adjusted until it equals the maximum undistorted value for which the valve is rated. The voltage across the resistance is measured by means of a double-range electrostatic voltmeter. The output is also passed to a distortion meter which gives the per-

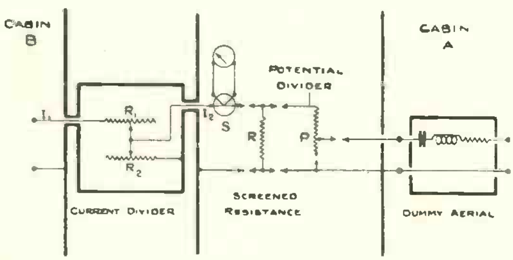


Fig. 4.—*Schematic arrangement of attenuator.*

centage of harmonics present in the output. This meter is illustrated in Fig. 6, and consists of an audio-frequency bridge which can be balanced at the fundamental frequency, leaving the harmonic remainder unbalanced and capable of measurement. The theory and operation of the distortion meter are discussed at length in the paper.

Part 2.—Proposed Method of Specifying Performance of Broadcast Receivers.

In this part of the paper, an attempt is made to draw up a schedule of tests by means of which the relative performance of different receivers may be assessed. In particular an attempt is made to reduce the specification of the various quantities measured to one single figure.

As regards sensitivity and classification of receivers, it is pointed out that most receivers are required to operate under certain known local conditions. Instead of a sensitivity test it is therefore suggested that a type classification should be used to determine the properties of the receiver within the limits imposed. This eliminates a number of irrelevant tests. Eckersley's schedule of Service Areas is recapitulated, viz. :—

"A" service area, greater than 10 mv/m.

"B" service area, 5 to 10 mv/m.

"C" service area, 2.5 to 5 mv/m.

and it is suggested that a fourth be added, viz. :—

"D" service area, below 2.5 mv/m. It is then suggested that broadcast receivers should be classi-

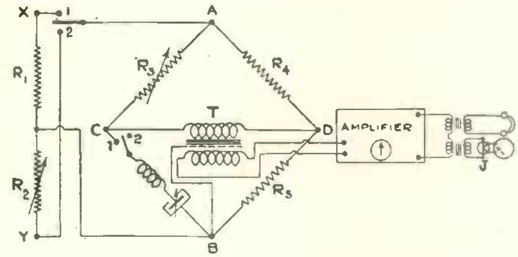


Fig. 6.—*Circuit arrangement of distortion meter.*

fied as suitable for one or more of the above areas and tested at the minimum corresponding to that area. It is also proposed that receivers should be classified in terms of their rated output, viz. :—

(1) Very small output—below 250 milliwatts.

(2) Small output—250 to 500 mw.

(3) Medium output—500 to 1000 mw.

(4) Large output—1000 to 5000 mw.

(5) Very large output—above 5000 mw.

Thus a "B3" receiver would give 500 to 1000 mw from a signal of 5 mv/m. Input of 20 mv would be applied to the dummy aerial, on the basis of 4m. effective height, and the receiver would be adjusted to give the maximum rated output at a modulation frequency of 400 c/s and a depth of 40 per cent. modulation. This adjustment would remain constant for all further tests at that radio-frequency.

In connection with selectivity, it is pointed out that simple ratios of the output at resonance to that at frequencies differing from resonance by small known amounts do not give sufficient infor-

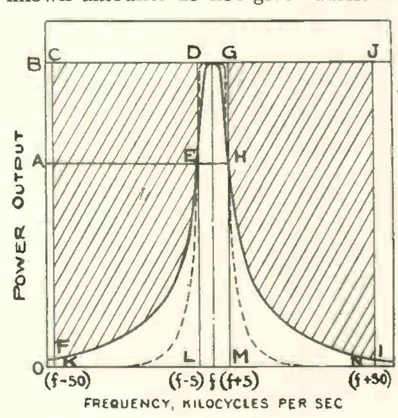


Fig. 7.—*Definition of selectivity.*

mation and, in fact, may lead to quite misleading results. If it is taken that the upper audio-frequency that should be catered for is 5 kc/s, a receiver giving no sideband cut-off should have a uniform response over a total band-width of 10 kc/s (*i.e.*, 5 kc/s on either side of resonance). Referring to Fig. 7, it is pointed out that the ratio OA/OB is the same for the simple tuned circuit as for the band-pass circuit given by the dotted-line curve, yet the two circuits are obviously quite different so far as selectivity is concerned. It is, therefore, suggested that the selectivity be expressed by the effective area of the curve between the 5 kc line and another line separated from resonance by some arbitrary frequency, for which 50 kc/s may be regarded as suitable.

This would then give an expression for selectivity of the form

$$\frac{1}{90P_f}\left\{90P_f - \left[\int_{f-50}^{f-5} Pdf + \int_{f+5}^{f+50} Pdf\right]\right\}$$

where f is the resonant frequency in kilocycles per second,

P is the power at any frequency,

and P_f is the power at the resonant frequency.

This is represented graphically in Fig. 7 by the sum of the shaded areas $CDEF$ and $GHIJ$, divided by the sum of the rectangles $CKLD$ and $GMNJ$. For a perfect filter system this would be unity, for any other characteristic the selectivity would be less than unity. It is suggested that this figure —expressed as a percentage—should be obtained at certain selected values of the resonant frequency and that by its use different receivers could be compared at these frequencies. It is also suggested that selectivity tests should be made at a very low modulation-frequency, *e.g.*, 50 c/s, so that the characteristic is virtually that which would be obtained with no modulation.

The audio-frequency response is normally specified by a curve of the audio output-power plotted

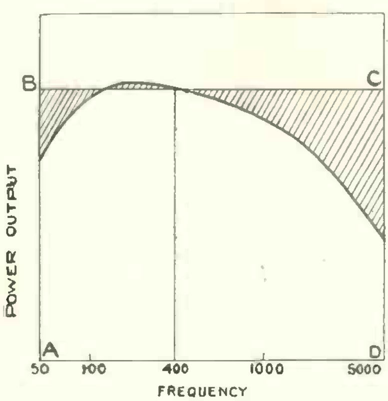


Fig. 8.—*Definition of audio-frequency response.*

against the modulation frequency for constant radio-frequency input e.m.f. and constant percentage modulation. Considering such a curve in Fig. 8, it is suggested that the best expression of the characteristic is the ratio of the sum of the shaded areas to the area of the rectangle $ABCD$, where AB is the value of power output at the standard modulation-frequency of 400 c/s. Since the perfect characteristic would have a numerical value of unity, this is defined by

$$1 - K\left(\frac{\text{Sum of shaded areas}}{\text{Area of rectangle } ABCD}\right)$$

where K is an arbitrary constant chosen so as to

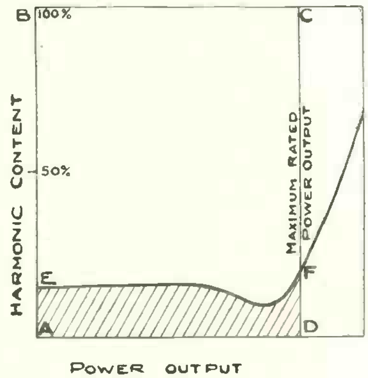


Fig. 9.—*Definition of purity factor.*

grade various characteristics in proportion to their degree of excellence. A value of K is discussed in the paper, and it is stated that a numerical value of 2 gives a comparatively satisfactory method of discriminating between a good and a bad audio-frequency characteristic.

In the same way a figure is derived for purity of output by reference to Fig. 9, showing the measured harmonic content against power output. It is here suggested that the "purity factor" should be defined as

$$1 - K\left(\frac{\text{Shaded area } AEFD}{\text{Rectangle } ABCD}\right)$$

where K is again an arbitrary constant, for which a value of 4 is suggested. For an output containing no harmonics, the purity factor would thus be 100 per cent.

Test results are illustrated in the paper on (1) a typical 3-valve receiver using reaction, a grid-circuit detector, l.f. amplifier and power stage, (2) a 4-valve receiver of screened grid amplifier, grid rectifier, l.f. amplifier and output. The results are summed up in Table 2 below, and an

TABLE 2.

Receiver.	Class.	Test frequency.	Selectivity.	Audio-frequency response	Purity factor.	Overall performance. figure.
		kilocycles per sec.	per cent.	per cent.	per cent.	per cent.
3-valve	"B 2"	1 000	80	78	66	41.2
4-valve	"C 2"	1 000	95.5	45	58	24.9

attempt is made to give an overall performance figure as the product of the three separate characteristics.

The paper concludes with an Appendix giving an exposition of the theory of the modulation meter.

Discussion.

MR. P. K. TURNER, who opened the discussion, thought that the overall figure of merit was impossible. In practice, different degrees of weight might be put on various points by the user, and three figures would therefore have to be considered. He thought that the proposed "D" class receiver should work at much less than 1 mv/m and should therefore be tested at an input of more like 25 μV/m. He protested against the use of 5 kc/s on the upper limit of audio-frequency and emphasised the need for 8 or 9 kc/s, which could still be obtained without interference on certain stations. As regards Fig. 8, he thought this response should include the loud-speaker, which might have resonances that would, for example, affect the height at 400 cycles. The mean height of the curve should also be taken as reference for the rectangle *ABCD*, instead of the level at 400 cycles. The vertical scale of Fig. 8 ought to be plotted logarithmically (*e.g.*, in decibels) taking say the 1/100 level as arbitrary zero. He had experienced difficulty in using the modulation arrangement shown by the author and asked for more information on this point. Might not a variometer be better as fine adjustment for small changes of frequency? As regards harmonic content, the most important figure was perhaps the value of the maximum harmonic present.

MR. F. S. BARTON pointed out that the dummy antenna scheme shown was only applicable to receivers working on an "aerial-earth" system. It did not apply to coils or to arrays where both leads might be symmetrically at high potentials. In the selectivity curve much interest lay in the width of the flat top and this should be defined in the specification. He suggested that the band-width at 3 or 6 db down and at 40 db down should be stated. He also pressed for extension of the upper audio-frequency limit, quoting experiments of the Bell Laboratories showing the number of instruments and sounds that went up much beyond 5 kc/s.

MR. M. G. SCROGGIE sought information as to the low value of the output resistance, viz., 60 Ω. Modern practice of testing tended to the use of no second cabin. As regards output purity, he suggested the use of a filter cutting out the fundamental. He also referred to the practical need of including the loud-speaker which was often used to let its characteristic compensate for other characteristics of the receiver. As regards selectivity, the degree of discrimination against a signal at 9 kc/s distance was a useful measure. The author had made a bold attempt to simplify receiver specification, but he thought it was impossible to use a single figure.

MR. W. B. MORRISON thought it was impossible for every manufacturer to maintain the apparatus necessary to perform all the tests. There was need for a central testing establishment to do such tests on particular models so that later models could be compared with the standardised sample. Such an establishment should be maintained by industry and its results used for the benefit of industry. On the instrumental side, he asked had the author made use of the dynatron oscillator. It was very easily modulated and also easily applied to the construction of a beat-frequency generator.

DR. R. L. SMITH-ROSE referred to the development of apparatus at the N.P.L. The elaborate screening used was necessary since it was desirable to make provision to meet every case that might arise. The wide range of wavelength covered also demanded good screening, *e.g.*, at short wavelengths. Continued requests for tests of unspecified detail had led to the drafting of schedules of tests that could be performed and to the final formulation of the simplification outlined in the paper. He hoped that this might lead to the formation of a Committee, either of the Institution or of the British Standards Association, to draw up an agreed specification of broadcast receiver performance.

MR. W. J. BROWN thought the figure of merit should include not only the loud-speaker but also the cabinet. The use of such a test-load was important especially with a pentode output on account of its variation with frequency. The numerical classification for sensitivity did not seem satisfactory. Actually, sensitivity varied with different positions of the tuning controls, this being particularly true of ganged tuning and still more of superheterodyne receivers with ganged tuning. He disagreed with testing at the maximum rated output, where saturation might lead to a spurious flatness, and suggested half maximum as a suitable level. The measurement of selectivity at constant output was also a better test, more comparable with the degree of discrimination called for in practice.

MR. H. A. THOMAS briefly replied to the discussion, particularly expressing the hope that the paper and discussion might lead to the formation in Britain of some standardising committee.

On the motion of the Chairman, MR. L. B. TURNER, the author was cordially thanked for his paper.

Correspondence.

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

Graphical Solution of Detector Problems.

To the Editor, The Wireless Engineer.

SIR,—It is with much diffidence that I would venture to criticise Mr. Lucas' graphical construction for detector problems in your April issue, since I myself originated a somewhat similar method which was published in your esteemed Journal as far back as 1927.* Stripped of unessentials, the problem to be solved is that of finding the mean value of the ordinate of a grid current curve which oscillates sinusoidally about a mean grid voltage value. To illustrate the difference between the two methods, let v_0 be the fixed value of grid voltage about which there oscillates a sine wave of amplitude E, the current ordinate at v_0 being I_0. Mr. Lucas' method is to join $I_{max.}$ to $I_{min.}$, as in Fig. 1, and find the point I_1 representing the mean value at a position half-way between I_0 and the chord. My method, shown in Fig. 2, is to take two new ordinates $I'_{max.}$ and $I'_{min.}$ equidistant by 0.866 E from v_0, and take I_1 as the mean of the three current ordinates $I'_{max.}$, I_0 and $I'_{min.}$ In practice, of course, $I'_{min.}$ (and sometimes I_0) is negligible, to the great simplification of the method, which in most cases resolves itself simply into taking one-third of the value of $I'_{max.}$

My criticism of Mr. Lucas' method is mainly on the score of the inaccuracies to which it leads in practical working. To demonstrate this, it will be sufficient to take an ideal case for which the mathematical equation of the characteristic is known, and by integration compute the mean value of current under the stimulus of a grid voltage oscillation of known amplitude. We can then compare with this the approximate values as obtained by the two graphical methods in question. Fortunately, data regarding such a characteristic are readily available.

(a) *The Correct Value in an Ideal Case.*

In the course of his article on grid rectification in *E.W. & W.E.* of November, 1925, Mr. Colebrook gave the following equation to represent a certain grid current characteristic,

$$I = 3.16 \times \epsilon^{5.55 v_g} \quad \ldots \quad \ldots \quad (1)$$

where ϵ is the Naperian base and I and v_g are in μA. and volts respectively. The leak used was 1.89 $M\Omega$ and grid bias zero. Under these conditions he calculated by a process of integration that the mean operating grid voltage during reception of a C.W. signal of 0.707 v. amplitude is $-$ 0.79 v. Hence the mean grid current flowing in the leak is $\frac{0.79}{1.89}$, or 0.418 μA. In other words, a signal amplitude of 0.707 v. operating about a mean value of $-$ 0.79 v. gives a mean current of 0.418 μA. with this characteristic. This is the result of accurately integrating the curve over a sinusoidal time base, and is, consequently, the theoretically correct value.

* "Grid Signal Characteristics and other Aids to the Numerical Solution of Grid Rectification Problems"—*E.W. & W.E.*, Aug & Sept., 1927.

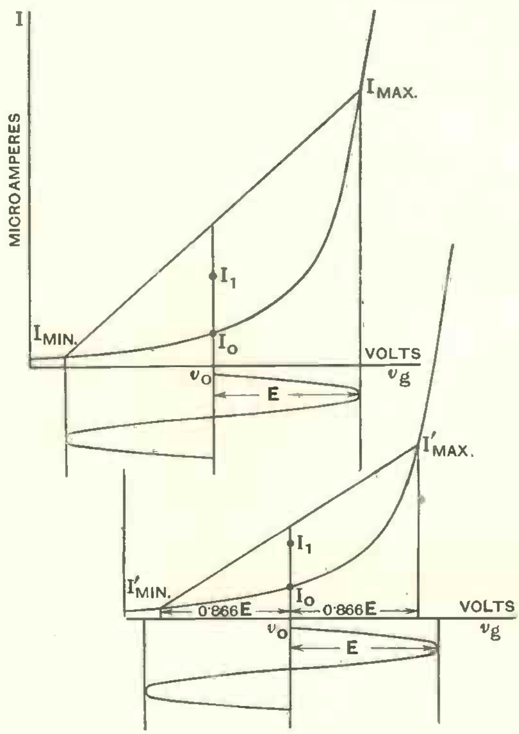
(b) *The Value According to Lucas' Method.*

Taking the same value, $-$0.79 volt, as mean operating point, let us proceed to find values of $I_{max.}$, I_0 and $I_{min.}$, as in Fig. 1. The values of v_g corresponding to these are respectively ($-$ 0.79 + 0.707), $-$ 0.79 and ($-$ 0.79 $-$ 0.707), *i.e.*, $-$ 0.083, $-$ 0.79 and $-$ 1.497 volts. Substituting these in the equation (1) for the curve, we obtain $I_{max.} = 1.995$ μA., $I_0 = 0.039$ μA., $I_{min.} = 0.001$ μA. Now, I_1, the mean current value, is equal to

$$I_0 + \tfrac{1}{2}\left(\frac{I_{max.} + I_{min.}}{2} - I_0\right),$$

i.e., it is

$$\tfrac{1}{2}\left(\frac{I_{max.} + I_{min.}}{2} + I_0\right).$$



Figs. 1 and 2.

Substituting the ascertained values we obtain $I_1 = 0.518$ μA.

(c) *The Value According to Barclay's Method.*

With the same operating grid point, take ordinates $I'_{max.}$ and $I'_{min.}$, as in Fig. 2, at values distant from v_0 by 0.866 times the amplitude, *i.e.*, 0.866 × 0.707, or 0.612 v. The values of v_g corresponding to $I'_{max.}$, I_0 and $I'_{min.}$ are therefore $-$ 0.178, $-$ 0.79 and $-$ 1.402, and by a similar substitution in (1) the values of $I'_{max.}$, I_0 and $I'_{min.}$ are respectively 1.178, 0.039 and 0.001 μA. The mean current value is now the average of these, *i.e.*, $\frac{1}{3} \times 1.218$, or 0.406 μA.

It will be seen that my approximation is only 3 per cent. below the correct value, while by Mr. Lucas' method it is no less than 24 per cent. in excess. The point is, of course, that in the rectification process a small error in grid current may reflect in a considerable error in the mean working voltage value. This is well brought out by the diagram Fig. 2 of Mr. Lucas' article, which clearly portrays the importance of the small current change $I_1 - I_0$ in relation to the mean position of the grid working point. I would venture to suggest that the error in his reasoning lies in the use made of infinite power series with increasing numerical coefficients. In the absence of definite convergence tests, such series should be labelled "dangerous."

I cannot help feeling that a better mode of approach to the whole subject is that set forth in the paper to which I have referred. Indeed, the graphical construction given in the second part of that paper has not, to the best of my knowledge, been excelled for simplicity and accuracy in dealing with the rectification of modulated C.W. I hope that Mr. Lucas will do me the kindness to believe that, before writing that paper, I had tried various methods, among them his, and had turned them down as insufficiently accurate for practical requirements. This must plead my excuse for again drawing attention to a method which, I am happy to observe, is now gradually finding favour with those for whose use it was devised.

Bieldside, N.B. W. A. BARCLAY.

A Common Error.

To the Editor, The Wireless Engineer.

SIR,—I would like to draw attention to an error which sometimes occurs in papers published in various technical journals. The error arises in connection with the combination of two sinusoids of different frequency, and the "beat notes" produced by the combination are referred to as physical entities at a point before they actually exist.

In illustration of this point consider the combination of the two sinusoidal voltages $E_1 . \cos wt$ and $E_2 . \cos (w + n) t$ by a device with a current voltage relationship of the form :

$$i = a_0 + a_1 e + a_2 e^2 + a_3 e^3 + \dots + a_n e^n + \dots \quad (1)$$

The injected voltage is,

$$e = E_1 . \cos wt + E_2 . \cos (w + n) t \quad (2)$$

i.e.,

$$e = E . \cos (wt + \phi) \quad (3)$$

where, as usual,

$$E^2 = E_1^2 + E_2^2 + 2E_1E_2 . \cos nt \quad (4)$$

and,

$$\phi = \tan^{-1} \frac{E_2 . \sin nt}{E_1 + E_2 . \cos nt} \quad (5)$$

I have found that some writers refer to the "beat notes" in the input circuit, and to the production of harmonics of the "beat note" in the input circuit, whereas, of course, the input voltage in (3) is complex in form and if resolved into its components only produces the two fundaments of (2).

It is only *after* the voltage of (3) has been operated upon by a function of, say, the form of (1) that the true "beat notes" can be said to have actual physical existence, when they are included in the function :

$$i = a_0 + a_1 [E . \cos (wt + \phi)] + a_2 [E . \cos (wt + \phi)]^2 + \dots + a_n[E . \cos (wt + \phi)]^n + \dots \quad (6)$$

In practice a selective device usually picks out the desired band of combination tones from all the tones represented by (6), and when specific cases arise (6) may be put into more convenient forms.

I think the error arises from a confusion with the phenomenon of "beats" in acoustics. The rapid rise and fall in amplitude of the combined air waves (*cf.* "E" of (3)) gives the effect of a new pulsating tone which is tacitly assumed to be a sinusoid of the same form as the original tones.

Incidentally, the current voltage relationship of the combining device need not necessarily be of the form given in (1) but may take an infinite variety of forms, important amongst which is the form for the linear rectifying device (*see* Colebrook, *W.E. & E.W.* for Nov., 1930, pp. 595 *et seq.*).

Neasden, Middlesex. W. F. FLOYD.

The Selectivity of Broadcast Receivers.

To the Editor, The Wireless Engineer.

SIR,—In your report of the discussion before the Wireless Section of the I.E.E. on the selectivity of broadcast receivers, the report of part of my remarks is not quite correct, and gives a somewhat misleading impression of my personal opinion.

On page 211, column 2, line 6 to end of paragraph, my actual statement was that several years ago we carried out tests which gave the results mentioned in your report. It is to be understood that these tests were carried out with the apparatus then available.

In my remarks will also be found a statement that some of the microphones used start to cut off at 6 000 cycles per second, in which case cutting off elsewhere in the chain at 7 000 cycles would not be expected to make a great deal of difference to the overall response, particularly when the frequency characteristics of the loud speakers which were available several years ago are taken into consideration.

Notice should also be taken of my remarks in regard to the new microphone which is now being tested by the B.B.C., concerning which I stated that with a receiver whose high-frequency circuits are 6 db. down at 5 000 cycles and 14 db. down at 8 000 cycles it was easily possible to distinguish the difference in the detail produced by the new microphone, which is due partly to the flatter frequency characteristic, and partly to the increased reproduction at frequencies above 6 000.

If you could find space to publish this letter I should be obliged, as I feel that your report may convey the impression that I am not in favour of reproduction of the higher audio frequencies.

London, S.W.4. H. L. KIRKE.

Abstracts and References.

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PROPAGATION OF WAVES.

EINE LEISTUNGSFÄHIGE EINRICHTUNG FÜR MESSUNGEN AN DEN HEAVISIDESCHICHTEN (An Effective Apparatus for Measurements on the Heaviside Layers).—H. Rukop and P. Wolf. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 13, 1932, pp. 132–134.)

Using the pulse method and wavelengths under 300 m. The transmitter (with a peak output of about 15 w) sends out a regular series of 0.0001 sec. dots at 1/25 sec. intervals, the control being accomplished photoelectrically by an optical slit in a rotating disc driven by a synchronous motor at a speed of 25 r.p. sec. Transmitter and receiver being located in Cologne and Cologne-Mülheim respectively, the space-wave incidence on the layers is practically vertical. Horizontal dipoles are used at both stations.

The chief point of interest is the recording apparatus. The signals, after four stages of r.f. and four more of a.f. amplification, feed a "point glow" lamp such as that described by Schröter for phototelegraphy (1929 Abstracts, p. 108). This lamp and, at a suitable distance, a photographic objective for focusing its "point" on to a photographic film, are carried on rigid 10-cm arms projecting from a horizontally rotating steel shaft about half a metre long, the optical axis of the lamp-and-lens system lying parallel to the axis of the shaft. The shaft, with its optical system, is driven at 25 r.p. sec. by a synchronous motor working off the same mains as the transmitter. Current to the glow lamp is carried through slip rings on the shaft. In this way, the point image of the lamp describes a circle in a plane perpendicular to the shaft. In this plane, at a short distance from the rotating lens, is a photographic chamber in which a strip of sensitised paper is in constant slow motion in a vertical direction. For about one quarter of each rotation of the optical system, the point image (supposing a signal to be continuous) sweeps arc-wise across the width of this strip: during the remaining three-quarters the strip is screened from the image, and by the time the active quarter-turn comes again the strip has moved on slightly so that a fresh arc is described close to the first, and so on.

