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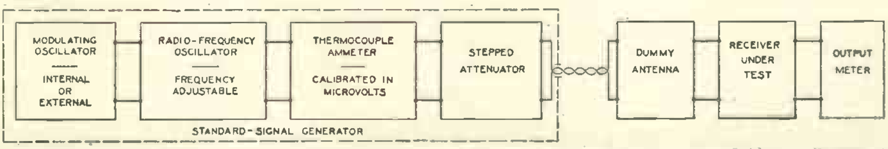

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The

WIRELESS ENGINEER

and EXPERIMENTAL WIRELESS

A Journal of Radio Research & Progress

Editor
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VOL. IX. FEBRUARY, 1932. No. 101.

Broadcasting with Ultra-short Waves.

IT is an interesting fact that the use of ultra-short waves is now being developed —or, perhaps, "explored" would be a more correct term—because of their short range. At one time all wave-lengths below about 200 metres were despised because of their supposedly rapid absorption and consequent uselessness for long-distance transmission. Then came the great discovery that, under certain conditions, short waves made long-distance transmission possible with an expenditure of power ridiculously small compared with that which had been found necessary for reliable long-wave transmission. Now a new phase is developing as the result of the discovery that for wavelengths below 10 metres the waves which travel over the earth's surface are rapidly damped out, while those which are radiated upward into space do not return again to the earth. They are thus admirably suited for those cases in which it is required to broadcast over a limited area, and to limit reception strictly to that area; the latter condition may arise from reasons of secrecy or from the desire to avoid interference in regions outside the limited area.

In February, 1931, we referred to von Ardenne's proposed use of ultra-short waves for the rebroadcasting of distant transmissions.

Schröter, of Berlin, pointed out the advantages of these quasi-optical waves in a Patent Specification dealing with picture transmission in 1926. The designation quasi-optical refers to the fact that the waves can only be received at points within sight of the transmitting aerial, the words "within sight" being interpreted in a geometrical sense. Schröter communicated a paper on the subject to the World Power Conference at Tokio, and he has made a number of experiments in the neighbourhood of Berlin, the results of which were described in the October number of *Elektrische Nachrichten Technik*. The first experiments were made with a quarter-wave vertical wire several metres above a roof in the city, transmitting at a wavelength of 3.4 metres; these were received at loud speaker strength inside massive buildings up to a distance of about 5 kilometres. The success of these tests led to the institution of a series of systematic tests at wavelengths from 3.2 to 11.6 metres with a 60-watt transmitter mounted on a roof about 6 miles from the centre of the city. It was found that over open country there was little difference between the absorption at 3 metres and that at 7 metres, but that the shadow cast by metal structures and the absorption due to houses increased very appreciably as the wavelength was reduced from 7 to 3 metres.

The character of the wave propagation was found to change when the wavelength exceeded about 8 metres, due to the return of energy from the space above the earth, but for wavelengths below 6 metres the radiation appeared to be entirely of the quasi-optical type. The range was found to increase rapidly when the wavelength reached about 8 metres; at 9 metres fading effects were observed, but, strange to say, they were not observed when the wavelength was increased to 11 metres. A crystal-controlled transmitter with 6 metre wavelength and an aerial power of about 250 watts was then erected at Nauen, the dipol being suspended at a height of 30 metres above the ground. After carrying out a series of experiments, this transmitter was transferred to the picture-transmitting laboratory of the Telefunken Company in Berlin, where it works at a wavelength of 7 metres and is used experimentally in the Berlin broadcast programmes. The controlling crystal has a wavelength of 112 metres, but the frequency is doubled at each stage of the generator, giving a final wavelength of 7 metres. The telephony power is at present 300 watts. The range and loudness of reception are found to be very sensitive to changes in the height of the transmitter, an increase of 15 metres in the height causing very striking increases in range and loudness. The loudness of the received signals in a room in a closely built part of the city depends on the height of the room above the ground or, more strictly speaking, on the depth of the room below the general roof level. As a rough approximation Schröter regards the mass of buildings as a homogeneous absorbing layer on the surface of the earth. The waves travel from the elevated dipol transmitter in straight lines and without loss until they strike the roof level; they then penetrate the layer of buildings with increasing absorption, so that a receiver gives increasingly weakened signals as it is taken from the attic down through the several floors to the ground level. This would appear to be a disadvantage of this method of broadcasting. Very unequal results would be obtained in a hilly town, loud signals being obtained in any situation from which the transmitting aerial was directly visible. With such short wavelengths it should be a relatively simple matter to place a reflecting surface above the aerial so that the energy, which would otherwise be radiated above the horizontal and lost, might be usefully employed.

The use of these ultra-short waves necessitated the design of suitable receivers, or of suitable amplifying and detecting stages to be used in conjunction with ordinary receiving sets. The Telefunken Company have experimented with super-regenerative receivers, a type first devised by Armstrong, but little used at the present time. The sensitivity could be made very great, but the background noise was excessive. They then developed a grid rectifier with back-coupling which could be connected to the gramophone socket of an ordinary receiver. A receiver of this type has been used in the survey of the signal strength obtained at various points in and around Berlin; it was a battery model, but it is claimed that all-mains sets have now been successfully designed both on the super-regenerative and on the grid rectification principles.

For the reception of radio-telephony on a wavelength of two metres the British Post Office has developed both the super-heterodyne and the super-regenerative type of apparatus. The former has two intermediate frequencies of 20×10^6 and 300,000, and therefore three detecting stages, but as it contains nearly 30 valves it is obviously designed for official use and not for the ordinary listener. The super-regenerative set is less ambitious and was used in the demonstrations of telephony on a two metre wave at the Telephone Exhibition recently held at South Kensington.

It is interesting to note that in the recent report of the Radio Research Board, it is stated that in searching for increased sensitivity in receivers for these quasi-optical waves, time has been devoted to the development of a supersonic heterodyne type of receiver. Here again it was found that extreme sensitivity was associated with excessive background noise due to the amplification of external disturbances. The Telefunken engineers found that the ignition systems of motor cars were bad offenders in this respect. It remains to be seen if it is possible to obtain great sensitivity in the reception of 5 to 10 metre waves without the troublesome sensitivity to random disturbances. This field of research is one that requires great accuracy and care in design and construction, but it is one which makes relatively small demands on space and equipment.

G. W. O. H.

The Design of the Band Pass Filter.*

By N. R. Bligh, B.Sc.

(Research Laboratories of the General Electric Company, Wembley, England.)

DURING the past two years many sets have been described using band pass filters, and their effect on the quality of the reproduction and selectivity has been pointed out.

It has been seen† that unfortunately the performance of these filters varies greatly with the wavelength to which they are tuned, and it is essential to have some means for rapidly estimating this performance at various wavelengths. Since the behaviour of such filters is more simply related to the frequency than the wavelength at which they work, in the rest of this article the term frequency is used in preference to wavelength. It is fortunate that with filters used for broadcast reception the actual band breadth of the filter is small compared with the frequency at which it works. For example, at one megacycle, that is, at a wavelength of 300 metres, we are mainly interested in the performance of the filter up to, say, ten kilocycles on either side of the working frequency to observe effects on the audio-frequency response of the set, and up to, say, fifty kilocycles in estimating the amount of interference the set will experience from neighbouring stations.

The fact that the band breadth is small in comparison with the working frequency enables us to make many convenient approximations in our design formula. Also in many cases the actual resistance of the circuits is of importance only near the resonance frequencies. At other frequencies the reactances are so large that the resistance can be neglected. Every circuit, however, must be examined to see if this holds.

There are two general classes of filter in use at present, these are indicated in Fig. 1 (*a*) and (*b*) and it will be shown that a combination of these, as illustrated in Fig. 1 (*c*), is also possible and is a material improvement of the simpler ones.

In this figure L and C are the normal tuning coils and condensers of the filter, while X_0 and X_0'' are the coupling reactances, either condensers, self-inductances, mutual inductances, or combinations of these.

It is of interest in the first instance to see how these filters would behave if the resistances of the circuits were so small as to be negligible.

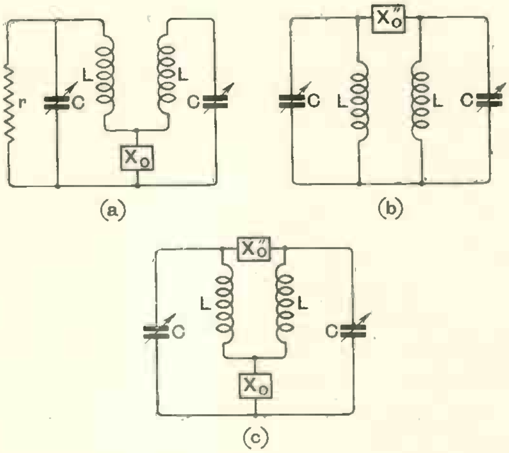

Fig. 1.

In these circumstances some very simple formulae‡ can be used for the semi-band breadth F. (The semi-band breadth is used as this corresponds to the audio-frequency having the greatest effective magnification.)

If the frequency at which the filter works is f_0 we have :—

For Fig. 1 (*a*)

$$F = \frac{f_0}{2}\frac{C}{C_0} = \frac{1}{4\pi}\sqrt{\frac{C}{L}}\frac{1}{C_0} \quad \dots \quad \dots \quad (1)$$

Where X_0 is a capacity C

$$F = \frac{f_0}{2}\frac{M}{L} = \frac{1}{4\pi}\sqrt{\frac{1}{C}}\frac{M}{\sqrt{L^3}} \quad \dots \quad (2)$$

Where X_0 is a mutual or self inductance M.

* MS. received by the Editor August, 1931.

† See *Wireless World*, Feb. 26th, 1930; April 2nd and 9th, 1930.

‡ See *Experimental Wireless*, Editorial, July, 1931.

For Fig. 1 (*b*)

$$F = \frac{f_0}{2}\frac{C_0''}{C} = \frac{1}{4\pi}\sqrt{\frac{1}{L}}\,\frac{C_0''}{\sqrt{C^3}} \quad \ldots \quad (3)$$

Where X_0'' is a Capacity C_0''.

$$F = \frac{f_0}{2}\frac{L}{L_0} = \frac{1}{4\pi}\sqrt{\frac{L}{C}}\,\frac{1}{L_0} \quad \ldots \quad (4)$$

Where X_0'' is an inductance L_0.

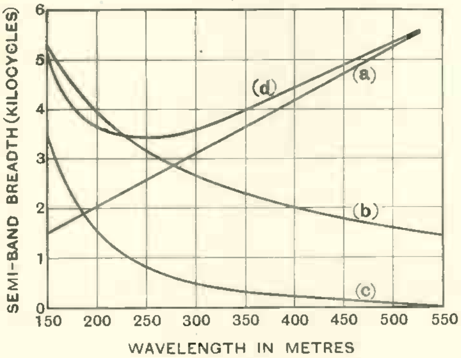

Fig. 2.—(a) X_0 *is a capacity of* 0.02 *microfarad.* (b) X_0 *is an inductance of* 0.108 *microhenry.* (c) X_0'' *is a capacity of* 0.12 *micro-microfarad.* (d) X_0 *is a capacity of* 0.02 *microfarad.* X_0'' *is a capacity of* 0.12 *micro-microfarad.*

If we work out equations 1-4 to find the values of coupling reactances for normal values of F, we find that C_0'' and M are small in value, whilst C_0 and L are large, *e.g.*, if $F = 5$ kilocycles, and $L = 200$ microhenries, then at a wavelength of 300 metres we find that the corresponding values of coupling reactances are :—

$C_0 = 0.015\ \mu$F, $L_0 = 20$ millihenries,
$C_0'' = 1.52\ \mu\mu$F, $M = 2$ microhenries.

The fact that the inductance L_0 must be of large value for type Fig. 1 (*b*) filters prevents its adoption, because the self-capacity of the inductance employed would usually be sufficiently large to upset the filter's operation completely.

By the use of equations 1-4 it is easy to plot curves showing the band breadths of these filters at various settings of the tuning condensers, and this has been done in Fig. 2. Curve (*a*) is for X_0 a capacity of 0.02 microfarad, curve (*b*) for X_0 an inductance of 1.08 henries, and curve (*c*) for X_0'' a capacity of 0.12 micro-microfarad. The tuning inductance in each case was 200 microhenries.

These graphs show at once the large variation in band breadth to be expected when using these filters and that some means must be found to reduce this. One method has already been given in *The Wireless World*,* and this with a second method is shown diagrammatically in Fig. 3.

It is a very useful property of these narrow band filters that the total band breadth for the mixed filter is given by the sum of the two band breadths it would have with either coupling alone.

There are two important points to be remembered when using the circuit of Fig. 3 (*a*). These are :—

(1) That the frequency at which the filter is working shall be well removed from the frequency at which $\omega^2 MC_0 = 1$, *i.e.*, the point at which the coupling is resonant.

(2) That the mutual inductance must be correctly connected so that the numerical sum of the reactances, *i.e.*, $\frac{1}{j\omega C_0} + j\omega M$ tends to remain a constant as ω varies. Neither of the circuits of Fig. 3 will give absolute constancy of band breadth, but an example of the use of the circuit in Fig. 3 (*b*) is given on Fig. 2 (*d*) where C_0' and C_0'' had the same magnitude as used for curves (*a*) and (*c*).

Having now made the preliminary investigations which are a useful guide to the general behaviour of the filter, the modification of these results by the resistance of the coils will be examined.

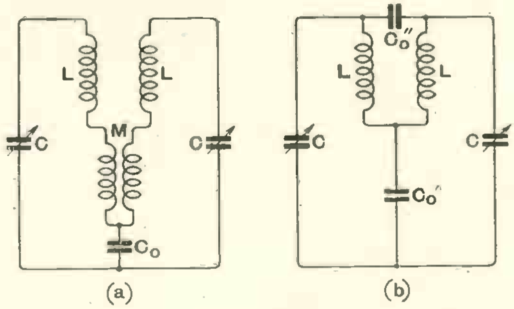

Fig. 3.

Some of the formulae have been given before, but will be restated here for the sake of completeness. Taking the original circuit of Fig. 1 (*a*), let each of the tuned circuits

* See *The Wireless World*, Feb. 18th, 1931 ; April 1st, 1931.

have an effective resistance R. This will be mainly located in the inductance coils and any other shunt resistances "r" such as the valve resistance, can be conveniently considered as a resistance $\frac{\omega^2 L^2}{r}$ which is added to R. (We will at present take it that each circuit has a similar resistance, but the alterations to allow for differing resistances are easily made.)

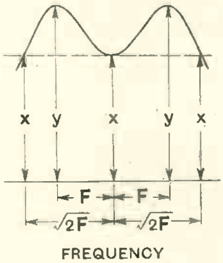

Fig. 4.

Now take X as the magnitude of the reactance coupling the two circuits together as in Fig. 1 (a), and let f be the difference between the frequency at which the amplification is being considered and the frequency at the middle of the band pass filter. That is, in the following formula the amplification is given for a sideband corresponding to a low-frequency modulation of a frequency f. As before, let F be the value of f which gives the maximum amplification; therefore, F is the semi-band breadth of the filter.

In calculating the response of a filter the particular case is taken when a voltage e is injected into the first tuned circuit, and a voltage E is produced across either the condenser or the inductance of the second tuned circuit. Then, if we call $\frac{E}{e}$ the magnification A we have

$$A = \frac{\omega LX}{R^2 + X^2 - 16\pi^2 f^2 L^2 \pm 8j\pi fLR} \qquad (5)$$

The frequencies F at which the magnification is a maximum are given by equation (6)

$$F = \pm \frac{\sqrt{X^2 - R^2}}{4\pi L} \quad \ldots \quad (6)$$

and the maximum magnification in equation (7)

$$A_{(max.)} = \frac{\omega LX}{2RX} = \frac{\omega L}{2R} \quad \ldots \quad (7)$$

Between the two frequencies of maximum magnification is a frequency of minimum magnification given by $f = 0$

and $$A_{(min.)} = \frac{\omega LX}{R^2 + X^2} \quad \ldots \quad (8)$$

There are two other frequencies at which the magnification is given by the equation (8), and these by considerations of equation (5) can be seen to occur at frequencies given by $\sqrt{2}F$.

This result is most useful as it enables five points on the response curve of a filter to be rapidly determined, as shown in Fig. 4, where the value of F is obtained as shown previously and the magnifications "x" are given by $A_{(min.)}$ and those of "y" by $A_{(max.)}$

Very often it is actually more important to know the frequency given by $\sqrt{2}F$ than the frequency F since at the former frequency the magnification is equal to that at very low frequencies.

The next thing to be considered is the ratio n of the maximum magnification to this low-frequency magnification; this ratio is called the *ratio of magnification*. Using the previous results (7 and 8) we find that

$$\frac{X}{R} = n + (n^2 - 1)^{\frac{1}{2}}$$

for a band pass filter. That is, if y/x, in Fig. 4, is fixed by the desired audio-frequency response, then the ratio of the coupling reactance to the circuit resistance is also fixed.

Now if the magnification ratio is fixed the formula for F can be stated in a slightly different manner. Thus :—

$$F = \frac{X}{4\pi L}\sqrt{1 - \left(\frac{1}{n + (n^2 - 1)^{\frac{1}{2}}}\right)^2}$$

$$= \frac{X}{4\pi L} P$$

or $$F = \frac{R}{4\pi L}\sqrt{(n + (n^2 - 1)^{\frac{1}{2}})^2 - 1}$$

$$= \frac{R}{4\pi L} Q$$

where P and Q are constants depending only on the value of n. This shows the most important result that if the ratio of magnification is decided from the point of view of maintaining good low-frequency reproduction, then the only way to adjust the band breadth is by the adjustment of the circuit resistance. Thus if n and F are fixed,

$$R = \frac{4\pi LF}{Q} \text{ and } X = R(n + (n^2 - 1)^{\frac{1}{2}})$$

It can also be seen from these equations that *if a filter of this type is to keep the same band breadth and the same magnification ratio at all settings of the tuning condenser, then the value of the circuit resistance must remain constant, as must also the coupling reactance, at whatever frequency the filter works.* In general, the circuit resistance increases with frequency, and hence either the magnification ratio decreases or the band breadth increases with increase of frequency.

For actual calculation of the shape of a magnification curve the following formula is very useful. If we wish to know the frequency f at which the magnification is $\frac{1}{x}$ times the maximum, then,

$$f = F\sqrt{1 \pm \frac{2RX}{X^2 - R^2}(x^2 - 1)^{\frac{1}{2}}}$$

Now F and $X^2 - R^2$ would have already been used to see if the band breadth is suitable, and $2RX$ to determine the peak amplification. Thus with a graph of $(x^2 - 1)^{\frac{1}{2}}$ against x the whole response curve is quickly obtained.

Filters of Constant Band Breadth.

The formulae already obtained (equation 6) show that to maintain the band breadth constant $X^2 - R^2$ must remain constant. For the simpler types of filter, and for that shown in Fig. 3 (*a*), curves have been previously given showing the variation of R^2 and X^2, with the frequency to which the filter is tuned. It will, therefore, be of interest to examine the circuit shown in Fig. 3 (*b*). It is possible to obtain exact formulae which enable the band breadth of the filter to be made equal at two separate settings of the tuning condensers. In practice it is seldom necessary to do this, and useful approximate formulae can be used.

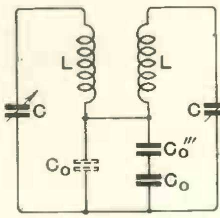

Fig. 5.

By means of the usual $\triangle$ to star transformation to a very close approximation the condenser C_0'' in Fig. 3 (*b*) can be replaced by a condenser C_0''' as shown in Fig. 5 without appreciable alteration of the behaviour of the circuit. It can be shown that $C_0''' = \frac{C^2}{C_0''}$. This circuit can be treated as the simple filter with one coupling condenser C_0 where $C_0 = \frac{C_0' C_0'''}{C_0' + C_0'''}$. In practice C_0'' (or C_0''') does not affect C_0 greatly at

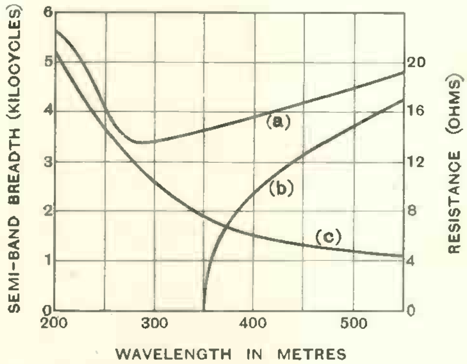

Fig. 6.—*Semi-band breadth of filter.* (a) *For combined capacity coupling.* (b) *For single capacity coupling. The resistance of each circuit is given in curve* (*c*).

the maximum setting of the tuning condenser, as C_0''' will then be found to be a capacity many times the value of C_0'. Thus to decide on the value of C_0' the coupling capacity C_0 required to give the correct band breadth at the longest wavelength is found and C_0' is chosen to have a value slightly greater than this. Then C_0 for the lowest wavelength to be considered is found and the capacity C_0''' is chosen which in series with the capacity C_0', already decided, gives this value of C_0. As an example, take a 200 microhenry coil, which has a resistance of 4.5 ohms at 550 metres and 26 ohms at 200 metres. The formula for the peak frequency slightly rearranged gives

$$C_0 = \frac{1}{2\pi f_0 \sqrt{R^2 + 16\pi^2 F^2 L^2}}$$

Hence, to give a band breadth of ten kilocycles, C_0 at 550 metres is 0.022 microfarad and 0.0037 microfarad at 200 metres. Taking C_0' as 0.025 microfarad, and finding C_0''' and then C_0'' to give the required value of C_0 at 200 metres gives C_0'' as 0.75 micro-microfarad. The curves in Fig. 6 give the actual band breadth variation—curve (*a*) for the combined capacity coupled filter using the values found above, and curve (*b*) when the small 0.75 micro-microfarad capacity is disconnected.

This shows that the combined coupling has greatly reduced the variation in band breadth, but that in the example it would have been better to use a slightly smaller coupling condenser than the 0.75 micro-microfarad one, since the curves of Fig. 7 show that the resistance of the circuit has greatly reduced the selectivity at the higher sideband frequencies.

It has been previously shown that the combined mutual inductance and capacity filter generally gives a rather suddenly narrowing band breadth at the higher frequencies, but these results show that the combined capacity filter tends to increase the band breadth at the higher frequencies, so that, doubtless, a combination of the two schemes shown in Fig. 3 could be used to obtain further constancy of band breadth. In practice, such an elaboration is seldom needed, and the resultant curves will be entirely satisfactory if the smaller coupling condenser is so adjusted that the band breadth at the shortest wavelength is slightly less than at the longest.

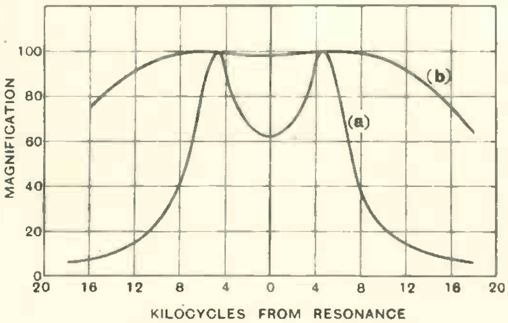

Fig. 7.—(a) *Percentage magnification at* 550 *metres.* (b) *Percentage magnification at* 200 *metres.*

In Fig. 8 (*a*) and (*b*) are given curves on a combined capacity coupled filter, and on a single capacity filter using tuning coils consisting of 60 turns of 29 S.W.G., D.S.C. on a two-inch diameter ebonite former. The small coupling capacity in this case consisted of two small brass plates 1.5 cm. diameter set 0.4 cm. apart, and the larger was 0.02 microfarad. This example shows that in such filters care must be taken not to bring the high potential ends of the tuning condensers or inductances near to one another.

In practice, the large coupling condenser can be so chosen that the band breadth is as required at, say, 550 metres. The set is then tuned to a lower wavelength, and a small condenser as described above joined

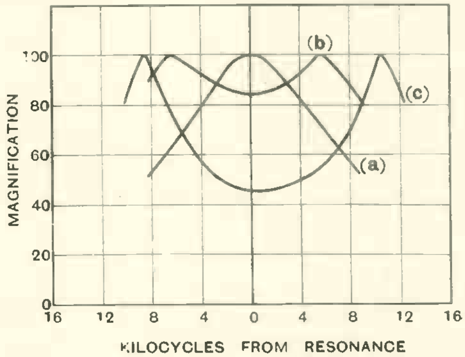

Fig. 8(*a*).—*Percentage magnification of experimental single capacity coupled filter.* (a) *Wavelength* = 250 *metres.* (b) *Wavelength* = 350 *metres.* (c) *Wavelength* = 500 *metres.*

across the high potential ends of the inductances and increased till the required band breadth is obtained. This adjustment is particularly easy to carry out, and by tuning in various stations at different wavelengths, and noting the deflections on a milliammeter joined in the anode circuit of the detector, a good compromise as to constancy of band breadth is soon arrived at.

It should always be remembered that if the peaks of the curve are, for example, 10 kilocycles apart, then the audio-frequency with maximum response will be 5 kilocycles, but that at $\sqrt{2} \times 5$, or 7.1 kilocycles, the response will still be quite large and equal in fact to the response at the lowest audio-frequencies.

Another useful fact is brought out by the examination of the properties of these circuits. This is, that *the maximum output voltage of a two-peaked filter is just half that of a single circuit, that is,* the magnification of a single circuit which is $\frac{\omega L}{R}$ is just twice that of the filter (equation 7). Also it is apparent that, *as long as the filter has two peaks, the maximum magnification obtained with the filter is independent of the coupling used,* though the sideband frequency at which this amplification takes place does, of course, increase the greater the coupling impedance. The amplification of the side-bands corresponding to the lower audio-frequencies decreases, however, the greater the band breadth.

There is one other point which is of interest when comparing single tuned circuits and the

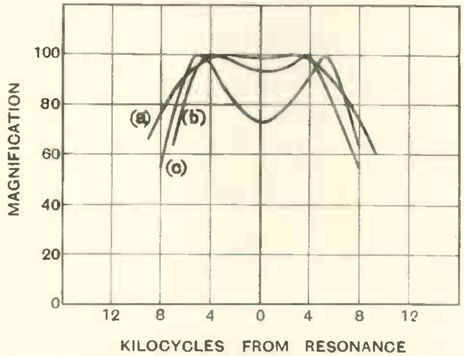

Fig. 8(*b*).—*Percentage magnification of experimental combined capacity coupled filter.* (a) *Wavelength* = 250 *metres.* (b) *Wavelength* = 350 *metres.* (c) *Wavelength* = 500 *metres.*

coupled filter. If we consider the magnification of a single tuned circuit at a frequency far from resonance and compare this with the magnification at resonance, the ratio is given by $\frac{R}{4\pi fL}$, and if there were two such circuits coupled by a valve, so that the second could not react on the first, for the overall response, this ratio would be given by $\frac{R^2}{16\pi^2 f^2 L^2}$. If we compare the magnification for a filter, composed of these two circuits, at a frequency far from its frequency of maximum amplification with the maximum magnification, the ratio is $\frac{RX}{8\pi^2 f^2 L^2}$. By comparing these two ratios we see that the interference from a distant station will be $\frac{2X}{R}$ times as great when using the filter as when using the two circuits in cascade. As an interesting example it will be found that if response curves for a filter and for the same two circuits coupled by a valve are examined when the filter has only one broad peak, that is, when $R = X$, then an interfering station, say, fifty kilocycles away, is just about twice as powerful with the filter as with the cascaded circuits. Generally the interference from distant stations will be worse than this as the filter curve is broadened.

One final word. *The filter must be carefully tuned.* It can be shown that if the band breadth is normally f_1 cycles and the two circuits are mistuned by $2f_2$ cycles, then the actual band breadth of the mistuned filter will be given by $\sqrt{f_1^2 + f_2^2}$. As a point of interest it may be remarked that if we are considering circuits in cascade as previously described, and again let $2f_2$ be the frequency which they are mistuned, the resultant response curve will be exactly similar to that of a filter, and all the previous formulae for the filter still hold if we replace the coupling reactance X by a reactance $4\pi f_2 L$.

NEW BOOKS.

Radio Construction and Repairing.

By J. A. Moyer and J. F. Wostrel (3rd edition).

A review of the first edition of this book appeared in our issue of April, 1928. The present edition has been considerably revised and enlarged to include the construction of modern superheterodyne receivers, while more space is devoted to short-wave apparatus, especially that designed for broadcasting and television. The glossary of Technical Terms has also been revised.

The book is, of course, written primarily for American amateurs and, especially in the constructional notes, the components and valves referred to are those standardised in the United States but, apart from this fact and the difference in terminology, the book should prove of service to amateur constructors.

Pp. 386 + ix with 179 figures. McGraw Hill Publishing Co., Ltd., London, price 15s.

Electricity, what It is and How It Acts.

Vol. II, by A. W. Kramer. The part played by the Electron in the propagation of light, radiation of heat, wireless waves, etc. Pp. 290 + xiv, with 112 illustrations and diagrams. Published by Technical Publishing Co., Chicago, U.S.A., price $2.

Radio Telegraphy and Telephony.

A complete textbook for students of wireless communications, by R. L. Duncan and C. E. Drew, 2nd edition, revised and enlarged, additional chapters having been written on Receiving Apparatus, Wireless as used in Aviation, and Broadcasting, while those on Valves, Commercial Transmitters, etc., have been enlarged and brought up to date. Pp. 1046 + xi, with 529 diagrams and illustrations. Published by John Wiley & Sons, Inc., New York, and Chapman & Hall, Ltd., London, price 45s. net.

Moving-coil Magnets.*

Precision Measurements of the Gap Flux Density.

By C. E. Webb, B.Sc. (Eng.), A.M.I.E.E.

(The National Physical Laboratory.)

THE extensive use of moving-coil loud-speakers, both of the permanent and electro-magnet patterns, has naturally directed attention to the problem of measuring the flux density produced in the annular air-gap in which the coil moves. A comprehensive account of the properties of loud-speaker magnets, with special reference to the flux distribution, has been given by N. W. McLachlan (*W.W.*, Vol. 27, p. 600, Nov. 26th, 1930), but, in view of the considerable increases in effective flux density recorded since the date of his paper, a short note on the method employed at the National Physical Laboratory for measuring these flux densities may be of interest. The method is the same in principle as that described by McLachlan, but differs from it in the manner of application.

The problem is to determine the density of the radial flux crossing the cylindrical air-gap of the magnet., *i.e.*, the number of lines of force per sq. cm. of circumferential area. This density clearly diminishes from the inner to the outer surface of the gap, since the same number of lines of force is spread over an increasing area. In practice the quantity measured is the total flux in a given axial length of the gap, and the flux density at any desired radius is then calculated by dividing this total flux by the appropriate circumferential area. Since the air-gap is narrow, it is sufficient to determine the flux density in the middle of the gap, *i.e.*, at the mean radius. Thus, if ϕ is the total flux, found by the method of measurement to be described, in an axial length of gap, x cms., and d cms. is the mean diameter of the gap (see Fig. 1), then the circumferential area is $x \times \pi d$ sq. cms., and the flux density required, B_g, is given by the simple relation

$$B_g = \frac{\phi}{x \times \pi d} \text{ lines per sq. cm.}$$

This calculation assumes that the flux is uniformly distributed over the gap within the axial length, x, under consideration. In practice this is normally fairly accurately true over the greater part of the gap, but towards the inner and outer ends of the gap there is an appreciable diminution of the density. It is important for precise results to ensure that the density is uniform over the axial length within which the flux is measured.

Method of Measuring Total Flux in a Given Axial Length.

The measurement of the flux, ϕ, is carried out by the standard method of moving a search-coil through the field and noting the deflection produced on a ballistic galvanometer connected to the coil. It is well known from elementary theory that the deflection is proportional to the product of the number of lines of force cut and the number of turns on the coil, provided that the time taken to complete the movement of the coil is small compared with the periodic time of the galvanometer. The galvanometer used is a moving-coil instrument of high sensitivity having a periodic time of the order of 10 secs., and as the movement of the search-coil can be carried out in a fraction of a second, the necessary condition is readily fulfilled.

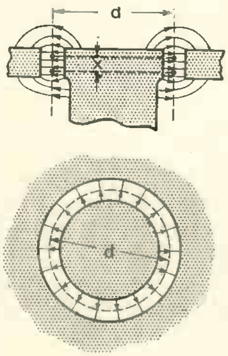

Fig. 1.

The ballistic galvanometer is calibrated by reversing a current of exactly 1 ampere in the primary of a mutual inductometer of accurately known value, the secondary being connected through the search-coil and a variable resistance to the galvanometer. If desired, the series resistance may be adjusted to a suitable value to make the galvanometer, for a search-coil of any given number

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of turns, read directly the flux cut. In order to avoid altering the resistance of the galvanometer circuit, the secondary of the inductometer is left in series during the flux measurements on the magnet.

The search-coil is wound on a thin cylindrical brass tube (*A*, Figs. 2 and 3), which fits loosely into the air-gap of the magnet. It consists of a single turn of fine d.s.c. copper wire (*B*, Figs. 2 and 3) in a V-shaped groove turned accurately perpendicular to the axis and as close as practicable to the end of the tube. The leads from the coil are twisted and brought out along an axial groove in the tube, both coil and leads being waxed securely into their respective grooves to prevent movement. After emerging from the axial groove at the end of the brass tube, the leads are taken through silk sleeving for a distance of about 18 in., so that there may be no induction through cutting the leakage flux, and are then connected to the galvanometer circuit.

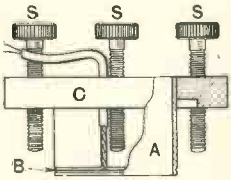

Fig. 2.

In making the measurements of flux, the coil is inserted to a definite position in the air-gap (its exact location being determined as described in the next paragraph) and withdrawn suddenly to a considerable distance from the magnet. The deflection produced on the galvanometer shows the total flux cut, which consists of the external leakage flux together with the flux in the air-gap between the outer end of the gap and the position from which the coil is withdrawn. The coil is then reinserted to a position displaced by a definite small distance from its former position, and a second reading is taken. The difference between the two deflections gives the flux passing through the circumferential area between the two positions from which the coil is withdrawn. A series of similar readings is obtained for a number of positions of the coil covering the whole axial length of the gap or, if desired, extending short distances beyond the inner and outer ends of the gap.

It only remains to describe the means adopted to locate the coil precisely in the gap. The method employed is by screw adjustment from the machined outer poleface of the magnet. Two arrangements of the adjusting screws have been used. In the first (see Fig. 2), the brass tube carrying the coil is mounted on a stout brass ring (*C*), which in turn is supported on a tripod of three long brass screws (*S*) of identical and very small pitch and provided with milled heads. The feet of these screws rest on the machined face of the magnet. They are first adjusted to bring the coil exactly into the plane of the outer poleface of the magnet. This may be done very accurately by eye, as the coil consists of a single turn in a V-groove. Other positions of the coil are then obtained by advancing or withdrawing each screw a definite number of turns or fraction of a turn, the axial displacement of the coil being given by the product of the number of turns of one of the screws and the pitch.

In the second and better type of coil-mounting (see Fig. 3), the brass tube is carried on a single central brass screw (*S*) of large diameter and small pitch ($\frac{1}{2}$ in. diameter with 40 threads per in. was used). The end of the screw is fitted with a circular flange (*F*), having its face turned accurately perpendicular to the axis, to enable it to stand on the magnet poleface. This type of mounting reduces the liability to backlash, simplifies the setting of the coil to any desired position, and allows of the coil being supported on the central pole-piece of the magnet instead of requiring a machined surface on the outer pole-piece (which is often not available). Adjustment of the coil to successive positions in the gap is carried out as before and the axial displacement deduced from the number of turns given to the screw and the pitch.

