EXPERIMENTAL WIRELESS
& The WIRELESS ENGINEER

VOL. VIII. FEBRUARY, 1931. No. 89

Editorial.

Rebroadcasting Distant Transmissions.

AT a meeting at the Heinrich Hertz Institute in Berlin, a paper was read by Manfred von Ardenne, on the 21st October, entitled, "A method for the production of good receiving conditions in large towns," and in the same number of the *Elecktrotechnische Zeitschrift* that the paper and discussion were published (20 XI. 1930) there appeared a further article by the same author entitled "Multiplex broadcasting on an ultra-short wave," in which an alternative method was described. According to Ardenne the background of disturbance in a large town is generally from 50 to 100 times as strong as it is in the country. This in itself would make the satisfactory reception of distant stations much more difficult in the town, but the state of affairs is far worse than the above figure would indicate because in passing across a large town strength of the distant signal may be reduced to a tenth of the value it would have in open country. If the signal strength of the distant transmission could be increased in the town to about 500 times its normal value, its relation to the disturbing background would be the same as in the country and equally good reception would be obtainable. Ardenne's proposal is to receive the distant transmission out in the country, far enough from the town to obtain the advantages of the strong signal and small disturbance, to amplify it, transmit it by means of wires to the centre of the town, further amplify it, and send it out from an aerial. It is important to note that all this is done at the original frequency without any rectification. Ardenne suggests that the relay station should be about 30 kms. from the centre of the town and that it should consist of from four to six receiving equipments, each tuned to one of the more important distant transmitters and each feeding a separate aerial in the centre of the town. If it were not for fading and the phenomena associated with it, this would give the people in a town the opportunity of receiving equally well and with equal ease their own local transmitter, and whatever six distant stations were considered by the authorities to be most suitable. The receivers at the relay station would be equipped with anti-fading devices and band-pass amplifiers; they would then feed into a common aperiodic amplifier the output of which, consisting of the mixture of the six high-frequency currents, would be transmitted into the town over a single line, then again amplified aperiodically before passing to the selective tuned amplifiers which feed the transmitting aerials. Ardenne does not propose to compete with the local transmitter, for he suggests an output of about

0.3 to 0.5 kW. for each aerial if the local transmitter has an output of 5 kW. He admits that over a certain region outside the town there will be interference between the waves thus sent out and those received directly from the distant station, but owing to fading phenomena the interference pattern would probably move about so that a person would sometimes be at a maximum point and sometimes at a minimum point; in fact, in Ardenne's opinion, such a person would not be able to differentiate between the effect due to the two waves and the ordinary fading effect. He also points out that people in the country have the choice of about 50 stations and could hardly object to losing half a dozen, some of which would probably be broadcasting identical programmes.

Technical Criticisms.

A number of leading personalities in German broadcasting took part in the discussion which followed the reading of the paper. Dr. Bredow pointed out that the scheme involved the transmission of waves at frequencies which were exclusively allocated to other countries. This is an interesting point seeing that the original waves are only picked up, amplified, and re-radiated. Dr. Bredow thought that even with the power suggested, interference in the original countries was not out of the question, and also, in view of the largely increased power of the regional stations under construction, the suggested power of 0.5 kW. would not be found adequate for the desired purpose. Both Dr. Bredow and Dr. Kiebitz thought that the quality of the long-distance reception was not consistently good enough for the suggested purpose, even with anti-fading devices. Every speaker feared that the suggested transmitters would cause interference with the local station in the many relatively insensitive and unselective receiving sets used by the people in the large towns. Dr. Schapira, as a Director of the Telefunken Company, sarcastically welcomed the suggested scheme because it would force people to give up their simple sets and buy more expensive ones.

Multiplex Broadcasting on an Ultra-short Wave.

Experiments with a 9-metre wave have been made in Berlin by the Post Office with the object of determining its suitability for broadcasting. Ardenne points out that if ordinary 9-metre broadcasting is employed the only part of an ordinary receiving set that could be used is the detector and low frequency amplifier since the radio frequency tuning devices and amplifier would be useless. The separation of several ultra-short wave programmes would need very special tuning devices. Ardenne therefore proposes to have a single ultra-short wave transmitter in the town modulated by the currents of ordinary broadcast frequency which have been transmitted over wires from the external relay station. The ultra-short wave would thus be modulated by, say, the six ordinary broadcast frequencies of the chosen distant stations, each of which is itself modulated by the music and speech. All that one need do to receive the programmes would be to insert a rectifier between the ultra-short wave receiving aerial and the normal broadcast receiver; the latter could then be tuned to any one of the six programmes. The ultra-short wave is so rapidly absorbed that its radius of action, and therefore of interference, would be confined to the immediate vicinity of the town and it would presumably cause no interference with the local transmitter. According to Ardenne, preliminary tests of the multiplex modulation and reception of ultra-short waves promise success for tests on a practical scale.