Owing to the synchronism between transmitter and recorder, the "dot" representing the ground wave always occurs with the optical system in the same position. The ground wave, therefore, is recorded on the strip as a continuous straight line parallel to the direction of motion of the strip; *i.e.*, parallel to the edges of the strip. In the specimen record (Fig. 2) this ground wave track is the line OT. The space ray returning from the layer arrives a little later in every revolution, so that the optical system has moved a little further; if the space ray signals arrive with a constant delay, they also will be recorded as a straight line parallel to the ground wave line but at a short distance from it. This distance, measured along the arc, is proportional to the height of the reflecting layer; in the actual apparatus here described, an effective height of 100 km gives a distance of about 1 cm (reduced to a half in the sample record).

This sample record (25th October, 1931) shows a run of nearly 2 hours, starting at sunrise at 6.45, with an 84-metre wave. At this moment only the ground wave is seen: a minute or two later a faint echo appears corresponding to a layer height of about 400 km. This echo rapidly becomes more distinct and the effective height sinks (along the line AB) to about 220 km, where it remains constant from about 7.30 to the end of the run at 8.30. Near the beginning of the run, just after sunrise, the doubly refracting state of the layer is shown by the branch track C beginning above the main track but gradually approaching the latter and merging into it round 7.20 (point B). Fainter branch tracks such as NE, DE, GE and HE (H should be introduced into the record, about halfway between G and E) are also seen: most of these are attributed to multiple reflections between earth and layer, but the exact meaning of some of them is uncertain (*see* middle para. p. 133, right hand col.).

Soon after 8 o'clock a lower layer at about 100 km makes its appearance, at first rather intermittently (point U) but later more continuously than the 220 km layer, which now loses some of its definiteness, the continuous line becoming intermittent though still retaining its position (8.10 to 8.25). "This layer is always present by day, as Goubau and Zenneck's researches have shown [1931 Abstracts, p. 432], but must generally be insufficiently dense to reflect the 84-metre waves used by us. For while our results immediately after sunrise (as shown here up to 8 o'clock) can be reproduced day after day, this is not the case as regards this lowest layer. Many of our runs show that this layer reflects the 84-metre wave only at quite irregular times and sometimes for quite short periods only." Occasionally it only makes itself evident about sunset. "We conclude that this irregular behaviour is due to changes in concentration caused by electrons coming from outside to the upper Heaviside layer and straying into the earth's atmosphere—electrons which may well be regarded as auroral electrons" [on which a paper by Brüche is now being published]. Where this 100 km line is shown, the record also gives clear indications of another line at about three times its distance from the ground wave line—presumably a multiple-reflection effect from the lower layer, though the analysis of this part of the record is complicated by the almost exact 1 : 2 ratio of the two layer heights.

The specimen record shows many dark arcs due to interference of various kinds; these are seen to be quite harmless so far as the analysis of results is concerned, a fact which renders the new method peculiarly suitable for tests in the crowded "amateur" band of wavelengths.

POLARISATION OF DOWNCOMING WIRELESS WAVES.—J. A. Ratcliffe and F. W. G. White. (*Nature*, 5th March, 1932, Vol. 129, p. 364.)

The writers of this letter have developed a method of observation of downcoming wireless waves which can be used to analyse the wave from any transmitter emitting a steady or a modulated wave, even when the nature of the polarisation is changing rapidly; a cathode-ray oscillograph is used and the normally and abnormally polarised components of the downcoming wave, received on two separate aerial systems and amplified, are applied to opposite pairs of plates of the tube. Aerial systems suitably chosen eliminate the ground wave. "The sense of rotation of an elliptically polarised downcoming wave is determined by momentarily detuning one of the amplifiers slightly."

An investigation of the downcoming waves from the London National transmitter received at Cambridge during the evening hours shows that the type of polarisation varies very rapidly, but the sense of rotation of the figure on the screen is always the same. The sense of rotation is anti-clockwise, looking along the ray in the direction of travel.

"These preliminary results therefore confirm previous results of Appleton and Ratcliffe and lend support to the theory outlined by them and recently mentioned by Professor Appleton" [March Abstracts, pp. 154–155.]

ON THE CONNECTION BETWEEN SHORT WAVE FADING AND DISTURBANCES OF THE EARTH'S MAGNETIC FIELD.—H. Mögel. (*E.N.T.*, Feb., 1932, Vol. 9, pp. 71–73.)

Summary of the paper dealt with in 1931 Abstracts, pp. 144–145. On pp. 73–74 the writer gives additional views on "near echoes" (within about 80 km of the transmitter, with delays of 0.01 to 0.02 sec., corresponding to reflections at distances of 1 500 to 3 000 km). The two facts, that strong and frequent near echoes are nearly always accompanied by an absence of "direct" echoes (1/1 000 sec. delay) and, conversely, that only feeble near echoes occur when the direct echoes are strong and frequent, is considered to be in opposition to van der Pol's theory of the production of the near echoes by reflection at the normal Heaviside layer and retarded velocity of propagation. The writer also remarks on the interesting behaviour of near echoes with respect to solar disturbances. On p. 74 he adds a section on Plendl's paper (January Abstracts, p. 29) on the effect of the eleven-year solar activity period on short wave propagation. He concludes :—"according to our results, the most favourable wavelength becomes greater, towards the minimum of the solar activity period, with increasing magnetic density of the lines involved, or with decreased distance from the pole. The displacement amounts, for example, to about 10% now (December, 1931) for S. America, Africa, Java and Siam, and about 40 to 100% for N. America and East Asia (Japan-China). The displacement, moreover, is greater for the night than for the day and transitional waves. Further reports will be made early in 1932."

SOLAR ACTIVITY AND RADIOTELEGRAPHY.—L. W. Austin. (*Proc. Inst. Rad. Eng.*, Feb., 1932, Vol. 20, pp. 280-285.)

Author's summary :—This report to the International Research Council on solar and radio relationships shows that the relationships are closer at short wavelengths than at long, that the effect of magnetic storms, which are assumed to be due to solar action, is, in general, to weaken night signals at all wavelengths and in the medium- and long-wave ranges to strengthen day signals. Curves are given which show that there is a direct correlation between the yearly averages of long-wave daylight transatlantic signals, sun spot numbers, and magnetic activity (1915–1930), a direct correlation between signals and magnetic activity averages by months (1924–1930), and an inverse correlation between sun spots and atmospheric disturbances averages by years (1918–1930).

RADIO TRANSMISSION OVER LONG PATHS.—Note from the U.S. Bureau of Standards. (*Journ. Franklin Inst.*, March, 1932, Vol. 213, No. 3, pp. 321–322.)

A short note on measurements of the signal strengths of a number of American and European short wave stations made at Dunedin, New Zealand. A full account of the work will be published in the February number of the Bureau of Standards *Journal of Research.*

DISTANCE RANGES OF RADIO WAVES.—Notes from the U.S. Bureau of Standards. (*Journ. Franklin Inst.*, March, 1932, Vol. 213, No. 3, p. 322.)

A note on a letter circular prepared by the Bureau of Standards which summarises the distance ranges of radio waves of various frequencies under average conditions. Copies may be secured upon request for Letter Circular 317, "Distance Ranges of Radio Waves," addressed to Bureau of Standards.

ULTRA-SHORT-WAVE SHIP AND SHORE COMMUNICATION.—Uda. (*See* under "Stations, Design and Operation.")

THE PROPAGATION OF ULTRA-SHORT WAVES IN A LARGE CITY.—G. Leithäuser. (*Rad., B., F. f. Alle*, Feb., 1932, pp. 50–51.)

Summary of a recent lecture.

AUFBAU UND TEMPERATUR DER STRATOSPHÄRE (Composition and Temperature of the Stratosphere).—B. Gutenberg. (*Gerlands Beitr.*, Vol. 32, 1931, pp. 87–94.)

The writer maintains that observational results suggest neither a hydrogen nor a helium atmosphere but one of nitrogen and oxygen, with which a lighter gas (helium or steam ?) becomes mixed as the height increases, at a comparatively high temperature (500 to 1 000° C).

THE ULTRAVIOLET ABSORPTION SPECTRUM OF OZONE.—A. Jakowleva and V. Kondratjew. (*Phys. Review*, 1st Feb., 1932, Series 2, Vol. 39, No. 3, p. 533.)

A preliminary account of measurements of bands in the ultra-violet absorption spectrum of ozone formed in an ozonator in the moment of a silent current passing through it.

WAVELENGTHS FOR AIRCRAFT COMMUNICATION.—Carr. (*See* under "Stations, Design and Operation.")

PAST AND FUTURE WORK ON WAVE PROPAGATION.—Heinrich Hertz Association. (*See* abstract under "Miscellaneous.")

A NEW METHOD OF ELIMINATING FADING?—Günther: Bureau of Standards. (*See* abstract under "Transmission.")

INVESTIGATION OF THE FRONT DEFORMATION OF AN ELECTROMAGNETIC WAVE.—I. S. Stekolnikov. (*Westnik Elektrot.*, No. 4, 1931, Sec. II, pp. 65–70.)

A cathode-ray oscillographic investigation of surges at 6 kv potential and upwards (*cf.* 1931 Abstracts, pp. 222 and 336) along lines. With a line of 200 m the front deformation found experimentally is greater than that calculated from theory; with lines of 440 m, theory and experiment agree. In the case of lines of 1 km, the front deformation is largely influenced by the capacity effect of the insulators.

ESTIMATION OF HEIGHTS REACHED BY AIR-WAVES WHICH DESCEND IN ZONES OF ABNORMAL AUDIBILITY.—F. J. W. Whipple: Gutenberg. (Summary in *Sci. Abstracts, Sec. A.*, Jan., 1932, Vol. 35, p. 40.)

Pointing out defects in Gutenberg's procedure (1931 Abstracts, pp. 317 and 435) and their remedy.

INFLUENCE OF ATMOSPHERIC CONDITIONS UPON THE AUDIBILITY OF SOUND SIGNALS.—B. R. Hubbard. (Summary in *Sci. Abstracts, Sec. A.*, Jan., 1932, Vol. 35, p. 40.)

On the causes of the irregularity noticed in the audibility of fog signals.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

ÜBER ZWEI VERSCHIEDENE ARTEN VON ATMOSPHÄRISCHEN STÖRUNGEN (On Two Different Types of Atmospheric).—F. Schindelhauer. (*E.N.T.*, Feb., 1932, Vol. 9, pp. 41–45.)

The author uses records obtained at Potsdam with an atmospheric recorder designed by Watson Watt and working at a frequency of 10 kc/s, and material obtained from the Radio Research Board's recorders at Lerwick, Aboukir and Bangalore, to obtain a graphical representation in polar co-ordinates of the daily and yearly variation in the direction of atmospherics. From the regularity of the daily variation and the frequent striking preference for several directions, he concludes that the origin of the disturbances cannot in general be meteorological (*e.g.*, thunderstorms). He thinks that it must be in the upper atmospheric regions and be due to the influence of the earth's magnetic field; at night the electrons chiefly rotate around the lines of force, but in the daytime there is an additional translatory movement along them.

Records recently obtained at Potsdam with increased amplification seem to show two kinds of atmospheric, which may be described as clicks and grinders respectively (this designation has no special reference to their acoustic effects). There is approximately a right angle between their directions and a regular daily variation in their appearance. Diagrams are given to illustrate the daily variation in the movements of electrons round the lines of magnetic force which would explain the atmospheric phenomena. The author definitely disagrees with the idea that atmospherics are due to radiation from the vertical path of a lightning flash. For previous papers by him, *see* Abstracts, 1929, pp. 101, 503; 1930, p. 389; and 1931, p. 206.

SIMULTANEOUS REGISTRATION OF POTENTIAL DROP, SPACE AND SURFACE CHARGE.—H. Mothes. (*Göttinger Nachr.*, No. 1, 1931, pp. 49–59: summary in *Physik. Ber.*, 1st Jan., 1932, Vol. 13, p. 46.)

"The records of air potential and space charge are not, in general, smooth curves but show almost oscillatory variations of different periods. The space charge curve runs generally in opposition to that of air potential. A high positive space charge at sunrise in summer corresponds to a minimum field strength."

RATE OF IONISATION OF THE ATMOSPHERE.—G. R. Wait and O. W. Torreson. (*Nature*, 12th March, 1932, Vol. 129, pp. 401–402.)

Results obtained with an apparatus for measuring simultaneously the small ion and large ion content from the same sample of air permit the calculation of q, the rate of ionisation, with greater accuracy than was previously possible. A maximum daily value of q is found. Possible explanations for the variations in q are indicated.

SEASONAL VARIATIONS IN MAGNETIC STORMS.—H. B. Maris. (*Phys. Review*, 1st Feb., 1932, Series 2, Vol. 39, No. 3, pp. 504–514.)

GEWITTER UND BLITZSCHUTZ (THUNDERSTORMS AND PROTECTION AGAINST LIGHTNING [INCLUDING FIGURES FOR DURATION, CURRENT STRENGTH, ETC., OF LIGHTNING STROKES]).—G. Cario. (Summary in *Physik. Ber.*, 1st Jan., 1932, Vol. 13, p. 119.)

THE TIME LAG OF THE ELECTRIC SPARK.—J. A. Tiedeman. (*Physics*, Dec., 1931, Vol. 1, No. 6, pp. 354–365.)

The time intervals were measured by a Lichtenberg figure method with a precision of 5×10^{-10} sec. For air, hydrogen and nitrogen, curves are given showing how the lag decreases with an increase in the number of electrons liberated during the application of the field. With comparatively high fields the lag reduces to approximately the time required for an electron to be liberated in the gap.

ÜBER DEN ENTLADEVERZUG IN HOMOGENEN ELEKTRISCHEN FELDERN UND LUFT VON ATMOSPHÄRENDRUCK (On the Discharge Delay in Homogeneous Electric Fields and Air at Atmospheric Pressure).—R. Strigel. (*Naturwiss.*, 18th March, 1932, Vol. 20, No. 12, pp. 205–206.)

LIGHTNING INVESTIGATION AS APPLIED TO THE AEROPLANE.—A. O. Austin. (Summary in *Sci. Abstracts, Sec. A.*, Jan., 1932, Vol. 35, p. 47.)

DIE SPEZIFISCHE IONISATION DER HÖHENSTRAHLUNG (The Specific Ionisation of Cosmic Rays).—W. Kolhörster and L. Tuwim. (*Zeitschr. f. Phys.*, 1931, Vol. 73, No. 1/2, pp. 130–136.)

The authors calculate from experimental results a value for the specific ionisation of cosmic radiation of 135 ions per cm to within $\pm$ 10%. This leads to a value of the lower limit of the energy of a single cosmic ray [" des einzelnen Höhenstrahls "] of magnitude 2×10^9 e-volts. This calculation is independent of any hypotheses as to the nature and absorption mechanism of cosmic radiation.

COSMIC-RAY IONISATION AND ELECTROSCOPE-CONSTANTS AS A FUNCTION OF PRESSURE.—R. A. Millikan. (*Phys. Review*, 1st Feb., 1932, Series 2, Vol. 39, No. 3, pp. 397–402.)

From the author's abstract :—" The residual ionisation in an electroscope at infinite depth in water, that is, its zero reading, is found to be an inverse function of the pressure. . . . Also, when in this electroscope the pressure was changed from one atmosphere to 30.1 atmospheres the observed ionisation current rose but 13.80-fold, which multiplying factor was found the same for gamma rays and for cosmic rays. Both of these pressure effects are shown to be due to lack-of-saturation in high pressure electroscopes [*cf.* Millikan and Bowen, Feb. Abstracts, pp. 90–91]. . . . The number of cosmic-ray ions at one atmosphere (24° C., 74 cm pressure) in this electroscope at Pasadena is found to be fairly accurately 2.63 ions per c.c. per sec. The sea level value of the ionisation in this electroscope is 2.48 ions per c.c. per sec."

ÜBER DIE SONNENZEITLICHE PERIODE DER HARTEN ULTRASTRAHLUNG (On the Solar Period of the Hard Cosmic Radiation)—W. Messerschmidt. (*Zeitschr. f. Phys.*, 1932, Vol. 74, No. 3–4, pp. 187–190.)

This paper reports the results of six months' continuous observation on hard cosmic radiation after penetration of 10 cm lead. A solar period in the form of a double wave was found but could not be explained as primarily due to radiation from the sun. No sidereal period could be discovered in the measurements.

FURTHER EXPERIMENTS ON THE UNIFORMITY OF DISTRIBUTION OF THE COSMIC RADIATION [ABSENCE OF DIRECT SOLAR EFFECT ON COSMIC RAY INTENSITIES].—R. A. Millikan. (*Phys. Review*, 1st Feb., 1932, Series 2, Vol. 39, No. 3, pp. 391–396.)

From the author's abstract :—" More careful and prolonged observations . . . yield the definite result that within the limits of the author's present observational uncertainty, which is of the order of a third of a per cent, the sun has no direct influence on cosmic-ray intensities. New evidence is presented that if observed and apparently systematic variations of the order of a third of a per cent are in fact real, they are best interpreted as the result of small changes in the blanketing effect of the earth's atmosphere due to air currents."

ON AN ATTEMPT TO DEFLECT MAGNETICALLY THE COSMIC RAY CORPUSCLES.—L. M. Mott-Smith. (*Phys. Review*, 1st Feb., 1932, Series 2, Vol. 39, No. 3, pp. 403–414.)

The experimental attempt described in this paper, preliminary work on which has already been referred to (1931 Abstracts, p. 377), had a negative result. The sensitivity was such that " an observable deviation would have been produced if the corpuscles were electrons of energy 2×10^9 e-volts or less or protons of energy 10^9 e-volts or less." " The difficulties involved in explaining this result are discussed and various possible interpretations are presented."

UNTERSUCHUNGEN UND ANWENDUNGEN DES GEIGER-MÜLLERSCHEN ZÄHLROHRES IN EINER SCHALTUNG MIT DER BRAUNSCHEN RÖHRE, INSBESONDERE KOINZIDENZSCHALTUNG (Investigations and Applications of the Geiger-Müller Counter in a Circuit with a Cathode-Ray Tube, particularly a Coincidence Circuit [for Cosmic Rays]).—G. Medicus. (*Zeitschr. f. Phys.*, 1932, Vol. 74, No. 5/6, pp. 350–378.)

This paper describes a method of using a Geiger-Müller counter in conjunction with a cathode-ray tube, without an amplifier, for counting coincidences in ionisation by cosmic rays. The discharge phenomena in the counter are investigated and the probability of response of the counter to cosmic ray coincidences is discussed.

ON THE CALCULATION OF THE ION COUNTER TUBE EFFECT OF THE COSMIC RAYS, AND THEIR ABSORPTION LAWS ACCORDING TO COUNTER TUBE MEASUREMENTS.—L. Tuwim. (Summary in *Physik Ber.*, 1st Jan., 1932, Vol. 13, p. 122.)

Continuation of the work referred to in 1931 Abstracts, p. 552.

CONTEMPORARY ADVANCES IN PHYSICS, XXIII. DATA AND NATURE OF COSMIC RAYS.—K. K. Darrow. (*Bell S. Tech. Journ.*, Jan., 1932, Vol. 11, No. 1, pp. 148–184.)

This article gives an account of the present state of our knowledge of cosmic ray phenomena and a list of the chief papers on the subject.

PROPERTIES OF CIRCUITS.

ÜBER DEN VERSTÄRKUNGSGRAD WIDERSTANDSGEKOPPELTER RÖHRENANORDNUNGEN (The Amplification Ratio of Resistance-Coupled Valve Combinations).—P. Kapteyn. (*Hochf: tech. u. Elek : akus.*, Feb., 1932, Vol. 39, pp. 41–48.)

An investigation to determine whether the usual design calculations lead to the construction of resistance-coupled r.f. and l.f. amplifiers with the highest possible efficiency—*i.e.*, with the maximum amplification per stage at the supply potentials now employed. " This question must be answered in the negative, since it is possible by suitably choosing the valves and coupling elements to increase the amplification considerably above that obtained by the usual arrangements. The fundamentals governing the development and working of such amplifiers will be discussed in the present paper."

The present instalment deals first with the derivation of six general formulae (7–12) for the calculation of the quantities governing the degree of amplification in multi-stage resistance-coupled amplifiers, and then devotes itself to the l.f. amplifier. The conditions for obtaining the optimum amplification figures are examined with the help of curves based on the above formulae: first the determination of the optimum anode resistance, and then the determination of the optimum penetration coefficient ($1/\mu$), being dealt with.

The practical application of the very small penetration coefficients (about 0.1 %) and high anode resistances, indicated by these investigations, along the lines originally set by von Ardenne, " shows itself—except perhaps for the audion circuit—as disadvantageous for single-grid valves and normal voltages, since the grid currents resulting from too small grid bias form a load on the input circuit which must show itself in diminished selectivity or in undesired distortions. In the case of indirect metal-vapour cathodes a negative bias of at least − 0.5 v has been found desirable in view of certain fluctuations in grid currents which are liable to occur. With this bias and a normal anode voltage of 150 v, the optimum penetration coefficient comes out at about 0.7 %.

" *Much more favourable results can be obtained, as the writer's researches show* " by the use of screen-grid valves of suitable design. With such valves the influence of the positively biased second grid can easily be made to shift the curve into the region of negative grid bias so that the penetration coefficient can be made " almost as small as desired." With a 5-megohm anode resistance and an anode voltage of 170 v, the writer thus obtains a potential amplification of 450 per stage. A load on the grid circuit is avoided, since the grid currents are quite negligible for a bias of, say, − 1.5 v. The retroactive capacity, which in high-amplification single-grid valves may be very high, is negligible if the second grid and its circuit are suitably carried out. In a footnote on p. 47 the writer discusses the use, in certain cases, of a third grid to prevent secondary emission, as in the ordinary pentode.

The next instalment will deal with r.f. amplifiers and with the elimination of reaction effects and the inclination to howl.

THE INFLUENCE OF THE INTERELECTRODE CAPACITY BETWEEN THE GRID AND THE ANODE IN MULTI-STAGE RESONANCE AMPLIFICATION.—V. I. Siforov. (*Westnik Elektrot.*, No. 3, 1931, Sec. I, pp. 108–115.)

Further development of the work dealt with in 1931 Abstracts, pp. 320–321. The writer derives the necessary and sufficient conditions for the absence of self-excitation in the case where the impedance of the tuned circuit is small in comparison with the valve impedance—as when screen-grid valves are used for short-wave amplification. *See* also next abstract.

ON THE INDISPENSABLE AND SUFFICIENT CONDITION OF ABSENCE OF SELF-EXCITATION IN A MULTI-STAGE RESONANCE AMPLIFIER.—V. I. Siforov. (*Westnik Elektrot.*, No. 7, 1931, Sec. I, pp. 213–222.)

For the writer's previous papers *see* preceding abstract. In the present paper the necessary and sufficient condition for the absence of self-excitation in an n-stage tuned amplifier, for any particular condenser values, is given as the inequality $Z_r/R_i < P_n\,(\mu\omega C_0 R_i)$, where Z_r is the equivalent resistance of the tuned circuit, C_0 the grid/anode capacity, and $P_n\,(q)$ a function which is given for the cases $n = 1$ to 4. The condition can also be expressed in the form $Z_r/R_i \leqq P\,(\mu\omega C_0 R_i)$, where $P\,(q) = \lim\,[P_n\,(q)]_{n\to\infty}$, giving $P(q) = 2/q$ for $q \leqq 2$ and $P(q) = \dfrac{1 + \sqrt{2q}}{2q - 1}$ for $q \geqq 2$. The expressions are also given for $Z_r \ll R_i$, when $n = 1, 2, 3, 4$ and ∞. Finally, if $\omega C_0 S Z_r^2 \leqq \frac{1}{2}$ and $\mu\omega Z_r \leqq 2$, the amplifier will not oscillate however great the number of stages and the equivalent impedance may be. Diagrams are given of the functions $P_1(q)$ . . . . $P_4(q)$ and $P(q)$ for values of q between 0.2 and 1 300. By means of these curves the parameters can be found for non-oscillation of the amplifier. If $Z_r > R_i$, the condition for the absence of self-oscillation is practically independent of the number of stages.