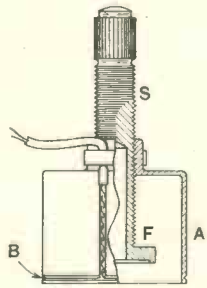

Fig. 3.

Method of Working Out Results.

The method of deducing the flux density from the observations described may best be seen from an actual example. In the table are given the readings taken, using a search-coil of the second pattern, on a loud-speaker electromagnet, together with the other data needed to work out the results.

TABLE.

Turns of screw from initial setting.	Galvanometer Deflection.
0	43.2
1	54.9
2	67.8
3	81.0
4	94.7
5	108.4
6	122.3
7	136.0
8	149.8
9	163.8
10	177.4
11	188.1

Mean diameter of air-gap = 3.95 cms.

Pitch of screw = 0.025 in. = 0.0635 cm.

Galvanometer calibration :—

Reversal of 1 amp. in a mutual inductance of 500 μH, corresponding to a change of linkage of 100,000 line-turns, produces a deflection of 100 divisions, *i.e.*, since the search-coil has 1 turn, 1 division indicates a flux of 1000 lines.

In Fig. 4 the points indicated by circles show these galvanometer readings in relation to the position in the air-gap from which the coil was withdrawn. It will be seen that all the points, except the first two and the last, lie very approximately on a straight line, showing that between positions 2 and 10 the flux density is practically uniform. The slope of this straight line may be deduced from any convenient pair of points on it and is found to be 13.7_2 divisions for one turn of the screw. This indicates an average total flux of 13,720 lines in any axial length of gap of 0.0635 cms.

Hence, applying the formula given above,

$$B_g = \frac{13{,}720}{0.0635 \times \pi \times 3.95} = 17{,}400 \text{ lines per sq. cm.}$$

This is the average flux density in approximately 75% of the air-gap, in which the flux density is practically uniform, and differs by 3 or 4% from the average for the whole air-gap.

The flux density in successive axial lengths equal to the pitch of the screw may be found from the differences between pairs of consecutive readings. The points indicated by crosses in Fig. 4 show these values of flux density, and the dotted curve drawn through them shows the distribution of flux along the axial length of the gap.

Conclusion.

The method described has the following advantages :—

(1) The use of a ballistic galvanometer of high sensitivity allows a search-coil of only one turn to be employed, and this admits of

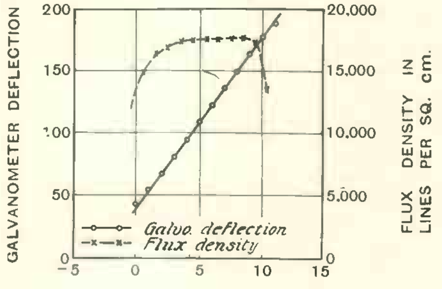

Fig. 4.

more precise location of the circumferential area within which the flux is measured.

(2) The use of a single coil which can be accurately located in any desired position in the gap gives greater flexibility to the method than is obtainable with differential coils such as have been largely used. The differential coil method is quicker where a large number of routine measurements have to be made under identical conditions, but does not allow measurements to be carried out over varying lengths of gap so readily as the adjustable single coil method.

(3) By taking a series of readings and plotting a curve, the uniformity of the field within the length of gap under test can be explored, and the actual value of flux density at each point can be determined instead of the mean value over a considerable length.

In conclusion the author desires to express his thanks to Dr. D. W. Dye, F.R.S., for his helpful interest in the work, and to Mr. A. Gridley for his valuable assistance in constructing the search-coils.

"Ganging" the Tuning Controls of a Superheterodyne Receiver.*

By A. L. M. Sowerby, M.Sc.

THE problem of "ganging" the tuning controls of a superheterodyne receiver differs radically from that of ganging an ordinary set for the reason that one of the tuned circuits—that of the oscillator—has throughout to be tuned to a frequency a fixed number of kilocycles away from that to which the signal-frequency circuits are tuned.

The writer knows of only three methods by which this frequency difference can be held over the whole tuning range.

(1) Straight-line-frequency condensers may be used, the rotor of that controlling oscillator-frequency being a fixed number of degrees behind or in advance of those controlling the signal-frequency circuits. In this mode of attack all tuned circuits are identical except for the difference mentioned.

(2) A tuning condenser of special law may be computed for the oscillator circuit, the law being chosen to fit in with that of the remaining tuning condensers.

(3) All tuning condensers may be alike, but that for the oscillator may have its law modified by a combination of series and parallel fixed condensers.

Method (1) has the disadvantage that the full 180-degree rotation cannot be used, which on the 200-600 metre band implies that to enable the full range to be covered circuits of exceptionally low minimum capacity must be used unless the standard maximum tuning capacity (0.0005 mfd.) is exceeded. Further, the straight-line-frequency law of the condensers will only hold for a specified minimum capacity in the circuit, which must be accurately reached if ganging is to be correct.

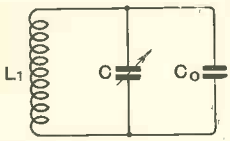

Fig. 1.—*Signal-frequency circuit.*

Method (2) has the obvious disadvantage that it requires a specially designed condenser; in other respects, it is ideal.

Method (3), unlike its rivals, can at best provide only approximate accuracy of ganging; it has, however, the very real advantage of convenience and ready applicability.

It is with this third method, viewed from the aspect of practical receiver design, that the present discussion deals.

Consider the two circuits shown in Figs. 1 and 2; the former of these represents a signal-frequency circuit, the latter the oscillator circuit.

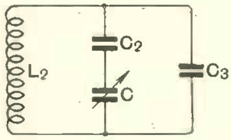

Fig. 2.—Oscillator circuit. At all settings of C it is supposed to have the same capacity as in Fig. 1.

In Fig. 1, the tuning condenser is supposed to be variable between the limits $C_{min.}$ and $C_{max.}$, while C_0 is intended to include all stray circuit capacity, other than that of the tuning condenser itself, that is in parallel with L_1. Normally a "trimmer" will be required to bring the circuit capacity up to the required total value.

It is clear that if $C_{max.}$ and $C_{min.}$ are known, the values of C_0 and L_1 necessary to cover any practicable band of frequencies can be calculated. Adjustment of C_0 will give the right ratio of maximum to minimum frequency, after which correct choice of L_1 will select the exact band of frequencies required.

In Fig. 2, the tuning condenser is considered to be identical with that of Fig. 1, so that for any given frequency the capacity of C is fixed by the needs of the signal-frequency circuit. We have, therefore, to find values of C_2, C_3, and L_2 which will fulfil as nearly as possible the condition that for all settings of C the circuit of Fig. 2 shall tune to a frequency a fixed number of kilocycles away from that to which the circuit of Fig. 1 is tuned.

C_2 serves to restrict the maximum total capacity, its restrictive effect being greatest when C is large. C_3, which, like C_0, includes all "strays," serves to restrict the

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capacity range at the lower end. The tuning range $\left(\frac{f_{max.}}{f_{min.}}\right)$ of Fig. 2 will therefore be less than that of Fig. 1; the oscillator, in consequence, has always to be tuned to a frequency higher than that of the signal.

The reduced tuning range could be attained by making C_3 large, without introducing C_2. Alternatively, it could be obtained by making C_2 comparatively small, without increasing C_3 above the inevitable minimum. Between these two extremes, any number of pairs of values for C_2 and C_3 could be found to provide the required tuning range. A value of L_2 could be found for any of these capacity combinations such that the maximum and minimum frequencies reached by the circuit would be those necessary to give the correct beat-frequency with the corresponding signal.

Since this latitude of choice remains even when we have laid down that the maximum and minimum frequencies shall be correct, we can make the problem determinate by adding the further condition that ganging shall be correct at some one other point in the tuning range, in addition to the extremes. This, if the intermediate point is correctly chosen, will make it possible to pick out the individual combination that will give the most nearly correct ganging at all points of the tuning range.

It will be convenient, in expressing these considerations in algebraic form, to specify the frequency values, whether of the signal circuit or that of the oscillator, in terms of the corresponding LC product. If we compute these values for the two extremes of the signal range, corresponding to capacities $C_{max.}$ and $C_{min.}$ of the tuning condenser, and also for an intermediate point, corresponding to an intermediate capacity C of the tuning condenser, we arrive at the following three equations for the signal-frequency circuit shown in Fig. 1.

$$(C_{min.} + C_0)L_1 = \alpha \qquad \text{(1)}$$

$$(C + C_0)L_1 = \beta \qquad \text{(2)}$$

$$(C_{max.} + C_0)L_1 = \gamma \qquad \text{(3)}$$

where α, β, and γ are the appropriate LC products. β specifies the frequency at which, in addition to the extremes, the ganging of the two circuits is to be perfect.

A similar set of equations, referring to the same three settings of the tuning condenser, must be provided for the oscillator circuit; the LC products will now be different, corresponding in each case to a frequency greater than that of the signals by the frequency proposed for the intermediate amplifier. The three equations are:—

$$\left(\frac{C_{min.}C_2}{C_{min.} + C_2} + C_3\right)L_2 = \delta \qquad \text{(4)}$$

$$\left(\frac{CC_2}{C + C_2} + C_3\right)L_2 = \epsilon \qquad \text{(5)}$$

$$\left(\frac{C_{max.}C_2}{C_{max.} + C_2} + C_3\right)L_2 = \eta \qquad \text{(6)}$$

in which δ, ϵ, and η are the three LC products to be associated with α, β, and γ respectively in the signal-frequency circuits.

In dealing with these equations it will be assumed that $C_{max.}$, $C_{min.}$, and the LC products are determined by the conditions to be fulfilled in designing the set; they will therefore be regarded as known, and other circuit-constants will be deduced in terms of them.

From (1) and (3),

$$\frac{C_{min.} + C_0}{C_{max.} + C_0} = \frac{\alpha}{\gamma}$$

whence $$C_0 = \frac{\alpha C_{max.} - \gamma C_{min.}}{\gamma - \alpha} \qquad \text{(7)}$$

From (1) and (3),

$$L_1 = \frac{\gamma - \alpha}{C_{max.} - C_{min.}} \qquad \text{(8)}$$

From (2),

$$C = \frac{\beta}{L_1} - C_0 \qquad \text{(9)}$$

From (4) and (5),

$$\left(\frac{C_2C}{C_2 + C} - \frac{C_2C_{min.}}{C_2 + C_{min.}}\right)L_2 = \epsilon - \delta$$

Also, from (5) and (6),

$$\left(\frac{C_2C_{max.}}{C_2 + C_{max.}} - \frac{C_2C}{C_2 + C}\right)L_2 = \eta - \epsilon$$

Combining these last two equations,

$$\frac{\left(\frac{C_2C}{C_2 + C} - \frac{C_2C_{min.}}{C_2 + C_{min.}}\right)}{\left(\frac{C_2C_{max.}}{C_2 + C_{max.}} - \frac{C_2C}{C_2 + C}\right)} = \frac{\epsilon - \delta}{\eta - \epsilon}$$

Simplifying, we get:

$$C_2 = \frac{C(\theta C_{min.} + C_{max.}) - C_{min.}C_{max.}(1 + \theta)}{C_{min.} + \theta C_{max.} - C(1 + \theta)} \qquad \text{(10)}$$

where $\theta = \frac{\epsilon - \delta}{\eta - \epsilon}$

From (4) and (6),

$$L_2\left\{\frac{C_2C_{max.}}{C_2 + C_{max.}} - \frac{C_2C_{min.}}{C_2 + C_{min.}}\right\} = \eta - \delta$$

whence

$$L_2 = \frac{(C_2 + C_{max.})(C_2 + C_{min.})(\eta - \delta)}{C_2^2(C_{max.} - C_{min.})} \quad (11)$$

And finally, from (4),

$$C_3 = \frac{\delta}{L_2} - \frac{C_2C_{min.}}{C_2 + C_{min.}} \quad \ldots \quad (12)$$

These equations (7 to 12) provide all the necessary information for design; it remains to calculate a practical case to see how closely the ganging is maintained at points intermediate between those we have been able to fix by choice of circuit constants.

Let us assume the following numerical values:

$$C_{max.} = 500\ \mu\mu\text{F}.$$
$$C_{min.} = 20\ \mu\mu\text{F}.$$

Frequency range to be covered, 1500 to 500 kilocycles (200 to 600 metres).

Intermediate frequency, 127 kilocycles.

Further, we will elect to have the ganging correct at 1000 kc., as well as at the ends of the tuning range.

First, the LC products are calculated, these being given by $LC = \frac{1}{4\pi^2 f^2}$

We then have:

$\alpha = 0.011258$ (1500 kc.)

$\beta = 0.025330$ (1000 kc.)

$\gamma = 0.101321$ (500 kc.)

$\delta = 0.009569$ (1627 kc.)

$\epsilon = 0.019942$ (1127 kc.)

$\eta = 0.064426$ (627 kc.)

From equation (7),

$$C_0 = 40\ \mu\mu\text{F}.$$

(This figure appears low, but it must be remembered that it does not include the minimum of the tuning condenser.)

From equation (8)

$$L_1 = 187.71\ \mu\text{H}.$$

From equation (9),

$$C = 94.94\ \mu\mu\text{F}.$$

Using this value in equation (10), we find:

$$C_2 = 1822.8\ \mu\mu\text{F}.$$

And, finally,

$$L_2 = 147.23\ \mu\text{H}.$$
$$C_3 = 45.21\ \mu\mu\text{F}.$$

Knowing these values, we can calculate the frequency to which each of the two circuits will be tuned by a series of selected capacities of the tuning condenser. Results of such a calculation are given in the following table, in which f_1 is the frequency to which the signal circuit is tuned, and f_2 that to which the oscillator is tuned. df is the ganging error, being the difference between $(f_2 - f_1)$ and 127 k.c., the intended value of $(f_2 - f_1)$.

Capacity of Tuning Condenser ($\mu\mu$F).	f_1 (kc.)	f_2 (kc.)	$(f_2 - f_1)$ (kc.)	df (kc.)
5	1731.7	1851.3	119.6	−7.4
10	1642.8	1766.1	123.3	−3.7
15	1566.4	1692.1	125.7	−1.3
20	1500.0	1627.0	127.0	—
25	1440.8	1569.1	128.3	+1.3
30	1388.4	1517.3	128.9	+1.9
35	1341.4	1470.6	129.2	+2.2
40	1298.8	1428.2	129.4	+2.4
45	1260.0	1389.4	129.4	+2.4
50	1244.5	1353.8	129.3	+2.3
60	1161.6	1290.5	128.9	+1.9
70	1107.6	1236.0	128.4	+1.4
80	1060.4	1188.2	127.8	+0.8
94.94	1000.0	1127.0	127.0	—
100	981.8	1108.5	126.7	−0.3
120	918.4	1044.2	125.8	−1.2
140	865.9	990.9	125.0	−2.0
160	821.4	945.9	124.5	−2.5
180	783.2	907.2	124.0	−3.0
200	749.8	873.6	123.8	−3.2
240	694.2	817.7	123.5	−3.5
280	649.4	772.9	123.5	−3.5
320	612.2	736.2	124.0	−3.0
360	580.8	705.3	124.5	−2.5
400	553.8	678.9	125.1	−1.9
450	524.8	650.9	126.1	−0.9
500	500.0	627.0	127.0	—

In Fig. 3, Curve A, df is plotted against f_1.

The extreme sharpness of tuning of the usual intermediate-frequency amplifier would suggest that the divergencies from the correct value of 127 kc. would be serious; in practice, however, the oscillator tuning takes charge, and is always set to give the required beat-frequency with the incoming signal. The error is thus transferred to the signal-frequency circuits, which are detuned from the signal being received by the amount df.

On the figures given, the loss of strength resulting from this detuning will be greatest for a station transmitting on about 670 kc. (450 metres), when the ratio df/f_1 is greatest, amounting to 0.0054. Taking the magnification of the tuned circuits at 70, which is a fair average for the modern screened coil, this leads to a reduction in signal-voltage to about 80 per cent. per stage. Three cascaded tuned circuits lead, therefore, to a loss of approximately 50 per cent. If any pair of these circuits is arranged as a band-pass filter, the loss in signal voltage will naturally be less.

Careful inspection of Curve A shows that the intermediate ganging-point chosen, 1000 kc., could have been altered to perhaps 850 kc. with advantage; at the worst point on the high-frequency side of the curve ($df = 2.4$ kc. at $f_1 = 1300$ kc.) df/f_1 amounts to only 0.00185. The ideal condition would clearly be that at the two points of maximum error df/f_1 should have the same value, leading to a greater numerical value of df on the high-frequency side of the curve.

Further refinement of accuracy could be achieved by bringing the two outer ganging-points a little inwards from the ends of the wave-range. By this means the maximum error could be approximately halved.

On the long waveband the errors in ganging turn out to be smaller, largely on account of the smaller wave range to be covered.

Let us assume that the long-wave tuning coil has an inductance of 2250 μH, and that its self-capacity is such as to raise C_0 to 45 $\mu\mu$F from the 40$\mu\mu$F to which the total "strays" were adjusted on short waves. Further, we will assume that it is decided to limit the range over which accurate ganging is required to 150 — 300 kc. (1000 to 2000 metres). The full tuning range will, therefore, not be used, and the values of $C_{max.}$ and $C_{min.}$ to insert in equations (7) to (12) will be those corresponding to 150 and 300 kc. respectively.

At 150 kc., total tuning capacity = 500.35 $\mu\mu$F.

At 300 kc., total tuning capacity = 125.09 $\mu\mu$F.

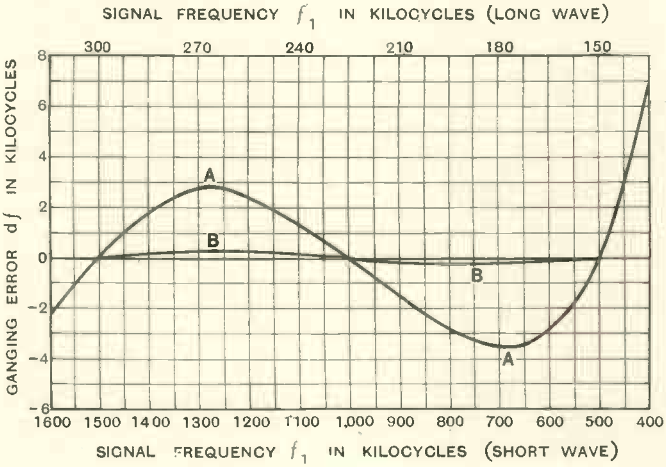


Fig. 3.

Since $C_0 = 45$ $\mu\mu$F.

$C_{max.} = 455.35$ $\mu\mu$F.

$C_{min.} = 80.09$ $\mu\mu$F.

Also $\alpha = 0.2815$

$\gamma = 1.1258$

At 225 kc. (intermediate ganging-point),

$C = 177.38$ $\mu\mu$F.

and $\beta = 0.50035$.

For the oscillator circuit,

$\delta = 0.13983$ ($f_2 = 427$ kc.)

$\epsilon = 0.20444$ ($f_2 = 352$ kc.)

$\eta = 0.33013$ ($f_2 = 277$ kc.)

Hence $\theta = 0.52117$

Applying the various equations we find, for the oscillator circuit:—

$C_2 = 687.14$ $\mu\mu$F.

$C_3 = 75.15$ $\mu\mu$F.

$L_2 = 945.9$ μH.

On calculating out the error curve we find the following figures :

f_1 (kc.)	f_2 (kc.)	$(f_2 - f_1)$ (kc.)	df (kc.)
300	427.00	127.00	—
275	402.23	127.23	+0.23
250	377.19	127.19	+0.19
225	352.00	127.00	—
200	326.81	126.81	−0.19
175	301.78	126.78	−0.22
150	277.00	127.00	—

These errors are shown in Curve B of Fig. 3. It is clear that they are quite negligible, since df/f_1 does not rise above one-sixth of the value found on the medium waveband.

The curves of Fig. 3 relate to an ideal case in which all circuit constants have precisely the values that are allotted to them by theoretical considerations. It remains to be seen whether small variations from the optimum values will result in any very large increase in the value of df/f_1.

In any practical receiver, C_3 will take the form of a "trimmer," and will be adjusted to give accurate ganging on the shortest wavelengths to be received. Only variations in L_2 and C_2, therefore, need to be considered.

Since at least one firm advertises that it maintains all coils issued to the public correct to within $\pm$ 0.5 per cent. of rated inductance, it will be sufficient in examining the effect of changes in L_2 to consider a variation of $\pm$ 1.0 per cent. in inductance. If no steps are taken to readjust the remaining circuit constants, such a variation will produce a change of 0.5 per cent. in f_2, which in turn will cause $(f_2 - f_1)$ to change by amounts varying from 3 to 8 kc. at different parts of the tuning range. Since similar, or larger, variations in C_2 are simultaneously possible, it is clear that ganging will suffer severely if steps are not taken to compensate for these variations.

In practice, the error in L_2 would be compensated by readjustment of C_2 and C_3, the former being adjusted at the highest wavelength to be tuned in, the latter at the lowest. This leads to the following values :

(*a*) For L_2 increased from 147.2 to 148.7 μH.

C_2 becomes 1749.4 $\mu\mu$F. in place of 1822.8 $\mu\mu$F.

C_3 becomes 44.6 $\mu\mu$F. in place of 45.2 $\mu\mu$F.

(*b*) For L_2 decreased from 147.2 to 145.8 μH.

C_2 becomes 1902.2 $\mu\mu$F. in place of 1822.8 $\mu\mu$F.

C_3 becomes 45.9 $\mu\mu$F. in place of 45.2 $\mu\mu$F.

Recalculation of the error-curves for these two cases gives the results shown graphically in Fig. 4 ; Curve A repeats the curve for the standard case, Curves B and C show respectively the errors when L_2 is increased or decreased by one per cent.

It will be seen that variation of L_2 has the effect of shifting the intermediate point of correct ganging away from the original position (1000 kc.). The choice of this point was not a very happy one ; even on Curve C the effective error, df/f_1, is slightly greater at 650 kc. than at 1225 kc. From these curves it would appear that β and ϵ (equations 2 and 5) should be calculated for about 850 kc. (354 m.).

Variations in L_2 up to about $1\frac{1}{2}$ per cent. can evidently be tolerated without serious loss of signal strength ; the effect of greater variations than this is indicated by Curve D,

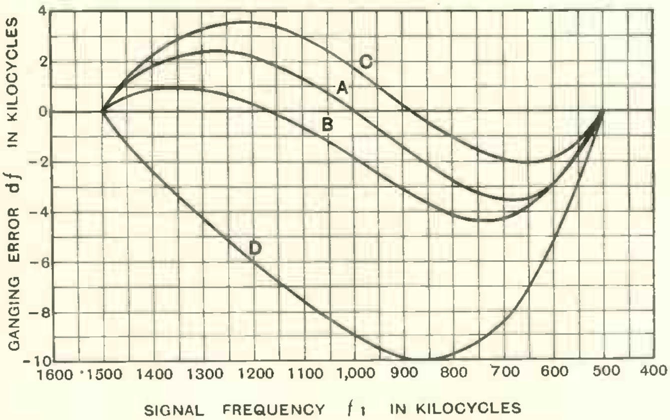


Fig. 4.—*Effect of varying L_2 and compensating by variation of C_2. A = standard ; B = L_2 increased by 1 % ; C = L_2 decreased by 1 % ; D = L_2 increased by 5 %.*

which refers to the case where L_2 is increased to 154.6 μH., 5 per cent. above the value originally calculated. The middle gang-ing-point is now outside the useful tuning range.

If C_2 is nominally fixed, and L_2 is made variable over a small range to compensate for accidental variations in its capacity, much the same curves are obtained. The figures given show that a change of 4 per cent. in C_2 is approximately equivalent to a change of 1 per cent. in L_2.

It may happen that there is a trimmer in parallel with the tuning condenser in the oscillator circuit. Ganging may then be achieved, at the lowest wavelength of the tuning range, either by adjusting this trimmer or by adjusting C_3. On the basis of the example taken, an increase in $C_{min.}$ from 20 to 30 $\mu\mu$F., necessitating a decrease in C_3 from 45.2 to 35.5 $\mu\mu$F., changes the frequency of the oscillator at the top end of the range by no more than 2.6 kc. Since this small change would be taken care of by a compensating adjustment of C_2 or L_2, there would only remain an error of the order of 1.3 kc. somewhere in the middle of the range. It is clear that the effect of quite large discrepancies in $C_{min.}$ may safely be neglected.

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.

Distortion in Valve Characteristics.

To the Editor, The Wireless Engineer.

Sir,—In reply to Mr. Turner's letter regarding my recent article on the Measurement of Distortion of Valve Characteristics, the general purport of the letter is undoubtedly correct, although I think Mr. Turner is unjustified in assuming that I fell into the trap of supposing that the higher harmonics did not affect the values obtained. It might have been advisable to have amplified the article a little in this direction, but I thought it sufficiently apparent from the method of treatment.

With an ordinary triode valve, it is usually sufficient to measure the distortion by obtaining an approximation of the amplitude of the second harmonic by the three ordinate method, but for pentode and screen grid valves, where the dynamic curves are S-shaped, and where the principal harmonic is the 3rd, the three ordinate method fails because it does not give even an approximate value for the 3rd. For this reason, I suggested the five ordinate method outlined in my article as a fairly simple method for dealing with the screen grid and pentode characteristics.

Only a fairly approximate value is usually required, because differences between valves and the fact that the ideal resistance load is seldom realised, introduces larger errors than the differences between true harmonic analysis and that given by the five ordinate method.

I was fully aware of the limitations of the method, but did not think that these limitations curtailed its usefulness.

Unfortunately, I have not had an opportunity to consider Mr. Turner's method, but if it is as simple to handle and gives greater accuracy, it will undoubtedly have an advantage over my method.

Rugby. G. S. C. Lucas.

Moving Coil Loud Speakers of Midget Design.

To the Editor, The Wireless Engineer.

Sir,—Recent developments in the technique of moving coil loud speaker design have resulted in the production of a range of " midget " instruments with a projected cone diameter of approximately 7 inches.

Extremely light and rigid cones are generally employed and it is now necessary to take into consideration the effect of the mass of the coil conductor, which is by no means negligibly small compared with the effective mass of the cone and its added air load at the lower frequencies, when the cone behaves sensibly as a rigid piston. It is intended to show, in the following brief analysis, that, at low frequencies above the natural period of the system, where it may be regarded as chiefly inertia controlled, there is a maximum cone velocity which will be reached when the mass of the coil conductor is equal to the effective mass of the cone and its added air load—this for a given power dissipation, W, across the coil conductor.

Assuming that the cone behaves as a piston at these low frequencies, its mass may be found by weighing, and the added inertia due to air approximately calculable from a formula given in paragraph 302, equation 14, of Lord Rayleigh's " Theory of Sound," Vol. II.

Let

M = total mass of system.

β = total damping resistance of system.

S = total restoring force on system.

For an applied sinusoidal force, $\bar{F}\cos\omega t$, the equation of motion is given as

$$\bar{F}\cos\omega t = M\frac{d^2x}{dt^2} + \beta\frac{dx}{dt} + Sx \quad .. \quad (1)$$

where x is the instantaneous displacement of the system.

Writing $\frac{d}{dt} = j\omega$

$$\bar{F}\cos\omega t = x\{-M\omega^2 + j\omega\beta + S\} \quad .. \quad (2)$$

Neglecting β and S as intended

$$x = -\frac{\bar{F}\cos\omega t}{M\omega^2} \quad .. \quad (3)$$

The velocity imparted to the system is given as

$$v = \frac{dx}{dt} = \frac{\bar{F}\sin\omega t}{M\omega} \quad .. \quad (4)$$

Let $M = m_0 + m$

where m_0 = mass of coil conductor.

m = mass of cone and air load.

$$v = \frac{\bar{F}\sin\omega t}{\omega\{m_0 + m\}} \quad .. \quad (5)$$

Let H = flux density in gap.

W = power dissipated across conductor coil.

l = length of conductor coil.

R = resistance of conductor coil.

a = cross sec. area of conductor coil.

ρ = specific resistance of conductor coil.

ρ^1 = density of conductor coil.

$\omega = 2\pi f$.

Rewriting equation (5) for max. instantaneous values of velocity (for convenience)

$$\bar{v} = \frac{\bar{F}}{\omega\{m_0 + m\}} \quad .. \quad (6)$$

Now $\bar{F} = Hl\sqrt{\frac{W}{R}}$

$$R = \frac{\rho l}{a}$$

$$m_0 = \rho' la.$$

Substituting in equation (6) and squaring both sides to eliminate the root

$$\bar{v}^2 = \frac{H^2l^2W}{\omega^2\frac{\rho l}{a}\{\rho'^2l^2a^2 + 2m\rho' la + m^2\}} \quad .. \quad (7)$$

Dividing the bracketed terms by $\rho' la$:

$$\bar{v}^2 = \frac{H^2W}{\omega^2\rho\rho'\left\{\rho' la + 2m + \frac{m^2}{\rho' la}\right\}} \quad .. \quad (8)$$

or

$$\bar{v}^2 = \frac{H^2W}{\omega^2\rho\rho'\left\{m_0 + 2m + \frac{m^2}{m_0}\right\}} \quad .. \quad (9)$$

$$\frac{H^2W}{\bar{v}^2} = \omega^2\rho\rho'\left\{m_0 + 2m + \frac{m^2}{m_0}\right\} \quad .. \quad (10)$$

If the value of $\frac{H^2W}{\bar{v}^2}$ is plotted against m_0 there is an optimum value of m_0 giving a maximum value of $\bar{v}^2$.

This occurs when $\frac{d\,.\,\frac{H^2W}{\bar{v}^2}}{d\,.\,m_0} = 0$

Differentiating

$$0 = \omega^2\rho\rho'\left\{1 - \frac{m^2}{m_0^2}\right\}$$

from which the practical maximum is obviously

$$m = m_0 \quad .. \quad .. \quad .. \quad .. \quad (11)$$

The writer is not aware of any earlier published proof of this somewhat important evaluation, and submits it for criticism, as certain fallacies may have been overlooked.

Thanks are due to Messrs. Kolster Brandes, Ltd., for permission to publish this matter.

F. R. W. Strafford.

Sidcup, Kent.

Percentage Harmonic Distortion.

To the Editor, The Wireless Engineer.

Sir,—As the originator of the discussion on Percentage Harmonic Distortion, in which a number of valued opinions have been expressed, perhaps I may be permitted to re-enter the forum in order to make some further comments on this subject which appears still to be not entirely beyond the reach of controversy.

In connection with the remarks contained in the Editorial of July last, I would point out what has apparently been overlooked, namely, that I did not make any claim for the correctness of the formula I derived, but rather the contrary; the main purpose being to call attention to the disagreement between the formulae which have been published, an object which has been more than justified by subsequent correspondence which has brought to light a greatly extended range of disagreement.

In view of the fact that the subject forms part of the basis on which different makes and types of valves are compared I feel that some purpose has been served by pointing out the lack of a universally accepted treatment of it.

The most important point which emerges from the discussion is, to my mind, that brought out by Mr. Greenwood, that the resistance of the circuit to the rectified component of the current is not necessarily the same as that to the alternating components. In fact, though he refers specifically to the choke-fed load, the same argument applies to all practical arrangements of working a loud speaker, whether choke, transformer, or direct feed. In the common case of load resistance equal to twice the valve resistance and negligible D.C. load resistance, the harmonic percentage is half that given by the usual formula.

I am unable to understand Mr. Bedford's analysis, which may be due to the fact that it appears to be based on the supposition that the effect of rectification is to bring the mean current midway between the maximum and minimum. That is as serious an error as that which I made in the first place in overlooking the rectified current when considering the ratio of harmonic to fundamental.

Whenever I have occasion to estimate harmonic distortion or power output, I am appalled at the assumptions which it is necessary to make in order to do so. Some of these have been specifically mentioned. The attribution of the harmonic to a square law curve is one which is totally unjustifiable in many practical cases. The assumption that the load is resistive and constant for a.c. of all frequencies is another which is far from being true in the best cases, and is not even a rough approximation in the worst. Even with a good moving coil loud speaker the load is at times mainly reactive, at times mainly resistive, and varies enormously in magnitude so that it is not justifiable to assume that it is the same for harmonic as for fundamental.

For practical purposes anything like an accurate estimate is out of the question; this being so, perhaps the conventional "9 : 11 scale" is as good a system as any, so long as this is admitted to be what it is, a useful arbitrary basis of comparison of valves and not a measure of actual working conditions.

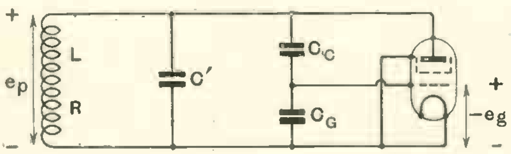
Edinburgh. M. G. SCROGGIE.

The Dynatron Oscillator.

To the Editor, The Wireless Engineer.

SIR,—In the November number of *The Wireless Engineer* an article by Colebrook appeared entitled "The Dynatron Oscillator." In this article a new circuit was described which markedly increased the frequency range of the usual dynatron circuit. It seemed to me that the explanation given below of this phenomenon would be of interest.

The circuit in question may be represented as follows:

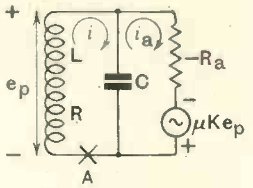


This circuit neglects all d-c. connections, by-pass condensers, etc., and represents only those parts of the circuits that influence the behaviour of the high frequency currents. We neglect the conductance of the control grid. The grid leak described in the original article (see Fig. 4) has an impedance high compared to that of C_c the coupling capacity or C_G the grid to ground capacity.

It can be seen that e_p will divide between C_c and C_G so that $e_g = Ke_p$ where $K = \frac{C_c}{C_c + C_G}$, C′ represents the plate to ground capacity plus the external circuit capacity. Let

$$C = C' + \frac{C_c C_G}{C_c + C_G},$$

and we can replace the above diagram with a simplified schematic diagram as follows.



As in the appendix of Colebrook's article, let us assume a voltage $e \sin \omega t$ inserted at (A). We get the three following equations

$$e_p = -i(R + jL\omega)$$

$$e - i(R + jL\omega) - (i - i_a)\left(-\frac{j}{C\omega}\right) = 0$$

$$\mu K e_p + (i - i_a)\left(-\frac{j}{C\omega}\right) + R_a i_a = 0$$

These when solved give the following two conditions for oscillation.

$$R_a = \frac{L}{RC}(1 + \mu K)$$

Condition for the start of oscillation.

$$\omega = \frac{1}{\sqrt{LC}} \sqrt{1 - \frac{R}{R_a}(1 + \mu K)}$$

Condition on the frequency of oscillation.

Sometimes it is preferable to write the frequency conditions as follows

$$\omega = \frac{1}{\sqrt{LC}} \sqrt{1 - R^2 \frac{C}{L}}$$

As can be seen at once, if K (the fraction of plate voltage fed back) is zero, the above conditions are exactly those given in Colebrook's article for the simple dynatron.

If μ is positive, as it is over the greater part of the dynatron characteristic (*i.e.*, for anode voltages above about 35 volts in the case of the tube illustrated in Fig. 1 of Colebrook's article) the factor $(1 + \mu K)$ increased the R_a required for oscillation with a given external circuit, or conversely decreases the $\frac{L}{RC}$ required for a given R_a. This is exactly the effect that Colebrook observed. According to this theory, it would be possible to select certain plate voltages (in the case of the tube mentioned above, 25 or 30 volts anode potential would be such a voltage) at which μ would be negative and up to a certain point an increase of C_c, and hence K, would tend to spoil the performance of the tube as an oscillator.

The decrease of stability as regards frequencies is to be expected because the grid conductance, which we have neglected in the above calculations, is a function of the intensity of oscillation. Changes in grid conductance cause a slight change in the frequency of the oscillator due to a modification of the circuit reactance.