Objections.

Even if such a system could be installed to operate satisfactorily it is very questionable whether it is at all desirable. With the great increase of power of most of the important continental stations and the improvements in receiving apparatus, tolerable reception of many distant stations can be obtained by all those who really wish to receive them, and we doubt whether there is any real demand for the improved reception of any chosen few. Conditions may be different in such a continental city as Berlin; if so, it would be a simple matter for the German Post Office to put either of Ardenne's suggested schemes to the test for a single distant station, assuming that the distant station raised no objection to its transmission being boosted up in this way on the original wavelength.

G. W. O. H.

Some Notes on Field-strength Measurement.*

By A. L. Green, B.Sc., A.M.I.R.E.

SUMMARY.—During the course of "fading" observations at Radio Research Station, Peterborough, it was realised that the absolute strength of atmospherically-returned wireless waves could be calculated from a knowledge of,

(*a*) the field strength of the steady ground wave in daylight and
(*b*) any "fading" curve taken at night.

The following notes are a record of some attempts made at Peterborough to measure field strengths as low as 0.5 millivolts per metre, with simple unshielded apparatus. A high standard of accuracy has not, so far, been attempted, but the results already obtained indicate a useful field for development.

Introduction.

FROM time to time, methods of measuring the field strength of a wireless transmitter have been described, and one has been impressed both by the difficulties encountered and by the complex apparatus which has been designed to circumvent them. To start with, of course, the quantities to be measured are extremely small: even in the wipe-out area of a broadcast transmitter the field is less than a tenth of a volt per metre, and at a distance of fifty miles it has fallen to about one-thousandth of a volt, while the field strength of transatlantic telegraphy is only to be measured in microvolts per metre. Assuming that we have an average receiving aerial tuned with a series capacity and inductance, the voltage developed across the latter is likely to be about one hundred times the number representing the field strength of the signal in volts per metre. This can be measured with a high-frequency voltmeter of the Moullin type, so long as the field strength is not much less than ten millivolts per metre, that is to say, up to about twenty miles from a broadcast transmitter. At greater distances the voltmeter will be too insensitive to give accurate readings and we must precede it with a high-frequency amplifier. Once the necessity for this addition has arisen, the difficulties commence. Two courses are open to us: we may measure the amplification factor of the set and divide the voltmeter reading by it, or we may inject into the aerial a known artificial signal which shall give, after amplification, the same voltmeter reading as that produced by the signal we are trying to measure. In practice, both methods give rise to the same difficulties, namely, elaborate screening of the amplifier, of a local oscillator, and of some kind of attenuation apparatus. This is because the same fundamental principle underlies all measurements of small field strengths. If the aerial cannot deliver enough high-frequency energy to work a voltmeter or thermo-junction without amplification, we must install a local oscillator which can do so. The larger currents or e.m.f.s obtained from it, after measurement, must be compared with the original signal. In the first method of comparison, that of measuring the amplification factor of the set, a large e.m.f. from the local oscillator is applied directly to the voltmeter and measured. The same e.m.f. is then so attenuated, for instance by a network of resistances, that the amplification of the set under test can just bring it back to the original value as shown on the voltmeter. Thus the amplification and attenuation factors are reciprocal: dividing the voltmeter reading by the amplification factor of the set to get the original signal is the same thing as multiplying by the fraction which represents the attenuation of the large current from the local oscillator, and this latter, of course, is the artificial signal injection method, so that, either way, local oscillator and attenuation box are required with the necessity of careful shielding, since otherwise the amplifier would pick up more by induction (and radiation) from the local oscillator than it received *via* the attenuator. The only way out of this screening difficulty is the abolition of the high-frequency amplifier, and then we are at grips again with the problem of insufficiently sensitive voltmeters and thermo-junctions. Something, however,

* MS. received by the Editor, October, 1929.

can be done to increase the sensitivity of high-frequency voltmeters.

The Balanced Valve Rectifier.