REGENERATION THEORY [STABILITY OF AMPLIFIERS WHOSE OUTPUT IS CONNECTED TO THE INPUT THROUGH A TRANSDUCER].—H. Nyquist. (*Bell S. Tech. Journ.*, Jan., 1932, Vol. 11, No. 1, pp. 126–147.)

The rule for stability arrived at runs as follows:—" Let the complex quantity $AJ\,(i\omega)$ represent the ratio by which the amplifier and feed-back circuit modify the current in one round trip. . . . . . Plot plus and minus the imaginary part of $AJ\,(i\omega)$ against the real part for all frequencies from 0 to ∞. If the point $1 + iO$ lies completely outside this curve the system is stable; if not, it is unstable."

ÜBER RESONANZERSCHEINUNGEN BEI FREQUENZTEILUNG (On Resonance Phenomena in Frequency Division).—L. Mandelstam and N. Papalexi. (*Zeitschr. f. Phys.*, 1931, Vol. 73, No. 3/4, pp. 223–248.)

Authors' summary:—A theoretical investigation [using Poincaré's method for periodical solutions of non-linear differential equations] shows that, by proper choice of the parameters in a condenser circuit with reaction, oscillations can be excited whose fundamental period is N times as great as the period of the exciting force (divided frequency oscillations). The amplitude of these oscillations is approximately calculated as a function of the amplitude of the exciting force and the detuning (resonance curve of the second kind) and the shape of these curves is discussed assuming a special form of the valve characteristic [fifth degree polynomial]. It is found that divided frequency oscillations are only excited when : (i) the amplitude of the exciting force satisfies certain inequalities, and (ii) the detuning lies within a defined (narrow) frequency region, whose magnitude depends essentially on the amplitude of the external e.m.f. It is pointed out that technical application of the results is possible. An account is given of experiments, whose results agree qualitatively with the theoretical deductions.

Frequency Multiplication by the Use of a Rochelle Salt Condenser.—Wologdin. (*See* under "Subsidiary Apparatus and Materials.")

A Thermionic Frequency Doubler.—Stedman. (*See* under "Subsidiary Apparatus and Materials.")

Property of a Circuit having Self-Inductance, Capacity and Resistance.—M. Osnos. (*Westnik Elektrot.*, No. 8, 1931, Sec. I, pp. 246-247.)

Russian version of the paper dealt with in 1931 Abstracts, pp. 553–554.

Form of the E.M.F. produced with Pulsating Angular Velocity.—L. V. Stecula. (*Westnik Elektrot.*, No. 5/6, 1931, Sec. II, pp. 107–111.)

Analysis of the sine wave of alternating period and amplitude produced when a generator, yielding a pure sine wave when driven at a uniform angular velocity, is driven with a pulsating angular velocity.

The Principles of Quadripole Theory.—E. W. Selach. (*Westnik Elektrot.*, No. 7, 1931, Sec. I., pp. 178–190.)

Synthesis of a Finite Two-Terminal Network whose Driving-Point Impedance is a Prescribed Function of Frequency.—O. Brune. (*Journ. Math. Phys., Massach. Inst. Technol.*, Aug., 1931, Vol. 10, pp. 191–236.)

In this treatment of the converse of the usual problem, methods are developed for determining one solution, at any rate, of the structure of a network when the impedance function is given.

Impedance Characteristics of Loaded Lecher Systems.—L. Tonks. (*Physics*, Jan., 1932, Vol. 2, No. 1, pp. 1–11.)

Author's abstract :—" Simple formulas are developed for the impedance of short lengths of Lecher systems terminated by resistances. This impedance is most simply expressible as a multiple of the surge impedance. The variation of impedance with system length is traced, and certain simple relationships are found. It is shown that any system of loads across a Lecher system is equivalent to a certain length of system terminated by a certain resistance. The formulas account for Takagishi's double hump phenomenon [1930 Abstracts, p. 404], and this phenomenon is applied to finding the bridge shortening of an actual bridge. A method of calculating resistance from a resonance curve is derived " [but a resonance curve fails to distinguish between resistance located at the bridge and resistance located at the fixed end of the system, and the separation has to be made experimentally].

Frequency-dependent Echo Damping Measurements on Lines, by the Singing-Point Method, and their Use for Determining Position, Nature and Magnitude of a Fault.—W. Weinitschke. (*T.F.T.*, Feb., 1932, Vol. 21, pp. 36–44.)

Continuation of the work referred to in February Abstracts, p. 92.

An Application of the Circle Diagram to the Design of Attenuation and Phase Equalisers. Part II.—N. M. Rust. (*Marconi Review*, Jan.–Feb., 1932, No. 34, pp. 1–10.)

Conclusion of the paper dealt with in March Abstracts, pp. 161–162.

The Natural Electromagnetic Oscillation of a Rod-shaped Conductor at the Surface of Separation of Two Media with Different Dielectric Constants.—Ruprecht. (*See* under "Directional Wireless.")

On the Theory of Beats.—V. S. Gabel. (*Westnik Elektrot.*, No. 7, 1931, Sec. I., pp. 207–212.)

A special analysis of the beating between two alternating currents, one of fixed frequency F and the other of a progressively changing frequency f, leads to the conclusion that in addition to the beats between the harmonics mF and nf there exist also beats of a higher order. If $f<F$, complex beats occur between mf and F; if $f>F$, similar beats occur between f and nF. The theory of the higher order beats for $f>F$ enables the order to be determined for any complex beat, if F lies in the audible zone ; this is of importance in connection with the calibration of standard frequency multivibrators.

Transient Response of the Triode Valve Equivalent Network.—W. Jackson. (*Phil. Mag.*, March, 1932, Series 7, Vol. 13, No. 85, pp. 735–736.)

This letter amplifies an introductory remark in the writer's paper of the same title (March Abstracts, p. 161).

Oscillations of Systems with Negative Characteristics.—Runge : Rosing : Steimel. (*See* under "Transmission.")

Asymmetry in Push-Pull Circuits.—E. S. Anceliović. (*Westnik Elektrot.*, No. 5/6, 1931, Sec. I., pp. 152–161.)

A theoretical and experimental investigation of the asymmetry caused by inequality of the valve parameters. The theory is tested on wavelengths of 307 and 2.60 metres, and gives good agreement. The influence of asymmetry is greater at short wavelengths.

[ANALYTICAL STUDY OF] PLATE DETECTION OF RADIO SIGNALS.—J. P. Woods. (*Electronics*, Jan., 1932, p. 30.)

Summary of the University of Texas paper referred to in February Abstracts, p. 92.

DISCHARGE TUBES: JUMPING GLOW PHENOMENON CAUSED BY HYDROCARBON VAPOUR.—W. A. Leyshon. (*Electrician*, 12th Feb., 1932, Vol. 108, p. 219.)

Short abstract of Miss Leyshon's paper on the "Periodic Movements of the Negative Glow in Discharge Tubes," and of the subsequent discussion.

TRANSMISSION.

DAS VERHALTEN DER ELEKTRONENRÖHRE BEI SEHR HOHEN FREQUENZEN (The Behaviour of the Electron Valve at Very High Frequencies).—H. E. Hollmann. (*Naturwiss.*, 11th March, 1932, Vol. 20, No. 11, pp. 181–182.)

This letter gives a preliminary account of investigations on the behaviour of valves at very high frequencies which show that Barkhausen-Kurz oscillations are a special case of a general principle of oscillation production. The statical characteristic is replaced by the so-called "Ultradynamic" characteristic, whose slope S_d is given by $\cos\phi \cdot \frac{di_a}{de_{st}}$, where $\phi = \omega\theta$ (ω = angular frequency, θ = time taken by electron to pass from grid to anode; e_{st} refers to the statical characteristic). The relation $\lambda^2 E_a = \frac{\text{const.}}{n^2}$, $(n = 1, 2, 3 \ldots)$, is found for the positions of maximum energy of the oscillation regions. For $\phi = m\pi$, where m is odd, the ultradynamic slope becomes negative and the characteristic inverted; the wavelength corresponding to the first inversion is $\lambda = \frac{1000 d_a}{\sqrt{E_a}}$, ($d_a$ = anode diameter), the equation originally given by Barkhausen if E_a is replaced by the grid voltage E_g in the retarding potential circuit. The Barkhausen-Kurz and Gill-Morrell oscillations may thus be traced back to the normal conditions of oscillations production. *Cf.* Kalinin, April Abstracts, p. 223; *also* Cockburn, Rostagni, and Kunz, same page; *also* Gill, and Gutton and Beauvais, January Abstracts, p. 34, and Potapenko, below.

ON THE DEPENDENCE OF THE LENGTH OF THE ULTRA-SHORT ELECTROMAGNETIC WAVES UPON THE HEATING CURRENT OF THE TUBE AND UPON THE AMPLITUDE OF THE OSCILLATIONS.—G. Potapenko. (*Phys. Review*, 1st Feb., 1932, Series 2, Vol. 39, No. 3, p. 547.)

Abstract only:—Previous work of the author has shown [1931 Abstracts, p. 613] that a vacuum tube may generate oscillations, the frequency of which exceeds many times the frequency of electronic oscillations around the grid. Ultra-short "dwarf" waves of a few centimetres wavelength were obtained by means of this method. Experiments have shown that the frequency of "dwarf" waves are not exact multiples of the frequency of the electronic oscillations as might be expected. The theory proposed by P. S. Epstein shows that this discrepancy may be explained by the influence of the amplitude of the generated oscillations upon the movement of the electrons around the grid. Investigations of the dependence of the lengths of the generated waves upon the heating current of the tube and upon the amplitude of oscillations completely confirmed the prediction of this theory.

ON THE MEASUREMENT OF THE ENERGY OF ULTRA-SHORT ELECTROMAGNETIC WAVES.—G. Potapenko. (*Phys. Review*, 1st Feb., 1932, Series 2, Vol. 39, No. 3, p. 551.)

Abstract only:—Because of the lack of methods for direct absolute measurement of the energy of ultra-short electromagnetic waves, the author proposes an approximate method of measuring the energy. This method is based on the determination of the amplitude of oscillations and of the current which appears in the plate circuit of the tube generating ultra-short waves. In this way the energy of "dwarf" waves (see preceding abstract) has been measured and a method of increasing their energy by means of negative plate potential has been studied. The power of ultra-short waves generated with *one* amplifier tube can in this manner be brought up to 0.08 watt for wavelengths of about 10 cm and up to 0.2 watt for wavelengths of about 60 cm.

INVESTIGATIONS IN THE FIELD OF THE ULTRA-SHORT ELECTROMAGNETIC WAVES. I. THE GENERATOR FOR THE PRODUCTION OF ULTRA-SHORT UNDAMPED WAVES.—G. Potapenko. (*Phys. Review*, 15th Feb., 1932, Series 2, Vol. 39. No. 4, pp. 625–637.)

Author's abstract:—A description of apparatus for the production of ultra-short undamped electromagnetic waves by the method of Barkhausen and Kurz is given. An investigation has been made of the method of detecting the oscillations by observing the current in the plate circuit of the generator. At a constant plate potential the current is approximately proportional to the amplitude of the oscillations. A comparison of generators with one and with two tubes shows the advantages of the former. In certain cases the energy of oscillations produced by generators with one tube can be considerably increased by a suitable choice of the "ballast" capacity of the generator [the single oscillator valve is balanced against a small condenser of variable capacity, or against a second valve of the same type and of equal capacity, kept with its filament cold].

INVESTIGATIONS IN THE FIELD OF THE ULTRA-SHORT ELECTROMAGNETIC WAVES. II. THE NORMAL WAVES AND THE DWARF WAVES.—G. Potapenko. (*Phys. Review*, 15th Feb., 1932, Series 2, Vol. 39, No. 4, pp. 638–665.)

Author's abstract:—The results are presented of an investigation of the production of ultra-short undamped electromagnetic waves by using the method of H. Barkhausen and K. Kurz.

Method of working diagrams. Normal waves and dwarf waves. A method is developed for the graphic representation of the work of generators of ultra-short waves. This method is based on the construction of special "working diagrams." These diagrams define the location of "regions of oscillations," which show the values of the natural periods of the oscillating circuits and the values of the grid potentials at which oscillations are generated. Vacuum tubes can generate two kinds of ultra-short waves. The first kind have a wavelength approximating that computed by Barkhausen's formula $\lambda^2 E_g = d_a^2 10^6$. Their period is nearly equal to the time required for the electrons to move from the filament to the plate and back (normal waves). The second kind of waves are considerably shorter (dwarf waves). Both kinds of waves satisfy the equation $\lambda^2 E_g =$ const. for points on the working diagram where the plate current (the amplitude of the oscillations) has its maximum value.

Complex working diagrams. Dwarf waves of higher orders. Vacuum tubes can have complex working diagrams with a large number of regions of oscillations. In such a case the tube generates different dwarf waves. Their length is two, three and four times shorter than that of the normal waves. Dwarf waves are accordingly divided into waves of the 1st, 2nd, 3rd, etc., orders. The shortest dwarf waves of the 4th order, generated by tubes of the type R5, had a wavelength $\lambda = 9.4$ cm. The presence of dwarf waves of higher orders shows that *vacuum tubes can generate oscillations of a frequency considerably greater than the frequency of the electronic oscillations.* Both the normal and dwarf waves belong to the same type of GM-oscillations. Limits were determined within which Barkhausen's formula is applicable. It is shown that the difference in the number of regions of oscillations on the working diagrams depends on the difference in the time required for the electrons to pass in different directions within the tube. The latter depends on the asymmetry in the arrangement of the electrodes.

The nature of dwarf waves. Dwarf waves are oscillations of the circuits within the tube or coupled with the tube which are excited in such a manner that during the time τ it takes for the electrons to pass from the filament to the plate and back, the circuits perform two complete oscillations (dwarf waves of the 1st order), three complete oscillations (dwarf waves of the 2nd order), etc. Thus the wavelengths are equal to: $\lambda_0 = c_0\tau$ (normal waves), $\lambda_1 = c_0\tau/2$ (dwarf waves of the 1st order), $\lambda_2 = c_0\tau/3$ (dwarf waves of the 2nd order), $\lambda_3 = c_0\tau/4$ (dwarf waves of the 3rd order), etc. Dwarf waves 9.5–18.5 cm long originate in oscillating circuits which are inside the tube. The advantages of dwarf waves of higher orders are shown, owing to the possibility of using lower grid potentials, which leads to a greater steadiness in the operation of the tube.

ON THE ELECTRICAL OSCILLATIONS OF VERY SHORT WAVELENGTH.—A. Rostagni. (*Phil. Mag.*, March, 1932, Series 7, Vol. 13, No. 85, pp. 733–734.)

In this note the writer claims that the observations made by E. W. B. Gill (January Abstracts, p. 34) on oscillations in a triode with positive grid can be explained by a theory already given by the writer of this note (*R. Acc. delle Scienze di Torino*, Vol. 66, 1931, pp. 123, 217, 383—1st Semester: Notes I, II, III. *Also* February Abstracts, pp. 92–93, and 1931, p. 267). *See* also next abstract.

ON THE ELECTRICAL OSCILLATIONS OF VERY SHORT WAVELENGTH.—E. W. B. Gill. (*Phil. Mag.*, March, 1932, Series 7, Vol. 13, No. 85, pp. 734–735.)

In answer to the note abstracted above, the writer shows that Rostagni's theory gives the periods of free oscillation of the space charges between the grid and anode of a valve but does not prove that the electrons passing across the valve will maintain these oscillations. The theory put forward by the writer (*see* preceding abstract) had as its object the exact explanation of this regeneration.

POLYPHASE ELECTRON TUBE OSCILLATORS [AND PARTICULARLY THEIR USE FOR ULTRA-SHORT-WAVE GENERATION].—A. Arenberg. (*Westnik Elektrot.*, No. 5/6, 1931, Sec. I, pp. 146–152.)

Continuation of the work dealt with in 1931 Abstracts, p. 438. *See* also same Abstracts, pp. 497–498.

SPECIAL TRANSMITTING CIRCUIT FOR ULTRA-SHORT (CENTIMETRE) WAVES.—F. Noack: Kohl. (*Rad., B., F. f. Alle*, Feb., 1932, pp. 58–60.)

A special Te-Ka-De valve is used, and "instead of choke coils in the grid and anode leads, Kohl uses a [metallic] sheet laid over the two leads, but not short-circuiting them. According to the wavelength, this sheet is moved along the leads nearer to or further from the valve."

CIRCUITS AND VALVES FOR ULTRA-SHORT (DECIMETRE) WAVES.—Rindfleisch and Rohde. (Summary in *Electronics*, Jan., 1932, p. 28.)

Chiefly B.-K. circuits. A table of suitable European valves is given, the French "Metal TMC" and the Telefunken RE 074 d (two grids) being particularly recommended. Receivers of the same type as the transmitters, but without Lecher wire systems, and two types of super-regenerative receiver, are described.

ÜBER SCHWINGUNGEN VON SYSTEMEN MIT NEGATIVER CHARACTERISTIK (Oscillations of Systems with Negative Characteristics).—I. Runge: Rosing: Steimel. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 13, 1932, pp. 84–91.)

Author's summary:—The occurrence of oscillations in systems with negative characteristic, in a circuit with a series resistance shunted by a condenser, is examined [in connection with Rosing's production of oscillations in a photoelectric cell circuit—1930 Abstracts, p. 515]. For this purpose Steimel's negative characteristic circuit [two-valve circuit, 1931 Abstracts, p. 92] was erected and its characteristic plotted. The stability conditions derived by Steimel were experimentally tested and confirmed.

The oscillations occurring in the "condenser" circuit (Rosing circuit) are shown to be relaxation oscillations and their manner of occurrence is explained completely on the lines of the usual relaxation oscillation circuit. The proportionality of the frequency to the reciprocal of the capacity is derived theoretically and confirmed by experiment. The results obtained are illustrated by oscillograms. The effect of a self-inductance connected in front of the condenser is investigated, and the transition from relaxation oscillations to harmonic oscillations is explained also by oscillographic records.

OVER-VOLTAGE IN THE SOURCE OF THE ANODE CURRENT BY GRID MODULATION OF A RADIO TELEPHONE TRANSMITTER.—G. A. Zeitlenok. (*Westnik Elektrot.*, No. 2, 1931, Sec. I, pp. 43–45.)

A NEW FADING-FREE METHOD OF BROADCAST TRANSMISSION.—H. Günther: Bureau of Standards. (*Rad., B., F. f. Alle*, Feb., 1932, p. 49: photograph only in *Electronics*, Jan., 1932, p. 27.)

A vague note on a reported Bureau of Standards development. The writer implies that the technique of recording photographically the arrival of the ground ray and of a steeply reflected ray is in some way brought into use to modify the radiation from the transmitting aerial in such a way that fading at the receiver is eliminated.

ON MODULATION OF FREQUENCY.—A. M. Kugushev. (*Westnik Elektrot.*, No. 2, 1931, Sec. I, pp. 72–80.)

The writer shows that frequency modulation is a result of phase modulation; the frequency-modulated oscillations possess a spectrum: in wireless telephony frequency modulation should be avoided, since it causes disturbances in the receiver in addition to widening the band of frequencies. It provides no reliable means for reducing short-wave fading.

ON THE CALCULATION OF ELECTRON TUBE OSCILLATORS [BASED ON ANODE DISSIPATION].—A. I. Joffe. (*Westnik Elektrot.*, No. 7, 1931, Sec. I, pp. 222–225.)

"The usual methods for the calculation of a valve require a laborious confirmation of the results, since these must simultaneously satisfy a number of conditions. The writer shows that the possibility exists for an exact determination of the conditions for maximum output and maximum efficiency, by starting from the anode dissipation. The results thus found require no further matching to other conditions."

CLASS "B" AUDIO POWER AMPLIFIERS [PLATE CURRENT FLOWING ONLY WHEN GRID IS EXCITED].—C. L. Farrar. (*Rad. Engineering*, Jan., 1932, Vol. 12, pp. 24–27.)

Class B amplifiers, where the valve is biased nearly to or at the cut-off point, have high power output and efficiency compared with Class A (where considerable plate current flows without grid excitation); the maximum efficiency of Class A is shown to be below 50 % (usually it is below 20 %) whereas that of Class B may be 78.5 % (60 % is not difficult to reach). But unlike Class A, Class B does not ordinarily give a true reproduction of the input, and is generally only used for r.f. amplification. If, however, two valves with identical characteristics are used in push-pull, Class B can be used for a.f. with as little distortion as Class A. *Cf.* Fay, below.

THE OPERATION OF VACUUM TUBES AS CLASS B AND CLASS C AMPLIFIERS.—C. E. Fay. (*Bell S. Tech. Journ.*, Jan, 1932, Vol. 11, No. 1, pp. 28–52.)

Class B amplifiers are defined as "those which operate with a negative grid bias such that plate current is practically zero with no excitation grid voltage, and in which the power output is proportional to the square of the excitation voltage"; class C as "those which operate with a negative grid bias more than sufficient to reduce the plate current to zero with no excitation grid voltage, and in which the output varies as the square of the plate voltage between limits." *Cf.* Farrar, above.

Author's abstract:—"A simple theoretical development of the action of a vacuum tube and its associated circuit when used as a Class B or Class C amplifier is given. An expression for the power output is obtained and the conditions for maximum outputs are indicated. The way in which the tuned plate circuit filters out the harmonics in the pulsating plate current wave is illustrated by a hypothetical example. A set of dynamic output current characteristics is developed graphically from a set of static characteristics. The Class B dynamic curves are found to give a better approximation to a straight line than the Class C curves because of a reversed curvature which appears at the lower ends. It is pointed out that the screen grid tube should function similarly to a high μ three-element tube in this type of operation. Experimental dynamic characteristics of a three-element tube, Western Electric 251–A, and of a screen grid tube, Western Electric 278–A, of identical dimensions are shown which verify the theoretical results. The screen grid tube gives about the same output and efficiency as the three element tube, but its dynamic characteristic tends to bend more rapidly at the upper end."

ASYMMETRY IN PUSH-PULL CIRCUITS.—Anceliovič. (*See* under "Properties of Circuits.")

RECEPTION.

THE AUTOTONE.—F. L. Devereux and H. F. Smith. (*Wireless World*, 24th February, 2nd and 9th March, 1932, Vol. 30, pp. 186–190, 214–219, 243–247.)

A four-valve receiver employing a double-circuit tuner followed by a grid detector. Of the three subsequent valves the first is an a.f. amplifier, the second is employed for tone correction purposes, and the third is the power output valve. Extreme selectivity is obtained by critical retroaction; the upper audio-frequencies lost in this process are subsequently restored by the tone-correcting valve. Special arrangements are employed in the receiver to maintain a virtually constant degree of retroaction over the whole of the tuning scale.

RADIO DESIGN AND THE TREND OF THE RADIO INDUSTRIES [IN U.S.A.].—(*Rad. Engineering*, Feb., 1932, Vol. 12, pp. 21–22.)

Fields hardly yet touched: building programme (exclusive of public works) estimated as showing a 17.5 % rise: new radio developments—including non-glare dials, bi-resonator r.f. tuning systems, tri-resonator intermediate amplifiers, image suppressors for discrimination against cross-talk, detectomatic (duo-diode) detector for proper demodulator action and automatic volume control, dual loud speakers for best quality reception. "21 manufacturers are now producing the new type farm radio receiver employing air-cell batteries" [*see* next two abstracts].

AN EFFICIENT BATTERY-OPERATED RADIO RECEIVER [USING EVEREADY 2.5 VOLT "AIR CELL" BATTERIES FOR FILAMENTS AND DRY CELLS FOR ANODES, GIVING 1 000 HOURS' WORKING].—L. E. Barton and L. T. Fowler. (*Rad. Engineering*, Feb., 1932, Vol. 12, pp. 23–24 and 38.)

The problem of obtaining sufficiently great a.f. output in a receiver of this type (whose cost for battery power is "less than twice the small cost for current to operate an a.c. receiver") is solved by reducing the plate battery drain by using the Class "B" audio-amplifier which takes nearly zero plate power in the absence of signals (*cf.* Farrar, Fay, both under "Transmission"). When a peak output of 1.2 watt is obtained at maximum volume on an average signal, the total average battery power to the whole set is 3.5 watts only. A special permanent-magnet m.c. loud speaker is embodied.

BATTERY DESIGN PROBLEMS OF THE AIR CELL RECEIVER.—F. T. Bowditch. (*Proc. Inst. Rad. Eng.*, Feb., 1932, Vol. 20, pp. 215–227.)

