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Editorial

The Broadcasting of Sound and Vision on Ultra-short Waves

THE recent Television Report has concentrated general attention on the band of wavelengths between 5 and 9 metres. Those actively engaged in the development of television have, however, been fully alive to the importance of this band for several years, for it was fairly obvious that high-quality television was only possible at a frequency very much higher than the modulation frequency of the picture; and with 200 lines or 40,000 picture elements repeated 25 times per second, this modulation frequency can reach 500,000. It is interesting to note that the January number of *Elektrische Nachrichten-Technik* contained a long article discussing the details of a suggested network of television transmitters to cover the whole of Germany. It was assumed that sound and vision would be transmitted on neighbouring wavelengths, as close as possible, the combined transmitter occupying therefore a given band width. The German language lends itself to the construction of omnibus words, and "Tonbild" transmission is used to signify the combination of sound (Ton) and picture (Bild) transmission. Allowing a band width of 2,400,000 cycles for a combined transmitter, five such transmitters can be accommodated within the range from 5.7 to 7.5 metres. The basis of this calculation is shown in the diagram. It is assumed that a single heterodyne oscillator will be used in the receiver; it is shown giving an intermediate frequency of 600,000 with the sound carrier, and in order to avoid interference between sound and vision the nearest sideband of the vision is assumed to give an intermediate frequency of 700,000. The intermediate frequencies of the vision band of waves will

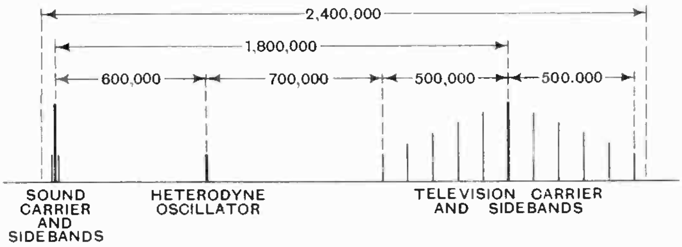

Diagram illustrating how the waveband 5.7 to 7.5 metres is utilised.

range from 700,000 to 1,700,000, and it will not be an easy problem to construct an amplifier capable of handling this and at the same time excluding the intermediate frequency of 600,000 belonging to the sound transmission. Having decided on the wavelengths the question arises of their geographical distribution and this necessitates a careful study of the range obtainable with different powers and with different heights of transmitting aerial. Experiments made by the German Post Office showed that, although the signal strength falls off much more rapidly as soon as the visible distance is passed, that is, as soon as the earth's curvature hides the transmitter from the receiver, it is not correct to assume that this fixes the limit of the working range. In the absence of obstacles the field-strength is inversely proportional to the distance ; if the radiated power is W watts and the distance d metres, the field-strength in volts per metre is equal to $9.5 \sqrt{W}/d$. If d is greater than the visible distance, *i.e.*, the distance determined by drawing a tangent to the earth from the transmitting aerial, this formula must be multiplied by a factor $e^{-\alpha d_1}$, where d_1 is the amount by which the total distance d exceeds the visible distance. From a number of experiments it was found that $\alpha = 0.1$ for these short waves. If the receiver is also raised above the earth's surface, the path consists of three parts, first through the air, following the tangent, then along the surface and then again through the air to the receiver following its tangent line.

The area served by a given radiated power is thus very dependent upon the height of the transmitter, and this fact has been the guiding principle in planning the suggested distribution of transmitters. In the north of Germany the country is flat and height can only be obtained by erecting towers, which would naturally be placed in the large centres of population ; in the centre and south, however, the country is mountainous, and the distribution has been devised so as to utilise prominent peaks for the purposes of transmission, apparently with little, if any, regard for the distribution of population. Thus, in the north, Berlin, Hamburg and Stettin are shown as transmitting centres, whereas farther south we find the Brocken (Harz), Feldberg (Black Forest), the Schneekoppe, and even the Zugspitze, the highest mountain peak in the Bavarian Alps, chosen as the sites of transmitters. Even with the greatly increased range obtained with such elevated transmitters, it requires at least twenty-one stations to cover the whole country, on the assumption that the radiated power is from 2 to 20 kW. and the minimum working field-strength 1 millivolt per metre. On this basis a transmitter on the Brocken would have a range of about 100 miles. A question of some importance in connection with the location of transmitters is the cable connecting the studio with the transmitter. When it is remembered that the currents may have a frequency of 500,000 or more it will be realised that their transmission from the studio to the transmitter raises some interesting problems which are not simplified by locating the transmitter on an Alpine peak.

It has been found that the disturbing factors which cause so much annoyance on the medium wave-band, such as electric trams, electric signs, rectifiers and atmospherics, have little or no effect on reception at these ultra-short waves ; the only disturbance is due to sparking plugs on motor vehicles.

An important point in reception is the extent to which these ultra-short waves are damped out in penetrating to the lower floors of blocks of lofty buildings in large towns. The German experiments gave rather reassuring results, but results must obviously be very dependent on the nature of the buildings and surroundings. An attempt was made to determine the constant β in the formula $E = E_0 e^{-\beta h}$, where E_0 is the field-strength on the roof where there is an unobstructed view of the transmitter and E the field-strength at any point in the building, h being the vertical distance between the two points in metres. One is not surprised to learn that β varied between 0.01 and 0.09, depending on the character of the building and surroundings. Those interested in this question of the transmission of ultra-short waves will find as an appendix to the article to which we have referred a very useful bibliography giving nineteen references, mainly, but not entirely, German.

G. W. O. H.

The Elimination of Interstation Interference*

By J. Robinson, D.Sc., Ph.D., M.I.E.E.

A system of wireless reception is described which employs a series of aerials with highly selective reception at each aerial, the rectified effects being combined at a convenient point. This allows us to eliminate all interstation interference, and to use one channel for a number of wireless services. This system is applicable to long and short wavelengths. The same aerial system can be employed for the simultaneous directional reception of a number of services.

IF we wish to provide facilities for many more wireless services we must devote our attention to the various types of interference which are encountered when transmitters are operated with their carrier waves close together. For some years I have made attempts to find methods of operating stations in this way, and various factors have had to be considered. With the normal type of amplitude modulated waves each transmission is associated with a band of frequencies, and it is the custom to reserve a definite band purely for one transmission. The modulation of carrier waves produces effects at other frequencies, which are called sidebands. Any attempt to operate more wireless services of this type thus implies that the sidebands of various services must overlap, and the problem of isolating merely the sidebands belonging to a desired transmission, without any disturbing effects from the sidebands of other transmissions which are in the same frequency band, has always appeared to make the solution of this problem very difficult, if not impossible. However, a solution of a practical nature is highly desirable.

I made a few preliminary attempts to provide satisfactory means for dealing with this problem, and suggested at first a frequency modulation method where the total frequency variation was very small.[1] However, frequency modulation involves a more complicated system of sidebands than amplitude modulation, and this method was not energetically pursued.

High Selectivity

My first step of a practical nature was more hopeful, and it was to increase the selectivity of receivers as far as possible. I gave demonstrations of the excellent properties of highly selective receivers in 1929, employing a quartz crystal to provide the selectivity. The name "Stenode" was given to a receiver of high selectivity with tone correction, and at an early stage it was discovered that, if two transmitters have their carrier frequencies brought comparatively close together so that a heterodyne whistle is obtained, the Stenode would enable us to receive and understand each programme with surprisingly little interference from the other. In fact, the chief interference was the heterodyne whistle, and to all intents and purposes modulation interference was eliminated.

This result was interesting, particularly in view of the fact that tone correction was employed to restore the desired programme to correct proportions. The interfering programme remained absent in spite of tone correction.

In discussing this result in the early stages, I drew attention to the phenomenon of detector demodulation,[2] pointing out that Beatty[3] and Butterworth[3] had already shown that a strong carrier would demodulate a weak carrier.

Since that date "High-selectivity tone-corrected circuits" have been investigated by the Radio Research Board, which issued a report on this subject, in 1932,[4] which proved clearly that such circuits do remove the interfering programmes, in spite of tone correction.

The Radio Research Report showed, however, that there are still certain forms of

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[1] British Patent 295957

[2] *Proc. Radio Club of America*, January, 1931, p. 7. *Radio News*, February and March, 1931.

[3] *Experimental Wireless*, June, 1928, p. 300; November, 1929, p. 619.

[4] *Radio Research Report*, No. 12.

interference to be dealt with, these being of a heterodyne type. In my paper in *Radio News* I had already pointed out that it was necessary to take special steps to remove heterodyne whistles between carrier waves.

We thus have the result that highly selective circuits remove certain forms of interstation interference, and thus they form a definite step in the progress towards the multiplication of services.

Let us examine the types of interference which are obtained if we operate with transmissions 1,000 cycles p.s. apart, each transmission being modulated up to 5,000 c.p.s.

When we tune to one carrier frequency by an ordinary (say a bandpass) receiver we shall receive the desired modulations with the following types of interference :

(*a*) Some or all of the interfering programmes.

(*b*) A series of heterodyne whistles produced by the interaction of the interfering carriers with the desired carrier.

(*c*) A series of whistles produced by the interaction of the interfering carriers amongst themselves.

(*d*) Inverted modulation effects from interfering stations produced by the interaction of the interfering sidebands and the desired carrier.

(*e*) A series of effects produced by interfering sidebands amongst themselves and with the various interfering carriers.

The interference is thus of a very complex and disturbing nature.

Now when the selectivity of the receiver is increased to the utmost, as in the case when a quartz crystal is employed, a number of these forms of interference automatically vanish, or are cut down to practical extinction, and the only forms of interference which remain, are those involving the desired carrier, viz. types *b* and *d*. In other words, we automatically eliminate three forms of disturbing interference. Now the quartz crystal at the same time produces a distortion of the desired signals, which is of a form which can be corrected by a low-frequency amplifier whose amplification is proportional to the frequency.

This correction does not restore the types of interference which were cut out, although it does restore the desired programmes and the types of interference *b* and *d*.

Thus, under such strenuous conditions, the use of high selectivity enables us to eliminate a number of forms of disturbing interference.

As already mentioned, the residual interference is really all of one type, i.e. heterodyne effects produced by interfering waves, whether carriers or sidebands, interacting with the desired carrier waves. The next step in the problem is thus to enable us to eliminate in a general manner any heterodyne effect which is produced by interaction of undesired waves with the desired carrier.

Before proceeding to show how heterodyne effects can be eliminated in a general manner, there is a point of interest in the difference between two types of heterodyne. In the first place, we have the well-known whistle which results from steady interfering waves such as an interfering carrier or an interfering sideband of a steady nature as regards frequency and amplitude. The second type results from sidebands of a varying nature which are associated with ordinary music and speech effects. The interference of this second type is now generally known as sideband splash. Owing to its variable nature, accurate measurements of splash are not easy. It is my opinion that such effects diminish in their disturbing influence as the selectivity improves, and that generally they are smaller than we expect from theoretical considerations.

However, this opinion is outside the scope of the present discussion, as there is no doubt that splash exists, no matter what its amplitude may be, and steps must be taken to remove it.

General Elimination of Heterodynes

There are certain points of resemblance between desired modulation and heterodynes. In the first place, both are produced by the interaction of two sets of waves of different frequencies. The desired modulation is produced at the receiver by the desired carrier and the desired sidebands. For the purposes of the present discussion it will be sufficient for us to assume that the desired effects are produced by a carrier and a single desired sideband. Both waves appear at the detector together, and as a result we obtain the desired modulation whose frequency is correct, and whose amplitude is proportional to the product of the amplitudes of the individual waves, viz. the carrier and the desired sideband.

Again, a heterodyne is produced by the interaction of two waves, one being the desired carrier and the other the interfering waves, and the frequency and amplitude of the heterodyne beat are obtained in a similar manner to the desired effect.

In order to distinguish between these two effects, some essential point of difference between them must be found. One such fundamental point of difference exists in the fact that usually the desired carrier and the desired sideband arrive at the receiver in the same direction, whilst in the case of the heterodyne the component waves—viz., the desired carrier and the interfering waves—usually arrive in different directions. Hence the problem resolves itself into the reception of desired effects whose component waves arrive in the same direction, excluding effects whose components arrive in different directions.

It will be shown below that if we employ two aerials at different points in space the desired signals will have the same acoustical phase for both aerials, provided the distance apart is not too large, whilst the heterodyne will have different acoustical phases for the two aerials. Hence, if we combine the rectified outputs from the two aerials the desired signals will add up arithmetically, whilst the heterodyne will add up vectorially. If we have a series of aerials arranged suitably, the desired signal strength will be proportional to the number of aerials, whilst the heterodyne will be cut down in strength. Actually the heterodyne can be made to be vanishingly small, no matter from what direction it may come, provided its direction differs from that of the desired waves by even a small angle.

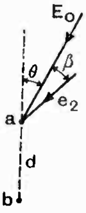

Fig. 1.

This will be made clear by reference to Fig. 1, where we have two aerials a and b separated by distance d. The desired waves E_0 arrive in a direction making an angle θ with line ab. The interfering waves e_2 arrive in a direction making an angle β with the desired signals. For simplicity, let the desired waves consist of a carrier and a single sideband

$$E_0 \sin \omega_0 t + e_1 \sin \overline{\omega_0 + p_1} t \quad .. \qquad .. \quad (1)$$

Let there be a single interfering carrier of form

$$e_2 \sin \overline{\omega_0 + p_2} t \quad .. \qquad .. \quad (2)$$

The high-frequency effects at the two aerials are as follows:—

$$(a) \;\; E_0 \sin \omega_0 t + e_1 \sin \overline{\omega_0 + p_1} t + e_2 \sin \overline{\omega_0 + p_2} t \quad .. \quad (3)$$

taking the time origin such as to have no phase difference for $t = 0$ at aerial a.

$$(b) \;\; E_0 \sin\left(\omega_0 t + \frac{2\pi d}{\lambda_0}\cos\theta\right) + e_1 \sin\left(\overline{\omega_0 + p_1} t + \frac{2\pi d}{\lambda_1}\cos\theta\right) + e_2 \sin\left(\overline{\omega_0 + p_2} t + \frac{2\pi d}{\lambda_2}\cos\overline{\beta + \theta}\right) \quad .. \quad (4)$$

The phase angles introduced at aerial b are $\frac{2\pi d}{\lambda_0}\cos\theta$ and $\frac{2\pi d}{\lambda_1}\cos\theta$ for the desired carrier and the desired sideband, and $\frac{2\pi d}{\lambda_2}\cos(\beta + \theta)$ for the interfering waves, where λ_0, λ_1, and λ_2 are the wavelengths corresponding to frequencies ω_0, $\overline{\omega_0 + p_1}$ and $\overline{\omega_0 + p_2}$.

Under the conditions that the modulation frequencies are small compared with the carrier frequency, and, further, that d is not too large, we can write $\lambda_0 = \lambda_1 = \lambda_2$. Then at aerial b we have

$$(b) \quad E_0 \sin\left(\omega_0 t + \frac{2\pi d}{\lambda}\cos\theta\right) + e_1 \sin\left(\overline{\omega_0 + p_1} t + \frac{2\pi d}{\lambda}\cos\theta\right) + e_2 \sin\left[\overline{\omega_0 + p_2} t + \frac{2\pi d}{\lambda}\cos(\beta + \theta)\right] \quad .. \quad (5)$$

When we rectify at each aerial we obtain,

$$(a) \;\; E_0 e_1 \cos p_1 t + E_0 e_2 \cos p_2 t \quad .. \qquad .. \quad (6)$$

$$(b) \;\; E_0 e_1 \cos p_1 t + E_0 e_2 \cos\left[p_2 t + \frac{2\pi d}{\lambda}(\cos\overline{\beta + \theta} - \cos\theta)\right] \quad .. \qquad .. \quad (7)$$

The desired signals are in phase whilst the heterodyne has different phases for the two aerials. For practical conditions this phase difference may have any value from zero to a very large angle. Thus, suppose $\theta = 0$, the phase difference is

$$\frac{2\pi d}{\lambda}(\cos\beta - 1),$$

and for $d = n\lambda$ this becomes

$$2n\pi(\cos\beta - 1).$$

Thus, suppose $n = 1$ (which means that the two aerials are one wavelength apart) and that $\beta = \pi$ (which means that the interfering waves travel in the opposite direction to the desired waves), the phase angle is -4π.

The heterodyne phase differences are thus of considerable values, whilst the desired signals are of the same phase at the two aerials.

The actual summation of the effects at the two aerials is effected after rectification, and hence we can employ a land line in order to effect the combination. The result is obtained from the expressions 6 and 7, and becomes,

$$2E_0e_1\cos p_1t + 2E_0e_2\cos\left[\frac{\pi d}{\lambda}(\cos\overline{\beta+\theta} - \cos\theta)\right]$$

$$\cos\left[p_2t + \frac{\pi d}{\lambda}(\cos\overline{\beta+\theta} - \cos\theta)\right] \quad .. \quad (8)$$

The amplitude of the heterodyne is

$$2E_0e_2\cos\left[\frac{\pi d}{\lambda}(\cos\overline{\beta+\theta} - \cos\theta)\right]$$

whilst that of the desired signals is $2E_0e_1$. The desired signal strength is thus independent of the direction of arrival of the desired signals. Further, it is independent of the distance apart of the aerials.

The heterodyne amplitude varies with a number of factors and depends on the distance between the aerials, and also on the angles θ, and $\beta + \theta$, as well as on the wavelength. Thus, for a given λ and a definite distance apart of the aerials d, the heterodyne will vanish whenever the directions of arrival determined by β and θ are such that

$$\frac{\pi d}{\lambda}(\cos\overline{\beta+\theta} - \cos\theta) = \pm\frac{\pi}{2}$$

or any odd multiple of $\pm\frac{\pi}{2}$. An examination of the amplitude of the heterodyne is interesting in so far as it shows that as the distance apart of the two aerials increases, the probability of having a particular heterodyne of zero value increases. In order to appreciate this point clearly we shall consider the simple case where the direction of the desired signals is in the line joining the two aerials. Then the heterodyne amplitude is

$$2E_0e_2\cos\left[\frac{\pi d}{\lambda}(\cos\beta - 1)\right].$$

The factor $\cos\frac{\pi d}{\lambda}(\cos\beta - 1)$ thus determines the amplitude of the heterodyne and shows how it depends on the distance between the aerials and on the angle between the desired and the interfering waves β.

If d is small, say $\frac{1}{50}\lambda$, the heterodyne is practically of the same value for all values of β, or for any direction of arrival of the interfering waves. This result is shown in curve a, Fig. 2, where the heterodyne amplitude is plotted against the angle β for various values of d.

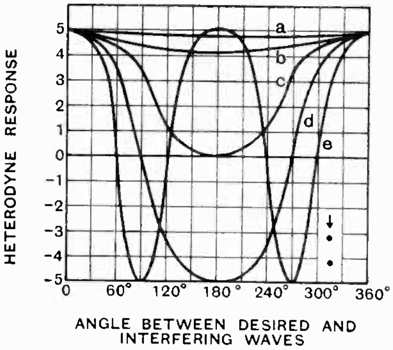

Fig. 2.—*Heterodyne amplitude for two aerials at different distances apart when the aerial effects are combined after rectification.*

Curve a, d = 0.02λ
,, *b, d* = 0.10λ
,, *c, d* = 0.25λ
,, *d, d* = 0.50λ
,, *e, d* = 1.00λ

If the aerials are placed farther apart but still in line with the desired signals and so that $d = \frac{1}{10}\lambda$, we begin to find that the heterodyne amplitude varies slightly with its direction. This result is given in curve b.

When the distance d is increased so that it is one-quarter of a wavelength, the result is shown in curve c, which shows that the heterodyne amplitude varies considerably with the direction of the interfering waves, being zero when the angle β is 180 deg.

When $d =$ half a wavelength, the heterodyne amplitude is shown by curve d, giving zero effects for 90 deg. and 270 deg. When d is a wavelength, we have zero amplitude for 60 deg., 120 deg., 240 deg. and 300 deg. (curve e).

Thus as the distance between the two aerials increases there are more and more directions of arrival of the interfering waves which will give zero heterodyne effect.

We can extend the simple conditions postulated above to the case of modulated interfering waves, in which case all component interfering waves arrive from the same direction so that all heterodyne effects from all interfering waves from the same source are eliminated simultaneously.

Thus for such a case we can employ high selectivity at each aerial to eliminate the interfering programmes, and we can then eliminate all interfering effects from that one source.

A number of practical methods for employing two aerials in this way can be suggested, such that the complete interfering effects from one or more sources can be eliminated. For instance, in case the distance d between the aerials is fixed, we can alter the relative phases of the acoustical effects of the two aerials before combination so as to guarantee that one or more interfering effects is reduced to zero.

Large Aerial Spacing

An assumption has been made that the modulation frequency is relatively low compared with the carrier frequency and, further, that the distance d is not too large. These assumptions allowed us to put $\lambda_0 = \lambda_1 = \lambda_2$. In case conditions are such that we are not warranted in making such an assumption, it is possible to introduce a correction to reduce the result to similar conclusions. We can obtain this result by rectifying the expressions 3 and 4 and summing them.

At aerial a, we obtain after rectification,

$$\text{(a)}\ E_0 e_1 \cos p_1 t + E_0 e_2 \cos p_2 t \quad \dots \quad \dots \quad (9)$$

$$\text{(b)}\ E_0 e_1 \cos\left[p_1 t + 2\pi d\left(\frac{\cos\theta}{\lambda_1} - \frac{\cos\theta}{\lambda_0}\right)\right] + E_0 e_2 \cos\left[p_2 t + 2\pi d\left(\frac{\cos\overline{\beta+\theta}}{\lambda_2} - \frac{\cos\theta}{\lambda_0}\right)\right] \quad \dots \quad \dots \quad (10)$$

Adding these effects gives us

$$2E_0 e_1 \cos\left[\pi d\left(\frac{\cos\theta}{\lambda_1} - \frac{\cos\theta}{\lambda_0}\right)\right] \cos\left[p_1 t + \pi d\left(\frac{\cos\theta}{\lambda_1} - \frac{\cos\theta}{\lambda_0}\right)\right] + 2E_0 e_2 \cos\left[\pi d\left(\frac{\cos\overline{\beta+\theta}}{\lambda_2} - \frac{\cos\theta}{\lambda_0}\right)\right] \cos\left[p_2 t + \pi d\left(\frac{\cos\overline{\beta+\theta}}{\lambda_2} - \frac{\cos\theta}{\lambda_0}\right)\right] \quad \dots \quad (11)$$

This shows that the amplitude both of the desired signal and of the heterodyne really depends on the various factors. The desired signal amplitude is controlled by $\cos \pi d\left(\frac{\cos\theta}{\lambda_1} - \frac{\cos\theta}{\lambda_0}\right)$.

If we write $\lambda_1 = \frac{c}{n_1}$ and $\lambda_0 = \frac{c}{n_0}$ where n_1 and n_0 are the frequencies corresponding to λ_1 and λ_2, the desired amplitude varies with

$$\cos\left[\frac{\pi d}{c}\cos\theta(n_1 - n_0)\right] = \cos\left(\frac{\pi N d}{c}\cos\theta\right) \quad (11\text{a})$$

where N is the modulation frequency.

It is at once apparent that we can write this as unity, unless N is very large, or unless d is large.

In a similar manner the heterodyne amplitude is controlled by

$$\cos\frac{\pi d}{c}\left[\overline{n_2 - n_0}\cos\theta + n_2(\cos\overline{\beta+\theta} - \cos\theta)\right]$$

the phase angle thus consisting of two parts $\frac{\pi d}{c}(N_2)\cos\theta$ where N_2 is the heterodyne frequency, and $\left[\frac{\pi d}{c} n_2(\cos\overline{\beta+\theta} - \cos\theta)\right]$.

Again obviously we can neglect the first part of this angle $\frac{\pi d}{c} N_2 \cos\theta$ unless N_2 or d are large.

There are cases where it will be advisable to take the correct phase angles into account, such as in the case of very large distance between the aerials, or in the case of television where the modulation frequency is high. In such cases it may be necessary to correct the phases of the desired signals before combination, but for the present we shall restrict the discussion to cases where we can put $\lambda_0 = \lambda_1 = \lambda_2$.

Multiple Aerials in Regular Formation

If we call the heterodyne phase difference between two aerials ϕ where

$$\frac{2\pi d}{\lambda}(\cos\overline{\beta + \theta} - \cos\theta) = \phi \quad \ldots \quad (12)$$

we can now employ a series of aerials in line all at distance d apart, and we obtain at the successive aerials (neglecting the constant E_0)

(a) $e_1 \cos p_1t + e_2 \cos p_2t$

(b) $e_1 \cos p_1t + e_2 \cos (p_2t + \phi)$

(c) $e_1 \cos p_1t + e_2 \cos (p_2t + 2\phi)$

(d) $e_1 \cos p_1t + e_1 \cos (p_2t + 3\phi) \quad \ldots \quad (13)$

and so on.

The summation for n aerials is

$$ne_1 \cos p_1t + e_2 \cos\left(p_2t + \frac{n-1}{2}\phi\right)\frac{\sin\frac{n}{2}\phi}{\sin\frac{\phi}{2}} \quad (14)$$

The amplitude for the desired signals is ne_1 thus being proportional to the number of aerials. The amplitude for the heterodyne is

$$k = e_2\frac{\sin\frac{n}{2}\phi}{\sin\frac{\phi}{2}} \quad \ldots \quad \ldots \quad (15)$$

which can be made vanishingly small, its form being the same as that obtained in the diffraction theory in optics, and again in beam wireless.

This discussion is perfectly general and applies to the case of normal modulation where there are many desired sidebands, and also to the case where there are many interfering heterodynes arriving from various directions. It provides thus a means of eliminating in a general manner any heterodyne effect which may be present. Thus a combination of highly selective receivers with multiple aerials provides a solution to the problem of the elimination of all inter-station interference even when the carrier waves are close together.

A very interesting fact at once becomes obvious, that such a linear formation of aerials will give these effects almost independently of the direction of arrival of the desired signals. This means that whilst the aerial system is directional as regards interfering signals, the desired signals may arrive in any direction. There is thus no need to erect a special system of aerials for special signals, and we can use such a system for waves arriving in any direction whatsoever. With one such aerial system we can tune all the aerials to one desired transmission, and obtain the desired effect of eliminating interference from all stations in the same sideband region, provided that these interfering stations arrive in a direction which differs from that of the desired waves by a small angle. If we wish to receive signals from another source, we must tune the aerial system to the waves from that source, when similar results will be obtained. There are, naturally, limiting conditions for the closeness of the frequencies of two transmitters, these being determined by the selectivity of the receivers.

As regards the directional efficiency for eliminating heterodyne interference, this is given by the factor

$$e_2\frac{\sin\frac{n}{2}\phi}{\sin\frac{\phi}{2}}$$

where $\phi = \frac{2\pi d}{\lambda}(\cos\overline{\beta + \theta} - \cos\theta)$.

This factor enables us to determine the magnitude of the angle β in order to guarantee the elimination of heterodynes. In order to make β as small as possible, we should make the number of aerials as large as possible, and in fact the efficiency of the system depends on the maximum width of the aerial system, just as in the case of a diffraction grating or a beam system.

Aerial arrays of different form can be employed, just as in the case of beams. The aerials can be arranged in linear formation, in rows of aerials or in circular formation. The principles for designing such aerial arrays are practically identical with those for beam transmission and thus there is no necessity here to discuss them in any detail.

Simultaneous Reception of Various Services

An aerial array with rectification at each aerial and with the low frequency combination of the effects can, as already described, be employed for the reception of desired waves from any direction. Thus for the reception of the signals for one service we can employ a landline which connects all the aerials to a central point.

If we employ a second landline to connect the aerials to the central point, we can simultaneously employ the aerial array for receiving two services. In this case we would tune each aerial to the second service, and if the selectivity employed is of a high order there should be little difficulty in employing each aerial with two selective devices tuned respectively to the two services, and with two rectifiers. At each aerial the effects are applied to the corresponding landline.

In the same way we can receive a number of services on the same aerial array, by employing one landline per service, and one selective device and one rectifier per aerial per service. This may at first glance appear to be a costly procedure, but closer consideration will show that it is not exceedingly costly, particularly when the result to be obtained is so free from interference.

One such aerial array becomes more efficient as the maximum dimensions are increased. With low frequency combination of aerials, there seems to be no reason why the maximum dimensions should not be exceedingly large. For instance, the aerials could extend from London to Edinburgh if necessary, particularly as landlines are already in existence for connecting the aerial effects. Under circumstances such as these, or even for much smaller spacing, multi-cored landlines can be employed for various services. It would further be necessary to bring the desired signals into phase before combination, as already indicated in Equation 11a.

An aerial system whose directional efficiency is of the order of 1 deg., must necessarily have large maximum dimensions, and undoubtedly the chief expenditure in such an installation is involved in the aerial system. With such an efficient aerial system, the added expenditure of providing one receiver per aerial per service, and further of providing a multi-cored instead of a single-cored landline would appear to be of small proportion.

A convenient method for obtaining the selectivity required at each aerial for each service is to employ quartz crystals. Thus if we have 100 aerials, we can employ 100 quartz crystals each cut to the same frequency, one crystal per aerial.

For a second service we would further need a second series of 100 crystals cut to the second desired frequency. If the crystals are cut in large numbers it will be comparatively easy to choose a number of crystals of almost identical frequency. Actually from practical consideration it would be preferable to use two or three crystals in parallel as a quartz unit, each of slightly different frequency to give a narrow bandpass crystal receiver in each case. As regards the cost of such large numbers of crystals, it is to be remembered that in such production the price per crystal will fall, and further, the selectivity is so high that little or no extra tuning devices will be required. In fact, employing two or three quartz crystals to give a narrow bandpass effect gives us the means for avoiding frequency variations at the transmitter, whilst at the same time it provides a means of producing each crystal cheaply. It is quite possible that such crystals will provide a very cheap method of reception for commercial services. In the case of aerial arrays with quartz crystal reception, tone correction can if necessary be employed at each aerial or once for all at the central point.

Long or Short Waves

The preceding discussion on the combination of the low frequency effects of a number of aerials is quite general, and applies to waves of any wavelength, whether short or long. It is not my object to enter into the merits of various wavelengths for communication purposes, as both long and short waves have their own peculiar advantages and disadvantages. My object is to show how all forms of interstation interference can be eliminated whether long or short waves are employed. My proposals are to employ high selectivity and the highest possible directional efficiency, and the latter can only be obtained by having the maximum dimensions of the aerial array as large as possible, when measured in the number of wavelengths. Hence to obtain high efficiency for short waves, the dimensions need not be very large. However for long waves of the order of 5,000 metres, in order to obtain high directional efficiency, the maximum spacing of the extreme aerials should be many miles. With this system of low frequency combination of aerial effects, it is possible to have an aerial system extending over very large distances indeed, so that it becomes a possibility to introduce very high directional efficiency into long wave communication. Incidentally such a highly directional system should cut down atmospheric disturbances, as these are usually directional.

Comparison of Low Frequency and High Frequency Aerial Combination

It is known that aerial arrays have already been employed for the reception of long waves, where the effects are combined at high frequency. In fact, the G.P.O. uses such high frequency combination.[1] This present proposal to combine the effects of aerials at low frequency instead of at high frequency should have pronounced advantages. In the first place, it appears to be much easier to obtain high directional efficiency by using low frequency combination, as the maximum aerial spacing can be increased as far as desired. On the other hand, there would appear to be serious practical difficulties in extending an aerial system when the effects have to be combined at high frequency. With low frequency combination, ordinary landlines can be used, which can be buried if desired, and they can be of very great length without introducing any difficulties, particularly as landline technique, including adjustment of phase, is well established, and comparatively easy to apply.

The high frequency combination of aerials which are separated by a long distance would introduce numerous difficulties, such as the possibility of the connecting wires acting as aerials.

There is another feature where low frequency combination appears to have outstanding advantages, and this is that the directional discrimination is effective only against the interfering waves, so that the array can be erected with little regard to the direction of desired signals. Once erected, the array can be employed for waves from any direction merely by tuning the system to the desired waves. With high frequency combination, the direction of maximum reception can of course be changed, but merely by changing the high frequency phases from the separate aerials in a suitable fashion. Thus low frequency combination would appear to have more flexibility than high frequency combination.

There is still another advantage of low frequency combination in that one aerial array can be employed for the simultaneous reception in a directional manner of a number of services.

On the other hand, it might be objected that the low frequency combination might have certain disadvantages. One which has been suggested to me is that there might be inequalities in the operation of rectifiers at the various aerials. Such a possible contingency does not appear to contain any serious difficulty, as all that such variation would effect of a serious nature would be the change of amplitude from the particular aerials. Naturally this point does introduce some difficulty, but if we have a large number of aerials, the statistical effect would tend to minimise errors due to such possible amplitude variations. On the most important feature that of the relative phase difference of heterodynes at different aerials, differences in detectors cannot have any effect, as the acoustical phase is independent of whether linear or square law or any other form of rectification is employed.

For short waves, it is naturally easier than for long waves to obtain high directional efficiency by high frequency combination of aerials, because the maximum dimensions are not very large. However, here again it would appear preferable to use very large spacing and thus low frequency combination, as high directional efficiency is obtained against the interfering effects, and it is immaterial as regards the desired signals whether the aerials are widely spaced or the reverse. The maximum directional efficiency against interference is always desirable. From the point of view of flexibility and of the use of one aerial array for a number of services, again low frequency combination appears to have advantages for short waves.