There has been developed, at the Peterborough station of the Radio Research

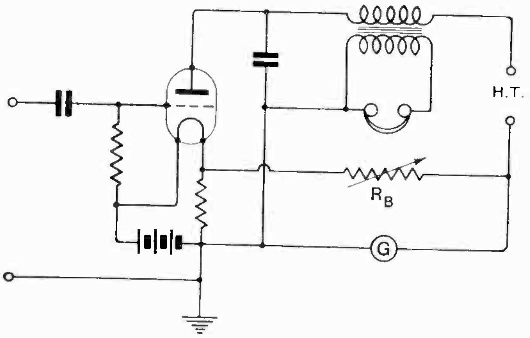


Fig. 1.—*Balanced valve for leaky grid rectification.*

Board, what is in effect a super-Moullin voltmeter. Originally it was designed to replace the crystal rectifier when used in conjunction with an amplifier and a galvanometer, for recording "fading" and the special transmissions used in Heaviside Layer Height measurements, but it was soon realised that it had other important applications. So long as calibration apparatus is available, the balanced valve rectifier makes an admirable high-frequency voltmeter of great sensitivity. In Figs. 1 and 2 are shown the leaky grid and anode bend balanced rectifiers, which have proved, out of a number investigated, to be the best compromise between sensitivity, constancy in operation, and safety when used with a delicate galvanometer. It should be remembered that the large, steady anode current of a valve rectifier, or the equal balancing current, would burn out a galvanometer accustomed only to micro-amperes: in the arrangements shown, a failure of the valve filament destroys both steady anode and balancing currents simultaneously. Fig. 3 is the parent circuit of the balanced rectifier, first suggested by Prof. E. V. Appleton, F.R.S. It is essentially a Wheatstone Bridge, in which two arms are, respectively, the filament resistance and the anode-to-filament resistance.*

* The anode-to-filament resistance is the ratio of anode voltage and anode current in this case: it is greater than the slope-resistance or impedance of the valve.

Figs. 1 and 2 are still bridge circuits, but a separate high-tension battery has been added to increase the sensitivity, and another minor alteration enables the galvanometer to be earthed. A six-volt accumulator for lighting the two-volt valve provides an e.m.f. of 4 volts in the filament rheostat, this excess voltage being used to balance out the steady anode current, the latter, in the case of a leaky grid rectifier, is of the order 2 milliamperes, so that the balancing resistance R_B is approximately

$$\frac{4}{2 \times 10^{-3}} \text{ or } 2{,}000 \text{ ohms.}$$

A resistance box reading up to 10,000 Ω is suitable here, but, for the anode bend rectifier, a continuously variable resistance of maximum value 100,000Ω will probably be necessary. Since the filament rheostat is in the negative battery lead, grid bias for the anode bend rectifier can be obtained without the use of a separate bias battery. If δi_a is the change in steady anode current for a given grid signal, and $i_{gal.}$ the corresponding galvanometer current, we have

$$i_{gal.} = \delta\, i_a \times \frac{R_B}{R_B + G}$$

so that, if the galvanometer resistance G is about 100 Ω and R_B not less than 2,000 Ω, the shunting effect of the balancing resistance of the galvanometer is negligible, and

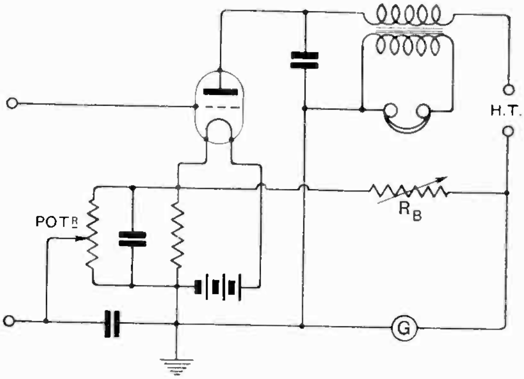


Fig. 2.—*Balanced valve for anode bend rectification.*

almost the whole of the change in steady anode current is registered.

Graph I shows the calibrations of

(*A*) the leaky grid rectifier and
(*B*) the anode bend rectifier

for grid signals up to 2.0 high-frequency volts, the galvanometer currents having been reduced to micro-amperes. It will be seen at once, that for small signals, the leaky grid rectifier is about twenty times more sensitive than the anode bend. The ordinates have been plotted as though they were of the same sign: actually δi_a is positive for the anode bend and negative for the leaky grid rectifier, but since we are only concerned with $\pm \delta i_a$ and not with