See two preceding abstracts. Author's summary:—"The present paper deals with those design features of battery-operated radio receivers which are important from the standpoint of obtaining the maximum useful battery life. The properties of the air cell A battery are discussed with relation to receiver design. The desirability of providing adequate performance until the B batteries have fallen to a very low voltage is shown. An analysis of several means of obtaining a satisfactory rate of grid voltage reduction with falling B battery voltage is included, together with a discussion of B battery resistance. It is shown that the considerations treated control a variation in useful B battery life of the order of 50 per cent."

DETECTOR DISTORTION AT LOW INPUT VOLTAGES.—H. A. Brown, G. W. Pickels and C. T. Knipp. (*Rad. Engineering*, Jan., 1932, Vol. 12, pp. 21–23.)

"While much has been done to secure undistorted detection at input potentials above one volt, little or no effort has been directed toward securing low distortion at input potentials of the order of one-tenth of a volt." This matter is of importance because it should be possible to simplify the receiver by providing fewer stages of tuned r.f. amplification, using band-selector tuning and two stages of high gain, high quality a.f. amplification. The writers investigate experimentally the degree of distortion encountered when using low input voltages to excite various well-known types of triode and tetrode as detectors; they employed a Belfils bridge to eliminate the fundamental component, and measured the proportion of second harmonic present. Among the valves tested were two types of alkali vapour detectors and the type UX-200 soft detector. The most practical results were obtained with standard heater-type s.g. valves, using a biased control grid instead of grid leak and grid condenser.

EFFECTS ON RECEPTION OF OVER-MODULATION.—C. E. Kilgour. (*Electronics*, Jan., 1932, pp. 9 and 36.)

"The recently initiated move to consider broadcast transmission and reception as two units of a single system so that the best over-all results may be obtained is to be greatly commended [*cf.* Graham, Feb. Abstracts, p. 96]. However, it is hard to see how receiver designers can do anything worth while to correct one very frequent and serious transmission defect, that of over-modulation." This point is developed in the rest of the paper.

CAUSES OF VOLUME FLUCTUATIONS IN A.C. MAINS-DRIVEN RECEIVERS.—(*Rad., B., F. f. Alle*, Feb., 1932, p. 79.)

THE WIRELESS WORLD THREE, D.C. MODEL.—W. T. Cocking. (*Wireless World*, 16th and 23rd March, 1932, Vol. 30, pp. 264–267 and 294–296.)

The battery and a.c. models of this receiver have been already dealt with (1932 Abstracts, p. 37).

DISTRIBUTING PROGRAMS IN THE WALDORF ASTORIA.—J. J. Kuhn. (*Bell Lab. Record*, Feb., 1932, Vol. 10, No. 6, pp. 187–193.) (*See* also Jan. Abstracts, p. 37.)

AN UNDESIRABLE COUPLING LINK IN RADIO RECEIVERS [COMMON EARTH LEAD TO AERIAL SYSTEM AND FILAMENTS OR CHASSIS, OR BOTH].—A. E. Teachman. (*Rad. Engineering*, Jan., 1932, Vol. 12, pp. 19–20.)

This connection originally came into being on account of its use in eliminating "hand capacity"; now that receivers are thoroughly shielded it is no longer needed for this purpose, and the only reason, except tradition, for retaining it is that some people regard it as a protective "earth" for all-electric sets. "It is the purpose here to give reasons why this common connection should be removed and to point out several benefits to operation of all-electric receivers if this is done. . . . At least one large corporation has already adopted this suggestion and is making use of it on a current model."

AUTOMOBILE RADIO PROBLEMS FACE SOLUTION IN 1932.—(*Electronics*, Jan., 1932, pp. 12–13.)

A RECEIVER FOR THE AUTOMATIC RECORDING OF TIME SIGNALS [FOR LONGITUDE DETERMINATIONS], AND THE RESPONSE TIME OF THE APPARATUS.—A. Schagger. (*Verh. d. Balt. Geod. Komm.*, 1931, pp. 161–164.)

Description of the apparatus used in the 1929 longitude determinations. An important point was the constancy, throughout the whole observation period, of the response time of the relay.

ULTRA-SHORT WAVE RECEIVERS [GERMAN].—R. Raven-Hart. (*Electronics*, Jan., 1932, p. 23.)

SPECIAL RECEIVING CIRCUIT FOR ULTRA-SHORT (CENTIMETRE) WAVES.—F. Noack: Kohl. (*Rad., B., F. f. Alle*, Feb., 1932, pp. 58–60.)

A circuit similar to the transmitting circuit dealt with under "Transmission."

RECEIVERS FOR ULTRA-SHORT (DECIMETRE) WAVES.—Rindfleisch and Rohde. (*See* abstract under "Transmission.")

PIEZOELECTRIC BAND-PASS FILTER.—J. Efrusi. (*Westnik Elektrot.*, No. 2, 1931, Sec. I, pp. 52–62.)

A discussion of the advantages derived by the use of low-frequency filters embodying piezoelectric crystals. A simple circuit with two crystals is given. The theory, method of action, and experimental results are dealt with fully.

RESISTANCE-COUPLED AMPLIFIERS WITH AN AMPLIFICATION OF THE ORDER OF 450 PER STAGE.—Kapteyn. (*See* abstract under "Properties of Circuits.")

TO TEACH SCHOOLS HOW TO SELECT RADIO EQUIPMENT. [PARAGRAPH ON THE CO-OPERATION BETWEEN R.M.A. AND U.S. OFFICE OF EDUCATION].—(*Electronics*, Jan., 1932, p. 26.)

AERIALS AND AERIAL SYSTEMS.

BERECHNUNG DER STRAHLUNGSENERGIE VON DIPOLANTENNEN—TELEFUNKENRICHTANTENNEN—NACH DER POYNTINGSCHEN METHODE (Calculation of the Radiation Energy of Dipole Aerials—Telefunken Beam Systems—according to the Poynting Method).—J. Labus. (*E.N.T.*, Feb., 1932, Vol. 9, pp. 61–67.)

Assuming equality of currents in the component dipoles, and a sinusoidal distribution; the effect of the earth is neglected. With the help of the Poynting vector, integrals are arrived at whose solutions are found by a law regarding Laplace integrals which plays a fundamental part in operational calculus. Numerical results are given in Fig. 4 for various numbers of dipoles.

RADIATION RESISTANCE OF COMPLEX ANTENNAS.—K. Tani. (*Rep. Radio Res. and Works, Japan*, No. 2, Vol. 1, 1931, pp. 157–183.)

Giving formulae and tables for the radiation resistance of directional aerials, for various phase angles and spacings between the elements.

THE EFFECT OF THE EARTH ON THE NATURAL WAVELENGTH, IMPEDANCE AND ADMITTANCE OF A SINGLE HORIZONTAL WIRE.—G. Hara. (*Mem. Ryojun Coll. Eng.*, No. 3, Vol. 4, 1932, pp. 185–207; summary in *Sci. Abstracts, Sec. B.*, Jan., 1932, Vol. 35, p. 44.)

Experimental results for the wavelength of a 10-metre aerial, over a salt field and over a cooling pond, are in good agreement with the approximate formulae here derived.

ANTENNA RESONANCE TRANSFORMERS.—V. V. Tatarinov. (*Westnik Elektrot.*, No. 4, 1931, Sec. I, pp. 125–131: summary in *Physik. Ber.*, 15th Dec., 1931, Vol. 12, pp. 2930–2931.)

SINGLE INSULATED TOWER AS BROADCASTING AERIAL.—I. T. and T. (*See* abstract under "Miscellaneous.")

INVESTIGATION OF AIRPLANE ANTENNAS ON MODELS.—P. A. Petrov. (*Westnik Elektrot.*, No. 4, 1931, Sec. I, pp. 131–137.)

Aeroplane aerials studied by Niemann in actual practice have now been represented by models, and the results with these prove that the behaviour of actual aerials can be predicted by tests on such models. Abraham's Principle of Similarity holds good—the capacities and natural wavelengths of an aerial and its model are according to their geometrical dimensions.

MORE ABOUT THE RADIATION RESISTANCE.—B. L. Rosing. (*Westnik Elektrot.*, No. 2, 1931, Sec. I, pp. 63–64.)

The writer discusses the question of the sign of the expression for the radiation resistance of an aerial system and arrives at the conclusion that in the usual treatment, based on the assumption of divergent radiation, it must be negative.

VALVES AND THERMIONICS.

THE RADIO-FREQUENCY PENTODE: A NEW USE OF THE SUPPRESSOR GRID.—E. W. Ritter. (*Electronics*, Jan., 1932, pp. 10–11.)

The writer deals first with the superiority of the r.f. pentode characteristics compared with those of a triode. It is not only in the region of low plate voltages that improvement is found: at the higher voltages the plate current/plate voltage curve is more nearly horizontal; *i.e.*, the plate resistance is higher, causing an increase in gain and selectivity.

Another advantage of the r.f. pentode is its uniformity of screen current. In the past it has not been practicable to use a screen resistor because of the wide variations in screen current between different valves and in the same valve according to its life. These variations were due to secondary emission from the screen, most of which is stopped by the suppressor grid; it is therefore possible to use a screen circuit resistance. The effects of this are considered, particularly in connection with volume control, automatic or otherwise. The advantages of the valve are summarised in the final section.

TWO SETS OF ELEMENTS IN ONE TUBE [THE "TRIPLE-TWIN" VALVE AND CIRCUIT].—C. F. Stromeyer. (*Rad. Engineering*, Feb., 1932, Vol. 12, pp. 39–40.)

"The triple-twin tube and circuit [here described] introduce a system for utilising the positive region of the grid voltage/plate current characteristic as well as the usual negative portion. This method produces a relatively high undistorted power output independent of grid current flow. A further advantage is gained by employing the tube as a combination detector and amplifier."

STATUS OF COLD-CATHODE TUBES ABROAD.—I. J. Saxl: Seibt: von Ardenne. (*Electronics*, Jan., 1932, pp. 17–19.)

(i) Electron emission by beta rays. (ii) Seibt's (cold) glow discharge valve (1930 Abstracts, p. 632). (iii) Photoelectric cathodes (von Ardenne, 1931 Abstracts, p. 98). (iv) Photoglow valves, where a gas-filled tube is put into the circuit in such a way that the initiating discharge voltage is not reached completely; a minute photoelectric current as low as 0.1 μA is sufficient to start a glow discharge current of 50 mA. Cold cathode valves of the photoelectric type can be made to give considerable a.f. amplification; for r.f. amplification a vacuum type must be used, and for this purpose a method of increasing the photoelectric emission of caesium, by depositing it upon layers of mixed oxides, has been developed. Emissions up to 65 μA per lumen have already been obtained.

THE "MICROMESH" VALVE.—I.T. and T. (*See* abstract under "Miscellaneous.")

DETERMINATION OF THE CUBE TERM IN A VALVE CHARACTERISTIC.—Stedman. (*See* abstract under "Subsidiary Apparatus.")

VALVE TEST STANDARDS.—American Standardisation Committee. (*Year Book Inst. Rad. Eng.*, 1931, pp. 144–176: summary in *L'Onde Élec.*, Jan., 1932, Vol. 11, p. 3 A.)

SHOT EFFECT IN SPACE CHARGE LIMITED CURRENTS.—E. W. Thatcher and N. H. Williams. (*Phys. Review*, 1st Feb., 1932, Series 2, Vol. 39, No. 3, pp. 474–496.)

Authors' abstract:—The shot effect in space charge limited currents from tungsten and thoriated tungsten has been investigated. The effective fluctuation level is recognised, in general, as the combination of a depression due to pure space charge, and an elevation due to the liberation of electrons by positive ions. The magnitude of the elevation may be such as to carry the fluctuation level far above that for the same current under temperature limitation, or it may simply alter the form of the depression curve. The abnormal fluctuations observed have been analysed, and their cause traced to inherent mixed emission from the metal surface. The effect of age and heat treatment has been studied for specimens of tungsten. A double grid tube has been used for obtaining a space stream consisting solely of electrons, and the conditions determined under which this stream is governed by the laws of pure chance applying in the simple shot effect theory. With this arrangement space charge measurements of fluctuations can be made over a considerable range with the same degree of precision attainable with temperature limited currents. Considerations involving statistical correlation between instantaneous values of the anode current provide a possible theoretical basis for the space charge depression of shot effect. This treatment yields an expression for the ratio of the mean square value of the fluctuation voltage under given space charge conditions to that under strict temperature limitation of the current: $\overline{V_s^2}/\overline{V_t^2} = f(i_0/i)e^{-\omega^2/2\alpha^2}$. i_0 is the space current, i the saturation current, or total emission associated with a particular emitter temperature, and their ratio characterises the space charge situation. It has been shown that in the absence of abnormal effects the depression of the mean square fluctuation voltage which results is independent of the frequency $\omega/2\pi$ at which it is measured. This conclusion provides information regarding the spread of the correlation function defined in the theoretical section. A relation showing the fluctuation depression proportional to the square of the current depression under space charge is indicated.

ON THE CALCULATION OF ELECTRON TUBE OSCILLATORS [BASED ON ANODE DISSIPATION].—Joffe. (*See* under "Transmission.")

ON THE CALCULATION OF AN ELECTRON TUBE OSCILLATOR [NOMOGRAMS FOR THE BARKHAUSEN FORMULA $V_g = (10.i_s)^{2/3}$].—G. A. Kiandsky. (*Westnik Elektrot.*, No. 7, 1931, Sec. I, pp. 225–227.)

RESISTANCE OF AN OSCILLATING TRIODE.—S. I. Zilitinkevitch. (*Westnik Elektrot.*, No. 2, 1931, Sec. I, pp. 45–52.)

Six new definitions and the corresponding expressions for the resistance of an oscillating triode. The first three, on the assumption of a d.c. anode supply, are: (i) the total dissipative resistance of the oscillating triode, (ii) the loading resistance, and (iii) the equivalent loss resistance. The other three, derived on the assumption of an a.c. anode supply, are: (iv) the effective resistance of the oscillating triode, (v) the effective resistance transferred to the load circuit, and (vi) the effective anodic loss resistance. All the effective resistances are negative.

NEGATIVE GRID POLARISATION IN A TRIODE [PARTICULARLY IN A TRIODE WITH A WEAKLY EMITTING CATHODE].—S. A. Obolensky. (Summary in *Physik. Ber.*, 15th Dec., 1931, Vol. 12, pp. 2936–2937.)

MEASUREMENT OF [CONTROL] GRID-ANODE CAPACITY OF SCREENED TUBES.—E. G. Momot. (*Westnik Elektrot.*, No. 3, 1931, Sec. I, pp. 99–104.)

The measurements (by current-potential values, using a valve voltmeter) were with a cold cathode and had possible errors of 10%. The test frequency was 5 × 10⁴ c/s. Tables for the capacities of Russian and other (chiefly German) valves are given.

PAPERS ON THE USE OF VALVES AS CLASS A, B AND C AMPLIFIERS.—Farrar: Fay. (*See* under "Transmission.")

DIRECTIONAL WIRELESS.

Die elektromagnetische Eigenschwingung eines stabförmigen Leiters an der Grenzfläche zweier Medien mit verschiedener Dielektrizitätskonstante (The Natural Electromagnetic Oscillation of a Rod-Shaped Conductor at the Surface of Separation of Two Media with Different Dielectric Constants [Application to Direction Finding Errors caused by Resonance with the Ship's Hull]).—H. Ruprecht. (*Hochf: tech. u. Elek: akus.*, Feb., 1932, Vol. 39, pp. 59–66.)

In addition to errors due to metallic parts of the ship, it is possible for the ship's hull as a whole to resonate to the signal frequency in so far as the electromagnetic field has a horizontal electrical component. The hull is at the surface of separation of two media with different dielectric constants, and the length of hull which would cause resonance with a given wavelength depends on the draught. The present paper investigates this relation, both theoretically and experimentally, the complex hull being represented for simplicity's sake by a cylinder of circular section of non-ferromagnetic material (brass); "centimetre" waves are used for the tests. Resonance may occur if the length of the ship lies between 1/2 and 1/18 of the received wavelength.

Peil-Registrierungen des Nachteffektes (Directional Records [on several spaced Direction Finders] of Night Effect).—M. Dieckmann. (*E.N.T.*, Feb., 1932, Vol. 9, pp. 46–48.)

On distant stations working on wavelengths of the order of 1 635 m. Fig. 4 shows the night results at three stations, spaced less than 100 metres. The object of this diagram is to show: (a) the practically uniform record (bottom strip) given by an Adcock aerial system (old type, with raised receiving hut) compared with the upper and middle records given by rotating frames, and (b) the similarity in point of shape and time of the latter two records, whose receivers are spaced less than $\lambda/10$. It is this second point which is of new interest, for when the spacing is increased to about λ the curves still show considerable resemblance in shape, but display, at certain pronounced points, *displacements in time up to 1 minute*, and more still if the spacing is increased further. As the spacing is increased, the similarity in shape decreases, till at about 25 km none remains. Fig. 5 shows, between the top and bottom records (corresponding to a spacing of 7.0 km), time differences between corresponding points reaching a value of 6 minutes. The middle record corresponds to a position about 1.57 km south of the top record position and about 5.43 km north of the bottom record position. These displacements in time are not constant, occasionally vanishing altogether.

The Development and Application of Marine Radio Direction Finding by the U.S. Coast Guard.—C. T. Solt. (*Proc. Inst. Rad. Eng.*, Feb., 1932, Vol. 20, pp. 228–260.)

The material presented is based on data obtained from more than 100 d.f. installations on vessels of various types and sizes ranging from 75-foot motor boats to cutters of 3 000 tons displacement. In addition to description of equipments, the difficulties due to the electrophysical properties of the vessels are explained and the methods of overcoming them described. Deviation as a function of frequency is discussed briefly. A short description of aircraft equipment, and an account of the results obtained, are included.

Radio Aids to Air Navigation.—L. A. Sweny. (*Wireless World*, 24th February, 1932, Vol. 30, pp. 192–195.)

The author gives a survey of the application of radio direction finding in its many forms to aerial navigation from the end of 1918 to the present time. Among the systems discussed are the Bellini-Tosi, Marconi-Adcock and the Equi-signal Radio Beacon system developed in the U.S.A. This latter system was adopted on the Paris-Dover route in the early part of 1931. Information is given concerning work now being carried on with a view to the further elimination of the human element by the development of apparatus which gives to the pilot visual indication of bearings.

Portable [Equi-Signal] Beacon Transmitter for the [U.S.] Army.—(*Rad. Engineering*, Feb., 1932, Vol. 12, p. 37.)

Radio Communication on the International [Pan American] Air Lines.—H. C. Leuteritz. (*Rad. Engineering*, Feb., 1932, Vol. 12, pp. 25–29.)

ACOUSTICS AND AUDIO-FREQUENCIES.

An Automatic Device for Recording, Correcting and Analysing Articulation Results.—J. Collard. (*Elec. Communication*, January 1932, Vol. 10, No. 3, pp. 140–146.)

The moment each test is finished the results are produced completely corrected and analysed: it is estimated that to carry out this work by manual labour would require about 20 man-hours for each complete test with a crew of nine operators.

Oscillograms as a Logical Form of Written Speech [and Musical Composition].—L. Stokowski. (*Electronics*, Jan., 1932, p. 24.)

An Adjustable Frequency Generator for the Voice Range [Valve-controlled Three-phase Motor Generator Set].—J. R. Power. (*Bell Lab. Record*, Jan., 1932, Vol. 10, No. 5, pp. 155–158.)

Capable of delivering 100 VA per phase at any frequency between 200 and 3 200 c/s, with a frequency constancy of $\pm$ 0.1%.

An Improved Audio-Frequency Generator.—E. G. Lapham. (*Proc. Inst. Rad. Eng.*, Feb., 1932, Vol. 20, pp. 272–279.) *See* January Abstract, p. 44.

Eliminating Harmonics in Bridge Measurements.—R. F. Field. (*Gen. Radio Exper.*, Dec., 1931, Vol. 6, pp. 4–6.)

MESURE DES INTENSITÉS SONORES PAR LA MÉTHODE DES SCINTILLATIONS (Sound Intensity Measurements by the Method of "Acoustic Twinkling").—F. Canac. (Summary in *Physik. Ber.*, 1st Jan., 1932, Vol. 13, p. 17.)

On the method dealt with in 1931 Abstracts, pp. 329-330. In the absence of disturbing noises an accuracy of 1 °/₀₀ can be attained, compared with an optimum 5 % with previous methods. The system is also suitable for measuring the distribution of sound intensity in rooms and buildings.

GERÄUSCH- UND LÄRMMESSUNGEN (Measurements on Noise and Din).—G. Bakos and S. Kagan. (*Zeitschr. V.D.I.*, 13th Feb., 1932, Vol. 76, No. 7, pp. 145–150.)

From the Heinrich-Hertz-Institut. Description of the methods and apparatus used in the official V.D.I. tests on Berlin noises.

MEASURING *versus* "JUDGING" LOUDNESS OF NOISE [THE CUBE ROOT LAW OF PERCEIVED INTENSITIES].—E. E. Free: Parkinson and Ham. (*Electronics*, Jan., 1932, p. 21.)

THE MEASUREMENT OF NOISE: A NEW SERVICE OF ELECTRICAL RESEARCH PRODUCTS.—S. K. Wolf: Acoustic Consulting Service. (*Inc. Bell Teleph. Quart.*, No. 3, Vol. 10, pp. 189–192.)

ON THE CONSTRUCTION OF SOUND REFLECTORS [FOR PULPITS, ETC.].—A. D. Fokker. (Summary in *Physik. Ber.*, 1st Jan., 1932, Vol. 13, pp. 16–17.)

On the work referred to by Trendelenburg (Feb. Abstracts, pp. 99–100). The limit of intelligibility in a cathedral was raised from 21 to over 65 metres.

RAUMAKUSTISCHE FRAGEN BEI KLANGÜBERTRAGUNGEN (The Effects of Interior Acoustics in the Recording and Reproduction of Sound).—F. Trendelenburg. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 13, 1932, pp. 46–58.)

Introduction: deterioration and improvement of sound effects by reflection phenomena: sound absorption: reverberation time and its influence. In connection with the last subject, it is mentioned that the cathedral in Speyer has recently been found to have a reverberation time of about 13 secs. (at 512 c/s) when empty and only 4 secs. when a congregation of 3 000 is present.

THE DESIGN AND ACOUSTICS OF BROADCAST STUDIOS.—S. J. Ebert. (*Rad. Engineering*, Jan., 1932, Vol. 12, pp. 13–16 and 34.)

MODERN TREATMENT OF BROADCASTING ACOUSTICS.—S. K. Wolf. (*Electronics*, Jan., 1932, pp. 14–16.)

PAPERS ON THE ACOUSTICS OF BUILDINGS.—E. Michel: F. R. Watson. (Summaries in *Physik. Ber.*, 1st Jan., 1932, Vol. 13, pp. 15 and 16.)

DIE VERZERRUNGSARTEN BEIM TONFILM (The Types of Distortion in Sound-on-Film Records).—F. Fischer. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 13, 1932, pp. 2–8.)

In a preliminary section on the various methods of recording, Breusing's c-r. tube system is mentioned, in which an intensity record is made by varying the brightness of the fluorescent spot by a control grid. The paper then deals with the acoustic, physical and physiological requirements of sound-on-film records, leading up to a discussion of (iv) linear distortion due to the effect of the slit width at different frequencies. Tests in which the upper and lower frequency limits have been gradually shifted (by the introduction of inductive and capacitive leads, respectively) have shown that the omission of frequencies under 150 c/s seriously spoils the character of reproduction, whereas frequencies between 5 and 6 thousand c/s have less influence, (v) Phase distortion. (vi) Non-linear distortion and the Goldberg condition. (vii) The Küpfmuller "klirr" factor: a test on the comparative results of a 20% factor in the intensity and transverse systems is mentioned. (viii) Other distortion sources—the effect of film speed variation. (ix) Background noise.

UNTERSUCHUNGEN ÜBER NICHTLINEARE VERZERRUNGEN BEIM TONAUFNAHMESYSTEM NACH DEM SCHWÄRZUNGSPRINZIP (Investigations on Non-linear Distortion in Sound-on-Film Systems on the Intensity Principle).—A. Narath. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 13, 1932, pp. 17–31.)