The sudden decrease in space current which occurs at the incidence of oscillation is a common phenomenon in many grid bias oscillators. It is due to a rectification at the control grid due to the high frequency current which is fed through the coupling condenser. This causes grid current to flow which biases the tube at a negative potential equal to the IR drop in the grid leak. This in turn decreases the space current.

Mountain Lakes, N.J. K. C. BLACK.

To the Editor, The Wireless Engineer.

Sir,—Mr. F. M. Colebrook in his article entitled "The Dynatron Oscillator" gives the following formula to obtain the frequency of oscillation :—

$$\omega = \frac{1}{\sqrt{LC}}\left(1 - \frac{R}{2R_a}\right) \quad \ldots \quad \ldots \quad (1)$$

From this it follows that :—

$$\frac{d\omega}{dR_a} = \frac{1}{\sqrt{LC}} \frac{R}{2R_a^2}$$

or approx. $$\frac{R_a}{\omega}\frac{d\omega}{dR_a} = \frac{R}{2R_a}$$

or if $\triangle f$ is a small change in the frequency f, and $\triangle R_a$ a small change in R_a

$$\frac{\triangle f/f}{\triangle R_a/R_a} = \frac{R}{2R_a} \quad \ldots \quad \ldots \quad (2)$$

Now the quantity on the left hand side represents the % frequency drift for a given small % change in R_a. Let the limit of this quantity as $\triangle R_a$ becomes vanishingly small be F. Then :—

$$F = \frac{R}{2R_a} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

To make F small we must either increase R_a or decrease R. Since it is inconvenient to change R_a a great deal, R should be made as small as possible. This implies a coil of small inductance. A limit is, however, set by the condition for oscillation :—

$$\frac{L}{CR} = R_a \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

At this point

$$F = \frac{R^2}{2L/C}$$

$$= \tfrac{1}{2}\left(\frac{R}{\omega L}\right)^2 \text{ approx.}$$

$$F = \frac{1}{2m^2} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

in which m is the effective magnification of the coil.

It is important to note that it is only possible to assume that R_a is the same in (1) and (4) when the valve is only just oscillating, and R_a may therefore be regarded as constant. When the valve is oscillating violently R_a is no longer constant over the cycle owing to the sharp bends at the extremities of the negative portion of the characteristic. Under these conditions although it may be possible to find an appropriate mean value of R_a for (1), it by no means follows that the same mean value is appropriate to equation (4), as is lightly assumed by your correspondent Mr. Francisco Pinto Basto.

Incidentally, if your correspondent doubts whether a change in R_a affects the frequency, I suggest he makes up an oscillator with about 1 Henry inductance and, say, 0.0001 μF tuning capacity. This is an extreme case, but under such conditions I have found it possible to get frequency changes of over 50%.

Returning to equation (5) we see that when the inductance is made so small that the valve only just oscillates, the frequency drift factor F depends inversely on the square of the magnification of the coil. Truly a plea for low-loss coils!

Sidcup, Kent. W. T. Percival.

The Stenode Radiostat.

To the Editor, Wireless Engineer.

Sir,—The Editorial in your December issue is in the nature of a reply to a letter by the secretary of my company. There are certain points in it which affect me personally, and I beg your indulgence to deal with these points.

The tendency is returning to divert attention from the principal issue raised by the "Stenode," which is, that International Wireless regulations are at present based on incorrect assumptions.

As regards the method in which the "Stenode" was first introduced, it has to be remembered that at the very outset there were people associated with it who had enough vision to see that the issues raised were wide enough to be of interest and importance to the general public as well as to the technical world. It is of universal interest to know whether international authorities are operating on correct or incorrect foundations.

At the time the "Stenode" was introduced, it was universally believed that side bands could not be overlapped without introducing mutual interference. It has now been shown that this belief is unfounded, and that it is now possible to place stations so close together that their sidebands do overlap and yet each programme can be received free from interference.

Some conditions under which this may occur are where the carrier frequencies are placed at such a distance that the heterodyne note between the carriers cannot be heard through the acoustic apparatus employed in the receiver, and when the interfering carrier is weak compared with the desired carrier.

This problem has been dealt with quite intensively in your own journal and in the columns of *Wireless World*, and I need only refer to the writings of Mr. Colebrook, Prof. Appleton, and the writer of your Editorial for August of last year, for this purpose.

The "Stenode" by its high selectivity arranges to make the neighbouring carrier wave weak at the detector of the receiver. In addition, the high selectivity causes a large increase of the carrier wave with a diminution of the percentage modulation, thus allowing for a rectifier to be employed which is of the linear type. These two facts allow the demodulation of the weak carrier to come into play, and hence after passing through the detector we are left with the desired signals without an appreciable amount of the interfering modulations. In the low frequency amplifier correction is applied to all modulations which are still remaining, and thus we are enabled to obtain the best quality of reproduction from the desired signals with the least possible amount of interference.

Thus, supposing we arrange to receive acoustic frequencies up to 5,000 cycles per second, and cut off everything above this, we can place our carrier frequencies 5,500 cycles apart when the heterodyne note will be inaudible and when both stations can be tuned to the signals received without interference from the other station.

This fact shows that it is now necessary to revise the basis on which International Wireless regulations are founded, because it shows that more stations can be simultaneously employed in the ether.

J. ROBINSON,
Technical Adviser.
British Radiostat Corporation, Ltd.

A Direct Reading Modulation Meter.

To the Editor, Wireless Engineer.

SIR,—I was very interested in the article on "A Direct Reading Modulation Meter" given in your December issue, as, for some time past, such a method has been in experimental use at the P.O. Radio Laboratory, Dollis Hill. The method is described and the principle developed mathematically by K. W. Jarvis in the Proceedings of the Institute of Radio Engineers for April, 1929, and it may be that Messrs. Cooper and Smith, who seem to have developed the method independently, would be very interested in this article.

It would appear that the criterion for a frequency characteristic of constant value is not so much that R_2 should be some multiple of R_1, but that R_2 should have a much higher impedance than C over the usual audio range. Values for R_1, R_2, and C of 60,000 ohms, 50,000 ohms, and 2 micro-farads respectively have been found to give satisfactory results. It might be that the reason for making the value R_2 much larger than R_1 was in order to make the impedance value of the parallel combination of R_2C and R_1 as near R_1 as possible, but even so, with the values quoted, there still arises a 10 per cent. error consequent upon using the actual and not the effective value of R_1 in the formula.

Finally it is desirable to point out that the value of E determined by the given formula is a peak value of voltage.

F. E. NANCARROW.
London, N.W.2.

The Variation of the Resistances and Interelectrode Capacities of Thermionic Valves with Frequency.

To the Editor, The Wireless Engineer.

SIR,—In his letter in your January issue, Dr. Hartshorn attempts to undermine my statement "that the displacement current will still be given by $\frac{dQ}{dt}$" by pointing out (without mentioning his authority) that the displacement current varies from point to point. It must surely have been obvious to Dr. Hartshorn that if his expression $C\frac{dV}{dt}$ fails in one place it must fail everywhere. In my letter, Q and $\frac{dQ}{dt}$ both refer to the anode.

My omission to refer to the admittedly important fact (to which I first drew attention in *Phil. Mag.*, March, 1928, p. 644, lines 3–5) that the displacement current varies from zero up to $\frac{dQ}{dt}$ as we go from cathode to anode was intentional, as I did not wish to confuse the issue for readers who may be new to the subject.

The issue, briefly, is as follows. The value of the displacement current (at the anode) cannot be given *both* by $\frac{dQ}{dt}$ *and* by $C\frac{dV}{dt}$ since the relation $Q = CV$ (on Dr. Hartshorn's own showing) does not apply to a space charge limited diode. Dr. Hartshorn prefers $C\frac{dV}{dt}$ and I prefer $\frac{dQ}{dt}$. My reasons for preferring $\frac{dQ}{dt}$ are simple and will now be given.

"Since the field at the cathode is reduced to zero by the effect of the space charge, there is no charge on the cathode. There is a charge Q (positive) on the anode. The lines of force from the anode all terminate on electrons, since there is zero field at the cathode, so that the sum of the charges on all the electrons in the space between the electrodes is $-Q$. Now the displacement current arises from the change in the electron content of the space, *e.g.*, the change in Q, with time. If at a time t the charge on all the electrons is $-Q$, suppose that at a time $t + dt$ the value of $-Q$ has changed to $-Q + dQ$ owing to certain electrons being displaced across the anode plane into the external circuit [dQ and dt are supposed infinitesimally small].

The charge on the anode, after dQ electrons have been displaced across it, is now only $Q - dQ$. Since the corresponding charge on all the electrons is $-Q + dQ$, still no lines of force reach the cathode. *The field remains zero at the cathode all the time.* The displacement current at the cathode is thus zero, while that at the anode is given by $\frac{dQ}{dt}$. For a more complete treatment of this effect readers are referred to *Phil. Mag.*, Feb. (Suppl.), 1931, p. 457.

The space variation of displacement current is, of course, compensated for by an equal and opposite space variation in electron convection current, so that the values of the two kinds of current add up to a value which is the same (at any instant) at all points between cathode and anode.

I conclude by strongly recommending Dr. Hartshorn to revise his knowledge of Classical Electron Theory before writing another paper on space charge matters. He may, meanwhile, rest assured that my two letters were consistent not only with one another but with my *Phil. Mag.* papers already referred to, and also with the Electron Theory of Matter as expounded, for example, by Professor O. W. Richardson in his book of that title.

W. E. BENHAM.
International Telephone and Telegraph Laboratories,
Hendon, N.W.9.

The Physical Society's Exhibition.

Matters of Wireless and Laboratory Interest.

THE Twenty-second Annual Exhibition of the Physical Society and the Optical Society was held this year at the Imperial College, South Kensington, on 5th, 6th, and 7th January. The Exhibition adequately fulfilled its usual function by illustrating the tendencies and progress of instrument design throughout the past year. As has been the case for a number of years, matters of interest in wireless measurements and allied technique were well represented. The casual observer was also struck by the increasing number of ways in which electrical methods are being allied to other forms of physical and physical-chemical technique, particularly in the matter of providing convenient methods of measurement and calibration of quite different physical phenomena.

Electrical Measuring Instruments.

This type of exhibit, while well represented, appeared this year to show less novelty in its radio interest than in its application to heavier engineering practice.

CROMPTON PARKINSON, LTD., showed a new form of their "A.C. Test" multi-range a.c. instruments, together with some new moving-iron instruments and a number of useful moving-coil instruments of various sizes and applications.

The display of ELLIOTT BROS. included a large number of instruments, including their "Multiversal" Test Set; 650 B Radio Test-set, portable moving-coil galvanometers, and a new range of rectifier instruments for a.c. working. Another new feature at this stand was a Frequency Indicator of deflectional type, the standard calibration being 900 to 1100 cycles per second.

EVERETT EDGCUMBE had also an extensive display of measuring instruments, a new feature of the year being a range of Dwarf thermo-couple instruments for d.c., a.c., or radio-frequencies, characterised by very rapid response. Ranges available cover 20 A down to 20 mA.

The display of EVERSHED VIGNOLE was concerned chiefly with insulation-measuring instruments of their well-known Meg and Megger type. A new instrument of this type was also shown by the RECORD ELECTRICAL COMPANY, in addition to their range of "Cirscale" instruments, while another interesting exhibit at this stand was the electrical tachometer in which a dynamo generates a voltage proportional to the speed of the rotating system to which it is applied, and a voltmeter indicates the voltage thus generated.

The display of the WESTON ELECTRICAL INSTRUMENT CO. was naturally devoted entirely to measuring instruments, including their well-known Laboratory Standards and Standard Portable types. This company had also their typical display of portable and small radio instruments, including rectifier instruments, and an electrical speed indicator of the general type, already mentioned.

A large range of portable instruments of various sizes (including rectifier and thermal instruments as well as electro static voltmeters) was shown by ERNEST TURNER, of High Wycombe. A new item was in the form of d.c. moving-coil relays, while this firm also showed a new type of double-range resistance-meter (using a d.c. movement) fully compensated for errors due to battery fluctuations.

The stand of MESSRS. FERRANTI, LTD., was devoted almost entirely to measuring instruments, the chief exhibits of radio interest being their well-known range of small meters, including instruments of moving-coil, moving-iron, thermal and rectifier type, also electrostatic voltmeters with scale-maxima ranging from 450 to 2500 volts. Similar ranges of movements were also shown in portable instruments of greater dimensions. A new addition to the range of small Ferranti meters was a self-contained resistance tester of the now popular type, while another new feature of this firm (although not directly of radio interest) was an inexpensive electrical clock for operation on 50 c/s. supply mains.

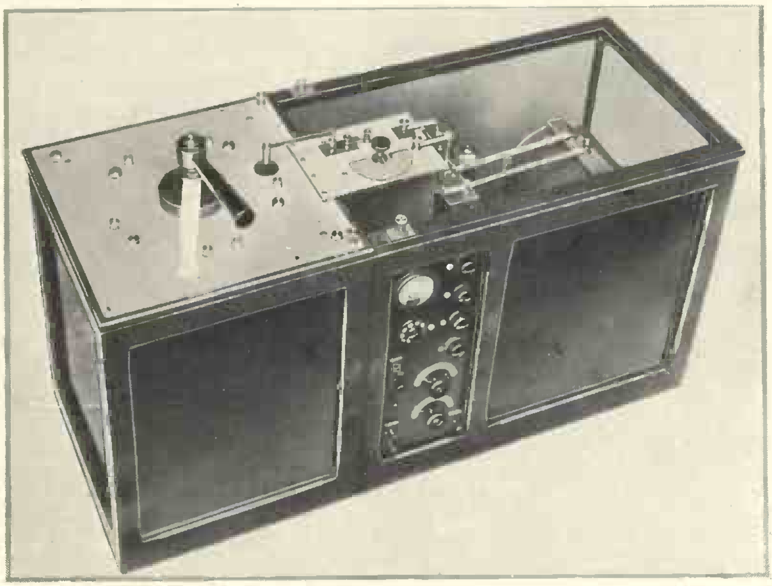
Cambridge thermionic millivoltmeter employing three stages as follows (1) H.F. amplifier, (2) detector, (3) balancing valve.

As at last year's exhibition, the WESTINGHOUSE Co. included at their stand typical instruments (by various of the above makers) incorporating their metal rectifier.

Laboratory Equipment.

This type of apparatus was on the usual scale that has characterised the exhibition for some years. While few striking features of outstanding novelty were shown, this section nevertheless continued to be of great interest to the radio and laboratory experimenter in showing the tendencies and refinements of instrumentation that are always in progress.

The display of the CAMBRIDGE INSTRUMENT Co. included a number of examples illustrative of the tendency, already mentioned, to use electrical indication in allied physical measurements. A new instrument by this company was a photo-electric relay for galvanometric measurements. The light beam from the primary galvanometer falls symmetrically upon the two opposed halves of a photo-cell. Movement of the light-spot produces a current in the secondary galvanometer, while the cell is free from lag and the current is so large that a relatively insensitive and therefore rapid instrument can be used in the secondary position. A new thermionic (Moullin) millivoltmeter was also displayed, using an h.f. amplifying valve, detector and balancing valve. This gives full scale for 30 mv. and the range can be extended up to 1.5 v. Another new range due to this company was attenuation boxes in the form of H-type networks, calibrated in decibels for 600 ohms impedance termination. Amongst other new items at this stand should also be mentioned : a range of low-current fuses, a Campbell Precision Condenser bridge, a somewhat redesigned form of this company's three-element Duddell oscillograph, and a new valve application in the form of Cosen's a.c. voltmeter.



Sullivan-Griffiths sub-standard generating wavemeter (30–2,000 *kc.*).

The stand of H. W. SULLIVAN, LTD. was, as usual, devoted entirely to laboratory and allied apparatus. Amongst this were two new screened generating sub-standard wavemeters, one of them using the Sullivan-Griffiths spaced-gap condenser, an improved form of this condenser also being shown. Amongst the frequency-standardising apparatus, for which this firm is well known, was shown a new (Dye pattern) temperature-controlled Elinvar fork of 1000 c/s., with its associated fork-controlled multi-vibrator wavemeter. Other frequency-standardising apparatus at this stand included a new form of the Lucas-Sullivan Quartz-controlled Multi-vibrator. Amongst other new instruments were also shown a radio-frequency capacity testing set and a capacity matching set for comparing ganged condensers (as in a multi-stage wireless receiver). A new wide-range portable capacity test-set, covering 50 $\mu\mu$F. to 1 μF., was also demonstrated in operation.

The exhibit of MUIRHEAD & Co. was devoted chiefly to frequency-standardising apparatus. This included a temperature-controlled (Dye pattern) fork of 1000 c/s. with phonic motor and clock, also a clock-controlled constant-speed set operating in conjunction with a 1000 c/s. fork and motor. Another item of interest at this stand was a new make of electro-magnetic oscillograph, well arranged for simplicity and convenience in operation.

H. TINSLEY & Co. had an extensive display of laboratory equipment, including potentiometers, galvanometers, bridges, standard inductances, capacities, resistances, etc. A new feature was Dr. Barlow's ammeter operating on the change of current in a diode which is already saturated from a filament lit by d.c., but whose emission is increased when alternating current traverses the

Sullivan capacity test set for matching ganged condensers.

filament. It is claimed that the instrument is accurate over the range of 25 c/s. to 6 megacycles.

At the stand of Gambell Bros., laboratory apparatus included a universal test-set covering wheatstone bridge, voltage, current, capacity and insulation measurement, sub-standard wavemeters,

Dr. Barlow's valve ammeter (H. Tinsley & Co.).

a standard variable condenser, a capacity bridge, and a number of portable reflecting galvanometers.

Newcomers to the exhibition were Sprenger & Co., who showed a new Demonstration Oscillograph of electromagnetic type, working up to 3 kc/s.

Salford Electrical Instruments, Ltd. (a subsidiary of the G.E.C.) had several exhibits of laboratory interest, including a frequency bridge—a self-contained portable unit for measurement of telephonic frequencies. This firm also displayed "Gecalloy" loading-coils, with cores of a new composite magnetic material.

The exhibit of the Telegraph Construction and Maintenance Co. was particularly devoted to high-permeability alloys, "Mumetal" and the like, with experimental demonstrations of the magnetic characteristics of these materials.

Besides the exhibits of rectifier instruments already mentioned, the Westinghouse Company had demonstrations including the use of their metal rectifier for absorbing inductive energy on breaking a circuit, also applications of the rectifier to telephonic and telegraphic apparatus.

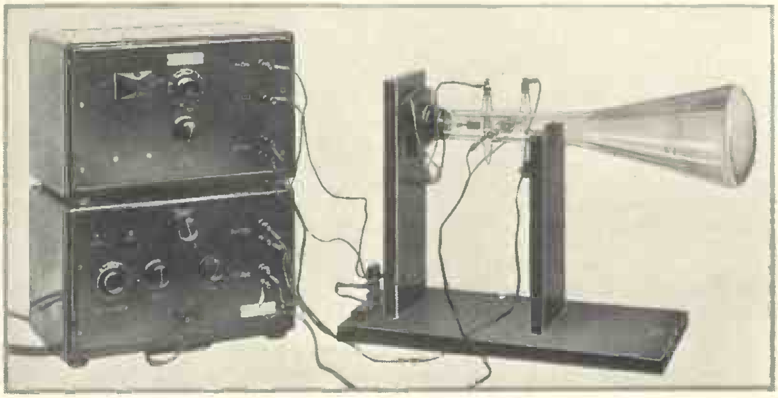
Cathode-ray oscillographs were shown at two stands. At that of Edwards & Co. was demonstrated the tube due to M. von Ardenne, now fairly well known in this country. This was shown in operation with various accessories—*e.g.*, h.t. supply unit for anode potential, etc.

A newly produced British oscillograph was also shown at the stand of the Ediswan Co. This appeared in three different bulb-sizes with the same general disposition of electrodes. These are arranged substantially as in the von Ardenne oscillograph, but the cathode is of indirectly heated form, while the tube is terminated on a British-type valve socket. The largest size of tube was demonstrated in operation on an a.c. wave form against a linear time-base.

Another exhibit belonging most properly to this section was that of the B.B.C. in conjunction with Muirhead & Co., at whose stand it was shown. This was a continuously recording modulation-meter, capable of being operated at a distance from the transmitter. The modulation-measuring device is due to the B.B.C. and is scaled to give logarithmic indications on an output instrument. In the demonstration the output instrument was a syphon-recorder used on a recording-milliammeter and giving a continuous inked record of modulation-depth.

Wireless Apparatus, Accessories, etc.

In this section the Marconiphone Co. had a number of receivers, which were shown for the first time at the last Radio Exhibition. Amongst radio-gramophones were included a 6-valve supersonic model with automatic record-changing, and a 3-valve model; mains receivers included a 3-valve model with self-contained speaker and a 2-valve set, with two models of permanent magnet moving-coil speakers and a new model of the company's pick up. This stand had also a full range of receiving valves, as had also the associated M.O. Valve Co., including all the newest valves of this year, *e.g.*, variable-mu valves, indirectly heated pentodes, and indirectly heated cathode d.c. valves. The latter company had also a display of larger-sized transmitting and rectifying valves, with demonstrations of manufacturing processes and the measurement of power output.



M. von Ardenne cathode ray oscillograph with mains supply and time base units.

The Mullard Wireless Service Co. had also a full range of valves of all sizes, including transmitting valves for short waves (down to 10 metres), while amongst receiving valves were shown this company's variable-mu valve and a new bi-grid valve for use, for example, as mixer valve in a supersonic receiver.

Besides the oscillograph already mentioned, the EDISON SWAN ELECTRICAL Co. had a display of valves and allied products. In addition to a range of Ediswan and Mazda valves, there were shown various mercury rectifying valves. This stand

Ediswan cathode ray tubes, types A, B and C.

also had exhibits of pick-ups and associated sound reproducing apparatus. In addition to the laboratory apparatus mentioned, GAMBRELL BROS. showed a new supersonic radio-gramophone for mains operation.

The BRITISH ELECTRIC RESISTANCE Co. showed a range of adjustable type box resistances, with various types of resistance element and methods of assembly. This company had also various fixed units, including wire-wound elements embedded in vitreous material, flat type resistances of small dimensions and non-inductive high-valve resistances in tubular Bakelite cases.

ISENTHAL & Co. had also a range of resistances and rheostats, along with their mercury switches and relays, photoelectric equipment, including several types of photo cells, glow relays and Kerr cells. Resistances of cartridge type were shown by the ZENITH ELECTRIC Co., who also had a new type transformer with sliding brush contact giving smooth adjustment of secondary voltage from zero to maximum.

Research and Experimental Section.

In this section were a considerable number of exhibits of wireless interest. The G.E.C. (RESEARCH LABORATORIES) showed a model of loudness-characteristics of sound reproducing devices, a photographic sound recorder, consisting of microphone, amplifier, recording light-tube and film attachment using 16 mm. film. ELECTRICAL AND MUSICAL INDUSTRIES (H.M.V.) showed a direct-reading modulation-meter (*c.f. W.E. & E.W.*, Dec., 1931) a "squegging" self-modulating oscillator for general laboratory testing, a test-set for the rapid determination of stage-magnification and mutual conductance of a resistance-coupled stage (*c.f. E.W. & W.E.*, February, 1931). An interesting exhibit was that of a variable-mu valve as an attenuator, utilising the fact that the valve has a length of characteristic in which grid bias and mutual conductance are exponentially related. This is used to serve as a logarithmic (decibel) attenuator with very little frequency-error.

The exhibit of the B. & H. ENGINEERING LABORATORIES was largely devoted to hot-cathode gas-filled devices—thyratrons and rectifiers, etc.—also appliances of the thyratron such as a capacity-controlled thyratron relay.

Amongst the exhibits of the NATIONAL PHYSICAL LABORATORY were :—(*a*) A meter for the measurement of the depth of modulation in a modulated wave, using two square-law valve-voltmeters, one measuring the d.c. component of the rectified current and the other measuring the component due to modulation. (*b*) Apparatus for measuring the total harmonic content in an audio-frequency voltage. A pure source is used to modulate the input to a receiver under test and a bridge method measures the total harmonic distortion introduced by the receiver. (*c*) A 2-stage valve-voltmeter, using a rectifying stage followed by a battery-coupled stage using a small dry battery. Full scale is obtainable from 70 millivolts. (*d*) Measurement of grid-anode capacity in screened-grid valves, utilising the change in effective grid-filament capacity when a large impedance is inserted in the anode circuit.

The POST OFFICE RESEARCH STATION (DOLLIS HILL) had a number of exhibits of radio and audio-frequency interest. These included :—(*a*) A device for increasing the sensitivity of valve relays, utilising a part of the rectified anode current fed back to the grid. (*b*) A transmission time-measuring set, measuring the time of transmission of a signal round a closed loop. (*c*) An a.c. voltage-measuring set using a diode as a continuously variable shunt. (*d*) A mechanical wave model of the modualtion of one sine wave by another. (*e*) Devices discriminating between speech and sinusoidal audio-frequency currents. (*e*) An artificial ear used for objective measurements on telephone receivers under working conditions. (*f*) A machine for the random selection of syllables such as are used for intelligibility tests, etc.

The ROYAL AIRCRAFT ESTABLISHMENT had one wireless exhibit, in the form of a d.f. "homing" installation for use on aircraft, giving visual indication of departure from the correct course.

PROF. G. I. FINCH showed a cathode-ray oscillograph time-base, particularly designed to obtain a stationary image from a recurrent transient, whose rate of recurrence is slightly irregular.

In the section devoted to Lecture and Instructional Exhibits, the TELEVISION SOCIETY had two exhibits, one a demonstration showing the fundamental principles of television and the other a television testing instrument, suitable, for example, for testing characteristics of amplifiers.

Multi-channel Television.

Paper by Mr. C. O. Browne, B.Sc., read before the Wireless Section, I.E.E., on 6th January, 1932.

THE system described is one which has previously been demonstrated by the Gramophone Co., using a cinema film at the transmitter. As a practical means of avoiding the limitations of frequency-width, better results are obtained at the expense of a number of transmission channels. This reduces difficulties of design both at the transmitter and receiver as well as in the transmission-link. The light available at the receiver for illumination of the screen is increased in proportion to the number of channels used; the velocity with which the scanning spots travel

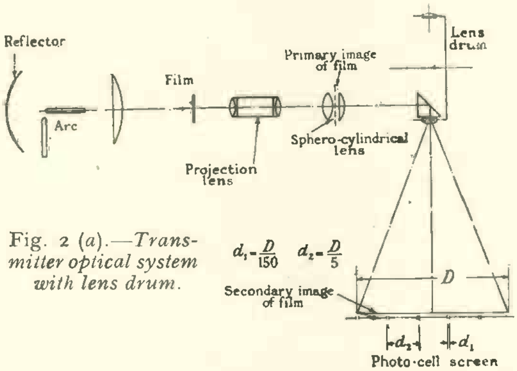


Fig. 2 (*a*).—*Transmitter optical system with lens drum.*

over the surface of the picture is decreased, so that the accuracy necessary for synchronising is reduced. In the system described, land-line connection is used and the picture at the receiver is projected on a screen of 24 inches by 16 inches.

It was considered necessary to use 15,000 picture-points, and to scan $12\frac{1}{2}$ times per second—this being a suitable sub-multiple of 50 c/s. a.c. mains frequency. The author shows that this calls for a frequency-band of $12\frac{1}{2} \times 15{,}000 \times 2 = 93{,}750$ c/s. Since intermittent motion was to be used at the transmitter, a further factor of 5/4 is involved to allow for travel of the picture between scanning operations. This brings the frequency-band up to 117,000 c/s. This is divided into five bands, transmitted separately and simultaneously.

The film is moved intermittently and is scanned in two mutually perpendicular directions while stationary. Fig. 2 (*a*)* is a diagrammatic representation of the transmitter optical system. A projector lens forms an enlarged image of the film at a sphero-cylindrical lens combination, and secondary images of the film are thrown—after reflection by a right-angle prism—on to the photocell screen by the lens drum. The sphero-cylindrical lens provides that two adjacent lenses of the drum are filled with light so that there is no discontinuity in illumination at the photocell screen. The images formed by the lens drum are 30 inches wide and overlap the cell screen, as indicated in Fig. 2 (*a*). The pitch between the lenses is such that each image is displaced by the width of a scanning-line from its predecessor, and after the traversal of 30 lenses the total displacement is 30 lines of $\frac{1}{5}$ width of the image. The magnification of the optical system is chosen so that the top of one picture is adjacent to the bottom of the preceding picture, there being no space between successive pictures. In order to facilitate focusing, the whole lens-drum is movable axially along its hollow shaft. Fig. 3 shows the relative positions of the photocell screens and the remainder of the transmitting mechanism.

The photocell, which constructs the beginning of each transmission channel, is a vacuum-type caesium cell, this type being chosen because of the attenuation of the higher frequencies by gas-filled cells. The voltage swing required to operate the Kerr cells at the receiver is of the order of 600 v. double amplitude, and a total amplification of 110 decibels is required between the photocell and the Kerr cell. The amplifiers used were designed to have a total magnification of 120 d.b., Fig. 4 giving a diagram of the transmitter amplifiers corresponding to one channel. These are divided into two sections, as shown, and the amplifiers on each bank are identical and are readily interchangeable. A potentiometer in each channel regulates their

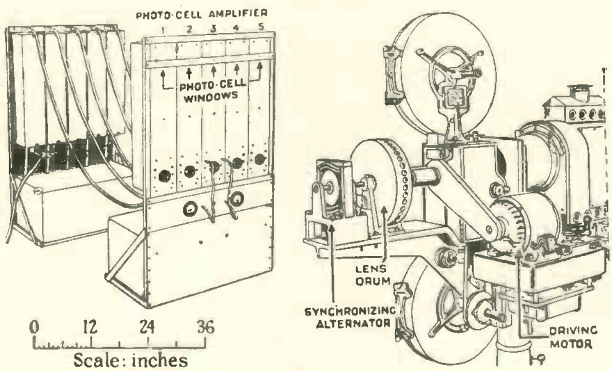


Fig. 3.—*Disposition of scanning mechanism and amplifiers.*

individual outputs to match-up the signal in each, but this is stated not to be critical. A network tuned to 30 kc/s. in the first anode circuit compensates for attenuation by the photocell of frequencies of 5 kc/s., while a similar network in the second bank compensates for losses in the trans-

* The author's original figure-numbers are adhered to throughout this abstract.

mission line and in the Kerr cells used at the receiver.

The optical system of the receiver is shown diagrammatically in Fig. 7. Light from an arc

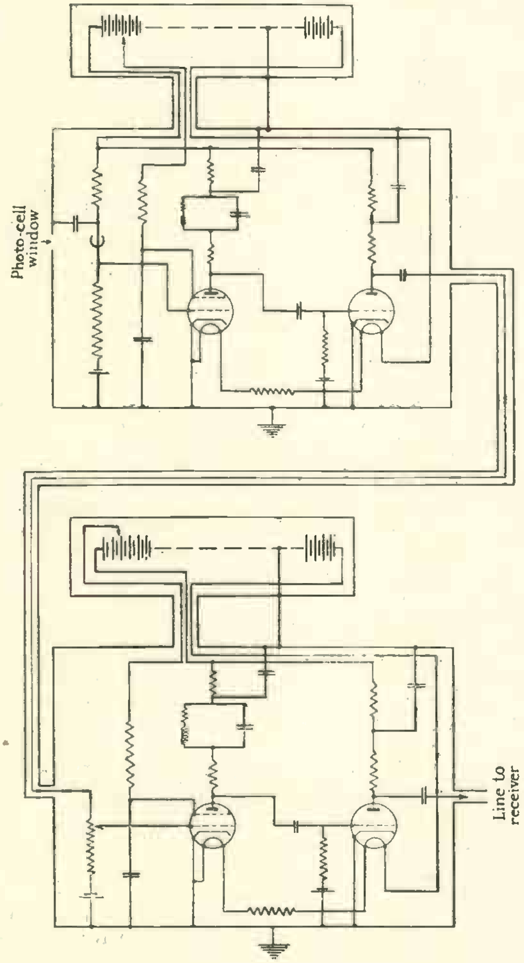


Fig. 4.—*Transmitter amplifiers.*

is divided into five pencils by a prism and lens system and each pencil is transmitted between separate plates of the Kerr cells which are all immersed in a common bath of nitro-benzene. The beams are then reflected by the mirrors of a mirror drum on to a translucent screen. Two lenses, forming enlarged images of the Kerr cells on the screen, constitute a projector combination and are placed for convenience in the incident and reflected beams. In order efficiently to use the necessarily limited apertures of the mirrors, the axes of the five pencils of light converge towards a centre situated approximately at the surface of the mirror drum. The double-prism system is included in order that the directions of the beams may be individually adjustable, while the Kerr-cell assembly is movable to and from the mirror drum for focusing. This drum is rotated by synchronous motor through a 2/1 spiral reduction gear. This gear includes provision for altering the phase-relationships between the driving and driven shafts, while a damped coupling-spring smooths out irregularities, a similar smoothing system being used in the drive of the transmitter motor. If a.c. mains are not available to synchronise motion of transmitter and receiver, a phonic motor, integral with the mirror drum, may be used. This is designed to operate from the 1250 c/s. signals generated at the transmitter, after sufficient amplification.

The voltage received from each of the transmission channels is of the order of 6 volts, corresponding to full picture modulation. A further amplification of about 100-fold is necessary before the signals may be impressed upon the Kerr cells at the receiver. This is done in a single transformer-coupled stage.

In the design of the Kerr cells a number of points had to be observed. First it was desirable that the cells should operate with comparatively low voltages and thus require amplifiers capable of handling comparatively low voltage-swings, also with sufficiently low steady voltage applied across the cells there is no fear of electrical breakdown in the nitro-benzene. Secondly, it is necessary to condense light on to each cell in order to obtain sufficient light on the receiver-screen, and in consequence the electrodes have to be shaped to accommodate the converging beam. The shape and dimensions of the Kerr-cell electrodes are shown in Fig. 9. These were constructed of brass, which was subsequently platinised in order to prevent tarnishing. The cells require a steady biasing potential of about 800 volts, superimposed on which are the picture signals having a double amplitude of 600 volts for maximum modulation. The cells will, however, stand an overload of 100 per cent. of the signal amplitude without electrical breakdown.

It is necessary to know the overall characteristics of the system, including the photocell and the transmitting and receiving amplifiers. Details are given in the paper of the methods of calibration

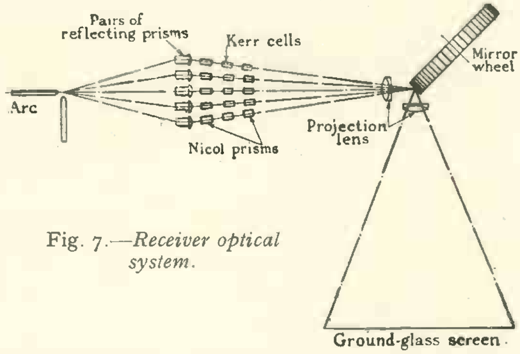


Fig. 7.—*Receiver optical system.*

used. The frequency-response curve of the transmitter alone is shown flat to within ± 1 decibel up to about 40 kc/s.; that of the complete system is shown flat to within ± 2 d.b. up to 25 kc/s.

The various sources of distortion that may occur in the received picture are :—

(*a*) Geometric distortion, due to defects in the optical systems, which give rise to erroneous positions of picture elements with respect to the boundaries of the received image.

(*b*) Non-linear electrical distortion, due to working over non-linear portions of the characteristics of components such as valves or Kerr cells. With the latter must also be associated chromatic distortion.

(*c*) Frequency distortion, which produces either deficient or accentuated definition at particular parts of the picture, and may introduce non-linear distortion.