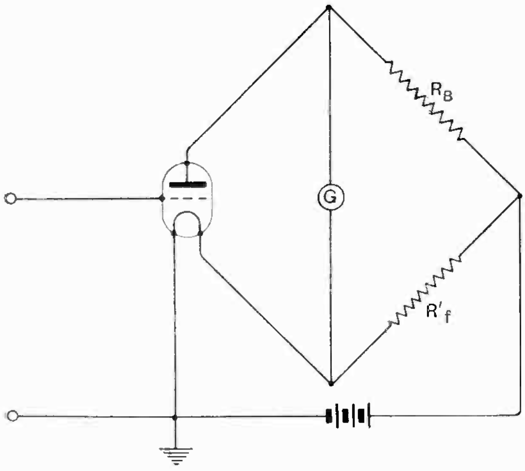


Fig. 3.—*Parent circuit of balanced valve rectifiers. The Wheatstone Bridge is completed by (a) the filament resistance and (b) the anode-to-filament resistance.*

$i_a \pm \delta i_a$, the only precaution to be taken is that of reversing the galvanometer leads in changing from one type of rectifier to the other.

A convenient arrangement of the apparatus is as follows:—

(*A*) Leaky grid rectifier
- Valve DEP215 $\mu = 6.25$, A.C. resistance $= 6{,}250$ ohms.
- High tension 30 volts.
- Grid condenser and leak 0.001μF. and 2 MΩ.
- Balancing resistance about 2,500 ohms.

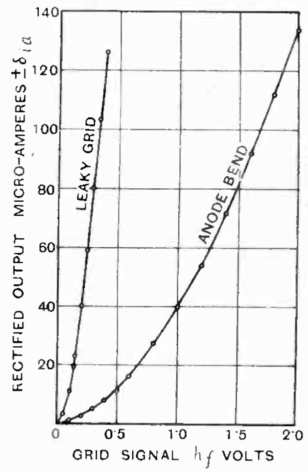
(*B*) Anode bend rectifier
- Valve DEH210 $\mu = 35$. A.C. resistance $= 75{,}000$ ohms.
- High tension, 90 volts.
- Grid bias 0.6 volts negative.
- Balancing resistance about 20,000 ohms.

The galvanometer is a Pye table type, full scale 100 divisions, and five divisions represent one micro-ampere. From Graph 1 we see that, in the case of the leaky grid rectifier, a signal of 0.05 h.f. volts produces a rectified output of 3 μA., that is, fifteen scale divisions, so that signals of the order 0.1 volts, and hence field strengths of 1.0 millivolts per metre, should be measurable with ease even when no amplifier precedes the balanced valve rectifier used as a high-frequency voltmeter.

The Balanced Valve Rectifier and Field-strength Measurements.

Method I.

During the course of fading observations at Radio Research Station, Peterborough, it was realised that an estimate could be made of the absolute strength of waves returned from the Heaviside Layer provided (*a*) the day-time field strength of the ground wave of a transmitter was known, and (*b*) fading records were taken at night. Graph 2 shows curves of the 2LO transmitter's signal at Peterborough for the day 27 XI '28. The first part of the curve, taken just after sunset, is a record of the ground ray with the atmospheric ray just beginning to appear, while the second half of the curve is a normal fading curve for the period two hours after sunset. The maxima of the latter represent the sum of, and the minima the difference between, the ground and atmospheric waves, so that if the field strength of the ground wave is known and the recording apparatus is calibrated, it is an easy matter to calculate the absolute strength of the atmospheric wave. For the day shown, the ground wave field strength was 0.7 mV. per m. and the atmospheric wave about 0.15 mV. per m. The apparatus used is shown in Fig. 4.



Graph 1.—*Calibration of anode bend and leaky grid balanced rectifiers.*

A flat-top vertical aerial is tuned by a series condenser C_1 and inductance L_1, while the resistance R'_{AE} composed of No. 47 S.W.G. Eureka wire, needed in the measurement of the aerial high-frequency resistance, can be shorted at will. The two-way switch puts the balanced valve rectifier