Author's summary:—Distortions due to non-linearity of the Kerr cell characteristic and to the negative and positive gradation curves are treated theoretically and their mutual effects discussed. Distortions due to the former cause are examined experimentally by a dynamic method and found to agree with the theory [pp. 23–24]. The distortions occurring as a result of photographic copying processes are determined experimentally, and freedom from distortion is shown to occur if the Goldberg condition is satisfied. It is found that under certain conditions the non-linearities of the individual characteristic curves give mutual compensation: in this case the Goldberg condition has no validity.

PAPERS ON AEG SOUND-FILM WORK.—Hehlgans and Lichte: AEG. (Summaries in *Physik. Ber.*, 1st Jan., 1932, Vol. 13, pp. 80–81.)

DETERMINATION OF THE RESOLVING POWER OF PHOTOGRAPHIC LAYERS: CORRECTIONS.—H. Frieser. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 13, 1932, p. 102.)

Corrections to the paper referred to in March Abstracts, p. 171.

EINE SCHALLÜBERTRAGUNGSANLAGE GROSSEN FREQUENZUMFANGES (A Sound Transmitting and Reproducing Equipment with a Wide Frequency Range [30 to over 10 000 Cycles per Second]).—W. Willms. (*E.N.T.*, Feb., 1932, Vol. 9, pp. 68–70.)

The microphone is a very small Wente condenser microphone with a practically straight curve from 40 to 12 000 c/s after slight electrical correction at the low frequencies. The amplifier for the m.c. loud speaker is a mains-driven 3-stage power amplifier with a push-pull output stage of 50 w anode dissipation. The early stages use indirectly heated filaments, the output stage valves—to diminish mains hum—are heated by rectified a.c. An electrostatic loud speaker is used in combination with the m.c. speaker: its amplifier output stage need have only half the anode dissipation owing to its greater efficiency. The two loud speakers and their amplifiers are combined by means of a frequency-sensitive potential divider (Fig. 4). Below about 6 000 c/s the supply to the electrostatic speaker is cut off.

Fig. 5 shows the frequency curve of the complete equipment; from 30 to 15 000 c/s the deviation from the central line amounts to ± 5 phon. To diminish directional effects at the higher frequencies, a reverse-horn ("gegentrichter") is placed in front of the electrostatic speaker, with the result that the directional diagram is better at 8 000 c/s than at 4 000 (at 8 000 only the electrostatic speaker is functioning, at 4 000 only the m.c. speaker). The non-linear distortion, for a 5-watt output, is only about 3 to 4%.

Results with the equipment bring out the great improvement in quality resulting from extending the frequency range towards the highest frequencies (*cf.* Snow, February Abstracts, pp. 98–99). This does *not* apply to gramophone reproduction.

Über die Bedeutung der Ausgleichsvorgänge in der Akustik (The Significance of Transient Processes in Acoustics).—H. Backhaus. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 13, 1932, pp. 31–46.)

An experimental investigation of the building-up processes in a number of different sounds. The very rapid building-up of the vowels in speech is shown: they have no characteristic building-up process, and are recognised by their musical spectrum. The characteristics of various consonants, and the influence on them of the vowel following, are dealt with. The importance of the form of the building-up characteristic in determining the tone quality of different musical instruments is then treated, and the final section deals with transient processes in loud speakers. "Attempts have been made to attribute the characteristic 'drummy' quality [especially in speech] which practically all loud speakers possess to a greater or less degree, to combination tones due to non-linear distortion. But such non-linearity has never been shown to exist." The writer attributes the effect to transient processes at natural frequencies in the low part of the spectrum. These natural frequencies must be made as low as possible and strongly damped. One of the many oscillograms (Fig. 31) shows the behaviour, at 1 800 c/s, of a loud speaker with particularly loose suspension and a natural frequency round 25 c/s. Neumann's suggested method of increasing the damping in m.c. loud speakers (March Abstracts, p. 170) is also referred to, as having resulted in a very considerable improvement.

Verzerrungen bei Mikrophonen und Lautsprechern (Distortion in Microphones and Loud Speakers).—C. A. Hartmann. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 13, 1932, pp. 9–17.)

The paper and its numerous diagrams, when combined with Janovsky's paper on the audibility of distortions (March Abstracts, p. 172), show that while neither microphone nor loud speaker has by any means ideal properties, their linear and directional distortions can often be corrected or even controlled so as to be desirable; non-linear distortion, on the other hand, remains a problem.

The Lapel Microphone [for Public Address Speakers].—W. C. Jones. (*Bell Lab. Record*, Jan., 1932, Vol. 10, No. 5, pp. 170–172.)

A "Whisper" Microphone of Rochelle Salt.—Möller: Heinrich Hertz Association. (*See* abstract under "Miscellaneous.")

A Moving Coil Microphone for High Quality Sound Reproduction.—W. C. Jones and L. W. Giles. (*Journ. Soc. Motion Picture Engineers*, Dec., 1931, Vol. 17, pp. 977–993: *Bell Tel. Syst. Technical Publications*, No. B-630.)

The microphone described in this paper is stated to retain all the inherent advantages of the moving coil type of structure while responding uniformly to a wide range of frequencies. "It is more efficient than the conventional form of condenser microphone and its transmission characteristics are unaffected by the changes in temperature, humidity and barometric pressure. Unlike the condenser microphone, the moving coil microphone may be set up at a distance from the associated amplifier and efficient operation obtained. Owing to its higher efficiency and lower impedance it is less subject to interference from nearby circuits. It is of rugged construction, and when used in exposed positions is less subject to wind noise."

Der Hornlautsprecher (The Horn Loud Speaker).—H. Stenzel. (*AEG-Mitteil.*, No. 5, 1931, pp. 310–316.)

In addition to the wattless effect due to the membrane mass, both the components of the radiation impedance are of influence in determining the acoustical behaviour of the horn-type loud speaker. These depend on the manner in which the sound radiation is given out to space, and can be calculated for definite shapes of horn. Corresponding curves are given for the cone-shaped and parabolic horns, the flat sound wall and the exponential horn. In addition, the space at the entrance to the horn and the transition of the horn mouth into free space are of prime importance for freedom from frequency dependence. *See* also March Abstracts, p. 170.

The Calculation of the Radiation at the Edges of Stretched Membranes, and the Derivation and Use of General Formulae for the Radiation Resistance.—H. Stenzel. (Summary in *Physik. Ber.*, 1st Jan., 1932, Vol. 13, p. 16.) *See* also 1931 Abstracts, pp. 214–215.

CIRCUIT MATCHING IN NETWORKS FOR RADIO DISTRIBUTION [TO LOUD SPEAKERS].—Six and Vermeulen. (*See* under "Stations, Design and Operation.")

MOVING COIL LOUD SPEAKERS OF MIDGET DESIGN.—F. R. W. Strafford. (*Wireless Engineer*, Feb., 1932, Vol. 9, pp. 75–76.)

A letter from the Kolster Brandes Laboratories on the use of midget loud speakers with a projected cone diameter of about 7 inches, where extremely light and rigid cones are used and the effect of the mass of the coil conductor must be considered. It is shown that at low frequencies above the natural period of the system, where it may be regarded as chiefly inertia-controlled, there is a maximum cone velocity which will be reached when the mass of the coil conductor is equal to the effective mass of the cone and its added air load—this for a given power dissipation across the coil conductor.

MOVING COIL MAGNETS: PRECISION MEASUREMENTS OF THE GAP FLUX DENSITY.—C. E. Webb. (*Wireless Engineer*, Feb., 1932, Vol. 9, pp. 67–69.)

A note on the method employed at the N.P.L. "The method is the same in principle as that described by McLachlan, but differs from it in the manner of application." The use of a ballistic galvanometer of high sensitivity allows a search-coil of only one turn to be employed, and this has certain advantages over the differential coils such as have been largely used.

REFLECTION METHODS OF MEASURING THE DEPTH OF THE SEA.—J. A. Slee. (*Journ. I.E.E.*, Feb., 1932, Vol. 70, No. 422, pp. 269–277: Discussion, pp. 277–280: long summary in *Wireless Engineer*, Jan., 1932, Vol. 9, pp. 20–22.)

SOUNDING THE OCEAN DEPTHS.—(*Wireless World*, 17th February, 1932, Vol. 30, pp. 158–160.)

Various practical systems employed on board ship for measuring the depths of the sea by reflection sounding are discussed, particular attention being paid to types of apparatus suitable for trawlers and merchant vessels.

VELOCITY OF SOUND IN TUBES AT AUDIBLE AND ULTRASONIC FREQUENCIES.—C. B. Vance. (*Phys. Review*, 15th Feb., 1932, Series 2, Vol. 39, No. 4, pp. 737–744.)

The author's experimental results on the velocity of sound in air in glass tubes of diameters between 0.1 cm to 3.0 cm at frequencies from 30 to 200 kc/s, measured by the Kundt's dust tube method, do not agree with those calculated by use of the Helmholtz-Kirchhoff equation but with those given by an equation of the form $V^1 = V_0[1 - C/D^2 - K/D(N)^{\frac{1}{2}}]$, where $V_0 = 331.77$ m/sec., $C = 0.001512$, $K = 0.174$, N = frequency and D = diameter of tube.

ÜBER DIE BESTIMMUNG DES DRUCKES IN LUFTSTOSSWELLEN (On the Determination of Pressure in Impulsive Air Waves).—W. Schneider. (*Zeitschr. f. Phys.*, 1932, Vol. 74, No. 1/2, pp. 66–87.)

This paper describes a method for determining the true value of pressure from the distorted records given by a membrane apparatus under high impulsive pressure.

DIE SCHALLABSORPTIONSBANDE DER KOHLENSÄURE (The Acoustic Absorption Band of Carbon Dioxide).—E. Grossmann. (*Physik. Zeitschr.*, 1st March, 1932, Vol. 33, No. 5, p. 202.)

A preliminary notice of a method of measuring the acoustic absorption coefficient of gas using piezo-quartz crystals as emitters and receivers of sound. The acoustic absorption coefficient is found not to be independent of the frequency, especially in the case of carbon dioxide.

THE TIME FACTOR IN TELEPHONE TRANSMISSION.—O. B. Blackwell. (*Bell S. Tech. Journ.*, Jan., 1932, Vol. 11, No. 1, pp. 53–66.)

This paper gives a general account of the state of present knowledge of the time factor in telephone transmission and a comprehensive list of literature on the subject.

PHOTOTELEGRAPHY AND TELEVISION.

DIE ÜBERTRAGUNG VON HALBTONBILDERN MITTELS KURZER WELLEN (The Transmission of Half Tone Pictures by Short Waves).—F. Schröter. (*E.N.T.*, Feb., 1932, Vol. 9, pp. 49–56.)

A fuller version of the paper dealt with in April Abstracts, p. 230.

ON THE ELECTRIC AND PHOTOELECTRIC PROPERTIES OF CONTACTS BETWEEN A METAL AND A SEMICONDUCTOR.—J. Frenkel and A. Joffé. (*Phys. Review*, 1st Feb., 1932, Series 2, Vol. 39, No. 3, pp. 530–531.)

A letter describing a continuation of a theory of one of the authors regarding the electric resistance of contacts between two metals (Frenkel, 1931 Abstracts, p. 222). An expression of the form $I_c = I_0\ (e^{V_1/kT} - 1)$ is found to give the photoelectric potential difference V_1 across the contact gap in terms of the current I_0 directly produced by light illuminating the gap and I_c the intensity of the light.

ÜBER DEN SPERRSCHICHTPHOTOEFFEKT (On the Attenuating-Layer Photoelectric Effect).—E. Duhme. (*Zeitschr. f. Elektrochem.*, No. 8/9, Vol. 37, pp. 682–684.)

The attenuating-layer photoelectric effect (as opposed to the internal photoelectric effect) is discussed as regards its dual phenomena, the anterior and posterior wall effects (*cf.* Duhme and Schottky, 1930 Abstracts, pp. 636–637), and compared with the processes in a Becquerel cell. "In the attenuating-layer wall cell we have to do with a first type Becquerel effect without electrolyte. But the processes taking place in attenuating-layer photoelectric cells are purely electronic and physical, not at all photogalvanic." The physical interpretation of the Becquerel cell processes, to be found in the literature on the subject, is considered to be supported by the phenomena and processes in copper oxide photoelectric cells.

Über die Einwirkung von polarisiertem Licht auf Sperrschicht-Photozellen (On the Effect of Polarised Light on Attenuating Layer Photoelectric Cells).—L. Bergmann. (*Physik. Zeitschr.*, 1st Jan., 1932, Vol. 33 No. 1, pp. 17–19.)

In this preliminary communication the author describes the use of a selenium photoelectric cell (1931 Abstracts, p. 445) to test the known theoretical relations between the intensities of light incident and refracted at a metallic surface, for light polarised parallel and perpendicular to the plane of incidence.

Über die Vorwärtsbewegung von Elektronen durch Licht (On the Forward Motion of Electrons under the Action of Light).—H. Dember. (*Physik. Zeitschr.*, 1st March, 1932, Vol. 33, No. 5, pp. 207–208.)

The author has already found (1931 Abstracts, p. 565) that light falling on crystals of certain light-absorbing semiconductors exerts a forward push on the electrons. In the experiments referred to in this note he shows that the phenomenon is a primary one and not due to attenuating layer effects. *See* also next abstract.

Über einen lichtelektrischen Effekt in Halbleitern (On a Photoelectric Effect in Semiconductors).—L. Bergmann. (*Physik. Zeitschr.*, 1st March, 1932, Vol. 33, No. 5, pp. 209–213.)

In this paper the author describes experiments continuing the investigation of an effect already described (April Abstracts, p. 232). Various semiconductors were investigated in a specially constructed cell, of which a description is given, and it was found that a generalised form of the phenomenon described by Dember (*see* preceding abstract) was really occurring.

A Further Experimental Test of Fowler's Theory of Photoelectric Emission.—L. A. Du Bridge. (*Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, pp. 108–118.)

Some Remarks on the Theory of Photoelectric Effect in Metals.—Ig. Tamm. (*Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, pp. 170–172.)

An answer to criticisms by Frenkel (1931 Abstracts, p. 622) of a paper by the writer and S. Schubin (*ibid.*, p. 392).

An Attempt to Detect High Photoelectric Absorption in Caesium Vapour at Double the Series Limit.—E. T. S. Appleyard. (*Phil. Mag.*, February 1932, Series 7, Vol. 13, No. 83, pp. 300–305.)

No absorption was found under experimental conditions which would readily have detected an atomic absorption coefficient greater than 10^{-15}.

Di alcune nuovo Ricerche fotoelettriche (Some New Photoelectric Researches).—Q. Majorana. (*Nuovo Cimento*, Dec., 1931, Vol. 8, No. 10, pp. 363–369.)

Description of the writer's results on directing a pulsating illumination on to a triode or photoelectric cell *in the neighbourhood* (without any direct connection) of the first triode of an amplifying series, the grid of this triode being left free. Further development of the work dealt with in 1929 Abstracts, p. 47. The present abstract should be taken as replacing the one on p. 173, March Abstracts.

Die Rotverschiebung der Photoionisation von Alkaliatomen durch Adsorption an negativen Salzoberflachen (The Displacement towards the Red of the Photoelectric Ionisation of Alkali Atoms by Adsorption at Negatively Charged Salt Surfaces).—J. H. de Boer and M. C. Teves. (*Zeitschr. f. Phys.*, 1931, Vol. 73, No. 3/4, pp. 192–200.)

Lichtelektrische Koagulation von Natrium in Steinsalz (Photoelectric Coagulation of Sodium in Rock Salt).—E. Rexer. (*Physik. Zeitschr.*, 1st March, 1932, Vol. 33, No. 5, pp. 202–204.)

The Photoionisation of Atomic Potassium.—M. Phillips. (*Phys. Review*, 1st Feb., 1932, Series 2, Vol. 39, No. 3, p. 552.)

Die Rotverschiebung der Photoionisation von Alkaliatomen durch Adsorption an negativen Salzoberflächen (The Displacement towards the Red of the Photoionisation of Alkali Atoms by Adsorption at Negative Layers of Salts [Alkaline Halides and Oxides]).—J. H. de Boer and M.C. Teves. (*Zeitschr. f. Phys.*, 1931, Vol. 73, No. 3/4, pp. 192–200.)

Die physikalisch-chemische Beschaffenheit der Metalloberfläche bei der selektiven lichtelektrischen Elektronenemission der Alkalimetalle (The Physico-chemical Composition of the Metallic Surface in the Selective Photoelectric Electron Emission from the Alkali Metals).—R. Suhrmann. (*Zeitschr. f. Elektrochem.*, No. 8/9, Vol. 37, pp. 678–682.) *Cf.* March Abstracts, p. 173.

Photoelectric Properties of Thin Films of Rubidium and Caesium on Silver.—J. J. Brady. (*Phys. Review*, 1st Feb., 1932, Series 2, Vol. 39, No. 3, p. 546.)

Some Experiments with Gas-filled Cs-O-Ag Photo Cells.—K. H. Kingdon and H. E. Thomson. (*Physics*, Dec., 1931, Vol. 1, No. 6, pp. 343–351.)

Authors' abstract:—The *amplification* of the cathode emission by *argon* is much greater for a tube with a photo-cathode than for a tube of similar geometry equipped with a thermionic cathode. This difference is attributed to large *secondary electron emission* by positive ion bombardment of the photo-cathode. If the *anode-voltage* of one of these argon-filled tubes is *abruptly increased*, the *time lag* in the resulting current change is of the order 5×10^{-5} sec. for the thermionic tube but of the order 10^{-3} sec. for the photo-tube. This lag is attributed to the life of the positive ion charge on the spongy surface of the photo-cathode. Measurements of the *spontaneous fluctuations* in the current through a gas-filled photo-tube indicate that the "noise" is of low frequency and associated with the gas amplification effect.

NEW HIGH-EFFICIENCY PHOTOCELL.—Lorenz Company. (Paragraph in *Electronics*, Jan., 1932, p. 30.)

No technical details are given, but the cell is said to give an output of the order of that given by a pick-up, distortionless reproduction up to 25 000 c/s being claimed. Voltage may be varied from 20 to 1 000 v, volume being readily controlled in this way.

FURTHER PROGRESS IN PHOTOELECTRIC CELLS.—H. Kröncke : Sewig. (*Rad., B., F. f. Alle.*, Feb., 1932, pp. 69–71.)

Including mention of Sewig's vacuum cell in which (as a result of Japanese observations on exceptionally high sensitivities occurring in certain samples of vacuum cells) he deposits a thin silver layer on the thin caesium layer and obtains an output of 45 μA per lumen.

PHOTOELECTRIC PROPERTIES OF THIN FILMS OF ALKALI METALS [IN CONJUNCTION WITH SILVER].—S. Asao. (*Physics*, Jan., 1932, Vol. 2, No. 1, pp. 12–20.)

Further development of the work dealt with in 1931 Abstracts, pp. 390–391.

THE EFFECT OF SURFACE CHANGES ON THE PHOTOELECTRIC EMISSION OF SILVER AND GOLD.—T. E. Clarke. (*Phil. Mag.*, March, 1932, Series 7, Vol. 13, No. 85, pp. 624–632.)

The work described in this paper makes it clear that "the photoelectric emission of a metal, in the absence of a strong accelerating field, can be used as an indication of changes occurring in the adsorbed gas layer on the surface of the metal."

PHOTOELECTRIC CELLS WITH SILVER/SILVER BROMIDE ELECTRODES IN POTASSIUM BROMIDE SOLUTION.—B. Vanselow and S. E. Sheppard. (*Zeitschr. f. wiss. Photogr.*, No. 1/2, Vol. 30, 1931, pp. 13–39.)

DIE KONSTRUKTION LICHTELEKTRISCHER ZELLEN MIT GROSSEN KATHODENFLÄCHEN (The Construction of Photoelectric Cells with Large Cathode Surfaces).—R. Fleischer. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 13, 1932, pp. 92–94.)

Description of an alkali cell so designed, and with so large a cathode surface, that without any polarising voltage it will give in sunlight a current large enough to drive a small meter motor at 30 r.p.m. The writer begins by formulating the ideal geometrical and physical conditions for as many as possible of the electrons set free at the cathode to reach the anode without the help of any accelerating potential :—(a) the cathode should be a point in the centre of a sphere whose walls form the anode ; (b) the free paths of the electrons should be large in comparison with the length of the journey from cathode to anode ; (c) both electrodes should be of the same material to avoid contact potentials ; and (d) there should be no electron emission at the anode.

Condition (a) is not practical for obvious reasons ; instead, a cathode as large as possible, enclosing the anode as completely as possible, is obtained by employing as cathode a thin coating on the adjacent walls of the inner and outer "test-tubes" of a Dewar flask. The anode, in the form of a "test-tube" of metallic gauze, is supported in the vacuum, equidistant from the two walls. Condition (b) is easily fulfilled : the anode-cathode gap is only about 15 mm, while the electron free path at 10^{-3} mm Hg is about 100 mm. Condition (c) is difficult, for even if the electrodes were of the same metal they would show different contact potentials owing to their different gas-contents. Condition (d) cannot be completely fulfilled as the illumination of the anode by direct or reflected light is unavoidable ; but the photoelectrically active anode surface is made very small by the use of a wide-meshed gauze.

In the model cell thus constructed, saturation occurs with an accelerating potential of 2 v. *With zero accelerating potential* 68.3% *of these electrons reach the anode.* Exposed to the sun in a room near a closed window, the cell shows a p.d. of 1.25 v between the two electrodes, and a current of 2.8×10^{-4} A is obtainable. The writer admits that the output is small in view of the cathode surface (about 1 200 cm²) ; this is partly because only a portion of this receives the direct illumination, but more because the cell has not undergone any "sensitising" process and can only be heated to low temperatures (round 120° C.).

THE ELECTRO-OPTICAL KERR CONSTANT OF LIQUID AND DISSOLVED SUBSTANCES, AND THE NATURE AND CAUSE OF THE MUTUAL INFLUENCE AND ORIENTATION OF THE MOLECULES IN THE LIQUID STATE.—G. Briegleb. (*Zeitschr. f. phys. Chem.*, *B.*, No. 2, Vol. 14, 1931, pp. 97–121.)

NEUERE ENTWICKLUNG DER GASENTLADUNGSLAMPEN FÜR FERNSEHZWECKE (New Development of the Gaseous Discharge Lamp for Television).—H. Ewest. (*Fernsehen u. Tonfilm*, Jan., 1932, Vol. 3, pp. 7–9.)

Including the "light spray" lamp referred to in March Abstracts, p. 171, which is applicable to mirror-wheel working, and the "sodium tube" (straight or U-shaped) which is suitable for Nipkow disc and mirror helix working, where distribution over a greater surface is necessary. *See* next abstract.

DIE ENTWICKLUNG DER NATRIUMDAMPFLAMPEN FÜR FERNSEHZWECKE (The Development of the Sodium Vapour Lamp for Television).—G. Schubert. (*Fernsehen u. Tonfilm*, Jan., 1932, Vol. 3, pp. 9–18.)

GLOW DISCHARGE TUBES AND THEIR TECHNICAL APPLICATIONS.—F. Michelssen. (*L'Onde Élec.*, Jan., 1932, Vol. 11, p. 8 A.)

Long summary of the *Funk* paper dealt with in 1931 Abstracts, p. 333.

MEASUREMENTS AND STANDARDS.

MEASUREMENT OF INDUCTANCE: THE CATHODE-RAY OSCILLOGRAPH METHOD.—G. I. Finch and R. W. Sutton. (*Electrician*, 12th February, 1932, Vol. 108, pp. 219–220.)

Short abstract of a Physical Society paper. The voltage fluctuations across the condenser in a damped L, C and R circuit are recorded by a c.-r. oscillograph. The relationship

$$L = CV^2\left\{\left(1 + \lambda + \tfrac{1}{2} + \frac{2}{\pi^2}\right)\lambda^2 + \left(\tfrac{1}{6} + \frac{2\lambda^3}{\pi^2}\right)\lambda^3\right\} \Big/ i_0{}^2$$

is derived, where V is the first peak voltage across C in a train of damped oscillations, i_0 the primary current through L at break of a charging circuit, and λ the logarithmic decrement of the oscillatory circuit. The measurement of V and λ from the oscillogram is discussed. The theory is only applicable where the self-capacity of the coil is negligible in comparison with C, and R is independent of the current traversing the coil.

IMPEDANCE CHARACTERISTICS OF LOADED LECHER SYSTEMS.—Tonks. (*See* under "Properties of Circuits".)