I do not suggest that high frequency combination of aerials should be immediately

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[1] *Proc. I.E.E.* (Wireless Section), 1928, p. 11.

abolished, and in fact there are many cases where both the high and the low frequency combination might usefully be employed together. For instance, with low frequency combination, the unit aerial may be a simple plain aerial without any directional properties. Again, it might be a simple loop, a combination of loops, or a combination of aerials at high frequency. In fact, the unit aerial might have any desired directional properties.

However, in case an aerial array is required to be used for a number of services which arrive from different directions, it would be preferable to make the unit aerial completely non-directional.

Applications

A system of wireless reception is thus put forward wherein all forms of interstation interference can be eliminated. This involves two distinct processes—first, the use of high selectivity to remove the type of interference represented by the interfering programmes, and next the combination of aerials to eliminate heterodyne effects. There are various fields of application of wireless, including commercial telephony and telegraphy, marine wireless communication, and broadcasting. Again, the application of television may soon be of importance.

In its fullest application, the present proposals would be of use in commercial telephony and telegraphy. However, before carrying the application to the utmost, desirable results can be obtained by comparatively simple aerial arrays with high selectivity at each aerial. A useful basis for such application is a quartz crystal receiver. This alone on a single plain aerial already eliminates a considerable amount of interference. As a unit receiver the quartz crystal cuts out the interfering programmes, and in addition it has other valuable features. One of these is that by employing a balancing condenser,[1] the resonance curve can be made asymmetrical so that one sideband is depressed. This receiver alone thus cuts down already any heterodyne effects on one side of the carrier wave. This advantage can be obtained on either side of the carrier at will, and thus we have a means for cutting down sideband splash, which is a highly desirable result particularly in broadcasting.

Again, from the general point of view, some commercial communication systems already eliminate the carrier and one sideband in transmission. The quartz crystal receiver would be a very useful receiver for such a transmission system, particularly if a small percentage of the original carrier is transmitted. Under such conditions, the high selectivity of the crystal would increase the small carrier component to relatively large amounts in comparison with the sidebands.

With a quartz receiver we can eliminate heterodyne effects on one side of the carrier. A very simple directional system will give us the means of eliminating one heterodyne effect on the other side of the carrier. Thus a simple loop with a quartz receiver will enable us to eliminate sideband splash from both sides of the carrier wave, in such cases as the broadcasting zone. For broadcasting this again is a desirable result. For marine purposes, for the central receiving station of radio relay services, and again for a number of commercial communication services, such a simple receiver would be very useful.

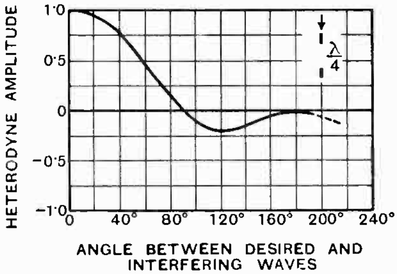

Fig. 3.—*Two loops in line of signals* $\frac{\lambda}{4}$ *apart.*

A stage in advance can be obtained by employing two plain aerials or two loops at some distance apart. Again, useful effects can be obtained with three aerials and so on.

It will be useful to give the results to be obtained by a few simple cases, which are subject of easy calculation.

Case 1.—Two aerials in the line of the desired signals at various distances apart. These cases have already been described (see Fig. 2). A case of special interest is

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[1] *Radio News*, Feb. 1931. *Radio Research Report*, No. 12.

curve c for the aerials $\frac{\lambda}{4}$ apart. This gives us zero heterodyne for interfering signals travelling in the opposite direction to the desired signals.

Case 2.—Two loop aerials with the planes of the loops, and the line joining them in the direction of the desired signals, the distance apart being $\frac{\lambda}{4}$. The result is shown in Fig. 3. The heterodyne amplitude is given by

$$\cos\left[\frac{\pi}{4}(\cos\beta - 1)\right]$$

for two plain aerials, and thus by

$$\cos\beta \, . \left[\cos\frac{\pi}{4}(\cos\beta - 1)\right]$$

for two loops.

In this case again the heterodynes in one semicircle are all cut down to low values.

Case 3.—Four open aerials, arranged at the corner of a rectangle, the sides being $\frac{\lambda}{4}$ and $\frac{\lambda}{2}$, the direction of the desired signals being that of the shorter side of the rectangle. The amplitude of the heterodyne is given by

$$\left[\cos\frac{\pi}{4}(\cos\beta - 1)\right] . \left[\cos\left(\frac{\pi}{2}\sin\beta\right)\right].$$

and the result is shown in Fig. 4.

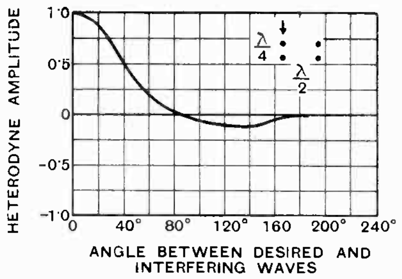

Fig. 4.—*Four open aerials at corners of a rectangle* $\frac{\lambda}{4}$ *by* $\frac{\lambda}{2}$.

Case 4.—Four open aerials in line and in the direction of the desired signals, the distance apart of the aerials being $\frac{\lambda}{4}$. The heterodyne amplitude is given by

$$\left[\cos\frac{\pi}{4}(\cos\beta - 1)\right] . \left[\cos\frac{\pi}{2}(\cos\beta - 1)\right]$$

and the result is given in Fig. 5.

Case 5.—This case is introduced to show in particular the advantage of having the aerial array as symmetrical as possible for different angles of incidence of the desired signals. This is a case of four rows of aerials, the aerials in each row being $\frac{\lambda}{4}$ apart, and the rows also $\frac{\lambda}{4}$ apart. The heterodyne amplitude is given by

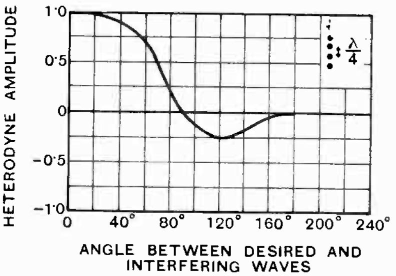

Fig. 5.—*Four open aerials* $\frac{\lambda}{4}$ *apart in line of desired signals.*

$$\left[\cos\frac{\pi}{4}(\cos\beta - 1)\right] . \left[\cos\frac{\pi}{2}(\cos\beta - 1)\right]$$
$$\left[\cos\frac{\pi}{4}\sin\beta\right]\left[\cos\frac{\pi}{2}\sin\beta\right]$$

and the result is given in Fig. 6.

The heterodyne curve is the same in the two cases for the desired signals along either side of the square.

For the utmost symmetry it would probably be preferable to arrange the aerials around the circumference of a circle, or in a series of concentric circles, but the calculation of the result in this case is not by any means simple.

Examples of such cases which are easy to calculate can be extended very considerably. It will be sufficient at present to consider the cases of 32 aerials arranged in a special manner, and to show the directional efficiency for two different angles of incidence of the desired signals.

Case 6.—Case of 32 aerials arranged in two rows of 16 aerials, the rows being $\frac{\lambda}{4}$ apart, and the spacing of the aerials in each row being $\frac{\lambda}{4}$.

For the case of the desired signals along the rows, the result is given in Fig. 7 (curve *A*), and for the case of the desired signals normal to the two rows, the result is given in Fig. 7 (curve *B*). The efficiency for both cases is quite good.

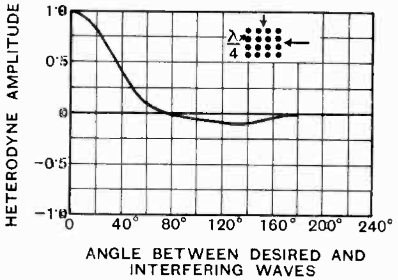

Fig. 6.—*Sixteen aerials in square formation, spacing of the aerials being* $\frac{\lambda}{4}$.

So far no reference has been made to the influence of fading conditions. For instance, for the shorter waves, the waves often arrive at an angle to the horizontal. This naturally will influence the general result, particularly in the case of arrays of very few aerials. Again, for arrays of a large number of aerials, the calculated result will be modified by this effect, but its influence will diminish as the number of aerials increases.

There are many other points of interest, such as the fact that if we wish to eliminate one particular interference with two aerials, we can fix the site of one aerial when there is an infinite number of positions for the second aerial which will satisfy these conditions, these positions lying on loci which make

$$\cos\left[\frac{\pi d}{\lambda}(\cos\overline{\beta+\theta}-\cos\theta)\right]=0.$$

Sufficient has been described for the present however to show that when highly selective circuits are employed, the only remaining interference to be eliminated is of the heterodyne type, and by employing a combination of aerials with highly selective reception at each, all interstation interference can be eliminated, and further, so long as the interference in any case emanates from only a few sources, the aerial array can be of a comparatively simple nature.

Summary

1.—A highly selective receiver eliminates interference of the type of the interfering programmes, even when carrier waves are brought close together. A special form of selective receiver, using a quartz crystal, eliminates in addition the heterodyne effects, including sideband splash on either side of the carrier at will.

2.—Employing two aerials and two receivers at different points in space gives the desired signals in the same acoustical phase, whilst the heterodyne effects are usually of different phase.

3.—Employing a series of aerials in regular formation and combining the rectified effects gives the desired signals with amplitude proportional to the number of aerials, whilst heterodyne effects tend to become eliminated owing to the varying phase differences from different aerials.

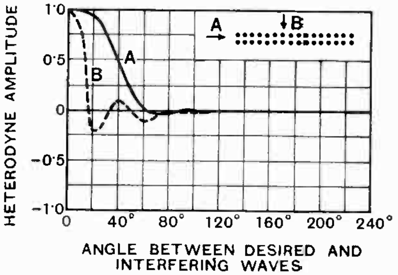

Fig. 7.—*Thirty-two aerials in two rows* $\frac{\lambda}{4}$ *apart, the aerials being* $\frac{\lambda}{4}$ *apart—for incidence of desired signals along the line of aerials (curve A), and for incidence perpendicular to line of aerials (curve B).*

4.—Such a series of aerials gives a maximum direction of reception which agrees in all cases with that of the desired signals. Hence the same aerial system can be used to receive directionally for different services.

5.—One aerial system can be employed for the simultaneous reception in a directional manner of various services.

Superimposed D.C. and A.C. in Iron-cored Transformers and Chokes*

Investigations with a Cathode Ray Oscillograph

By C. R. Cosens, M.A.

IT is well known that the behaviour of an iron-cored transformer or choke is seriously affected by direct current in the windings.† Calculation of results is only approximate; experiment is tedious on account of the number of readings which have to be taken due to the large number of variables (D.C. current, amplitude of A.C., etc.) when the usual methods are adopted. But it has been found that by means of a cathode ray oscillograph a transformer may be made to draw its own B-H or hysteresis loop (as well as current and voltage curves on a time base).

While photographs of the resultant pictures on the oscillograph screen can be enlarged and measured up with an accuracy of two or three per cent., it must be admitted that the method does not give "N.P.L. accuracy"; none the less, the results are quite sufficiently accurate for any ordinary purpose, especially as apparently identical cores give measurably different results. The saving of time is obvious, the whole of the photographs taken for the illustrations to this paper were exposed in less than 20 minutes, plotting the curves "by hand" would have taken days. Furthermore, the effects of gradual changes can be seen, for example, the D.C. current can be increased slowly and photographs taken of such of the resultant curves as show sufficient differences to be worth noting.

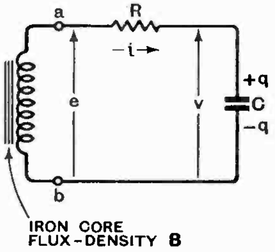

Fig. 1.

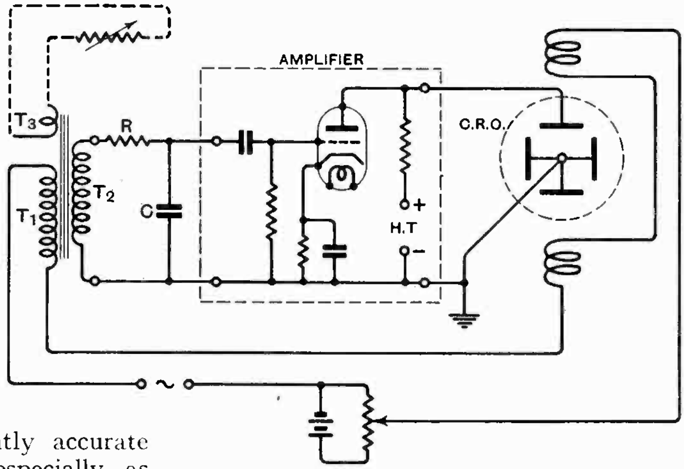

Fig. 2.

The method of obtaining the hysteresis loop depends on the fact that if to a, b, Fig. 1, the terminals of the secondary of a transformer, we connect in series a resistance R and a capacity C (such that at the lowest frequency we are interested in, the impedance of C is small compared to that of R), then the potential difference v across C will be proportional to the time-integral of e, or $\int e dt$, where e is the transformer secondary emf; that is to say, v will be proportional to the flux-density producing e.

At 50 frequency supply, convenient values are $R = \frac{1}{2}\text{M}\Omega$, $C = 2\mu\text{F}$

Then (Fig. 1)

$$e = v + Ri = v + R\frac{dq}{dt} = v + RC\frac{dv}{dt} \quad \ldots \quad (1)$$

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* MS. accepted by the Editor, July, 1934.

† See bibliography

If $v = V \sin 2\pi ft$, $RC\dfrac{dv}{dt} = (\frac{1}{2} \times 10^6) \times (2 \times 10^{-6})$

$$\times\ 2\pi \times 50V \cos 2\pi ft = 100\ \pi V \cos 2\pi ft$$

and if we ignore v compared to $RC\dfrac{dv}{dt}$, we incur a scale error of 1 in $(100\ \pi)^2$ and a phase-angle error of $\dfrac{1}{100\pi}$ radians, or about 0.2 deg.

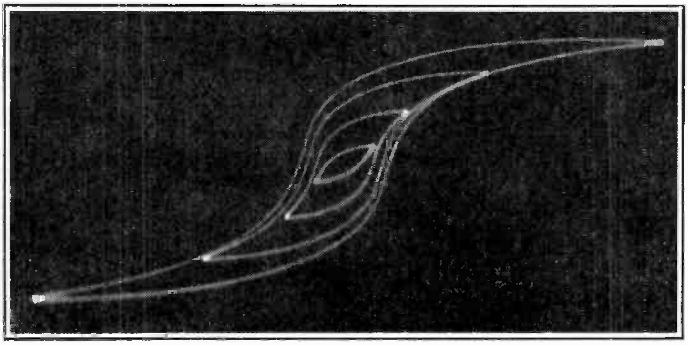

Fig. 3.

Higher harmonics will of course introduce even less error.

Hence it is sufficiently accurate to write for [1] :—

$$e = RC\frac{dv}{dt} \text{ or } v = \frac{1}{RC}\int e dt \quad .. \quad (2)$$

If the transformer secondary have T turns on a core A sq. cm. section, and if B be the flux-density in the core, $e = TA\dfrac{dB}{dt}$,

$\therefore\ \int e dt = TAB.$

$$\therefore [2] \text{ gives } v = \frac{TA}{RC} \times B \quad .. \quad .. \quad (3)$$

With e of the order of 100 volts, v will be too small to apply directly to the oscillograph, but a single-valve amplifier, as shown in the complete diagram of connections in Fig. 1, will give sufficient deflection.

If I be the value of the magnetising current in the primary winding of T_1 turns and l the length of the mean path of the magnetic flux :—

$$H = \frac{4\pi T_1}{10l} \times I^* \quad .. \quad .. \quad (4)$$

and we have merely to provide a deflection perpendicular to the B deflection, and proportional to I. This can be done either by putting a low resistance in series with the transformer primary and amplifying the drop across this with another amplifier ; or, more simply, we may pass the primary current through a pair of deflecting coils placed opposite the neck of the tube, as shown diagrammatically in Fig. 2.

The spot on the screen will then describe a curve whose coordinates are proportional to B and H respectively.

The scale for H can be determined by noting the deflection of the spot produced by a measured current in the primary, and using equation (4), taking maximum values for H and I.

Similarly the value of $B_{\text{max.}}$ producing a given deflection of the spot can be found by a measurement of the voltage applied to the primary, say of RMS value V_1

$$\text{since } V_1 = 10^{-8} \times 4.44\, nT_1 A \times B_{\text{max.}} \quad .. \quad (5)$$

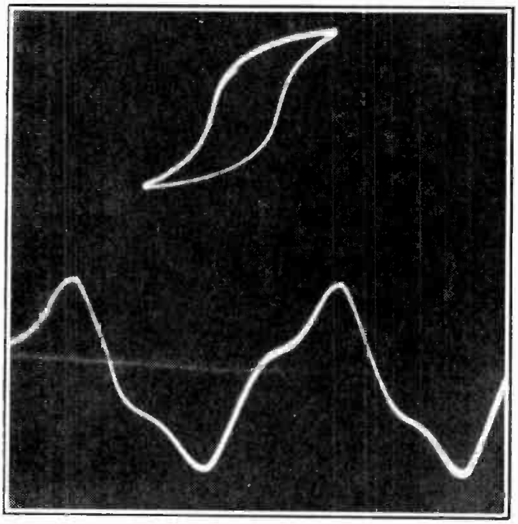

Fig. 4.

To study the effect of D.C. superimposed on A.C., the arrangement shown in Fig. 2 can be used. A low-resistance potential divider fed from a couple of secondary cells

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* This assumes that the flux-path is entirely in iron, with no air-gap, as do the usual ballistic methods.

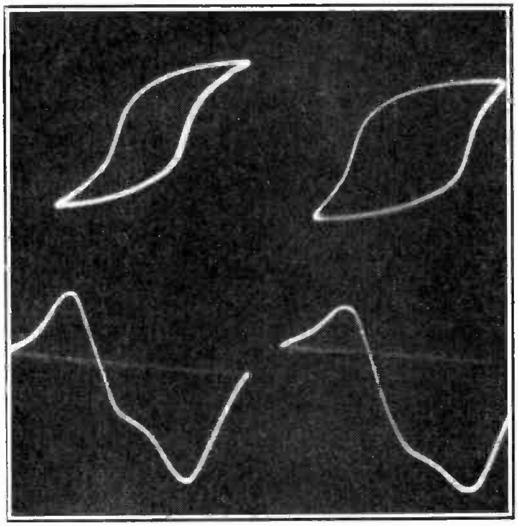

Fig. 5.

is placed in series with the A.C. supply. The D.C. cannot be passed through an additional winding on the transformer, as this would provide in effect a short-circuited secondary.

The dotted circuit represents an extra winding T_3 of a few turns, which can be joined to an adjustable resistance, thereby simulating the effects of eddy currents.

By removing the "B deflection" from the oscillograph plate, and substituting some form of linear time-base, the curve of current against time may be displayed. It is then usually desirable that B and e.m.f. should be practically sinusoidal. This will only be the case if the supply voltage is sinusoidal, and the resistances in circuit are of low impedance compared to the primary reactance. It is for this reason that the potential divider for D.C. supply was specified to be of low resistance.

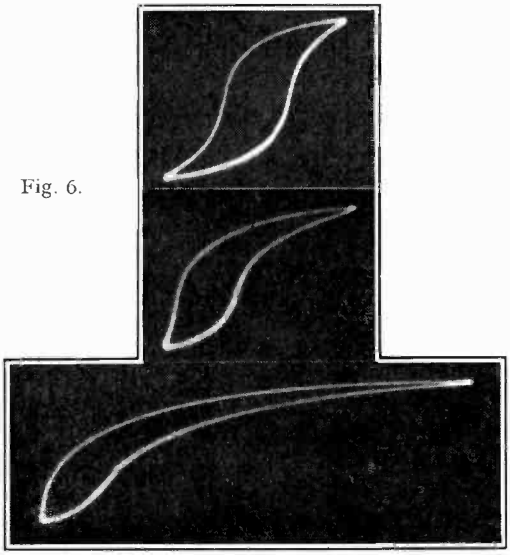

Fig. 6.

Photographs of a few curves obtained in this way from a laminated Stalloy core of about 6 cm² section are shown in Figs. 3 to 7, all at 50 ∼.

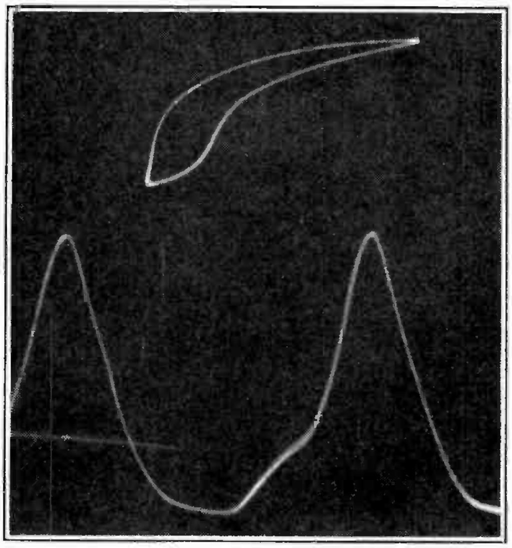

Fig. 7.

Fig. 3 shows four superimposed hysteresis curves (obtained by four successive exposures on the same plate) $B_{\max.} = 1{,}600$; 5,000; 8,000; 11,000 lines per sq. cm.; approx. H scale 1 cm. = 1 c.g.s. unit.

Fig. 4 shows the hysteresis curve and current-time curve, $B_{\max.} = 6{,}500$.

Fig. 5 as Fig. 4, but right-hand curves with added "artificial eddy currents" (see above). (All above with no D.C.)

Fig. 6. $B_{\max.} = 6{,}500$ due to A.C. only; D.C. superimposed to give mean H of 0, 2, and 4 units.

Fig. 7. $B_{\max.} = 6{,}500$ due to A.C. only; D.C. superimposed to give mean H of 3 units; hysteresis curve, and (below) current-time curve with sinusoidal B.

The last two are instructive, showing how "effective inductance," proportional to dB/dH, varies through the cycle, and is much reduced by the presence of D.C.

Photographic data.—Cossor Type A tube; Gun. 800 v. 32μA. Exposure $\frac{1}{2}$ sec. at F_4, Ilford Golden Iso Zenith plate. Image on negative $\frac{3}{4}$ size of that on tube.

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Book Review

Bessel Functions for Engineers

By N. W. McLachlan. pp. xii + 192. Published by Oxford University Press, Warwick Square, London, E.C.4. 15s. net. 1934.

This book is the fourth volume in the Oxford Engineering Science Series; and those who have followed his work in recent years, particularly on the theory and performance of loud speakers, will be little surprised to find Dr. McLachlan turning his attention now to a text-book on the Bessel Function analysis designed specially for the needs of the engineering scientist. The book should be assured of a welcome, if on one score alone: it has been too long a reproach to British engineering science that so little provision has been made for the mathematical education of the student beyond the bare elements of the Calculus. In other countries, and particularly in Germany—where the names of Runge, Krause, Mehmke, Schafheitlin, to mention but a few, have long been familiar as outstanding exponents of teaching and writing clearly and concisely on higher mathematical topics for the technician—progress has been much more rapid; yet of late years signs have not been wanting of an awakening in this respect as regards publications in English, and specialised texts on Differential Equations for the engineer in general, on Differential Equations concerned with the particular problems of line telephony, on Probability and Statistics in engineering, on Tensor Analysis applied to electromagnetic problems, and so forth, have been making regular appearances.

Dr. McLachlan carries on this excellent work by the treatise now under review, and the result is eminently satisfactory. The engineer whose training has been restricted to the usual theoretical course, need not be scared off by the unfamiliar title. The author makes the daring claims that his treatment of the subject is simple yet rigorous enough for engineers, and that no prior knowledge beyond that which should be obtainable in an engineering degree course is required; and the reviewer (highly sceptical at first) finds himself disposed to agree that the claims have, in the essentials, been borne out.

It is very probable that, largely in consequence, the book may come in for some vigorous handling from reviewers whose interests centre mainly in the purely mathematical aspect, and its rigid treatment: when the author, out of regard for the class of readers he desires to attract, denies himself the use of contour integration, of the Heaviside operators, etc., there are bound to be gaps impossible to fill satisfactorily, and passages where the discussion is lengthy and laborious; and the occasional doubtful rigour of proof, and the excision of many parts of the theory usually regarded as essential, will no doubt excite the strong criticism of the pure mathematician, but the author may well accept that with equanimity. He has produced a book which will meet the needs of the public he addresses himself to, a public which will not resent an occasional omission or assumption (especially when the assumption is candidly stated), provided the analytical applications to practical, and modern, problems are clearly set forth.

And this is probably the chief merit of Dr. McLachlan's book—that it is "live" from start to finish. The reader obtains the strong impression that the study which it embodies was forced upon him by his own realised needs. There can be no better evidence of this than the large amount of space in the text occupied by direct practical applications of the theory, as it develops, to problems in acoustics, vibrations mechanical and electrical, design of loud-speaker horns, electrical transmission lines, resistance of conductors to A.C.'s, and many others. Also in this connection should be mentioned the exceptionally generous collection of examples for practice, between 500 and 600 in all: this is a quite invaluable feature of a book of the kind, and one in which the typical German *Lehrbuch* is lamentably deficient. Many of these examples are distinctly heavy; but the reasonable reader will make a judicious selection to suit himself. We have worked through a considerable number and lighted on no errors—a testimony to the care in the compilation and checking.

Within the limits of a short review it would be impossible to detail the contents of the book, chapter by chapter: it would however be equally unfair to pass over without mention Chapter VIII, where a simplified analysis has been applied to the Kelvin ber and bei, and to the ker and kei functions. It is not too much to say that this marks a distinct and original advance in the compact discussion of these functions.

Lastly, the book has an excellent index, and a useful bibliography, though it is surprising to note such omissions from the latter as the series of memoirs by Dr. John Dougall on the theory of vibrations in isotropic elastic plates, the treatise on Bessel Functions by Schafheitlin, and that by Professor H. M. Macdonald on Electric Waves. There are also some eleven pages of short tables, with ample references to sources where more extended tables are available, and a sixteen-page collection of formulae.

The typography and the reproduction of the many diagrams are in accordance with the high standard of the Oxford University Press; and we commend the book cordially to the notice, and the use, of technical readers.

Whistling Notes in Superheterodyne Receivers*

By Dr. M. J. O. Strutt

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Contents.

I. Whistling Notes Caused by One Single Input Signal

ASSUMING the first detector to be the generator of the whistling notes, which comes to assuming a perfect i.f. filter circuit, the action of superheterodyne receivers is briefly this: An input signal $E_i \sin \omega_i t$ is put on the input grid of the first detector. An auxiliary voltage $E_h \sin \omega_h t$ is also put on the first detector. Then, in the anode circuit of this detector there will be a current component $i_0 \cos \omega_0 t$, where

$$\omega_0 = |\omega_h - \omega_i| \quad \ldots \quad \ldots \quad (1)$$

By the i.f. filter circuit between first detector and i.f. amplifier only the angular frequency ω_0 is passed. A voltage of this frequency comes to the second detector and is then rectified. Now, assuming the tuned circuits before the first detector sufficiently perfect as to admit only an input voltage of frequency ω_i on the input grid of the first detector, we investigate the question: For what relative values of ω_i and ω_0 may whistling notes be heard after the second detector of the ideal receiver just described?

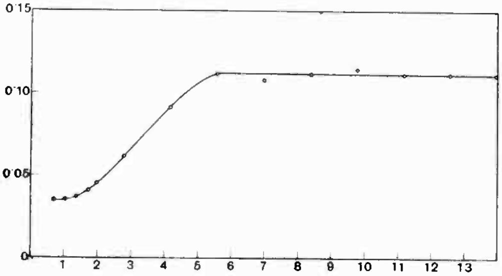

Fig. 1.—*Vertical axis: Ratio F_{nm}/S_e for $n = 2$ and $m = 1$ expressed in reciprocal volts. Horizontal axis: Oscillator volts peak value on input grid. Tube: h.f. pentode Philips type AF 2.*

The cause of such whistling notes must obviously reside in frequencies, little different from ω_0, passed by the i.f. filter and coming on the second detector together with ω_0 itself. The difference note is then heard after the second detector. Such spurious frequencies $\omega_0 \pm \delta$ where δ is a few thousand c/s at most, may arise from combinations of overtones $n\omega_i$ with harmonics $m\omega_h$, thus:

$$\pm m\omega_h \pm n\omega_i = \omega_0 \pm \delta \quad \ldots \quad (2)$$

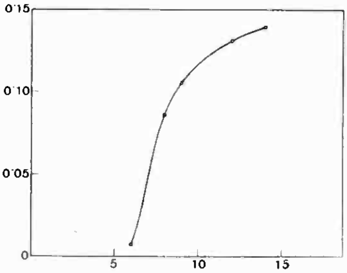

Fig. 2.—*Vertical axis as in Fig. 1. Horizontal axis: Oscillator volts effective value on oscillator (i.e., first) grid. Tube: Octode Philips type AK 1.*

By the equations (1) and (2) the relative values of ω_0 and ω_i at which such spurious frequencies arise are fully determined. Assuming the usual situation in receivers, that $\omega_h > \omega_i$, one finds

$$\omega_h = \omega_i + \omega_0.$$

Equation (2) gives rise to the following possibilities:

$$m\omega_h - n\omega_i = \omega_0 \quad \ldots \quad \ldots \quad (2a)$$

$$-m\omega_h + n\omega_i = \omega_0 \quad \ldots \quad \ldots \quad (2b)$$

$$m\omega_h + n\omega_i = \omega_0 \quad \ldots \quad \ldots \quad (2c)$$

leading to:

$$\left.\begin{aligned} \frac{\omega_0}{\omega_i} &= \frac{m - n}{1 - m} \\ \text{or} \quad \frac{\omega_0}{\omega_i} &= \frac{n - m}{1 + m} \\ \text{or} \quad \frac{\omega_0}{\omega_i} &= \frac{m + n}{1 - m} \end{aligned}\right\} \quad \ldots \quad \ldots \quad (3)$$

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* MS. accepted by the Editor, November, 1934.

In these equations m and n are whole numbers, 0, 1, 2, 3, etc. Of course, the quotient ω_0/ω_i is subject to the condition of being positive, which puts a restriction on the choice of m and n. Thus, if $m \geqq 1$, we have always $n > m$. Some values of ω_0/ω_i, depending on m and n are computed in the following table :

$\frac{\omega_0}{\omega_i}$ ..	3	3	$\frac{5}{2}$	2	2	$\frac{5}{3}$	$\frac{3}{2}$	$\frac{4}{3}$	1	1	1	$\frac{3}{4}$	$\frac{2}{3}$	$\frac{3}{5}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{2}{5}$	$\frac{1}{3}$	$\frac{1}{3}$
n ..	3	7	6	2	5	7	4	6	1	5	7	6	4	7	2	5	6	3	7
m ..	0	1	1	0	1	2	1	2	0	2	3	3	2	4	1	3	4	2	5

In quite the same way the case of $\omega_h < \omega_i$, which is less usual in receivers, may be dealt with.

II. Whistling Notes Caused by Several Simultaneous Input Signals

If the mixer tube has no amplification stage before it and rather poor tuned input circuits, or even aperiodic antenna coupling, one or more unwanted signal frequencies, besides the wanted one, may come on the input grid. Calling again the wanted input signal frequency ω_i and the unwanted ones ω_1, ω_2, ω_3, etc., the equations to be satisfied are :

$$\omega_h - \omega_i = \pm\, \omega_0$$

$$\pm\, m\omega_h \pm n\omega_i \pm n_1\omega_1 \pm n_2\omega_2 \pm n_3\omega_3 + \ldots = \omega_0 \pm \delta.$$

Obviously the number of possible combinations is here very large, so that one is wondering somewhat, that superheterodyne receivers can actually be used. There are, however, a few restrictions on the many possibilities issuing from these two equations, which practically eliminate a great number of cases.

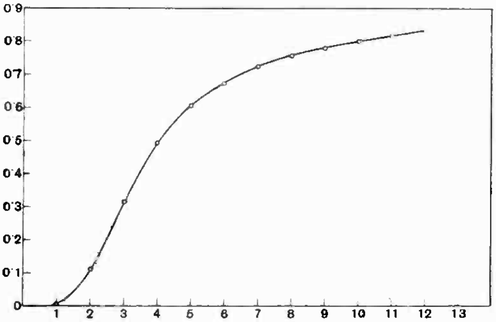


Fig. 3.—*Vertical axis as in Fig. 1, but $m = 2$, $n = 1$ and hence dimensionless. Horizontal axis as in Fig. 1. Tube : h.f. (remote cut-off type) pentode Philips type E 447.*

As already mentioned, one restriction is due to the selectivity of input circuits before the first detector. If we except strong local transmitters, practically no signals come on the input grid the frequency of which differs from ω_i by 20 kc/s or more. Furthermore, the power of any combination to give whistling notes in a receiver decreases as m increases and as $n + n_1 + n_2 + n_3 + \ldots$ increases. Hence whistling notes of high order are not very probable. The decrease just mentioned is dealt with more fully in the following section.

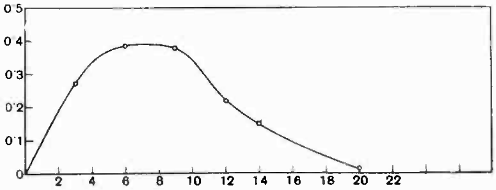


Fig. 4.—*Vertical axis as in Fig. 3. Horizontal axis : Oscillator volts effective value on oscillator grid (i.e., third grid from cathode). Tube : Philips triode hexode type ACH 1.*

III. First Detector as Generator of Whistling Notes

As long as input signals on the input grid of mixer tubes do not exceed, say, 0,5 volt, the anode current component of intermediate frequency ω_0, caused by a combination, where $n\omega_i$ enters, is proportional to E_i^n. In order to see this, one should consider the alternating anode current as a function of the voltages $e_i = E_i \sin \omega_i t$ and $e_h = E_h \sin \omega_h t$.