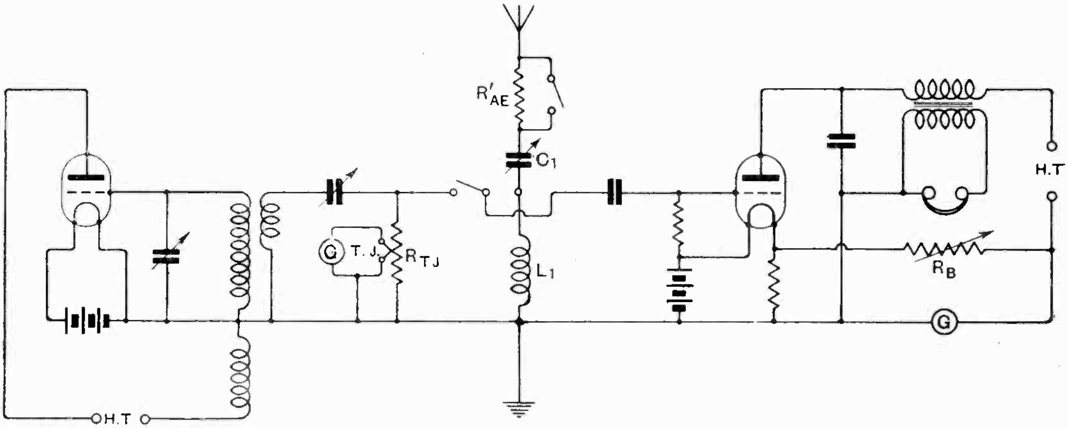


Fig. 4.—*Simple unshielded apparatus for measuring field strengths. On the right is a leaky grid balanced rectifier. On the left is a H.F. oscillator feeding into the calibrating resistance R_{TJ}.*

across either the aerial tuning inductance or the resistance R_{TJ}, which is actually the heater resistance of a non-contact thermo-junction TJ. The procedure is to tune in the signal with the condenser C_1 and note the galvanometer deflection: then insert R'_{AE} and note the reduced deflection. Switch the rectifier over to the calibration apparatus, adjust the oscillator to approximately the same wavelength as the received signal and the currents flowing in the thermo-junction so that the balanced valve rectifier gives the same outputs as it did when connected to the aerial, with and without R'_{AE}. Reference to the thermo-junction galvanometer, and a knowledge of the heater resistance, give us the voltages V and V' developed across the latter and applied to the rectifier. These will be equal to the signal voltages across the coil, and will be proportional to the currents flowing in the coil and therefore in the aerial. If the aerial current was originally I, falling to I' when the resistance R'_{AE} was added, with V and V' the corresponding voltages developed across the coil L_1, then

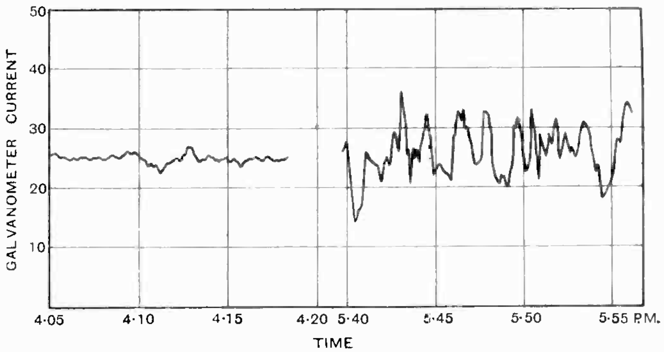
$$\frac{I}{I'} = \frac{V}{V'}$$

and $R_{AE} = R'_{AE} \times \dfrac{I'}{I - I'} = R'_{AE} \times \dfrac{V'}{V - V'}$

by the resistance-variation method of measuring H.F. resistance, while the field strength of the signal

$$F = \frac{I \times R_{AE}}{h},$$

where h is the aerial effective height or



Graph 2.—*2LO received at Peterborough, November 27th,* 1928. *Sunset* 3.56 *p.m.*

approximately

$$F = \frac{R_{AE}}{h} \times \frac{V}{L_1 p}$$

where p is the angular frequency of the signal. Corrections for self-capacity and H.F. resistance of the tuning coil are generally unnecessary if care is taken to wind an efficient solenoid. In the actual coil used, the data were

Inductance 118 μH.
H.F. Resistance 6 ohms at 360 metres wavelength.
Self-capacity in circuit 21 $\mu\mu$F.

so that the correction factor was 0.93,

$$\text{and} \quad I_{AE} = \frac{V}{L_1 p \times 0.93}$$

It should be especially noted that, in spite of the presence of a local oscillator, no shield of any kind is required, since the balanced valve rectifier contains no circuits tuned to the local signal, nor is the latter in existence when the aerial is operative. The only quantity still unknown is the effective height of the aerial, and this was measured by the well-known method* of comparison with a large single turn loop of known area, in this case 198 square metres. It was found that the transmitter 5GB was powerful enough to produce a measurable H.F. current both in this loop and in the vertical aerial, so that insertion of thermo-junctions and "added-resistances" in each gave the high-frequency resistances and the signal currents. Hence the effective height of the aerial

$$= \frac{I_{AE}}{I_L} \times \frac{R_{AE}}{R_L} \times \frac{2\pi}{\lambda} \times A$$

where λ is the wavelength of 5GB and A the loop area. R_{AE} and R_L include the resistance of a thermo-junction heater in each case. The thermo-junction reading for the loop current is subject to a correction for loop self-capacity, but if the tuning capacity is made large there will only be a small error in the calculations for H.F. resistance and for total loop current. The flat top of the vertical aerial was about 30 feet average height, and the effective height was computed to be 6.1 metres, that is 0.67 of the real height.