PRÄZISIONSVERFAHREN ZUR MESSUNG KURZER UND ULTRAKURZER WELLEN (A Precision Method of Measuring Short and Ultra-Short Waves). —W. Fehr. (*E.N.T.*, Feb., 1932, Vol. 9, pp. 57–60.)

A paper on the method dealt with in 1931 Abstracts, p. 624. It has now been extended to wavelengths down to 2 m, with an accuracy of about 0.01%. Slight modifications of the method are necessary for wavelengths below about 5 m, owing to the decreased harmonic output of the oscillator *MS*, and a short-wave oscillator (wavelength about 20 m) has therefore to be introduced.

A DEVICE FOR ACCURATE MEASUREMENT AND CHECKING OF THE FREQUENCY OF A [DISTANT] RADIO STATION.—N. K. Titov and A. J. Weinberg. (*Westnik Elektrot.*, No. 4, 1931, Sec. I, pp. 119–125.)

Frequency standards are provided by the harmonics of two oscillators, the ultimate reference being to a tuning fork. Specimen frequency measurements of numerous stations are given.

A SIMPLIFIED METHOD OF INTERPOLATION BY HIGH-FREQUENCY MEASUREMENTS [INTERPOLATION FORMULA FOR WAVEMETER].—I. B. Selutin. (*Westnik Elektrot.*, No. 2, 1931, Sec. I, p. 80.)

ON THE THEORY OF BEATS [APPLICATION TO THE CALIBRATION OF MULTIVIBRATORS].—Gabel. (*See* under "Properties of Circuits".)

THE STATION FINDER.—A. L. M. Sowerby. (*Wireless World*, 9th March, 1932, Vol. 30, pp. 238–241.)

An accurate buzzer wavemeter for the amateur constructor. The medium and long broadcasting wavebands are covered.

ON THE CRYSTALLINE STRUCTURE OF THIN LAYERS OF METALS [SPUTTERED ON QUARTZ AND MICA].—Z. Debińska. (Summary in *Physik. Ber.*, 1st Feb., 1932, Vol. 13, p. 274.)

PHYSICAL PROPERTIES OF PIEZO-QUARTZ PLATES IN CONNECTION WITH THEIR ACCURATE MANUFACTURING FOR A GIVEN FREQUENCY. —E. S. Muchkin. (*Westnik Elektrot.*, No. 7, 1931, Sec. I, pp. 190–204: summary in *Physik Ber.*, 15th Dec., 1931, Vol. 12, pp. 2904–2905.)

NOTES ON THE FREQUENCY STABILITY OF QUARTZ PLATES.—L. B. Hallman, Jr. (*Rad. Engineering*, Feb., 1932, Vol. 12, pp. 15–19.)

"This article summarises a representative portion of the material published to date on the subject of quartz piezoelectric oscillators, as applied particularly to the broadcast transmitter, and the reader will find in it a brief, concise statement of the amounts that various factors will change frequency."

QUARTZ PLATE MOUNTINGS AND TEMPERATURE CONTROL FOR PIEZO OSCILLATORS.—V. E. Heaton and E. G. Lapham. (*Proc. Inst. Rad. Eng.*, Feb., 1932, Vol. 20, pp. 261–271.) *See* January Abstracts, p. 49.

TOURMALIN CRYSTALS FOR WAVES UNDER 50 CENTIMETRES.—Leithäuser: Heinrich Hertz Association. (*See* abstract under "Miscellaneous.")

ON THE MAGNETOSTRICTION OF IRON-NICKEL ALLOYS.—Y. Masiyama. (*Sci. Reports Tôhoku Univ.*, No. 4, Vol. 20, pp. 574–593.)

THE ISOCHRONISM OF A PENDULUM ACTUATED BY IMPULSES AFTER PASSING THROUGH THE VERTICAL.—Ch. Féry and N. Stoyko. (*Comptes Rendus*, 22nd Feb., 1932, Vol. 194, pp. 689–691.)

AN ELECTROSTATIC VOLTMETER [POSSESSING SEVERAL UNIQUE FEATURES].—W. W. Nicholas. (*Bur. of Stds. Journ. of Res.*, Jan., 1932, Vol. 8, pp. 111–118.)

THE FORMULAE OF THREE TORSION ELECTROMETERS [QUADRANT, BINANT AND DUANT].—G. Nadjakoff. (*Comptes Rendus*, 8th Feb., 1932, Vol. 194, pp. 546–549.)

A NEW ELECTROMETER [SMALL, WITH "MULTI-NEEDLE" MOVING ELEMENT, GIVING 1 600 DIVISIONS TO THE VOLT WITH 1 SECOND PERIOD].—Kerr Grant. (*Journ. Scient. Instr.*, Jan., 1932, Vol. 9, pp. 17–19.)

A GENERATING VOLTMETER FOR THE MEASUREMENT OF HIGH POTENTIALS.—P. Kirkpatrick and I. Miyake. (*Review Scient. Instr.*, Jan., 1932, Vol. 3, pp. 1–8.)

THE GAIN CONTROL AND THE DECIBEL.—H. Stanesby. (*Wireless Engineer*, Jan., 1932, Vol. 9, pp. 18–19.)

On the design calculations of gain control resistances. Tables are given for two gain controls each of 1 000 ohms total resistance, one giving a range of 40 db in steps of 1 db, and the other a range of 100 db in steps of 5 db.

A NEW METHOD OF DIELECTRIC CONSTANT MEASUREMENT [GASES] AT RADIO FREQUENCIES.—H. L. Andrews. (*Physics*, Dec., 1931, Vol. 1, pp. 366–379.)

A method eliminating the difficult condenser calibration required by earlier heterodyne methods. The constant is obtained in terms of a single frequency standard, whose absolute frequency can be determined by auxiliary apparatus described.

LOSSES IN LIQUID DIELECTRICS AT RADIO FREQUENCIES [AND THE MEISSNER "IMMERSION" METHOD OF MEASURING THE SELF-CAPACITY OF COILS].—Jackson. (*See* under "Subsidiary Apparatus and Materials.")

SUBSIDIARY APPARATUS AND MATERIALS.

A THERMIONIC FREQUENCY DOUBLER.—C. K. Stedman. (*Physics*, Jan., 1932, Vol. 2, No. 1, pp. 42–47: Abstract only in *Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, p. 184.)

The output voltage e of a valve operated over a suitable restricted range of grid voltages e_g may be represented by the parabola $e = b_0 + b_1e_g + b_2e_g^2$. By adding to this, in opposite phase, the output of another valve operated on the straight part of its curve, the term b_1e_g may be balanced out entirely and the system will then operate as a frequency doubler. With a type 201 A valve an output of 0.175 v of frequency $2f$ was obtained from an input of 1.0 v of frequency f. Actually the curve of the system is never a symmetrical parabola over a very wide range of grid voltages (since the coefficient of the cube term in the valve equation is not negligibly small) and the distortion arising from this fact is discussed. Incidentally, the dissymmetry of the experimental curves offers a method of determining the cubic term of a valve characteristic and thence the amount of third harmonic distortion—without harmonic analysis of output curves.

BEITRÄGE ZUR THEORIE DES FREQUENZWANDLERS (Contributions to the Theory of the [Magnetic] Frequency Transformer).—F. Gutzmann. (Brunswick Dissertation: summary in *Physik Ber.*, 15th December, 1931, Vol. 12, p. 2930.)

FREQUENZVERVIELFACHUNG DURCH ANWENDUNG EINES KONDENSATORS MIT SEIGNETTESALZDIELEKTRIKUM (Frequency Multiplication by the Use of a Rochelle Salt Condenser).—V. Wologdin. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 13, 1932, pp. 82–84.)

The properties of a condenser with Rochelle salt as a dielectric have already been described (1931 Abstracts. pp. 221–222). The writer now deals with its action, analogous to that of an iron-cored choke in a resonant circuit, in producing both odd and even harmonics. One of the many oscillograms presented shows the production of the 37th harmonic. In the case of such high multiplication the resultant current is seen to be damped, the process here being one of shock excitation, as in magnetic frequency multiplication by the Schmidt method (1930 Abstracts, p. 466). For the use of Rochelle salt as a microphone, *see* Möller, in abstract of Heinrich Hertz Association Meeting, under "Miscellaneous."

ON RESONANCE PHENOMENA IN FREQUENCY DIVISION.—Mandelstam and Papalexi. (*See* under "Properties of Circuits.")

A CLOCK-CONTROLLED CONSTANT-FREQUENCY [MOTOR-] GENERATOR.—A. B. Lewis. (*Bur. of Stds. Journ. of Res.*, Jan., 1932, Vol. 8, pp. 141–157.)

Author's abstract:—A synchronous motor-generator set is described in which the motor is forced to rotate in synchronism with signals from a standard clock circuit. This result is obtained by first running a specially wound motor synchronously from a 3-phase commercial power line. The field of this synchronous motor is then electrically rotated about the motor frame by an amount which exactly compensates for the departure of the frequency of the commercial power from true 60 cycles. This rotation of the motor field is produced by a rotary synchroscope which is in turn controlled by thyratron tubes, the grids of which are excited by a clock-driven tuning fork. The output of the generator is used to operate cycle counters, synchronous timers, or other light synchronous machinery.

The possibilities and limitations of the machine are discussed and data are given to indicate the accuracy ($\pm$0.004 second) which may be expected from the machine when used as a timing device. Safety devices are described which shut down the machine should it for any reason fall out of synchronism with the clock signals or hunt excessively. The machine has an ultimate load capacity of 4 kw, and can take a suddenly applied load of 2 kw without serious hunting.

CONSTANT FREQUENCY OSCILLATORS.—F. B. Llewellyn. (*Bell S. Tech. Journ.*, Jan., 1932, Vol. 11, No. 1, pp. 67–100.)

See March Abstracts, pp. 163–164.

THE CATHODE RAY OSCILLOGRAPH.—J. B. Johnson. (*Bell S. Tech. Journ.*, Jan., 1932, Vol. 11, No. 1, pp. 1–27.)

See March Abstracts, p. 176.

DIE PHOTOGRAPHISCHE WIRKUNG LANGSAMER KATHODENSTRAHLEN (The Photographic Effect of Slow Cathode Rays).—V. Weidner. (*Ann. der Physik*, 1932, Series 5, Vol. 12, No. 2, pp. 239–264.)

This paper describes an investigation of the photographic effect of cathode rays in the velocity range 0–1 100 volts on various silver bromide emulsions.

REGISTRATION OF CATHODE RAYS BY THIN FILMS OF METALS AND METAL COMPOUNDS.—W. W. Nicholas and C. G. Malmberg. (*Bur. of Stds. Journ. of Res.*, Jan., 1932, Vol. 8, pp. 61–65.)

Account of a search for a method of registering cathode rays which could be carried out entirely in daylight (*cf.* Carr, 1931 Abstracts, p. 163) *and in which no development process would be required.* The most successful results were those obtained with thin transparent films of compounds (especially nitrates and halogen compounds) of Bi, Sn and Cd.

SPANNUNGSEFFEKT BEI ELEKTROLYTISCHEN LÖSUNGEN UND KATHODENOSZILLOGRAPH (Voltage Effect in Electrolytic Solutions and Cathode Ray Oscillograph).—W. Fucks. (*Ann. der Physik*, 1932, Series 5, Vol. 12, No. 3, pp. 306–318.)

This paper describes a method of measuring, by means of a cathode ray oscillograph, changes of resistance occurring during short period voltage impulses, and its application to the investigation of electrolytes.

SOURCES OF ERROR IN VACUUM MEASUREMENTS WITH A MERCURY VAPOUR CONDENSING TRAP.—M. Rusch and O. Bunge. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 13, 1932, pp. 77–81.)

THE USE OF GLYCOL-PHTHALIC ANHYDRIDE RESIN AS A HIGH-VACUUM CEMENT.—T. P. Sager and R. G. Kennedy, Jr. (*Physics*, Dec., 1931, Vol. 1, No. 6, pp. 352–353.)

VOLTAGE-REGULATING AUTO-TRANSFORMER.—F. Bedell and J. Kuhn. (*Review Scient. Instr.*, Jan., 1932, Vol. 3, pp. 20–23.)

Compounded by connecting some or all of the primary windings differentially in series with the secondary, a 150-watt transformer of this type gave a 2.5% fluctuation for a 30% primary voltage change.

A THYRATRON VOLTAGE REGULATOR FOR AN ALTERNATOR.—C. E. Weinland. (*Review Scient. Instr.*, Jan., 1932, Vol. 3, pp. 9–19.)

AUTOMATIC VOLTAGE CONTROL BY MEANS OF A PHOTOELECTRIC CELL.—H. T. Clark and W. Kohlhagen. (*Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, p. 184.)

Abstract only. The method of Lark-Horovitz and Sherman (1929 Abstracts, p. 286) has been modified by using electrical control throughout.

IMPULSVERLÄNGERER, BEI DEM DIE SEKUNDÄRZEIT VON DER PRIMÄRZEIT ABHÄNGIG IST (Impulse Prolonging Circuits in which the Secondary Time is dependent on the Primary Time).—W. Grube. (*Zeitschr. f. Fernmeldetech.*, No. 9, Vol. 12, pp. 132–137.)

Continuation of the work dealt with in January Abstracts, p. 50. *See* also the same journal, same volume, pp. 107–112.

AN APPARATUS [OPPOSED CONDENSER DISCHARGE METHOD] FOR MEASURING THE OPERATING TIME OF ELECTROMAGNETIC RELAYS.—V. I. Kovalenkov, M. V. Raskin and M. F. Nečitajlo-Andrejenko. (*Westnik Elektrot.*, No. 4, 1931, Sec. I, pp. 137–142.)

INVESTIGATIONS ON GOLD ALLOYS FOR CONTACTS. PART I.—C. Benedicks and J. Härdén. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 13, 1932, pp. 71–76.)

A SENSITIVE FLEXIBLE THERMOSTAT [USING PHOTOELECTRIC CELL AS LINK BETWEEN GALVANOMETER AND HEATING CURRENT.]—J. R. Roebuck. (*Review Scient. Instr.*, Feb., 1932, Vol. 3, pp. 93–100.)

A SIMPLE HARMONIC CONTINUOUS CALCULATING MACHINE.—J. M. Robertson. (*Phil. Mag.*, February, 1932, Supp. No., Series 7, Vol. 13, No. 84, pp. 413–419.)

"A mechanical method is described for summing single, double and triple Fourier series, and solving sets of linear and certain transcendental simultaneous equations."

A MANUAL RECORDER [MANUAL CURVE DRAWING EQUIPMENT DEVELOPED FROM THE RADIO FADING RECORDER].—H. S. Wilkins. (*Gen. Radio Exper.*, Dec., 1931, Vol. 6, p. 7.)

This commercially available equipment uses a roll of standard adding machine paper; as an example of its application, it can be used in conjunction with a beat-frequency oscillator synchronously driven, in studies of acoustics.

COMPOUND COMPASS FOR DRAWING ARCS OF GREAT RADIUS.—L. W. McKeehan. (*Review Scient. Instr.*, Jan., 1932, Vol. 3, pp. 52–54.)

THE PHOTOELECTRIC RECORDER [FOR ELECTRICAL INDICATING INSTRUMENTS REQUIRING SMALL ENERGY INPUT].—C. W. La Pierre. (Summary in *Elec. Engineering*, Jan., 1932, Vol. 51, p. 41.)

THE STROBOGLOW [GRID-GLOW TUBE STROBOSCOPE].—L. R. Quarles. (*Review Scient. Instr.*, Feb., 1932, Vol. 3, pp. 85–90.)

A photograph here included, showing a rotating disc carrying near its edge some lines of writing, indicates the definition obtained with the aid of this device. The disc was rotating at 2 000 r.p.m., with a peripheral speed of 10 000 feet per minute.

OPERATING CHARACTERISTICS OF THE ELECTRO-OPTICAL SHUTTER.—H. W. Washburn. (*Phys. Review*, 15th Feb., 1932, Series 2, Vol. 39, No. 4, pp. 688–701.)

"This paper is concerned with an accurate mathematical solution of the Abraham and Lemoine type of electro-optical shutter." "The accurate solution of the problem of the discharge of the Kerr cell shows that the initial discharge wave causes the cell to close more rapidly than is indicated by the approximate solution involving lumped constants, and moreover that the effect of the discharge wave can be enhanced by increasing the distributed capacity along the leads, thereby materially increasing the rate of closing of the shutter."

CHARTS FOR [TELEPHONE OR RADIO] TRANSMISSION LINE PROBLEMS.—H. E. Hertig. (*Physics*, Dec., 1931, Vol. 1, pp. 380–387.)

IRON-CORED INDUCTANCES, WITH AIR-GAP, CARRYING A DIRECT CURRENT COMPONENT.—R. Gürtler. (*Hochf: tech. u. Elek: akus.*, Feb., 1932, Vol. 39, pp. 48–59.)

Second and final part of the paper dealt with in April Abstracts, p. 236.

DETERMINATION OF THE CONSTANTS OF LOW-DAMPING TRANSFORMERS [GRAPHICAL METHOD].—P. Oehlen. (*T.F.T.*, No. 4, Vol. 20, pp. 110–114.)

CONTRIBUTION À LA THÉORIE DU REDRESSEMENT (Contribution to the Theory of Rectification).—Y. Rocard. (*L'Onde Élec.*, Jan., 1932, Vol. 11, pp. 23–44.)

The writer deals with the predetermination of the rectified current and other factors in fairly simple cases which are, however, characteristic of practical conditions. Thus curves and tables are given for such arrangements as :—(i) half-wave rectification by arc ; (ii) full-wave rectification by arc ; (iii) half- and full-wave valve rectification, delivering to a zero or very small capacity ; (iv) the same, delivering to an infinite capacity ; (v) rectification by a valve with internal resistance, delivering to a filter whose entrance capacity is of any value, or to a filter with entrance inductance (T connection) ; (vi) rectification by arc, delivering to an entrance inductance and a load shunted by an infinite capacity. The final section (vii) deals with the possibility of a short circuit of the transformer across the valves in a multi-phase rectification.

RECTIFIER VALVES WORKING OFF FULL MAINS VOLTAGE (200 V A.C. MAINS).—G. Ganz Company. (*Rad.*, *B.*, *F. f. Alle*, Feb., 1932, pp. 49–50.)

" The Vienna valve makers G. Ganz & Co. have succeeded in making rectifier valves for connection straight on to the 220 V a.c. mains, without the interposition of any transformer, so that all anode and grid-bias voltages can be obtained in an almost ideal way. These rectifiers are based on the same principle as the indirectly heated amplifier valves, for the full mains voltages, produced by Ganz & Co. last year, which unluckily could not be sold in Germany for reasons connected with patent rights. The new rectifier valves are not subject to this limitation, so that they will shortly be obtainable everywhere." There is no need to use the Ganz amplifier valves with these rectifiers : Telefunken and Valvo 20-volt types are suitable. The makers are developing the use of their rectifiers in the Greinacher circuit, for 110-volt mains, so that sufficient d.c. voltage may be obtained. The rectifiers can also be used on 150-volt mains, by the interposition of a small series resistance.

RECTIFIER VALVE WITH INDIRECTLY HEATED CATHODE AT FULL MAINS VOLTAGE [" OSTAR "].—H. Olvenstedt. (*Die Sendung*, 22nd and 29th January, 1932, Vol. 9, pp. 78 and 97.)

No transformer or resistance is required : there are three types, for 110, 150 and 220 volts respectively. At present the outputs are for 50 and 100 mA. The same makers have also produced new indirectly heated amplifier valves working directly on the full d.c. mains voltage. *See* also *Wireless World*, 23rd March, 1932, Vol. 30, p. 298.

PAPERS ON AIR CELL BATTERIES AND THEIR USE FOR RADIO RECEIVERS.—*See* abstracts under " Reception."

NEW RESEARCHES ON ELECTROLYTIC VALVE ACTION.—A. Güntherschulze and H. Betz. (Long summary in *Physik. Ber.*, 1st Feb., 1932, Vol. 13, pp. 301–302.)

ZUR THEORIE DER ELEKTROLYTISCHEN VENTILWIRKUNG (On the Theory of the Electrolytic Valve Action).—W. J. Müller. (*Zeitschr. f. Phys.*, 1931, Vol. 73, No. 7/8, pp. 560–564.)

A discussion of the experiments of Güntherschulze and Betz (1931 Abstracts, p. 515) in the light of a theory already proposed by the writer and Konopicky ; the unipolar conduction in the covering layer of the electrolytic valve, assumed by Güntherschulze and Betz, is found to be unnecessary.

MIKROGRAPHISCHE UNTERSUCHUNG DER " KUPROX "-GLEICHRICHTER (Micrographic Investigation of the " Kuprox " Rectifier).—M. Torres. (*Zeitschr. f. Phys.*, 1932, Vol. 74, No. 11/12, pp. 770–772.)

" The single crystals of copper oxide correspond to the single crystals of the underlying copper and generally extend throughout the whole thickness of the oxide layer. Pélabon's theory of rectification [1930 Abstracts, p. 641] is not confirmed," whereas the result of the micrographic investigation is in full agreement with that of Schottky. *Cf.* Perucca, April Abstracts, p. 232.

THE DESIGN OF POWER RECTIFIER CIRCUITS.—M. V. Callendar : McDonald. (*Wireless Engineer*, Jan., 1932, Vol. 9, pp. 24–25.)

A letter on McDonald's paper referred to in Feb. Abstracts, p. 108, ending :—" When these additional points are considered, it will appear that the half wave circuit has not such a superiority as is claimed by Mr. McDonald, but that each type of circuit has its sphere of usefulness : in particular, the h.w. circuit is best for high voltages, and in cheap eliminators (*e.g.*, where a moving coil speaker is not likely to be used)."

NEW DESIGNS IN HIGH POWER MERCURY VAPOUR RECTIFIERS, AND THEIR PHYSICAL BASES.—M. Wellauer. (*Bull. Assoc. suisse d. Elec.*, 19th Feb., 1932, Vol. 23, No. 4, pp. 85–97.)

CHARACTERISTIC CURVES OF THE ALUMINIUM RECTIFYING CELL.—L. L. Barnes. (*Phil. Mag.*, Jan., 1932, Series 7, Vol. 13, No. 82, pp. 76–81.)

" The aluminium cell is a serviceable rectifier or such uses as charging storage batteries from a.c. supply, and some of its characteristics are outlined as an indication of the manner in which the optimum conditions for its working can be determined.

The cell under test consists of aluminium and lead electrodes in a solution of sodium borate."

THE RELATIVE PERMEABILITY OF IRON, NICKEL AND PERMALLOY IN HIGH FREQUENCY ELECTROMAGNETIC FIELDS.—E. M. Guyer. (*Journ. Franklin Inst.*, Jan., 1932, Vol. 213, No. 1, pp. 75–88.)

"The final conclusion, based upon the experimental measurements described in this paper, is that there is no anomalous variation in the relative magnetic permeability of iron, nickel and permalloy at frequencies corresponding to the band of wavelengths from 70 to 200 metres, and, in particular, that there is no sharp break or phenomenon suggestive of electromagnetic absorption in the curves for these materials at or near 100 metres . . . It is further concluded that there exists no irregular variation in high-frequency resistance, and consequently no corresponding change in magnetic permeability for iron and permalloy wires at wavelengths in the neighbourhood of two metres."

DIE ABHÄNGIGKEIT DER PERMEABILITÄT VON EISENDRÄHTEN VOM FELDE BEI HOCHFREQUENZ (How the High Frequency Permeability of Iron Wires Depends on the Field).—M. Wien. (*Physik. Zeitschr.*, 15th Feb., 1932, Vol. 33, No. 4, pp. 173–175.)

A PRELIMINARY COMMUNICATION ON FERROMAGNETIC PLATINUM-CHROMIUM AND PLATINUM-IRIDIUM ALLOYS.—E. Friederick. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 13, 1932, p. 59.)

A correction (*ibid.*, No. 2, p. 102) changes the last three words of the title to "Iridium-Chromium Alloys," and the "10% platinum" mentioned in the summary to "90% platinum."

HYDROGENISED IRON OF HIGH PERMEABILITY.—P. P. Cioffi. (*Bell Lab. Record*, Jan., 1932, Vol. 10, No. 5, pp. 159–163.)

MODERN LOADING EQUIPMENT [INCLUDING COILS WITH PERMALLOY DUST CORE—"STANELEC"]. Part I.—J. B. Kaye. (*Elec. Communication*, January, 1932, Vol. 10, No. 3, pp. 147–166.)