If we put $e_i = x$ and $e_h = y$ then we have

$$i = f(xy) = f_0 + xf_x + yf_y + x^2 f_{xx} + y^2 f_{yy} + 2xyf_{xy} + \ldots$$

by the well-known double Taylor series expansion. All the f's are constants not containing e_i and/or e_h. A whistling note combination into which $n\omega_i$ and $m\omega_h$ enter, arises from a product $\sin n\omega_i \,.\, \sin m\omega_h$.

Obviously, this product is not directly present in the above series for the anode current. But this series contains a term, proportional to

$$e_i^n\, e_h^m \text{ or } E_i^n (\sin \omega_i t)^n \,.\, E_h^m (\sin \omega_h t)^m,$$

and by the well-known decomposition :

$$(\sin \omega_i t)^n = \pm \left(\tfrac{1}{2}\right)^{n-1}$$

$$\left[\left\{ \begin{matrix} \sin \\ \text{or } \cos \end{matrix} \right\} n\omega_i t \mp n \left\{ \begin{matrix} \sin \\ \text{or } \cos \end{matrix} \right\} (n-2)\omega_i t \pm \ . \ . \ . \right]$$

it is seen, that this term enters into the whistling combination mentioned. Of course, terms with $e_i^p \,.\, e_h^q$, where $p > n$ and $q > m$ also enter into this whistling note, as is shown by the above decomposition. But, as e_i and E_i are supposed to be small, these terms are small with regard to $e_i^n\, e_h^m$. As, however, p cannot be smaller than n, the anode current is proportional to E_i^n as stated. If voltages of frequencies ω_i, ω_1, ω_2, ω_3, etc., are simultaneously present on the input grid, with amplitudes E_i, E_1, E_2, E_3, etc., the anode current component, of intermediate frequency ω_0, due to a combination, in which $n\omega_i$, $n_1\omega_1$, $n_2\omega_2$, etc. enter, will be proportional to E_i^n, $E_1^{n_1}$, $E_2^{n_2}$, etc. The proof is similar to the one, just mentioned. Hence whistling notes, due to combinations, into which large values of $n + n_1 + n_2 + \ . \ . \ .$ enter, will be faint, if the input voltages on the input grid of the first detector tube do not exceed, say, 0,5 volts.

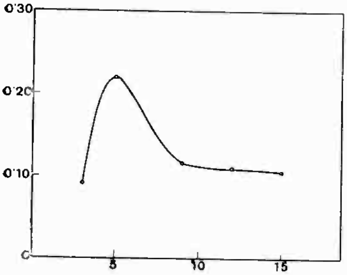


Fig. 5.—*Vertical axis as in Fig.* 1. *Horizontal axis as in Fig.* 4. *Tube as in Fig.* 4.

The oscillator voltage E_h is not, in general, so small as to give rise to a similar simple power law, as was found for the input voltage. If it is also small, say less than 1 volt, this same power law holds, naturally. But, even if E_h is not small, with fixed n, a whistling note will in general be fainter, if m is a great number, thus fainter for, say, $m = 10$ than for $m = 2$. This may be inferred from the convergence of the Fourier series, into which the anode slope versus time curve may be decomposed.

The setmaker is interested in the ratio between whistling notes, generated by the first detector and the music or speech. Hence we have to analyse the strength of the whistling notes, as they are heard behind the second detector. It is assumed that amplification and rectification after the first detector are *linear*. Then, the anode current component of the first detector, of angular frequency $\omega_0 + \delta$ resulting from a whistling combination, where $n\omega_i$ and $m\omega_h$ enter, will be called

$$F_{nm}\, E_i^n$$

as it is proportional to E_i^n. Hence F_{nm} is a factor, independent of the input voltage to the first detector. On the other hand, the anode current component of angular frequency ω_0, resulting from the wanted combination $\omega_0 = \omega_h - \omega_i$ is

$$S_c\, E_i,$$

where S_c is the conversion conductance. Now these two anode current components give rise to voltages on the input of the i.f. amplifier tube and also on the second detector. Assuming δ to be so small that the i.f. filter circuit passes $\omega_0 \pm \delta$ as well as ω_0, *i.e.*, without additional attenuation, if compared with ω_0, a combination tone of angular frequency δ is heard behind the second detector. The strength of this combination tone can be evaluated if we bear in mind that this means detection of a single sideband wave of modulation depth

$$2\,\frac{F_{nm}\, E_i^n}{S_c\, E_i}\,.$$

As compared with detection of the double sideband modulation of E_i a factor $\frac{1}{2}$ must be introduced. Hence the relative strength

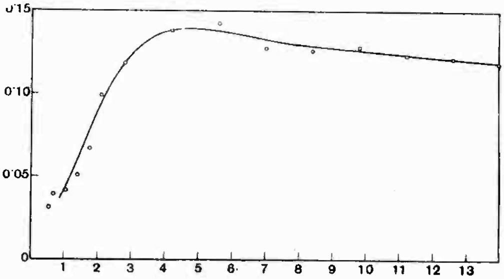


Fig. 6.—*Vertical and horizontal axis as in Fig.* 1. *Tube : Philips h.f. pentode type CF* 1.

of the whistling tone behind the second detector, compared with the strength of the wanted music, is

$$\frac{F_{nm} E_i^n}{S_c E_i M} \quad \ldots \quad \ldots \quad (4)$$

where M is the modulation depth of E_i. As S_c and F_{nm} are independent of the input signal amplitude E_i, a knowledge of F_{nm}/S_c enables one to calculate the relative strength aforesaid by equation (4) for *any* input signal on the first detector.

For some commercial first detector valves, the values of F_{nm}/S_c have been measured (see Figs. 1, 2, 3, 4, 5, 6 and 7).

IV. Strength of Input Signal to Give Best Compromise between Whistling Notes and Valve Noise

It is assumed, that a noise voltage of equivalent amplitude value E_r is present on the input grid of the first detector. As mixing, amplification and demodulation is equal for E_r and for E_i, the relative noise behind the second detector will be

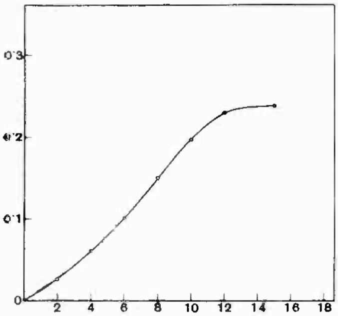


Fig. 7.—*Vertical axis as in Fig. 3. Horizontal axis as in Fig. 2. Tube: Philips Octode type A K1.*

$$\frac{E_r}{M E_i} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

The voltage E_r is of the order of 1 microvolt, if no amplification before the first detector is used. With amplification, E_r finally increases proportional to E_i. The ratio E_r/E_i is in this case finally equal to the ratio e_r/e_i, where e_r and e_i are equivalent noise voltage and input voltage on the grid of the first amplifier tube of the set before the first detector. Taking $M = 30\,\%$, a curve illustrating (5) is curve 1 of Fig. 8. Curve 2 of this Fig. 8 gives the expression (4) for $n = 2$, $m = 1$ and $F_{nm}/S_c = 0{,}1$, which is a common value with commercial first detectors. Obviously, a value of some 1 or 2 millivolt for E_i, *i.e.*, the input voltage amplitude on the first detector will be selected in this case, the relative noise level being about 0,003 and the whistling level negligible besides the thermal noise. A more than one stage amplification before the mixing stage and E_i of the order of 0,1 volts would result in very disagreeable whistling notes.

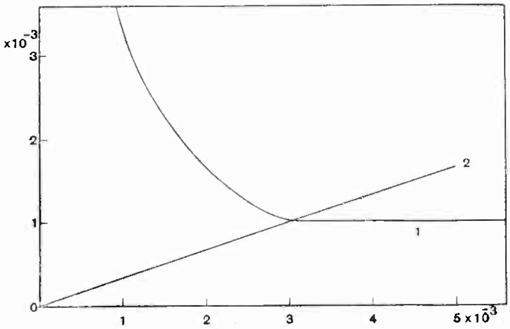


Fig. 8.—*Vertical axis: Noise to music ratio heard behind second detector. Horizontal axis: input signal volts on input grid of mixer tube. Curve 1: Tube noise (shot effect). Curve 2: Whistling noise for $n = 2$, $m = 1$.*

V. Summary

Whistling notes, generated by the first detector valve of a superheterodyne set, if only one input signal is present, are considered. The mathematical relation between the intermediate frequency and the input frequency, which leads to whistling notes is set forth. A formula for the ratio between whistling note strength and music heard behind the second detector is derived. Measured values are given, permitting of easy calculation of this ratio for any of the valves quoted. It is shown how a compromise between valve noise and whistling notes noise can be reached, the total disturbance level being as small as possible.

The author takes pleasure in expressing his appreciation of the able assistance given by Mr. N. S. Markus in the measurements described above.

For a bibliography reference is made to the Author's article, "Mixing Valves," in this journal (Feb., 1935).

Crystal Oscillators for Radio Transmitters

An Account of Experimental Work carried out by the Post Office

Paper by C. F. Booth, A.M.I.E.E., and E. J. C. Dixon, B.Sc., A.M.I.E.E., read before the Wireless Section, I.E.E., on February 6th, 1935

Abstract

THE paper gives an account of work carried out by the Radio Section of the Post Office between 1925 and 1934 on the development of the use of quartz crystal oscillators in a number of different applications, of which the most important was the control of the carrier frequency of short-wave transmitters used for overseas radio services. In the introductory part of the paper Cady's terminology is used, as illustrated in Fig. 1*, where the crystal is described by reference to the three axes X, Y and Z, of which Z is the optical axis, X the electrical axis, and Y the third or "mechanical" axis. The "cut" of the plates is described by the axis normal to the plane of the plate. "X" and "Y" plates can be cut from the angle of a crystal having their planes at 30 deg. to one another. Longitudinal oscillations are those in which the motion of the vibrating particles is parallel to the direction of the propagation of the wave. They are briefly referred to as "X waves," when the direction of propagation is along the X axis, and so on. Oscillations of the Y-cut plate are referred to as "shear" oscillations; the direction of wave propagation is parallel to the Y axis, however, and the oscillations are referred to as "Y waves in a Y-cut plate."

After describing the frequency-measuring apparatus, the paper passes on to discussion of the present practice in the use of X-cut plates for the control of short-wave transmitters, and to experiments with such plates. These deal with (a) the

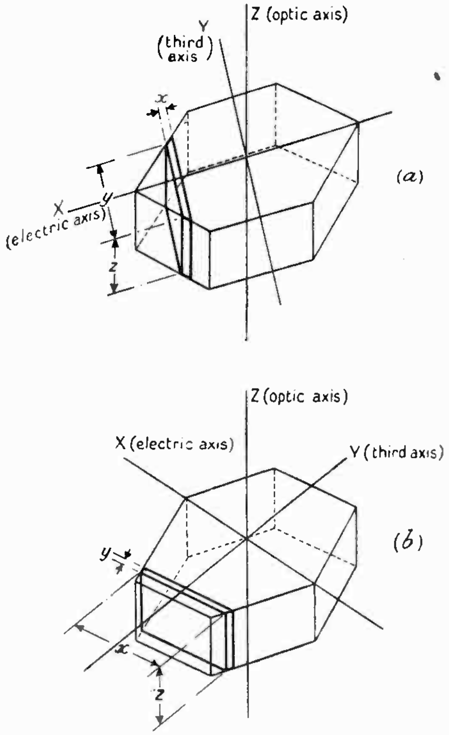
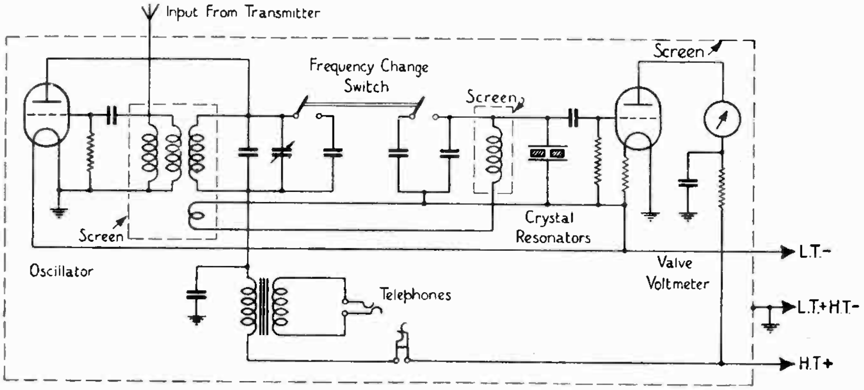


Fig. 1.—*Plates cut from quartz crystal. (a) "X"-cut plate. (b) "Y"-cut plate.*



(Left) Fig. 19.—*Circuit diagram of coast station frequency meter.*

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* The authors' figure numbers are adhered to throughout this abstract.

frequency constants of the X, Y and Z waves in square and circular X-cut plates; (*b*) the frequency/temperature coefficient; (*c*) the effect of an air gap on the frequency of the X wave in X-cut square and circular plates; (*d*) the effect of added weight on the top electrode of a contact type holder; (*e*) the limiting effect of the "build up" of osclllations on the maximum keying speed; (*f*) the internal heating of the plate due to oscillation. Similar measurements are described in relation to the Y cut, and it is concluded that, in general, the complexity of behaviour is such that, except for special purposes, the X-cut plate is much to be preferred for normal commercial use.

Incidentally, it is mentioned that, since the paper was originally drafted, an account has been published of a method of making Y-cut plates which reduces unwanted couplings between the X and Y modes, and achieves a zero frequency/temperature coefficient over a wide temperature range.

The paper next describes special applications of the quartz crystal, these being a frequency meter of the frequency range 50,000 to 74,000 kc/s, and a frequency meter for the spot frequencies of 431 and 500 kc/s, designed to check the frequencies of the coast station transmitters controlled by the Post Office. The former involves a process of measurement whereby the frequency of an oscillator is set by the adjustment of an interpolating condenser, both with the unknown frequency and with two selected harmonies of a substandard of frequency—a crystal controlled oscillator—which lie respectively above and below the unknown frequency. Then, from a knowledge of the three readings of the interpolating condenser and of the values of the two selected harmonic frequencies, the unknown frequency is determined. The coast station frequency meter is illustrated in Fig. 19, from which its arrangement is obvious.

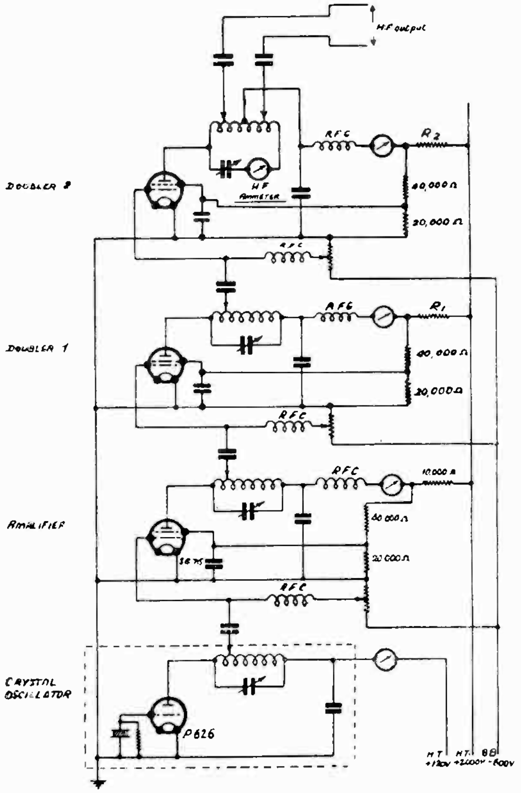


Fig. 30.—*Typical P.O. crystal oscillator, amplifier, and doubler circuits.*

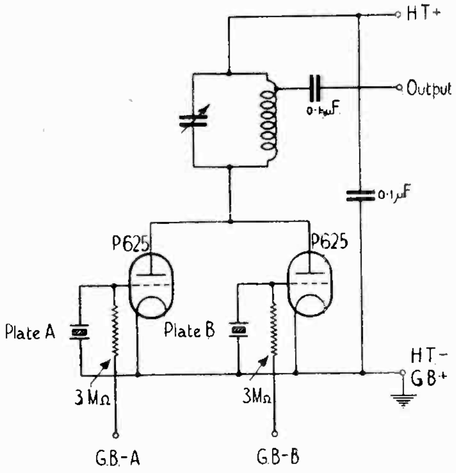


Fig. 33.—*Double-frequency oscillator for voice smoothing.*

The paper next deals with developments in crystal holders. In the best type the design relies to a large extent on good workmanship to secure that the electrodes shall be parallel and that the centre line of the micrometer screw shall be normal to the plane of the electrodes. A demountable compensating holder is also described in the paper. The principle underlying the design of compensating holders is that the dimensions of the holder or at least of its important variable—the gap between the upper electrode and the plate—shall change with varying temperature. The change must have the correct sense and must be of such dimensions that the frequency-change due to the gap is equal and opposite to the frequency-change due to the inherent frequency/temperature coefficient of the plate.

In connection with circuits, the typical P.O. crystal oscillator, amplifier and doubler circuits are shown in Fig. 30. A double oscillator for voice switching is shown in Fig. 33. This makes it possible to radiate alternatively two carriers spaced by an amount equal to the discrimination of a telephony receiver. The two carriers might, for example, be 10,000 kc/s and 10,010 kc/s, with provision for voice switching. Two crystals A and B are used, having frequencies of say 2,500 and 2,502.5 kc/s respectively (for a case where the oscillator is followed by two double circuits). A common anode circuit is tuned to a frequency sufficiently above that of the higher-frequency crystal to ensure that approximately equal output is given on each frequency. The bias values A and B are derived from a voice operated device so that when A is negative B is zero, and vice versa.

In a section dealing with temperature-control and allied apparatus, the most interesting item is the thermantostat, the circuit of which is given in Fig. 38. The essential features are that the total heat is supplied continuously and that the heater and thermometer elements are one and the same. The temperature cycle is thus eliminated and the power supplied is inversely proportional to the difference in temperature between the oven and the ambient, and the sensitivity of the thermostat device is in no way limited by thermal time-lag.

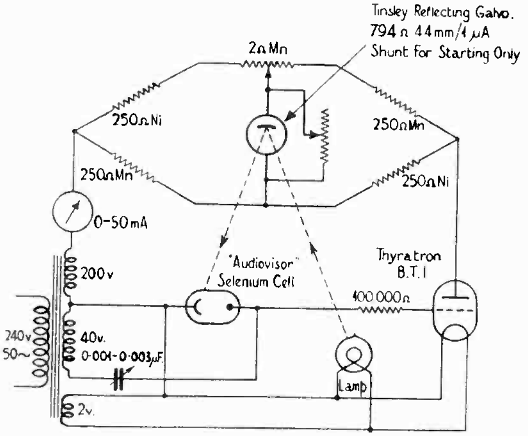


Fig. 38.—*Circuit diagram of thermantostat.*

In the concluding section of the paper results are quoted of the frequency stability of service transmitters with crystal control. A stability of 5 parts in 10^6 is shown in one case over three separate days. Results are also quoted for a transmitter made in England, and sent overseas for use. After dismantling in England, transporting, reassembling and putting into working operation, the frequency did not differ by more than 11 parts in 10^6 from the original calibration at Dollis Hill.

Discussion

The discussion, which was opened by MR. A. URE, was directed chiefly to details of crystal operation and use. The speakers included Messrs. H. J. LUCAS, J. E. R. VIGOUREUX, F. S. BARTON, A. J. GILL and DR. E. H. RAYNER. The last-named speaker gave interesting details of last year's international comparison of frequency when observations in Belgium, Germany, France, Italy and Holland agreed to 1 part in 10^8 with the standard 1,000-cycle modulation supplied from the N.R.L. MR. F. S. BARTON stated that the zero-temperature-coefficient cut, referred to in the paper, was now being used a great deal in America and was proving very satisfactory. A new X-ray method of adjustment had also recently been developed in America and had been found much superior to the optical methods of adjustment mostly employed.

Book Review

Electromagnetism

By Prof. H. M. Macdonald, F.R.S., pp. 178 + xv. G. Bell and Sons, Ltd., York House, Portugal Street, London, W.C.2. Price 12s. 6d. (1934.)

Professor Macdonald has occupied the Chair of Mathematics at Aberdeen University for many years and is well known to radio engineers as the author of "Electric Waves," published in 1902.

His present book approaches the subject of electromagnetism from the ultra-mathematical point of view and follows the classical methods of the pre-Heaviside days. We gather that the author does not claim to have established any new results, but rather to have developed and restated known results in a manner which he considers more fundamental and more logical. "The scheme which is developed rests on the hypothesis that electrical effects in space which is devoid of matter are propagated according to the laws of Ampere, Faraday and Fresnel, that the presence of material media modifies the mode of propagation, and that this modification can be taken account of by assuming a distribution of electric currents and magnetic currents throughout the space occupied by the material media," and in another place: "In discussing material media the natural hypothesis to make is that, so far as propagation of electrical effects is concerned a material medium can be represented by an electric current distribution and a magnetic current distribution throughout the space." Although, as the author adds in a footnote, the idea of a magnetic current is due to Faraday, we feel sure that it will be a new conception to most readers at the present day. The magnetic current density m is the time rate of change of the intensity of magnetisation, and since he writes $B = H + 4\pi I$, it will be seen that $dH/dt + 4\pi m$, which appears in the equations, is equivalent to taking two bites to the more familiar dB/dt.

In the introduction we read: "Ampere's law, which gives the relation between electric current and magnetic force, and Faraday's law, which gives the relation between electric force and the time rate of change of magnetic force, are independent of the nature of the material media." We do not understand what this means, for while it is true that the magnetic force H produced by a given current is independent of the medium, the electric force induced in any given case is not dependent on the time rate of change of H but of B, and the relation between them is certainly dependent on the nature of the medium. This statement suggests that the author uses some of these terms in a sense different from that in which they are employed by electrical engineers.

Symbols are always a difficulty, and it is somewhat worrying to find that "j is a vector whose time rate of increase is the electric current"; we suspect that the author really means "current density." This j has therefore no connection with $\sqrt{-1}$, but bears a very close resemblance to Maxwell's electric displacement D.

On p. 3 the printer has dropped a 4 out of equation (6) and an x out of equation (7); on p. 90, J. T. Thomson should be J. J. Thomson.

G. W. O. H.

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.

Mixing Valves

To the Editor, The Wireless Engineer

SIR,—I was interested to note that Dr. Strutt in his article on "Mixing Valves" in *The Wireless Engineer*, February, 1935, arrives at a theoretical formula for the conversion conductance of a multi-grid frequency changer which gives results similar to those obtained by the application of the formulae given in my article on "Heptode Frequency Changers" in the December 1934 issue of this Journal.

The author obtains (p. 62) a formula giving the conversion conductance as

$$S_c = \frac{1}{\pi} S_{\max.} \sin a$$

where

$S_{\max.}$ = max. value of anode current-control grid voltage slope (at zero oscillator grid voltage)

a = one-half the angular width of a rectangle approximating the actual slope-time curve when the heterodyne voltage is applied to the oscillator grid.

When this expression is applied to the 2A7 heptode valve dealt with in "Heptode Frequency Changers," operating under conditions of nearly optimum heterodyne, *i.e.* the conditions of Test 1 illustrated by the curve of Fig. 7 for $E_0 = 9$ volts peak, by plotting to a time scale the variations of mutual conductance with a sinusoidal oscillator input of 9 volts peak, and approximating the resultant curve by means of a rectangle, a value of $a \doteqdot 70°$, and $S_{\max.} = 1.17$ mA/volt is obtained. These values give a value of conversion conductance $S_c = 0.35$, whilst the measured value is 0.296 (*see* Fig. 8 of my article).

If the actual values for this test (*i.e.* $E_0 = 9$ volts, P = oscillator grid base − oscillator steady bias voltage = 20 − 8.6 = 11.4 v) are substituted in formula (3) of my article

$$g_c = \frac{gE_0}{2}(a + 2bP)$$

where $a = .0011$ and $b = .00245$, constants determined from the static characteristics of the 2A7 valve, a value of $g_c = 0.289$ is obtained, agreeing with the observed value to within 2.4 %.

I consider that the relatively large error of 18 % obtained by Dr. Strutt's method is due to the difficulty in accurately approximating the actual slope-time curve by a rectangle which would give the same value of fundamental frequency component when developed into a Fourier series.

With regard to the conditions of heterodyne giving the greatest ratio of signal to "shot" noise, I have plotted the value of $\sqrt{I_a}/g_c$ against E_0 for the test shown in Fig. 8 (a and b), both from the measured and the calculated values (g_c being calculated from equations 3 and 5, and I_a from equations 2 and 8, "Heptode Frequency Changers") with the results shown in the curves below. It will be seen that $\sqrt{I_a}/g_c$ reaches a substantially constant minimum value at $E_0 = 10$ volts, *i.e.* that value corresponding to the maximum conversion conductance. Thus it will be seen that the value of heterodyne for optimum conversion conductance also gives a maximum value of signal/"shot" noise (assuming that, as is normally the case, the effective impedance of the valve is high compared with the anode load dynamic resistance), and that this value is $\frac{M}{2}$ where M = oscillator grid voltage required to reduce the anode current of the valve to zero. Substituting this value in equation (3)

$$g_c = \frac{gM}{4}(a + bM)$$

which, a being $\ll bM$, reduces to

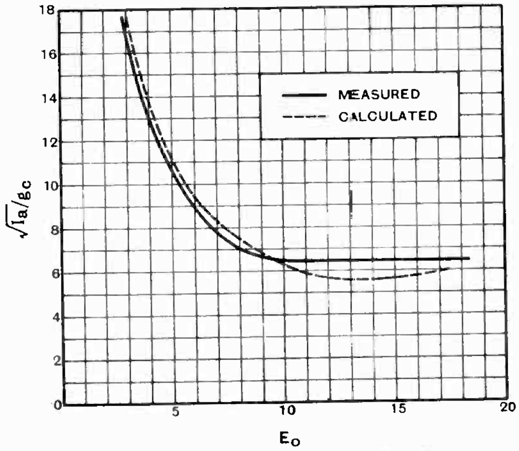
$$g_c = g\frac{bM^2}{4}$$

Since bM^2 is very nearly unity, this becomes

$$g_c = 0.25\,g$$

corresponding very nearly with Dr. Strutt's value of $S_c = 0.27\,S_{\max.}$ (equation 10), S_c corresponding to g_c and $S_{\max.}$ corresponding to g in my article.

It would have been very interesting had Dr. Strutt included sufficient test results in his article, to have derived, for the purpose of comparison with the curves shown below, the corresponding values of $\sqrt{i_a}/S_c$.



Values plotted for the test shown in Fig. 8 of the writer's article.

In the table are given for reference some constants and operating characteristics of three frequency changers employing electronic mixing.

It will be observed that the ratio of mean anode current when the optimum heterodyne is applied, the oscillator grid being self-biased by means of the usual grid leak and condenser, to the anode current with no oscillator input, is very nearly the same for the three valves, and has a mean value of about 0.38. This value is given by the term

$$\left(\frac{bE_0^2}{2} + aP + bP^2\right)$$

in equation (2), and is independent of the initial value of the anode current, and hence of the control grid bias, and is also practically independent of the actual anode current-oscillator grid voltage characteristic, assuming that this is of the normal form represented by

$$i_a = I_0(ae_0 + be_0^2)$$

where i_a = anode current at any given control grid bias and oscillator grid voltage of e_0 (measured from M).

I_0 = anode current with $e_0 = M$,

and also that be_0^2 is large compared with ae_0 as is normally the case.

Valve.	2A7 Heptode.	41 MPG Heptode.	F.C.4 Octode.
(*a*) Anode voltage	200	250	250
(*b*) Screen voltage	150	100	85
(*c*) Control grid bias (for *d*, *g* and *h*) volts	−2.8	−1.5	−1.5
(*d*) I_0 = max. anode current (for *a*, *b* and *c*), mA ..	9.0	10.1	6.8
(*e*) I_a = mean anode current (for *a*, *b*, *c* and *j*), mA ..	3.4	3.9	2.6
(*f*) g = max. mutual conductance (for *a*, *b* and *c*) mA/V	1.13	3.8	1.7
(*g*) g_c = max. conversion conductance (for *e* and *j*) mA/V	0.29	0.96	0.425
(*h*) $\sqrt{I_a}/g_c$ (for *e* and *g*)	6.5	2.05	3.8
(*i*) M = oscillator grid base (volts)	20	11.6	8.5
(*j*) E_0 = optimum heterodyne (for *g* and *h*), peak volts..	10	5.8	4.25
(*k*) "*a*" (for *a*, *b* and *c*)	0.0011	0.0063	0.0049
(*l*) "*b*" (for *a*, *b* and *c*)	0.00245	0.0070	0.0133
(*m*) I_a/I_0	0.38	0.39	0.38

Thus it is possible in a very simple manner to ensure that the frequency changer is operating under optimum conditions giving maximum signal/"shot" noise ratio and maximum conversion conductance, by adjusting the oscillator input (*e.g.*, by variation of oscillator anode voltage) to such a value that the mean anode current is reduced to 0.38 of its value with zero oscillator input, the anode, screen and control grid voltages being kept constant.

Although the equations referred to were developed for heptodes, I have found them to be equally applicable to octodes, which have characteristics of the same general form as heptodes, but without the "dynatron" kink. Also, the method of representing the anode voltage-anode current characteristics of a heptode at varying grid voltages, shown in Fig. 12 of "Heptode Frequency Changers," by a series of divergent straight lines passing through a point corresponding to zero anode current and a large negative anode voltage, appears to be applicable to tetrodes and pentodes of normal type, as well as octode frequency changers, with a good degree of accuracy. This means that the effective impedance of a tetrode or pentode or the conversion impedance of an octode, is approximately inversely proportional to the mean anode current, a result which, as far as I am aware, has not been published before.

I would like to take this opportunity of correcting an omission in "Heptode Frequency Changers." It should have been stated in connection with Fig. 8 that the curves "*d*" and "*e*" are plotted to a scale of oscillator input of one-half that of curves "*a*" and "*b*," which are plotted to the marked scale, since in "*d*" and "*e*" the oscillator input is one-half the steady bias voltage, whilst in "*a*" and "*b*" the oscillator input is equal to the steady bias voltage. In other words, the oscillator input scale for curves "*a*" and "*b*" can be taken to represent the steady bias for all four curves.

London, W.13. R. J. WEY.

The Industry

COMMUNICATIONS for Partridge & Mee, Ltd., should, in future, be addressed to the firm's works at Aylestone Park, Leicester.

A contract for the supply of a complete new set of batteries for the Burnham (Somerset) radio station, has been secured by the Alton Battery Co., Ltd., of Alton, Hants.

Piezo-electric quartz crystals of various types, and also amateur transmitting apparatus, are described in a catalogue issued by the Quartz Crystal Company, Kingston Road, New Malden, Surrey.

Passengers at Croydon Airport are now informed of aeroplane arrivals and departures, luggage arrangements, etc., through Tannoy public address equipment. Announcements can be made from microphones in the Croydon offices of each of the operating air lines.

Ward and Goldstone, Ltd., of Frederick Road, Salford, 6, Lancs., have introduced a special form of twin cable for use as a down-lead with dipole and similar aerials.

Abstracts and References

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PROPAGATION OF WAVES

930. Ultra-Short [8.7 m] Waves in Urban Territory.—C. R. Burrows, L. E. Hunt and A. Decino. (*Elec. Engineering*, January, 1935, Vol. 54, No. 1, pp. 115–124.)

Extension of the paper dealt with in 1933 Abstracts, p. 318, to include data on transmission within the city of Boston and the additional problems introduced by man-made interference. "Fig. 2 shows that the field strength is in general inversely proportional to the square of the distance from the transmitter. . . . The mean curve through the data is 12db below the curve for level terrain free from obstacles, plotted from equation 5, indicating the additional attenuation due to man-made structures. An analysis of ten individual points shows that the reduction in field due to the obstacles (*i.e.*, in addition to the level terrain attenuation) is independent of the distance, so that there is no *absorption* due to the buildings in the usual meaning of the word; otherwise the additional attenuation would increase with the distance. This method of interpretation is radically different from that of investigators of the propagation of ultra-short waves through urban areas whose papers have come to the attention of the authors (Abstracts, 1932, p. 30—Schröter, Sohnemann; 1934, p. 30—Muyskens and Kraus). They have assumed that the transmission occurs as in free space except for the additional attenuation *through the absorbing layer of buildings*." Similarly, "while the empirical formula arrived at by Jones (1933, p. 334) may represent his data satisfactorily, the physical picture assumed, of a free space field times an absorption factor, is untenable since it requires a radiated power approximately 20 db below that measured."

Regarding interference, with the receiver on top of an office building the predominating noise was caused by a sub-station next door, except when the aerial was lowered to about the roof level, when the elevator motor and switching noises in the near-by penthouse exceeded all others. These latter noises were reduced by a fairly large factor by raising the aerial to its proper position, thanks to the directivity of the aerial (vertical half-wave aerial connected to balanced circuits by symmetrical 2-wire transmission line) and the increased distance. "This fact has an important bearing on reception of signals on the roofs of office buildings, since elevator switching noise is in general the limiting factor."

931. Progress on the Ultra-High Frequencies [190-Mile Range on 56Mc/s without Height at Either End: 75-Mile Range on 224Mc/s to Mountain].—R. A. Hull. (*QST*, January, 1935, Vol. 19, No. 1, pp. 35 and 80, 82.)