The field strength at Peterborough of the 2LO transmitter appeared to vary a little from day to day, but the values were between 0.5 and 1.0 millivolts per metre. The balanced valve rectifier dealt with signals of the order 0.1 H.F. volts, so that its substitution for the valve voltmeter has extended the applicability of this simple method of measuring field strengths from about 10 mV. per m. down to less than 1.0 mV. per m. The one great disadvantage of this apparatus is, of course, the lack of selectivity in the single tuned circuit, but this defect has been remedied in the method about to be described.

Method II.

As long ago as 1923 there was described† a beautifully simple method of measuring

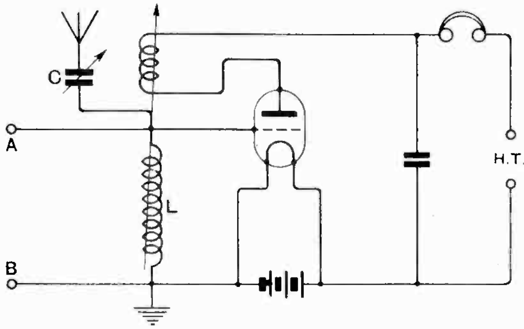


Fig. 5.—*Original circuit of the Appleton method of measuring field strengths.*

field strengths depending on the principle of the pulling-into-step of two closely-coupled oscillators. It has not been widely used up to the present time, probably because the simplicity itself has fostered a suspicion that it could only be of use very near to a powerful transmitter. As originally described, the apparatus required is shown in Fig. 5: this is merely an oscillating valve coupled through the series condenser C with an aerial. A valve voltmeter is connected across the tuning coil L to measure the oscillating voltage V_{AB}. If now the capacity of C is varied, the frequency of the local oscillations can be made to pass through that of the transmitter, when the well-known heterodyne squeal will be heard in the telephones: however, if the valve is only feebly oscillating and the received signal is a strong one, there will be a wide silent space in which the free and forced oscillations are in step, while at the edges of this silent space there are sharp minima

* *See* Moullin: Radio-Frequency Measurements.

† E. V. Appleton: *Proc. Camb. Phil. Soc.*, 23, 231, 1923.

in the voltmeter readings separated by a small frequency change of δn, where n is the transmitting frequency. If E is the e.m.f. of the signal, in the aerial it has been shown that

$$\frac{\delta n}{n} = \frac{1}{\sqrt{2}} \times \frac{E}{V_{AB}}$$

so that the field strength

$$F = \frac{E}{h} = \frac{\delta n}{n} \times \frac{V_{AB}}{h} \text{ V. per m. RMS.}$$

where h is the aerial effective height in metres, and V_{AE} is measured in peak H.F. volts.

It is noteworthy that we need know neither the tuning coil constants nor the aerial high-frequency resistance. If now we apply the balanced valve rectifier to the problem we arrive at the circuit of Fig. 6, in which the same valve acts as both oscillator and voltmeter, and anode bend rectification is used to secure a smooth control of reaction. The primary winding of the telephone transformer acts also as a high-frequency choke and the variable condenser C_R controls the degree of oscillation. It was soon found that the grid coil L_1 should be chosen so that the aerial series condenser C has a large capacity of the order 1,000 $\mu\mu$F.: otherwise a small change δC in C alters the oscillating voltage across the coil considerably, and, at the same time, the greater C is, the greater

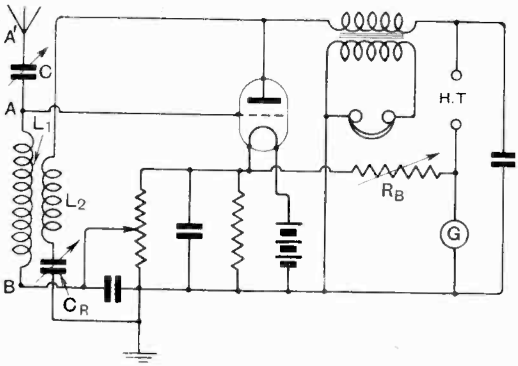


Fig. 6.—*The Appleton method using a balanced valve as both detector-oscillator and voltmeter.*

is the change in C for a given small frequency change δn, and the easier its measurement. It is convenient to be able to calibrate the valve rectifier on the spot, and to do this the coils L_1 and L_2, and the aerial, are removed, while a thin wire resistance carrying a known H.F. current is connected across the points AB: the artificial signal is adjusted to produce the same rectified output as did the oscillating voltage V_{AB}, and hence the latter is measured.