(*d*) Phase distortion, which gives rise to fictitious positions of picture-elements upon the receiver screen.

These various forms of distortion are discussed at some length in the paper.

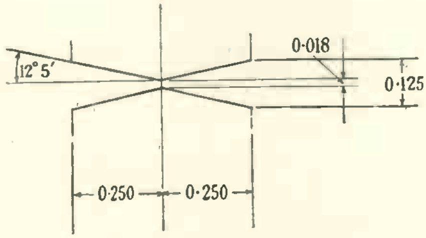


Fig. 9.—*Kerr-cell electrodes (dimensions in inches).*

Under the conditions in which the apparatus has been used, a 3-phase a.c. supply has been available for synchronising transmitter and receiver, and no difficulty has been experienced in this connection. Synchroni ing by means of the 1250 c/s. signal is satisfactory, although hunting between adjacent poles of the phonic motor caused some difficulty. This was due to the presence of backlash in the reduction gear, but would otherwise have been removed by the damping of the spring coupling. An effective remedy was to mount the d.c. motor directly upon the mirror-drum and to provide the former with an auxiliary fly-wheel.

Discussion.

The discussion was opened by Mr. H. M. Dowsett who expressed interest in the Kerr cell, and considered the method described a neat application. Kerr cells have been used in Marconi facsimile work, and under experimental conditions with certain arrangements of electrodes and gap they had got a cell to work up to 2800 v., while the nitro-benzene stood up to 4500 v. He expressed interest in the types and details of distortion described by the author. The cathode-ray oscillograph had been suggested as a receiving device for television, but the different scanning from that of a disc transmitting station would be likely to give more distortion. The five-channel method gave difficulties of aligning the picture and matching the channels. He suggested sweeping the whole picture with a phase-difference between the channels and recombining them at the receiving end through suitably modified optical systems.

Mr. Wright briefly queried the author's details of size of aperture and the number of picture points.

Mr. Watson Watt asked: Was the author's limitation of frequency a physical or administrative limit? As regards physical or technical difficulties was it more difficult to use one wide channel or a number of channels each of correspondingly narrow frequency-width?

Mr. Bailey referred to the difficulties of flat amplification over the band quoted by the author. Did not the tuned network for upper-frequency correction introduce phase displacements? Round about resonance phase-changes were very abrupt. He suggested the use of a wide transmitted band with later rectification possibly in the Kerr cell itself. High-frequency resonance effects could be obtained in the Kerr cell.

Mr. Hughes queried the use of television, particularly whether it was most likely to develop on the lines of domestic application or for larger-scale reproduction, for example in a cinema theatre for the immediate transmission and reproduction of events to a large number of people.

Mr. Wadsworth pointed out that the work described in the paper had no reference to televi ion in the broadcast band of frequencies. In connection with the use of very short waves (below 10 metres), besides difficulties of band-width there would still be difficulties of range with these waves. With reference to the attenuation of higher frequencies with gas-filled photocells, he asked was there no loss at these frequencies due to capacity of cell-leads?

The author replied to various of the matters raised in the discussion, when the meeting terminated with a vote of thanks, moved by the Chairman, Lt.-Col. A. S. Angwin.

Abstracts and References.

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PROPAGATION OF WAVES.

ÜBER DIE RAUMWELLEN VON EINEM VERTIKALEN DIPOLSENDER AUF EBENER ERDE (On the Space Waves from a Vertical Doublet on a Plane Earth).—B. van der Pol and K. F. Niessen. (*Ann. der Physik*, 1931, Series 5, Vol. 10, No. 4, pp. 485–510.)

The authors have previously (1931 Abstracts, p. 30) used operational methods to study the propagation of waves from a vertical doublet on a plane earth; they discussed in particular the field at the earth's surface. In this paper they derive by two different operational methods a formula for the Hertzian vector Π which holds for *all* angles of elevation above the earth's surface (including glancing and zero angles of incidence), the earth being regarded as a good, though not necessarily perfect, conductor; the point of observation P is assumed to be many wavelengths distant from the emitting doublet. The formula obtained is

$$\Pi(R, z) = \frac{e^{jk_1R}}{R}\left[1 + \sqrt{\frac{\rho_0(R)}{\rho'}}\cdot 2\sqrt{\rho'}e^{-\rho'}\int_{\sqrt{\rho'}}^{j\infty} e^{t^2}dt\right],$$

where z is the height of P above the earth's surface, r the distance from the doublet of the projection of P on the earth's surface,

$$R = \sqrt{r^2 + z^2},\ k_p{}^2 = \frac{\epsilon_p n^2 + jn\sigma_p}{c^2},\ p = 1, 2,$$

as defined in the previous paper referred to above,

$$\rho_0(R) = \frac{jk_1{}^3R}{2k_2{}^2}, \text{ and } \rho' = \rho_0(R)\left(1 + \frac{k_2z}{k_1R}\right)^2.$$

An alternative form is

$$\Pi = \frac{e^{jk_1R}}{R}\left[\tfrac{1}{2} + \tfrac{1}{2}\cdot\frac{k_2z - k_1R}{k_2z + k_1R} + \sqrt{\rho_0(R)}e^{-\rho'}\int_{\sqrt{\rho'}}^{j\infty}\frac{e^{t^2}}{t^2}\,dt\right].$$

The authors show that Sommerfeld's formula for small or zero z is a special case of their result and that when the angle of elevation is of finite size their formula is the same as the approximate formula found by Wise (1930 Abstracts, p. 46). The zone of validity of Wise's formula is found and compared with that of the authors', which is only invalid for points in the neighbourhood of the doublet, whereas, for small z, Wise's formula only holds for very distant points.

The summary contains a list and comparison of formulae so far derived from Sommerfeld's general expression for Π (r, z).

POLARIZATION OF HIGH-FREQUENCY WAVES AND THEIR DIRECTION FINDING.—Namba, Iso and Ueno. (*Proc. Inst. Rad. Eng.*, Nov., 1931, Vol. 19, pp. 2000–2019.)

See 1931 Abstracts, p. 491.

POLARIZATION PHENOMENA OF LOW-FREQUENCY WAVES.—S. Namba. (*Proc. Inst. Rad. Eng.*, Nov., 1931, Vol. 19, pp. 1988–1999.)

See 1931 Abstracts, p. 490.

PRELIMINARY NOTE ON AN AUTOMATIC RECORDER GIVING A CONTINUOUS HEIGHT RECORD OF THE KENNELLY-HEAVISIDE LAYER.—T. R. Gilliland and G. W. Kenrick. (*Bur. of Stds. Journ. of Res.*, Nov., 1931, Vol. 7, No. 5, pp. 783–789.)

Using the Breit and Tuve group retardation method modified for continuous operation. The crystal-controlled transmitter is keyed by a chopper in the grid circuit of the first amplifier, giving pulses of say 2×10^{-4} sec.; an optical shutter is suggested as a possible improvement. A revolving mirror at the receiving station is driven by a synchronous motor working on the same power system as that driving the chopper. Spurious markings on the moving film due to interference coming over the power lines are obviated by gearing the chopper and mirror to their motors by an odd gear ratio (127 to 64), so that any disturbance patterns occurring at power frequency do not remain stationary but drift gradually across the film.

ECHOMESSUNGEN IN DER DRAHTLOSEN TELEGRAPHIE (Echo Measurements in Wireless Telegraphy).—G. Goubau. (*Ann. der Physik*, 1931, Series 5, Vol. 10, No. 3, pp. 329–372.)

The experiments described in this paper have already received full notice in these Abstracts, 1930, p. 328, and 1931, p. 432. The purpose of this account of them is to record the separate experimental results.

DIE IONISATION DER ATMOSPHÄRE UND DIE AUSBREITUNG DER KURZEN ELEKTRISCHEN WELLEN, 10–100 M., ÜBER DIE ERDE. I U. II (The Ionisation of the Atmosphere and the Propagation over the Earth of Short Electric Waves, 10–100 metres. I and II).—K. Försterling and H. Lassen. (*Zeitschr. f. tech. Phys.*, 1931, Vol. 12, No. 10, pp. 453–469.)

This report summarises the present state of knowledge of propagation of short electromagnetic waves and the chief problems which arise in this connection. Previous papers of the authors (Abstracts, 1927, pp. 115 and 441: 1929, p. 145) form the basis of the report and are extended and partially rewritten. The first part deals with the composition and state of ionisation of the upper layers of the atmosphere, including the question of the formation of two ionised layers. The second part discusses, on classical lines, the propagation of electromagnetic waves in an inhomogeneous, stratified medium such as the Heaviside layer. It is found that zigzag reflection between the two ionised layers can only take place when it is night at both emitter and receiver but day in the intervening region. A list of literature references is appended.

PLASMA-ELECTRON RESONANCE, PLASMA RESONANCE AND PLASMA SHAPE.—L. Tonks. (*Phys. Review*, 15th September, 1931, Series 2, Vol. 38, No. 6, pp. 1219–1223.)

Author's abstract :—" Plasma-electron resonance is a completely internal oscillation in a plasma and has a frequency dependent only on the electron density, whereas plasma resonance depends upon boundary conditions as well. The frequency of neither is influenced by the Debye-Hückel ion cloud. Previous theory relating plasma-resonance frequency to plasma shape is amplified and demonstrated experimentally." *Cf.* Abstracts, 1929, p. 273 ; 1931, p. 490.

L'ADSORPTION DES IONS PAR DES PARTICULES SPHÉRIQUES CONDUCTRICES DANS UN CHAMP IONISÉ (The Adsorption of Ions by Conducting Spherical Particles in an Ionised Field).—M. Pauthenier and Mme. Moreau-Hanot. (*Comptes Rendus*, 30th Nov., 1931, Vol. 193, pp. 1068–1070.)

A theoretical study of the charge and movement taken by a spherical conducting particle of radius a ranging from a few microns to a hundred, in an ionised field of known intensity E_0. " At first, the sphere progressively increases its defence against the attack of the ions ; it finishes by being completely surrounded by a repulsive zone which the ions can no longer penetrate except by thermal agitation. Calculation shows that one passes from stage 2 [three-quarters of cross section enveloped] to stage 3 [complete envelopment] for a charge very close to the critical value $3E_0a^2$, and that in the case considered the minimum thickness of the repulsive zone is close to $\frac{a}{3}$ when the charge exceeds the critical charge by one-tenth. When the radius is only 3μ this thickness is already ten times the mean free path of the ions in air at normal pressure. The eventual rôle of the Brownian movement is thus rapidly limited in the case of the large particles which are actually in question. These considerations are, of course, at the basis of the dynamics of the large ions in ionised spaces."

SHORT WAVE RECEPTION AND ULTRA-RADIATION.—W. M. H. Schulze. (*Nature*, 14th Nov., 1931, Vol. 128, pp. 837–838.)

This letter directs attention to " an undoubted analogy in the changes in short-wave reception and in the changes in intensity of ultra-radiation during terrestrial magnetic disturbances." Corlin's ultra-radiation observations (1931 Abstracts, p. 552, and *Lund Obs. Circ.* No. 3, 1931) permit the conclusion to be drawn that increase of ionising ultra-radiation makes reception conditions worse, and conversely.

LA STRATOSPHÈRE ET LES COUCHES LES PLUS ÉLEVÉES DE L'ATMOSPHÈRE (The Stratosphere and the Uppermost Atmospheric Layers).—Ch. Maurain : Piccard. (*Revue Scientif.*, 26th Sept., 1931, Vol. 69, pp. 545–553 ; summary in *Rev. Gén. de l'Élec.*, 14th Nov., 1931, Vol. 30, pp. 792–793.)

A lecture based on the Piccard-Kipfer ascent. At the height of 16 km. it was found that the ionisation produced by the cosmic radiation was weaker than that found at lower levels. " This indicates some influence . . . . on the part of the density of the atmosphere, such as the production of a secondary radiation playing a predominant part in the ionising process." More measurements are needed on the subject—either direct, such as those of Idrac up to 20 km. (1929 Abstracts, p. 147), or indirect.

SOME OBSERVATIONS OF THE BEHAVIOUR OF EARTH CURRENTS AND THEIR CORRELATION WITH MAGNETIC DISTURBANCES AND RADIO TRANSMISSION.—Bemis. (*See* under " Atmospherics.")

DIE ÜBERTRAGUNG VON TELEGRAPHENZEICHEN (The Transmission of Telegraphic Signals).—Bartelink and Bast. (*E.N.T.*, Nov., 1931, Vol. 8, pp. 480–488.)

" The authors believe they have here described a method of treatment which without the use of discontinuous functions enables the events in a telegraphic transmission system to be examined. In particular the treatment not only allows the maximum range, especially of phantom current circuits, to be increased, but also places the preliminary calculation of a telegraphic link on a similar basis to that of telephony circuits."

SOLUTIONS GRAPHIQUES NOUVELLES DU CALCUL DES LIGNES ÉLECTRIQUES DE TRANSMISSION À HAUTE TENSION (New Graphical Solutions of the Calculation of H.T. Transmission Lines).—A. Blondel. (*Comptes Rendus*, 7th Sept., 1931, Vol. 193, pp. 409–414.)

COMPARAISON ENTRE UNE LIGNE À CONSTANTES RÉPARTIES ET UN CIRCUIT EN T (Comparison between a Line with Distributed Constants and a T Circuit).—A. Blondel. (*Comptes Rendus*, 12th Oct., 1931, Vol. 193, pp. 556–559.)

Further development of the above.

SUR LES ONDES PÉRIODIQUES À LA SURFACE DE L'EAU (The Periodic Waves on the Surface of Water).—J. Baurand. (*Comptes Rendus*, 23rd November, 1931, Vol. 193, pp. 992–994.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

SOME OBSERVATIONS OF THE BEHAVIOUR OF EARTH CURRENTS AND THEIR CORRELATION WITH MAGNETIC DISTURBANCES AND RADIO TRANSMISSION.—Isabel S. Bemis. (*Proc. Inst. Rad. Eng.*, Nov., 1931, Vol. 19, pp. 1931–1947.)

Author's summary :—This paper presents correlations between the abnormal earth currents noted during magnetic storms and transoceanic radio transmission on both long and short waves. The radio transmission data were collected on the telephone circuits operating between New York and London and between New York and Buenos Aires. The earth current data were collected on two Bell System lines extending approximately a hundred miles north and west from New York. The results of this work establish facts which have been known in a general way for some time.

The direction of flow of abnormal earth currents in the neighbourhood of New York seems to be along a northwest–southeast line. Coincident with such abnormal currents are periods of poor short-wave radio transmission. However, on long waves, daylight transmission over transatlantic distances is improved. On the short-wave circuit to Buenos Aires, transmission is adversely affected but only to a moderate extent.

Les Bandes d'Émission de l'Aurore polaire dans le Spectre du Ciel nocturne (The Emission Bands of the Polar Aurora in the Spectrum of the Night Sky).—J. Dufay. (*Comptes Rendus*, 30th November, 1931, Vol. 193, pp. 1106–1108.)

Height of the Polar Aurora in Canada.—J. C. McLennan, H. S. Wynne-Edwards, and H. J. C. Ireton. (*Canadian Journ. Research*, Sept., 1931, Vol. 5, No. 3, pp. 285–296 and plates.)

Triangulation measurements lead to heights from 70 to 130 km. for the lower limits of bands, with a marked maximum between 90 and 95 km. The mean height for all lower limits of bands is 95 km., compared with 105 km. for the Scandinavian observations. The 70 km. lowest height is also lower than the 80 km. Scandinavian value.

Audibility of the Aurora Polaris.—H. U. Sverdrup. (*Nature*, 12th Sept., 1931, Vol. 128, p. 457.)

A letter suggesting that the supposed audibility of the aurora may really be due to the "swishing breath" of the observers themselves.

Le Champ électrique au Sommet du Puy de Dôme (The Electric Field at the Summit of the Puy de Dôme).—E. Mathias and G. Grenet. (*Comptes Rendus*, 28th September, 1931, Vol. 193, pp. 470–473.)

The daily variation in winter (minimum—not maximum as printed—122 v/m spread over 0^h to 3^h, maximum 237 v/m at 15^h) agrees with that of the Pic du Midi but is much greater than that observed at the surface of oceans. The annual variation, with a minimum in summer and a maximum in winter, agrees with that obtained at most stations but disagrees with the observations at the high Pic du Midi and Zugspitzgipfel stations, where the field is maximum in summer and minimum in winter.

Quelques Remarques sur la Durée de la Période solaire actuelle (Some Remarks on the Length of the Actual Solar Period).—H. Mémery. (*Comptes Rendus*, 28th September, 1931, Vol. 193, pp. 483–485.)

Correlation between Sunspots, Calcium Flocculi and the Sun's Radiation.—K. Sotome. (Summary in *Sci. Abstracts, Sec. A*, Oct., 1931, Vol. 34, p. 857.)

Maxima of Intensity of Solar Radiation observed at Nice and at Thorenc (Maritime Alps).—L. Gorczynski. (*Comptes Rendus*, 30th November, 1931, Vol. 193, pp. 1108–1110.)

Photographie de la Couronne solaire en dehors des Éclipses (Photography of the Solar Corona apart from Eclipse Times).—B. Lyot: Esclangon: Fabry. (*Comptes Rendus*, 7th Dec., 1931, Vol. 193, pp. 1169–1172: 1172: 1172–1173.)

Both Esclangon and Fabry emphasize the importance of Lyot's latest success. His previous work (1931 Abstracts, p. 91) allowed him to photograph the spectrum of the corona: he has now succeeded in obtaining direct photographs of the corona itself, showing jets of light stretching to more than 7′ from the sun's edge.

Mean Areas and Heliographic Latitudes of Sunspots in the Year 1930. (*Monthly Not. Roy. Astron. Soc. Supp.*, 1931, pp. 1004–1007.)

Interruptions to Lines Concentrated at Sunrise.—E. E. George and W. R. Brownlee. (*Elec. World*, 10th October, 1931, Vol. 98, pp. 658–661.)

See 1931 Abstracts, p. 495. Records for the years 1927–1930 show that 71 % of transmission line interruptions not due to lightning fall within a band 1½ hours wide covering the period of sunrise. No definite explanation has yet been found.

Zur Struktur der Ultrastrahlung. II (On the Structure of Cosmic Radiation. II. Comparison Measurements with Two High Pressure Ionisation Chambers).—W. S. Pforte. (*Zeitschr. f. Phys.*, 1931, Vol. 72, No. 7/8, pp. 511–527.)

"An apparatus already described (1931 Abstracts, p. 264) was used to measure the similarity of the variations in intensity of the hard cosmic radiation in two different measuring chambers with commoned compensation. If the chambers were placed side by side, about 1.5 metres apart, no or very little agreement in the variations was found; if on the other hand they were superposed, a strong temporal similarity of the variations occurred (correlation about 0.5). Correction was made for the influence of atmospheric variations. The barometer coefficient was found to be − 1.25 %/cm. Hg., in agreement with the results of former measurements. The variations chiefly followed statistical laws, and were of mean magnitude about ± 0.55 % in both cases. A slight solar temporal effect was found but no sidereal time effect has hitherto been determined.

Ionisation as a Function of Pressure and Temperature.—A. H. Compton, R. D. Bennett and J. C. Stearns. (*Phys. Review*, 15th Oct., 1931, Series 2, Vol. 38, No. 8, pp. 1565–1566.)

A letter calling attention to the fact that "the ionisation of air traversed by gamma-rays from radium is a function of the pressure, and that this dependence upon the pressure is greater when the pressure is high." Recombination theory shows that the variation of ionisation with pressure should be nearly the same with gamma-rays as with cosmic rays. "When nitrogen is used, the ionisation remains proportional to the pressure up to pressures much higher than is the case with air."

THE CONSTANCY OF COSMIC RAYS.—R. D. Bennett, J. C. Stearns and A. H. Compton. (*Phys. Review*, 15th Oct., 1931, Series 2, Vol. 38, No. 8, pp. 1566.)

A consequence of the facts noted in the preceding abstract is that the results of experiments indicating a variation in the intensity of cosmic radiation with the time of day may have been influenced by lack of uniformity of the temperature of the apparatus. An experimental study of "the variations in the intensity of cosmic rays in a high altitude in such a way that possible temperature variations would not influence the results" showed "no variations in the intensity greater than the variations to be expected from purely statistical considerations."

A NEW EXPERIMENT BEARING ON COSMIC-RAY PHENOMENA.—L. M. Mott-Smith and G. L. Locher. (*Phys. Review*, 15th Oct., 1931, Series 2, Vol. 38, No. 8, pp. 1399–1408.)

Authors' abstract:—This new experiment consists in combining a Wilson cloud expansion apparatus with Geiger-Müller electron-counters in a manner which allows the simultaneous study of individual cosmic-ray particles by the two methods. Its purpose was to see whether the coincidence effect in electron-counters is actually caused by the passage of an ionising particle through them as has been generally assumed. This was considered desirable because it was felt that the several conflicting cosmic-ray experiments could perhaps be more satisfactorily explained by assuming the coincidences to be produced by photons. In this work a series of expansion photographs was taken under experimental conditions which allowed a definite correlation of an ion-track appearing in the expansion chamber with a discharge of a Geiger-Müller counter. It was found that the discharges of a counter due to cosmic radiation are accompanied by ion-tracks resembling those due to fast β-rays from radioactive sources. This result means that, in accord with previous beliefs, the coincidence effects are caused by ionising particles. The best assumption we can make at present appears to be that these are high-energy electrons. The possibility that these effects are due to photons appears to be excluded, so that the reconciliation of the conflicting experimental data in this field will have to follow other lines.

DAS WESEN DER ULTRASTRAHLUNG (The Nature of Cosmic Radiation).—J. Barnóthy and Magdalene Forró. (*Zeitschr. f. Phys.*, 1931, Vol. 71, No. 11/12, pp. 778–791.)

"In order to determine the nature of cosmic radiation [by investigating the influence of the earth's magnetic field upon it], its intensity distribution was determined in the directions perpendicular to the magnetic meridian between 50° (West) and 140° (East). Intensity maxima were found at 90° and 120°."

MEASUREMENTS ON THE ABSORPTION OF THE PENETRATING CORPUSCULAR RAYS COMING FROM INCLINED DIRECTIONS.—B. Rossi. (*Nature*, 5th September, 1931, Vol. 128, p. 408.)

A letter describing an experiment showing that the slant rays are softer than the vertical ones; the corpuscular rays are assumed to generate in the atmosphere a softer secondary corpuscular radiation, the relative amount of which is larger in an inclined direction than in the vertical one.

THE CORPUSCULAR EXPLANATION OF COSMIC RAYS.—F. Soddy. (*Nature*, 5th Sept., 1931, Vol. 128, p. 408.)

A letter pointing out difficulties in the corpuscular explanation of cosmic rays.

SULLA RADIAZIONE PENETRANTE (On the Penetrating Radiation.)—A. Piccard (Brussels). (*Bollet. d' Inform. Consig. Naz. d. Richerche*, September, 1931, pp. 225–228.) *See* also Maurain, under "Propagation of Waves."

LA RADIATION ULTRAPÉNÉTRANTE (The Ultra-Penetrating Radiation).—R. Desoille: Geiger. (*Rev. Gén. de l'Élec.*, 26th Sept., 1931, Vol. 30, pp. 495–498.)

An article based on Geiger's paper and the subsequent discussion (1931 Abstracts, p. 552).

BEITRAG ZUR FRAGE STATISTISCHER SCHWANKUNGEN DER EIGENSTRAHLUNG IN STRAHLUNGSAPPARATEN (Contribution to the Question of Statistical Fluctuations of the Natural Radiation of Radiation Apparatus [Application to Investigations on Cosmic Rays]).—W. M. H. Schulze. (*Physik. Zeitschr.*, 15th October, 1931, Vol. 32, No. 20, pp. 808–810.)

DIE SPEZIFISCHE IONISATION DER HÖHENSTRAHLUNG (The Specific Ionisation of Cosmic Radiation).—W. Kolhörster and L. Tuwim. (*Naturwiss.*, 6th Nov., 1931, Vol. 19, No. 45, p. 917.)

The specific ionisation of cosmic radiation is found to be 135 ions per cm. within $\pm$ 10 %, which is quite different from that of any rays from radioactive substances. The energy of a single cosmic ray ["eines einzelnen Höhenstrahls"] is found to be $> 2.10^9$ electron volts. This energy determination is independent of hypothetical formulae (*e.g.* that of Klein-Nishina) or of special assumptions as to the nature of the corpuscles.

SIMILARITY BETWEEN COSMIC RAYS AND GAMMA RAYS.—R. A. Millikan and I. S. Bowen. (*Nature*, 3rd Oct., 1931, Vol. 128, pp. 582–583.)

A letter suggesting that the cause of departure from linearity in the pressure–ionisation curve of cosmic rays and gamma rays from radium and thorium really lies in lack of saturation of the ionisation currents (*cf.* Abstracts, 1931, Broxon, p. 435; Hoffmann, p. 494; Millikan and Cameron, 1928, p. 689; 1931, p. 264).

HIGH-FREQUENCY [ULTRA-PENETRATING] RAYS IN THE AURORA BOREALIS, AND HIGH ALTITUDE TESTS ON MOUNT EVEREST.—E. A. Smith. (*Proc. Indiana Acad. Sci.*, Vol. 39, p. 285.)

The writer maintains that his results show that the radiations investigated (5.7×10^{-12} to 2.9×10^{-13} cm.) originate in the aurora.

BRANCHING OF LIGHTNING.—B. F. J. Schonland and T. E. Allibone. (*Nature*, 7th Nov., 1931, Vol. 128, pp. 794–795.)

Observations of the electric field change at the ground caused by the disappearance of the elevated charge in a thundercloud indicate that in at least 95 % of the 404 flashes examined the cloud-pole was negative. "Photographs of South African flashes to ground show a high preponderance of downward branching (21/24) and suggest, therefore, that in these flashes the branching was the reverse of that observed in laboratories. Final evidence was obtained by correlating photographic records of the field changes with photographs and sketches of the flashes producing them" (*cf.* Halliday, Jan. Abstracts, p. 32). The conclusion is drawn that the branching criterion for cloud polarity is invalid. The conditions under which a positive discharge is suppressed and the negative enhanced are discussed with the aid of studies of the discharge of an impulse generator delivering 10^6 volts to a point-plane gap, in which, provided the conditions are correct, negative branching of a magnitude comparable with positive branching can be produced.

BRANCHING OF LIGHTNING.—J. L. P. Macnair. (*Nature*, 5th Dec., 1931, Vol. 128, p. 969.)

Confirmation of the conclusions of Schonland and Allibone (*see* above abstract) is obtained optically by the observation of very distant flashes.

SUR LES ÉCLAIRS FULGURANTS ASCENDANTS (On Ascending Lightning Flashes).—E. Mathias. (*Comptes Rendus*, 16th Nov., 1931, Vol. 193, pp. 909–912.)

As regards *ascending* flashes, Simpson's theory required, in the writer's opinion, further confirmation owing to the lack of photographs of such flashes. He now obtains excellent confirmation in old sketches and descriptions dating before photography was applied to such subjects. These also establish the fact that certain long flashes make their passage at such a reduced speed that they last 1, 2 or 3 seconds, *seeming to voyage in a resistant medium*. This is explained on the "fulminant matter" hypothesis, which also deduces the "rounded or spherical terminations" actually observed and photographed in both ascending and descending flashes.

AN OPTICAL STUDY OF THE FORMATION STAGES OF SPARK BREAKDOWN.—F. G. Dunnington. (*Phys. Review*, 15th Oct., 1931, Series 2, Vol. 38, No. 8, pp. 1535–1546.)

A description of a visual and photographic study of the manner in which a static breakdown occurs in an air gap with an approximately homogeneous initial field. The electro-optical shutter developed by the author (*see* under "Subsidiary Apparatus") was used.

DURATION AND MAGNITUDE OF A LIGHTNING DISCHARGE.—R. S. J. Spilsbury. (*Nature*, 21st Nov., 1931, Vol. 128, p. 872.)

A letter describing an unusual case of damage by lightning; experiments arranged to simulate the conditions enabled an estimation to be made of the maximum duration of the discharge as 20×10^{-6} second and the average rate of energy input to each metre of conductor as 150 000 kilowatts.

SUR L'ÉCLAIR EN CHAPELET AVEC GRAINS (Granulated "Bead Necklace" Lightning).—E. Mathias. (*Comptes Rendus*, 7th Dec., 1931, Vol. 193, pp. 1140–1143.)

Further considerations on the subject dealt with in 1931 Abstracts, p. 265.

THE THEORY OF THE ELECTRIFICATION OF AEROSOLS.—H. S. Patterson. (*Phil. Mag.*, Dec., 1931, Series 7, Vol. 12, No. 81, pp. 1175–1182.)

See also 1931 Abstracts, p. 610.

CHARGED AEROSOLS AND BALL LIGHTNING.—W. C. Reynolds. (*Nature*, 3rd Oct., 1931, Vol. 128, p. 584.)

A letter suggesting that charged aerosol behaviour (*cf.* Abstracts, 1931, Cawood and Patterson, p. 610; 1930, Marchant, p. 209; 1930, Reynolds, p. 331) may be extended to attenuated masses of electrified gas and thus explain the phenomena of ball lightning.

METHODS FOR MEASURING INTERFERING NOISES.—Espenschied. (*See* under "Acoustics and Audio-frequencies.")

A DYNATRON TRIP RELAY CIRCUIT APPLICABLE TO THE RECORDING OF ATMOSPHERICS OF VARIOUS STRENGTHS.—Fucks. (*See* abstract under "Subsidiary Apparatus.")

PROPERTIES OF CIRCUITS.

ENTARTUNGSERSCHEINUNGEN AM RÖHRENSENDER (Degeneration [into Relaxation Oscillations] in Valve Oscillators).—W. Reichardt. (*E.N.T.*, Nov., 1931, Vol. 8, pp. 502–512.)

In a previous paper (1931 Abstracts, p. 610) the writer showed that in the transformer-coupled reaction circuit, under suitable conditions, there is an uninterrupted transition from sinusoidal to relaxation oscillations. He now extends this to the normal transmitter circuit, applying the same graphical method. In the present case the influence of the grid current produces special relations, with the result that the investigation of the degeneration processes is chiefly qualitative only. Since the sinusoidal oscillations must always suffer a certain amount of degeneration, the writer's results throw light on the frequently encountered phenomenon—not easily intelligible on the simple theory—of the *dependence of transmitter frequency on the anode potential and the heating of the cathode.* Finally, an approximate theory is developed for the relaxation oscillations in the condition of extreme degeneration.

UNTERSUCHUNGEN ÜBER DIE PFEIFBEDINGUNGEN DES ZWEIDRAHTVERSTÄRKERS UND IHRE AUSWERTUNG FÜR EIN NEUES VERSTÄRKUNGSMESSVERFAHREN (Investigations on the Singing Conditions in Two-Wire Amplifiers, and their Application to a New Amplification Measuring Method).—W. Weinitschke. (*T.F.T.*, Oct., 1931, Vol. 20, pp. 303–312.)

Theoretical only: practical details and applications of the method are promised in a later paper.

ANALYTICAL STUDY [BASED ON CARSON'S SERIES DEVELOPMENT] OF VALVE CIRCUITS FOR ANODE DETECTION OF TELEPHONY SIGNALS. —I. P. Woods. (*Univ. of Texas Bull.*, 8th April, 1931, pp. 7–71; summary in *Rev. Gén. de l'Élec.*, 7th November, 1931, Vol. 30, pp. 751–752.)

MUTUAL DEMODULATION AND ALLIED PROBLEMS.—H. L. Kirke. (*Wireless Engineer*, November, 1931, Vol. 8, p. 600.)

Pointing out an error in a figure in the editorial (1931 Abstracts, p. 611), which will modify the subsequent formulae.

TRANSMISSION.

LES GAZ IONISÉS ET LE FONCTIONNEMENT DES LAMPES À GRILLE POSITIVE (Ionised Gases and the Behaviour of Valves with Positive Grids).—Th. V. Jonescu. (*Comptes Rendus*, 12th Oct., 1931, Vol. 193, pp. 575–577.)

Using the results obtained in his previous paper (1931 Abstracts, p. 315), the writer interprets the behaviour of positive-grid valve circuits and arrives at the formula $\lambda^2 V = \frac{c^2}{\frac{4}{9}\cdot\frac{k}{\pi^3}\cdot\frac{e}{m}\cdot\frac{1}{r^2}} = \text{const.}$, which Barkhausen reached by quite different reasoning involving the path time between filament and plate. The typical behaviour of the positive-grid valve begins when the grid potential has a value sufficient to produce saturation. In this case, "packets" of electrons carry on oscillations in the ionised gas. The frequency ν' of these packets probably depends also on the internal dimensions of the valve. When ν, the natural frequency of the ionised gas, which is a function of the grid potential V, is about equal to ν' or one of its multiples, resonance occurs between the natural oscillation of the gas and that of the electron packets.

"It is thus that one can explain how it is that oscillations can be maintained at several discrete frequencies, agreeing with the Barkhausen formula, and at the same time; for with a constant filament heating one obtains other regions of oscillation by increasing the grid potential. These new oscillations do not verify the Barkhausen formula, but they can be explained on the supposition that ν is a multiple of ν'. Pierret's observations, that certain valves only oscillate well when their electrodes are sufficiently heated, explaining this by supposing that the electrodes give off gas, is in agreement with our theory. The diminution of wavelength by increase of gas pressure, as well as by the heating of the filament (for a constant grid potential) is explained by the increased density of ionisation round the grid."

SUR LES OSCILLATIONS ENTRETENUES PAR LES LAMPES À GRILLE POSITIVE (The Oscillations occurring in Valves with Positive Grids).—A. Rostagni. (*Comptes Rendus*, 30th November, 1931, Vol. 193, pp. 1073–1075.)

Jonescu's interpretation of his results (*see* preceding abstract) leads to the generally accepted constancy of $\lambda^2 V$ but makes the constant not merely dependent on the internal dimensions of the valve but also on the ratio of the number of positive ions to the number of electrons. This ratio can therefore be calculated from observed values of λ and V. The writer's application of this procedure to his series of values for highly evacuated valves leads to the result that the number of positive ions should be of the same order of magnitude as the number of electrons. This condition, however, would be expected to produce, in the non-oscillating state, values of plate current which have actually *not* been observed.

Jonescu's explanation, therefore, would seem inapplicable to highly evacuated valves. It may apply to those oscillations which depend essentially on the pressure of the residual gas and which disappear directly this pressure is reduced below a certain limit (*cf.* Gutton and Beauvais, Jan. Abstracts, p. 34). For the other type of oscillation, the truly electronic, the writer has proposed another interpretation, from a viewpoint analogous to that of Jonescu, connecting these oscillations to the natural oscillation of the cloud of electrons *in the grid–plate space* (*cf.* Gill, Jan. Abstracts, p. 34). It is known that a cloud of N electrons, in statistical equilibrium in a condenser subjected to an alternating p.d., behaves as an inductance across the condenser (neglecting the disturbance caused by the space charge in the electric field). The system is therefore equivalent to an oscillating circuit whose period can be expressed as a function of N. The corresponding wavelength is given by

$$\lambda = \sqrt{\frac{\pi m v}{\epsilon^2 N}} = \frac{3.35 \times 10^6 \sqrt{v}}{\sqrt{N}},$$

ϵ and m being the charge and mass of the electron, v the volume enclosed by the condenser plates.

Applying the above to the grid-plate system of a positive grid valve, the writer obtains values of λ agreeing well with experiment. In particular, the relation $\lambda = \frac{K}{\sqrt{N}}$ is verified very satisfactorily by tests on five different types of valve. The number N is calculated with allowance for space-charge effects. The most suitable value for the constant K (determined by the method of least squares) is never far from the theoretical value $3.35 \times 10^6\sqrt{v}$. According to the writer's interpretation, therefore, the fundamental factor which determines the oscillatory process is the number N. As this is a function of both i_e (the emission current) and ν, the often-repeated observation is justified that the oscillations depend not only on ν but also on i_e. The Barkhausen relation $\lambda^2 V =$ const. results (where it is fulfilled) as a special consequence. The Pierret and Gill-Morrell oscillations, etc., may also conform with this interpretation.