932. Sayville and Southampton to Manhattan Results on 5.83m Ultra-Short Waves.—Kolster. (*See* 988.)

933. Ultra-Short Wave Communication between Observatories on the Summit and at the Base of Mt. Fuzi [4.2 and 4.6 Metre Waves].—Soga. (*See* 1210.)

934. On the Bending of Electromagnetic Micro-Waves below the Horizon [Treatment based on Huyghens' Principle explains Marconi's Ranges without Help of Atmospheric Influences].—P. S. Epstein. (*Proc. Nat. Acad. Sci.*, January, 1935, Vol. 21, No. 1, pp. 62–68.)

"Marchese Marconi mentions that the signals were heard until the maximum distance of 230km . . . Under favourable conditions the reception was clear until 205km, then it became erratic and only occasionally audible. Comparing this with our table, we must conclude that *the experimental range of the waves did not materially exceed the expectations of a theory disregarding all atmospheric influences. Qualitatively the observations agree with the predictions of our formulae*. . . Atmospheric influences had an unquestionable effect inasmuch as they could spoil the reception, causing 'slow and deep fading' of the signals which, at times, reduced them to complete inaudibility. More quantitative observations are required to answer the question whether they could occasionally also help the reception." The results of Schelling, Burrows and Ferrell on 17–3.5 metres (1933 Abstracts, p. 318), attributed to reflection from the earth's surface, are referred to: they do not conflict with the writer's formulae, since at the shorter wavelengths such effects would be less important, at great distances, than the curvature of the earth.

935. Inverse Distance Law obeyed by 9 cm Micro-Waves up to 16 Miles Line-of-Sight.—Wolff, Linder and Braden. (*See* 986.)

936. On Some Relations between Electric Wave Lenses and Optical Lenses.—H. Kikuchi. (*Journ. I.E.E. Japan*, November, 1934, Vol. 54 [No. 11], No. 556, pp. 1203–1207: English summary pp. 136–138.) *See* also 937, below.

937. On the Characteristics of Interference Surfaces of Electromagnetic Waves [caused by Presence of Prolate Spheroid and of Electric Wave Lens].—H. Kikuchi. (*Journ. I.E.E. Japan*, November, 1934, Vol. 54 [No. 11], No. 556, pp. 1203–1207: English summary pp. 138–139.) For Kikuchi's "electric wave lens" *see* 1934 Abstracts, p. 324, and 936, above.

938. Dispersion and Absorption Curves for Radio Wave Propagation in the Ionosphere according to the Magneto-Ionic Theory.—D. F. Martyn. (*Phil. Mag.*, February, 1935, Supp. No., Series 7, Vol. 19, No. 126, pp. 376–388.)

The writer discusses the dispersion and absorption curves given by the Appleton-Hartree formula for magneto-ionic propagation (*see*, for example, Appleton, Abstracts, 1928, p. 683, and 1933, p. 30; Hartree, 1931, p. 143; *also* Mary Taylor, 1933, p. 263, and 1934, p. 373; Baker & Green, 1933, pp. 385–386). He uses the graphical method developed by Bailey (1934, p. 606, second abstract) and gives curves for five typical wavelengths (between 100 and 20 000 m), three collisional frequencies (10^4, 10^5, 10^6 per sec.), and directions making angles 0°, 45° and 90° with the magnetic field. The Lorentz-Hartree polarisation term is included in the calculations. The ratio of the axes of the polarisation ellipses and the tilts of these axes tend to limiting values as the ionisation tends to zero. The curves are used to extend the conclusions of Green and Builder (1934, p. 431) and it is shown that Hollingworth's long-wave polarisation measurements (1928, p. 460) are consistent with the refraction and absorption of long waves at heights of about 90 km.

939. Musical Atmospherics [Dispersion Theory tests Refractive Index Formula].—Eckersley. (*See* 958.)

940. Ionisation of the Kennelly-Heaviside Layer [due to Solar X-Radiation, not Ultra-Violet Light].—E. A. W. Müller. (*Nature*, 2nd Feb. 1935, Vol. 135, pp. 187–188.)

This letter gives arguments, based on the mass-absorption coefficient of ultra-violet light and X-radiation, in favour of the hypothesis that the latter, coming from the sun, is the main ionising agent in the E region.

941. Recent Measurements of Upper-Atmospheric Ionisation [Addendum to Paper by E. O. Hulburt].—E. V. Appleton. (*Phys. Review*, 1st Jan. 1935, Series 2, Vol. 47, No. 1, p. 89.)

See 358 of February. This letter makes clear the difference between the main ionised region F_2 and the subsidiary "shelf" F_1: the explanation of radio skipped distances on an electron-limitation hypothesis is to be found in F_2 ionisation. Effective electrical carriers in E region appear to be of electronic, not molecular, mass. Critical frequency measurements for region F_2 appear really to indicate "an abnormal depression of the value of maximum ionisation when the sun is high," due to increased temperature and consequent expansion of the outermost atmospheric regions.

942. A Determination of Atmospheric Pressure at the Level of the Ionosphere, based on Long-Delay Echoes.—J. Fuchs. (*Meteorolog. Zeitschr.*, No. 12, 1934, pp. 454–457.)

In a previous paper (356 of February) the writer concludes that long-delay echoes are due to processes in the F layer. It is meanwhile found, "as will be reported elsewhere, that it is the zenithal, almost vertically radiating component of the vertical polar diagram of the transmitting aerial which produces the long-delay echoes and is strongly subjected to double refraction, while the main signal is due to the more horizontal component." The treatment of the data shows that these vertically incident waves only give rise to long-delay echoes when their peak points lie at a level where the collision frequency $\nu < 2$/sec. (most of the long-delay echoes being observed on 31 m waves, for which, as a first approximation, $d = e^{-\nu t/2}$). The average value for ν, for long-delay echo observations, is 0.5/sec.; it varies between 0.2 to 1.5/sec. Since it is known that the height at which the maximum electron density occurs in the F layer is subject to periodic as well as aperiodic changes, it follows that long-delay echoes can only occur when the level of maximum electron density (where the peak point of the long-delay wave must lie) is above the level defined by $\nu = 2$/sec. The collision frequency, thus easily found from long-delay echo observations, is directly related to the values of temperature and pressure at the same level. Taking the mean free path length in air at 273° (fortunately the values are little different for the various gases and are not greatly altered by large differences in temperature—*see* table) the writer obtains, for $\nu = 0.2$ to 1.5 per second, values of pressure from $p = 5 \times 10^{-10}$ to 4×10^{-9} mm Hg at the height of maximum electron density of the F layer. Assuming lower and upper height limits as 200 and 350 km respectively, it is deduced that the composition of the air in the F layer is little different from that at the surface and that hydrogen and helium are not present in any appreciable quantities.

943. Ionospheric Measurements at Losap Island [South Sea Islands] during the Solar Eclipse of February 14th, 1934.—K. Maeda. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, pp. 89–103.)

In English. "It is found that the ultra-violet radiation from the sun is the prominent agent . . . and the effect of the neutral corpuscle from the sun is slightly observed and ends earlier on the F layer than on the E layer" [but *see* Minohara and Ito, 944]. Measurements in North America and Europe during the solar eclipse of August 31st, 1932, are tabulated and compared with the present results. The pulse method was employed, on 4 Mc/s throughout.

944. Ionosphere Heights measured in the South Sea Islands [and the Occurrence of the "Noon Phenomenon"], and Radio Observations made during the Solar Eclipse of February 14th, 1934.—T. Minohara and Y. Ito. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, pp. 109–120.)

In English. In the ionosphere height measurements from 1st to 17th February, echoes were obtained only on frequencies 1.5–9 Mc/s, although the available frequency range was 0.6–10 Mc/s. The test distance was 97 km. The so-called "noon phenomenon" narrowed the frequency band yielding echoes: it may be explained by the existence of an absorption layer of ozone, or by the absorption of the F echo by the E layer. For the eclipse observations a 4 Mc/s frequency was used: "as the frequency employed was not suitable for the purpose, the effect of the corpuscular eclipse on the E layer could not be observed. The effect of the corpuscles on the F layer also could not be observed, although theoretically the wave used should have made observation possible" [but *see* Maeda, 943].

945. Measurements of the Heights of the Kennelly-Heaviside Layer in Japan.—II. From February to August, 1933.—Minohara and Ito. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, pp. L-1 to L-30.) For Part I *see* 1934 Abstracts, p. 29.

946. Measurements of Electron Densities of the Ionosphere.—K. Maeda and M. Konomi. (*Journ. I.E.E. Japan*, October, 1934, Vol. 54 [No. 10], No. 555, p. 1114: Japanese only.)

947. On the Relation between the Kennelly-Heaviside Layer and the Meteorological Conditions.—J. Obata and Y. Munetomo. (*Journ. I.E.E. Japan*, November, 1934, Vol. 54 [No. 11], No. 556, pp. 1144–1147: English summary p. 130.)

948. Oscillations of Sharply Peaked Wave Form from the Electron-Coupled "Outer Grid" Dynatron.—Hayasi. (*See* 1007.)

949. [Data of] Luminous Night Clouds over Norway in 1933 and 1934 [Clouds due to Cosmic Dust].—C. Störmer. (*Nature*, 19th Jan. 1935, Vol. 135, pp. 103–104.) *See* also 1934 Abstracts, p. 553.

950. The Lisbon Meeting of the C.C.I.R. [including the Day and Night Field-Strength Curves for Different Values of Sigma].—Harbich. (*E.T.Z.*, 24th Jan. 1935, Vol. 56, No. 4, pp. 80–82.)

951. On the Propagation of Broadcasting Waves.—M. Kinase and S. Ueno. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 11: summary only, in English.)

"Considerable data relating to ground wave intensity, measured around all our stations, were reduced to 1 kw radiation power and averaged, excluding values over sea water. To a distance of about 100 km the result agrees with the curve calculated by Sommerfeld's formula, assuming the earth's conductivity to be a little over 10^{-14} cgs, while at further distances it drops more rapidly than the curve calculated by Watson's formula. The sky waves at night were also observed, the average of which shows a maximum at a distance about 300 km from the transmitters, while it approaches the inverse distance curve at about 500 km. It is seen from this fact that the sky waves are radiated most powerfully, from $\frac{1}{4}$ wave-length antennas, in a zenith angle of about 70°, assuming the height of the K.-H. layer to be 100 km."

952. An Analysis of Continuous Records of Field Intensity at Broadcast Frequencies.—K. A. Norton, S. S. Kirby and G. H. Lester. (*Journ. of Res. of Nat. Bur. of Stds.*, December, 1934, Vol. 13, No. 6, pp. 897–910.)

The method of recording used was referred to in 1934 Abstracts, p. 47. This paper gives typical records of received field strengths from various stations of frequencies from 630 to 1 460 kc/s. The records were analysed in terms of the peak field intensities observed during 10-minute intervals and curves are given of sample diurnal variations of the attenuation factors of several stations and of night field-intensity measurements as functions of distance. An empirical formula was found to fit the data, which is shown with the averaged data. Explanations are offered on the bases of (1) optical reflection of the sky wave from a reflecting region at a height of 100 km, and (2) a calculation of attenuation as being proportional to the number of reflections, the average collision frequency and the cosine of the angle of incidence at the reflecting region

953. Time-Lags in Magneto-Optics [Improved Apparatus: Measurements in CS_2 and HCl].—H. W. Farwell and J. B. Hawkes. (*Phys. Review*, 1st Jan. 1935, Series 2, Vol. 47, No. 1, pp. 78–84.)

954. Instantaneous Speeds in Air of Explosion Reports at Short Distances from the Source [Abnormally High Speeds near the Source, Abnormally Low Speeds a little farther away].—F. L. Partlo and J. H. Service. (*Physics*, January, 1935, Vol. 6, No. 1, pp. 1–5.)

955. Simultaneous Travel of a Surge of Stress and a Group of High-Frequency Waves of Stress in a Steel Wire [Wave-Group travels at Lower Speed than Surge in Hard-Drawn Wire].—T. F. Wall. (*Nature*, 26th Jan. 1935, Vol. 135, pp. 151–152.)

956. On the Theorems of Existence relating to Permanent Periodic Waves in Two Dimensions in Heterogeneous Liquids.—Dubreil-Jacotin. (*Comptes Rendus*, 14th Jan. 1935, Vol. 200, No. 3, pp. 210–212.)

957. Spheroidal Functions, *and* Addition Formulae for Spheroidal Functions [and Their Application to the Study of Wave Motion].—Stratton: Morse. (*Proc. Nat. Acad. Sci.*, January, 1935, Vol. 21, No. 1, pp. 51–56 and 56–62.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

958. Musical Atmospherics [Dispersion Theory tests Refractive Index Formula: Agreement with Observations].—T. L. Eckersley: Burton and Boardman. (*Nature*, 19th Jan. 1935, Vol. 135, pp. 104–105.)

The writer calls attention to Burton and Boardman's observations on audio musical atmospherics (1934 Abstracts, p. 86: *see* also p. 433) and relates them to his own theory of the dispersion of a pulse in the ionosphere (*Phil. Mag.*, Vol. 49, 1925, p. 1250, and 1929 Abstracts, p. 38). He finds that observations and theory are in good agreement and that the theory can only apply to the observations if the Lorentz-Hartree polarisation term should *not* be included in the formula for the refractive index, as Darwin concludes on theoretical grounds (1934 Abstracts, pp. 606–607 and back reference).

959. Circuits for Elimination of Atmospheric Interference with the Reception of Radio-Telegraphic Signals.—Volpian. (*See* 1024.)

960. Some Studies on Thunderstorms.—H. Noto. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, pp. 121–166.)

In English. Part I: Changes in electric field under thunderclouds: "by no means so simple as explained in the schematic form proposed by G. C. Simpson and S. K. Banerji; . . . the structure of thunderclouds must be studied before any discussion of the polarity of thunderstorms can be possible." Part II: Relation between direction of travel of thunderstorms and the direction of the upper wind at various heights: "it was found that a thunderstorm is generally dragged down by winds existing at heights of 2 000 metres and higher above the ground. . . . In most cases, as the height increased, the wind direction reached that of a thunderstorm in a clock-wise direction [149 clockwise to 47 counter-clock-wise]. This will be of some interest in studying the nature of thunderstorms in connection with cyclones."

Part III: On the physical nature of thunderclouds: "the inner structure of clouds is very complex, of irregular forms, consisting of many masses of clouds separated from one another by thin clouds. From observations of lightning flashes it was concluded that the conductivity of a dense cloud is greater than that of dry air in the laboratory. From laboratory results it is estimated that about 300m above the ground the effect of barometric pressure on lightning discharges decreases 30%. The space-charge density and the voltage of a cloud element due to the charge on it were calculated. . . . The attainable voltage of cloud elements due to the charge carried by themselves, thus obtained, was under several volts. The foregoing results are favourable to the theory proposed by Dr. T. Terada and Dr. T. Kobayasi. The distribution of charge in thunderstorms was investigated. Judging from actual changes under thunderclouds, these clouds probably consist of many masses with different signs, the typical form suggested by G. C. Simpson or C. T. R. Wilson not being numerous in actual thunderstorms." Part IV deals with impurities in rain-water and snow.

961. Electrical Conductivity of the Air at Points [frequently] struck by Lightning.—G. Viel: Dauzère. (*Rev. Gén. de l'Élec.*, 15th Dec. 1934, Vol. 36, No. 24, pp. 837–841.) Experimental confirmation of Dauzère's theory (1933 Abstracts, p. 441.)

962. Lightning Strokes and Buildings.—Ch. Morel. (*Bull. Assoc. suisse des Élec.*, No. 24, Vol. 25, 1934, pp. 652–657.)

963. Review of the Progress in the Study of Thunderstorms and in the Protection of Electrical Installations against Over-Voltages.—K. Berger. (*Bull. Assoc. suisse des Élec.*, No. 24, Vol. 25, 1934, pp. 641–652.)

964. Impulse Flashover of Suspension Insulators and Rod Gaps [New Data for Negative and Positive Waves].—G. D. Heye. (*Gen. Elec. Review*, December, 1934, Vol. 37, No. 12, pp. 548–550.)

965. On the After-Discharge and the Back-Discharge Figures, *and* A Study of the Discharge from Positive Electrodes.—Mochizuki and Imanishi: Shioya. (*Journ. I.E.E. Japan*, October, 1934, Vo. 54 [No. 10], No. 555, pp. 1059–1062 and 1062–1067: English summaries pp. 120–121 and 121–123.)

966. Contributions to a Study of the Nature of the Oscillating Spark Discharge [Number of Partial Discharges and Total Duration].—I. C. Purcaru. (*Zeitschr. f. Physik*, No. 5/6, Vol. 93, 1935, pp. 315–319.) For previous work *see* 44 of January.

967. Observing the Solar Corona [by Television Technique].—A. M. Skellett. (*Bell Lab. Record*, December, 1934, Vol. 13, No. 4, pp. 113–116.) *See* also 1934 Abstracts, p. 610.

968. Light of the Night Sky [Excitation of Auroral Green Line in Rapidly Interrupted Discharge].—J. Kaplan. (*Nature*, 9th Feb. 1935, Vol. 135, p. 229.) For previous work *see* 1931 Abstracts, pp. 494 and 609.

969. [Data of] Luminous Night Clouds over Norway in 1933 and 1934 [Clouds due to Cosmic Dust].—C. Störmer. (*Nature*, 19th Jan. 1935, Vol. 135, pp. 103–104.) *See* also 1934 Abstracts, p. 553.

PROPERTIES OF CIRCUITS

970. Beat Notes, Combinational Tones, and Sidebands [with Oscillating Radio and Acoustic Circuits].—H. Hazel. (*Phil. Mag.*, January, 1935, Series 7, Vol. 19, No. 124, pp. 103–114.)

This paper refers to the "sideband controversy" of 1928–1931 (*see* for example G. W. O. H., Abstracts, 1930, p. 570; Moullin, Colebrook, Robinson, 1931, p. 440; Robinson, Fortescue, 1932, p. 36) and describes experiments on the simultaneous reception of radio or acoustic oscillations, using devices of linear aperiodic response to analyse complex disturbances into their periodic components. Stress is laid upon the difference between " beat tones " produced by " mere addition of frequencies," which elicit no response in detecting devices tuned to their frequency, and " combination tones " or " sidebands," the result of modulation (defined as " the multiplication of one periodic disturbance by another "), which can be secured in either linear or non-linear circuits. The writer is of the opinion that much of the controversy was really due to " the illegitimate use of non-linear elements in detecting apparatus."

971. NOTE ON THE THEORY OF THE WAVE TRAP OR REJECTOR CIRCUIT [and the Asymmetry of Its Selectivity].—F. Klutke. (*Hochf:tech. u. Elek:akus.*, January, 1935, Vol. 45, No. 1, pp. 19–20.)

The writer has already shown (1934 Abstracts, pp. 37–38) that if the wave trap is adjusted by a variable condenser C_v, the inductance L and the incoming frequency ω being constant, the complex resistance reaches a maximum when $C_v = L/(R^2 + \omega^2 L^2)$; this maximum is L/C_vR. If, on the other hand, the adjustment is by means of a variometer L_v, the maximum is reached when $C = L_v/(R^2 - \omega^2 L_v^2)$ and its value is L_v/CR. If, now, both capacity and inductance remain fixed and the frequency is varied, the first arrangement gives $\omega = \omega_0\sqrt{1 - R^2 . C_v/L}$ . . . . (18) and the second gives $\omega = \omega_0\sqrt{1 + R^2 . C/L_v}$ . . . . (19), where $\omega_0 = 1/\sqrt{CL}$. This difference, which is very small for ordinary circuits in the broadcast band, has the following significance :—

If the wave trap is tuned to a frequency ω by a variable condenser, the relation (18) holds good. On varying ω it is then found that the wave-trap resistance for increasing frequencies first increases, reaches a maximum for a frequency $\omega = \omega_0 = 1/\sqrt{LC}$, then becomes again equal to L/CR at the frequency given by (19), and then quickly decreases. But if the wave trap is tuned by a variometer, the relation (19) holds good. Then on *decreasing* ω the resistance first increases, reaches a maximum when $\omega = \omega_0$, and decreases after passing through the frequency given by (18). Thus the selectivity of the wave trap is asymmetrical : if capacity-tuned, the higher frequencies near the " tuning " frequency are cut; if variometer-tuned, the lower frequencies. The breadth of the frequency band for which the wave trap has a higher resistance than for the " tuning " frequency, is given in good approximation by $\Delta\omega = R^2 . C/L . \omega_0$. It can also be shown that with the capacity-tuned trap the resonance resistance L/C_vR is a pure non-reactive one, while with the variometer-tuned trap the maximum of the non-reactive (energy) component of the resistance (reached when $1/\omega C = \omega L$) is also L/CR, but L has here a value different from that when the maximum complex resistance is tuned to.

972. MATRICES APPLIED TO THE MOTIONS OF DAMPED SYSTEMS [Method of Calculation Applicable to Circuits with Resistance].—W. J. Duncan and A. R. Collar. (*Phil. Mag.*, February, 1935, Series 7, Vol. 19, No. 125, pp. 197–219.) Continuation of paper referred to in 1934 Abstracts, p. 397.

973. ON THE CHARACTERISTICS OF DISSIPATIVE TRANSMITTING NETWORKS [New Method of Calculation].—Z. Kamayachi. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 19–20 : short summary only, in English.) For an approximate method *see* 1934 Abstracts, p. 611.

974. THE LOW-PASS AND HIGH-PASS FILTER [Degree of Filtering known from Transformation Ratio, by converting Formula to that of Equivalent Transformer Circuit : etc.].—K. Hashida and Y. Takashima. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 19 : summary only, in English.)

975. RELATION BETWEEN LOSS-FACTOR OF INDUCTANCE COIL AND RELATIVE BAND-WIDTH OF THE BAND-PASS FILTER.—Y. Watanabe and Z. Kamayachi. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 42 : summary only, in English.)

976. A NOMOGRAM FOR THE BAND-PASS FILTER (Zobel Type).—A. T. Starr and H. C. Hall. (*Journ. I.E.E.*, December, 1934, Vol. 75, No. 456, pp. 749–754.)

" This paper gives a method for calculating the attenuation of the eight [Zobel] types of sections by means of a nomogram, so that the preliminary calculations can be made very quickly and easily and then the detailed calculation of Zobel can be applied to the final structure. The method employed simplifies the problem of design considerably."

977. ON A NEW METHOD OF BAND-PASS FILTERS AND AMPLIFIERS AS LATTICE TYPE.—H. Nukiyama. (*Journ. I.E.E. Japan*, December, 1934, Vol. 54 [No. 12], No. 557, pp. 1288–1292 : Japanese only.)

978. A NEW THEOREM IN OPERATIONAL CALCULUS TOGETHER WITH AN APPLICATION OF IT [Extension of van der Pol's Theorem : Application to Low-Pass Filter taking Resistance of Coils into Account].—J. P. Schouten. (*Physica*, January, 1935, Vol. 2, No. 1, pp. 75–80.) For van der Pol's theorem *see* 1934 Abstracts, p. 556 (two).

979. ON THE DESIGN OF RETARDATION NETWORKS.—K. Nagai and R. Kamiya. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts pp. 42–43 : summary only, in English.) For previous papers *see* 1933 Abstracts, p. 97 (two).

980. CALCULATION OF THE UNDISTORTED MAXIMUM OUTPUT OF A TRIODE POWER AMPLIFIER WHEN THE LOSS IN COUPLING DEVICE [Transformer or Choke] IS TAKEN INTO ACCOUNT.—Y. Fukuta. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 16 : short summary only, in English.)

981. Contribution to the Experimental Study of Ferro-Resonance.—E. Rouelle. (*Rev. Gén. de l'Élec.*, 24th November, 1st, 8th and 15th December, 1934, Vol. 36, Nos. 21/24, pp. 715–738, 763–780, 795–819 and 841–858.)
For *Comptes Rendus* Notes *see* 701 of March.

982. Fundamental Considerations on Mechanisms of Various Oscillators [Relaxation].—R. Usui. (*Journ. I.E.E. Japan*, September, 1934, Vol. 54 [No. 9], No. 554, pp. 975–984: English summary pp. 110–111.) Extension of previous papers on negative-resistance oscillators—*see* 1934 Abstracts, p. 266.

983. Low-Frequency Relaxation Oscillations in Resistance-Coupled Amplifiers.—A. B. Sapojnikov and E. A. Vilks. (*Izvestia Elektroprom. Slab. Toka*, October, 1934, No. 8, pp. 20–25.)

A mathematical investigation is given of the conditions under which low-frequency oscillations appear in a three-stage resistance-coupled amplifier using a common anode-supply battery. Formula (16) indicates that these oscillations occur when $I_0R_0 > V_2$, where I_0R_0 is the potential drop in the battery and V_2 is the grid potential due to the drop in the grid leak of the second stage. It also follows from (16) that the smaller the value of the second coupling resistance, and of the grid leaks (the first valve is assumed to have a "free" grid), the larger must be R_0 for the oscillations to appear. A number of experiments were carried out using a variable resistance in series with the anode battery, and some of the curves obtained are shown. These experiments seem to bear out the theory in particular for high values of the grid leaks (of the order of 500000 ohms). The curves also show that the frequency of oscillation increases when either R_0 or the anode voltage is decreased; also that when the filament voltage is varied this frequency passes through a minimum which for different circuit conditions always occurs at the same filament voltage.

984. On the Design of Mechanical Oscillating Systems.—A. A. Harkevich. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 4, 1934, pp. 1142–1156.)

A discussion on the new theory of the analogy between mechanical and electrical oscillating systems proposed by Hähnle (Abstracts, 1932, p. 636), and Firestone (1934, p. 204). It is pointed out that although the basic theory is very valuable the method of considering equivalent electrical circuits presents no advantage for mechanical systems with cross connections, and cannot be applied at all to systems in which angular and linear displacements take place simultaneously. A number of examples of the latter kind are given, and are solved on the basis of the theory but without recourse to equivalent electrical circuits.

TRANSMISSION

985. Electronic Theory and the Magnetron Oscillator.—W. E. Benham. (*Proc. Phys. Soc.*, 1st Jan. 1935, Vol. 47, Part I, No. 258, pp. 1–52: Discussion pp. 52–53.)

This paper extends the writer's previous analysis (1931 Abstracts, p. 212) to include any degree of space-charge limitation and the effect of a constant magnetic field. Initial velocities and accelerations are also considered and the general solution for the steady state derived, starting from the initial equations of motion of a selected particle. The condition for the critical magnetic field (in which the electrons are just brought to rest at the anode) is worked out; for magnetic fields in excess of this value, the turning-point of the electrons and the potential-distribution are found. The latter is only slightly influenced by the magnetic field. A discussion is given of the prolongation of transit time by space charge and the magnetic field. The ultra-dynamic condition implied by the presence of rapidly alternating currents is treated mathematically in §§ 5 and 6, where the aim is to arrive at a complete solution for the a.c. component of electron velocity, the "alternating velocity," in terms of the a.c. current itself. The alternating potential at the critical plane is shown in Figs. 4 and 5, which lead to a discussion of the oscillatory properties of the planar magnetron. The effect of cathode temperature on oscillation intensity is also considered; the theoretical optimum operating temperature corresponds to an anode current of roughly half the saturation value. The formation and nature of "virtual" cathodes is finally discussed.

986. Transmission and Reception of Centimeter Waves [Micro-Waves of 9cm, from New Split-Anode ("End-plate") Magnetron giving 2.5 Watts: Measuring Methods: Inverse Distance Law obeyed up to 16 Miles Line-of-Sight: Modulation by Transmission through Ionised Gas: Various Detectors, including Special Split-Anode Magnetron and Crystals].—I. Wolff, E. G. Linder, and R. A. Braden. (*Proc. Inst. Rad. Eng.*, January, 1935, Vol. 23, No. 1, pp. 11–23.)

The use of the "end-plate" is to apply an electrostatic field along the filament axis so as to draw the electrons out to the ends of the anodes. Hitherto this had to be accomplished by tilting the tube so that the filament was at 3–10 degrees to the magnetic field, but with the new arrangement the filament can be parallel to the field. The transmission line from the split anodes is short-circuited close to the anodes by a straight bar: this prevents the formation of long-wave parasitic oscillations and stabilises the 9cm waves by providing a small looped circuit tuned to their frequency. For the ionised-gas modulation method *see* 1934 Abstracts, p. 495.

987. The Standing-Wave [Ultra-Short-Wave] Oscillator and the Vacuum-Tube Position [Wavelength Shortened by connecting Valve near Centre of System].—M. Mori. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 16: summary only, in English.)

988. Generation and Utilisation of Ultra-Short Waves in Radio Communication [Frequency Stabilisation by Flywheel Action of "High-Q" External Circuit: Sayville and Southampton to Manhattan Results on 5.83 Metres—48 and 86 Miles to City Office: etc.].—F. A. Kolster. (*Proc. Inst. Rad. Eng.*, December, 1934, Vol. 22, No. 12, pp. 1335–1353.)

For a preliminary paper on the copper "tophat" oscillatory circuits *see* Abstracts, 1934, p. 378. The radiated power was about 200 w. At the longer range the receiving aerial was about 3000 ft below the line of sight, or 2000 ft allowing for atmospheric refraction in average conditions. At this range, day-to-day variations of signal strength were found and occasional short periods of fading during the day (explained on Jouaust's variable atmospheric refraction basis—1931, p. 317). Over a period of a week the Southampton signals in the city office were generally well above the noise level: on a few occasions they dropped to that level, but only rarely did they completely disappear. Calculations indicate that if the transmitting aerial were raised to 350 ft the minimum signal strength would be about equal to the present average; a better method would be to use a beam aerial of moderate height. At the shorter range (from Sayville) very strong and remarkably steady signals were obtained.

989. A PORTABLE B-TYPE ULTRA-SHORT-WAVE TELEPHONE SET [Transceiver, changing over by Raising or Lowering Anode Voltage: Grid connected directly to Plate through High Resistance: for 5.28 m Wave].—Ohtaka and others. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 47: summary only, in English.) *See* also summary of paper by Ohtaka alone, on same page.

990. AN ELECTRON OSCILLATOR WITH PLANE ELECTRONS [and "Backing-Plate": for B.-K. Micro-Waves].—B. J. Thompson and P. D. Zottu. (*Proc. Inst. Rad. Eng.*, December, 1934, Vol. 22, No. 12, pp. 1374–1385.) The full paper, a summary of which was dealt with in 1934 Abstracts, p. 384, l-h column.

991. EXPERIMENTS WITH INVERTED DIODES HAVING VARIOUS FILAMENT CATHODES [for Micro-Waves].—J. S. McPetrie. (*Phil. Mag.*, February, 1935. Supp. No., Series 7, Vol. 19, No. 126, pp. 501–551.)

These diodes were referred to in 1934 Abstracts, p. 325. The present paper describes experiments demonstrating that "the velocity of emission of the electrons from the cathodes is not an important factor" in the determination of the oscillating properties of these diodes. The oscillations must be due to direct transit of electrons between the electrodes.

992. THE ELIMINATION OF UNWANTED OSCILLATIONS IN MICRO-WAVE GENERATORS WITH BRAKE-FIELD CIRCUIT.—O. Pfetscher and K. Müller. (*Hochf:tech. u. Elek:akus.*, January, 1935, Vol. 45, No. 1, pp. 1–11.)

The great objection, for practical use, to the brake-field circuit is its multiplicity of frequencies. Thus with spiral-grid valves (section B1), although by various devices—such as leading out the two ends of the grid by parallel wires forming the beginning of a Lecher-wire pair (Fig. 1b) or by leading them out in opposite directions to form one side of a Lecher system whose other side is formed by a second electrode system, in push-pull, in the same bulb (Figs. 1c and 2)—simple relations between wavelength and the stretched length of grid can be obtained, nevertheless the desired single-wave condition is not reached. Hollmann's circuit (Fig. 3a), with grid and anode connected at both ends to Lecher wires symmetrically bridged by condensers and the grid short-circuited, for symmetry, by a longitudinal strap, or constructed in rod form instead of spiral, is said to give as a rule only two frequency zones, and a recent Telefunken valve (Fig. 4) for waves around 50 cm and comparatively high power, used in this circuit, has been claimed to have only one degree of freedom. The writer's tests, however, lead him to conclude that, even when the heating circuit is stabilised by being converted into a tuned Lecher-wire system, the arrangement has several possible frequencies owing to the existence of several circuits—a primary system inside the bulb, a loosely coupled heating circuit, and the tightly coupled grid/anode Lecher systems on either side. In addition there is the possibility of the electron mechanism forming another coupled system with a period of its own (King, Abstracts, 1932, p. 637).

These results lead to the conclusion that the simplest possible system should be aimed at and that the valve should be designed for one practically fixed wavelength, the accurate tuning being accomplished with the help of a variable coupled "secondary" circuit (grid tapping and heating circuit, pp. 9–10, not 26 as stated at the end of p. 5: *see* also later). The writer has therefore constructed a number of valves for different wavelengths from 18 to 64 cm, all on the same design and all with 17 mm anode diameter and 5 mm grid diameter. According to this design the whole primary circuit was enclosed in the bulb and was made up of a length of concentric conductor (*cf.* Mouromtseff and Noble, 1932, p. 636); all supports were made of quartz rod, and wherever metallic parts (springs, etc.) were unavoidable they were electrically separated from the oscillatory system. The double (concentric) conductor was made up of concentric molybdenum cylinders which, at the required point, formed the anode and grid, the latter being perforated with longitudinal slits. The axial filament was of about the same length as the electrode-forming parts of the conductors, and its leads were brought out at right angles to the axis, holes being presumably provided in the cylinders to allow for their passage. The first and simplest version of the design was the $\lambda/4$ system of Fig. 10, where the electrodes were formed by the open end of the concentric conductor, the other end being closed with a capacity. The geometrical length was 12.9 cm, and the fact that the wavelength was 56 cm, instead of $4 \times 12.9 = 51.6$ cm, was due to the capacitive effect of the quartz supports at the ends. The only other wave found was a very feeble one of 64 cm (probably due to reflection), the harmonics being apparently suppressed.