The effective aerial height is found as in Method I, while $\frac{\delta n}{n}$ is best calculated from a knowledge of the aerial capacity C_A, the tuner C, and the self-capacity C_s of the coil L_1, since

$$\frac{\delta n}{n} = \frac{1}{2} \times \frac{C_A{}^2 \times \delta C}{(C + C_A)\ (C + \delta C)\ (C_A + C_s)}$$

Since the valve is in a sensitive oscillating condition, the aerial capacity can be measured by the simple substitution for it of a calibrated variable condenser, by adjusting the frequency of oscillations to that of a local heterodyne, first with the aerial connected and secondly with the calibrated condenser in its place, that is between the points A' and earth.

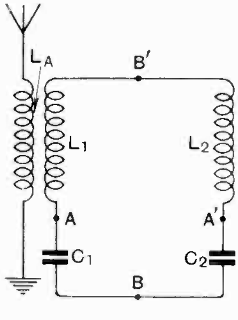


Fig. 7.—*Attenuation Device I.*

With this more modern apparatus, the Appleton method works well even for small field strengths less than one millivolt per metre, and it has the great advantage of being intensely selective, even though there is only the one tuned circuit; also there is no need for screening of any kind. The following data give an idea of the results to be obtained, even with experimental apparatus.

Transmitter	2LO	5GB	5XX
V_{AB} in h.f. peak volts	1.0	8.8	4.3
C in $\mu\mu$F.	1,500	1,380	580
$C + \delta C$ in $\mu\mu$F. ..	1,560	1,660	740
C_A in $\mu\mu$F.	250	250	250
h effective height in metres	6	6	6
$\delta n/n$	0.0028	0.013	0.0325
Field strength in millivolts per m.R.M.S.	0.5	19	23

The edges of the silent space are a little indefinite when the transmitter is strongly modulated, but since the estimation of δC

can be done in a few seconds, it is quite convenient to wait for a lull in the programme.

Attenuation Device I.

We have seen that when small field strengths are to be measured, the need arises for

(*a*) a local oscillator supplying large currents and

(*b*) an attenuator of known reduction factor.

Several varieties of the latter are well-known, for instance

(1) a network of thin wire resistances;

(2) an arrangement of shunting capacities;

(3) a calibrated mutual inductance or a radio-goniometer.

The Director of this station has suggested that the properties of the circuit of Fig. 7 might be applicable to the design of an attenuator. Suppose the inductance L_A is connected to an aerial and the whole circuit L_1 L_2 C_1 C_2 is tuned to the transmitter frequency p such that

$$\frac{1}{p^2} = (L_1 + L_2) \div \left(\frac{1}{C_1} + \frac{1}{C_2}\right).$$

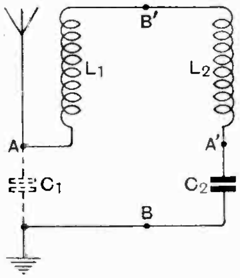


Fig. 8.—*Attenuation Device I: the capacity of the aerial replaces condenser C_1.*

Then if an amplifier is tapped across the points AA', the full resonant signal voltage V_{AA}' will be available, but if the points BB' are used, only a fraction of V_{AA}' can be obtained. If now the condenser C_1 is made the actual capacity of an aerial the circuit of Fig. 8 results, where B is the earth. It is a little more convenient to make our tapping points AB and $B'B$, and then if $L_1 = L_2$,

$$\frac{V_{B'B}}{V_{AB}} = \frac{C_2 - C_1}{2C_2}.$$

The method of measuring field strengths would be to tune in the signal and note the deflection of the galvanometer in a balanced valve rectifier, using the connection AB, then change to $B'B$, switch on a local oscillator which shall produce a large measurable current in the aerial and the same rectified output as did tl signal.