VACUUM TUBES AS [ULTRA-] HIGH-FREQUENCY OSCILLATORS.—E. D. McArthur and E. E. Spitzer. (*Proc. Inst. Rad. Eng.*, Nov., 1931, Vol. 19, pp. 1971–1982.)

Authors' summary :—" The problem of tubes for generating power at wavelengths below five metres is discussed. The theory of the triode and split-anode magnetron is considered with particular reference to the limitations imposed by operation at short wavelengths. Essential data are given for examples of each type of tube, showing the power that can be obtained at various wavelengths." The writer concludes that at present the triode is best for wavelengths down to about 1.5 m., the split-anode magnetron for wavelengths between 1.5 and 0.75 m., while below 0.75 m. it is necessary to resort to oscillators whose frequency is determined by the electron transit time (B.-K., or Okabe magnetron). At present, the triode is the only type for use as an amplifier. A new G.E.C. triode, water-cooled and with a pure tungsten filament, is announced ; curves are given for its output and efficiency at wavelengths from 2 to 5 metres ; maximum output, round 5 metres, is about 2.7 kw.

A RECENT DEVELOPMENT IN VACUUM TUBE OSCILLATOR CIRCUITS [Constant Frequency by Electronic Coupling].—J. B. Dow. (*Proc. Inst. Rad. Eng.*, Dec., 1931, Vol. 19, pp. 2095–2108.)

Author's summary :—" A constant frequency oscillator, which depends for its operation upon the use of electron coupling between the oscillation generating portion of the circuit and the work circuit, is described. This form of coupling is employed to isolate the work circuit from the frequency-determining portion of the system. The oscillator is of the two-anode type (UX–865) and it is shown that by suitable choice of anode voltages compensating effects may be obtained whereby changes in generator voltage may be made to have a negligible effect upon the frequency of oscillation."

A master oscillator embodying these principles has been used in the initial stages of a 500-watt transmitter for a sufficient time to demonstrate conclusively that for frequencies up to 24 megacycles the performance indicated by the experimental results may be attained. Signals from this transmitter have been almost invariably reported as " pure d.c. crystal control."

NEW METHODS OF FREQUENCY CONTROL [PARTICULARLY FOR ULTRA-SHORT-WAVE TRANSMITTERS] EMPLOYING LONG LINES [LECHER WIRES OR APERIODIC LINES IN PLACE OF CRYSTAL CONTROL].—J. W. Conklin, J. L. Finch and C. W. Hansell. (*Proc. Inst. Rad. Eng.*, Nov., 1931, Vol. 19, pp. 1918–1930.)

Authors' summary :—The practical difficulties encountered in commercial operation of short-wave transmitters, due to the great number of radio-frequency stages required for crystal control, are summarised. The objections to crystal control for some transmitters operated on frequencies above 35 000 kilocycles are given. Methods are described for meeting these objections through frequency control by long radio-frequency transmission lines, which have inherently large volt-ampere capacity and which make possible a considerable reduction in operating costs and improvement in reliability. Methods for applying the lines to the control of oscillator frequencies by using them as relatively constant low power factor resonant circuits and as aperiodic means for feeding regenerative energy from anode circuits to grid circuits are described. A method is given for obtaining both the advantages of crystal oscillators as frequency standards and the economies and reliability of long line transmitter frequency control. Applications of the methods described to experimental and commercial transmitters are mentioned.

A MULTI-FREQUENCY CRYSTAL-CONTROLLED MONITOR USED TO CONTROL A TRANSMITTER.—Reinartz. (*See* abstract under " Measurements and Standards.")

EIN STROBOSKOPISCHER VERFAHREN ZUR MESSUNG VON FREQUENZ- UND PHASENMODULATION (A Stroboscopic Method of Measuring Frequency- and Phase-Modulation [in Amplitude-Modulated Transmitters]).—A. Heilmann. (*E.N.T.*, Nov., 1931, Vol. 8, pp. 469–476.)

The modulated oscillations (or, in the case of short waves, the intermediate frequency oscillations representing these after a frequency-changing process—to make the r.f. amplification easier) are applied to the deflecting system of a c.-r. oscillograph so that the spot forms an annular figure whose width depends on the degree of modulation.

In the absence of modulation the figure will be a circle, and the time mark produced by a sudden change in potential (from an auxiliary pulse generator) will appear as a dot on this circle : this dot will appear stationary if the time oscillations have a frequency exactly equal to, or a whole multiple of, the carrier frequency. In the presence of modulation the dot will move radially between the outer and inner edges of the annular figure (provided frequency- and phase-modulation are both absent) so that a straight radial line will be seen across the width of the ring. If frequency- or phase-modulation is present, the time mark will wander sideways and thus will form a stationary curve across the width of the ring. *This curve gives directly the phase variation in relation to the modulation phase ;* the phase change between two modulation phases is given by the angle between the lines joining the two corresponding time marks to the centre of the ring. This knowledge is of special value, as it often helps to trace in a simple way the cause of the phase modulation.

By fastening against the fluorescent screen a scale of transparent paper engraved with a system of angles and concentric circles, the degree of modulation and of phase-modulation can be read off directly, and the effect of changes at the transmitter can be watched. An alternative method, not yet fully investigated, is to exchange the functions of main and auxiliary voltages so that the latter produces a circle of constant size on which the time mark (now produced by the main frequency) moves. The paper ends with a discussion of possible sources of error and the ways of avoiding them.

DIE FOURIERANALYSE MODULIERTER HOCHFREQUENZ (The Fourier Analysis of Modulated High Frequency Currents).—M. Grützmacher. (*E.N.T.*, Nov., 1931, Vol. 8, pp. 476–480.)

After a section describing and illustrating the high-frequency analyser used in the Telefunken procedure (1931 Abstracts, p. 149, Runge) for the investigation of the amplitude- and frequency-modulation of transmitters, the writer discusses the modulation record (oscillogram) thus obtained from the Witzleben transmitter. He calls attention to the inequality of the two first side-frequencies—a phenomenon found with nearly every transmitter and for a long time not properly explained, until Runge (*loc. cit.*) showed that simultaneous amplitude- and frequency-modulation necessarily produced such inequalities of the side-frequencies. He then discusses by vector methods the simplest and most frequently occurring cases of simultaneous amplitude- and frequency-modulation, obtaining formulae for the "instantaneous frequency," from which the "stroke" of the frequency modulation—*i.e.* the maximum departure from the carrier frequency—can easily be calculated. The final formula, $x = \frac{(a + d + e) F - (d - e) f}{(a + d + e)}$, involves only the amplitudes and frequencies of the individual side-frequencies which can be read off the modulation record.

A final section deals with the simultaneous amplitude- and frequency-modulation *at various modulating frequencies*, from about 200 to 3 000 c.p.s. Fig. 7 shows the measurements on a broadcasting transmitter with master drive, which was known to display fairly pure simultaneous frequency- and amplitude-modulation, and which during the test was modulated with constant voltage at different frequencies. The curves show the increase of dissymmetry with decreasing frequency. Below 500 c.p.s. the frequency-modulation predominates: at 500 c.p.s. the amplitude of the one side-frequency has become zero (the amplitude-modulation vector equals the frequency-modulation vector), while at higher frequencies the two curves approach asymptotically the condition of pure amplitude-modulation.

NOTE SUR LE PROCÉDÉ DE "MODULATION PAR DÉPHASAGE"—SYSTÈME S.F.R. CHIREIX (Note on the "De-phasing" Method of Modulation—S.F.R. Chireix System).—H. Chireix. (*Bull. de la S.F.R.*, Sept.-Oct., 1931, Vol. 5, pp. 141–148.)

"In the modulating systems normally used the conversion of the h.t. direct current takes place with an efficiency which cannot be much over 35 % if it is desired to keep the advantage of a modulation percentage over 80 or 90 %. The new system has enabled an efficiency of 63 % to be reached under the same conditions" [in the case of "Radio Paris"; *see* also under "Stations, Design and Operation."]

THE IMPEDANCE OF THE VALVE GENERATOR FOR A CONSTANT-VOLTAGE MODULATING FREQUENCY.—J. Groszkowski. (*Wiadomości i Prace Inst. Radjot., Warsaw,* No. 2–3, Vol. 3, pp. 35–46.)

The impedance is shown to be complex, its components (real, positive, and imaginary, negative) being functions of the modulating frequency. The theoretical solution and experimental proof are given, and practical conclusions are discussed.

LE SYSTÈME DE COMMUNICATIONS . . . ETC. (The Single Side-Band System Applied to Short Wavelengths).—A. H. Reeves. (*L'Onde Élec.*, Nov. 1931, Vol. 10, pp. 476–512.)

See 1931 Abstracts, p. 554.

A 24 000 WATT BAND-PASS FILTER [FOR TESTS ON SIMULTANEOUS TELEPHONIC TRANSMISSIONS ON SINGLE AERIAL].—Brotherton. (*See* under "Subsidiary Apparatus.")

HIGH-POWER PERFORMANCE FROM THE SMALL 'PHONE TRANSMITTER: A CLASS B MODULATOR FOR SETS USING TYPE '10 TUBES.—J. J. Lamb. (*QST*, Dec., 1931, Vol. 15, pp. 10–22.)

See also Jan. Abstracts, p. 36 (Barton).

RECEPTION.

QUANTITATIVE UNTERSUCHUNGEN AN RUNDFUNKEMPFÄNGERN (Quantitative Investigations of Broadcast Receivers—Part I: The Testing Equipment).—A. Harnisch. (*Zeitschr. f. Hochf: tech.*, November, 1931, Vol. 38, pp. 181–188.)

From the Dresden Institute of Communication Engineering. The representation of actual receiving aerials by artificial aerials (A, § a, and B, § a). The test transmitter (A, § b, and B, § d):—Investigation of the suppression of frequency modulation for leaky-grid circuit with varying values of grid leak: final adoption of a value of 50 000 ohms. The supply to the transmitter from current sources outside the screening (Fig. 11):—no trouble with filament supply, since the filaments are earthed: anode supply (carrying also the modulating l.f.)—the choice between d.c.-a.c. series connection and parallel connection (Fig. 14), the former being preferred since in the latter the choke coil, dependent on frequency, affects the frequency of the oscillatory circuit. The filtering of the anode supply.

Avoidance of parasitic couplings between transmitter and receiver (p. 183): choice between meticulous screening of transmitter and potential divider, of receiver and artificial aerial, and the compromise of moderate screening of both systems: the advantages of this compromise and the method of carrying it out: the lead from potential divider to artificial aerial is enclosed in the earthed lead from potential divider to receiver, by the use of single-core lead-covered cable.

The potential divider (A, § b, p. 184, and B, § b). Rejection of the simple capacitive divider (Fig. 7) and adoption of the chain links shown in Fig. 8, bridged by a 2 000 cm. variable condenser. Its advantages, and the good results obtained with it. Its calibration (B, § c). The output voltage of the transmitter is indicated by a thermo-galvanometer, whose resistance is increased by a 10-ohm series resistance of special bifilar form giving a capacitive shunt and ensuring a constancy ($\pm \frac{1}{2}$ %) of output resistance for wavelengths between 200 and 2 000 metres (Figs. 11 and 16).

THE SUPERHETERODYNE AS THE RECEIVER OF THE FUTURE.—R. Wigand: Brüller. (*Rad., B., F. f. Alle*, December, 1931, pp. 526–529.)

An article prompted by Brüller's paper (1931 Abstracts, pp. 615–616).

SINGLE CONTROL SUPERHETERODYNES. — H. Andrewes. (*Wireless World*, 25th November, 1931, Vol. 29, pp. 616–618.)

Details are given of the necessary steps to be taken to keep the adjustment of the oscillator in its correct relationship to the tuning control when these two functions are carried out by a ganged condenser.

SINGLE DIAL SUPERHETERODYNE.—F. H. Haynes and W. T. Cocking. (*Wireless World*, 2nd and 9th December, 1931, pp. 654–658 and 684–686.)

A five-valve battery-driven superheterodyne. A point of interest is the ganging together of the tuning and oscillator circuits, an unusual feature in a receiver intended for the amateur constructor. The band-pass principle is used in the intermediate amplifier as well as in the signal frequency tuner.

THE VARIABLE-MU THREE.—W. I. G. Page and W. T. Cocking. (*Wireless World*, 18th and 25th November, 1931, Vol. 29, pp. 574–578 and 620–621.)

A three-valve a.c. mains-operated receiver for the amateur constructor. The principal points are :—band-pass tuning, two stages of high frequency amplification using variable-mu valves, volume control by variation of the grid bias of the high frequency amplifying valves, and combined power grid detector and output valve using an indirectly heated pentode.

CONTROLLING VOLUME WITH THE VARIABLE-MU VALVE.—N. R. Bligh and E. D. Whitehead. (*Wireless World*, 25th November, 1931, Vol. 29, pp. 606–607.)

Volume is controlled by varying grid bias between 2 and 40 volts and this necessitates very careful consideration of the voltage distribution between the electrodes ; it is essential that screen-grid volts be kept constant through this wide variation in grid bias volts if the correct "tailing" characteristic of the variable-mu valve is to be maintained. In this article formulae for the calculation of the various resistance values necessary to achieve this end are discussed.

THE REMOTE VOLUME CONTROL.—W. T. Cocking. (*Wireless World*, 2nd December, 1931, Vol. 29, pp. 638–639.)

A new method of controlling the volume of a receiver at a distance without introducing distortion and instability usually associated with such an arrangement. Advantage is taken of the special properties of the variable-mu valve.

POWER GRID AND LEAKY GRID—A COMPARISON. —W. I. G. Page. (*Wireless World*, 2nd and 9th December, 1931, Vol. 29, pp. 631–632 and 672–674.)

A CURE FOR DETECTOR DAMPING.—C. H. Smith. (*Wireless World*, 16th December, 1931, Vol. 29, pp. 687–688.)

The article discusses various forms of getting rid of damping in the case of a grid detector and suggests that the reduction of the capacity of the grid condenser to an abnormally low value is the most efficacious method.

RADIO RECEPTION AND SUN SPOTS.—H. T. Stetson. (*Sci. News Letter*, 7th November, 1931, p. 293.)

Radio reception improved 400% during the months March to September, 1931, whilst sunspot activity decreased, the sunspot index for September being only half its March value. The writer predicts that reception will continue to improve during the winter months, attaining conditions which have not been duplicated since the great improvement in radio receivers and the advent of the high-powered transmitting stations of recent years.

SHORT WAVE RECEPTION AND ULTRA-RADIATION.— Schulze. (*See* under "Propagation of Waves.")

WIRD DER RUNDFUNK DURCH ULTRAKURZE WELLEN GESTÖRT ? (Do Ultra-Short-Wave Transmissions Interfere with Broadcast Reception ?). (*Rad., B., F. f. Alle*, October, 1931, p. 447.)

A note on reports from Amsterdam of interference with ordinary broadcasting caused by 7.85-metre experimental transmissions. The cases of interference appear to have been situated within 150 metres of the transmitter.

TROLLEYBUSES AND RADIO RECEPTION.—S. W. Duncan. (*Electrician*, 16th Oct., 1931, Vol. 107, p. 527.)

A letter stating that interference with reception was greatly diminished by introducing stopper coils in the leads to each trolley arm. London United Tramways are fitting such coils to their fleet of 60 trolleybuses.

DAS SIEMENS-STÖRSUCHGERÄT (The Siemens Interference Tracing Apparatus).—Siemens Company. (*Rad., B., F. f. Alle*, Nov., 1931, pp. 489–490.)

REDUCTION OF RADIO INTERFERENCE FROM TELEPHONE POWER PLANTS.—J. M. Duguid. (*Bell Lab. Record*, Dec., 1931, Vol. 10, No. 4, pp. 124–126.)

THE NEW ZEALAND RADIO [RECEIVER] MARKET. (*Elec. Review*, 2nd October, 1931, Vol. 109, p. 521.)

Note on an official report. The demand is for sets capable of receiving Australian stations 1 200 to 2 500 miles away, and American stations 4 000 miles away. Fine selectivity is also essential on account of local stations. At a recent exhibition the majority of sets were American, not one English set being shown. Details of duties and preferences are given.

PROBLEMS THAT FACE THE RADIO ENGINEER.—V. M. Graham. (*Electronics*, November, 1931, pp. 174–175.)

"Broadcast system and receiver must be regarded and designed as a unit: sets and tubes need to be correlated without cramping or complicating either." A diagram shows the variation, during the last three seasons, of the average selectivity of [American ?] receivers.

LE NOUVEAU CENTRE RÉCEPTEUR RADIOÉLECTRIQUE DE NOISEAU (The New State Radio Receiving Centre at Noiseau [Paris]).—G. Espinasse. (*Ann. des P.T.T.*, September, 1931, Vol. 20, pp. 744–765.)

THE CONSTRUCTION OF FILTER CIRCUITS IN THE GERMAN BROADCAST RECEIVER INDUSTRY.—E. Schwandt. (*Funk-Bastler*, June, 1931, Vol. 12, pp. 371–376: summary in *L'Onde Élec.*, October, 1931, Vol. 10, pp. 71–72A.)

AERIALS AND AERIAL SYSTEMS.

DEVELOPMENTS IN SHORT-WAVE DIRECTIVE ANTENNAE.—E. Bruce. (*Bell S. Tech. Journ.*, Oct., 1931, Vol. 10, No. 4, pp. 656–683.) *See* 1931 Abstracts, p. 555.

ON THE SPACE WAVES FROM A VERTICAL DOUBLET ON A PLANE EARTH.—van der Pol and Niessen. (*See* under "Propagation of Waves.")

AERIALS AND REFLECTORS USED IN ITALIAN 50-CENTIMETRE WAVE DEMONSTRATION.—G. Marconi. (Photographs in *Electrician*, 27th Nov., 1931, Vol. 107, p. 761.)

TOWERS WITH REDUCED STAYING, BOUVIER-BOURSEIRE SYSTEM.—Soc. S.F.R.: Bourseire. (*Bull. de la S.F.R.*, August, 1931, Vol. 5, pp. 124–137: *Ann. des P.T.T.*, Nov., 1931, Vol. 20, pp. 919–932.)

VALVES AND THERMIONICS.

EXPERIMENTELLE UNTERSUCHUNGEN ÜBER DESTILLATIONSKATHODEN (Experimental Investigations of Distillation Cathodes [Acid Process, Barium on Platinum]).—W. Hinsch. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 12, 1931, pp. 528–541.)

Espe having dealt thoroughly with the thermit process, the present investigations were made to examine equally carefully the cathodes made by the acid process. In order to obtain clear and reproducible results, pure tungsten was first used in place of the oxidised tungsten employed as base by Espe. It was found, however, that while such cathodes gave excellent emission, they were very sensitive to over-heating, losing their emission very quickly. Tests were therefore made with clean platinum; this—treated by the acid process—gave a good and reproducible emission, and was therefore used throughout the main experiments: in an appendix the writer returns to tests with tungsten as the base.

The barium-platinum cathode, when heated (anode potential cut off) to the extent which would have destroyed the emission in the case of barium-tungsten, showed on return to the normal heating current an improved emission. Further periods of heating (0.75 A. in place of the normal 0.3–0.5 A.) improved the emission still more, the final value being more than 4 times the original. The curve after this treatment showed a well-defined saturation bend, whereas this was visible neither for the original cathode nor during the earlier stages of the "forming" process. Microscopic examination led to the conclusion that the absence of this bend was due to roughness of the surface owing to the formation of a platinum-barium alloy; as the "forming" proceeded, this strongly emitting alloy spread itself smoothly over the whole surface. This explanation was confirmed by measurements of A and ϕ during the process: ϕ remained constant, A increased. The alloy is thought to be not very rich in barium, and to carry on its surface a thin, perhaps monomolecular, layer of barium.

Comparison of the work functions for pure tungsten and platinum, for these metals with the addition of barium, and finally for barium oxide and "formed" barium oxide, suggests that within the limits of error the effect of a barium layer in all cases produces the same decrease of work function—about 2.1–2.5 V. On the assumption that the action of the coating is attributable to the formation of an electrical double layer, it may perhaps be concluded that the moment of the dipoles forming this layer depends chiefly on the nature of the coating and only very slightly on the base. But further measurements are needed before this can be considered as established.

THERMIONIC EMISSION AND ELECTRICAL CONDUCTIVITY OF OXIDE CATHODES.—A. L. Reimann and L. R. G. Treloar. (*Phil. Mag.*, Dec., 1931, Series 7, Vol. 12, No. 81, pp. 1073–1088.)

Authors' abstract:—Experiments are described which form a continuation of the work initiated and discussed by Reimann and Murgoci [1930 Abstracts, pp. 278–279]. A more accurate method has been employed for measuring conduction phenomena in oxide cathodes, and new information has been obtained on (1) the variation of the conductivity of the coating and of the thermionic emission with temperature; (2) the relation between the conduction current and electrode potential difference at various temperatures; (3) the relation between the thermionic current and anode potential at various temperatures. The theoretical position is discussed in the light of this new knowledge together with the results of recent work by other observers.

It is concluded that the weight of experimental evidence is still in favour of the theory of the mechanism of these cathodes according to which the current, thermionically emitted at the surface of the core metal, is carried almost exclusively by barium [and/or strontium and/or calcium] ions through the coating, at the outer surface of which it is re-emitted thermionically.

ZUR ELEKTRONENTHEORIE DER METALLE (On the Electron Theory of Metals).—L. Nordheim. (*Ann. der Physik*, 1931, Series 5, Vol. 9, No. 5, pp. 607–640, and No. 6, pp. 641–678.)

DER SCHROTEFFEKT NACH DER QUANTEN-MECHANIK (The Shot Effect on the Quantum Mechanics [Theoretical Investigation]).—H. Fröhlich. (*Zeitschr. f. Phys.*, 1931, Vol. 71, No. 11/12, pp. 715–719.)

THE ACTION OF POSITIVE IONS OF CAESIUM ON A HOT NICKEL SURFACE.—P. B. Moon. (*Proc. Camb. Phil. Soc.*, Oct., 1931, Vol. 27, No. 4, pp. 570–577.)

UNTERSUCHUNG ÜBER DIE GLÜHELEKTRISCHE EMISSION DES EISENS (Investigation of the Thermionic Emission of Iron).—G. Siljeholm (*Ann. der Physik*, 1931, Series 5, Vol. 10, No. 2, pp. 178–222.)

THE EQUILIBRIUM DISTRIBUTION OF POTENTIAL AND OF ELECTRONS OUTSIDE THE SURFACE OF A CONDUCTOR.—A. T. Waterman. (*Phys. Review*, 15th Oct., 1931, Series 2, Vol. 38, No. 8, pp. 1497–1505.)

THERMIONIC EMISSION FROM A PLANE ELECTRODE.—R. S. Bartlett. (*Phys. Review*, 15th Oct., 1931, Series 2, Vol. 38, No. 8, pp. 1566–1567.)

The author has set up "an arrangement for measuring the thermionic current between parallel [plane] electrodes of nickel" and finds that, within the limits of his rather large experimental error, "the dependence of current upon applied field and upon temperature is the same as in the cylindrical electrode case."

DEVELOPMENT OF A CIRCUIT FOR MEASURING THE NEGATIVE RESISTANCE OF PLIODYNATRONS.—E. N. Dingley, Jr. (*Proc. Inst. Rad. Eng.*, Nov., 1931, Vol. 19, pp. 1948–1950.)

The term "pliodynatron" has been applied to valves with dynatron characteristics in which a control grid has been placed between the filament and the other elements in order to control the negative resistance characteristic. Thus any screen-grid valve in which the screen grid is kept more positive than the plate, and the control grid is used to regulate the negative resistance, may be called a pliodynatron. Such arrangements are assuming greater importance in engineering work, and the present paper describes a bridge test circuit for the quick and accurate determination of the negative resistance—a measure of the valve's utility—without recourse to the older and more laborious method of plotting the E_p/I_p curve.

CATHODE-RAY TUBE AS A RECORDER OF RECEIVING VALVE CHARACTERISTICS.—M. von Ardenne. (Summary in *Electronics*, November, 1931, p. 204.)

In the *Funk Magazine* paper here summarized, the rapid tracing of the characteristic curve by this method, and the difficulties to be overcome, are described, and full details are given of a practical apparatus for mains supply.

UNIVERSAL TUBE TEST EQUIPMENT.—O. H. Brewster and K. F. Mayers. (*Electronics*, Nov., 1931, pp. 198–199.)

EINE SELBSTTÄTIGE PRÜF- UND SORTIERMASCHINE FÜR VERSTÄRKERRÖHREN (An Automatic Testing and Sorting Machine for Amplifier Valves).—W. Traub and F. Menzler. (*E.T.Z.*, 8th Oct., 1931, Vol. 52, pp. 1277–1278.)

Description of an equipment capable of dealing with all types of valves, including screen-grid, at the rate of 1800 per hour.

SIMPLE METHOD FOR THE MEASUREMENT OF VERY LOW GRID CURRENTS IN "ELECTROMETER" VALVES.—L. Sutherlin. (*Electronics*, Oct., 1931, p. 148; *ibid.*, Nov., p. 206.)

PENTODE TUBES USED AS TRIODES.—J. R. Nelson. (*Electronics*, Dec., 1931, pp. 226–227 and 254.)

"The per cent second harmonic is rather high, so that its use as a single output tube, connected as a triode, is not recommended. It does, however, appear to offer some advantage when used in push-pull as a triode, namely a 50% reduction in input voltage over that required by a 245 for about the same power, and less matching difficulties than if it were used as a pentode."

SPECIAL SYMMETRICAL R.F. AMPLIFIER VALVE.—Angwin. (*See* abstracts under "Measurements and Standards" and "Miscellaneous.")

THE ADVANTAGES OF THE VARIABLE-MU VALVE.—W. T. Cocking and W. I. G. Page. (*Wireless World*, 11th November, 1931, Vol. 29, pp. 546–549.)

An article summarising the advantages of the new variable-mu valve, which are :—greatly increased selectivity, simplification of volume control, easy application of automatic and "distant" systems of volume control and elimination of various types of background noises. For volume control by variable-mu valves, *see* under "Reception"—two.

VACUUM TUBES AS [ULTRA-] HIGH-FREQUENCY OSCILLATORS [including G.E.C. Water-cooled Triode for 1.5 to 5 Metres].—McArthur and Spitzer. (*See* under "Transmission.")

NEW ELECTRON TUBES—FACTS AND RUMOURS.—(*Electronics*, Dec., 1931, pp. 216–217.)

(i) The G.E.C. ultra-short-wave transmitting triode (*see* above). (ii) The Cable "Triple-Twin" output valve containing an amplifier valve and a power valve directly coupled in one envelope, delivering 4.5 watts with an input of 4 volts r.m.s. (iii) Variable-mu radio-frequency pentode, type 239. (iv) Three-element gaseous discharge valve (Weiller) in which the grid has *complete control over the plate current* instead of only being able to start it.

THE 500 KW. DEMOUNTABLE VALVE.—Angwin. (*See* abstract under "Miscellaneous.")

B.T.H. MAZDA THYRATRON, TYPE BT.1.—(*Journ. Scient. Instr.*, Sept., 1931, Vol. 8, pp. 296–302.)

GESCHWEISSTE SENDERÖHREN (Welded Transmitting Valves).—Philips Lamp Works. (*Rad. B., F. f. Alle*, Nov., 1931, pp. 476–478.)

A description of the welding processes used in making chrome-iron and glass transmitting valves.

MANUFACTURING SPRAY SHIELD TUBES.—Lewis: Grigsby-Grunow Company. (*Electronics*, November, 1931, p. 193.)

PURIFICATION OF MAGNESIUM.—W. Kaufmann and P. Siedler. (Summary in *Electronics*, November, 1931, p. 204.)

DIRECTIONAL WIRELESS.

LA RADIOGONIOMÉTRIE APPLIQUÉE AUX LIGNES AÉRIENNES (Radio Direction Finding Applied to Air Lines [and the "Aéropostale" Opposed Frame Radiogoniometer]).—Serre. (*L'Onde Élec.*, Nov., 1931, Vol. 10, pp. 513–520.)

Conclusion of the paper dealt with in January Abstracts, p. 39. The combination of four vertical frames in two pairs arranged in the form of a horizontal cross, and the use of a commutator, are first discussed, and then the writer devotes himself to a comparison of the system with the Adcock system. "In the Adcock system, it is possible to suppress completely the effect of the horizontal fields. In the Aéropostale system, the effect is only attenuated, and even in the two oblique 'privileged' directions it can produce effects reaching one-fifth of that produced by an equal vertical field arriving horizontally. But we have seen that these horizontal fields are less troublesome than the vertical fields whose direction of propagation has undergone deviations after reflections. Now in this case the comparison of the curves of the e.m.f.s produced by such fields as functions of the angle β (Fig. 21, p. 517: full curve, Aéropostale; dotted curve, Adcock) shows the advantage of the former system. The middle curve refers to the simple Aéropostale system without compensation for the 45° fields, and already shows its advantages. At short range, where the incidence of the reflected fields is nearly 90°, the two systems are about equal. At long ranges the Aéropostale system is much more advantageous."

The paper ends with an account of tests at Algiers and Agadir, which were followed by the use of the system for guiding night flights between Casablanca and Cap Juby. The frequent occurrence of troublesome night effects within a certain zone, using the simple 4-frame system—*i.e.*, without 45° compensation—is discussed, and explanations suggested. A new arrangement with 45° compensation, consisting of a crosswise combination of two 4-frame "stepped" systems (see former abstract) is now being constructed.

RADIOGONIOMETERS FOR MARINE WORK [Comparison of Fixed Loop and Rotating Frame Receivers].—(*Bull. de la S.F.R.*, June, 1931, Vol. 5, pp. 74–86.)

Cf. and contrast 1931 Abstracts, p. 388.

POSITION LOCATION AT SEA.—R. Naismith. (*Journ. Scient. Instr.*, September, 1931, Vol. 8, pp. 279–282.)

Outline of an instrument which records automatically the absolute intensity of the field strengths from a rotating beacon, and of a procedure to use it to determine both distance and bearing, for short distances over sea where the inverse distance/intensity relation may be considered to hold good.

NEW AIRCRAFT BEACON: VISUAL TYPE [EQUI-SIGNAL] COURSE INDICATOR FOR CROYDON AERODROME.—Marconi Company. (*Electrician*, 27th Nov., 1931, Vol. 107, p. 756.)

A WATCH COMPASS FOR NAVIGATIONAL DIRECTION FINDING [FOR USE ON ROTATING LOOP BEACON SIGNALS].—S. J. Matthews. (*Journ. Scient. Instr.*, Oct., 1931, Vol. 8, p. 327.)

DIAGRAM FOR POSITION FINDING BY LONG DISTANCE BEARINGS AND FOR FINDING THE BEARING OF ONE POINT FROM ANOTHER.—T. J. Richmond. (*Hydrographic Rev.*, Nov., 1931, Vol. 8, No. 2, pp. 106–111.)

FOG-PENETRATING PROPERTIES OF INFRA-RED AND ULTRA-VIOLET RAYS.—S. H. Anderson. (*Scient. American*, Oct., 1931, Vol. 87, p. 264.)

Anderson's tests have shown that rays from all parts of the visible spectrum are about equally affected by fog, and since the red and orange rays have to be more intense to produce sight reception, the use of beacons of these colours is based on a fallacy. Infra-red and ultra-violet rays, on the other hand, penetrate the fog better. The former are very easily produced, but at present only very sensitive laboratory methods of detecting them are known.

ACOUSTICS AND AUDIO-FREQUENCIES.

AUDIBLE FREQUENCY RANGES OF MUSIC, SPEECH AND NOISE.—W. B. Snow. (*Bell S. Tech. Journ.*, Oct., 1931, Vol. 10, No. 4, pp. 616–627.)

Author's abstract:—This paper describes the use of an electro-acoustic system, transmitting the audible frequency range almost uniformly, in determining by ear the frequency ranges required for faithful reproduction of music, speech, and certain noises.

Sounds were reproduced alternately with and without filters limiting the frequency range transmitted by the electrical circuit. The filter cut-offs producing just noticeable changes in the reproduction were deduced from judgments of listeners as to the presence or absence of filters. It was found that for absolute fidelity all musical instruments except the piano require reproduction of the lowest fundamentals. The frequencies above 5 000 cycles were shown to be important, some instruments and particularly noises requiring reproduction to the upper audible limit.

Tests were made in which experienced listeners judged the degradation of "quality" produced by a series of filters. The judgments showed definitely that the quality continues to improve as the frequency range is extended down to 80 or up to 8 000 cycles. Although somewhat indefinite on cut-offs outside these limits, they indicate that reproduction of the full audible range was considered most nearly perfect.

ARTICULATION TESTS IN ENGLISH, GERMAN AND FRENCH USING ESPERANTO PRONUNCIATION. (*Journ. téléphonique*, May, 1931, Vol. 5, pp. 159–161.)

AUDIO-FREQUENCY COMPENSATION METHODS.—J. G. Aceves. (*Electronics*, Dec., 1931, pp. 224–225.)

RAUMAKUSTISCHE KIPPSCHWINGUNGEN ("Room-Acoustic" Relaxation Oscillations).—H. E. Hollmann and Th. Schultes. (*E.N.T.*, Nov. 1931, Vol. 8, pp. 494–502.)

Authors' summary :—An arrangement is described for the production of room-acoustic relaxation oscillations, on the principle that in an electrical "trip" circuit—such as the well-known flashing circuit with glow-discharge tube—the condenser as the electrical energy reservoir is replaced by a room as acoustical energy reservoir, while by means of microphone and loud speaker the acoustical energy is transformed into electrical control potentials, and *vice versa*. In practice, the glow-discharge tube is replaced by the well-known Turner "kallirotron" circuit used as a trip circuit [Fig. 3], which has the advantages of requiring no power for its control and having an adjustable ratio for its trip potentials [equivalent to the "discharge" and "quench" voltages of the glow-discharge tube]. The action of this trip circuit, in response to a control potential on one of its grids, is examined with the help of a diagram embodying the two dynamic characteristics, and the trip potentials are calculated from the valve curves and the circuit constants. Similar treatment of a single two-grid valve trip circuit [Jaeger and Schaeffers] is given ; this circuit however is considered inferior to the kallirotron circuit for this particular purpose [owing to the wide and accurate adjustability of the latter circuit].

Finally, a formula for the calculation of the relaxation oscillation frequency, from the acoustic properties of the room and the data of the trip circuit, is given, so that—conversely—*information as to the room acoustics may be deduced from the measured oscillation frequency*. The consequences for practical measurements are discussed [determination of reverberation time, etc.].

ACOUSTICS OF VERY LARGE AUDITORIUMS DO NOT CONFORM WITH CUSTOMARY METHODS OF ANALYSIS AND CORRECTION.—S. K. Wolf. (*Electronics*, Nov., 1931, pp. 186–187.)

BEMERKUNG ZU DER ARBEIT VON E. WAETZMANN UND H. HEISIG : "UNTERSUCHUNGEN ÜBER AKUSTISCHE SCHWELLENWERTE" (Remark on the Paper of E. Waetzmann and H. Heisig : "Investigations on Acoustic Threshold Values").—E. Waetzmann. (*Ann. der Physik*, 1931, Series 5, Vol. 10, No. 7, p. 846.)

A letter pointing out that the method described in the paper mentioned (Jan. Abstracts, p. 42), for measurements in an undisturbed acoustic field, needs further examination, though the results obtained are probably right.