The next variation tried was a $\lambda/2$ system (Fig. 11), each end of the conductor being capacitively closed by a mica condenser of about 1000 cms. Only one wave was found, the 56 cm fundamental: the wavelength calculated from the geometrical data was in this case 55.4 cm. Here at last the desired single-wave condition, conforming with the geometrical dimensions, seems to have been attained. This was confirmed by the construction of a smaller valve (Figs. 12 and 13) for a 20 cm wave. Fig. 14 shows, with this valve, that the effect of heating-circuit tuning on the wavelength is very small, and also that the r.f. currents in the heating circuit pass through very marked maxima which decrease as the Lecher-pair length increases, owing to the increasing radiation resistance.

The next step was to eliminate the necessity for the mica condensers. This aim, together with other advantages, was attained by the push-pull $\lambda/2$ valve of Fig. 15, where a single length of concentric conductor, with electrodes at either end, was used. The output was brought out by a loop from the grid-tube tapped symmetrically on either side of the neutral point. This also was a successful arrangement, only one wave (24.5 cm) being given: the concentric tube was 12.5 cm long. The next valve (Fig. 16) was a variation of the last, the concentric conductor being bent at the point of symmetry so as to form a U-shaped resonator. This had several advantages: thus the two filaments were brought close together so that the two heating systems could be combined into one low-damped parallel-wire system, and the grid-tube tappings (for leading out the output: their positions are shown by two small circles) were brought so close that they could be prolonged as a Lecher pair with low radiation. There was a single band of wavelengths around 63 cm, the geometrical value being 58 cm; the excess was probably due to a quartz support at the ends. Fig. 17 shows how the tuning of the grid tapping and the heating circuit affects the wavelength, etc. This point, and the formation of a second (coupling) wave, is discussed on p. 9. The schematic picture (Fig. 19) of the primary circuit with its grid tapping *EDF* shows that the tapping circuit *DECFD* is coupled to the U-shaped circuit by the common length *ECF* and has its resonance (as trial showed) when adjusted so that the length *CED* is about $\lambda/2$. For reasons given in the first paragraph of p. 10 it is desirable to make the grid tapping system as short as possible, not longer than $\lambda/2$. If a longer double line is wanted for conveying the output, it may be coupled inductively (Fig. 20).

The curves of all these new valves show that in certain regions a simultaneous variation of grid and anode voltages produces almost proportional amplitude changes without altering the wavelength. Thus Clavier's modulation method for spiral-grid valves (1934, p. 514) can be applied without modification to the new valves. The final section of the paper deals with another variation of the general design, a push-pull combination of two "closed" $\lambda/2$ systems (Fig. 22), by which the necessity for the mica condensers is again avoided and also the radiation from the heating leads is reduced to a minimum. With such valves the energy in the heating circuit is about equal to that in the grid tapping, so that the latter can be dispensed with, although in the valve pictured such a tapping is provided.

993. ON THE THEORY OF THE BARKHAUSEN-KURZ [Micro-Wave] OSCILLATIONS.—H. Alfvén. (*Phil. Mag.*, February, 1935, Supp. No., Series 7, Vol. 19, No. 126, pp. 419–422.)

A note pointing out that a study of the behaviour of a valve in the pre-oscillating condition will probably give the key to the whole B.-K. problem (*cf.* 1933 Abstracts, pp. 619–620). At a constant emission, the valve acts as a positive resistance at certain grid and anode voltages and as a negative resistance at other voltages. Negative resistances are found for several different voltage ranges and these correspond to the normal waves and the dwarf waves respectively. These phenomena seem to be inexplicable by Gill's theory (94 of January). The behaviour can be explained on a theory already given by the writer (Alfvén, *Uppsala Universitets Arskrift*, 1934), in which however the effect of space-charge is neglected.

994. SOME NOTES ON THE [Micro-] WAVELENGTH EQUATION OF BARKHAUSEN AND KURZ [and Formulae for Minimum and Maximum Wavelengths and for corresponding Grid Voltages].—S. Sonada. (*Journ. I.E.E. Japan*, December, 1934, Vol. 54 [No. 12], No. 557, pp. 1271–1277: English summary p. 148.)

995. SOME EXPERIMENTS ON MICRO-WAVE OSCILLATION OF TRIODES EACH HAVING AN INTERNAL FILAMENT-CONDENSER [More Stable Oscillation and Increased Output: No Effect on Wavelength: Optimum Relations between Grid and Anode Voltages].—S. Ohtaka. (*Journ. I.E.E. Japan*, December, 1934, Vol. 54 [No. 12], No. 557, pp. 1277–1281: English summary p. 149.)

996. ON ELECTRONIC OSCILLATION OF TRIODES WITH THE SO-CALLED B-TYPE CIRCUIT [Anode and Grid bridged with High Resistance: for Ultra-Short and Micro-Waves: a Link between Diode and Triode Electronic Oscillations].—S. Ohtaka. (*Journ. I.E.E. Japan*, December, 1934, Vol. 54 [No. 12], No. 557, pp. 1282–1288: English summary p. 149.)

997. THE ELECTRONIC OSCILLATION [B.-K., G.-M., and Potapenko "Dwarf" Micro-Waves] AS A STANDING WAVE IN AN ORGAN PIPE.—R. Usui. (*Journ. I.E.E. Japan*, November, 1934, Vol. 54, [No. 11], No. 556, pp. 1213–1219: long English summary pp. 140–141.)

998. A METHOD OF DISTINGUISHING DWARF WAVES FROM PIERRET'S OSCILLATIONS [Micro-Waves].—S. Sonoda. (*Journ. I.E.E. Japan*, October, 1934, Vol. 54 [No. 10], No. 555, p. 1115: Japanese only.)

999. ON ELECTRONIC OSCILLATIONS OF ULTRA-SHORT WAVELENGTH IN TRIODES [Special Concentric-Electrode Triodes for Micro-Waves: Wavelength independent of External Grid Circuit: Potapenko's Formula Satisfied: etc.].—I. Yamamoto and Y. Degawa. (*Journ. I.E.E. Japan*, July, 1934, Vol. 54 [No. 7], No. 552, pp. 734–738: long English summary pp. 91–92: abbreviated summary, without diagrams, in *Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 20–21.)

1000. The Modulation of Ultra-Short-Wave Transmitters [Heising-Latour Parallel-Valve Method Best: Grid Modulation nearly as Good: Anode Modulation Unsatisfactory].—W. Möller. (*Radio, B., F. für Alle*, January, 1935, No. 1, pp. 2–8.) *See* also 659 of March.

1001. The Short-Wave Transmitters of the German Broadcasting Company [Portable and Mobile, for Outside Broadcasts: Wavelengths 50–120 m].—W. Nestel. (*E.T.Z.*, 6th Dec. 1934, Vol. 55, No. 49, pp. 1195–1197.)

1002. A General Purpose 50-Watt Transmitter [Five-Band: with Self-Neutralising Buffer, Full-Wave Doubling, and Permanently Neutralised Push-Pull Amplifier].—G. Grammer. (*QST*, January, 1935, Vol. 19, No. 1, pp. 16–21 and 96, 98, 99.)

1003. The Valve Generator with Retroactive Coupling.—F. Tank. (*Bull. Assoc. suisse des Élec.*, Nos. 18 and 21, Vol. 25, 1934, pp. 500–503 and 571–573.) To be continued.

1004. Further Studies on the Duodynatron Oscillator [Distortionless 100% Modulation of R.F. by L.F. Oscillation: Synchronisation by Mutual Couplings between Inner-Grid and Anode Oscillations: Effect of Filament Temperature: etc.].—T. Hayasi. (*Journ. I.E.E. Japan*, December, 1934, Vol. 54 [No. 12], No. 557, pp. 1258–1264: English summary p. 145.)

1005. Frequency Stability of the Duodynatron Oscillator [and Its Suitability as a Stable Beat-Frequency Oscillator: the "Mutual Frequency Variation"].—T. Hayasi. (*Journ. I.E.E. Japan*, December, 1934, Vol. 54 [No. 12], No. 557, pp. 1265–1270: English summary pp. 146–148.)

1006. Simultaneous Generation of the Electron Oscillation and the Dynatron Oscillation with a Single Triode.—T. Sugimoto. (*Journ. I.E.E. Japan*, September, 1934, Vol. 54 [No. 9], No. 554, p. 1019: Japanese only.)

1007. Electron-Coupled Oscillation excited by the ["Outer Grid"] Dynatron "Kippschwingung," and a New Method of generating Oscillation of Sharply Peaked Wave Form.—T. Hayasi. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, pp. 81–88.) In English. *See* 1934 Abstracts, p. 613, r-h column: for the writer's paper on the "outer grid" (electron-coupled) dynatron *see* the next abstract in same column.

1008. On the Modulation of Tetrode Valves.—R. V. Lvovich and V. P. Verhovtsev. (*Izvestia Elektroprom. Slab. Toka*, October, 1934, No. 8, pp. 1–9.)

One way of indicating the operating conditions of a triode is to give the value of

$$\nu = (V_g - E_{g0})/E_a(1 - \xi),$$

where V_g is the amplitude of the grid swing, E_{g0} the grid bias, E_a the steady anode voltage, and ξ the ratio of peak anode voltage swing to steady anode voltage. It is known from experience that when $\nu > 0.8$ (or < 0 when $\xi > 1$) the valve is overloaded and troughs appear at the peaks of the anode-current curve.

The corresponding expressions for a tetrode giving the operating conditions with regard to the screen grid (ν_1) and control grid (ν_2) respectively are:

$$\nu_1 = E_u/E_a(1 - \xi) \text{ and } \nu_2 = (V_g - E_{g0})/E_u,$$

where E_u is the steady screen-grid voltage. Experiments and inspection of characteristic curves show that the critical values for ν_1 and ν_2 are the same as for ν in the case of a triode, *i.e.* 0.8. A tetrode can thus be operated under one of the following four conditions: (*a*) underloading, when $0 < \nu_1 < 0.8$, and $0 < \nu_2 < 0.8$; (*b*) overloading with respect to the screen grid, when $\nu_1 > 0.8$ or < 0, and $0 < \nu_2 < 0.8$; (*c*) overloading with respect to the control grid, when $0 < \nu_1 < 0.8$ and $\nu_2 > 0.8$ or < 0; or (*d*) overloading with respect to both grids, when $\nu_1 > 0.8$ or < 0 and $\nu_2 > 0.8$ or < 0.

The possibilities of various systems of modulation with a tetrode are next examined in detail, and the following conclusions reached:—(1) For grid modulation the tetrode must be operated under condition (*a*). (2) Condition (*b*) is most suitable for anode modulation. (3) Modulation on the screen grid is possible under condition (*c*) but is not recommended in view of the tendency of the valve to oscillate. (4) Simultaneous modulation on two electrodes presents difficulties and is not recommended. A number of experiments were carried out to check the above conclusions and the modulation curves obtained are shown.

1009. On the Modulating and Operating Characteristics of R.F. Amplifying Valves [Analysis: Method of selecting Parameters of Valves for Plate or Grid Modulation or for Amplification of Modulated R.F. Currents, for Given Output and Depth of Modulation: Experimental Confirmation: Modulation Differences between Low-Emission and High-Emission Valves: etc.].—A. Marino. (*Alta Frequenza*, October, 1934, Vol. 3, No. 5, pp. 541–597.)

1010. Magnetically Modulated Valve Oscillator [with Conical Anode for Linear Modulation].—F. J. Elser. (U.S.A. Pat. 1 957 327, pub. 1.5.1934: *Hochf:tech. u. Elek:akus.*, January, 1935, p. 34.)

1011. 'Phone Transmission with Voice-Controlled Carrier Power [" Floating Carrier " System using Class B Plate Modulation to control Carrier Power].—G. W. Fyler. (*QST*, January, 1935, Vol. 19, No. 1, pp. 9–12.)

1012. Energy-Economising Modulation Methods [SIF, SFR (Chireix), Lorenz, Push-Pull Class B, Floating Carrier].—H. Wehrlin. (*Bull. Assoc. suisse des Élec.*, No. 23, Vol. 25, 1934, pp. 626–628.)

1013. A Method of Modulation with Pentode [giving Suppressed - Carrier Transmission without other Special Device].—S. Chiba and T. Okabe. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts pp. 43–44 : summary only, in English.)

1014. On Frequency Modulation by Phase Rotation of Feeding-Back Voltage.—S. Narumi and M. Ichimasu. (*Journ. I.E.E. Japan*, June, 1934, Vol. 54 [No. 6], No. 551, pp. 539–541 : English summary pp. 73–74.)

1015. Observation of Phase Modulation with the Braun Tube.—Sakamoto, Ide and Yamamoto. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 23 : summary only, in English.)

1016. A System of Phase Modulation and Its Application to Picture Transmission.—Y. Niwa and T. Inokuti. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 31 : short summary only, in English.)

1017. A High-Speed Transmitter utilising a Hot-Cathode Thyratron [capable of 6 000 Letters per Minute : using Marking and Spacing Photocells].—K. Kondô. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 26–27 : summary only, in English.)

1018. Better Crystal Stability without a Heater Oven.—E. L. Dillard. (*QST*, January, 1935, Vol. 19, No. 1, pp. 34 and 74, 76, 78, 80.)

1019. Away with Quartz Control for Short- [and Ultra-Short] Wave Transmitters !—N. Werner. (*Radio, B., F. für Alle*, December, 1934, No. 12, pp. 185–188.)

1020. On the Frequency Variation of the Commercial Short-Wave Radio Transmitter [and the Abolition of Thermostatic Control].—I. Koga and M. Nagaya. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 25–26 : summary only, in English.) *See* also 1021.

1021. Thermal Characteristics of Piezo-electric Oscillating Quartz Plates [Zero Temperature Coefficients, for Short- and Long-Wave Transmitters, by Use of Very Thin Plates of Special Cut].—I. Koga. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, pp. 61–76.)

In English. The oscillators arrived at from these researches have been so successful that the Japan Wireless Telegraph Company decided in March, 1934, to replace their old thermostat-controlled oscillators by the new oscillators and their associated circuits (*see* 1020), and all Japanese fixed stations " are on the point of undergoing the same improvement." The long-wave plates are going to be employed in a precision frequency meter, and in a crystal clock of extremely stable frequency. Dealing first with short-wave oscillators, the writer refers to his previous papers on " thickness vibrations " (Abstracts, 1933, p. 632) : the theoretical result, that the influence of temperature on the frequency is dependent on θ, the co-latitude of the normal to the principal surfaces (cut parallel to the electrical axis), is confirmed by the experimental data in table 1, which also shows that for $\theta \approx 55^\circ$ and 138° the temperature coefficients became zero (just before changing sign). From these and similar data the temperature coefficients of the adiabatic elastic constants were determined, from which the temperature coefficients of frequency for any values of θ may be calculated (*see* Fig. 4 for the close agreement of calculated and observed values). The second differential coefficients of the adiabatic elastic constants are then determined (p. 65). Section 4 stresses that the results are only true if the plates are sufficiently thin compared with the dimensions of the principal surfaces. Using plates 25 mm × 30 mm the writer investigates the variation with thickness of both frequency and temperature characteristics (table IV and Fig. 5), going down to thicknesses of the order of 0.55 mm for frequencies around 5 Mc/s.

Section 5 deals with long-wave oscillators, also cut with one side parallel to the electrical axis ; section 6 with the method of determining the orientation of the principal planes and of checking (with an X-ray spectrometer) the correctness of the standard plates. Section 7 describes the method of measuring the variation of frequency with temperature, and section 8 deals with the practical applications and actual results. The quartz plate container is used in a slanting position so that the plate rests by gravity against a corner of the spacing washer : a change-over of frequency is obtained by slipping a different plate into the container, the upper electrode being adjustable so as to give a fixed air gap. For an English summary of a previous paper, by Koga and Takagi, *see* same journal, Abstracts p. 22.

1022. Quartz Plates with a Very Small Temperature Coefficient of Oscillation Frequency [X-Cut Plate with Special Orientation with respect to Y Axis].—S. Matsumura and S. Kanzaki. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, pp. 105–108.)

In English. For previous work *see* 1933 Abstracts, p. 514. " There exists an optimum dimensional ratio in order to give a minimum temperature coefficient of frequency for each value of ϕ with respect to the Y axis. For example, when $k = 0.5$ and $\phi = -20^\circ$, the temperature coefficient of frequency is less than -1×10^{-6}."

1023. Practical Operating Advantages of Low Temperature - Frequency Coefficient Crystals [particularly the " V-Cut " Crystal].—F. C. Baldwin and S. A. Bokovoy. (*QST*, January, 1935, Vol. 19, No. 1, pp. 26–27 and 92.)

RECEPTION

1024. Circuits for the Elimination of Atmospheric Interference with the Reception of Radio-Telegraph Signals.—V. G. Volpian. (*Izvestia Elektroprom. Slab. Toka*, October, 1934, No. 8, pp. 26–38.)

The following atmospheric suppression circuits were tested, in conjunction with a superheterodyne receiver of wave-range 2000–18000m and band-widths of 250 and 700c/s in the r.f. and i.f. amplifiers respectively (on a 12 000 m wave):—(A) Limiter and time-delay circuit, a three-valve arrangement with the property that however great the atmospheric amplitude may be the undulator will not mark unless the atmospheric lasts longer than a pre-determined time. A complete analysis of this circuit is given, with a numerical example. (B) Non-linear frequency-dividing circuit. The theory was given by Mandelstam and Papalexi (1932 Abstracts, pp. 279–280). A push-pull version of the circuit was used. Inspection of the curves representing the equations of such a circuit shows that signals of short duration would not produce oscillations strong enough to work the undulator. (C) Low-frequency band-pass filter, 3-section lattice type, with cross elements each consisting of a condenser and inductance in series, for a frequency of 1260c/s and a band-width of 220c/s. This width is suitable for telegraphy up to 275w.p.m., while for more usual speeds such as 150w.p.m. a band-width of 120c/s is sufficient.

Calling the proportion of signals mutilated by atmospherics 100% when no eliminating circuit is in use, it was found that circuit A reduced this to 44%, circuit B to 20%, and circuit C to 5%. The most suitable circuit is therefore the l.f. band-pass filter.

1025. Electrical Interference with Broadcasting: Interim Report of the Committee to the Council.—(*Journ. I.E.E.*, December, 1934, Vol. 75, No. 456, pp. 801–806.)

General: compulsory *versus* voluntary suppression. Appendix I: the effect of different receivers on interference ratios (screened receivers: response range of frequencies: square-law and linear detectors: straight and superheterodyne: AVC: listening volume): review of possible steps which listener can take. Appendix II: Report of International Special Committee. Section I iii of this states that for interference-free reception it is desirable that the level of interference should be 40db lower than the mean level of "the wanted signal defined above, *i.e.* of a field of 1mv/m modulated at 20%." This cannot at present be assured to listeners, "practical values proposed by different delegations being equivalent to 21, 21.5, and 30.5db." The French, German and British methods of measurement are defined.

1026. The Measuring-Technique Foundations for the Radio Interference Definition of the SEV.—E. Aubort and W. Gerber. (*Bull. Assoc. suisse des Élec.*, No. 24, Vol. 25, 1934, pp. 669–670.)

The SEV definition of "intolerable interference" (when its audibility exceeds that of a signal received with a field intensity of 1mv/m modulated to a depth of 5% at a frequency of 1000c/s: except for short intermittent disturbances—*see* 1027) differs from the definitions given by other countries. The reasons leading to the SEV definition are here given.

1027. Directions for the Protection of Radio Receiving Installations against the Radioelectric Interference caused by Heavy- and Light-Current Installations.—ASE and UCS. (*Bull. Assoc. suisse des Élec.*, No. 24, Vol. 25, 1934, pp. 675–676.) Amendments to the proposals referred to in 1934 Abstracts, p. 561, l-h column. *See* also 1026.

1028. The Fight against Radioelectric Interference in Switzerland.—E. Trechsel. (*Bull. Assoc. suisse des Élec.*, No. 18, Vol. 25, 1934, pp. 482–485.)

1029. Papers on Interference with Broadcast Reception.—Siemens & Halske Company. (*E.T.Z.*, 6th Dec. 1934, Vol. 55, No. 49, pp. 1209–1210: summaries only.)

1030. Noise Suppressors [The Problem of Interference with Broadcast Reception].—M. G. Scroggie. (*Wireless World*, 1st Feb. 1935, Vol. 36, pp. 104–106.)

1031. Radio Noises and Their Cure.—Tobe Deutschmann Corporation. (At Patent Office Library, London.)

1032. Measurement of the Characteristic Values of Sources of Broadcast Interference.—K. Müller: Siemens & Halske. (*Bull. Assoc. suisse des Élec.*, No. 25, Vol. 25, 1934, pp. 715–718: long summary.)

1033. The Interference Meter St.M.G.33: a New Help in the Fight against Broadcast Interference.—Siemens & Halske. (*Hochf:tech. u. Elek:akus.*, January, 1935, Vol. 45, No. 1, pp. 32–33.)

1034. On the Detection of Micro-Waves [by Positive-Grid Triode].—N. Carrara. (*Alta Frequenza*, December, 1934, Vol. 3, No. 6, pp. 661–672.)

In a previous paper (Abstracts, 1933, p. 38) the writer has examined the mechanism of detection of micro-waves by a positive-grid triode, which was shown to act as a diode rectifier (virtual cathode and plate) with very small electrode separation, and to function on frequencies up to 10^9c/s. It was found that the grid voltage could be varied within wide limits (100–300 volts) without any marked change in the signal strength. The l.f. amplifier, or the telephones, could be put equally well either in the plate circuit or the grid circuit. A subsequent paper (1933, p. 503) discussed the inferior qualities of a true diode compared with those of such a triode. The results of these researches were used in the design of a receiver (Fig. 5) which has been extensively employed at ranges of the order of 100km (1934, p. 33).

Hollmann, however (1934, pp. 34–35), found it preferable to have the l.f. amplifier in the grid circuit, and found also that the signal strength varied very considerably with the grid voltage, the signal-strength curve (Fig. 6) showing a number of maxima and minima as this voltage was varied between zero and 200 volts. It is this latter discrepancy which the present writer now examines. Using his own circuit of Fig. 3 (no Lecher-wire system, aerial straight to plate) he obtains the curve family of Fig. 8, where between 50 and 210 volts of grid voltage the signal-strength curves are almost horizontal (small troughs at about 80 volts being attributed to a resonance effect in the internal valve circuit). Examination of the equivalent circuit (Fig. 10) of the circuit of Fig. 3 shows that this independence of grid voltage is to be expected. But if the signal voltage is applied to the plate by way of an oscillatory circuit such as is shown in Fig. 2 (Lecher-wire system with bridging condensers and dipole aerial at one end) the amplitude of the potentials impressed on the plate is a function of the impedance of the grid/plate gap, which would vary with the grid voltage. Thus the different results obtained by Hollmann and the writer are explained by a difference in the experimental conditions.

1035. Detectors for 9cm Micro-Waves, including a Special Split-Anode Magnetron.—Wolff, Linder and Braden. (*See* 986.)

1036. Receiving Apparatus for Ultra-Short Waves [including the Ultra-Audion with Super-Regeneration].—W. Möller. (*Radio, B., F. für Alle*, February, 1935, No. 2, pp. 20–26.) *See* also 659 of March.

1037. The Holmdel Laboratory [for Investigation of Short and Ultra-Short-Wave Reception Phenomena].—Friis. (*Bell Lab. Record*, December, 1934, Vol. 13, No. 4, pp. 117–121.)

1038. New Circuit for Resistance Tuning.—F. M. Colebrook. (*Wireless World*, 8th Feb. 1935, Vol. 36, pp. 138–139.) Further development of the work referred to in 1934 Abstracts, p. 615, r-h column.

1039. A New Development in Radio-Frequency Amplifiers.—F. M. Colebrook. (*Wireless World*, 18th Jan. 1935, Vol. 36, pp. 52–54.)

Drawing attention to certain drawbacks associated with the use of screen-grid valves and recommending the use, under certain circumstances, of a special form of triode amplifier. The principle of this amplifier is not entirely new ; it is a modified form of the system used several years ago under the popular name of "Tuned-Aperiodic-Tuned."

1040. Modern Design of H.F. Stages for the Amateur Superhet: Matching, Tracking and Stabilising Multi-Tuned Circuits.—J. Millen and D. Bacon. (*QST*, January, 1935, Vol. 19, No. 1, pp. 13–15 and 100, 102, 104.)

1041. Frequency Transformation [with Special Reference to Single-Span Tuning].—F. M. Colebrook. (*Wireless World*, 15th Feb. 1935, Vol. 36, pp. 174–176.)

1042. First Continental Single-Span Receiver [made by German Manufacturers].—H. J. Wilhelmy. (*Wireless World*, 1st Feb. 1935, Vol. 36, pp. 107–108.)

1043. QA Receiver [for Use with the "Push-Pull Quality Amplifier"].—W. T. Cocking. (*Wireless World*, 8th and 15th Feb. 1935, Vol. 36, pp. 134–137 and 158–160.) *See* 1934 Abstracts, p. 445.

1044. Mechanical Filters suitable for Single-Signal Superheterodynes [including Quartz Bar with Input Electrodes and Output Electrodes at Opposite Ends].—H. V. Noble. (*Proc. Inst. Rad. Eng.*, December, 1934, Vol. 22, No. 12, pp. 1331–1332 : summary only.)

"These pairs of electrodes are electrically and magnetically shielded from each other. Selectivity curves show the filter to have a band width of about 30 cycles, about one-tenth that of the conventional quartz filters. A completely shielded unit was shown which required only the connection of one lead to the plate of the first detector tube and a second to the grid of the first i.f. amplifier tube."

1045. Effects of Inter-Electrode Capacities on the Performance of Valve Amplifiers.—C. Matteini. (*Alta Frequenza*, October, 1934, Vol. 3, No. 5, pp. 517–540.)

Author's summary :—The paper first outlines the effects due to the inter-electrode capacities on the behaviour of valves acting as amplifiers, and then determines the magnitude of these effects by considering the phase differences between the exciting voltage on the grid and the output voltage in the anode circuit. On the basis of the equations thus obtained, an analysis is made of the changes produced in the resonance curves of tuned-anode and band-filter amplifiers ; and the increase in amplification due to the retroaction through the grid/plate capacity is calculated. The upper limits of amplification which must not be exceeded for stable working are determined for one or more stages, both for tuned-anode and transformer-coupled amplifiers. Diagrams are also given for evaluating the retroaction gain under the various conditions of stable working.

1046. The Detector as a Radio-Frequency Load.—F. M. Colebrook. (*Wireless World*, 22nd Feb. 1935, Vol. 36, pp. 193–195.)

Dealing with the design theory of tuned coupling circuits which are affected both by the preceding r.f. amplifying valve and by the succeeding detector. It is shown that a transformer designed for maximum voltage amplification is not necessarily the best when the detector load is taken into account.

1047. An Analysis of Power Detection.—Y. Koike. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 41 : summary only, in English.)

1048. High Quality Technique [Essential Requirements of a Complete Receiver, and the Necessity for Restrictions of R.F. Response except for Local Reception].—W. T. Cocking. (*Wireless World*, 1st Feb. 1935, Vol. 36, pp. 110–112.)

1049. Tone-Compensated Volume Control.—S. O. Pearson. (*Wireless World*, 15th Feb. 1935, Vol. 36, pp. 161–163.)

1050. Modern Tuning Coils [and the Principles of Their Design].—(*Wireless World*, 18th Jan. 1935, Vol. 36, pp. 58–61.)

1051. The Influence of Losses on the Merit of H.F. Circuits [Resonance Curve Measurements: Ohmic, Eddy Current and Skin Effect Losses: Losses due to Parallel Valve Resistances, Parallel Ohmic Resistances, Screening, Bad Contacts, etc.].—H. Richter. (*Radio, B., F. für Alle*, January, 1935, No. 1, pp. 8–13.)

1052. On a New System of Receiving Set for Carrier Telegraphy [including a New Ampli-Filter of Resonance-Current Type].—Watanabe, Kamayachi and Kikuchi. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 4, Abstracts p. 49: summary only, in English.)

1053. Recent Progress in Radio Technique at the 11th Annual Paris Exhibition.—M. Adam. (*Rev. Gén. de l'Élec.*, 24th Nov. 1934, Vol. 36, No. 21, pp. 741–748.)

AERIALS AND AERIAL SYSTEMS

1054. Control of Radiating Properties of Antennas [by Concentrated Capacity at Top with Series Inductance, Concentrated or Distributed, connecting it to Top of Antenna: Increased Radiation Efficiency: Control of Radiation Angle: Reduction of Ground Losses].—C. A. Nickle, R. B. Dome and W. W. Brown. (*Proc. Inst. Rad. Eng.*, December, 1934, Vol. 22, No. 12, pp. 1362–1373.)

The top capacity may be a sphere, cylinder or disc. In the first two cases it may house the (concentrated) series inductance; in the last case the disc may consist of a rim of copper pipe filled in with a wire network. In all cases the concentrated series inductance can be replaced by a distributed one consisting of a wire parallel to the aerial and connected to it at a suitable point down the latter (if necessary through a variable inductance or capacity) but insulated at the top. By this arrangement of capacity joined by series inductance, the reactance to earth referred to the top of the aerial can be made positive, zero or negative in any amount desired, so that it is possible to go from a minimum current at top ("unloaded aerial") to minimum current at base, and on through minimum current at middle back to minimum current at top. It is considered particularly applicable to frequencies between 500 and 300 000 kc/s.

1055. The High Aerial of the Munich High-Power Broadcasting Station [New Dipole Aerial on 163 m Wood Tower: Efficiency increased to 90% (compared with 75–80%) by Flat Surfaces of Wire to increase Capacity].—Lorenz Company. (*E.T.Z.*, 3rd Jan. 1935, Vol. 56, No. 1, p. 19: paragraph only.)

1056. A Simple Method for Reducing the Tower Effect on the Distribution of Field Intensity [by imitating Umbrella Aerial by Wires sloping down from Top of Tower].—Ueno and Momotsuka. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 9–10: summary only, in English.)

1057. On Beam Antennas with Free [Radiation Coupled] Reflectors [Expressions and Curves for Reflector Current, Directivity and Gain: Comparison with Directly Fed Reflectors].—H. Takeuchi. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 13: short summary only, in English.)

1058. On the Free Electric Oscillations of a Linear Conductor [with Application to Short-Wave Aerials].—Y. Kato. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 12–13: summary only, in English.) A formula is quoted which may be applied to determining the length of an element of a short-wave antenna designed for a particular wavelength.

1059. Green's Theorem, Huyghens' Principle, and Bechmann's Problems in Antenna Radiation.—H. Kikuchi. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 40: summary only, in English.)

1060. Distribution of Retarded Potential near the Tuned Straight Radiator.—H. Iwakata and S. Tanaka. (*Journ. I.E.E. Japan*, November, 1934, Vol. 54 [No. 11], No. 556, pp. 1148–1158: English summary pp. 130–131.)

1061. On the Current Distribution along Horizontal Receiving Antennas, and their Directional Properties.—T. Nakai and Y. Isagawa. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 40.)

1062. Some Notes on "Sleeve Coupling."—Nakamura and Ohshima. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 21: summary only, in English.) Further development of the work dealt with in 1934 Abstracts, p. 92.

1063. An Improvement in Twisted-Pair Feeders.—R. C. Graham. (*QST*, January, 1935, Vol. 19, No. 1, pp. 22–23 and 92.)

1064. Doublet Receiving Antenna [with 600 ft Transmission Cable] and Bucking Circuit [for neutralising Transmitter Signals] for Duplex Operation.—S. W. Seeley. (*QST*, January, 1935, Vol. 19, No. 1, pp. 28 and 82, 84.)

1065. Wide-Band Transmission over Balanced Circuits.—Clark. (*See* 1122.)

1066. An Automatic Aerial Change-Over System.—G. J. Mihelson. (*Izvestia Elektroprom. Slab. Toka*, Aug./Sept. 1934, No. 7, pp. 8–12.)

Two separate short-wave aerials are connected to branches of the same transmission line, and the arrangement is such that energy is automatically supplied only to the particular aerial which is tuned to the operating frequency, thus obviating the necessity for changing over transmission lines when changing wavelength. Associated with each of the branching transmission lines to the two aerials is a special filter system. This consists of a short transmission line less than a quarter of a wavelength long, running beneath and parallel to the main line, to which it is connected by two vertical conductors having a length generally of the order of one metre. One end of the auxiliary line is open while the other may be either open or short circuited.

Each filter system is thus shunted across its associated main transmission line, at a certain distance from the branching point of the two lines, and is so dimensioned as to present at the point of connection an infinite impedance to the frequency of the associated aerial and zero impedance to the unwanted frequency. Methods are indicated for determining the dimensions of the system for given wavelengths, and the two cases when the auxiliary transmission line has both ends open circuited or one end short circuited are separately discussed. Numerical examples are added. It is pointed out in conclusion that the auxiliary lines can be shortened by 20 to 40%, and their characteristic impedance reduced, by suspending from them a number of 20 × 30cm copper plates.