RELATIONSHIPS AMONGST THE MAGNETIC PROPERTIES OF MAGNET STEELS AND PERMANENT MAGNETS.—K. L. Scott. (Summary in *Elec. Engineering*, January, 1932, Vol. 51, p. 44.)

THE THERMOELECTRIC PROPERTIES OF FERROMAGNETIC SUBSTANCES.—L. F. Bates. (*Phil. Mag.*, February, 1932, Supp. No., Series 7, Vol. 13, No. 84, pp. 393–412.)

A description of a series of experiments on the thermoelectric properties of short rods of manganese arsenide.

ON SOME PROPERTIES OF VACUUM THERMO-COUPLES.—J. Jaffray. (*Comptes Rendus*, 1st Feb. 1932, Vol. 194, pp. 451–452.)

Continuation of the work dealt with in Feb. Abstracts, p. 110.

NOTES ON RADIATION THERMOPILES.—J. Strong. (*Review Scient. Instr.*, Feb., 1932, Vol. 3, pp. 65–70.)

TELLURIUM-BISMUTH VACUUM THERMOCOUPLE.—C. H. Cartwright. (*Ibid.*, pp. 73–79.)

A NEW TYPE OF RADIOMETER [USING THE CONDENSER ULTRA-MICROMETER PRINCIPLE].—A. L. M. Dingee. (*Ibid.*, pp. 80–84.)

INCREASING THE CHARGE SENSITIVITY OF VACUUM TUBE AMPLIFIERS.—G. F. Metcalf. (*Phys. Review*, 15th Feb., 1932, Series 2, Vol. 39, No. 4, p. 745.)

This letter indicates the possibilities of using systems of neutralising the input capacity of valve amplifiers to increase the charge sensitivity and speed of operation of these amplifiers. The charge sensitivity of 2×10^{-17} coulomb/mm obtained with a Pliotron valve could thus be increased to 2×10^{-19}, or about one electron per scale division, good stability being retained.

A GRID RESISTANCE OF 10^{11} OHMS, OF MANGANESE DIOXIDE AND ALUNDUM MADE INTO A CEMENT WITH WATER GLASS.—D. R. Morey. (*Review Scient. Instr.*, Jan., 1932, Vol. 3, p. 26.)

In a paper on a photoelectric device for measuring the amount of plane polarised light in low intensity radiations, and for measuring small rotations of the plane of polarisation.

INVESTIGATIONS ON THE SPECIFIC RESISTANCE OF THIN METALLIC LAYERS, ESPECIALLY OF SILVER AND TUNGSTEN.—L. Hamburger and W. Reinders. (Long summary in *Physik. Ber.*, 1st Jan., 1932, Vol. 13, p. 53: *see* also *ibid.*, pp. 53–54.)

FACTORS OF REFLECTION AND TRANSMISSION OF CERTAIN METALS DEPOSITED BY CATHODE SPUTTERING.—A. de Gramont. (*Comptes Rendus*, 22nd Feb., 1932, Vol. 194, pp. 677–679.)

AN IMPROVED HIGH RESISTANCE UNIT [FROM A FEW TO SEVERAL HUNDRED THOUSAND MEGOHMS].—R. C. Rentschler and D. E. Henry. (*Review Scient. Instr.*, Feb., 1932, Vol. 3, pp. 91–92.)

By sputtering carbon or graphite on to a glass spiral in an inert gas, resistances are obtained which are very constant and pass a current strictly proportional to the applied voltage.

ON THE CRYSTALLINE STRUCTURE OF THIN LAYERS OF METALS.—Debińska. (*See* under "Measurements and Standards".)

COMPOSITION TYPE RESISTORS FOR RADIO RECEIVERS [FAULTS, REQUIREMENTS AND TESTS].—L. Podolsky. (*Rad. Engineering*, Jan., 1932, Vol. 12, p. 32.)

THE EVOLUTION OF RESISTORS USED IN RADIO [COMPRESSION-TYPE AND WIRE-WOUND].—H. G. Cisin: Clarostat Company. (*Rad. Engineering*, Feb., 1932, Vol. 12, pp. 33–34.)

THE EFFECTS OF IRON ON THE ELECTRICAL CONDUCTIVITY AND TENSILE STRENGTH OF ALUMINIUM.—M. Kuroda. (Summary in *Physik. Ber.*, 1st Jan., 1932, Vol. 13, pp. 54–55.)

SKIN EFFECT CURVES.—G. B. Robinson. (*Rad. Engineering*, Jan., 1932, Vol. 12, p. 30.)

"The unique form of this group of curves was made possible by the discovery that the skin effect ratio equation given by the Bureau of Standards [Circular 74] could be re-arranged to show that a given value of d.c. resistance per foot length of conductor gives a definite skin effect ratio *regardless of the diameter of the conductor*" [this does not apply to magnetic materials]. Thus the curve table given supplies the skin effect ratio for any round straight wire of non-magnetic material.

ELEKTRISCHE EIGENSCHAFTEN VON GEDEHNTEM GUMMI (Electrical Properties of Stretched Rubber).—A. Gemant. (*Zeitschr. f. Phys.*, 1931, Vol. 73, No. 7/8, pp. 526–537.)

THERMAL AND ELECTRICAL CONDUCTIVITY OF DIELECTRICS [AND A POSSIBLE RELATION BETWEEN THE TWO].—M. I. Mantrov. (*Westnik Elektrot.*, No. 2, 1931, Sec. III, pp. 23–28.)

THE PREDETERMINATION OF THE A.C. BEHAVIOUR OF DIELECTRICS [BY MEASUREMENT OF CHARGE AND DISCHARGE CURRENTS UNDER CONTINUOUS POTENTIAL].—J. B. Whitehead and A. Banos, Jr. (Summary in *Elec. Engineering*, January, 1932, Vol. 51, p. 44.)

PHENOL PLASTIC FOR MOULDED CASES FOR THE TROPICS.—I. T. and T. (*See* abstract under "Miscellaneous.")

THE DIELECTRIC STRENGTH OF RUSSIAN MICAS.—Florensky, Mantrov and Budnicky. (*Westnik Elektrot.*, No. 5/6, 1931, Sec. III, pp. 68–83.)

TESTS ON RAISING THE DIELECTRIC STRENGTH OF INSULATING OILS BY FILTRATION THROUGH GLASS POWDER COMPOSITIONS.—P. H. Prausnitz and F. Obenaus. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 13, 1932, pp. 94–97.)

INSULATIONS – VITRIFIED. A GENERAL DISCUSSION OF THE TECHNICAL OUTLOOK.—H. Warren. (*Electrician*, 26th Feb., 1932, Vol. 108, pp. 286–288.)

POTENTIAL DISTRIBUTION RADIATION AND ELECTRICAL CONDUCTION IN PAPER.—E. B. Baker and R. F. James. (*Physics*, Feb., 1932, Vol. 2, No. 2, pp. 73–81.)

DIELECTRIC LOSS AND RELAXATION TIME IN ROSIN.—J. B. Whitehead. (*Ibid.*, pp. 82–92.)

LOSSES IN LIQUID DIELECTRICS AT RADIO FREQUENCIES [AND THE MEISSNER "IMMERSION" METHOD OF MEASURING SELF-CAPACITY OF COILS].—W. Jackson. (*Wireless Engineer*, Jan., 1932, Vol. 9, pp. 14–17.)

Experiments in connection with the writer's previous work on the dielectric losses associated with the formers of single-layer coils (1928 Abstracts, p. 346). Moullin had found that attempts to express the dielectric loss in terms of constant power factor of the self-capacity were not very successful, the p.f. in one case ranging from 28 % at 200 c.p.s. to 16 % at 1 600 c.p.s. The present experiments, however, in which liquid dielectrics were used seem to show that the supposition of a constant p.f. of the dielectric circuit is justified in the case of castor and paraffin oils, paraffin wax and new transformer oil, though not in the case of turpentine and olive oil.

THE EFFECT OF ELECTROLYTES ON THE DIELECTRIC CONSTANT OF WATER.—PARTS III AND IV.—R. T. Lattey and W. G. Davies. (*Phil. Mag.*, February, 1932, Supp. No., Series 7, Vol. 13, No. 84, pp. 444–455.)

Continuation of the work referred to in February Abstracts, p. 109.

DISPERSIONSMESSUNGEN AN FLÜSSIGKEITEN, INSBESONDERE BIOLOGISCHEN LÖSUNGEN MIT UNGEDÄMPFTEN WELLEN IM BEREICH VON 1 BIS 4 M WELLENLÄNGE (Dispersion Measurements of Liquids, in particular Biological Solutions with Undamped Waves of Length 1 to 4 m).—E. May and H. Schaefer. (*Zeitschr. f. Phys.*, 1931, Vol. 73, No. 7/8, pp. 452–459.)

ÜBER DIE ABSORPTION VON DIPOLFLÜSSIGKEITEN UND ELEKTROLYTLÖSUNGEN IM GEBIET KURZER ELEKTRISCHER WELLEN (On the Absorption of Dipole Liquids and Electrolyte Solutions in the Region of Short Electrical Waves [of lengths 76 m, 48 m, and 28 m]).—J. Malsch. (*Physik. Zeitschr.*, 1st Jan., 1932, Vol. 33, No. 1, pp. 19–21.)

STATIONS, DESIGN AND OPERATION.

DUPLEX RADIO TELEPHONY ON FEW METRE [ULTRA-SHORT, 4-METRE] WAVES BETWEEN SHIP AND SHORE.—S. Uda. (*Technol. Rep. Tôhoku Imp. Univ.*, No. 2, Vol. 10, 1931, pp. 17–26.)

Successful telephonic communication was obtained over about 25 km, the land station being on the sea shore; reception on the ship became rather difficult and occasionally failed when she sailed too close to intervening islands, *but at the land station it remained good.* Further experiments, this time using wave reflector and director systems at the transmitter, were carried out between sites on high ground 60 km apart. Extremely loud signals were obtained, both with vertically and horizontally polarised waves; no distinguishable difference was found. Reception on the ship, from the transmitter on the high ground above mentioned (130 metres above sea level) was difficult at the extreme 60 km but was practicable again below 40 km.

ULTRA-SHORT WAVE IN HAWAII TELEPHONE SERVICE.—(*Electronics*, Jan., 1932, p. 27.)

LA NOUVELLE STATION DE RADIODIFFUSION RADIO-PARIS (The New Broadcasting Station Radio Paris [at Saint Rémy l'Honoré]).—H. Staut. (*L'Onde Élec.*, Jan., 1932, Vol. 11, pp. 5–22.)

Including sections on the dephasing modulation system referred to in February Abstracts, p. 94 (Chireix).

THE NEW RADIO STATION AT SAINT-RÉMY L'HONORÉ (the New Radio Paris).—M. Adam. (*Génie Civil*, 13th Feb., 1932, Vol. 100, pp. 163–168.)

THE HEILSBERG HIGH POWER BROADCASTING STATION, EAST PRUSSIA.—H. Schumacher. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 13, 1932, pp. 98–101.)

THE PRAGUE HIGH-POWER BROADCASTING EQUIPMENT.—D. B. Mirk. (*Elec. Communication*, January, 1932, Vol. 10, No. 3, pp. 106–130.)

THE RADIO [FREQUENCY] MONITORING STATION AT GRAND ISLAND, NEBRASKA.—(*Rad. Engineering*, Jan., 1932, Vol. 12, pp. 17–18.)

PIPING SYSTEM FOR POWER TUBE COOLING WATER AT RADIO STATION KDKA.—E. M. Sollie. (*Rad. Engineering*, Jan., 1932, Vol. 12, pp. 31 and 35.)

PROBABLE FUTURE INCREASE IN AVAILABLE RADIO CHANNELS [FROM 2 240 TO 3 922 IN 5 YEARS' TIME].—S. R. Winters: Bureau of Standards. (*Rad. Engineering*, Jan., 1932, Vol. 12, p. 33.)

LINING UP BROADCASTING CIRCUITS [AND A CRITICISM OF THE C.C.I. DECISIONS].—E. K. Sandeman. (*Elec. Communication*, January, 1932, Vol. 10, No. 3, pp. 131–133.)

" . . . It is submitted that any method of lining up circuits which inherently demands a higher power-handling capacity from the amplifiers than is warranted by the required circuit levels is wasteful."

SWISS LAND-LINE RADIO. (*Electronics*, Jan., 1932, p. 28.)

By paying twice the normal radio fee, telephone subscribers may attach a loud speaker with one stage of a.f. amplification (approved types) to their telephone line for reception of local programme only. No radio transmission is involved, though the programme is that of the radio station. *Cf.* April Abstracts, p. 240.

WAVELENGTHS FOR AIRCRAFT COMMUNICATION.—C. B. Carr. (*Marconi Review*, Jan.–Feb., 1932, No. 34, pp. 16–25.)

An article written primarily to assist " those responsible for drawing up specifications of performance for aircraft wireless equipment." It includes a table of summer and winter skip distances for waves ranging from 15 to 100 metres.

RADIO COMMUNICATION ON THE INTERNATIONAL [PAN AMERICAN] AIR LINES.—H. C. Leuteritz. (*Rad. Engineering*, Feb., 1932, Vol. 12, pp. 25–29.)

RADIO BROADCAST FROM FAST BOBSLED [3RD OLYMPIC WINTER GAMES]. (*Rad. Engineering*, Feb., 1932, Vol. 12, p. 20.)

PAPERS ON POLICE RADIO SIGNALLING SYSTEMS.—Dunsheath: Kavanagh: Lampkin. (*Rad. Engineering*, Jan. and Feb., 1932, Vol. 12, pp. 11–12, pp. 30–32; *Electronics*, Jan., 1932, pp. 22 and 36.)

AANPASSING AAN RADIODISTRIBUTIE-NETTEN (Circuit Matching in Networks for Radio Distribution [to Loud Speakers]).—Jhr. W. Six and R. Vermeulen. (Summary in *Physik. Ber.*, 15th Dec., 1931, Vol. 12, pp. 2935–2936.)

The system considered is one in which a number of " points " for loud speakers are provided at a limited distance only from the supply source.

GENERAL PHYSICAL ARTICLES.

THE MOTION OF A CHARGED PARTICLE. PART I.—C. Störmer. (*Zeitschr. f. Astrophysik*, No. 1, Vol. 3, 1931, pp. 31–52.)

Study of the motion of a charged particle under the combined action of the force due to a magnetic dipole and of a central force varying inversely as the square of the distance from the dipole.

A NEW CHARACTERISTIC OF THE DIRAC ELECTRON—Al. Proca. (*Comptes Rendus*, 22nd Feb., 1932, Vol. 194, pp. 691–693.)

" Thus everything occurs as if a Dirac electron possesses, besides its electrical charge e, a free magnetic charge, oscillating, and of amplitude numerically equal to the first, $\mu = e$."

OPMERKINGEN OVER VARIATIES IN HET ELECTRISCH GEDRAG VAN VERSCHILLENDE STOFFEN (Remarks on the Variations in Electrical Behaviour of Various Substances [including Application to Thermionic Emission]).—L. Hamburger. (*Physica*, No. 1, Vol. 12, 1932, pp. 19–31.)

Considering the variation of a quantity X as a function of a variable Y, the wide applicability of the relation $lnX = klnY$ (+ const.) is demonstrated. Even in cases where the relation is not exact, its application is useful for the sake of " uniform " comparison over wide ranges of variation between divergent fields of research. The writer proposes to use, as the significant coefficient of variation, $\phi = dlnX/dlnY$, or $\Delta lnX/\Delta lnY$; the commonly used $\Delta X/X_0 \cdot 1/\Delta T$ being rejected.

GRAVITY AND ELECTRICITY ARE MERGED IN NEW MATHEMATICS.—C. Lanczos. (*Sci. News Letter*, 5th Dec., 1932, pp. 355–356.)

By applying the simplest form of the " principle of least action" to Riemannian geometry a combination of two functions is arrived at. From one of these are derived the laws of gravitation, and from the other a new and consistent explanation of the laws of electricity and magnetism. *See* next two references.

ELEKTROMAGNETISMUS ALS NATÜRLICHE EIGENSCHAFT DER RIEMANNSCHEN GEOMETRIE (Electromagnetism as a Natural Property of Riemannian Geometry [Theoretical Investigation]).—C. Lanczos. (*Zeitschr. f. Phys.*, 1931, Vol. 73, No. 3/4, pp. 147–168.)

ELECTRICITY AS A NATURAL PROPERTY OF REIMANNIAN GEOMETRY.—C. Lanczos. (*Phys. Review*, 15th Feb., 1932, Series, 2, Vol. 39, No. 4, pp. 716–736.)

MISCELLANEOUS.

SYMBOLIC CALCULUS.—B. van der Pol and K. F. Niessen. (*Phil. Mag.*, March, 1932, Series 7, Vol. 13, No. 85, pp. 537–577.)

This paper contains a full account of the extended form of the Heaviside operational calculus and derives many new results of practical value, a list of which is given at the end.

FUN WITH HEAVISIDE'S CALCULUS.—W. C. Johnson, Jr. (*Gen. Elec. Review*, No. 10, Vol. 34, pp. 559–564.)

THE APPLICATION OF QUADRATIC FORMS IN AN INFINITY OF VARIABLES TO BOUNDARY PROBLEMS IN PARTIAL DIFFERENTIAL EQUATIONS.—S. W. P. Steen. (*Proc. Camb. Phil. Soc.*, Jan., 1932, Vol. 28, Part 1, pp. 23–34.)

THE METHOD OF LEAST SQUARES.—H. J. Brennen. (*Phys. Review*, 1st Jan., 1932, Series 2, Vol. 39, No. 1, p. 189.)

THE 1931 MEETING OF THE HEINRICH HERTZ ASSOCIATION.—(*E.N.T.*, Feb., 1932, Vol. 9, pp. 75–79.)

Collaboration with the U.R.S.I.; reports and future programmes on (*a*) propagation and fading of broadcasting waves; (*b*) propagation of 60–15 m and ultra-short (including "decimetre") waves; (*c*) atmospherics; (*d*) television; (*e*) precision measurements; (*f*) miscellaneous. In this last class, Möller reports on damping measurements on a Lecher wire system for waves under 1 metre, and on a piezoelectric "whisper microphone" using Rochelle salt; and Leithäuser mentions his work on tourmalin crystals as control oscillators and luminous resonators for waves under 50 cm. "It is also contemplated to employ the high-frequency oscillations for the investigation of materials."

ELECTRICAL COMMUNICATION IN 1931.—I.T. and T. (*Elec. Communication*, Jan., 1932, Vol. 10, No. 3, pp. 101–105.)

Items mentioned include:—the "Micromesh," a valve having exceptionally small clearances between the electrodes, with "an extremely high gain and much better characteristics than tubes heretofore available": moulded cases of phenol plastic for the tropics: and a new type of broadcasting aerial consisting of a fabricated tower resting on a single insulator, with one set of guys at about the half-way point. So far, the height has been about 0.6λ: the signal strength over a wide coverage is about 40 % greater than that of the standard type $\lambda/4$ aerial.

THE PHYSICAL SOCIETY'S EXHIBITION: MATTERS OF WIRELESS AND LABORATORY INTEREST.—(*Wireless Engineer*, Feb., 1932, Vol. 9, pp. 80–83.)

RADIO—BROADCASTING—TELEVISION IN 1932: ADVANCES IN SOUND-RECORDING: INDUSTRIAL USES OF TUBES.—(*Electronics*, Jan., 1932, pp. 2–4: 4–5 and 38: 5 and 38.)

ELECTRICAL PROGRESS IN 1931—TELEVISION: RADIO TELEPHONY: VACUUM TUBES.—W. G. W. Mitchell: H. Faulkner: L. J. Davies. (*Electrician*, 29th Jan., 1932, Vol. 108, pp. 132: 140–141: and 141–142.)

THE GERMAN P.O. SECTION AT THE 8TH BERLIN RADIO EXHIBITION.—G. Kette. (*T.F.T.*, Dec., 1931, Vol. 20, pp. 378–384.)

A CHRONOLOGICAL HISTORY OF ELECTRICAL COMMUNICATION—TELEGRAPH, TELEPHONE AND RADIO. (*Rad. Engineering*, Jan. and Feb., 1932, Vol. 12, pp. 6 and 13.)

These first instalments take us from 600 B.C. (Thales attributes the attractive properties of amber and the lodestone to a soul or spirit dwelling within these substances) to 1827 (Ohm announces definitions of electrical laws).

ABBREVIATION OF THE TITLES OF TECHNICAL JOURNALS.—(*E.N.T.*, Jan., 1932, Vol. 9, p. 38.)

Notice of a brochure published in Berlin giving the rules decided on by the International Commission and a list of some 1 150 abbreviated titles based on these rules.

SUMMATION MEASUREMENT METHODS IN TELEMETERING, AND THEIR CHIEF DEFICIENCIES.—W. Stäblein. (*Elektrot. u. Masch: bau*, 31st January, 1932, Vol. 50, pp. 69–76.)

COMUNICAZIONI TELEFONICHE AD ONDE CONVOGLIATE SU CONDUTTORI AD ALTA TENSIONE (Carrier-Current Telephony on H.T. Lines).—G. Bourelly. (*L'Elettrotec.*, 5th and 15th Jan., 1932, Vol. 19, pp. 3–13 and 25–33.)

SPEED OF SIGNAL TRANSMISSION OVER CARRIER TELEGRAPH CHANNELS.—(*P.O. Elec. Eng. Journ.*, Jan., 1932, Vol. 24, Part 4, pp. 269–270.)

MEASUREMENT OF THE HYGROMETRIC STATE OF A GASEOUS MASS BY A RELAXATION OSCILLATION METHOD: APPLICATION TO TESTS OF INTERNAL COMBUSTION AND STEAM ENGINES.—P. Le Rolland and T. Te Lou. (*Comptes Rendus*, 18th Jan., 1932, Vol. 194, pp. 258–260.)

Calculation and Experimental Investigation of the Vibrations of Aeroplanes [Recording a "Vibration Spectrum" by the Küssner "Optograph"].—H. G. Küssner. (Summary in *Physik. Ber.*, 1st Jan., 1932, Vol. 13, pp. 20–21.)

The Electrical Measurement of Mechanical Oscillations.—H. Thoma. (Summary in *Physik. Ber.*, 1st Jan., 1932, Vol. 13, p. 19.)

Shock Measurements [with the Langer-Thomé Acceleration Meter].—P. Langer. (*Ibid.*, p. 19.)

Electromagnetic Vibrograph [Ultra-Micrometer Device with Balanced Transformer Circuit and Varying Air-Gap] and Its Use in connection with Turbo-Generator Rotors.—F. Sieber. (*Brown Boveri Rev.*, August, 1931, Vol. 18, pp. 248–251; summary in *Sci. Abstracts, Sec. B.*, December, 1931, Vol. 34, p. 651.)

The device referred to in January Abstracts, p. 54. The transformer is fed with current at about 500 c.p.s. from a valve oscillator; a graph is made by a recording ammeter.

Rubber Conveyors are Synchronised by Tubes [using Variable Reactors and Thyratrons].—B. S. Havens. (*Electronics*, Jan., 1932, p. 21.)

Photoelectric Cells in Precision Inspection Work [by Automatic Reading of Deflection-type Measuring Instruments].—W. J. Tietz and C. Paulson. (*Electronics*, Jan., 1932, pp. 6–8.)

Photo-Cells and Advertising.—R. C. Walker. (*Wireless World*, 23rd March, 1932, Vol. 30, pp. 292–293.)

Various practical arrangements are discussed in which photo-cells can be used to control illuminated advertising signs and similar arrangements.

Electricity in Modern Medicine:—Artificial Fever: Electrosurgery: Electrocardiograph.—Tenney: Ward: Williams. (*Elec. Engineering*, Jan., 1932, Vol. 51, pp. 56–57.)

A New Method of Irradiating the Body Cavities with Ultra-Violet Rays [using a Tungsten Spark-Gap].—G. Loeck. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 13, 1932, p. 101.)

Types of Changes in Brain, Spinal Cord and Nerve Cells following an Electric Shock.—W. B. Kouwenhoven and O. R. Langworthy. (*Elec. Engineering*, Dec., 1931, Vol. 50, pp. 929–932.)

Electro-Cardiographs Using Voltage, not Current, Indication.—H. Gabler. (*Zeitschr. f. Instr:kunde*, Jan., 1931, Vol. 51, pp. 29–36.)