THE USE OF THE CATHODE-RAY OSCILLOGRAPH IN THE STUDY OF DISTORTION, PHASE-RELATIONS, ETC.—Zworykin. (*See* abstract under "Subsidiary Apparatus.")

"An additional refinement in the conventional circuit employed for this purpose is the use of the time frequency applied to the control element, giving exact duration of various parts of observed curves."

OBJEKTIVE MESSUNG UND SUBJEKTIVE BEOBACHTUNG VON SCHALLVORGÄNGEN (Objective Measurement and Subjective Observation of Acoustic Phenomena).—F. Trendelenburg. (*Naturwiss.*, 20th Nov., 1931, Vol. 19, No. 47, pp. 937–940.)

A description of the relative merits of acoustic measuring apparatus giving (*a*) the objective intensities of the frequencies in the spectrum of the sound under observation and (*b*) their subjective intensities as observed by the human ear, the sensitivity of which varies with frequency to a large extent and has also a non-linear characteristic. Examples including heart sounds and automobile exhausts are given, which show that (*b*) is generally preferable except in the case of speech, in which there is little difference between the records obtained by the two methods.

RECENT DEVELOPMENTS IN ACOUSTICS, PARTICULARLY APPLIED ACOUSTICS (Continued).—F. Trendelenburg. (*Zeitschr. f. Hochf : tech.*, Sept., Oct. and Nov., 1931, Vol. 38, pp. 115–118, 153–159, and 189–195.)

The September instalment deals with non-linear distortion, its audibility threshold, its effect on timbre, etc. ; the production of the voice, its directive properties, and its energy distribution over the acoustic spectrum. Sivian's interesting result is referred to, explaining the hollow quality of extra-loud reproduced speech compared with natural speech of equal volume. The October instalment deals with architectural acoustics (including the work of Fokker and Strutt on sound reflectors for cathedrals, etc.), absorption and acoustic transparency. The final November instalment deals with sound recording, including disc, film and steel-wire processes: Buchmann and Meyer's optical method for the examination of disc records: testing of electrical pick-ups: design and performance of electrical recorders: needle scratch: and finally a long section on distortion in electro-optical processes. An important feature of this whole series is the extensive bibliography interspersed throughout its pages.

PERCENTAGE HARMONIC DISTORTION.—L. H. Bedford: Greenwood. (*Wireless Engineer*, Nov., 1931, Vol. 8, pp. 599–600.)

A criticism of Greenwood's letter (1931 Abstracts, p. 619). "It would appear from his analysis that the '9 : 11 scale method' is not applicable to the case of a choke-fed output stage, and that the use of such a scale would lead to too low a value for the distortionless output power. Such a conclusion is definitely incorrect, and it is interesting to see where the error lies."

METHODS FOR MEASURING INTERFERING NOISES.—Lloyd Espenschied. (*Proc. Inst. Rad. Eng.*, Nov., 1931, Vol. 19, pp. 1951–1954.)

Bell System methods of measuring interference noises, particularly in radiotelephony. (i) "Warbler method"; (ii) transmission measuring set—variable attenuator, valve voltmeter and indicating instrument with moderately sluggish needle; (iii) short-wave static measurement with field-strength measuring set; (iv) integration methods, using fluxmeter or making the static impulses charge a condenser with resistance in series, this condenser being discharged at short intervals; (v) directional observations with cathode ray tube; (vi) noise standard or buzzer method; (vii) circuit noise meter; (viii) threshold of audibility method; (ix) "sound meter" for room noise and sounds in general (1931 Abstracts, p. 563).

DREI EINFACHE METHODEN DER TECHNISCHEN AKUSTIK (Three Simple Investigation Methods [based on Chladni Figures] for Experimental Acoustics). — N. Andrejew. (*E.N.T.*, Nov., 1931, Vol. 8, pp. 488–494.)

A description of three methods used in the Leningrad State laboratories:—(i) Investigation of the amplitude distribution of telephone diaphragms by scattered powders, sloping the diaphragm carefully till the "ring of critical amplitude" is left. Fig. 4 shows the results obtained in investigating the frequency response of a telephone receiver with and without a hole in its case: the second maximum in curve II is due to the hole introducing a Helmholtz resonator effect. In these resonance characteristic tests one single particle is used, placed in the middle of a slightly sloped membrane, the current being gradually increased till the critical point is reached where the particle begins to creep down the slope (1930 Abstracts, pp. 162 and 340). The method is largely used, being applied also to loud-speaker cones, magnetostriction oscillators, etc. Glass powder is found to be the best, the particles being about 0.3 mm. in diameter.

(ii) The contact-hammer ("chattering contact") method originated by Bragg (1929 Abstracts, p. 519). Fig. 7 is a photograph of the practical instrument, the "Amplitudometer." Fig. 8 shows the circuit used, by which the arrival at the critical amplitude is detected in telephones. The accuracy of this method appears to be roughly the same as that of (i), namely around 3–5%.

(iii) The use of the same contact-hammer idea in a special form for measuring sound impulses, leading to the plotting of sound-field polar diagrams of loud speakers, etc. *See* 1930 Abstracts, p. 281, Belov.

THE "NUMAN" CIRCUIT AS A VALVE NOTE GENERATOR (VALVE HUMMER).—W. Muchlinsky. (*Chem. Fabrik*, 2nd Dec., 1931, p. 463.)

For bridge measurements of electrical conductivity, the writer recommends the "Numan" circuit (1929 Abstracts, p. 506) using a tetrode, followed by a l.f. pentode stage.

A NEW METHOD OF MEASURING FREQUENCIES [USING JOHNSEN-RAHBECK EFFECT].—Makower and Makower. (*See* under "Measurements and Standards.")

THE HEATING OF LIQUIDS BY THE ABSORPTION OF SOUND, AND ITS RELATION TO THE ENERGY OF INTENSE HIGH-FREQUENCY SOUND WAVES.—W. T. Richards. (*Proc. Nat. Ac. Sci.*, Nov., 1931, Vol. 17, pp. 611–616.)

ULTRASONICS: SOME PROPERTIES OF INAUDIBLE SOUND.—F. Ll. Hopwood. (*Nature*, 31st Oct., 1931, Vol. 128, pp. 748–751.)

SUPERSONIC SATELLITES AND VELOCITY.—W. H. Pielemeier. (*Phys. Review*, 15th Sept., 1931, Series 2, Vol. 38, No. 6, pp. 1236–1246.)

A sequel to the paper referred to in 1931 Abstracts, p. 563. The supersonic velocity appears to approach a limiting minimum value with decreasing intensity, but to be independent of frequency.

ON THE CIRCULATIONS CAUSED BY THE VIBRATION OF AIR IN A TUBE.—E. N. da C. Andrade. (*Proc. Roy. Soc.*, Dec., 1931, Vol. A 134, pp. 445–470.)

THE INDUCTOR DYNAMIC LOUD SPEAKER.—D. A. Oliver. (*Wireless World*, 18th November, 1931, Vol. 29, pp. 579–582.)

Including performance curves.

THE MOVING IRON LOUD SPEAKER.—S. J. Tyrell. (*Wireless World*, 18th November, 1931, Vol. 29, pp. 590–592.)

An article dealing with the advantages of the moving iron type of loud speaker, more especially when used with battery-driven receivers with small power outputs. Practical design data are given.

LOUD SPEAKERS UNDER TEST.—(*Wireless World*, 18th November, 1931, Vol. 29, pp. 593–598.)

Quantitative data concerning the acoustic response of thirty modern loud speakers of all types.

ON THE AMPLITUDE OF DRIVEN LOUD SPEAKER CONES: DISCUSSION.—M. J. O. Strutt: N. W. McLachlan. (*Proc. Inst. Rad. Eng.*, Nov., 1931, Vol. 19, pp. 2030–2034.)

An argument on Strutt's paper dealt with in 1931 Abstracts, pp. 388 and 502.

MODERN APPARATUS FOR THE REPRODUCTION OF SPEECH AND MUSIC.—N. W. McLachlan. (*Nature*, 26th September, 1931, Vol. 128, pp. 517–519.)

A general account of the design and operation of loud speakers for various purposes.

NEW MOVING COIL MICROPHONE.—A. Dinsdale. (*Wireless World*, 16th December, 1931, Vol. 29, p. 683.)

Description of a new microphone developed in the Bell Telephone Laboratories for the Western Electric Co. Uniform response up to 10 000 cycles is claimed. The instrument is compact, impervious to atmospheric conditions and largely so to interference from nearby electrical currents.

MOVING-COIL TELEPHONE RECEIVERS AND MICROPHONES.—E. C. Wente and A. L. Thuras. (*Bell S. Tech. Journ.*, Oct., 1931, Vol. 10, No. 4, pp. 565–576.)

"A description is given of a moving-coil head receiver and a microphone designed particularly for high quality transmission. The instruments have a substantially uniform response from 40 to 10 000 c.p.s."

THE USE OF ROCHELLE SALT CRYSTALS FOR ELECTRICAL REPRODUCERS AND MICROPHONES.—C. B. Sawyer. (*Proc. Inst. Rad. Eng.*, Nov., 1931, Vol. 19, pp. 2020–2029.)

Author's summary:—The paper begins with a brief historical *résumé* of the development of piezo activity for acoustic uses. References are given.

Methods developed by the author and his associates permit the cheap commercial production of Rochelle salt crystals and sections thereof, but the saturation and variation with temperature of Rochelle salt (shown in diagrams) must be compensated for by special assemblies of the Rochelle salt sections. The underlying principle of the special assemblies is that of mutual opposition with resultant magnification of motion. This principle of opposition may be utilised to produce bending or twisting elements of Rochelle salt of great simplicity. Such elements may then be combined with appropriate acoustic members to operate with great sensitivity and efficiency in either an input or output circuit. Rochelle salt requires no exciting field of any sort, which property results in the elimination of the necessity for any external excitation.

Microphones, pick-ups, and especially speakers are described, with some discussion of limiting conditions of load, temperature, and other operating conditions.

The article concludes with a tabulated summary of advantages offered by the use of Rochelle salt sections.

PORTABLE SPEECH-INPUT EQUIPMENT.—E. G. Fracker. (*Bell Lab. Record*, Oct., 1931, Vol. 10, No. 2, pp. 49–53.)

SOUND RECORDING ON UNSENSITISED BACK OF PICTURE FILM BY VARIATIONS IN THE THICKNESS.—Brachet: Huguenard. (Summary in *Electronics*, Nov., 1931, p. 205.)

The variations in thickness are made with a heated stylus and the sound record can be added without reducing the width of the image.

ADVANTAGES OF VERTICAL CUT SOUND RECORDS.—H. A. Frederick. (*Electronics*, Nov., 1931, p. 187.)

SOUND PRINTER COMPENSATING AUTOMATICALLY FOR SHRINKAGE OF NEGATIVE.—J. S. Watson and R. V. Wood. (*Electronics*, Nov., 1931, pp. 187 and 186.)

GLOW-LAMP NOISELESS RECORDING.—E. H. Hansen. (*Electronics*, November, 1931, pp. 177–179 and 214.)

THE PRODUCTION OF NEGATIVES WITH FINER GRAIN THAN THAT OF THE ORIGINAL EMULSION, BY DEVELOPMENT WITH PARAPHENYLENE-DIAMINE.—A. Lumière and A. Seyewetz. (*Comptes Rendus*, 16th Nov., 1931, Vol. 193, pp. 906–909.)

A SIMPLE STYLUS AND ROTATING DRUM SPEECH RECORDER, FROM A LOUD SPEAKER MOVEMENT.—Ketterer. (*Funk*, 14th Aug., 1931; summary in *Electronics*, Nov., 1931, p. 205.)

IMPROVED "MID-ODI" LONG-PLAYING GRAMOPHONE NEEDLE. (*Rad., B., F. f. Alle*, Nov., 1931, p. 481.)

Announcement of an improved form of the needle referred to in 1931 Abstracts, pp. 444–445.

THE A.E.G. HOME RECORDING OUTFIT.—A.E.G. (*Rad., B., F. f. Alle*, October, 1931, pp. 461–463.)

THE BECHSTEIN-SIEMENS-NERNST "GRAND": A NEW UNIVERSAL INSTRUMENT [SMALL GRAND PIANO WITH AMPLIFIERS AND TIMBRE-SELECTING DAMPING, ETC.].—Schultz: Noack. (*Rad., B., F. f. Alle*, Nov., 1931, pp. 504–507.)

ECHO SOUNDING: BRITISH ADMIRALTY GEAR, TYPE 752: SUBMARINE SIGNAL CORPN. UNIVERSAL FATHOMETER, TYPE 432. (*Hydrogr. Review*, November, 1931, Vol. 8, No. 2, pp. 168–183.)

ECHO SOUNDING; THE ADVISABILITY OF USING CONTINUOUS RECORDING.—P. Marti. (*Ibid.*, pp. 184–185.)

A record by the Marti equipment (Abstracts, 1929, p. 169; 1931, p. 445), by which a shoulder of a submarine volcano was discovered, illustrates the advantage of continuous recording.

PHOTOTELEGRAPHY AND TELEVISION.

PHOTOELECTRONS AND NEGATIVE IONS.—E. M. Wellish. (*Nature*, 26th Sept., 1931, Vol. 128, pp. 547–548.)

A preliminary account of work dealt with in detail in *Proc. Roy. Soc.* for Dec., 1931.

ÜBER DIE LICHTELEKTRISCHEN EIGENSCHAFTEN DES CADMIUM, INSBESONDERE DEN EINFLUSS VON GASEN AUF DIESELBEN (On the Photoelectric Properties of Cadmium, and in Particular the Influence of Gases thereon).—H. Bomke. (*Ann. der Physik*, 1931, Series 5, Vol. 10, No. 5, pp. 579–615.)

Author's summary :—An exhaustive investigation of the photoelectric phenomena shown by cadmium gave the following results :

1. Evaporation of cadmium in cells which have been thoroughly outgassed gives cadmium films whose long-wave limit is at 304×10^{-6} mm. and whose photoelectric behaviour can be reliably repeated. Cadmium cells made in this way show in addition considerable constancy as regards time.
2. When such a cell is baked out again, the long-wave limit is not further depressed.
3. The photoelectric effect of cadmium is strongly influenced by the presence of gas. (*a*) It is decreased by oxygen, nitrogen, hydrogen, carbon dioxide and argon, when these are carefully dried before the experiment. (*b*) Water vapour increases the photoelectric yield and displaces the photoelectric limit considerably in the direction of longer wavelengths.
4. Cadmium films produced in a cell which had not been baked out had a long-wave limit at about 325×10^{-6} mm. This is presumably due to small traces of water vapour.
5. Sealed cadmium cells filled with one of the rare gases which has not been dried show distinct fatigue phenomena ; the sensitivity, greatest when the cells are made, decreases after some time. At the same time a corresponding retrogression of the long-wave limit takes place.
6. Vacuum cells, sensitised by filling with damp argon, also showed photoelectric fatigue phenomena.

THE SHOT EFFECT IN PHOTOELECTRIC CURRENTS.—B. A. Kingsbury. (*Phys. Review*, 15th Oct., 1931, Series 2, Vol. 38, No. 8, pp. 1458–1476.)

Author's abstract :—The shot effect, as it occurs in a photoelectric current, has been used to secure an evaluation of the electron charge. A new and original method of amplifier calibration, which involved the use of a modulated light beam, simplified the measurements and the computation of the result. In the absence of space charge, the experimental value of the electron charge was 1.61×10^{-19} coulombs for a thermionic current, and about 25 per cent greater for a photoelectric current. It was found that the shot effect is enormously increased in photoelectric currents which are amplified by collision ionisation. Statistical variations which might be expected to occur in a beam of radiant energy could not be detected, since, within the limits of experimental accuracy, the shot effect in photoelectric currents was found to be independent of the frequency of the light producing electron emission.

THE VECTORIAL PHOTOELECTRIC EFFECT IN THIN FILMS OF ALKALI METALS.—H. E. Ives. (*Phys. Review*, 15th September, 1931, Series 2, Vol. 38, No. 6, pp. 1209–1218.)

Author's abstract :—It is assumed that the photoelectric effect exhibited by thin films of alkali metals on specular platinum surfaces is proportional at any wavelength to the electric intensity just above the platinum. This electric intensity is found, using the optical constants of platinum, by computing the intensities of the wave patterns formed by the interference of the reflected and incident beams. These computations are made for various angles of incidence and for light polarised in and at right angles to the plane of incidence. The intensities thus found exhibit very large ratios of value for the two planes of polarisation, in striking agreement with the characteristics of the vectorial photoelectric effect. The changes of amplitude of the perpendicular electric vector on entering the alkali metal film, as computed from the optical constants of the alkali metal, account for the experimentally found low values of the emission ratios at long, and their high values at short, wavelengths.

CONTACT POTENTIAL DIFFERENCES BETWEEN IRON AND NICKEL AND THEIR PHOTOELECTRIC WORK FUNCTIONS.—G. N. Glasoe. (*Phys. Review*, 15th Oct., 1931, Series 2, Vol. 38, No. 8, pp. 1490–1496.)

The photoelectric long wave limits and the contact potential difference of electrolytic iron and electrolytic nickel have been determined on the same specimens and under identical conditions. A description of the method and the results of the experiments are given here. The difference in the work functions is equal to the measured contact potential difference between the metals within the limits of error of the photoelectric measurements.

THE PHOTOELECTRIC EFFECT FROM THIN FILMS OF ALKALI METAL ON SILVER.—H. E. Ives and H. B. Briggs. (*Phys. Review*, 15th Oct., 1931, Series 2, Vol. 38, No. 8, pp. 1477–1489.)

From the authors' abstract :—The region of low reflecting power profoundly affects the photoemission [from thin films of alkali metal on silver], but in a manner not to be explained simply by reduction of light reflected back through the alkali metal film or by the absorption of light by the silver. The results obtained are very satisfactorily explained by computing, from the optical constants, the intensity at the surface of the interference pattern formed by reflection just above the silver surface.

SECONDARY EMISSION FROM NICKEL BY IMPACT OF METASTABLE ATOMS AND POSITIVE IONS OF HELIUM.—M. C. Harrington. (*Phys. Review*, 1st Oct., 1931, Series 2, Vol. 38, No. 7, pp. 1312–1320.)

IONISATION OF CAESIUM VAPOR BY LIGHT.—F. W. Cooke. (*Phys. Review*, 1st Oct., 1931, Series 2, Vol. 38, No. 7, pp. 1351–1356.)

An account is given of a low-pressure measurement of the photo-ionisation of caesium vapour as a function of the wavelength of the light.

TEMPERATURE DEPENDENCE OF PHOTOELECTRIC EFFECT IN METALS.—L. A. Young and N. H. Frank: Fowler. (*Phys. Review*, 15th Aug., 1931, Series 2, Vol. 38, No. 4, pp. 838–839.)

A letter proposing an amendment to the probability of escape of electrons from metal surfaces adopted by Fowler (1931 Abstracts, p. 622).

ÜBER DEN PHOTOELEKTRISCHEN EFFEKT IM Cu_2O-Cu GLEICHRICHTER (On the Photoelectric Effect in the Cuprous Oxide – Copper Rectifier).—E. Perucca and R. Deaglio: von Auwers and Kerschbaum. (*Ann. der Physik*, 1931, Series 5, Vol. 10, No. 3, pp. 257–261: 262.)

This note calls attention to the results of experiments on copper oxide rectifiers which seem to disagree with those of von Auwers and Kerschbaum (1931 Abstracts, p. 103). The latter reply.

PAPERS ON SEMI-CONDUCTORS.—Wilson: Leo. (*See* under "Subsidiary Apparatus.")

VARIATION DISCONTINUE DE LA FORCE ÉLECTROMOTRICE DES PILES PHOTOVOLTAÏQUES À LIQUIDES COLORÉS (Discontinuous Variation of the E.M.F. of Photovoltaic Cells with Coloured Liquids).—A. Grumbach and F. Taboury. (*Comptes Rendus*, 7th Dec., 1931, Vol. 193, pp. 1178–1180.)

BEITRÄGE ZUR PHYSIK DER NITROBENZOLKERRZELLE. II. ÜBER DIE GÜLTIGKEIT DES GESETZES VON KERR FÜR NITROBENZOL BEI ELEKTROSTATISCHEN FELDERN BIS $1.5 \cdot 10^5$ V/cm (Contributions to the Physics of the Nitrobenzol Kerr Cell. II. On the Validity of Kerr's Law for Nitrobenzol with Electrostatic Fields up to 1.5×10^5 v/cm).—F. Hehlgans. (*Physik. Zeitschr.*, 15th October, 1931, Vol. 32, No. 20, pp. 803–808.)

Kerr's law gives a square-law relation between applied field strength and path difference. This is found to hold for highly purified nitrobenzol with electrostatic fields up to 1.5×10^5 volts per cm. with an accuracy of about $\pm$ 1%.

THE ELECTRICAL CONDUCTIVITY OF ACETONE [AND NITROBENZENE] FOR DIRECT CURRENT.—Garrigue. (*Comptes Rendus*, 16th November, 1931, Vol. 193, pp. 925–926.)

VELD EN IONENCONCENTRATIE NABIJ DE KATHODE VAN EEN BOOGONTLADING (Field and Ion Concentration near the Cathode of a Glow Discharge Tube).—W. de Groot. (*Physica*, No. 9, Vol. 11, 1931, pp. 307–320.)

THE MEASUREMENT OF FLUORESCENCE BY MEANS OF THE PHOTOELECTRIC CELL.—R. Toussaint. (*Comptes Rendus*, 16th Nov., 1931, Vol. 193, pp. 933–934.)

A METHOD OF MEASURING THE INTEGRATED LIGHT FROM SHORT FLASHES OF HIGH INTENSITY [PHOTOELECTRIC TUBE CHARGING A CONDENSER IN GRID CIRCUIT OF THYRATRON].—L. R. Koller. (*Review Scient. Instr.*, Sept., 1931, Vol. 2, pp. 551–553.)

ÜBER DIE RICHTUNGSVERTEILUNG DER PHOTOELEKTRONEN KURZWELLIGER RÖNTGENSTRAHLEN (On the Directional Distribution of the Photoelectrons from High Frequency X-Radiation).—E. Lutze. (*Ann. der Physik*, 1931, Series 5, Vol. 9, No. 7, pp. 853–864.)

THE PHOTOELECTRIC EFFECT FOR γ-RAYS [THEORETICAL INVESTIGATION].—H. R. Hulme. (*Proc. Roy. Soc.*, Oct., 1931, Vol. 133, No. A 822, pp. 381–406.)

INNERER UND ÄUSSERER PHOTOEFFEKT (Internal and External Photoelectric Effect [from γ-rays]).—H. Casimir. (*Physik. Zeitschr.*, 1st Sept., 1931, Vol. 32, No. 17, pp. 665–667.)

ÜBER DEN ATOMAREN PHOTOEFFEKT BEI GROSSER HÄRTE DER ANREGENDEN STRAHLUNG (On the Atomic Photoelectric Effect for Very Hard Exciting Radiation [Theoretical Investigation]).—F. Sauter. (*Ann. der Physik*, 1931, Series 5, Vol. 9, No. 2, pp. 217–248.)

TABELLEN VOOR DE STRALINGSFORMULE VAN PLANCK (Tables for Planck's Radiation Formula).—W. de Groot. (*Physica*, No. 8, Vol. 11, 1931, pp. 265–274.)

VOM FERNSEHEN IN DEN VEREINIGTEN STAATEN (Television in the U.S.A.).—(*Rad., B., F. f. Alle*, Nov., 1931, pp. 495–496.)

IMPROVEMENTS IN CATHODE RAY TUBE DESIGN [" KINESCOPE "].—Zworykin. (*See* under "Subsidiary Apparatus.")

ULTRA-SHORT WAVES AND TELEVISION.—G. von Arco. (*Rad., B., F. f. Alle*, Oct., 1931, pp. 428–430.)

A NEW DYNATRON TRIP RELAY CIRCUIT AND PULSE GENERATOR.—Fucks. (*See* abstract under "Subsidiary Apparatus.")

THE USE OF THE TURNER KALLIROTRON CIRCUIT AS A TRIP RELAY.—Hollmann and Schultes.

(*See* abstract under "Acoustics and Audio-frequencies.")

MEASUREMENTS AND STANDARDS.

RADIO PROBLEMS [P.O. WORK ON FREQUENCY MEASUREMENT].—A. S. Angwin. (*Electrician*, 13th November, 1931, Vol. 107, pp. 662–663.)

Describes the work of the P.O. Laboratory at

Dollis Hill and the Colney Heath frequency measurement station. It is mentioned that the stability of the amplifier stages is obtained by the use of a special type of r.f. amplifying valve, which gives the advantages of the push-pull circuit and of minimum reaction from output to input circuits. It consists of two similar systems of electrodes arranged symmetrically about a single cathode and connected so that reaction potentials from the output to the input of one half of the valve are counterbalanced by equal and opposite potentials transferred from the output of the other half (*see* also same author, under " Miscellaneous ").

P.O. Frequency Measurements.—Angwin. (*See* abstract under " Miscellaneous.")

A New Method of Measuring Frequencies [using Johnsen-Rahbeck Effect].—A. J. Makower and W. Makower. (*Journ. Scient. Instr.*, Sept., 1931, Vol. 8, pp. 286–288.)

" The arrangement under electrostatic forces of lycopodium powder in ridges on a moving slate enables alternating current frequencies to be measured by counting the ridges formed." The method has already been applied successfully to frequencies up to 1 000 c.p.s.; accuracy of measurement is well within 1% and could be increased considerably by using a larger slate and a spiral instead of a circular trace. Extension to still higher frequencies is being studied.

A Recent Development in Vacuum Tube Oscillator Circuits [Constant Frequency by Electronic Coupling].—Dow. (*See* under " Transmission.")

Der Stahloszillator mit phasenreiner Rückkopplung (The Coupled Steel Oscillator).—C. H. Becker. (*Ann. der Physik*, 1931, Series 5, Vol. 10, No. 5, pp. 533–557.)

" A description is given of a frequency standard for frequencies of the order of 5 000 c.p.s. It consists of a composite steel rod, self-excited to longitudinal vibrations by means of a special valve circuit. Investigation of the arrangement showed that the frequency temperature coefficient was smaller than 1.10^{-6} degrees and that in certain easily attained conditions the frequency was independent of the running conditions to within $\pm 1.10^{-6}$ of its value." The phase of the alternating anode voltage in the valve circuit is kept at exactly 180° from that of the grid alternating voltage by a variable capacity C_R in the anode circuit in series with the coil of self-induction L_2 of the electromagnet which excites the steel rod; C_R is adjusted to resonance with L_2.

The Crystal Monitor: a Multi-frequency Crystal-controlled Oscillator [with 6.25 kc. Steps].—J. L. Reinartz. (*QST*, Dec., 1931, Vol. 15, pp. 31–32.)

Using a conventional push-pull crystal oscillator circuit (oscillating at 1 000 kc.) with the addition of two fixed 100 $\mu\mu$F. condensers, from each plate to the grid of the other valve. The principle employed is to have two circuits, each oscillating, the difference of frequency being a multiple of the fundamental (crystal) frequency. The spacing of the beat notes can be altered by changing the grid leaks. The monitor can be applied to controlling a transmitter.

A New [Quartz] Oscillator for Broadcast Frequencies [Type 700-A].—O. M. Hovgaard. (*Bell Lab. Record*, Dec., 1931, Vol. 10, No. 4, pp. 106–110.)

To meet the latest requirements, variations due to the plate holder must be eliminated, and in the recently designed 1-A quartz plate this is accomplished by clamping the quartz rigidly between electrodes having on their surfaces a number of small " lands " or raised portions, which constitute the physical contacts between quartz and electrodes and also introduce an air-gap between the quartz and the electrode surfaces. Mercury-in-glass thermostats replace the former bimetallic strips; the bulb is large, with a very thin wall, and bulb and capillary are so proportioned that *the expansion and contraction of mercury near the surface of the bulb causes flexing of the meniscus of the column*: thus the time-lag is reduced to a minimum. The temperature control system is designed so that the thermal impedance of all paths between the heater and the quartz plate are high with the exception of the path containing the thermostat: the two parts of this path are so designed that the thermal impedance from the heater to the thermostat is reasonably low and the thermal impedance from the thermostat to the quartz has the characteristics of a low-pass filter. The " deviation capability " of the new oscillator is 24.4, compared with 318.7 for the old.

Vibrations of Quartz Plates.—U.S. Bureau of Standards Notes. (*Journ. Franklin Inst.*, Oct., 1931, Vol. 212, No. 4, pp. 521–522.)

A preliminary note of the work dealt with below.

Some Experimental Studies of the Vibrations of Quartz Plates [0° and 30° Cut].—R. B. Wright and D. M. Stuart. (*Bur. of Stds. Journ. of Res.*, Sept., 1931, Vol. 7, No. 3, pp. 519–553.)

Authors' abstract:—" Numerous modes of vibration of 0 and 30 degree cut circular and rectangular crystalline quartz plates were studied experimentally. Various methods were employed in studying these modes, which are piezoelectrically excited. The behaviour of lycopodium powder applied to the vibrating faces proved to be the most fruitful source of information [*cf.* Straubel, 1931 Abstracts, pp. 505, 568–569]. A number of photographs of the patterns thus formed are produced and described. Although of limited utility, two mechanical devices also were employed in these studies " [suspended vane and optical system, for studying air currents emanating from the periphery of circular plates: probing mechanism, by which " nodal regions " are found on which the probing needle can be brought to bear without preventing oscillation].

" The direction of maximum radial displacement was determined for the two active lower frequency modes of 0° circular plates. It was found that these directions are nearly parallel to directions of critical values of Young's modulus. Facts were disclosed concerning specially oriented rectangular plates and rods. Experimental values of Young's modulus based on vibration frequencies of the latter were found to agree closely with corresponding values computed from a known theoretically derived expression. Rough experimental verification of the direction of one of the critical values of Young's modulus was obtained.

"Equations are derived for the modulus of rigidity and Poisson's ratio for crystalline quartz as functions of orientation, and graphs of these two functions as well as of Young's modulus are given.

"Methods are indicated, which may prove advantageous, of rigidly mounting quartz plates" [and of clamping rods—*see* p. 535. "The possibilities offered through the clamping of circular plates at the centre, both 0° and 30°, look quite promising. One very interesting method . . . involves the drilling of a small hole in the centre of each face of the plate to a depth of nearly one-half its thickness. The plate may then be rigidly held by means of two rods fixed to the electrodes"].

In their "Comments and Conclusions" the writers remark that among other results, the relating of the frequencies of the three modes of strongest response of a rectangular plate to its three dimensions is shown to be prompted by misconceptions. Their results answer in a very definite manner many questions such as those brought up by Kao (1931 Abstracts, pp. 49 and 92). They explain, also, the reason for the variation in intensity, over the end of a 0° rod, of the supersonic waves emanating therefrom (Tawil, 1930 Abstracts, p. 515). *See* also Straubel, *loc. cit.*

THE ELASTIC EQUILIBRIUM OF A THICK RECTANGULAR PLATE.—B. Galerkin. (*Comptes Rendus*, 12th Oct., 1931, Vol. 193, pp. 568-571.)

ÜBER DEN ZUSAMMENHANG ZWISCHEN DEN OPTISCHEN UND PIEZOELEKTRISCHEN EIGENSCHAFTEN DER SCHWINGENDEN QUARZPLATTEN (On the Connection between the Optical and Piezoelectrical Properties of Oscillating Quartz Plates).—V. Petržílka. (*Ann. der Physik*, 1931, Series 5, Vol. 11, pp. 623–632.)

Observations in convergent linear polarised light are recorded which correspond to those of Tawil (*C.R.*, 1926, Vol. 183, p. 1099) in parallel polarised light in the direction of (*a*) the electrical and (*b*) the optical axis.

ANOMALOUS VARIATION OF THE ELECTRICAL CONDUCTIVITY OF QUARTZ WITH TEMPERATURE AT THE TRANSFORMATION POINT.—H. Saegusa and S. Shimizu. (*Nature*, 14th Nov., 1931, pp. 835–836.)

MESSGERÄTE FÜR DIE FELDSTÄRKE VON RUNDFUNKSENDERN UND IHRE EICHUNG (Field-Strength Measuring Equipments for Broadcasting Wavelengths, and their Calibration).—R. Thomson. (*T.F.T.*, Oct., 1931, Vol. 20, pp. 312–315.)

Description of the apparatus used by the High-frequency Commission of the Württemberg Electrotechnical Verein, including a recording voltmeter equipment (which has the advantage of recording and of being calibrated by d.c., but the disadvantage of requiring two filament batteries) and a later model in which indirectly heated valves are used and which requires only one battery.

MÉTHODE DE MESURE D'UN CHAMP MAGNÉTIQUE ALTERNATIF DE HAUTE FRÉQUENCE (A [Mercury Thermometer] Method of Measuring an Alternating Magnetic Field of High Frequency).—F. Esclangon. (*Comptes Rendus*, 12th October, 1931, Vol. 193, pp. 577–579.)

A method developed for measuring fields of some tens of gauss and of frequencies around 10^7 per second, used in the study of the electrodeless discharge. The cylindrical reservoir of a mercury thermometer is used as a body heated by eddy currents produced by the alternating field. The penetration into the mercury at these frequencies is only about $\frac{1}{8}$ mm., and if the reservoir is several millimetres in diameter the energy absorbed can be calculated as equal to $\frac{1}{8}d\sqrt{N\rho}\,.\,H^2\,.\,10^{-7}$ watt per unit of length, where H is the *effective* intensity of the field, d the diameter of the reservoir, N the frequency of oscillation and ρ the resistivity in e.m.u. The writer's tests confirm that the rate of heating is proportional (to within a few hundredths) to the square of the field and to the square root of the frequency. The method seems applicable even to absolute measurements. Sources of error are briefly discussed.

METERS AND INSTRUMENTS: REMOTE INDICATION AND EARTH MEASUREMENT DEVICES.—F. C. Knowles. (*Electrician*, 13th November, 1931, Vol. 107, pp. 656–658.)

A THROUGH [RING] TYPE CURRENT TRANSFORMER AND AMPLIFIER FOR MEASURING ALTERNATING CURRENTS OF A FEW MILLIAMPERES.—W. B. Kouwenhoven. (*Review Scient. Instr.*, Sept., 1931, Vol. 2, pp. 541–548.)

I.E.E. METER AND INSTRUMENT SECTION: CHAIRMAN'S ADDRESS.—F. C. Knowles. (*Journ. I.E.E.*, Dec., 1931, Vol. 70, pp. 36–43.)

DEVELOPMENT OF A CIRCUIT FOR MEASURING THE NEGATIVE RESISTANCE OF PLIODYNATRONS.—Dingley. (*See* under "Valves and Thermionics.")

A STROBOSCOPIC METHOD OF MEASURING FREQUENCY- AND PHASE-MODULATION: THE FOURIER ANALYSIS OF MODULATED HIGH FREQUENCY CURRENTS.—Heilmann: Grützmacher. (*See* under "Transmission.")

SINGING CONDITIONS IN TWO-WIRE AMPLIFIERS, AND THEIR APPLICATION TO A NEW AMPLIFICATION MEASURING METHOD.—Weinitschke. (*See* abstract under "Properties of Circuits.")

QUANTITATIVE INVESTIGATIONS OF BROADCAST RECEIVERS.—Harnisch. (*See* under "Reception.")

THE NOMENCLATURE OF THE FUNDAMENTAL CONCEPTS OF ELECTRICAL ENGINEERING.—G. W. O. Howe. (*Journ. I.E.E.*, Dec., 1931, Vol. 70, pp. 54–61.)

BRITISH STANDARD LETTER SYMBOLS FOR USE IN ELECTROTECHNICS.—(*Br. Engineering Stds. Assoc.*, No. 423, 1931, 10 pp.)

SUBSIDIARY APPARATUS AND MATERIALS.