VALVES AND THERMIONICS

1067. DISTORTION OF AMPLIFICATION FACTOR.—R. Feldtkeller. (*E.N.T.*, December, 1934, Vol. 11, No. 12, pp. 403–409.)

Non-linear distortion in amplifying valves is due not only to curvature of the valve characteristic, *i.e.*, voltage variation of the internal resistance, but to distortion of the amplification factor μ. This was shown by Petersen and Evans (*Bell S. Tech. Journ.*, 1927, Vol. 6, p. 442). Increase of external resistance causes decrease of the distortion, owing to relative decrease of the internal resistance, but the distortion never falls below a finite value, due to the amplification factor. This becomes noticeable in practice only in cases of marked over-matching (Fig. 7). The present paper gives a theoretical investigation which starts from the double power series for the dynamic characteristic as a function of both the anode and grid voltage (eqn. 1). The derivatives of μ with respect to anode voltage and grid voltage (eqn. 12) are given and an expression is found for the "klirr" factor in terms of these and the internal and external anode resistances alone (eqn. 14). § 3 discusses the open-circuit "klirr" factor. In § 4 further relations are found, for the case when μ is a function of the ratio grid-voltage/anode-voltage (U_g/U_a) only. In § 5 the sign of the characteristic curvature is discussed and it is found that, with the limitation of § 4, there is no value of R (the external voltage in the anode circuit), with a positive real part, for which the "klirr" factor vanishes. In § 6 an example is considered, based on a measured set of characteristics of a normal single-grid valve. Fig. 1 shows the amplification factor and lines of constant μ, which are oblique; Fig. 2 shows the internal resistance, Fig. 3 the steepness and its derivative with respect to grid voltage. Figs. 4 and 5 the open-circuit and closed-circuit "klirr" factors respectively. The closed-circuit "klirr" factor may be 20 times as large as that on open circuit. This difference increases with negative grid bias and with increasing anode voltage. In § 7 the results of over-matching are considered; eqn. 32 gives an expression for the "klirr" factor as a function of its values on open and closed circuit (with μ, the internal and external anode resistances, and U_g/U_a).

The most favourable working point (§ 8, Fig. 8) is found for a given power output to be that at which, with a given external resistance, the output is obtained with the smallest value of the non-linear distortion. From Fig. 8 the optimum working point and external resistance may be determined.

1068. THE "KLIRR" [Non-Linear Distortion] FACTOR OF PENTODES.—J. Kammerloher. (*Hochf:tech. u. Elek:akus.*, January, 1935, Vol. 45, No. 1, pp. 11–13.)

According to Feldkeller (1931 Abstracts, p. 35) the characteristic of an amplifier valve in the negative working zone is given by $I_a = G \cdot U^{\gamma}_{st}$. For pentodes, γ lies between 1.5 and 2. The writer finds that for $\gamma = 1.5$ the "klirr" factor is given by $\frac{1}{8} \cdot \mathfrak{U}_g/U_{st} \cdot 100\%$, and for $\gamma = 2$ by $\frac{1}{4} \cdot \mathfrak{U}_g/U_{st} \cdot 100\%$, where $\mathfrak{U}_g$ is the alternating grid voltage and U_{st} the modulating voltage. This shows that for a given alternating grid voltage the "klirr" factor is smaller, the smaller the grid bias U_g. But it is necessary that $\mathfrak{U}_g - U_g \leq 0$, so that the smallest "klirr" factor is given when the grid bias is made equal to the alternating grid voltage. Experimental confirmation, satisfactory considering the probable measurement errors and the approximate representation of the working processes, is given from the pentodes Valvo L496D and RENS1374.

1069. ON THE MODULATING AND OPERATING CHARACTERISTICS OF R.F. AMPLIFYING VALVES.—Marino. (*See* 1009.)

1070. EXPERIMENTS WITH INVERTED DIODES HAVING VARIOUS FILAMENT CATHODES.—McPetrie. (*See* 991.)

1071. THE DEVELOPMENT OF THE RECEIVING VALVE.—S. R. Mullard. (*Journ. I.E.E.*, January, 1935, Vol. 76, No. 457, pp. 10–16 and Plate.) Chairman's Address to the Wireless Section.

1072. DEVELOPMENT OF THE MODERN BROADCAST RECEIVING VALVE.—Mullard: Sowerby. (*Nature*, 12th Jan. 1935, Vol. 135, pp. 54–55.) Note on papers by Mullard (1071, above) and Sowerby (*Wireless World*, 21st and 28th Sept., 12th Oct., and 2nd Nov., 1934.)

1073. PAMPHLETS ON RADIO TUBES.—RCA Radiotron. (At Patent Office Library, London.)

1074. THE USE OF VACUUM TUBES IN MEASUREMENTS [Bibliography of 596 Items, on Fundamental Properties of Valve Circuits and on Measuring Methods and Apparatus using Valves].—J. W. Horton. (*Elec. Engineering*, January, 1935, Vol. 54, No. 1, pp. 93–102.)

1075. A NEW SECTION PAPER MADE TO PLOT THE CHARACTERISTICS OF TRIODE VALVES.—T. Kuno. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 28: in English.)

1076. THE PRE-DISCHARGE CURRENT AND DISCHARGE CONDITION IN GAS-FILLED HOT CATHODE TUBES [Mercury-Vapour- and Argon-Filled Triodes: Comparison with High-Vacuum Triodes].—I. Runge. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 16, 1935, pp. 38–42.)

Assuming that the presence of the ions is equivalent to an additional positive voltage on the grid, the original current i_0 which would flow in high vacuum, for the same grid voltage V_g, is found theoretically to be so affected that if i_z is the current at the moment of striking the discharge, $i_z/i_0 =$ exponential e. Thus in the presence of gas the current can attain a value e times the corresponding high-vacuum current, before a discharge takes place. In the space-charge region the ratio i_z/i_0 is larger, namely 5.2. On attempting to confirm these results experimentally it was found that at very low gas pressures they did not hold good, the current often reaching 20 times the high-vacuum value before the discharge occurred. This is explained by the fact that the assumption of an additional positive grid voltage, proportional to the number of ions, demands a charge density which is uniform both in space and time, whereas at very low gas pressures the discontinuous structure of the ionic stream shows itself. Thus the value attainable by the pre-discharge current is the higher, the more uniformly the ions are distributed and the less they interact locally between themselves. This also explains the high pre-discharge currents in valves with grids wound with thin wire. With grids of perforated plate the current density in the holes can be high enough to start the discharge while the total pre-discharge current is still small, because the perforated grid favours a certain lack of uniformity in distribution. Thus the writer found that by cutting out certain turns in a spiral grid the pre-discharge current was greatly reduced.

1077. SHOT EFFECT AND THERMAL AGITATION IN AN ELECTRON CURRENT LIMITED BY SPACE CHARGE [Space Charge decreases Shot Effect: Thermal Agitation affects Internal Valve Impedance].—G. L. Pearson. (*Physics*, January, 1935, Vol. 6, No. 1, pp. 6–9.)

A description of an experimental verification of a formula due to Llewellyn (Abstracts, 1930, pp. 279–280). The valve used had a pure tungsten filament, with grid and anode connected and very low anode voltage, to reduce thermal noise. For the amplifying system and output measuring device used *see* 136 of January. A curve is given (Fig. 2) showing the experimental and theoretical values of the shot effect. Good agreement was obtained with the decrease predicted by the formula; values calculated from a relation due to Moullin and Ellis (1934, p. 321) are also shown but the agreement is less good.

A formula for thermal agitation, also due to Llewellyn (*loc. cit.*) was tested with the same apparatus (with oxide-coated and thoriated tungsten cathodes) and curves obtained are shown in Fig. 3; the values of filament temperatures which must be assumed to obtain agreement with theory are much lower than those actually used.

1078. EQUILIBRIUM EMISSION AND ACTIVITY CHANGES IN OXIDE-COATED CATHODES.—A. J. Maddock. (*Phil. Mag.*, February, 1935, Supp. No., Series 7, Vol. 19, No. 126, pp. 422–436.)

This paper describes experiments supporting the theory that "a layer of barium exists at the outer surface of the oxide giving the enhanced emission, the activity of the cathode depending on the amount of surface covered." The cathodes were subjected to temperature treatment alone, *i.e.* there was no flow of emission current; the ageing or forming process and activation and deactivation of the filaments and equilibrium conditions at various temperatures are described. The loss of emission which occurs on deactivation by flashing is found to be directly proportional to the emission before flashing.

1079. ELECTRON EMISSION FROM OXIDE CATHODE [Formulae for Emission Constants and Transverse Resistances, etc., from Measurements of Latent Heat of Evaporation of Electrons].—S. Hamada. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 17: summary only, in English.) For a previous paper *see* 1934 Abstracts, p. 385.

1080. ELECTRON DIFFRACTION ON OXIDE-COATED FILAMENTS [Barium and Strontium Carbonates on Nickel].—H. Gaertner. (*Phil. Mag.*, January, 1935, Series 7, Vol. 19, No. 124, pp. 82–103.)

1081. ON THE LIBERATION OF GASES FROM TUNGSTEN WHEN HEATED IN A VACUUM.—S. V. Ptitsin. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 4, 1934, pp. 1189–1194).

An account of an experimental investigation mainly concerned with the diffusion of gases from the interior to the surface of the metal. Tentative explanations of the results obtained are given and some of the more important formulae are quoted.

DIRECTIONAL WIRELESS

1082. DERIVATION OF A GENERAL FORMULA FOR CALCULATING THE ANGLE OF THE EQUI-SIGNAL ZONE OF A RADIO BEACON.—N. A. Miasoedov. (*Izvestia Elektroprom. Slab. Toka*, October, 1934, No. 8, pp. 9–20.)

A general formula (3) is derived for the limiting angle of the equi-signal zone as the product of two factors, one depending on the general condition of reception and the other on the characteristics of the beacon. The first factor is expressed as a percentage, and for normal conditions varies from 2% to 12%. The method of calculating the second factor is given in detail with an explanatory table and examples. The calculations for the case of the double figure 8 polar diagram approximate very closely to the experimental results obtained by Murphy and Wolfe (*Beacon Journ. of Soc. of Automotive Eng.*, Sept. 1926, Vol. 19). In addition, experiments were carried out with a view to checking the formulae derived for the case of two polar curves of the cardioid type. The results obtained have confirmed the validity of the general formula on which the calculations are based.

1083. A New "Returning-Type" Rotating Radio-Beacon.—M. Okada. (*Rep. of Rad. Res. in Japan.*, October, 1934, Vol. 4, No. 3, pp. 185–195.) In English. *See* 1934 Abstracts, p. 620.

1084. Radio-Beacons for Maritime and Aerial Navigation [Survey].—G. Montefinale. (*Alta Frequenza*, December, 1934, Vol. 3, No. 6, pp. 673–704.)

1085. Radiogoniometers [Survey: Errors due to Hull, Cables, etc.].—V. de Pace. (*Alta Frequenza*, October, 1934, Vol. 3, No. 5, pp. 598–621.)

1086. A Note on the Deviation of Observed Bearings in High-Frequency Long-Distance Transmission.—S. Namba and T. Tukada. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 10–11: summary only, in English.)

"According to the results of protracted experiments . . . fluctuations in the direction of arrival of h.f. waves transmitted from stations at moderate distances—say from 2000 to 10000 km—are generally of the order of about ±5° on both sides of the true direction. From the results of calculations described in the present paper and also from experimental evidences obtained in moderate-distance transmissions, it is concluded that the 'deviated energy' [deviated at ionosphere from great circle plane] plays an important rôle when the transmission distance exceeds 16000 km. At a distance of 18000 km the energy may arrive at the receiver almost equally from any direction throughout 360°, so far as the effect of attenuation along respective paths is not taken into account. In addition, some interesting results of d.f. experiments observed for Buenos Aires and Rio de Janeiro, carried out simultaneously at Hiraiso, near Tokyo, and Tansui, near Taihoku, are shown and discussed."

1087. Acoustic Measurement of Aircraft Altitude [3000 c/s Frequency Chosen: Directivity, Beam Gain and Angles, etc.].—Nukiyama, Yamada and Kikuti. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 30–31: summary only, in English.)

ACOUSTICS AND AUDIO-FREQUENCIES

1088. The Calculation of the Degree of [Electroacoustic] Efficiency of [Aluminium] Piston Membranes carrying Current [Application to Loudspeakers].—H. Neumann and K. Warmuth. (*E.N.T.*, December, 1934, Vol. 11, No. 12, pp. 413–417.)

This paper extends previous work of the writers (*see* 1934 Abstracts, pp. 503–504) to the case of an aluminium membrane, oscillating in a rigid wall and radiating in two directions; the dependence of the most favourable membrane thickness on the area and frequency was closely investigated, starting from eqn. 1 for the electroacoustic efficiency η, an equation given in the former paper. The equation is simplified and eqn. 5 found for the optimum thickness d_{max}. The equation shows that d_{max} is independent of the magnetic field H and only depends on the area F and frequency f; it decreases with increasing frequency. Figs. 1–6 show the graphical evaluation of the equations 4 and 5 for η_{max} and d_{max}, for all sets of values of practical importance. Strong magnetic fields are found to exert a favourable influence on reproduction at both low and high frequencies; Fig. 6 shows d_{max} as a function of f for various values of F. Small surfaces give better frequency characteristics. The calculations are exact to 5 or 8%.

1089. Electrodynamic Horn Loudspeaker with Rectangular Diaphragm with Moving Coil fixed along the Longer Sides.—Telefunken. (German Pat. 599 805, pub. 9.7.1934: *Hochf:tech. u. Elek:akus.*, January, 1935, p. 36.)

1090. New Insulating Materials with High Thermal Conductivity, for Loudspeaker Magnets, etc.—Meissner. (*See* 1192.)

1091. Non-Resonant Loudspeaker.—P. Jessop. (*Wireless World*, 22nd Feb. 1935, Vol. 36, pp. 185–186.) Details are given of the construction of a special loudspeaker cabinet intended to eliminate resonances and also of a device for improving the distribution of high notes.

1092. A Simple Output Measuring Set for Loudspeakers [requiring No Sound-Proof Chamber: Short Tube ending in Acoustic Terminating-Cone: Rayleigh Disc in Middle of Tube, Calibrated Microphone in Window near End].—Osida and Hashimoto. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 45: summary only, in English.)

1093. A Lapel Microphone of the Velocity [Ribbon] Type.—H. F. Olson and R. W. Carlisle. (*Proc. Inst. Rad. Eng.*, December, 1934, Vol. 22, No. 12, pp. 1354–1361.)

1094. Electrodynamic Ribbon Microphone with Improved High-Note Transmission by Pressure Chamber between Ribbon and Felt-Filled Space.—Telefunken. (German Pat. 602 845, pub. 18.9.1934: *Hochf:tech. u. Elek:akus.*, January, 1935, p. 35.)

1095. The Subjective Limit of Perceptibility and a Method for the Objective Determination of Film Transport Disturbances in Sound-Film.—F. Lautenschlager. (*E.N.T.*, December, 1934, Vol. 11, No. 12, pp. 409–413.)

To obtain known fluctuations in the forward motion of film, a mechanical device was used which is shown diagrammatically in Fig. 1, with photograph in Fig. 2 and description in §2. The fluctuation function produced was transferred to the image of the slit on a uniformly moving film. The optical fluctuations were transformed into sound in the usual way. Observations were limited to the distortion of a pure tone of angular frequency ω by a sinusoidal transport disturbance of amplitude λ and angular frequency Ω. Three films were used with recorded wavelength λ (for method of production *see* Lautenschlager, 460 of February) each with two "howls" of frequency N; they were listened to with slit amplitude x increasing from zero, and the limit x^* where the disturbance became just perceptible to the subject was determined. Table 1 shows the result. The phase $2\pi x^*/\lambda$ was found to be approximately constant, so that film transport fluctuations must be regarded as phase and not as frequency modulations (*see* 400 of February). The "klirr" factor of the perceptibility limit was about 7%, agreeing with that found by other writers.

The writer has already described analyses of the spectra of combination tone frequencies (*see* 400 of February); he now discusses the acoustic analysis of film transport fluctuation on the basis of results obtained in this former paper and finds that this objective method is as sensitive as the subjective method only when the amplitude of the transport fluctuation is at least 0.1/N. It is suitable only for fluctuation frequencies of more than 10c/s. Analysis at higher frequencies may be performed in several stages.

1096. Magnetic Recording and Its Application [" Super-Permalloy " best for Magnet Core: Effect of Positions of Magnet Cores on Frequency Characteristic: etc.].—K. Nagai and T. Igarashi. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 33–34: summary only, in English.)

1097. An Amplifier with Glow-Discharge Tubes [for Gramophone Reproduction, etc.].—P. Miram: Peek. (*Radio, B., F. für Alle*, December, 1934, No. 12, pp. 188–195.) *See* also 1934 Abstracts, p. 562.

1098. Output Characteristics of Push-Pull Audio-Amplifiers.—Y. Fukuta. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 40: summary only, in English.)

1099. Distortion of Amplification Factor [and Its Effect on the " Klirr " Factor, especially in Over-Matched Conditions].—Feldtkeller. (*See* 1067.)

1100. Measurement of the Electro-Mechanical Coefficient of Acoustic Apparatus.—F. N. Trotsevich. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 4, 1934, pp. 1131–1133).

It is shown that this coefficient can be defined as the ratio of the change in the magnetic flux to the displacement of the mechanical system, and it is suggested that when expressed in these units it can easily be determined experimentally. A description follows of the determination of the coefficient for a loudspeaker and a gramophone pick-up.

1101. Electro-Acoustic Transmission Systems [Lecture].—F. Fischer. (*Bull. Assoc. suisse des Élec.*, Nos. 2 and 3, Vol. 26, 1935, pp. 36–45 and 74–80.)

1102. The Measurement of Loudness [Theoretical Discussion of Principles].—N. R. Campbell and G. C. Marris. (*Proc. Phys. Soc.*, 1st Jan. 1935, Vol. 47, Part I, No. 258, pp. 153–170: Discussion pp. 170–183.)

This theoretical paper examines proposed scales of loudness and attempts " to determine only whether any one of these is distinguished from the remainder by being founded more firmly on facts and being more free from arbitrary convention." Convenience or practicable accuracy are not primarily considered. Scales for a single frequency and for sounds in general are discussed. " To the question whether a scale uniquely determined by facts can ever be set up," the writers " reply with a guarded negative."

1103. A High-Speed Level Recorder for Acoustic Measurements.—E. H. Bedell: Wente, Bedell and Swartzel. (*Bell Lab. Record*, November, 1934, Vol. 13, No. 3, pp. 75–79: *Journ. Acoust. Soc. Am.*, January, 1935, Vol. 6, No. 3, pp. 121–129.)

1104. Reverberation Time and Absorption Measurements with the High Speed Level Recorder.—Bedell and Swartzel. (*Journ. Acoust. Soc. Am.*, January, 1935, Vol. 6, No. 6, pp. 130–136.)

1105. Reverberation Measurements in Auditoriums.—Stanton and others. (*Journ. Acoust. Soc. Am.*, October, 1934, Vol. 6, No. 2, pp. 95–105.)

1106. Sound Reinforcement in Theatres [Acoustic Deficiencies and Their Correction].—A. T. Sinclair. (*Wireless World*, 8th Feb. 1935, Vol. 36, pp. 150–151.)

1107. The Acoustic Side of Broadcasting.—M. G. Scroggie. (*Wireless World*, 8th Feb. 1935, Vol. 36, pp. 130–133.)

Pointing out that reverberation in studios and listening rooms plays such an important part in modifying the sound which eventually reaches the ear through the medium of broadcasting that investigation of these effects should take precedence over further efforts to obtain " straight-line " characteristics in transmitting and receiving apparatus.

1108. A Modified Theory for the Reverberation [Criticism of Eyring's Modification of Sabine's Formula: the Writer's Formula and Results].—A. Hirayama: Eyring. (*Journ. I.E.E. Japan*, June, 1934, Vol. 54 [No. 6], No. 551, pp. 565–572: English summary pp. 76–78.) *See* also Abstracts, 1933, p. 163 (two); and for Eyring's formula, 1931, p. 45.

1109. Notes on the Duration of Reverberation in some Broadcasting Studios in Japan: an Approximate Theory for the Reverberation of a Cubical Room: *and* On the Room Error of a Dead Room.—K. Hoshi: A. Hirayama: Hirayama and Yoshida. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 34–35.)

1110. The Acoustic Spectrometer.—C. N. Hickman. (*Bell Lab. Record*, October, 1934, Vol. 13, No. 2, pp. 60–62: *Journ. Acoust. Soc. Am.*, October, 1934, Vol. 6, No. 2, pp. 108–111.)

1111. Scales for Sound Measurements used in Machinery Noise Reduction.—E. J. Abbott. (*Journ. Acoust. Soc. Am.*, January, 1935, Vol. 6, No. 3, pp. 137–149.)

1112. Noise Measurements on Electrical Machines [Analyser with Variable Resonance Circuit of Constant Decrement: Objective Soundmeter: Specimen Results].—W. Willms. (*E.T.Z.*, 10th and 17th Jan. 1935, Vol. 56, Nos. 2 and 3, pp. 25–28 and 53–56: Discussion pp. 69–70.) From the Heinrich-Hertz Institute.

1113. Noise Measurements for Engineering Purposes.—B. G. Churcher. (*Elec. Engineering*, January, 1935, Vol. 54, No. 1, pp. 55–65.) *See* also 185 of January.

1114. Quieting Substation Equipment [after Measurements with Analysing Soundmeter].—E. J. Abbott. (*Elec. Engineering*, January, 1935, Vol. 54, No. 1, pp. 20–26.)

1115. Standardisation of Noise Meters.—R. G. McCurdy. (*Elec. Engineering*, January, 1935, Vol. 54, No. 1, pp. 14–15.)

1116. A Research of Direct-Reading Depth-meter for Pilot [Continuous Depth Reading in Shallow Water by Quasi-" Frequency Modulation" Principle using Supersonic Waves].—S. Matsuo. (*Journ. I.E.E. Japan*, November, 1934, Vol. 54 [No. 11], No. 556, pp. 1164–1168: English summary p. 133.)

1117. The Testing of the Quartz Plates used in making Mosaics for Supersonic Sounders.—S. Rosani. (*Alta Frequenza*, October, 1934, Vol. 3, No. 5, pp. 643–649.)

1118. Echo Depth Recording using High Frequency Magnetostriction Oscillators.—A. B. Wood, F. D. Smith and J. A. McGeachy. Summary of I.E.E. paper. (*Wireless Engineer*, February, 1935, Vol. 12, No. 137, pp. 81–84.)

1119. Acoustic Measurement of Aircraft Altitude.—Nukiyama and others. (*See* 1087.)

1120. Instantaneous Speeds in Air of Explosion Reports at Short Distances from the Source.—Partlo and Service. (*See* 954.)

1121. Beat Notes, Combinational Tones, and Sidebands [with Radio and Acoustic Circuits].—Hazel. (*See* 970.)

PHOTOTELEGRAPHY AND TELEVISION

1122. Wide-Band Transmission over Balanced Circuits [Band Widths of 1 Mc/s and More, for Television, etc., without Use of Coaxial Lines].—A. B. Clark. (*Elec. Engineering*, January, 1935, Vol. 54, No. 1, pp. 27–30.)

The Espenschied-Strieby paper (810 of March) confines itself to the coaxial line structure, in which electrical balance is abandoned and dependence placed entirely on metallic shielding; but it points out that wide-band transmission is also applicable to balanced conductor systems. The present writer examines first the extent to which such wide bands can be placed on existing types of structure which are based on balance, and then the question whether new construction designed particularly for such wide bands should depend on balance or shielding alone or on a combination of the two.

At 1 Mc/s an ordinary 16-gauge cable pair has an attenuation of about 14 db/mile and a small coaxial structure one of only about 6 db/mile. But thanks to Black's negative feed-back amplifier (1934 Abstracts, p. 328, r-h column) the idea of such high attenuations as 14 db/mile "is no longer appalling" even though it means repeaters spaced only about 4 miles apart. As regards cross-talk, for telephony it would probably be uneconomical to apply megacycle frequency ranges to more than a single pair in an existing cable, but with television the cross-talk requirements are much less exacting owing to the smaller necessary range of intensities; tests show that 2 or more television channels, each 1 Mc/s wide or possibly wider, can be transmitted over separate properly arranged pairs in the same direction in a single existing cable without serious disturbance due to cross-talk. With open-wire lines the conditions are about the reverse of those with cables, for the attenuation is only about 1 db/mile but the cross-talk difficulty is much more serious. But tests indicate that, thanks to the lenient television requirements, several million-cycle channels can be transmitted over different pairs of a single open-wire line without serious disturbance, without radical changes in present wire configurations.

Returning to the consideration of cables, the writer then compares, from various view-points including price and freedom from outside interference, the coaxial line and possible balanced pairs surrounded by individual shields. He also envisages the possibility of balanced pairs considerably larger in size than ordinary pairs and with the rubber-disc or other construction giving low dielectric losses, but with no shields round the individual pairs, shielding from outside interference being provided by the outside lead sheath of the cable.

1123. Image Defects in Cathode-Ray Television, and Their Elimination.—E. Hudec. (*E.T.Z.*, 10th Jan. 1935, Vol. 56, No. 2, pp. 28–32.)

Figs. 9a and b show an intensity-controlled cathode-ray tube designed to avoid the various defects discussed in the paper. Thus it has an indirectly heated cathode (to give as nearly a "point" source as possible); the modulating and concentrating system described in section 2 (Wehnelt cylinder and concentrating electrode, giving modulation of spot brightness without change of spot size, over a large range); two pairs of auxiliary deflecting plates to avoid the "ion cross" phenomenon (section 4) due to distortion of the deflecting field by the space charge (the alternative solution being the "kneed" form of tube shown in Fig. 6); the guard cylinder to protect the electrons from external influences in their passage to the deflecting plates (section 6) which are deliberately put at some distance from the anode; the "collector" ring between deflecting plates and screen, to prevent distortion due to electrons and ions returning from the screen (section 5); and the screening electrode between the two pairs of deflecting plates, to prevent interaction between the fields (section 7). The whole electrode system is centered with the greatest care by means of special gauges (section 3), particularly to avoid " side-pull error " due to imperfect centering of the cathode and Wehnelt cylinder. The screen is prepared according to the method of section 8.

1124. AN EXPERIMENTAL STUDY OF THE CATHODE-RAY TELEVISION SYSTEM USED BY VON ARDENNE [and the Design of Amplifier with Characteristic almost Flat up to 2 Mc/s: High Frequencies lost by Time Lag of Calcium Tungstate Screen: etc.].—Takayanagi, Suzuki and Matsuyama. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 33: summary only, in English.)

1125. CATHODE RAY TELEVISION.—(*Wireless World*, 22nd Feb. 1935, Vol. 36, pp. 182–184.)

1126. ONE METHOD OF GENERATING CURRENTS AND VOLTAGES OF SAW-TOOTH WAVE FORM FOR TELEVISION [Condenser, Pentode as Oscillator and Condenser Short-Circuiting Device, and Pentode Amplifier: Methods of Synchronising].—Takayanagi, Yamashita and Yamaguchi. (*Journ. I.E.E. Japan*, May, 1934, Vol. 54 [No. 5], No. 550, p. 429: long English summary pp. 65–66.)

1127. SIMULTANEOUS GENERATION OF THE ELECTRON OSCILLATION AND THE DYNATRON OSCILLATION WITH A SINGLE TRIODE.—T. Sugimoto. (*Journ. I.E.E. Japan*, September, 1934, Vol. 54, [No. 9], No 554, p. 1019, Japanese only.)

1128. ON THE PROBLEM OF VOLTAGE STABILISATION OF D.C. SOURCES [as used in Television: Valves give Better Constancy than Glow Discharge Tubes].—Krawinkel and Scholz. (*See* 1187.)

1129. THE EFFECT OF REGENERATION ON THE QUALITY OF THE TELEVISION IMAGE.—K. Takayanagi and T. Horii. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 32–33: summary only, in English.)

1130. TELEVISION USING MECHANICAL SCANNING.—D. V. Stepanov. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 4, 1934, pp. 1157–1162).

A method is indicated for relating the intensity of illumination at a television transmitter with the characteristics of the receiver. Considering transmission by wire line, the minimum change in the input to the receiver, Δe_g, is determined from the maximum gain permitted by valve noise and the allowable voltage variation on the neon lamp. If R_g is the amplifier input impedance and ΔI_ϕ the variation in current through the photocell, then $\Delta e_g = \Delta I_\phi R_g$. A formula (11) is derived for a given transmitter of the scanning type, from which ΔI_ϕ can be determined when passing from the lightest to the darkest part of the object, and from the characteristic of the photocell the required relationship can thus be obtained. It is pointed out that this reasoning can equally well be applied to the case of radio transmission.

1131. TELEVISION TRANSMITTING APPARATUS [100-Line, with Nipkow Disc].—Takayanagi and others. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 46: summary only, in English.)

1132. SYNCHRONISING SYSTEM FOR 100-LINE TELEVISION.—Takayanagi, Takahashi and Ochiai. (*Journ. I.E.E. Japan*, November, 1934, Vol. 54 [No. 11], No. 556, pp. 1196–1202: short English summary p. 136.)

1133. WIRELESS TRANSMISSION AND RECEPTION OF TELEVISION (100-Line).—Nakasima and Takayanagi. (*Journ. I.E.E. Japan*, October, 1934, Vol. 54 [No. 10], No. 555, pp. 1039–1040: short English summary p. 119.)

1134. TRIAL CONSTRUCTION OF A NEW TELEVISION RECEIVER [using Mirror Screw].—K. Nakanishi. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 31–32: summary only, in English.)

1135. REPORT OF TELEVISION COMMITTEE.—(*Wireless World*, 8th Feb. 1935, Vol. 36, pp. 142–143.)

A summary of the report of the Television Committee appointed by the P.M.G. in May, 1934.

1136. TELEVISION IN GREAT BRITAIN.—(*Nature*, 9th Feb. 1935, Vol. 135, pp. 209–210.)

Note on Report of Television Committee, 1935, and commercial receiving sets.

1137. TELEVISION PROSPECTS.—(*Wireless World*, 25th Jan. 1935, Vol. 36, pp. 86–87).

1138. TELEVISION AT THE 1934 BERLIN RADIO EXHIBITION.—R. Thun. (*Radio, B., F. für Alle*, October, 1934, No. 10, pp. 153–156.)

1139. SCANNING IN TELEVISION [Methods of improving Definition without increasing Sideband Spread].—(*Wireless World*, 1st Feb. 1935, Vol. 36, p. 117.)

1140. TRANSMISSION OF PICTURES BY FREQUENCY MODULATION [for Reduction of Fading by use of Amplitude Limiter: Successful Method].—Z. Osawa. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts pp. 48–49: summary only, in English.)

" No appreciable distortion occurs at the modulating, transmitting and demodulating systems of the frequency modulation. The generally accepted view that distortion is inseparable from frequency modulation is not warranted."

1141. A SYSTEM OF PHASE MODULATION AND ITS APPLICATION TO PICTURE TRANSMISSION.—Y. Niwa and T. Inokuti. (*Journ. I.E.E. Japan*, May, 1934, Vol. 54 [No. 5], No. 550, p. 433: English summary p. 56.)

1142. PAPERS ON PHOTOTELEGRAPHIC DEVELOPMENTS [" Constant-Frequency Variable Dot " System: Carbon-Paper Recorder: etc.].—(*Proc. Inst. Rad. Eng.*, December, 1934, Vol. 22, No. 12, pp. 1330, 1331, 1333: summaries only.)

1143. INFLUENCE OF THE ELECTRON CURRENT FROM THE CATHODE ON THE STRIKING POTENTIAL OF AN "INDEPENDENT" GASEOUS DISCHARGE [in Photocells].—P. W. Timofeew. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 4, 1934, pp. 1182–1188.)

The variation of the striking potential is investigated under various conditions, and the dependence on the electron current is shown to be due to the formation of a space charge of positive ions starting during the "dependent" phase of the discharge, the density of this space charge being dependent on the value of the electron current. For "independent" and "dependent" discharges *see* Kluge, 483 of February.

1144. ON THE FREQUENCY CHARACTERISTIC OF SELENIUM BARRIER-LAYER PHOTOCELLS [Sensitivity and Frequency Characteristic Improved by Bias Voltage in Blocking Direction: "Frequency Characteristic" requires Load Resistance to be Specified].—M. Kobayasi and Z. Osawa. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 49: summary only, in English.)

1145. ON THE BARRIER-LAYER PHOTOELECTRIC CELL [Selenium/Iron].—H. Suzuki. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 50.) English summary of paper referred to in 1934 Abstracts, p. 624.

1146. THE SPECTRAL DISTRIBUTION AND THE TEMPERATURE DEPENDENCE OF THE CRYSTAL PHOTOELECTRIC EFFECT IN SINGLE CRYSTALS OF PYRARGYRITE AND STEPHANITE.—J. Bärisch. (*Ann. der Physik*, Series 5, No. 8, Vol. 21, 1934/35, pp. 804–812.)