The Pende Cardiac and Pulmonary "Teletransmitter."—G. Santucci. (*La Ricerca Scientifica*, Nov., 1931, Vol. 2, pp. 328–336.)

Selective Heating by Short Radio Waves and Its Application to Electrotherapy.—J. C. McLennan and A. C. Burton. (*Canadian Journ. of Res.*, November, 1931, Vol. 5, No. 5, pp. 550–566.)

Extension of the work dealt with in 1931 Abstracts pp. 54 and 54–55.

The Action of Short-Wave Apparatus compared with that of Diathermy Apparatus.—Rhenisch. (Summary in *Physik. Ber.*, 15th Nov., 1931, Vol. 12, p. 2636.)

Action at a Distance on the Development of the Eggs of the Echinus [Mitogenetic Radiation].—J. and M. Magrou and P. Reiss. (*Comptes Rendus*, 12th Oct., 1931, Vol. 193, pp. 609–612.)

Absorbable Radiation from Resistance Cells of Semi-conducting Lead Chloride.—G. Déchène: Reboul. (*Comptes Rendus*, 16th Nov., 1931, Vol. 193, pp. 922–925.)

Reboul's researches (1931 Abstracts, p. 458) have shown that a semi-conductor traversed by an electric current is, in general, the seat of emission of an absorbable radiation. This emission is localised at the surfaces of entry and departure of the current, and is connected with the presence, at these surfaces, of a sudden discontinuity of potential, explained by the existence of a strong concentration of ions produced by the passage of the current through a thin layer where the electrodes touch.

The writer has obtained particularly clear and consistent results by the use of lead chloride; unlike most semi-conductors, this gives potential discontinuities hardly varying at all with time. Various results are described.

On a Special Form of Activity in Matter.—G. Reboul. (*Comptes Rendus*, 15th February, 1932, Vol. 194, pp. 602–603.)

The effects described in previous Notes (Abstracts, 1931, p. 458, and January, p. 53) may be attributed either to a chemical action or to the action of an electromagnetic radiation emitted by the activated body. The present Note gives reasons for attributing them to the latter cause—a very absorbable radiation, belonging to the invisible part of the spectrum and emitted by a mechanism presenting some analogy to phosphorescence.

Production Peaks and Valleys.—A. C. Lescarboura. (*Rad. Engineering*, Jan., 1932, Vol. 12, pp. 28–30.)

"What shall we do to level our production activities throughout the year for a better distribution of overhead costs?"

Can Inventive Genius be Organised? [Radio Patent Pool].—G. P. Simons. (*Rad. Engineering*, Jan., 1932, Vol. 12, p. 27.)

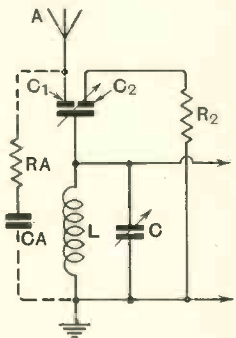
Some Recent Patents.

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.

COUPLING CIRCUITS.

Application date, 31st July, 1930. No. 364580.

The object is to vary the mutual coupling between two circuits, without affecting the tuning constants, so that volume control can be applied without any falling-off in selectivity. This is effected by providing a "balancing circuit" R_2, C_2 (simulating the resistance *RA*, and capacity *CA* of the aerial *A*) and coupling the tuned circuit *L, C* both to the balancing circuit and the aerial through a differential condenser C_1, C_2. Alternatively, a three-coil inductive coupling may be substituted for the condenser C_1, C_2. As the aerial coupling is increased, the coupling with the balancing circuit is decreased, and *vice versa*, so that whilst the aerial input is varied, the usual detuning and damping effects on the circuit *L, C* are counterbalanced.



No. 364580.

Patent issued to British Thomson-Houston Co., Ltd., and T. H. Kinman.

"PICK-UP" VOLUME CONTROL.

Convention date (France), 12th April, 1930. No. 365392.

The pick-up is shunted by a number of separated inductance coils arranged in series, each preferably having the same "time constant" as that of the pick-up winding. A switch enables one or more of the coils to be cut-out in order to regulate volume. The time constant of one or more of the shunt windings may be deliberately varied in order to impart or emphasise any desired "tone characteristic" to the reproduction.

Patent issued to J. Bethenod.

PICTURE TRANSMISSION.

Application dates, 20th October, 1930, and 6th March, 1931. No. 365632.

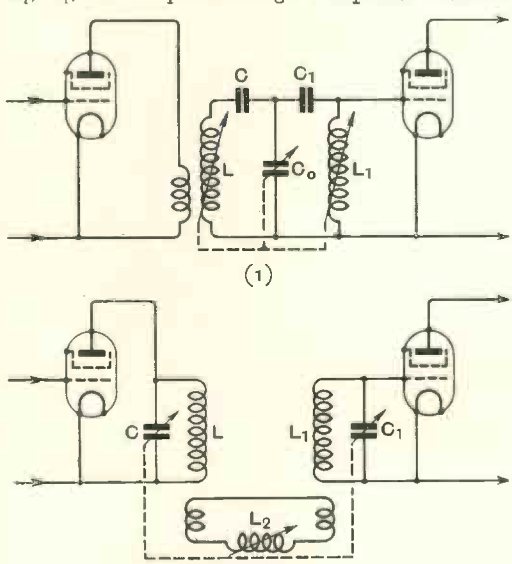
A still or moving picture is analysed in sections by different light-sensitive coils, and the resulting currents are stored as magnetic "images" on a steel wire or cylinder. Transmission is effected by means of a modulating "pick-up" which traverses the cylinder from end to end, and a similar system is used for recording the incoming signals at the receiving end. The various "sections" are then integrated by five pick-up devices, which traverse the recording drum in parallel, so as to reproduce the complete picture, together with speech if desired. Means are provided to compensate for distortion. The method is applicable to reproduction in natural colours by using appropriate colour screens for the different sections.

Patent issued to R. A. Aspden.

CONSTANT-BAND TUNING.

Convention date (U.S.A.), 12th December, 1929. No. 362170.

A band-pass input or intervalve coupling comprises two tuned circuits, variably coupled together, in combination with means for varying the extent of the inter-circuit coupling simultaneously with the tuning-adjustments, so as to maintain a constant band-width of 10 kC. over the whole tuning range. As shown in Fig. 1, the circuit L, C, C_0, is coupled to the circuit, L_1, C_1, C_0 through the common capacity C_0. The circuits are tuned to the signal frequency by varying the inductances L, L_1, whilst the width of the accepted band is kept constant by varying the capacity C_0, all three elements being ganged together as shown in dotted lines. In the form shown in Fig. 2 the two tuned circuits, L, C, and L_1, C_1, are coupled through a separate inductive link comprising a variometer element, L_2, which is ganged to the two tuning-condensers, C, C_1. Several other alternative methods of ensuring a consistent band-width are described in the specification.



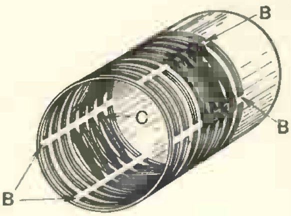
No. 362170.

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

H.F. INDUCTANCES.

Application date, 30th October, 1930. No. 366126.

The coil is formed by cutting-out slots in the periphery of a cylinder of varnished and impregnated paper, and supporting the windings on the intervening ridges *B* so as to form internal "chords" *C*, as shown. Preferably the ridges *B* are countersunk to the depth of the windings in order to present a smooth cylindrical surface externally.



No. 366126.

Patent issued to Lissen, Ltd., and W. H. Fuller.

TWO-WAY TELEVISION.

Application dates, 12th November, 1930, and 25th August, 1931. No. 365241.

In order to allow a person at one end of a telephone line to see a full-face instead of a side-face image of the person at the other end, the receiver at each terminal station is located inside the solid angle formed by the scanning beam of the associated transmitter. In one arrangement a single scanning disc is provided with two separate sets of spiral holes, one set being fitted with small 45° mirrors which project the light from a central neon lamp on to a viewing screen located directly in front of the speaker. In order that the latter may view the received image without being inconvenienced by the intensity of the local scanning-beam, ultra-red rays are used for transmission.

Patent issued to J. L. Baird, and Baird Television, Ltd.

PIEZO-ELECTRIC CRYSTALS.

Application date 18th September, 1930. No. 363410.

A piezo-electric crystal used for frequency-measuring is mounted between two main electrodes in an evacuated bulb. The main electrodes are associated with two similar metal plates, the whole forming a compound condenser unit from which leads are taken to pins at the base in the manner of a four-electrode valve. Incoming oscillations are applied to the crystal across the two main electrodes, the associated electrodes forming a condenser "bridge" to counterbalance any capacity effect across the crystal.

Patent issued to H. Andrewes, E. L. Gardiner, and British Radiostat Corporation, Ltd.

RADIO BEACONS.

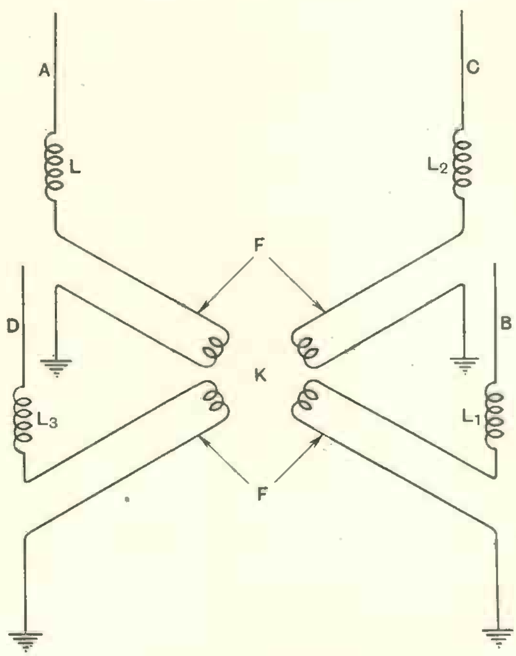
Convention date (France), 18th October, 1930. No. 363561.

The different loop-aerials of a rotating-beam transmitter are coupled separately to a single oscillatory circuit. Each coupling-circuit includes a constantly rotating condenser, these being driven through suitable reduction gearing from a common motor. Since each loop is only in tune with the main oscillatory circuit at one point in the movement of its rotating condenser, it will be energised periodically, but at definite intervals. During other times it radiates no energy. The different condensers are rotated at different speeds so as to impart a characteristic signal note on the radiated carrier-wave.

Patent issued by G. du Bourg de Bozas.

Application date, 21st June, 1930. No. 363617.

In order to secure clear-cut directional effects from a beacon station of the rotating-loop type, there should be no radiation in a direction perpendicular to the plane of the windings. In practice it is found that there is considerable upward radiation, which increases in intensity with the sine of the angle of elevation, and which on reflection from the Heaviside Layer gives rise to the so-called "night-error." According to the invention a number of spaced vertical aerials, *A*, *B*, *C*, *D*, are arranged to transmit a rotating "beam" of energy, and are energised through a goniometer coupling *K* by horizontal or inclined feeder-lines *F*, the currents in which are kept equal and in phase-opposition, so that there is no effective radiation from them. The correct current-distribution in the feeder lines is ensured by means of variable inductances, L—L_3, inserted in each of the vertical limbs.



No. 363617.

Patent issued to R. L. Smith-Rose and H. A. Thomas.

GRAMOPHONE PICK-UPS.

Convention date (Germany) 21st July, 1930.
No. 362836.

The swing carrier-arm for the pick-up is made as a permanent magnet, the actual stylus-unit being pivoted to the end polepieces so that it can be swung upwards in order to change the needle, etc. The arrangement ensures a powerful field without placing a heavy load on the record. Alternatively a pick-up of ordinary construction is mounted on the end of a magnetic carrier-arm so as to increase the normal field.

Patent issued to H. Sachs.

Convention date (U.S.A.) 24th October, 1929.
No. 363449.

In a pick-up designed for use with hill-and-dale records, the reduced end of one polepiece of the magnet projects into an opening in the shaped end of the other polepiece, so as to form a peripheral gap for the flux. A cylindrical coil-holder of the moving-coil type is mounted inside this gap, the stylus being mounted co-axially at one end of it, so as to move the coil up and down parallel with its own axis.

Patent issued to Electrical Research Products, Inc.

LOUD SPEAKERS.

Convention date (U.S.A.), 28th September, 1929.
No. 361976.

For high efficiency, theory indicates that the mass reactance of the diaphragm should be small in comparison with its radiation resistance. Mass reactance, although not dissipating the sound energy, tends to diminish the vibrational velocity, thereby lessening the effective sound-radiation. For this reason cone-speakers in general have a low efficiency, particularly over the higher audible range. The addition of an amplifying horn, on the other hand, permits the use of a small diaphragm having but little mass resistance. In order to cover the entire audible range up to the neighbourhood of 10,000

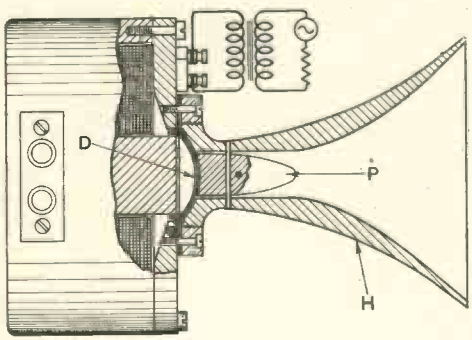


Fig. 1. No. 361976.

cycles, according to the invention, the qualities of the different types of speaker are combined in a single unit. As shown in Fig. 1, the diaphragm D is driven by a moving coil and works into a short exponential horn H fitted at the bottom with a conical plug P to give an annular throat. In Fig. 2 a speaker S of the type just described is combined with a second moving-coil speaker S_1 working into a large exponential horn H_1 adapted to favour the lower notes. The high-range speaker S is located inside and terminates near the flare

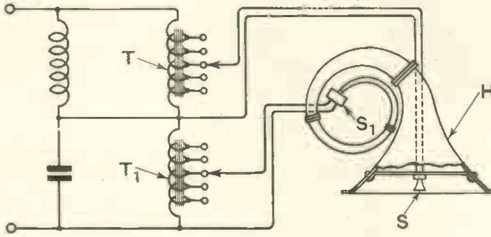


Fig. 2. No. 361976.

of the horn H_1, both instruments being separately energised through different tappings T, T_1 from the common input.

Patent issued to Electrical Research Products Inc.

TELEVISION IN COLOUR.

Convention date (U.S.A.), 25th October, 1929.
No. 365166.

Relates to a system for reproducing pictures in natural colours, in which three primary-colour sources, a neon lamp for the red and two argon lamps for the blue and green, are separately controlled by image currents flowing in individual channels. The image currents originally comprise a direct current component, a lower-frequency component and a higher-frequency component, but in order to facilitate manipulation and amplification, the two former are suppressed, leaving the third to transmit the characteristic details of the image. The invention consists in the provision of means for substituting for the suppressed currents an equivalent and automatic control—preferably by regulating the grid bias of the amplifiers—over the three primary colour sources at the receiving end.

Patent issued to Electrical Research Products Incorporated.

MODULATING SYSTEMS.

Application date 14th November, 1930.
No. 363480.

In order to reduce the average aerial current during no-signalling periods, or whilst "quiet" passages of music are being transmitted, the modulating current is applied simultaneously to separate amplifying and rectifying valves. The output from the amplifier is applied directly to the modulator, whilst the output from the rectifier is applied to vary the mean value of the aerial current, for instance, by varying the grid bias on one or more of the intermediate valve amplifiers. To prevent distortion the lower of the values between which the aerial current fluctuates is kept substantially constant.

Patent issued to H. Baron.

DIRECTIVE SIGNALLING.

Convention date (Germany), 21st December, 1929.
No. 364782.

Directional working on the ultra-short waves is made dependent on the fact that such waves when radiated from a short rod or dipole aerial are substantially polarised in one plane. A similar dipole used in reception will therefore pick up maximum energy when it is arranged parallel with the transmitter, and minimum energy when at right angles to it. A pair of transmitting and receiving aerials are accordingly mounted at right-angles to each other on a rotatable stand, the latter being associated with a scale to indicate direction.

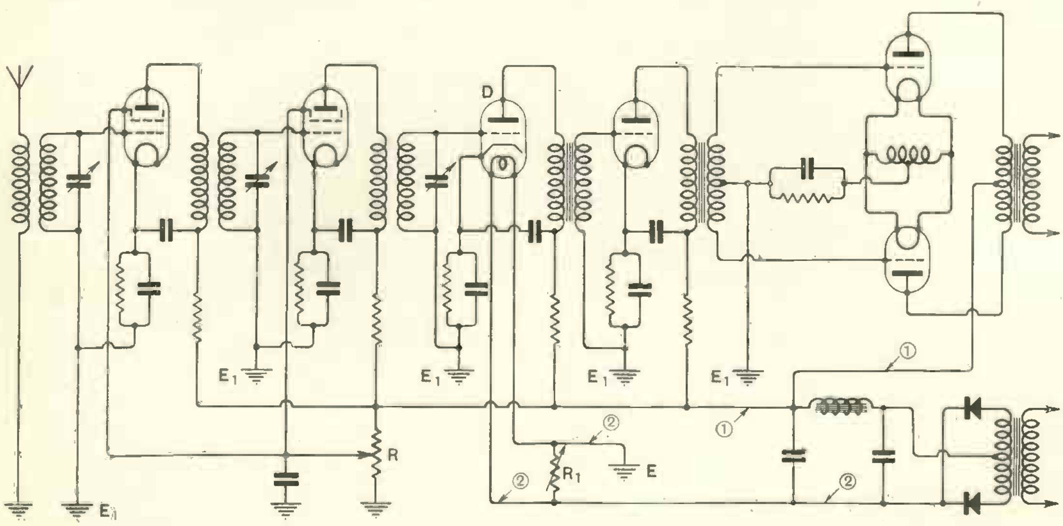
Patent issued to Telefunken Ges. für Drahtlose Telegraphic mbh. and W. Ludenia.

MAINS-DRIVEN RECEIVERS.

Convention date (U.S.A.), 12th February, 1930.
No. 362243.

To cut-out any tendency to "noise," the heating element for the detector valve *D*, instead of being supplied directly from the mains, is energised by the anode current of the other valves, particularly the L.F. stages. The remaining valves may be of the directly heated type. The positive line 1 of the eliminator circuit supplies the anodes of all the valves, the return line 2 passing through the heater element of the valve *D* to earth at *E*. The other cathodes are earthed at the points E_1 so that all the anode-cathode currents pass *via* these points through the heating-filament of the valve *D* back to the return line 2 of the eliminator. The heating current to the detector valve can be regulated either by the rheostat *R*, or by a resistance R_1 shunted across the eliminator "positive" and earth.

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

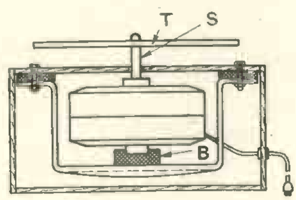


No. 362243.

GRAMOPHONE MOTORS.

Convention date (Germany), 16th April, 1930.
No. 364695.

A single-phase induction motor is supported on the under side by a single stub embedded in a block *B* of rubber or other resilient material. The shaft *S* carrying the turntable *T* passes with a loose fit through a hole in the casing. The rubber block *B* suppresses any vibrations due to magnetic pulsations as the stator and rotor come into step, and, at the same time, accommodates itself to the slight "precessional" movement which usually occurs at the moment of synchronisation.



No. 364695.

Patent issued to C. Lorenz Aktiengesellschaft.

ELIMINATING DISTURBANCES.

Convention date (Holland), 7th June, 1930.
No. 363956.

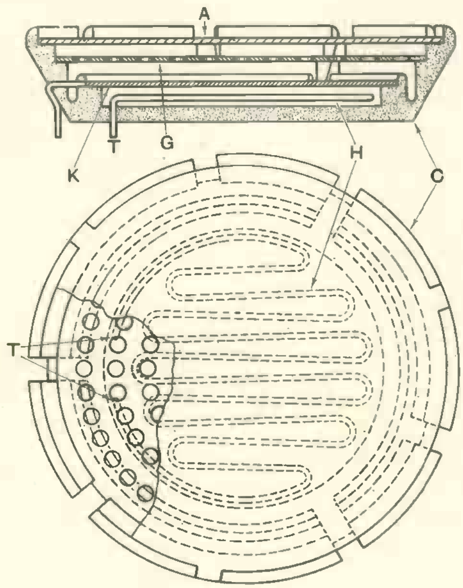
A filter for suppressing high-frequency disturbances, particularly from electric-light mains, consists of a H.F. choke in each main, the ends of both chokes being inter-connected by two condensers arranged in series. A separate terminal is taken from between each pair of series condensers, one or more, or all, of the available terminals being earthed according to existing conditions.

Patent issued to N. V. Philips' Gloeilampenfabrieken.

THERMIONIC VALVES.

Convention date (Germany), 13th November, 1929. No. 363755.

The electrodes of a valve are mounted in fixed relation to each other in a common support of magnesia or other insulating substance. The support *C* is in the form of a dish with stepped



No. 363755.

sides for holding and spacing the electrodes. The heating element *H* is laid at the base in zig-zag form, the terminals being shown at *T*, whilst the cathode *K* is mounted immediately above and is disc-shaped. The perforated-plate grid and the anode are shown at *G* and *A* respectively. The arrangement is suitable for mass-manufacture, valves of any required "characteristic" being assembled by selecting a suitably perforated grid.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie m.b.H.

Application date, 26th September, 1930. *No.* 364098.

Three grids are interposed consecutively between the cathode and anode, the one nearest the anode being connected to the cathode or to a fixed point of low potential. The one nearest the cathode is the control grid, whilst the intermediate one is biased to a high positive potential. The first-mentioned grid is provided with additional screening parts to intercept any fringing flux. The arrangement reduces interelectrode coupling to a very small value and enables the valve to handle large grid swings without distortion.

Patent issued to E. Y. Robinson and Associated Electrical Industries, Ltd.

DISTANT CONTROL BY RADIO.

Application date, 4th November, 1930. *No.* 364237.

An "unmanned" fog-signal located on a distant rock is controlled by wireless from a shore station. The received signal first closes a pair of contacts which allows current from a storage battery to heat a wire and so close a thermostatic switch. This in turn starts-up a motor to operate the main fog signal. Owing to the time lag imposed by the thermostatic control the apparatus will respond only to a predetermined train of waves, and not to casual impulses. A second series of transmitted waves serves to throw the fog signal out of action.

Patent issued to Chance Bros. & Co., Ltd., and J. H. Abbink-Spaink.

DIRECTION-FINDING.

Application date 17th July, 1930. *No.* 363374.

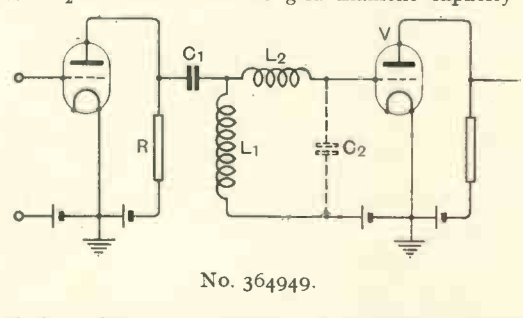
Directional signals received from a rotating beacon transmitter are recorded by a stylograph on a record sheet carried by a drum driven at a speed synchronous with that of the rotating beacon. A circular protractor scale, mounted co-axially with the drum, and on one side of it, is adjusted independently so as to give a direct indication of the required bearings by comparison with the trace on the record sheet.

Patent issued to R. L. Smith-Rose and H. A. Thomas.

RESISTANCE-COUPLED AMPLIFIERS.

Convention date (Germany), 24th March, 1930. *No.* 364949.

It is sometimes desirable to modify the frequency characteristic of a resistance-coupled amplifier, to compensate either for the effect of an input transformer, or of some preceding source of line distortion. According to the invention the amplification curve is "lifted" at both ends of the audible range by the insertion of inductances L_1, L_2, following the coupling resistance element *R* and condenser C_1. The coil L_1 and condenser C_1 form a series circuit resonant at a low frequency, thus emphasising the lower notes. Similarly the coil L_2 in series with the grid filament capacity



No. 364949.

of the valve *V* (or of a separate capacity C_2) is resonant at a high frequency, and so serves to "lift" the notes at the upper end of the scale. At these frequencies the effect of the coil L_1 as a shunt resistance is negligible.

Patent issued to Siemens and Halske Akt.

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