A 24,000 WATT FILTER.—M. Brotherton. (*Bell Lab. Record*, Dec., 1931, Vol. 10, No. 4, pp. 127–130.)

Description of a band-pass filter constructed for tests to determine whether two-voice channels at different carrier frequencies could be transmitted from a single aerial without objectionable interference arising from modulation in the aerial. It weighs over one ton, and its copper shield is " large enough to house an automobile."

IMPROVEMENTS IN CATHODE RAY TUBE DESIGN.—V. K. Zworykin. (*Electronics*, Nov., 1931, pp. 188–190.)

The latest form of the special " Kinescope " tube dealt with in 1930 Abstracts, p. 283, is here described and illustrated. The cathode is indirectly heated, permitting operation on a.c. supply; a coiled tungsten filament is mounted within a nickel sleeve having on one end a cup-shaped depression coated with barium-strontium oxide. As before, a second, accelerating anode (beyond the deflecting zone) is provided by a silver coating on the cone-shaped portion of the bulb and on part of the neck, this coating being in electrical contact with a lead-in wire sealed through the cone wall. The deflecting fields (usually magnetic), being applied close to the first anode, act on the electrons *when their velocity is comparatively low*. Thus for television purposes the second anode is worked at +2000 v., the first at + 400 v., while the control electrode is at − 45 v. The focusing effect of the second anode, mentioned in the previous abstract, " is accomplished apparently by an interaction of the electrostatic field between the first and second anode and the magnetic field of the electrons in motion." It is very sharp and can be simply controlled by adjusting the ratio between the potentials of the two anodes. A varying potential applied to the control electrode changes the second anode current and consequently the intensity of the fluorescent spot, *without affecting the ray deflection*.

EIN NEUARTIGES ENTLADUNGSROHR AUS GLAS FÜR DEN KATHODENSTRAHLOSZILLOGRAPHEN (A New Glass Discharge Tube [with High Vacuum Jacket] for the Cathode Ray Oscillograph).—F. Hauffe. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 12, 1931, pp. 560–562.)

The principal dimensions of a glass discharge tube, length and diameter, are governed by the maximum excitation voltage used. On the other hand, for high spot intensity, a small diameter, a small distance between cathode and anode, and high excitation voltages are required. These two aspects may be reconciled, according to the writer and his colleagues' experiments, by surrounding the small diameter discharge tube by a co-axial glass jacket sealed on after evacuation of the tube and itself then highly evacuated. A bulge along the equator of the jacket gives a certain elasticity which prevents breakage by unequal expansion of the two tubes.

CATHODE RAY OSCILLOGRAPH OPERATING ON 350 V.—Standard Telephones and Cables. (*Engineer*, 23rd Oct., 1931, Vol. 152, p. 437.)

EIN EINFACHER STOSSGENERATOR FÜR EINMALIGE UND PERIODISCHE VORGÄNGE (A Simple Pulse Generator for [Control by] Single and Periodic Phenomena [Dynatron Trip Relay Circuit for Use with C.-R. Oscillograph, etc.]).—W. Fucks. (*Archiv f. Elektrot.*, 12th Nov., 1931, Vol. 25, pp. 723–744.)

For high-voltage phenomena the Rogowski condenser–spark gap combination (Abstracts, 1929, p. 341) can hardly be improved upon, while for small voltages (*e.g.*, in recording atmospherics) Gabor's valve circuit and H. Peek's simplification of it (1931, p. 571) are available; both these re-set themselves, and the latter can also be made to repeat its trip action periodically—a property useful for the production of successive potential pulses for measuring and testing purposes and for phototelegraphy and television

The present paper describes a new arrangement, suitable for all these purposes, based on a single triode and distinguished by its simplicity and great flexibility. The valve is connected in the Hull dynatron circuit, which is adjusted so that the descending part of the anode-current characteristic cuts the zero line (before and after reaching its negative maximum) *at two points very close together*; a condenser charged to the correct potential and connected across plate and filament then finds itself in a stable condition, any excess of charge flowing through the valve and any loss of charge being made good by the grid battery.

This stable condition is upset by the arrival of the signal across a resistance in the plate, or more usually the grid, circuit, the discharge of the condenser being thus brought about. Or the setting-off action may be applied by capacitive or inductive coupling.

The operating time, the trip- and re-setting processes are investigated. The application of the device to time-axis and ray-locking purposes in c.-r. oscillography, and to measuring-bridge work using impulses of various shapes and of periods of the order of 10^{-6} sec., is discussed. Finally the use of the relay as a simple and cheap recorder for all types of electromagnetic disturbance (*e.g.*, atmospherics) is described, and Fig. 35 shows a combination of three relay circuits each of different sensitivity; *e.g.*, the first may respond to an impulse of 6 volts, the second 12 and the third 18 volts, and an indicating or recording instrument may be included in each anode circuit. Such a circuit responds only to impulses of one polarity, but a duplication of the circuit would allow the recording of impulses of both polarities.

A METHOD OF OBTAINING A LINEAR TIME AXIS FOR A CATHODE RAY OSCILLOGRAPH.—A. L. Samuel. (*Review Scient. Instr.*, Sept., 1931, Vol. 2, pp. 532–540.)

See 1931 Abstracts, pp. 571–572. "The practical upper limit of sweep frequency . . . is of the order of 10 000 sweeps per second. This limit is not definite but the stability of the device and its ease of control become less as the frequency is increased."

THE USE OF THE TURNER KALLIROTRON CIRCUIT AS A TRIP RELAY.—Hollmann and Schultes. (*See* abstract under "Acoustics and Audio-frequencies".)

STROBOSCOPIC DEVICE FOR USE WITH THE OSCILLOGRAPH AND ITS APPLICATION TO THE INVESTIGATION OF THE SKIN EFFECT.—A. Moskwitin. (*Archiv f. Elektrot.*, 10th Sept., 1931, Vol. 25, No. 9, pp. 631–640.)

AN IMPROVED CUT-OFF FOR HIGH VACUUM WORK.—R. W. Ditchburn. (*Journ. Scient. Instr.*, No. 8, Vol. 8, 1931, pp. 267–268.)

DRUCKREDUZIERVENTIL FÜR VAKUUMARBEITEN (A Pressure Reducing Valve for Vacuum Apparatus).—W. Klose. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 12, 1931, p. 558.)

Description of a gas inlet giving a small, reproducible rate of flow which when once set continues constant for several hours.

A GREASELESS AND CHEMICALLY INERT VALVE FOR HIGH VACUA [SILVER BELLOWS AND SEATING OF FUSED SILVER CHLORIDE].—H. C. Ramsperger. (*Review Scient. Instr.*, Nov., 1931, Vol. 2, pp. 737–749.)

A DEVICE FOR CONTROLLING THE FLOW OF GAS INTO A VACUUM SYSTEM [INTRODUCING A PIECE OF WIRE INTO RUBBER TUBING BEFORE APPLYING PINCH CLAMP].—H. P. Knauss. (*Ibid.*, p. 750.)

AN IMPROVED MCLEOD GAUGE.—S. D. Dryden. (*Review Scient. Instr.*, September, 1931, Vol. 2, pp. 514–518.)

NEW BLONDEL PORTABLE OSCILLOGRAPH.—J. Vassillière-Arlhac. (*Rev. Gén. de l'Elec.*, 24th Oct., 1931, Vol. 30, pp. 669–677.)

THE CALIBRATION OF OIL-DAMPED OSCILLOGRAPHS.—E. L. E. Wheatcroft. (*Journ. Scient. Instr.*, Oct., 1931, Vol. 8, pp. 319–324.)

ÜBER DIE UNTERDRUCKUNG DER WELLIGKEIT BEI GLEICHSTRÖMEN (The Suppression of Ripple in Direct Currents [Design Calculations of Smoothing Circuits for D.C. from Dynamos]).—F. Weichart. (*Zeitschr. f. Hochf: tech.*, November, 1931, Vol. 38, pp. 169–181.)

To illustrate the first results of this paper the following example may be cited :—A d.c. dynamo is to deliver 10 A. at 10 000 V. with a ripple not greater than 0.025 % of the d.c. voltage. Measurements show that the following frequencies are present :—50 c.p.s. with 16 V. eff., 300 c.p.s. with 15 V. eff., and 1000 c.p.s. with 12 V. eff. How can the required smoothing be most economically effected by a simple inductance-capacity combination ? Curve XII shows a solution to be 10 H. and 10 μF. With this combination, the ripple frequencies mentioned above sink to below 1 % at 300 and 1000 c.p.s., while at 50 c.p.s. a residue of 10 % is left, the total ripple amounting to 1.6 V.—well below the 2.5 V. stipulated.

The paper then deals with those cases where a simple inductance-capacity circuit is insufficient, and a series of such circuits is required. Where, as in the example on p. 178, the requirements can be met by two alternatives (curves XVI and XXII), one a simple and the other a compound circuit, these must be compared from the economical viewpoint. Finally, the special requirements of a wireless receiver and a transmitter with grid-circuit modulation, on the one hand, and a choke-controlled transmitter on the other, are discussed. For the former, where the anode current must vary in synchronism with the low frequencies, the internal resistance of the current source (machine plus filter) for all these frequencies must be as small as possible ; for the latter, it must be as large as possible—necessitating the introduction of a high-inductance choke between filter and transmitter. With a view to these cases, the paper ends by considering the determination of this internal resistance of machine plus filter. The special case of rectified a.c. will be dealt with at some later time.

RADIO-FREQUENCY PLATE AND FILAMENT SUPPLY FOR RECEIVERS.—Edelstein. (*Funk*, 25th September, 1931,)

Giving complete separation of the receiver from the mains. One oscillator valve supplies filament and anode voltages to a normal battery receiver : the first is adjusted by a condenser and the second (and also grid bias) by resistances.

IMPROVING THE REGULATION OF A MOTOR-GENERATOR.—R. A. Fereday. (*Journ. Scient. Instr.*, No. 7, Vol. 8, 1931, pp. 232–233.)

Exciting the generator by the armature current of the motor, a suitable resistance being included for adjustment of the excitation voltage.

IMPROVING THE VOLTAGE REGULATION OF RECTIFIER-FILTER SYSTEMS: TWO NOVEL SCHEMES [VOLTAGE-REGULATING INPUT CHOKE AND VOLTAGE REGULATING TRANSFORMER] FOR REDUCING PLATE VOLTAGE VARIATION WITH CHANGE IN LOAD.—E. Glaser. (*QST*, Oct., 1931, Vol. 15, pp. 13–20.)

COPPER OXIDE RECTIFIERS.—K. Singh. (*Elec. Review*, 14th Aug., 1931, Vol. 109, pp. 247–248.)

An article giving the preparation, action and mathematical theory of copper oxide rectifiers.

COMPARISON BETWEEN CRYSTAL, COPPER-OXIDE, AND ELECTROLYTIC ALUMINIUM RECTIFIERS.—A. Stefanini. (Long summary in *Rev. Gén. de l'Élec.*, 17th October, 1931, Vol. 30, pp. 634–637.)

THE THEORY OF ELECTRONIC SEMI-CONDUCTORS.—A. H. Wilson. (*Proc. Roy. Soc.*, Oct. and Nov., 1931, Vols. 133 and 134, Nos. A 822 and A 823, pp. 458–491 and 277–287.)

The second part extends the theory to include the effects of impurities, which appear to dominate the electrical properties of the semi-conductors.

ELECTRICAL AND OPTICAL BEHAVIOUR OF SEMI-CONDUCTORS. IV. ON SURFACE CHARGES ON SEMI-CONDUCTORS *in Vacuo*.—W. Leo. (*Ann. der Physik*, 1931, Series 5, Vol. 9, No. 3, pp. 347–365.)

The semi-conductors investigated were cupric and cuprous oxide, and Kelvin's method for the determination of contact voltages was used. It was found that electrons from a glowing filament remain on the surface of the semi-conductor, forming an attenuating layer of very small thickness, which completely corresponds to that found in copper oxide rectifiers. The surface is not covered uniformly with the layer but spots of normal conductivity remain. The capacity of the attenuating layer amounts to at least 0.005 μF./cm^2 and the layer thickness must thus be of the dimension of a molecule.

PAPERS ON MERCURY ARC RECTIFIERS.—Hull and Brown: Slepian and Ludwig: De Blieux. (*Elec. Engineering*, October, 1931, Vol. 50, pp. 788–798.)

NEW APPLICATIONS OF HIGH-POWER MERCURY VAPOUR RECTIFIERS WITH GRIDS TO VOLTAGE AND POWER REGULATION.—M. Schenkel and J. von Issendorff. (Summary in *E.T.Z.*, 1st Oct., 1931, Vol. 52, pp. 1257–1258.)

NEW APPLICATIONS OF THE HIGH-POWER MERCURY VAPOUR RECTIFIER WITH GRID CONTROL.—E. Kern. (*Bull. d. l'Assoc. suisse d. Élec.*, No. 22, Vol. 22, pp. 533–543.)

THE DESIGN OF POWER RECTIFIER CIRCUITS: APPLICATIONS OF MERCURY VAPOUR OR THERMIONIC VALVES.—D. McDonald. (*Wireless Engineer*, Oct., 1931, Vol. 8, pp. 522–531.)

D.C. [THYRATRON] INVERTER FOR RADIO RECEIVERS.—W. R. G. Baker and J. I. Cornell. (*Electronics*, Oct., 1931, pp. 152–154.)

The thyratron inverter, used for power supply to broadcasting receivers in direct current districts, depends for its satisfactory working largely on the correct design of its grid excitation system. The equipment here described has a better overall efficiency than rotating machines, and is particularly well adapted to supplying synchronous phonograph combinations (especially those incorporating automatic record changers) owing to its small voltage change between full and no load.

ÜBER DEN GLEICHRICHTEREFFEKT UND ÜBER LEUCHTERSCHEINUNGEN AN CARBORUNDKRISTALLEN (On the Rectifying Action and Luminous Effects of Carborundum Crystals.)—B. Claus. (*Ann. der Physik*, 1931, Series 5, Vol. 11, No. 3, pp. 331–356.)

The experiments described include the investigation of the rectifying action of carborundum crystals under known contact pressures. Measurements indicate that an attenuating film is present at the contact surface.

TYPE II PHOSPHORESCENCE OF THE CARBORUNDUM DETECTOR, ELECTRICAL CONDUCTIVITY OF CARBORUNDUM AND UNIPOLAR CONDUCTIVITY OF CRYSTAL DETECTORS.—O. W. Lossew. (*Physik. Zeitschr.*, 1st Sept., 1931, Vol. 32, No. 17, pp. 692–696.)

Further development of the work dealt with in 1930 Abstracts, p. 176.

THE OSCILLATING CRYSTAL [CRYSTAL DETECTOR] AND THE REASONS FOR ITS BEHAVIOUR.—E. Habann. (*Ann. der Physik*, 1931, Series 5, Vol. 9, No. 1, pp. 1–22.)

A study of the behaviour of certain metallic oxides in crystal detectors, with special reference to the parts of their characteristics with negative slope, which are explained by the action of air absorbed at the detecting surfaces.

LAUE SPOTS FROM PERFECT, IMPERFECT AND OSCILLATING [QUARTZ] CRYSTALS.—C. S. Barrett. (*Phys. Review*, 15th Aug., 1931, Series 2, Vol. 38, No. 4, pp. 832–833.)

S.F.R. PRECISION THERMOSTAT FOR PIEZOELECTRIC OSCILLATORS.—Soc. S.F.R. (*Bull. de la S.F.R.*, August, 1931, Vol. 5, pp. 117–123.)

Giving a frequency stability of about 1 in 400 000 and allowing a crystal to be brought to give exactly the required frequency.

TEMPERATURE REGULATOR MAINTAINING A FURNACE AT 1 000° C. WITH A CONSTANCY OF 0.2%.—H. Rechenberg. (*E.T.Z.*, 3rd December, 1931, Vol. 52, pp. 1498–1499.)

A VOLTAGE REGULATOR FOR FURNACE CONTROL [MERCURY THERMOMETER RELAYS GIVING CONSTANT R.M.S. VOLTAGE IN HEATING CIRCUIT].—V. H. Stott. (*Journ. Scient. Instr.*, Oct., 1931, Vol. 8, pp. 313–316.)

AN IMPROVED CONSTANT TEMPERATURE DEVICE.—L. M. Pidgeon and A. C. Egerton. (*Journ. Scient. Instr.*, No. 8, Vol. 8, 1931, pp. 268–269.)

A method of operating the device dealt with in 1930 Abstracts, p. 463, "which renders it very much more serviceable."

MESSKONDENSATOR MIT EINER VON EXAKT NULL LINEAR ANSTEIGENDEN KAPAZITÄT (Measuring Condenser Whose Capacity Increases Linearly from an Exact Zero.)—K. Kuhlmann. (*Archiv f. Elektrot.*, 12th October, 1931, Vol. 25, No. 10, pp. 666–668.)

This paper describes the construction and use of a condenser whose capacity increases linearly from an exact zero. It is arranged so that the total capacity is divided into two parts of which one is used as the measuring capacity and the other acts as a guard-ring.

Life Test for [Paper] Condensers.—H. W. Houck. (*Electronics*, Sept., 1931, p. 114.)

From the Dubilier laboratories. From several years' records of thousands of tests to breakdown, it is found that the life on d.c. varies inversely as the 5th power of the impressed voltage. This is a conservative estimate: with some condensers the relation is as high as 7th power. Using the 5th power relation, accelerated life tests (*e.g.*, at twice the rated voltage) become practicable.

A Beat Method for Determining the Dielectric Constants of Liquid Conductors.—W. Graffunder and R. Weber. (*Ann. der Physik*, 1931, Series 5, Vol. 9, No. 7, pp. 887–904.)

A full description of a method of which a preliminary account received notice in 1931 Abstracts, p. 109.

The Influence of Electrolytes on the Dielectric Constant of Water.—R. T. Lattey and W. G. Davies. (*Phil. Mag.*, Dec., 1931, Series 7, Vol. 12, No. 81, pp. 1111–1136.)

Including a full description of the "voltage tuning" method of measurement.

Insulating Materials.—A. R. Dunton. (*Electrician*, 9th October, 1931, Vol. 107, pp. 483–485.)

Methods of testing the ageing characteristics of a number of commercial insulating materials are described, with results, and a list is given of the materials in approximate order of resistance to deterioration under various specified conditions.

Insulations—Mineral. Part I.—H. Warren. (*Electrician*, 23rd Oct., 1931, Vol. 107, pp. 546–548.)

Deals with the characteristics and applications of mica and asbestos products, with special reference to present and future developments.

The Behaviour of Rubber-less Insulating Moulding Materials under Prolonged Immersion Tests.—W. Zebrowski. (*E.T.Z.*, 29th Oct., 1931, Vol. 52, pp. 1353–1355.)

The Effect of Sunlight on Ebonite.—M. C. Timms. (*Electrician*, 30th Oct., 1931, Vol. 107, p. 586.)

The Electrical Properties of Russian Colophony.—Bogorodizky and Maigeldinov. (*Archiv f. Elektrot.*, 12th Nov., 1931, Vol. 25, pp. 759–768.)

Proximity Effect in Cable Sheaths.—H. B. Dwight. (*Pub. from Massach. Inst. Tech.*, Serial No. 71, 6 pp.)

The Theory of Thermal Breakdown of Solid Dielectrics.—P. H. Moon. (*Pub. from Massach. Inst. Tech.*, Serial No. 72, 14 pp.)

Über ein neues Galvanometerrelais (A New Galvanometer-Relay [using an Ultra-Micrometer Device]).—S. Reisch. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 12, 1931, pp. 541–549.)

A full paper on the galvanometer mentioned in January Abstracts, p. 53, when the writer's new form of ultra-micrometer, on which it is based, was dealt with. As the thread of a string galvanometer lies between the two poles of an electromagnet, so a thin metal foil is stretched with its plane lying parallel to the lines of force. Two fixed plates, with a small air-gap between each and the central foil, form the fixed electrodes of the ultra-micrometer condenser. By increasing the cross section of the thread a thousand times by substituting the foil, the current sensitivity is correspondingly decreased; but the resistance is also decreased in proportion, so that the voltage sensitivity remains unchanged. But since optical magnification on a string galvanometer is limited to about 1 000, while the ultra-micrometer magnification can exceed one million, the voltage sensitivity is increased from about 10^2 mm/μv. to about 10^5 mm/μv.; moreover, there is no need for the usual hole bored in the pole-pieces, which causes such inhomogeneity of the field in a string galvanometer.

An arrangement using the retroaction principle enables the damping to be regulated. The possibility is discussed of moving the limit of sensitivity to beyond 10^{-10} v/mm, for single measurements and without unduly increasing the time necessary for a reading.

A Vacuum Tube Relay and Race Timer.—W. M. Roberds: Speakman. (*Review Scient. Instr.*, Sept., 1931, Vol. 2, pp. 519–521.)

On Speakman's lines (1931 Abstracts, p. 458) but using no mechanical relay. The two-triode circuit which takes its place functions as follows:—Normally the plate current of T_1 maintains the grid of T_2 so far negative that no plate current flows. Now if some impulse is impressed on the grid of T_1 so as to make it slightly negative, the plate current in this triode is decreased, thereby raising the potential of the grid of T_2. If the impulse is sufficiently strong, the plate current will flow in T_2 and, returning through r, will make the grid of T_1 more negative, thus setting up a regenerative process. Under these conditions, the plate current of T_2 quickly builds up to a maximum. If the time constants are kept low, this maximum current may be reached in less than a thousandth of a second after the reception of the original excitation; *it continues to flow until some external cause makes the grid of T_2 negative enough to stop it.*

The Production of Sensitive Vacuum Thermo-elements and Vacuum Thermo-relays by Cathode Sputtering.—Z. Klemensiewicz and Z. Wasowicz. (*Zeitschr. f. Phys.*, 1931, Vol. 71, No. 11/12, pp. 817–820.)

"Vacuum thermo-elements and vacuum thermo-relays of high sensitivity and low inertia have been obtained by cathode sputtering of metallic conductors on thin layers of insulating material; their characteristics have been investigated."

Some Properties of Vacuum Thermo-Couples [Contact and Non-Contact Types].—J. Jaffray. (*Comptes Rendus*, 16th Nov., 1931, Vol. 193, pp. 926–927.)

Both types gave practically a straight line for the log Δ/log I curve (for a certain range) thus conforming to the relation $\Delta = KI^n$. Calculating K and n by the method of least squares, n is found to vary with the thermo-couple and is not, in general, equal to 2; for the contact ("old") type it is always rather greater than 2, for the non-contact ("new") type it is always rather less than 2.

Thermocouples Whose Elements are Longitudinally and Transversely Magnetised Ferromagnetic Substances.—S. Seass. (*Phys. Review*, 15th Sept., 1931, Series 2, Vol. 38, No. 6, pp. 1254–1257.)

Thermocouples of Longitudinally and Transversely Magnetised Wires.—C. W. Heaps. (*Phys. Review*, 1st Oct., 1931, Series 2, Vol. 38, No. 7, p. 1391.)

A letter pointing out the difficulty of interpreting in a simple way the experiments of Ross (1931 Abstracts, p. 628).

Over-Voltages at "Break" in Small Vacuum Switches.—E. O. Seitz. (*E.T.Z.*, 15th Oct., 1931, Vol. 52, pp. 1305–1307.)

A cathode-ray oscillographic investigation of the action of switches similar to the "hair-trigger" type dealt with in 1931 Abstracts, p. 628.

A [Copper-Oxide] Photoelectric Relay for [Mirror] Galvanometer Measurements.—A. V. Hill. (*Journ. Scient. Instr.*, No. 8, Vol. 8, 1931, pp. 262–265.)

Relay working off A.C. and supplying D.C. (French Pat. 705310, Ducrot, pub. 4th June, 1931.)

See *Rev. Gén. de l'Élec.*, 26th Sept., 1931, Vol. 30, p. 112 D.

On the Measurement of High Resistance by the Bridge Method.—J. A. C. Teegan. (*Phil. Mag.*, Oct., 1931, Series 7, Vol. 12, No. 79, pp. 840–843.)

Resistances of the order of 2×10^8 ohms may be measured by a bridge method, using not a quadrant electrometer but an ordinary galvanometer, if an amplifying valve is used to give a sensible current through the galvanometer.

A Spark Method of Measuring High Resistance [of the order of 10^8 ohm].—J. A. C. Teegan. (*Nature*, 3rd Oct., 1931, Vol. 128, p. 585.)

A Combination of Bridge and Potentiometer, and Its Advantages as a Potential Divider.—E. Denina. (*L'Elettrotec.*, 5th April, 1931, Vol. 18, pp. 222–224.)

On the Electrical Resistance of Carbon.—Z. Nishiyama. (*Zeitschr. f. Phys.*, 1931, Vol. 71, No. 9/10, pp. 600–615.)

Electrodeposited Metal Foils.—H. Kersten. (*Review Scient. Inst.*, Oct., 1931, Vol. 2, pp. 649–653.)

Making use of the fact that electrolytic deposits do not adhere well to polished stainless steel.

Investigations of the Electrical Conductivity of Thin Metallic Layers [Application to the Production of High Resistances]. G. Braunsfurth. (*Ann. der Physik*, 1931, Series 5, Vol. 9, No. 4, pp. 385–418.)

Drahtwiderstände in Bandform ([Non-Inductive, Non-Capacitive] "Silko" Wire Resistances in Ribbon Form).—(*Rad.*, *B.*, *F. f. Alle*, Nov., 1931, pp. 483–484.)

"Completely non-microphonic, constant, inductance- and capacity-free, capable (according to size of wire) of carrying 2 to 6 watts," these resistances are made of a ribbon in which the resistance wire runs zig-zag through the warp of insulating thread.

The Protection of Potential Transformers by the "RL" Micro-fuse.—R. Loubet. (Summary in *Rev. Gén. de l'Élec.*, 21st Nov., 1931, Vol. 30, 170–171D.)

Zur Theorie des Transformators (The Theory of the Transformer).—H. Barkhausen, (*E.T.Z.*, 26th November, 1931, Vol. 52, pp. 1463–1466.)

Comparison of the three different ways of treating transformer theory, namely, that of the physicist and high-frequency "specialist" (according to self- and mutual-induction coefficients), that of the power engineer (magnetic flux), and that of the communication engineer (equivalent circuit).

Apparatus for Measuring the Number of Turns, up to 3000, in a Winding.—C. Dannatt: Metropolitan Vickers Company. (*Electrician*, 14th Aug., 1931, Vol. 107, pp. 218–219.)

Shielding for Electric Circuits.—J. G. Ferguson. (*Bell Lab. Record*, Nov., 1931, Vol. 10, No. 3, pp. 88–92.)

The Eglin-Cartier Baudot Reproducer without Rotating Parts.—P. Mercy. (*Ann. des P.T.T.*, Oct., 1931, Vol. 20, pp. 809–822.)

A Special Planimeter for Measuring R.M.S. Values.—H. Adler. (*E.T.Z.*, 5th Nov., 1931, Vol. 52, pp. 1387–1388.)

The New Brown Potentiometer Recorder.—T. R. Harrison. (*Review Scient. Inst.*, Oct., 1931, Vol. 2, pp. 618–625.)

Including a humidity compensator to allow for the expansion of the paper roll chart in humid summer conditions.

A PRISMATIC DERIVATOR.—E. von Harbou. (*Journ. Scient. Instr.*, No. 7, Vol. 8, 1931, pp. 227–228.)

See 1931 Abstracts, p. 453.

THE ELECTRO-OPTICAL SHUTTER—ITS THEORY AND TECHNIQUE.—F. G. Dunnington. (*Phys. Review*, 15th Oct., 1931, Series 2, Vol. 38, No. 8, pp. 1506–1534.)

A detailed account of "a development in the design of the single cell type of electro-optical shutter, together with a theory describing its action." The use of the shutter in the study of spark breakdown is described (*see* under "Atmospherics and Atmospheric Electricity").

STATIONS DESIGN AND OPERATION.

LES INSTALLATIONS RADIOÉLECTRIQUES DANS LES COLONIES FRANÇAISES (Radio Installations in the French Colonies).—H. Staut. (*Rev. Gén. de l'Élec.*, 15th August, 1931, Vol. 30, pp. 253–267.)

THE FRENCH COLONIAL BROADCASTING SERVICES.—M. Adam. (*Ibid.*, 22nd August, pp. 291–303.)

THE AUSTRIAN BROADCASTING NETWORK.—G. Schwaiger and others. (*Elektrot. u. Masch: bau*, Nos. 29 and 30, Vol. 49, 1931, pp. 561–567 and 580–586.)

THE NEW "RADIO-VITUS" BROADCASTING STATION [NEAR PARIS].—(*Television*, Aug., 1931, Vol. 4, pp. 237–239.)

RELAY BROADCAST TRANSMITTER, TYPE BR.1A [FOR SWEDEN].—(*Marconi Review*, July-August, 1931, No. 31, pp. 15–20.)

FIELD STRENGTH CHART OF THE NORRKÖPING RE-HIGH-POWER BROADCASTING STATION.—S. Baczynski. (*Telefunken-Zeit.*, No. 57, Vol. 12, 1931, pp. 32–37.)

FIELD STRENGTH CHART OF THE NORRKÖPING RELAY STATION. — S. Lemoine. (*Teknisk Tidskr.*, 5th September, 1931, Vol. 61. p. 165.)

In an article on certain Swedish relay stations.

LA STAZIONE RADIOTELEGRAFICA A ONDE CORTE DELLA CITTÀ DEL VATICANO (The Vatican Short-Wave Telegraph Station).—G. Gianfranceschi. (*L'Elettrotec.*, 15th Oct., 1931, Vol. 18, pp. 731–733.)

SYNCHRONIZATION OF WESTINGHOUSE RADIO STATIONS WBZ AND WBZA.—S. D. Gregory: Westinghouse Company. (*Rad. Engineering*, Sept., 1931, Vol. 11, pp. 29–33.)

POWER EQUIPMENT AT KDKA'S NEW STATION.—R. L. Davis. (*Elec. Engineering*, Nov. 1931, Vol. 50, pp. 865–868.)

NEW BROADCASTING STATION OF THE COMPAGNIE FRANÇAISE DE RADIOPHONIE AT SAINT RÉMY [AND THE USE OF THE "DE-PHASING" SYSTEM OF MODULATION].—(*Bull. de la S.F.R.*, July, 1931, Vol. 5, pp. 96–104.)

With a power of 80 kw. in the aerial which can be raised to 120 kw. by the use of the "de-phasing" system of modulation (*see* under "Transmission").

THE BROADCAST INSTALLATIONS IN THE NEW "HOUSE OF RADIO," BERLIN.—G. Lubszynski and K. Hoffmann. (*Proc. Inst. Rad. Eng.*, Nov., 1931, Vol. 19, pp. 1955–1970.)

THE PONTOISE RADIOTELEGRAPH STATION.—V. Vigneron. (*Ann. des P.T.T.*, Nov., 1931, Vol. 20, pp. 862–881.)

PRAGUE BROADCASTING STATION.—(*Electrician*, 27th Nov., 1931, Vol. 107, p. 739.)

Details of the new 200 kw. transmitter at Cesky-Brod.

SHORT-WAVE BROADCASTING STATIONS OF THE WORLD [LIST AND MAP].—(*Electronics*, November, 1931, pp. 180–181.)

INTERFERENCE EFFECTS WITH SHARED-FREQUENCY BROADCASTING.—C. B. Aiken. (*Bell Lab. Record*, Nov., 1931, Vol. 10, No. 3, pp. 79–82.)

SOME DEVELOPMENTS IN COMMON FREQUENCY BROADCASTING.—G. D. Gillett. (*Bell S. Tech. Journ.*, Oct., 1931, Vol. 10, No. 4, pp. 577–600.)

See 1931 Abstracts, p. 573.

WELLENFRAGE UND WELTRUNDFUNKVEREIN (The Wavelength Problem and the U.I.R.).—P. Münch. (*T.F.T.*, Nov., 1931, Vol. 20, p. 342.)

APPLICATION OF PRINTING TELEGRAPH TO LONG-WAVE RADIO CIRCUITS.—A. Bailey and T. A. McCann. (*Bell S. Tech. Journ.*, Oct., 1931, Vol. 10, pp. 601–615.)

SHIP TO SHORE TELEPHONE INSTALLATION ON THE S.S. EMPRESS OF BRITAIN.—Marconi Company. (*Marconi Review*, Sept.–Oct., 1931, No. 32, pp. 18–25.)

RADIO TO THE RESCUE [POLICE RADIO, ESPECIALLY DE FOREST RADIO POLICE SYSTEM IN LOS ANGELES].—W. J. Barkley. (*Rad. Engineering*, Sept., 1931, Vol. 11, pp. 34–35.)

BROADCASTING IN SWITZERLAND.—(*Elec. Review*, 14th August, 1931, Vol. 109, pp. 245–246.)

Reorganisation of the system is nearing completion, the first of two new main transmitters being the 25 kw. station at Sottens. Using a portable transmitter, field strength contour maps were made in order to find the best site.

GENERAL PHYSICAL ARTICLES

A Search for an Electrostatic Analog to the Gravitational Red Shift [Negative Results in Test for Change in Frequency of Light due to Difference in Electrostatic Potential between Source and Measuring Apparatus].—R. I. Kennedy and E. M. Thorndike. (*Proc. Nat. Ac. Sci.*, Nov., 1931, Vol. 17, pp. 620–622.)

Bemerkungen zu unserer Arbeit: "Elektrische und magnetische Effekte . . ." (Remarks on our Paper: "Electric and and Magnetic Effects on Metallic Wires Structurally Influenced by Heat, Magnetisation or Sound").—A. V. Hippel and O. Stierstadt. Supplementary Remarks by O. v. Auwers. (*Zeitschr. f. Phys.*, 1931, Vol. 72, No. 3/4, pp. 266–274.)

A sequel to the paper referred to in 1931 Abstracts, p. 574.

Thermoelectromotive Forces Produced by a Magnetic Field.—S. R. Williams. (*Science*, 17th July, 1931, Vol. 74, pp. 75–77.)

Electromagnetic Fields Derived from Non-Commuting Potentials.—B. Cassen. (*Proc. Nat. Ac. Sci.*, July, 1931, Vol. 17, pp. 430–434.)

The Theoretical Bases of Electrotechnics: Electronic Interpretation of Energy Exchange in Alternating Currents.—M. Boll. (*Rev. Gén. de l'Élec.*, 18th July and 3rd October, 1931, Vol. 30, pp. 93–106 and 541–547.)

See also 1931 Abstracts, p. 493.

On the Analogy between the Electromagnetic Field and a Fluid containing a Large Number of Vortex Elements.—J. J. Thomson. (*Phil. Mag.*, Nov., 1931, Series 7, Vol. 12, No. 80, pp. 1057–1063.)

Dielectric Constants of Aqueous Solutions.—R. Weber. (*Zeitschr. f. Phys.*, 1931, Vol. 70, No. 11/12, pp. 711–722.)

On the Dielectric Constants of Electrolytic Solutions.—W. Orthmann. (*Ann. der Physik*, 1931, Series 5, Vol. 9, No. 5, pp. 537–569.)

Investigation of the Electric Field Distribution in Dielectric Liquids by means of Electrical Double Refraction—Electro-optical Kerr Effect).—J. Dantscher. (*Ann. der Physik*, 1931, Series 5, Vol. 9, No. 2, pp. 179–216.)

Diffusie van Deeltjes met Inachtneming van Botsingsverliezen (The Diffusion of Particles [emitted by a Reflecting Plane] taking into Account the Energy Loss).—W. de Groot. (*Physica*, No. 10, Vol. 11, 1931, pp. 337–342.

A New Method of Producing Negative Ions.—J. S. Thompson. (*Phys. Review*, 1st October, 1931, Series 2, Vol. 38, No. 7, p. 1389.)