According to Dember (*e.g.* Abstracts, 1932, p. 232) single crystals of pyrargyrite and stephanite show the crystal photoelectric effect. The purpose of this investigation was to discover whether they behave like cuprite and whether the properties of the crystal photoelectric effect found by Barth and Dember (1933, p. 400) are typical of this effect or merely peculiarities of cuprite. The measurements were made with a valve electrometer (Barth, 1934, p. 217) and are shortly described: many curves (Figs. 2–5) are given for the dependence of the effect on wavelength and temperature. It was found that the maximum of the effect at low temperatures increased like an exponential function and moved from longer to shorter wavelengths linearly with increasing temperature. All crystals showed a change of law in the variation of the maximum value with temperature and it was concluded that the phenomenon was due to absorption of water vapour. A distinction is made between *primary* and *secondary* crystal photoelectric effects; the primary effect, here chiefly described, is characterised as the current which is produced when no external field is present; its onset occurs simultaneously with the onset of illumination and the final value is reached in a few seconds. The primary effect has its greatest values at low temperatures, where secondary phenomena are very small. These properties are similar to those of the internal photoelectric effect, described by various writers (*e.g.* Athanasiu, 1934, p. 391). The properties of cuprite are thus generalised to other crystals. A piezoelectric effect was also found with several crystals.

1147. THE TECHNIQUE OF KERR CELLS [particularly the Purification of Nitrobenzene and the Construction of High-Potential Low-Capacity Types].—H. J. White. (*Review Scient. Instr.*, January, 1935, Vol. 6, No. 1, pp. 22–26.)

1148. ULTRA-SHORT [8.7 m] WAVES IN URBAN TERRITORY.—Burrows, Hunt and Decino. (*See* 930.)

1149. HOT-CATHODE PHOTOELECTRIC RELAY.—Raydel. (*See* 1251.)

MEASUREMENTS AND STANDARDS

1150. EXACT CALCULATION OF [the Inductance of] CYLINDRICAL AIR-CORE COILS.—J. Hak. (*Rev. Gén. de l'Élec.*, 22nd Dec. 1934, Vol. 36, No. 25, pp. 875–881.)

Author's summary:—"After defining the simplifications which are necessary to obtain, by integration, the exact formulae expressing the self-inductance of cylindrical bobbins, the writer gives two of these formulae and a graph facilitating numerical calculation. He gives expressions allowing the correction of the results thus obtained by the evaluation of the errors due to the insulation of the turns and to the actual section of the conductor: both circular and rectangular conductor cross-sections are provided for. A numerical example shows the application of the different formulae and of the graph." The results may be considered exact to 1 or 2 thousandths for usual cylindrical coils, even if the turns are fairly widely spaced.

1151. "THE NEGATIVE RESISTANCES OF VALVES AND THEIR MEASUREMENT": CORRESPONDENCE.—Boella: Dilda: Pinciroli. (*Alta Frequenza*, December, 1934, Vol. 3, No. 6, pp. 728–731.) Further argument on Pinciroli's paper (1934 Abstracts, p. 450).

1152. THE ABSOLUTE MEASUREMENT OF ELECTRICAL RESISTANCE BY A NEW ROTATING-COIL METHOD [Study of Inductance Laws underlying Method].—H. R. Nettleton and E. G. Balls. (*Proc. Phys. Soc.*, 1st Jan. 1935, Vol. 47, Part I, No. 258, pp. 54–67: Discussion p. 68.)

1153. HIGH FREQUENCY RESISTANCE STANDARD ["Rotor-Decade" Box].—W. D. Voelker. (*Bell Lab. Record*, January, 1935, Vol. 13, No. 5, pp. 136–140.)

1154. A SIMPLE METHOD OF MEASURING RESISTANCE AND CAPACITY WITH THE HELP OF THE GLOW-DISCHARGE TUBE ["Glimmeter"].—Fr. Nass. (*Radio, B., F. für Alle*, October, 1934, No. 10, pp. 164–166.)

1155. THE RESISTANCE OF EARTH ELECTRODES: MEASURING METHODS AND INSTRUMENTS [Survey].—F. Witz. (*Rev. Gén. de l'Élec.*, 26th Jan. 1935, Vol. 37, No. 4, pp. 123–132.)

1156. The Effects of Electrodes on Measurements of Permittivity and Power Factor on Insulating Materials in Sheet Form.—Hartshorn, Ward, Sharpe and O'Kane. (*Journ. I.E.E.*, December, 1934, Vol. 75, No. 456, pp. 730–736.)

1157. A Compensation [Zero] Method of Phase Angle Measurement in a Large Frequency Range [10 to 100 000 c/s: and Some Results].—N. Smirnov and I. Ash. (*Izvestia Elektroprom. Slab. Toka*, October, 1934, No. 8, pp. 44–51.)

1158. Dielectric H.F. Losses [and Their Measurement: Loss Factor (Tangent of Loss Angle, in Multiples of 10^{-4}) and the AEF "Loss Number" *p*, corresponding to Power Factor and expressed in Thousandths: Some Values for the New Dielectrics].—H. Keller. (*Bull. Assoc. suisse des Élec.*, No. 25, Vol. 25, 1934, pp. 718–719.)

1159. Direct-Reading Impedance Measuring Set [Portable].—S. Baba. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 45: short summary only, in English.)

1160. Comparative Method for the Measurement of a High D.C. Potential [by Small Capacity discharged by Rotating Commutator through Galvanometer].—J. Listray. (*Rev. Gén. de l'Élec.*, 24th Nov. 1934, Vol. 36, No. 21, pp. 739–740.)

1161. The Rectifying Peak Voltmeter as a Standard Instrument [Addendum: Effect of Lead-Capacity on Error due to Over-Biasing].—A. T. Starr. (*Proc. Phys. Soc.*, 1st Jan. 1935, Vol. 47, Part I, No. 258, p. 184.) *See* 1934 Abstracts, p. 162, r-h column.

1162. Electrostatic Mirror Voltmeter for Low Voltages [for Quick Measurements between 1 and 20 Volts: Applicable to Frequencies up to 100 Mc/s].—A. Palm. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 16, 1935, pp. 51–52.)

The special design of electrostatic voltmeter is housed in a tall wooden box, to give a long suspension and a suitable scale distance, the scale being mounted below a slot in the top. The box contains also the lamp, lens, and total-reflection prism. The four "quadrants" are really two squares each divided into two parts by a slanting slot, these slots being out of line but parallel; and the vane is a long narrow rectangle which in its zero position lies underneath the whole lengths of these two slots. The maximum deflection of the vane is only about 8°. One terminal is connected to two diagonally opposite "quadrants," and the other to the remaining two "quadrants" and the vane. The scale is such that from 1 to 3 and 12 to 20 volts one-tenth of a volt can be read accurately, while between 3 and 12 volts it is still more open. At 20 v and 1 Mc/s the total current taken is about 2 mA, only a quarter of which flows through the suspension. The latter can carry 50 mA, so that the upper frequency limit is about 100 Mc/s. For a full-scale deflection the spot comes to rest in about 15 seconds.

1163. A Portable Electrostatic Voltmeter [for Voltages down to 125 Volts].—A. Taüber-Gretler. (*Bull. Assoc. suisse des Élec.*, No. 21, Vol. 25, 1934, pp. 556–561.)

1164. A Useful Idea for a Milliammeter.—"Cathode Ray." (*Wireless World*, 11th Jan. 1935, Vol. 36, p. 39.) A metal rectifier is used in conjunction with a sensitive milliammeter so that the latter is rendered (roughly) self-adjusting, thus enabling it to be employed for measuring currents whose values vary over very wide limits.

1165. Galvanometry *in Vacuo* [New M.C. Galvanometer for Magnetic Measurements: Swing built up by Photocell Circuit].—W. B. Ellwood. (*Bell Lab. Record*, January, 1935, Vol. 13, No. 5, pp. 151–155) "Sensitivity . . . . some 135 times that of the galvanometers previously used in these Laboratories."

1166. The Use of Vacuum Tubes in Measurements.—Horton. (*See* 1074.)

1167. Measurement of the High-Frequency Components of Radio Receivers in Mass Production [and a Special Instrument for Rapid and Exact Measurements].—J. M. Unk. (*Bull. Assoc. suisse des Élec.*, No. 21, Vol. 25, 1934, pp. 561–568.)

1168. On a Direct-Reading Radio-Frequency Deviation-Meter of Very High Precision [Frequency Monitor suitable for 50-Cycle Accuracy at Broadcasting Stations]. — Y. Itow and T. Yokoyama. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, pp. 167–180.)

In English. Comparison and comments on commercial monitors using luminous quartz, beat-frequency with calibrated valve voltmeter, and beat-frequency using charging current to condenser; leading to a description of the writers' monitor consisting of a standard-frequency oscillator, a valve detector-amplifier, and a special cross-coil frequency meter so designed that the currents in the inductance and capacity arms equalise at 500 c/s. A very full description is given of the steps taken to obtain a satisfactory standard-frequency oscillator, including the design of a special quartz-holder.

1169. On an Ultra-Short-Wave Wavemeter [for Wavelengths to below One Metre: Tuned-Circuit Coil kept Small and Close to Condenser, Auxiliary Coil used as Pick-up].—H. Ataka. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 48: summary only, in English.)

1170. Piezoelectric Crystals with Low Temperature Coefficients of Frequency [Principal Planes parallel to Optical and One Electrical Axis: Dimensions such that Longitudinal Vibration is a Harmonic of the Thickness Vibration].—R. A. Heising. (U.S.A. Pat. 1 958 620: pub. 15.5.1934: *Hochf:tech. u. Elek:akus.*, January, 1935, p. 34.)

1171. THERMAL CHARACTERISTICS OF PIEZOELECTRIC OSCILLATING QUARTZ PLATES, *and* QUARTZ PLATES WITH A VERY SMALL TEMPERATURE COEFFICIENT OF OSCILLATION FREQUENCY. — Koga: Matsumura and Kanzaki. (*See* 1021 and 1022.)

1172. THE ABSENCE OF HYSTERESIS IN PIEZOELECTRIC PHENOMENA. — P. Bernard. (*Comptes Rendus*, 14th Jan. 1934, Vol. 200, No. 3, pp. 222–223.) Further development of the work dealt with in 835 of March.

1173. THE POTENTIAL DISTRIBUTION BETWEEN PARALLEL PLATES AND CONCENTRIC CYLINDERS DUE TO ANY ARBITRARY DISTRIBUTION OF SPACE CHARGE [in Dielectric Slab: Theoretical Investigation, including Sinusoidal Distribution applicable to Piezoelectric Resonator].—W. G. Cady. (*Physics*, January, 1935, Vol. 6, No. 1, pp. 10–13.)

1174. A RADIO FIELD INTENSITY METER [Range 3–500 mV/m, with Loop Aerial and Two Valves].—Momotsuka and Tomita. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 25: summary and diagram only, in English.)

SUBSIDIARY APPARATUS AND MATERIALS

1175. EXPERIENCES ON IMPROVING THE CATHODE-RAY OSCILLOGRAPH [Copper Anode: Blocking Device: Device for improving Spot: Speed of nearly 10 000 km/s].—Ohkohchi. (*Journ. I.E.E. Japan*, September, 1934, Vol. 54 [No. 9], No. 554, pp. 953–956: short English summary p. 107.)

1176. THE TWO-ELEMENT CATHODE-RAY OSCILLOGRAPH.—Narasaki, Miyamoto and Ochi. (*Journ. I.E.E. Japan*, June, 1934, Vol. 54 [No. 6], No. 551, pp. 584–589: English summary pp. 80–81.) *Cf.* Kasai and others, 1934 Abstracts, p. 627.

1177. ON THE OSCILLOGRAPHY OF STEEP-FRONTED SURGES [with the Dufour Cathode-Ray Oscillograph: Danger of Reducing Spot Brightness by Short Illumination Time: Magnetic *versus* Electrostatic Sweep Technique].—Teszner: Gondet and Beaudoin. (*Rev. Gén. de l'Élec.*, 29th Dec. 1934, Vol. 36, No. 26, pp. 915–917.) Criticism of the paper referred to in 294 of January. The authors reply.

1178. THEORY OF ELECTRON GUN [Electron-Optics of Generation, Concentration, Control and Focusing of Cathode-Rays: Theory of Thick Electron Lenses: Mathematical and Graphical Design Procedure].—Maloff and Epstein. (*Proc. Inst. Rad. Eng.*, December, 1934, Vol. 22, No. 12, pp. 1386–1411.)

1179. DISCUSSION ON "NOTE ON A DEMONSTRATION OF A LOW-VOLTAGE ELECTRON MICROSCOPE USING ELECTROSTATIC FOCUSING."—W. Henneberg: Benham. (*Journ. I.E.E.*, January, 1935, Vol. 76, No. 457, pp. 111–112.) For Benham's paper *see* 1934 Abstracts, p. 627, r-h column. *See* also 1180, below.

1180. THEORETICAL BASIS FOR THE DAVISSON-CALBICK FORMULA FOR THE FOCAL LENGTH OF AN ELECTRON LENS.—Henneberg. (*See* 1179, above.)

1181. "GEOMETRISCHE ELEKTRONENOPTIK" [Book Review].—Brüche and Scherzer. (*E.T.Z.*, 31st Jan. 1935, Vol. 56, No. 5, pp. 119–120.)

1182. COIL ARRANGEMENTS FOR PRODUCING A UNIFORM MAGNETIC FIELD [as for Neutralisation of Earth's Field in Cathode-Ray Oscillography].—F. K. Harris. (*Journ. of Res. of Nat. Bur. of Stds.*, September, 1934, Vol. 13, No. 3, pp. 391–410.)

Beyerle's work (Abstracts, 1931, p. 396) was made use of in the oscillograph previously described (1934, p. 218). "In the present paper it is proposed to give a more complete analysis of the field near the axis of such coils and to show that certain further modifications in the shape of the compensating coils will result in a considerable gain in uniformity of the field."

1183. A NEW AMPLIFYING CATHODE-RAY OSCILLOGRAPH EQUIPMENT [with High Amplification by use of Valves as Anode Resistances].—Hehlgans. (*See* 1253.)

1184. GLASS-TO-METAL SEALS [Calculations and Measurements of Stress resulting from Thermal Strain]. — Hull and Burger. (*Physics*, December, 1934, Vol. 5, No. 12, pp. 384–405.)

Theoretical and experimental tests are given of the postulate that strains can be avoided if and only if the thermal expansions of metal and glass are the same. Calculated stresses are compared with those observed photoelastically in carefully annealed test seals. Measurements of the contraction coefficients of glass and metals are shown in Fig. 8 and photographs of soft glass seals, viewed through crossed Nicols and a quartz wedge, in Figs. 9 and 10. Two new sealing alloys, *fernichrome* and *fernico*, are described; these have expansion characteristics curved in such a manner that they match those of certain glasses with fidelity. Seals made with these combinations are found to be almost free from strain. Many numerical data are given.

1185. [Theoretical] ANALYSIS OF THERMAL STRESSES IN SEALED CYLINDERS AND THE EFFECT OF VISCOUS FLOW DURING ANNEAL [Application to Long Glass-to-Metal Seals].—Poritsky. (*Physics*, December, 1934, Vol. 5, No. 12, pp. 406–411.)

1186. THE PRE-DISCHARGE CURRENT AND DISCHARGE CONDITION IN GAS-FILLED HOT-CATHODE TUBES.—Runge. (*See* 1076.)

1187. ON THE PROBLEM OF THE VOLTAGE STABILISATION OF D.C. SOURCES [by Valve Methods where Glow-Discharge Stabilisers give Insufficient Constancy]. — Krawinkel and Scholz. (*Funktech. Monatshefte*, December, 1934, No. 12, Supp. pp. 61–63.)

"Up to the present, commercial glow-discharge stabilisators will not give a constancy within 0.01%; where such constancy is required, valve circuits must be used." Two types of such a circuit are here given. Such methods were applied to Krawinkel's 4-stage d.c. amplifier for television (1934 Abstracts, p. 623), the actual stabilising circuit being given in Fig. 9.

1188. Voltage Stabiliser controlled by a Thermionic Pentode [and one 45 V Dry Battery: Fluctuations less than 1 in 5 000: General Theory of Similar Circuits].—R. D. Evans. (*Review Scient. Instr.*, October, 1934, Vol. 5, No. 10, pp. 371–375.)

A modification of the Street and Johnson method (1932 Abstracts, p. 653) all batteries being eliminated except the one in the control-grid circuit, from which no current is drawn.

1189. The Constancy with Time of Glow-Discharge Characteristics, and Its Effect on Voltage-Stabilising Circuits.—K. Lämmchen. (*Hochf:tech. u. Elek:akus.*, December, 1934, Vol. 44, No. 6, pp. 193–195.)

In stabilising circuits where specially great voltage constancy is required, either the bridge connection with one glow-discharge tube is used or else a cascade circuit with two tubes. Although both these arrangements give a very good constancy, on prolonged runs it is found that fluctuations do occur which are somewhat larger than can be accounted for by incomplete straightness of the characteristic and hysteresis effects. The writer has investigated the changes with time of the discharge characteristic, to which these fluctuations are due: he finds that they vary with the amount of "modulation" of the discharge tube, *i.e.* the changes in the current in the glow discharge. For small modulations such as ± 3 mA, in a tube whose maximum load is 40 mA, the voltage constancy attainable over a long run would be from ± 0.01 to 0.02%, whereas for a modulation over the whole permissible range it would be no better than ± 0.1 to 0.15%.

1190. The Design of Filters for the Circuit of D.C. Pulsating Voltage [and the Comparison between Air and Iron Cores: the "Reverse L-Type Filter"].—Kamazawa. (*Journ. I.E.E. Japan*, September, 1934, Vol. 54 [No. 9], No. 554, pp. 993–1002: English summary p. 113.)

1191. The Potential Distribution between Parallel Plates and Concentric Cylinders due to Any Arbitrary Distribution of Space Charge.—Cady. (*See* 1173.)

1192. Insulating Materials with Specially High Thermal Conductivity: New Possibilities of Economy in Copper [Thermal Conductivity of Organic Insulators increased between 3 : 1 and 8 : 1 by Admixture of Crystalline Quartz, Asbestos, etc.].—Meissner. (*E.T.Z.*, 6th and 13th Dec. 1934, Vol. 55, Nos. 49 and 50, pp. 1193–1195 and 1218–1222: Discussion pp. 1236–1237.)

Among the numerous and varied applications are mentioned loudspeaker magnets (Fig. 5) and small transformers, chokes, etc., for mains equipments for radio receivers (Fig. 14).

1193. Amenit, a New Insulating Material which can be Drilled and Filed.—Görler Company. (Mentioned in Wigand's article on the Berlin Exhibition—*see* 1244.)

1194. Properties of Rubber-Free, Non-Ceramic Plastic Insulating Materials.—Imhof and Stäger. (*Bull. Assoc. suisse des Élec.*, Nos. 19 and 20, Vol. 25, 1934, pp. 509–516 and 538–544.) For criticism and reply see *ibid.*, No. 26, pp. 759–760.

1195. The Electrical Conductivity of Glass. Part I. The Formation of Highly Resistant Layers. Part II. Current Increase Phenomena with Highly Resistant Layers.—Kiehl. (*Physics*, December, 1934, Vol. 5, No. 12, pp. 363–369: 370–373.)

1196. Glass as an Electrical Material.—Fuwa. (*Journ. I.E.E. Japan*, July, 1934, Vol. 54 [No. 7], No. 552, pp. 739–745: Japanese only.)

1197. The Effect of Frequency of Impressed Electromotive Force upon the Power Loss and Dielectric Constant of Various Glasses.—L. S. McDowell, P. Bullard and M. E. Whitney. (*Phys. Review*, 15th Nov. 1934, Series 2, Vol. 46, No. 10, p. 939.) Abstract only.

1198. High-Tension Condenser in Form of Porcelain or Glass Spiral Tube.—Comp. Gén. d'Electrocéramique. (French Pat. 772 138, pub. 23.10.1934: *Rev. Gén. de l'Élec.*, 26th Jan. 1935, Vol. 37, No. 4, p. 29 D.)

1199. VDE Proposed Standard Dimensions for Condensers for Broadcast Receivers.—(*E.T.Z.*, 15th Nov. 1934, Vol. 55, No. 46, pp. 1136–1137.)

1200. A Method of Correcting the Periodic Error of a Gear-Driven Precision Condenser [used in Dielectric Constant Measurements, etc.].—Binns and Kisner. (*Review Scient. Instr.*, October, 1934, Vol. 5 No. 10, pp. 377–378.)

1201. Far-Flung Foes of Insulation [Moisture, Dryness, Dust, Oils, etc.].—Barringer. (*Gen. Elec. Review*, November, 1934, Vol. 37, No. 11, pp. 498–503.)

1202. Dielectric H.F. Losses.—Keller. (*See* 1158.)

1203. Electric Conduction through Thin Metallic Films [represented as Bifurcated Circuit with Semi-Conducting and Metallic Branches: Suggestions as to Manufacture as High Resistances].—Fukuda and Saito. (*Journ. I.E.E. Japan*, June, 1934, Vol. 54 [No. 6], No. 551, pp. 542–548: English summary p. 74.)

1204. Electrical Characteristics [Deviations, Variations due to Overloading, Temperature Effects] of Commercial High Resistances for Radio Receivers.—Tanimura. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts pp. 22–23: short summary only, in English.)

1205. An Experimental Study on High-Frequency Inductance Coils [Greater Voltage Magnification given by Two Co-Axial Single-Layer Solenoids in Parallel than by Ordinary Single-Layer Coils of about Same Dimensions].—Kanazawa. (*Rep. of Rad. Res. in Japan*, July, 1934, Vol. 4, No. 2, Abstracts p. 27: summary only, in English.)

1206. The Screening of Air-cored Coils by Plates and Closed Containers.—J. Hak. (*Hochf:tech. u. Elek:akus.*, January, 1935, Vol. 45, No. 1, pp. 14–19.)

In a previous paper (Abstracts, 1934, p. 334) the writer described his approximate method, by subdivision, of calculating the screening effect of finite cylinders. He now applies the method to flat discs and closed screening cans. Even with comparatively coarse subdivision the method gives, with the discs, sufficiently accurate results to allow the additional loss and the decrease of inductance to be calculated. By analysing the case of a closed can he shows that the effect of the two ends is generally small compared to that of the cylinder, even when the cylinder height is only equal to the diameter. Since, moreover, the influence of the axial skin effect in the cylinder can be estimated by comparison with the worked-out examples, the simplest method of dealing with a closed can is first to calculate the additional loss and decrease of inductance for the cylinder, assuming uniform current distribution, and then to allow for skin effect and the action of the two ends.

1207. Ferrocart Coils: Their Application in High-Frequency Technique.—Schneider: Vogt. (*Electrician*, 14th Dec. 1934, Vol. 113, No. 2950, pp. 770–772.) With illustrations of some of the recent types, including a band-pass filter unit with adjustable band width and resonance frequency.

1208. Investigation of New Alloys of High Coercive Force in Strong Magnetic Fields.—Zaimowski and Kusnetzow. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 4, 1934, pp. 1246–1249.)

1209. A Circuit Breaker for Radio Speech-Control Circuits [replacing Fuses].—Bauer and Seaman. (*Gen. Elec. Review*, November, 1934, Vol. 37, No. 11, pp. 495–497.)

STATIONS, DESIGN AND OPERATION

1210. Ultra-Short-Wave Communication between Observatories on the Summit and at the Base of Mt. Fuzi [4.2 and 4.6 Metre Waves].—Y. Soga. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, pp. 181–184.)

In English. Results of a year's radiotelephone service. The protection of aerials and feeders against silver thaws and violent snow-storms, by wooden conduits, is mentioned, and the effect of silver thaw (when beginning to melt) on the tuning. Messages are often impossible when thunderstorms are about. At the lower station "certain periodic noises are heard, but without seriously interfering with communication: the cause of this noise is unknown"; and conditions are "very noisy when it is snowy or windy around the summit of Mt. Fuzi."

1211. An Extension of Land Telephone Lines by Ultra-Short-Wave Radio [Cape Cod Link on 63 and 65 Mc/s].—F. F. Merriam. (*Bell Lab. Record*, October, 1934, Vol. 13, No. 2, pp. 34–38.)

1212. Radio Broadcast Station KYW moves into New Quarters at Philadelphia.—(*Elec. Engineering*, January, 1935, Vol. 54, No. 1, p. 130.)

"Notable for its compactness. Two features that resulted in saving much space are the use of extremely compact nitrogen-filled radio capacitors and a high voltage rectifier of new design. Foremost among the other technical innovations of the station are its directional antenna system [described] the use of a.c. for all transmitting tube filaments, and the use of a cathode-ray oscilloscope for monitoring." To neutralise the noise introduced by a.c. ripple, a "magnetron suppressor" device is used to oppose the ripple in the plate circuit of the radio power amplifier by a current of proper phase relation, wave form and amplitude.

1213. Radio Broadcasting Station KOA [Denver].—J. J. Farrell. (*Gen. Elec. Review*, October, 1934, Vol. 37, No. 10, pp. 442–451.)

1214. The Installations of the Société Radio-Suisse.—Rothen. (*Génie Civil*, 26th Jan. 1935, Vol. 106, No. 4, pp. 99: summary only.)

1215. On the Equipments for International Radio Telephone Communication in Japan.—T. Nakagami. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 49: summary only, in English.)

1216. Third Reunion of the C.C.I.R.—T. Gorio. (*La Ricerca Scient.*, 15th Jan. 1935, 6th Year, Vol. 1, No. 1, pp. 44–52.)

1217. Rediffusion and Teleprogramme Systems in Broadcasting.—(*Nature*, 2nd Feb. 1935, Vol. 135, p. 196.) Note on paper by Rendall and van Mierlo (892 of March).

1218. The Voice-Operated Compandor.—N. C. Norman. (*Bell Lab. Record*, December, 1934, Vol. 13, No. 4, pp. 98–103.) Latest development of the device referred to in 1934 Abstracts, p. 572, r-h column.

1219. An Improved Volume Indicator [Type 700 A, for Broadcasting Speech Input Equipments].—R. E. Kuebler. (*Bell Lab. Record*, December, 1934, Vol. 13, No. 4, pp. 122–125.)

GENERAL PHYSICAL ARTICLES

1220. PRINCIPLES OF THE NEW QUANTIC ELECTRODYNAMICS.—Born and Infeld. (*Comptes Rendus*, 3rd Dec. 1934, Vol. 199, No. 23, pp. 1297–1299.)

1221. DEDUCTION OF THE DIRAC WAVE EQUATION FROM QUANTUM ELECTRODYNAMICS.—Born and Infeld. (*Comptes Rendus*, 26th Dec. 1934, Vol. 199, No. 26, pp. 1596–1598.)

1222. ON THE QUANTISATION OF THE NEW FIELD EQUATIONS. I.—M. Born and L. Infeld. (*Proc. Roy. Soc.*, Series A, 1st Dec. 1934, Vol. 147, No. 862, pp. 522–546.) For previous papers *see* 1934 Abstracts, p. 338.

1223. ON THE EXPRESSION FOR DENSITY IN THE NEW THEORY OF THE PHOTON.—L. de Broglie. (*Comptes Rendus*, 26th Nov. 1934, Vol. 199, No. 22, pp. 1165–1168.)

1224. A REMARK ON THE INTERACTION BETWEEN MATTER AND THE ELECTROMAGNETIC FIELD.—L. de Broglie. (*Comptes Rendus*, 28th Jan. 1935, Vol. 200, No. 5, pp. 361–363.)

1225. THEORETICAL STUDIES OF THE DIFFUSION OF DE BROGLIE WAVES.—J. Winter. (*Ann. de Physique*, December, 1934, Series 11, Vol. 2, pp. 455–560.)

1226. ON THE SPIN OF THE PHOTON.—de Broglie and Winter. (*Comptes Rendus*, 29th Oct. 1934, Vol. 199, No. 18. pp. 813–816.)

1227. ON THE INTERPLAY OF WAVES, SPIN, AND NUMBERS.—Sevin. (*Comptes Rendus*, 15th Oct. 1934, Vol. 199, No. 16, pp. 702–704.)

1228. NEW DETERMINATION OF THE ELEMENTARY ELECTRIC CHARGE [Measured on Alpha Particles from Polonium: Value $(4.768 \pm 0.005) \times 10^{-10}$ CGS Units].—E. Schopper. (*Zeitschr. f. Physik*, No. 1/2, Vol. 93, 1934, pp. 1–21.)

1229. OBSERVATIONS OF [Damped and Undamped] HIGH-FREQUENCY DISCHARGES USING A KERR CELL AS AN ELECTRO-OPTICAL SHUTTER.—Asami and Shioya. (*Journ. I.E.E. Japan*, August, 1934, Vol. 54 [No. 8], No. 553, pp. 856–860: English summary pp. 104–105.)

1230. OBSERVATION OF MOVEMENT PHENOMENA PRODUCED BY ELECTRIC FIELDS IN DIELECTRIC FLUIDS [using the "Schlieren" Method: Movement of Free Charges determines Electric Current].—R. Hofmann. (*Zeitschr. f. Physik*, No. 11/12, Vol. 92, 1934, pp. 759–795.)

1231. POTENTIAL DISTRIBUTIONS ABOUT AN INFINITELY EXTENDED LINE ELECTRODE ON THE SURFACE OF A HORIZONTALLY STRATIFIED EARTH. II [Theoretical Investigation for Two-Layer and Three-Layer Earth].—M. Muskat. (*Physics*, January, 1935, Vol. 6, No. 1, pp. 14–26.) For reference to I *see* 1933 Abstracts, p. 518.

MISCELLANEOUS

1232. [Numerical Values of] BESSEL FUNCTIONS OF NEARLY EQUAL ORDER AND ARGUMENT.—J. R. Airey. (*Phil. Mag.*, February, 1935, Series 7, Vol. 19, No. 125, pp. 230–235.)

1233. [Numerical Values of] THE BESSEL FUNCTION DERIVATIVES $\partial(J_\nu(x))/\partial_\nu$ and $\partial^2(J_\nu(x))/\partial_\nu^2$.—J. R. Airey. (*Phil. Mag.*, February, 1935, Series 7, Vol. 19, No. 125, pp. 236–243.)

1234. THE DETERMINATION OF PERIODIC FUNCTIONS [Two Methods based on Heaviside's Symbolic Calculus].—Neufeld. (*Rev. Gén. de l'Élec.*, 26th Jan. 1935, Vol. 37, No. 4, pp. 116–120.)

1235. PAPERS ON SPHEROIDAL FUNCTIONS.—Stratton: Morse. (*See* 957.)

1236. ON THE EXPLICIT SOLUTION OF CERTAIN DIFFERENCE EQUATIONS [Reduction to Riccati's Differential Equation].—L. M. Milne-Thomson. (*Proc. Roy. Soc.*, 1st Nov. 1934, Series A, Vol. 147, No. 860, pp. 76–87.)

1237. THE THEORY OF LOCI [of Points in Vector Diagrams of A.C. Technique: New Elementary Construction of Circular Third Order Curves].—A. Herrmann. (*Arch. f. Elektrot.*, 12th Dec. 1934, Vol. 28, No. 12, pp. 813–817.)

1238. MAPPING OF FIELDS [including Conjugate Functional Methods and Conformal Representation: with Bibliography].—Weber. (*Elec. Engineering*, December, 1934, Vol. 53, No. 12, pp. 1563–1570.)

1239. EXPERIMENTAL PROBABILITY.—A. L. Clark. (*Canadian Journ. of Res.*, November, 1934, Vol. 11, No. 5, pp. 658–664.)

1240. [Comments] ON THE STATISTICAL THEORY OF ERRORS.—W. E. Deming and R. T. Birge. (*Phys. Review*, 1st Dec. 1934, Series 2, Vol. 46, No. 11, p. 1027.) *See* 1934 Abstracts, p. 632.

1241. ON THE APPLICATION OF LEAST SQUARES.—III. A NEW PROPERTY OF LEAST SQUARES [Zero Value of a Certain Sum over Fitted Points].—W. E. Deming. (*Phil. Mag.*, February, 1935, Supp. No., Series 7, Vol. 19, No. 126, pp. 389–402.)

1242. ENGINEERING INSPECTION: NOTES ON THE APPLICATION OF STATISTICAL METHODS TO PRODUCTION.—Nordica. (*Radio Engineering*, September, 1934, Vol. 14, No. 9, pp. 9–13.)

1243. THE BEHAVIOUR OF BIOLOGICAL BODIES AT HIGH FREQUENCIES [Conductivity Dispersion Curve of Blood in Ranges 50cm to 3m and 18–700m: Lecher System for Ultra-Short Waves, Bolometer Method for Short and Medium Waves].—H. Dänzer. (*Ann. der Physik*, Series 5, No. 8, Vol. 21, 1934/35, pp. 783–790.) For a previous paper *see* 635 of February.

1244. SHORT AND ULTRA-SHORT WAVES AT THE 1934 BERLIN RADIO EXHIBITION.—R. Wigand. (*Radio, B., F. für Alle*, October, 1934, No. 10, pp. 156–159.)

1245. THE 1934 BERLIN RADIO EXHIBITION [Receivers, Valves, Loudspeakers, Television].—F. Fuchs. (*Hochf:tech. u. Elek:akus.*, January, 1935, Vol. 45, No. 1, pp. 21–26.)

1246. WIRELESS AT THE PHYSICAL SOCIETY'S EXHIBITION.—(*Wireless World*, 18th Jan. 1935, Vol. 36, pp. 73–74.)

1247. THE THIRD REUNION OF THE C.C.I.R. [Lisbon, 1934].—(*Alta Frequenza*, December, 1934, Vol. 3, No. 6, pp. 712–727.)
With field-strength curves and ionosphere ionisation diagrams.

1248. SOME RESULTS OF THE THIRD [Lisbon] REUNION OF THE C.C.I.R.—Corbaz. (*Bull. Assoc. suisse des Élec.*, No. 26, Vol. 25, 1934, pp. 752–754.)

1249. THE LISBON MEETING OF THE C.C.I.R.—Harbich. (*E.T.Z.*, 24th Jan. 1935, Vol. 56, No. 4, pp. 80–82.)

1250. THE FIFTH CONGRESS OF THE U.R.S.I. [London, 1934].—(*Alta Frequenza*, December, 1934, Vol. 3, No. 6, pp. 705–711.)

1251. HOT-CATHODE PHOTOELECTRIC RELAY.—A. A. Ravdel. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 4, 1934, pp. 1174–1181.)

This new relay consists of a soft vacuum tube having a hairpin filament mounted between two electrodes, one of which acts as an anode and is maintained at a positive potential relative to the filament, while the other is left free. A coating of calcium is deposited on the inside of the bulb opposite the gap between the electrodes, and is maintained at a negative potential. When this coating is illuminated the anode current of the tube varies with the intensity of illumination, being greatest for small light values.

The following explanation is put forward:—When the relay is in darkness the anode current is large, and the free electrode assumes approximately zero potential. Under the influence of light, electrons are emitted by the photoelectric layer, and some of these reach the free electrode, which acquires a negative charge and, acting as a control grid, reduces the anode current of the tube. The magnitude of this charge depends on the relative intensities of the photoelectric current and the positive ion current due to residual gas in the tube. When the intensity of illumination is decreased the photoelectric current is reduced, and a new equilibrium is reached in which the charge is less than before. It should be noted that since the positive ion current rises and falls with the anode current it is increased when the intensity of illumination falls and *vice versa*, and so accelerates the discharging and charging of the free electrode. The time lag was not measured accurately, but oscillograms show that for a frequency of 1 000 c/s there is still appreciable variation in the anode current. Calculation shows that this time lag should be greater for weak illumination than for strong.

The sensitivity of this type of relay varies with the intensity of illumination, being about 500 mA per lumen for weak illumination and 50 mA per lumen for strong. An average figure of 100 mA per lumen may be assumed.

1252. THE USE OF A PHOTOCELL FOR MEASURING THE TEMPERATURE OF AN INCANDESCENT LAMP.—E. K. Putseiko. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 4, 1934, pp. 1163–1169).

A comparison of two methods of measuring the temperature of incandescent lamps by a photocell, using two-colour filters. In the first method the photocell is calibrated experimentally with standard lamps, and in the second by calculations based on its spectral sensitivity. The accuracy of the calculated tables is found to be within the limits of observational error.

1253. A NEW AMPLIFYING OSCILLOGRAPH FOR THE RECORDING OF ACTION CURRENTS, USING A CATHODE-RAY TUBE [for Electrocardiography, etc.].—Hehlgans. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 16, 1935, pp. 42–51.)

A portable equipment giving roll-film records in full daylight. For cardiography a simple two-tetrode amplifier is employed, but for the most delicate physiological uses the writer's special amplifier (440 of February), based on Rudolph's method of valves as anode resistances, is employed for its very high amplification.

1254. A MAGNETIC BRAKE FOR APPLYING AN EVEN TENSION TO A MOVING THREAD [using Photocell Control].—Stanbury and Marshall. (*Journ. Scient. Instr.*, November, 1934, Vol. 11, No. 11, pp. 348–357.)

1255. NEW RECORDING APPARATUS FOR DISTANT INDICATION OF ROLLER PRESSURES.—(*E.T.Z.* 15th Nov. 1934, Vol. 55, No. 46, pp. 1120–1121.)

1256. A SEISMOGRAPHIC RECORDER [Ink Records by Mirror Vibrations exciting Photocell].—Wolfe. (*Review Scient. Instr.*, October, 1934, Vol. 5, No. 10, pp. 359–361.)

1257. PHOTOELECTRICITY AND THE CHEMICAL INDUSTRY.—Walters. (*World Power*, January, 1935, Vol. 23, No. 133, p. 6: summary only.)

1258. PHOTOMETRIC STUDY [with Photocell] OF MICROBIC MULTIPLICATION.—Faguet. (*Comptes Rendus*, 4th Feb. 1935, Vol. 200, No. 6, pp. 498–500.)

1259. GALVANOMETER RELAYS [using Two Photocells, in parallel with and opposition to each other, across Galvanometer].—D. H. Follett. (*Nature*, 2nd Feb. 1935, Vol. 135, p. 187.)

1260. EFFECT OF TEMPERATURE AND OF VISIBLE AND INFRA-RED RADIATION ON THE ELECTRICAL RESISTANCE OF BORON [and the Great Effect of Wavelengths around 0.85μ].—Freymann and Stieber. (*Comptes Rendus*, 19th Nov. 1934, Vol. 199, No. 21, pp. 1109–1110.) Possibly a purely thermal effect but possibly also a photo-conductivity action as in selenium.

1261. THE UNION PACIFIC STREAMLINER THAT TALKED [Optical Telephony from Moving Train].—(*Gen. Elec. Review*, December, 1934, Vol. 37, No. 12, p. 578.)

1262. Application of Electron Tubes in Industry [including Ultra-High-Speed Photoelectric Relays, Theatre Light Control, Welder Control, etc.].—Chambers. (*Elec. Engineering*, January, 1935, Vol. 54, No. 1, pp. 82–92.)

1263. Ultra-Micrometer with Stabilised Valve.—Marinesco. (*Comptes Rendus*, 7th Jan. 1935, Vol. 200, No. 2, pp. 118–120.)

With the arrangement described, variations in the length of the order of 10^{-7} cm can be measured. Without a thermostat the writer has demonstrated the speed of growth of plants (10^{-5}–10^{-6} cm/s) and temperature changes of the order of 1/10 000°C. With some small modifications the apparatus can be converted into an automatic alarm for fire-damp.

1264. Kerr Effect, Optical Anisotropy and Molecular Structure [Survey].—Stuart. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 16, 1935, pp. 28–38.)

1265. A New Method for the Investigation of Photographic-Photochemical Processes, using the Electro-Optical Kerr Effect.—Narath. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 568–572: *Physik. Zeitschr.*, 1st Dec. 1934, Vol. 35, No. 23, pp. 992–996.)

1266. Time-Lags in Magneto-Optics [Improved Apparatus: Measurements in CS_2 and HCl].—H. W. Farwell and J. B. Hawkes. (*Phys. Review*, 1st Jan. 1935, Series 2, Vol. 47, No. 1, pp. 78–84.)

1267. A New Torque Meter for Oscillographic Recording [using Vibrating Steel Wire].—Moser. (*Bull. Assoc. suisse des Elec.*, No. 25, Vol. 25, 1934, pp. 689–694.) For corrections see *ibid.*, No. 26, p. 760.

1268. The Measurement of the Roughness of Surfaces [Survey].—(*Génie Civil*, 5th Jan. 1935, Vol. 106, No. 1, pp. 15–17.)

1269. Electric Motor with Quartz Rotor.—Soc. Optique et Préc. Levallois: de Gramont. (French Pat. 754 305: *Génie Civil*, 12th Jan. 1935, Vol. 106, No. 2, p. 52.) *See* 1933 Abstracts, p. 575.

1270. Multiple Earthing and Its Effect on Induced Noise [in Neighbouring Telephone Cables].—Collard. (*Elec. Communication*, October, 1934, Vol. 13, No. 2, pp. 130–141.)

1271. On the Theoretical Determination of Earth Resistance from Surface Potential Measurements.—A. F. Stevenson. (*Phil. Mag.*, February, 1935, Series 7, Vol. 19, No. 125 pp. 297–306.)

See also Abstracts, 1934, p. 455 (Stevenson) and 111 (Slichter). The present paper adopts expansions of conductivity and surface potential as Fourier series, instead of the power series previously used; the method only for the solution of the appropriate differential equations is given.

1272. Magnetic Methods of Testing Materials.—Gerlach. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 15, 1934, pp. 467–469.)

1273. The Effect of Magnetic Fields on the Heat Flow in Gases.—Senftleben and Pietzner. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 15, 1934, pp. 562–564.)

1274. Some New Experiments on the Harmful Effects caused by Strong Currents to the Users and the Instruments of Telecommunication.—(*Ann. des P.T.T.*, November, 1934, 23rd year, No. 11, pp. 1028–1041.)

1275. The Effects of Ultra-Short Waves on Bacilli. Part I.—Sasada, Nakamura and Wakabayashi. (*Journ. I.E.E.* Japan, October, 1934, Vol. 54 [No. 10], No. 555, p. 1116: Japanese only.)

1276. Recent Developments in Physical Instruments for Biological Purposes.—Bayliss and Kerridge. (*Journ. Scient. Instr.*, January, 1935, Vol. 12, No. 1, pp. 1–5.)

1277. Electron-Tube Telemetering for Gas and Water Works.—Watts. (*Electronics*, February, 1935, pp. 50–51 and 62.)

1278. Recent Development of Carrier-Current Telephony [on Lines and Cables].—Budzinski. (*Hochf:tech. u. Elek:akus.*, February, 1935, Vol. 45, No. 2, pp. 42–50.)

1279. A Conference on Applied Physics [including Attributes and Abilities for Industrial Physicists].—(*Review Scient. Instr.*, February, 1935, Vol. 6, No. 2, pp. 31–38.)

1280. The Physical Society's Exhibition. Notes on Exhibits of Wireless Interest.—(*Wireless Engineer*, February, 1935, Vol 12, No. 137, pp. 74–80.)

1281. The Radio Exhibition: a Technical Survey of Olympia, 1934.—(*Wireless Engineer*, October, 1934, Vol. 11, No. 133, pp. 533–541.)

1282. National Physical Laboratory: Annual Summer Visitation.—(*Wireless Engineer*, August, 1934, Vol. 11, No. 131, p. 427.)

1283. U.R.S.I. London Congress: Short Account of Subjects Discussed and Recommendations Adopted.—(*Wireless Engineer*, November, 1934, Vol. 11, No. 134, pp. 603–604.)

1284. Amateur Radio in the Soviet Union.—Krauss. (*QST*, October, 1934, Vol. 18, No. 10, pp. 22 and 98, 100, 102.)

1285. An Electromagnetic [Magnetostriction] Method for Measuring Young's Modulus for Iron, Steel, and Nickel Rods.—Wall. (*Journ. I.E.E.*, December, 1934, Vol. 75, No. 456, pp. 784–786.)

1286. The Use of Piezoelectric Quartz for the Study of Varying Pressures and Vibrations at High Frequencies [Survey].—Langevin. (*Rev. Gén. de l'Élec.*, 5th Jan. 1935 Vol. 37, No. 1, pp. 3–10.) For a modification of a statement regarding the necessary ratio of oscillograph frequency to maximum frequency to be recorded, see *ibid.*, 19th Jan. 1935, Vol. 37, No. 3, p. 74.

1287. A New Recording Dilatometer of High Sensitivity.—Goetz, Buchta and Ho. (*Review Scient. Instr.*, December, 1934, Vol. 5, No. 12, pp. 428–431.)

1288. Continuous Checking of the Drying and Impregnating Processes on Paper, by a Capacity-Indicating Method.—Waldschmidt. (*E.T.Z.*, 24th Jan. 1935, Vol. 56, No. 4, pp. 83–84.)

1289. A Recording Extensometer [Portable, on Capacity-Change Principle].—de la C. Chard. (*E.T.Z.*, 27th Dec. 1934, Vol. 55, No. 52, pp. 1276–1277.) *See* also 1934 Abstracts, p. 573, r-h column.

1290. The Measurement of Pressure exerted by a Material maintained at Constant Length, when It absorbs Moisture [using Extensometer and Photoelectric Control of Motor].—Davey. (*Journ. Scient. Instr.*, November, 1934, Vol. 11, No. 11, pp. 362–364.)

1291. Electro-Acoustic Boxes, Maihak System, for Measuring the Reactions of the Subsoil beneath Foundations and the Expansion of the Concrete.—Maihak. (*Génie Civil*, 26th Jan. 1935, Vol. 106, No. 4, p. 96: summary of *Engineer* article.)

1292. Accurate Frequency Control with Thermionic Tubes [Astronomical Telescope Drive].—(*Electronics*, September, 1934, p. 284.)

1293. High-Tension D.C. Transmission: Electronic Rectifiers and Inverters open New Power Possibilities.—Willis, Bedford and Elder. (*Electronics*, February, 1935, pp. 56–57 and 62.)

1294. A Thyratron-Commutated 400 hp Motor.—Alexanderson. (*Electronics*, February, 1935, pp. 54–55.)

1295. Microanalysis [Its Advantages and Application to Valve, Photocell and Other Problems].—Hermance. (*Bell Lab. Record*, November, 1934, Vol. 13, No. 3, pp. 81–87.)

1296. Industrial Electronic Control Applications [Photoelectric Control and Inspection: Time-Delay Relays using Cold Cathode Grid-Glow Tubes: Electronic Speed and Voltage Regulators: etc.].—Gulliksen and Stoddard. (*Elec. Engineering*, January, 1935, Vol. 54, No. 1, pp. 40–49.)

1297. Valve and Photoelectric Technique in the Study of Flame Movement, Ionisation and Radiation in Explosions.—Kirkby. (*Journ. Chemical Soc.*, February, 1935, pp. 160–165 and 165–168.)

1298. The Use of Photoelectric Apparatus in Chemistry.—Lange. (*Die Chemische Fabrik*, 23rd Jan. 1935, Vol. 8, No. 3/4, pp. 31–35.)

1299. Weighing Machine with Photoelectric Indication and Registration.—Busse and Görlich. (*Zeitschr. V.D.I.*, 24th Nov. 1934, Vol. 78, No. 47, pp. 1386–1387.)

1300. Sticky Material protected by Photocell [Rubber Sheeting in Shoe Factory].—(*Electronics*, September, 1934, p. 285.)

1301. Photoelectric Speed Trap [giving Warning when Motor Car passes a Pair of Photocells too rapidly].—Shepard. (*Electronics*, February, 1935, p. 59.)

1302. "Semagraph" Automatic Photoelectric Type-Setting Machine.—(*Electronics*, February, 1935, p. 54.)

1303. Illumination Meter [for Direct Measurement in Foot-Candles at a Given Place].—Salford Elec. Instr., Ltd. (*Journ. Scient. Instr.*, October, 1934, Vol. 11, No. 10, pp. 331–332.)

1304. Photocell used for Spectroscopy Measurements.—(*Electronics*, February, 1935, pp. 58–59.)

1305. Photoelectric [Spectro-] Photometer.—Hilger Ltd. (*Journ. Scient. Instr.*, January, 1935, Vol. 12, No. 1, p. 29.) *See* Follett, 1934 Abstracts, p. 516: also 1307, below.

1306. A New Type of Self-Registering Microphotometer.—Woodward and Horner. (*Journ. Scient. Instr.*, January, 1935, Vol. 12, No. 1, pp. 17–22.)

1307. The Use of Microphotometric Methods [using Two Photocells connected Differentially] in Divided-Beam Spectrophotometry.—D. H. Follett. (*Proc. Phys. Soc.*, 1st Jan. 1935, Vol. 47, Part 1, No. 258, pp. 125–134: Discussion pp. 134–135.)

1308. A Combined Recording Microphotometer, Densitometer and Comparator [Radiometer preferred to Photocell].—Leighton, Smith and Henson. (*Review Scient. Instr.*, December, 1934, Vol. 5, No. 12, pp. 431–434.)

1309. A Precision Radiation Integrator [Condenser/Photocell Method].—Müller and Shriver. (*Review Scient. Instr.*, January, 1935, Vol. 6, No. 1, pp. 16–21.)

1310. The Spectral Sensitivity of Photoelectric Counters.—Audubert and Reithmuller. (*Comptes Rendus*, 28th Dec. 1934, Vol. 200, No. 5, pp. 389–391.)

1311. "Handbuch der Funktechnik und ihrer Grenzgebiete": Vol. II, Sections 4 and 5.—Low-Frequency Transformers: Resistances, Fixed and Variable, Volume Controls, Tone Controls, etc.: Tuning Scales and Indicators, Switches, etc.—(*Radio, B., F. für Alle*, October, 1934, No. 10: detachable Supplement.) This instalment of the "Handbook" (1934 Abstracts, p. 213, r-h col.) describes and illustrates numerous German components.

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.

DIRECTION-FINDING

Application date, 21st April, 1933. *No.* 416126

The object is to carry out direction-finding observations from which the disturbing effects due to reflection from the Heaviside Layer are eliminated. Signals are transmitted in pulses, each lasting less than the five-thousandth part of a second. The rate at which the pulses are transmitted comes within the audible range, though the intervening intervals are sufficiently long to cover all the reflection effects from each pulse.

Reception takes place on two loop-aerials set at right angles and connected to two receivers of low time-constant, which are controlled by a rotating commutator not synchronised with the recurrence-frequency of the transmitted signals. As heard in a pair of head-phones, the regular character of the signals received direct can be distinguished both in amplitude and character from the reflected components, so that a clear-cut zero reading can be ensured in direction-finding. If received on a cathode-ray indicator, the direct wave produces a quasi-stationary line, corresponding to the direction of the transmitter, whilst the reflected signals show elliptical or circular tracings which can be ignored.

Patent issued to E. V. Appleton, L. H. Bainbridge-Bell, J. F. Herd, and R. A. W. Watt.

TELEVISION SYSTEMS

Convention date (*Germany*), *29th May*, 1933.
No. 416298

Relates to the known system of televising outdoor scenes by first taking a cinematographic film of the event. This is immediately passed through a scanning device and so used to modulate an outgoing carrier wave. According to the invention, this type of apparatus is fitted with additional chambers for storing one or more "finished" reels which are intended to be transmitted so as to fill in any intervals between the topical events under survey.

Patent issued to Fernseh Akt.

HIGH-FREQUENCY COUPLINGS

Convention date (*Holland*), *23rd August*, 1933.
No. 416302

In a double wave-band set it has already been proposed to use a light coupling between the primary and secondary windings of an input or intervalve coupling transformer, so that a single short-circuiting switch across part of the secondary winding suffices to short-circuit a section of both the primary and secondary windings, on the short-wave setting. This arrangement does not, however, remove the self-inductance and ohmic resistance of the nominally short-circuited section of the primary coil.

According to the invention, the damping effect of this part of the coil on the tuned circuit is avoided by inducing into it a "reverse" current from the secondary winding so as to neutralise the residual anode current. The required balancing current is obtained by providing an extra winding or two on the secondary coil.

Patent issued to N. V. Philips Gloeilampenfabrieken.

MODULATING SYSTEMS

Convention date (*U.S.A.*), *23rd July*, 1932.
No. 416396

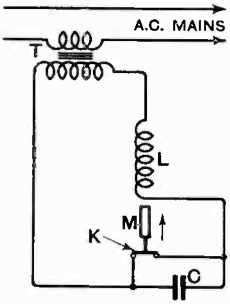
In amplitude modulation there is usually present some degree of phase modulation, just as there is an amplitude-modulated component in the output from most frequency or phase modulating systems. In both cases the admixture is undesirable and likely to cause distortion. The invention consists in first modulating a carrier by varying the phase or frequency of the wave, separately modulating it by amplitude variation, and then combining the two products in a common circuit in such proportions that the undesired modulation-characteristic is substantially balanced out, leaving a pure amplitude or frequency modulated carrier, as the case may be.

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

REMOTE CONTROL SWITCHING

Application date, 30th October, 1933. *No.* 416400

Overload in an A.C. mains supply is caused automatically to generate high-frequency oscillations which are then used to control a remote switch in order to restore the circuit to normal. The known presence of harmonic frequencies in the A.C. supply is utilised to secure the desired result. As shown in the Figure, the secondary winding of a saturated iron-core transformer *T*, inserted in series with the mains, is shunted by an inductance *L* and condenser *C* forming a circuit tuned to a high harmonic of the A.C. supply. Normally the contacts *K* are closed by spring pressure, but in the event of an overload the electro-magnet *M* is vibrated by the coil *L*, to bring the condenser *C* intermittently into circuit, and so build up pulses of high-frequency current. These are then transmitted through the mains and used to switch off the supply.



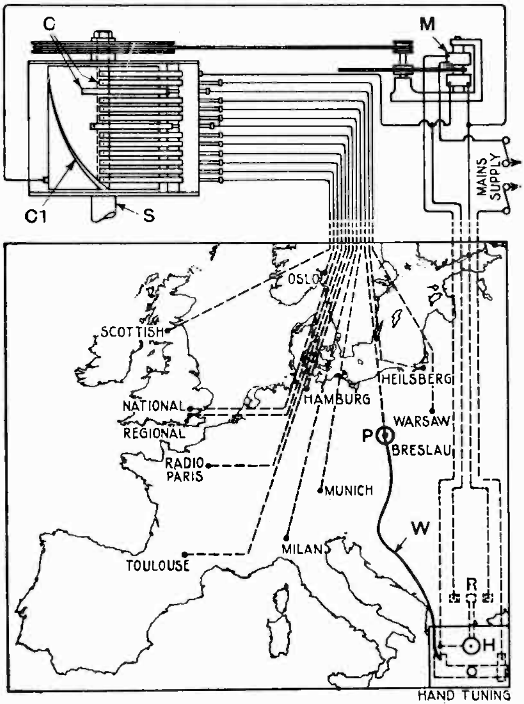
No. 416400.

Patent issued to E. Hallowell, and Northern Utilities Trust, Ltd.

"AUTOMATIC" TUNING

Application date, 14th March, 1933. *No.* 416435

Tuning is effected automatically by plugging into a socket formed in a panel marked with a map showing the geographical position of the desired station. The insertion of the plug completes a circuit which drives a motor through a distance determined by a cam related to the selected station. For long-wave stations a wave-change switch is automatically brought into action, the normal short-wave setting being restored on withdrawal of the plug. Provision is made to reverse the tuning motor should it over-run the correct distance, and also to de-energise the control circuits as soon as the correct setting has been effected. The receiving circuits are automatically "muted" so as to shut out background noise whilst changing from one station to another.



No. 416435.

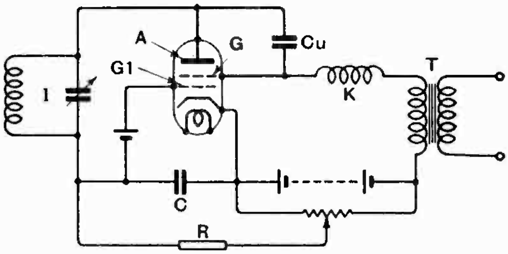
The Figure illustrates a simplified system in which the provision normally made for remote control, as well as certain other refinements, are omitted. The selector plug as shown is inserted at the Breslau station. This closes the circuit of the tuning motor *M* through the loose-plug connecting wire *W* and the mains supply. The motor then drives the spindle *S* of the ganged tuning-condensers (not shown) until its circuit is broken by a selector cam *C*1 and associated contacts *C*. In this simplified form provision is made for "fine tuning" through a hand knob *H* and a reversing switch *R* which drives the motor in one direction or the other as required.

Patent issued to Electric and Musical Industries, Ltd., and F. A. Mitchell.

AUTOMATIC VOLUME CONTROL

Application date, 16th March, 1934. *No.* 416464

The D.C. component of the rectified current produced by a valve operating in a "retarding-field"—or Barkhausen-Kurz—circuit is utilised to control the sensitivity of that valve or of a preceding amplifier. The grid *G* is given a high, and the anode or retarding-electrode *A* a low, positive bias. The input from the circuit *I* is applied primarily across anode and cathode, the output being taken from the grid *G*. A small condenser coupling *Cu* allows part of the H.F. input to reach the grid *G*, a choke *K* blocking such currents off from the output transformer *T*. This double connection counterbalances the effect of H.F. current variations on the charging of the load condenser *C*. The latter controls the working point of the control grid *G*1, in conjunction with the drop in voltage produced by the rectified output current flowing through the resistance *R*. The effect of the combined biasing control is to diminish the overall sensitivity of the valve as the amplitude of the carrier input increases, thus maintaining a constant output across the transformer *T*.



No. 416464.

Patent issued to J. J. V. Armstrong.

Application date, 16th March, 1933. *No.* 416501

Fading is prevented in a superhet receiver by varying the amplitude of the local oscillations produced by a valve-generator of the dynatron type, as the strength of the incoming carrier rises or falls. The amplitude of the output from a dynatron oscillator does not change immediately as the biasing potential on the control grid is altered, but only after a perceptible time-lag. This fact is utilised to simplify, or even to omit, the usual means for smoothing the rectified carrier-wave before applying it for the purpose of automatic volume control. A second advantage of the arrangement is that control bias applied to a dynatron generator regulates the amplitude of the output without causing any alteration in the frequency generated.

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

POWDER CORES FOR H.F. COILS

Application date, 13*th March*, 1933. *No.* 416583

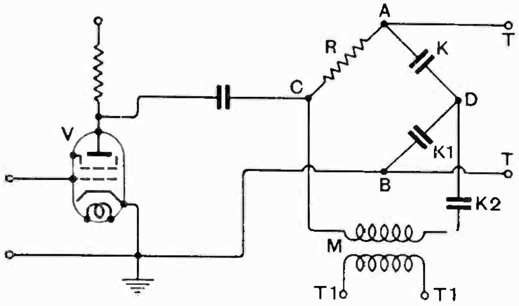
A magnetic core for high-frequency coils consists of a film of cellulose acetate, as used in cinematography, charged with finely powdered iron, preferably by blowing or spraying the film whilst it is in a viscous or semi-viscous state. In this way each individual particle is effectively insulated from the others. The film is afterwards rolled, squeezed, and polished, and then rolled into suitable core shapes.

Patent issued to V. G. van Colle, and Ward and Goldstone, Ltd.

TELEVISION SYSTEMS

Application date, 13*th February*, 1933. *No.* 416720

For synchronising purposes the line-scanning frequency and the lower "frame" or picture frequency are both superposed on the same carrier wave for transmission. At the receiving end both frequencies are received on a common circuit, from which they are separated out and applied to suitable saw-toothed oscillators. In order to avoid any back-coupling between the two local oscillators through the common circuit, the latter is arranged as a Wheatstone bridge and the two scanning frequencies are taken off across the diagonals.



No. 416720.

As shown in the Figure, the mixture of line (2,400 cycles) and picture (24 cycles) frequencies is applied between the grid and cathode of the valve *V*, the output impedances *R*, *K*, *K*1 forming a balanced bridge. The higher frequency flows through the tuned acceptor circuit *M*, *K*2 shunted across the diagonal *C D* and is taken off at the terminals *T*1, *T*1. The condenser *K*2 in this line heavily attenuates the lower frequency, which appears however at full strength across the diagonal *A B*, and is fed to the terminals *T*, *T*.

Patent issued to Electric and Musical Industries, Ltd., M. Bowman-Manifold, and E. C. Cork.

CATHODE-RAY RECEIVERS

Convention date (*Germany*), 21*st April*, 1933.
No. 416834

In order to enlarge the image formed on the fluorescent screen of a cathode-ray tube, an optical system is used comprising a main "collecting" lens having a diameter of not less than 10 centimetres, and a smaller lens corrected for spherical abberation due to the slightly convex shape of the screen. Chromatic abberation is substantially eliminated by inserting a filter to absorb the blue rays, or by tinting the back surface of the fluorescent screen with chrome yellow.

Patent issued to A. C. Cossor, Ltd.

TELEVISION TRANSMITTERS

Application date, 23*rd February*, 1933. *No.* 416848

A cathode-ray tube is fitted with a photo-electric surface upon which the picture to be transmitted is focused. Immediately in front of this surface is placed a wire-gauze screen, which is transparent to light and is positively biased. The light variations of the picture produce corresponding streams of electrons from the photo-sensitive electrode, which flow towards the positively charged gauze electrode. In doing so they create space-charges in the track of the scanning-ray from the "gun" part of the tube, and so give rise to voltage variations which are used to modulate the outgoing carrier wave.

Patent issued to Marconi's Wireless Telegraph Co., Ltd., H. M. Dowsett, and R. Cadzow.

ELECTROLYTIC CONDENSERS

Convention date (*Germany*), 21*st February*, 1933.
No. 416896

It is desirable that the storage layer used in an electrolytic condenser should be highly porous so as to absorb a maximum of electrolyte. At the same time it should be as thin as possible, in order to restrict the dimensions of the condenser. Ordinary paper fails in the first respect, and textile materials in the second, since a sufficient thickness must be used to prevent danger of contact between the metallic coatings. According to the invention a "composite" storage layer is used, built up of strips of filter paper separated by "distance" strips of compressed condenser paper.

Patent issued to Elektrizitats Akt Hydrawerk.

VARIABLE RESISTANCES

Convention date (*Denmark*), 27*th March*, 1933.
No. 416902

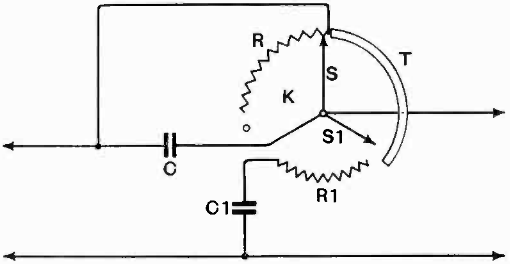
Relates to a high-resistance unit of the type in which powdered material is subjected to variable pressure by means of a movable electrode. According to the invention, the parts are so arranged that the control knob is effectively insulated so as to protect a user against the risk of shock. Both input and output electrodes are located on the underneath part of the casing, the path of the current being from one terminal, through an internal spiral spring, to the upper or moving electrode, and then back to the second electrode through the powdered material. The value of the resistance in circuit is regulated by screw pressure applied to the moving electrode through an insulating disc.

Patent issued to Bang and Olufsen A.S.

TONE CONTROLS

Application date 24th March, 1933. *No.* 416982.

One set of impedances C, R is designed to attenuate the low frequencies more than the high, whilst a second set C_1, R_1 attenuates the high frequencies more than the low, either control being brought into action as desired by means of two sliders, S, S_1, connected together and operated by a single knob K. As shown in the Figure the condenser C is short-circuited by the slider S, and the slider S_1 is out of contact with the resistance R_1, so that no tone control is effective. When the knob K is rotated anti-clockwise, the condenser C is shunted by an increasing resistance R until at the extreme point, the condenser alone is in series with the input, and low-note attenuation is at its maximum. On a clockwise rotation of the control knob, the slider S_1 throws the circuit R_1, C_1 in shunt with the input terminals so as to by-pass the high frequencies. In this direction the condenser C is continuously short-circuited by the slider S and a conducting strip T, which is out of reach of the slider S_1.



No. 416982.

Patent issued to Standard Radio Relay Services, Ltd.; G. M. O. Jenkins; and P. Adorjan.

MOVING-COIL SPEAKERS

Application date 3rd April, 1933. *No.* 416988.

One side-limb of the permanent magnet is of the usual shape, whilst the second side-limb has an equal length as regards magnetic circuit, though geometrically it occupies less space on the opposite side of the centre limb or pole-piece. The extra space so provided is used to accommodate a matching transformer for the output circuit. The combined overall length of the magnet and transformer is, at the same time, kept within the diameter of the frame or housing of the loud speaker cone.

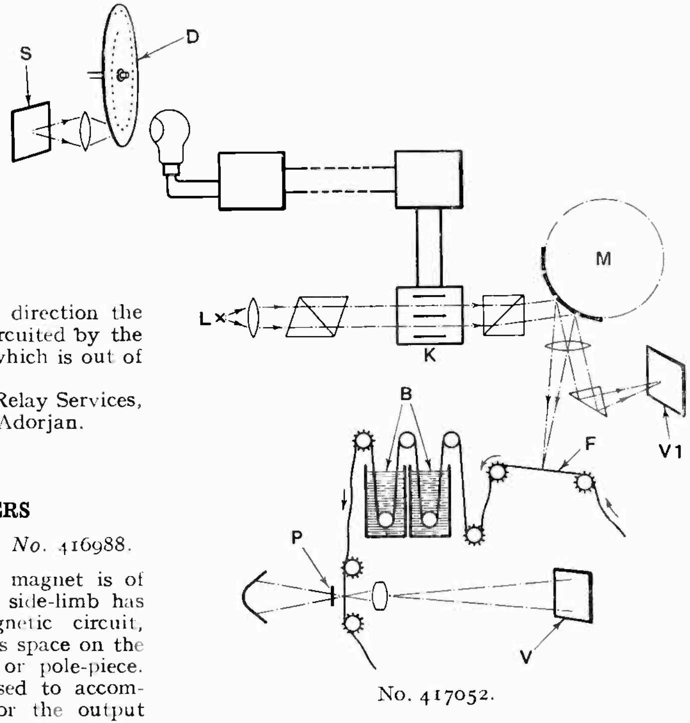
Patent issued to H. S. Haring and Magnavox (Great Britain), Ltd.

TELEVISION SYSTEMS

Application date 21st March, 1933. *No.* 417052.

At the transmitting end, the picture-repetition frequency is deliberately scaled down, say from 16 to 4 per second, and steps are taken at the receiving end to overcome the resulting "flicker" which would normally accompany the projection of moving events at a frequency so far removed from that required to produce the essential persistence-of-vision effect.

As shown in the Figure, the original picture or scene S is scanned by any known means, such as the rotating disc D, at the low speed contemplated. At the receiver the incoming signals are applied to a Kerr cell K, so that the controlled ray of light from a lamp L is distributed by a mirror drum M over a photographic film so as to reproduce the original picture. The film is immediately passed through a developing bath B, and is then fed to a cinematograph projector which throws it on to a viewing-screen V. The projector is adapted to throw each picture four times in succession, so that the picture-repetition frequency is thus increased from 4 to the normal 16 per second. The system is, of course, mainly applicable to the television of scenes where there is no movement at a large angular velocity over the field of view. For monitoring purposes, the scene may be projected directly from the rotating mirror M on to a fluorescent screen V_1.



No. 417052.

Patent issued to L. C. Martin.