A letter reporting the observation of negative ions formed at a metal surface by bombardment with positive ions,

Photoelectrons and Negative Ions.—Wellish. (*See* under "Phototelegraphy and Television.")

The Probability Law governing Ionization by Electron Impact in Mercury Vapor.—C. R. Haupt. (*Phys. Review*, 15th July, 1931, Series 2, Vol. 38, No. 2, pp. 282–295.)

The Colour of the Light from High-Frequency Discharges in Helium.—J. S. Townsend. (*Phil. Mag.*, Dec., 1931, Series 7, Vol. 12, No. 81, pp. 1168–1175.)

Über die raumladungsbeschwerte Townsendentladung im dichten Nebel (On the Townsend Discharge in Heavy Mist, when Loaded with Space Charge).—W. Deutsch. (*Ann. der Physik*, 1931, Series 5, Vol. 10, No. 7, pp. 847–867.)

Wird das Anfangselektron beim Stossdurchschlag lichtelektrisch ausgelöst? (Is the Initial Electron in an Impulsive Discharge Set Free by Photoelectric Action ?)—K. Buss and K. Mosch. (*Archiv f. Elektrot.*, 12th Nov., 1931, Vol. 25, pp. 744–746.)

MISCELLANEOUS.

I.E.E. Wireless Section: Chairman's Address.—A. S. Angwin. (*Journ. I.E.E.*, Dec., 1931, Vol. 70, pp. 17–35.)

Importance of frequency stability (C.C.I.R. recommendations): Dollis Hill frequency sub-standard: St. Albans (Colney Heath) Frequency-measuring Station: comparisons between St. Albans Station and Dollis Hill sub-standard: crystal-controlled transmitters: master-oscillator-controlled transmitters: simple self-oscillating circuits (low-power shore stations): short-wave mobile stations: measurements of interference: development of controlled transmitters as used by the British P.O.: stability of amplifier stages (the special valve for high-frequency amplifying stages: *see* also "Measurements and Standards"): demountable valves (illustrated description of the new continuously evacuated 500 kw. valve [Jan. Abstracts, p. 39] and its tests at Rugby).

The Radio Research Board Report.—(*Engineer*, 6th Nov., 1931, Vol. 152, p. 485: *Electrician*, 6th Nov., 1931, Vol. 107: *Nature*, 21st Nov., 1931, Vol. 128, pp. 861–862.)

Reviews of the Report for the period ended 31st December, 1930.

The Design and Construction of Electrostatic Generators.—H. Chaumat and E. Lefrand. (*Comptes Rendus*, 7th Dec., 1931, Vol. 193, pp. 1176–1178.)

Continuation of the work dealt with in 1929

Abstracts, p. 465—two. The single-plate machine now developed gives a steady 24 watts at 300 000 volts—34 times as great a power as that given (at 70 000 volts) by a Wimshurst slightly larger in diameter and driven at the same speed.

FOURIER ANALYSIS OF FUNCTIONS WITH DISCONTINUITIES, ANGULAR POINTS AND SIMILAR PROPERTIES.—G. Koehler and A. Walther. (*Archiv f. Elektrot.*, 12th Nov., 1931, Vol. 25, pp. 747–758.)

ON CURVE-FITTING BY MEANS OF LEAST SQUARES.—W. R. Cook. (*Phil. Mag.*, Nov., 1931, Series 7, Vol. 12, No. 80, pp. 1025–1039.)

THE TRANSFORMATION OF $\sqrt{-1}$: A NEW EQUATION FOR THE CYCLOID.—G. S. Berkeley: C. Turnbull. (*Electrician*, 11th Sept., 1931, Vol. 107, p. 344.)

A MECHANICAL METHOD FOR THE SOLUTION OF SECOND ORDER LINEAR DIFFERENTIAL EQUATIONS.—E. C. Bullard and P. B. Moon. (*Proc. Camb. Phil. Soc.*, Oct., 1931, Vol. 27, No. 4, pp. 546–552.)

THE DIFFERENTIAL ANALYZER. A NEW MACHINE FOR SOLVING DIFFERENTIAL EQUATIONS.—V. Bush. (*Sci. News Letter*, 17th Oct., 1931, Vol. 20, p. 253 ; *Journ. Franklin Inst.*, Oct., 1931, Vol. 212, No. 4, pp. 447–488.)

SIMULTANEOUS INTEGRATION OF TWO DIFFERENTIAL EQUATIONS OF THE FIRST ORDER.—B. Gambier. (*Comptes Rendus*, 5th Oct., 1931, Vol. 193, pp. 509–512.)

ON DISSIPATIVE SYSTEMS AND RELATED VARIATIONAL PRINCIPLES.—H. Bateman. (*Phys. Review*, 15th Aug., 1931, Series 2, Vol. 38, No. 4, pp. 815–819.)

QUANTISED SINGULARITIES IN THE ELECTROMAGNETIC FIELD.—P. A. M. Dirac. (*Proc. Roy. Soc.*, Sept., 1931, Vol. 133, No. A 821, pp. 60–72.)

ON THE MOMENT DISTRIBUTION OF MOMENTS IN THE CASE OF SAMPLES DRAWN FROM A LIMITED UNIVERSE.—L. Isserlis. (*Proc. Roy. Soc.*, 1st Aug., 1931, Vol. 132, No. A 820, pp. 586–604.)

THE U.I.R. ASSEMBLY AT OUCHY-LAUSANNE.—M. Adam. (*Rev. Gén. de l'Élec.*, 28th Nov., 1931, Vol. 30, pp. 870–873.)

Including sections on Schaeffer's tests on the interference between two stations 9 kc. apart, and on the measurement of the space radiation of 32 European broadcasting stations.

THE BERLIN RADIO AND PHONO SHOW. (*Rad., B., F. f. Alle*, October, 1931, pp. 417–423, 430–444, and 459–461.)

THE SPOKESMAN FOR THE RADIO ENGINEER.—S. C. Cooper. (*Proc. Inst. Rad. Eng.*, Oct., 1931, Vol. 19, pp. 1843–1848.)

THE E.M.F. OF FILTRATION PRODUCED BY THE RISE OF SAP IN PLANTS [CHARACTERISTIC CURVE RESEMBLING THAT OF A DETECTOR, AND EXPLAINING CERTAIN H.F. RESULTS].—N. Marinesco. (*Comptes Rendus*, 6th July, 1931, Vol. 193, pp. 89–91.)

BIOLOGICAL EFFECTS OF GAMMA RAYS.—W. G. Whitman and M. A. Tuve. (*Phys. Review*, No. 3, Vol. 37, 1931, pp. 330–331.)

THE PENETRATION OF RADIATION FROM DIFFERENT SOURCES INTO WATER AND BODY TISSUES.—W. E. Forsythe and F. Christison. (*Gen. Elec. Review*, July, 1931, Vol. 34, pp. 440–443.)

THE SENSITIVITY OF THE HUMAN BODY TO WEAK ALTERNATING CURRENTS (50 C.P.S.).—E. Albers-Schönberg. (*E.T.Z.*, 1st Oct., 1931, Vol. 52, pp. 1249–1250.)

A COMPARISON BETWEEN THE BIOLOGICAL EFFECTS OF SHORT AND ULTRA-SHORT WAVES.—J. Saidman. (*Comptes Rendus*, 3rd November, 1931, Vol. 193, pp. 783–785.)

NEW ELECTROTHERAPEUTIC APPARATUS FOR THE PRODUCTION OF ALTERNATING LONG-PERIOD WAVE CURRENTS AND OF PULSATING CURRENTS.—Delherm and Laquerrière. (*Comptes Rendus*, 29th June, 1931, Vol. 192, pp. 1766–1767.)

A technique involving valves and the charging and discharging of condensers is outlined, which replaces unsatisfactory mechanical methods (resistance with rotating contact, etc.).

LOCAL EFFECTS ON RATS DUE TO VERY HIGH FREQUENCY FIELDS [20 MEGACYCLES].—J. Saidman, J. Meyer and R. Cahen. (*Comptes Rendus*, 29th June, 1931, Vol. 192, pp. 1760–1762.)

THE PROBLEM OF RADIATIONS [SOLAR SPECTRUM : RADIATION FROM GASES : MITOGENETIC RAYS : ROENTGEN AND GAMMA RAYS : IRRADIATION OF ERGOSTEROL, ETC., ETC.].—H. Konen. (*Zeitschr. V.D.I.*, 15th August, 1931, Vol. 75, pp. 1033–1037.)

DOSIMETER FOR HIGH- AND ULTRA-HIGH FREQUENCY THERAPEUTIC TREATMENTS.—K. Heinrich. (*Elektrot. u. Masch : bau.*, 8th November, 1931, Vol. 49, pp. 831–833.)

TRAWLING BY ELECTRICITY : FUNDAMENTAL CONSIDERATIONS ON THE CATCHING OF FISH BY GALVANOTAXIS.—W. Holzer. (*E.T.Z.*, 19th November, 1931, Vol. 52, pp. 1442–1444.)

A COLD-CATHODE 110-VOLT GASEOUS ILLUMINANT.—Spanner, Germer, Doring. (*Electronics*, Oct., 1931, pp. 140–141.)

Combining the advantages of the mercury-vapour lamp and the neon tube ; an efficiency 3 to 5 times that of the best filament-type incandescent lamp is claimed. A barium oxide coated cathode is used.

Counting Objects without Photocells [by Effect of Approach on a Circuit including a Low-Grid-Current—"Electrometer"—Valve].—W. C. White. (*Electronics*, Nov., 1931, p. 200.)

Light-sensitive Relays now on the Market.—(*Electronics*, November, 1931, pp. 194–195.)

New Uses of Photoelectric Cells in Industry. (*Ibid.*, pp. 196–197.)

Control of carton wrapping: steel bars cut to length: passage of skip hoists in mines: saves 10% by accurate counting of butter cartons of slightly varying weight: throws out brown or otherwise discoloured beans.

Ultra-Micrometer based on Change of Coupling between Windings of a Transformer: Galvanometer Deflection Method and a Null Method.—A. Guillet. (*Comptes Rendus*, 30th November, 1931, Vol. 193, pp. 1066–1068.)

The galvanometer deflection method makes use of a galena rectifier. The null method uses a constant e.m.f. in conjunction with some form of interruptor; two air-core transformers are connected in series, being so designed that equal changes in mutual inductance ΔM correspond to displacements ϵ_1, ϵ_2, such that $\Delta M = \epsilon_1 a = \epsilon_2 \cdot \frac{1}{b}$. Then a deformation ϵ_1 corresponds to a change $\epsilon_2 = ab\epsilon_1$, a and b both being large. Thus a magnifying power ab is obtained, and there is no need to keep constant the various experimental factors—value of current, frequency of interruption, etc.

Methods used in Electrical Prospecting.—J. I. Heller. (*Electronics*, Nov., 1931, pp. 184–185 and 214.)

On the Magnitude and Depth Effect of the Capacitive Influence on a Line by a Dishomogeneity of the Subsoil [Method of Geophysical Exploration].—W. Stern. (*Zeitschr. f. Geophys.*, No. 3/4, Vol. 7, 1931, pp. 166–174.)

The apparatus described, working on the heterodyne principle, measures capacity changes down to $\pm 10^{-4}$ cm.

Some Experiments relating to Geophysical Prospecting [Equiquadrature Method].—D. C. Gall. (*Journ. Scient. Inst.*, Oct., 1931, Vol. 8, pp. 305–313.)

Balancing Methods for the Elimination of Induced Noise in Telephone Cables.—H. Jordan: Collard. (*E.N.T.*, Oct., 1931, Vol. 8, pp. 421–430.)

Coming to very much the same conclusions as those already reached by Collard (1931 Abstracts, p. 341.)

Mutual Impedance of Grounded Wires lying on the Surface of the Earth.—R. M. Foster. (*Bell S. Tech. Journ.*, July, 1931, Vol. 10, No. 3, pp. 408–419.)

Transients in Grounded Wires Lying on the Earth's Surface.—J. Riordan. (*Bell S. Tech. Journ.*, July, 1931, Vol. 10, No. 3, pp. 420–431.)

Effect of Ground Permeability on Ground Return Circuits.—W. H. Wise. (*Bell S. Tech. Journ.*, July, 1931, Vol. 10, No. 3, pp. 472–484.)

The Inductive Effects of a Single Line traversed by an Alternating Current.—F. Pollaczek. (*Rev. Gén. de l'Élec.*, 21st Nov., 1931, Vol. 30, pp. 819–828.)

French version of Pollaczek's 1927 paper.

Measurements by means of Models of the Coupling between Two Lines or Cables through Earth Currents.—A. Mühlinghaus. (*E.N.T.*, Sept., 1931, Vol. 8, pp. 379–387.)

The Disturbing Influence of High Current or High Voltage Lines on Communication Lines: the Interfering Potential and Its Measurement.—Ch. Degoumois. (*Bull. d. l'Assoc. suisse d. Élec.*, No. 21, Vol. 22, 1931, pp. 517–522.)

Measures to Protect Telephone Lines against Disturbances from High Current or High Voltage Power Lines.—C.C.I.T. (*Rev. Gén. de l'Élec.*, 19th Sept., 1931, Vol. 30, pp. 433–434.)

Theory of the Co-existence of Power and Communication Lines from the Point of View of Their Mutual Induction.—(*National Elec. Light Assoc. Publication*, April, 1931, No. 118, pp. 1–15.)

Interference between Power and Communication Circuits: Summary of Recent Information (1926 to 1929).—W. G. Radley. (*Journ. I.E.E.*, Sept., 1931, Vol. 69, pp. 1117–1148.)

The Transmission of Telegraphic Signals.—Bartelink and Bast. (*See* under "Propagation of Waves.")

A Vacuum Tube Relay and Race Timer.—Roberds. (*See* under "Subsidiary Apparatus.")

The Reisch Ultra-Micrometer Used as a Galvanometer Relay.—Reisch. (*See* abstract under "Subsidiary Apparatus.")

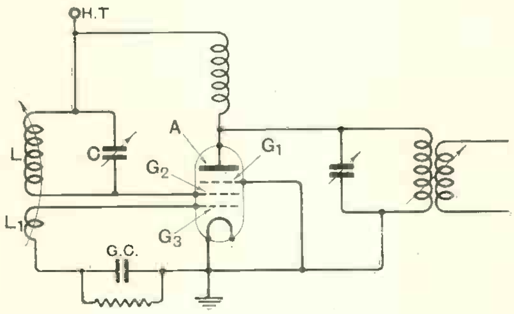
Some Recent Patents.

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.

VALVE GENERATORS.

Application date, 20th June, 1930. No. 357244.

A three-grid valve is used for generating oscillations having a frequency independent of variations either in the output load or in the supply voltages. The master oscillator circuit *L*, *C* is connected across the anode *A* and grid G_2, the latter being



No. 357244.

screened from the former by an interposed grid G_1 connected to earth. This serves to prevent the transfer of complex impedance effects between the output and input circuits. The back-coupling coil L_1 is connected across a third grid G_3 and the cathode, through a condenser *GC* shunted by a very high resistance to ensure sharply defined exciting-impulses.

Patent issued to Graham Amplion Ltd. and A. D'A. Hodgson.

PHOTO-ELECTRIC CELLS.

Application date, 5th June, 1930. No. 356747.

The sensitivity of a photo-electric cell is increased by using Krypton or Xenon as a gas filling instead of Helium, Neon, or Argon. The sensitivity varies with the pressure of the contained gas up to an optimum point and then falls off. For instance, for an applied voltage of 60 there is a maximum response with Krypton at a pressure of 50 microns of mercury, whilst at 30 volts the optimum pressure is 80 microns. With Xenon the gas pressure should be 20 microns with an applied voltage of 60 volts or over.

Patent issued to The Gramophone Co., Ltd., and W. F. Tedham.

GLOW-DISCHARGE TUBES.

Application date, 13th September, 1930. No. 359054.

In order to increase the intensity of illumination in a Neon lamp of the kind in which the glow electrode is backed with mica or similar insulating material, the same electrode, instead of being flat, consists of two or more surfaces inclined at an angle of about 60° in the direction of the line of vision. Alternatively the electrode may consist of a series of such surfaces so as to present a corrugated effect.

Patent issued to J. L. Baird and Television Ltd.

MATCHING INDUCTANCES.

Convention date (Holland), 25th October, 1929. No. 359168.

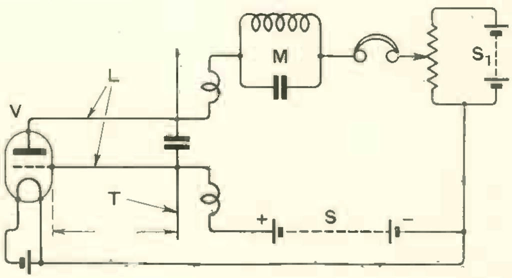
Provision is made for matching or "trimming" inductances in the case where several windings are mounted on a common core which is completely enclosed in a screening-pot as in mass-production "ganged" tuning-units. Each winding is associated with a small metal disc mounted on a spindle taken out to the side of the screening-pot. The disc is rotated to vary the effective inductance value by "spade tuning," and is then sealed at the correct adjustment by soldering.

Patent issued to N. V. Philips Gloeilampen Fabrieken.

SHORT-WAVE OSCILLATORS.

Convention date (Germany), 10th July, 1929. No. 358145.

A short-wave valve oscillator of the Barkhausen-Kurz type, in which the generated frequency is mainly determined by electronic vibrations inside the valve, is given a negative-resistance characteristic, and a modulating-frequency is automatically applied from a closed circuit connected in the output. As shown in the figure, a high positive potential is applied to the grid of the valve *V* from a source *S*, and an adjustable voltage



No. 358145.

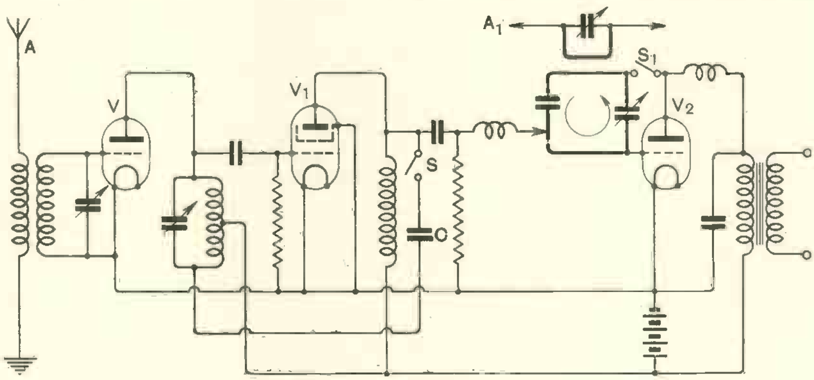
to the plate from a source S_1. A tuning-element *T* is moved along the Lecher-wire circuit *L* until it is in resonance with the electron vibrations, when "frequency reaction" sets in and a rapid rise in anode current occurs. A circuit *M* tuned to the desired frequency is then utilised to impose modulating signals on the high-frequency output.

Patent issued to H. E. Hollmann.

LONG AND ULTRA-SHORT WAVE RECEIVER.

Convention date (*Germany*), 25*th February*, 1930. No. 357913.

Signals between 1000–2000 metres are received on a "straight" amplifier circuit which can be readily converted into a super-regenerator for receiving signals between 3–6 metres. As shown,



No. 357913.

the circuit is set for long-wave reception from the aerial *A*. By closing the switches *S*, S_1, the valve V_1 is back-coupled through a condenser *C* to generate "quenching" oscillations for the super-regenerative amplification of short-wave signals fed to the amplifier V_2 from a short wave aerial A_1. When used in this way the first amplifier valve *V* is switched off.

Patent issued to Telefunken Gesell. für Drahtlose Telegraphie m.b.H.

DIRECTION-FINDING.

Convention date (*U.S.A.*), 29*th June*, 1929. *No.* 357640.

The angular bearing of a distant transmitter is determined by a method which depends upon the phase-difference between two received waves, or between one received wave and a locally generated wave. In one arrangement the two windings of a frame transmitter are energised with out-of-phase components, so that they radiate what may be called a spiral wave, *i.e.*, one in which the absolute phase varies according to its orientation. This is applied in reception to an instrument of the synchroscope type which indicates the phase-difference between the incoming signal and a second wave of standard frequency, which may come either from the distant transmitter or be produced locally. The deflection gives a direct indication of the required bearing.

Patent issued to Electrical Research Products, Inc.

LIGHT-SENSITIVE CELLS.

Convention date (*Germany*), 30*th August*, 1929. *No.* 358214.

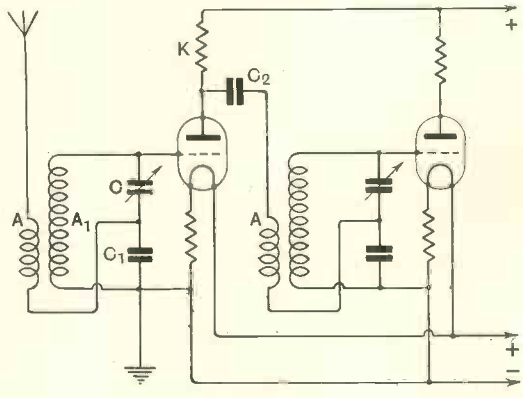
The object of the invention is to increase the internal resistance of a light-sensitive cell of the cuprous-oxide type in order to "match" it with the grid-filament resistance of an amplifying valve, so as to increase the effective output. With this type of cell the generated current depends upon the quantity of light falling upon it, irrespective of the area of incidence. The light is accordingly concentrated into a circular beam by means of a lens, and is focused upon a sharply defined "ridge" of photo-sensitive material. The resistance of the cell is stated to be that of a number of elementary strips connected in parallel, so that by cutting down the area the number of parallel strips is reduced, with a consequent increase in the effective resistance.

Patent issued to Siemens & Halske Akt.

CONSTANT-COUPLING CIRCUITS.

Application date, 12*th June*, 1930. *No.* 358996.

To ensure a constant coupling-factor at all frequencies, and to preserve stability, the input and output couplings are arranged as shown in the figure. The aerial coil *A* is taken to a point between two condensers *C*, C_1, shunting the input or secondary coil A_1. The condenser *C* is variable whilst C_1 is fixed and earthed. The intervalve coupling is similarly arranged, except that the primary winding *A*, following the condenser C_2,



No. 358996.

is reversed in order to induce an in-phase current in the secondary winding. The plate voltage is applied through a choke *K* so that no direct current flows in the primary winding of the intervalve transformer.

Patent issued to A. E. White.

TELEVISION.

Convention date (U.S.A.), 19th July, 1929. No. 356880.

In a system of television depending upon the rapid transmission of a cinematographic film, the film is moved at a constant speed past a scanning-disc on which the "pitch" of the spirally arranged poles is made equal to the width of the "frame line" separating successive pictures on the film. In this way the frame line is automatically removed from the path of the scanning ray.

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

Application date, 16th June, 1930. No. 357143.

Advantage is taken of the fact that the human eye has only a very small area of distinct vision in the total field of view, to economize the amount of detail in a televised picture. The scanning is deliberately made uneven, the centre of interest being transmitted in high detail, whilst the remainder is of lower definition. The scanning-force wave-form is modified so that its time rate of change is less as it traverses the central area of interest than when it covers outlying or boundary regions. This enables a larger picture to be covered with a given range of transmitted frequencies.

Patent issued to J. H. O. Harries.

Convention date (U.S.A.), 17th May, 1930. No. 357941.

A lamp of the flaming-arc type is used to reconstitute the image of a televised picture upon a viewing screen. In order to secure clear definition, the light is limited to that coming from the arc alone, the light from the electrodes being shut off by using two scanning discs and suitably restricting the size of the apertures in one of them.

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

Convention date (U.S.A.), 19th July, 1929. No. 357687.

Relates to television systems based on the scanning and transmission of a "talkie picture" of the sound-on-film type. For ordinary theatrical reproduction the normal projection speed of 24 film frames per second would require a wider frequency band than is at present practicable in the ether. The rate of scanning is accordingly regulated by means of a slotted obturator disk so that the normal 24 frames is effectively reduced to say 20 frames per second, whilst at the same time the sound track is transmitted at the normal rate so as to maintain correct synchronisation between the two.

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

Application date, 14th July, 1930. No. 358920.

A succession of travelling arc discharges are caused to pass across a pair of spaced electrodes which are then moved bodily in the plane of and at right-angles to the direction of the discharge in order to completely scan the picture to be televised. The electrodes are spaced close together at the point where the scanning arc is initiated, and then diverge to a point where the arc "breaks" after it has travelled through the required distance.

Patent issued to W. W. Triggs.

Convention date (France), 1st July, 1929. No. 358087.

In order to overcome the inherent speed limitations of the ordinary mechanical scanning devices used in television, they are replaced by a system of "optical slots" produced by subjecting a transparent body such as quartz, tourmaline, nitrobenzene, etc., to "pressure waves," which produce a deformation in the medium and therefore modify its optical properties. The pressure waves may be produced by piezo-electric action, and can be controlled to travel through the medium at any desired scanning speed. A similar optical system, subjected to similar pressure waves, is used in reception, the identity of the piezo-electric body rendering further synchronisation unnecessary.

Patent issued to L. M. J. Loiseau and Cie pour la Fabrication des Compteurs et Materiel d'Usines à Gaz.

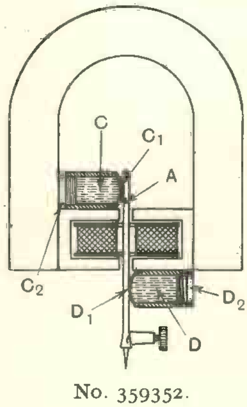
Application date, 16th June, 1930. No. 358971.

To make the most effective use of the total amount of "detail" which can be transmitted under existing limitations of scanning speed and permissible width of signal frequencies, the elementary areas into which the transmitted picture is subdivided in scanning are more finely graded near the centre of interest of the picture than elsewhere. The scanning device may consist of two "mosaics" of light-sources, one more closely grained than the other and movable relatively to it. The arrangement can also be used to give a stereophonic effect.

Patent issued to J. H. O. Harries.

GRAMOPHONE PICK-UPS.

Convention date (Germany), 22nd February, 1930. No. 359352.



No. 359352.

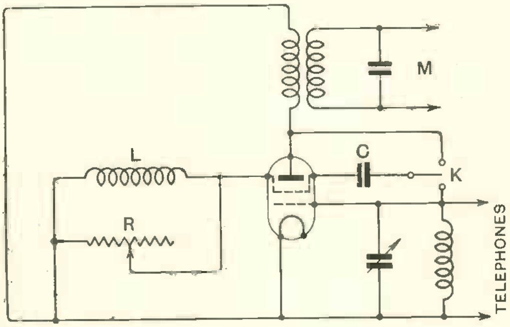
The armature A of an electro-magnetic sound recorder or reproducer is supported and damped by two or more cylinders C, D containing viscous liquid, such as oil. The pressure of the flexible ends C_1, D_1 against the armature A is regulated by adjustable screw plungers C_2, D_2.

Patent issued to International General Electric Co., Inc.

SCREEN GRID AMPLIFIERS.

Application date, 18th July, 1930. No. 359041.

In order to vary or eliminate any residual inter-electrode capacity in a screen-grid amplifier, the screen electrode is connected to a point of fixed high potential through an air-cored inductance *L*, which may be shunted by a variable resistance *R*. The theoretical value of the inductance *L* for zero capacity-coupling is derived from a given formula expressed in terms of the working frequency, and the internal anode-grid, anode-screen, and screen-grid capacities. A method of measuring the value of the anode-grid inter-electrode capacity is described by injecting HF oscillations from a circuit *M* and taking readings on a pair of phones with the condenser *C* connected



No. 359041.

(*a*) to the anode, (*b*) to the control grid, (*c*) when the switch *K* is open.

Patent issued to H. L. Crowther and C. H. Smith.

SELECTIVE RECEPTION.

Application date, 18th August, 1930. No. 357345.

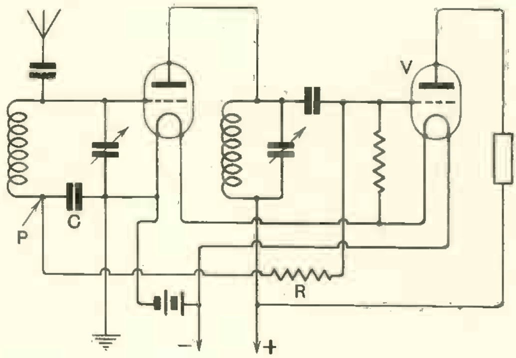
In order to improve selectivity and to maintain constant quality over the whole tuning range of a ganged multi-circuit receiver, the incoming carrier wave and the modulation side-bands are amplified separately, the former in a sharply tuned circuit and the latter in circuits having a flat-topped resonance curve. The two sets of oscillations are then fed to a two-valve rectifier, the carrier-wave in parallel and the side-bands in push-pull. One result is that only the modulation components associated with the original, and separately amplified, carrier wave appear in the rectified output, free from any interfering components that may have been present in the broadly tuned circuits preceding the double rectifier.

Patent issued to E. Y. Robinson and Associated Electrical Industries, Ltd.

AUTOMATIC VOLUME-CONTROL.

Convention date (Holland), 15th April, 1930. No. 358861.

Instead of using a resistance in the plate circuit of the detector valve to alter the effective grid-bias applied to a preceding valve, for the purpose of applying automatic gain-regulation, the same object is secured by inserting a high resistance *R* between the grid of the detector *V* and a point *P* in the input circuit of the high-frequency amplifier



No. 358861.

valve. A small condenser *C* isolates the point *P* from the common filament circuit, and prevents any undesirable coupling between the two valve stages.

Patent issued to N. V. Philips Gloeilampen Fabrieken.

LOUD SPEAKERS.

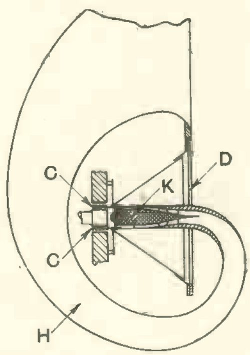
Convention date (Germany), 26th June, 1929. No. 358044.

Mechanical damping is applied to a loud speaker diaphragm so as to reduce its natural resonance and emphasise its response to the high-note frequencies. The damping elements consist of a number of fine wires of highly elastic metal, such as tungsten or steel, in the form of small loops or springs located between the diaphragm and rigid supporting-members arranged on both sides of it. The damping elements are situated along the loops of the natural overtones of the diaphragm, the correct positions being determined by a previous Chladni-figure test.

Patent issued to E. Podszus.

Application date, 31st July, 1930. No. 359081.

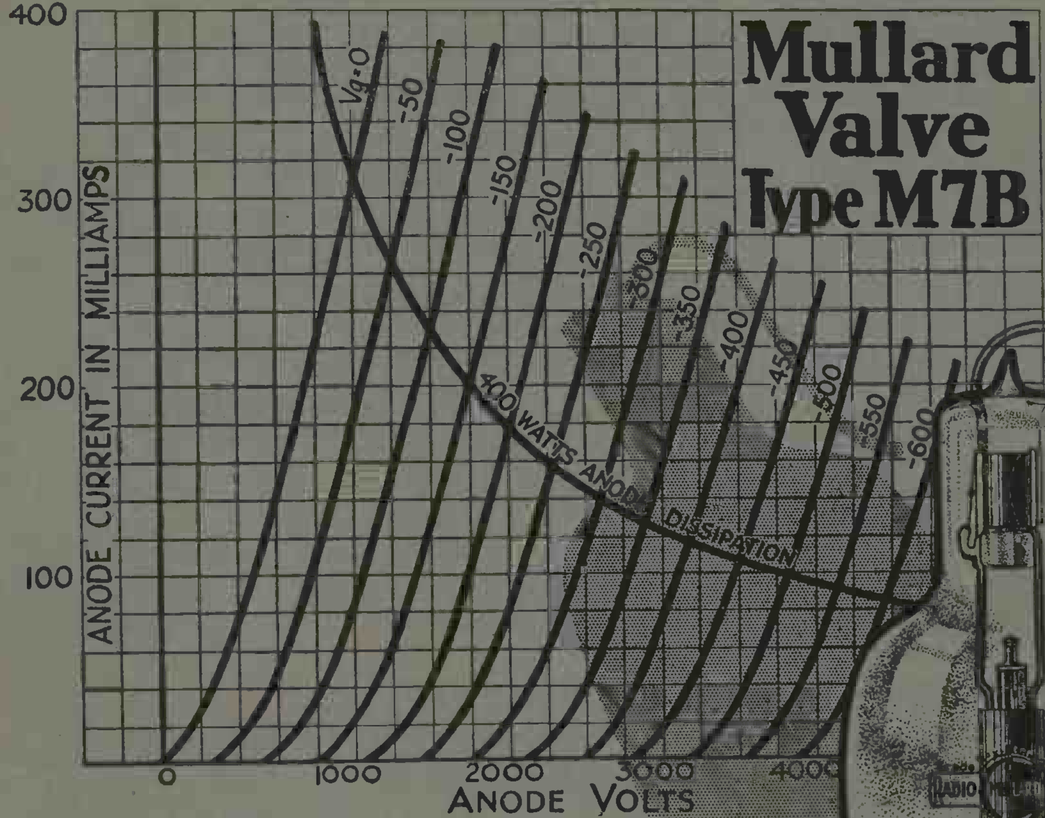
To secure an even balance between the high and low notes, a cone type of speaker is combined with a horn, as shown. The moving-coil is mounted on a cylinder *C*, to which is bolted a rigid member *K* inserted in the end of the horn *H*. The conical diaphragm *D* is impulsed directly and emphasises the lower register.

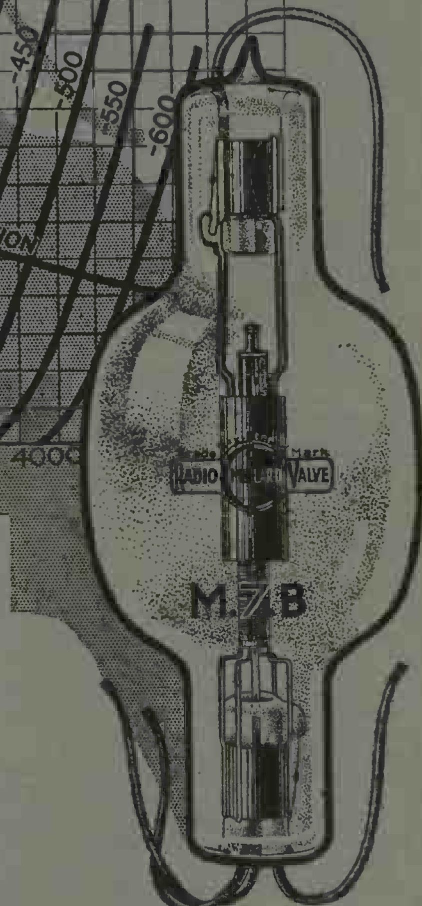


No. 359081.

Patent issued to the General Electric Co., Ltd. and D. A. Oliver.

Mullard Valve Type M7B





This valve is specially suited for use as an output valve in Public Address Amplifiers of the largest type such as are employed in the open air at football grounds, and for similar purposes where an undistorted output of about 100 watts is required. It is also suitable for use as a modulator in choke control telephony transmitters.

OPERATING DATA.

Filament Volts - 16.5 volts
Filament Current 9.5 amps
Total Emission - 0.55 amps
Max. Anode Volts 3,000 volts
Anode Impedance 3,100 ohms
Amplification Factor 7
Max. Continuous Dissipation 400 watts

The maximum output of about 100 watts is obtained with an anode voltage approximately 2,800 volts, and an anode current of 140 milliamps, the load impedance being about 10,000 ohms.

The list price is £20. 0. 0. and a special insulated holder can be supplied for £3. 10. 0.

Mullard
THE · MASTER · VALVE

MADE IN ENGLAND

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