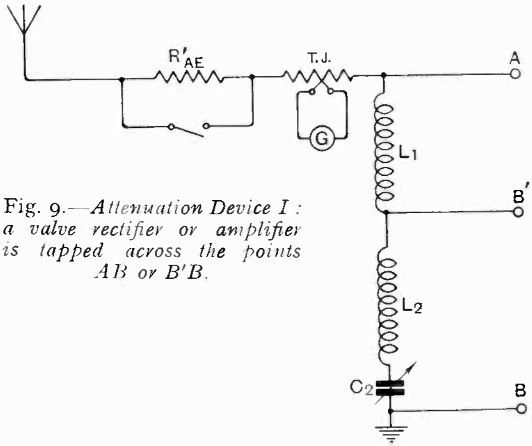


Fig. 9.—*Attenuation Device I: a valve rectifier or amplifier is tapped across the points AB or $B'B$.*

The original signal current I_{AB} is then computed as

$$I_{AB} = I_{B'B} \times \frac{C_2 - C_1}{2C_2},$$

where $I_{B'B}$ is actually measured by a thermo-junction in the aerial. A suitable circuit is shown in Fig. 9: it is, of course, necessary to use a leaky grid rectifier here in place of the anode bend. The aerial resistance and effective height are found in the usual way

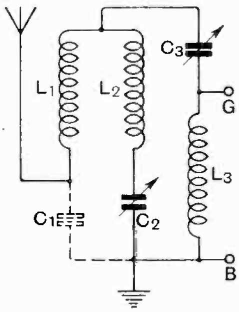


Fig. 10.—*A wave-trap suggested by Attenuation Device I. The circuit $L_1L_2C_1C_2$ is tuned to the interfering signal, while an amplifier is connected across the points GB.*

and data for the 5GB transmission are as follows:—

Tuning capacity C_2 ..	=	2,225 $\mu\mu$F.
Aerial capacity C_1 ..	=	250 $\mu\mu$F.
Aerial resistance, including thermo-junction and tuning coils	=	75 ohms.
Aerial effective height ..	=	6 metres.
Aerial current $I_{B'B}$ ..	=	4.6 mA. peak.

From which the field strength

$$F = \frac{75}{6} \times \frac{4.6}{\sqrt{2}} \times \frac{(2{,}225 - 250)}{4{,}450}$$

or 18 mV. per m. R.M.S.

This method of attenuation is, of course, equally applicable to more complicated apparatus, including a screened amplifier, while at the same time an admirable "wave-trap" is suggested on the lines of Fig. 10,

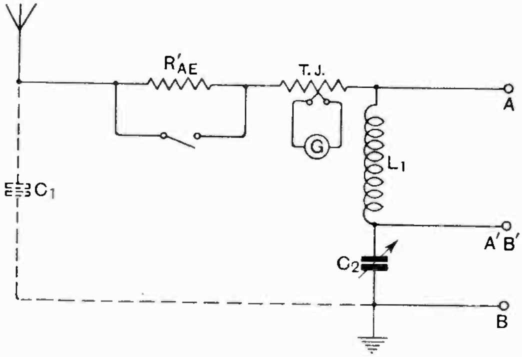


Fig. 11.—*Attenuation Device II: a valve rectifier is connected to either AB or A'B', B.*

in which the circuit $L_1 L_2 C_1 C_2$ is carefully tuned to the interfering signal, an effort being made to choose L_1 and L_2 equal and of an inductance such that C_2 is approximately equal to C_1, while the desired signal is tuned by the circuit $L_3 C_3$ and applied to the amplifier from the points GB. In this form the circuit somewhat resembles a well-known method of working duplex telephony.

Attenuation Device II.

On going a step further with the circuit of Fig. 8, that of removing the coil L_2, we see that

$$\frac{V_{A'B}}{V_{AB}} = \frac{C_1}{C_2}$$

and the resultant circuit is as in Fig. 11, where the points B' A' coincide. The method of procedure is similar to the last: tune in the signal, using the tapping points AB, and note the rectified output of the balanced valve. Then change to $A'B$, switch on a powerful local oscillator and read the aerial current which will produce the same rectified output as before. The original, and unmeasurable, aerial current due to the signal is therefore

$$I_{AB} = I_{A'B} \times \frac{C_1}{C_2}.$$

The aerial resistance, including that of thermo-junction and tuning coil, is found by the resistance-variation method. It should be noted here that C_2 must be much greater than the aerial capacity C_1 if the current produced in the aerial by the local oscillator is to be measurable; also, if the rever seis true and C_1 is greater than C_2, then the greater rectified output is obtained when the amplifier or rectifier is connected across the points $A'B$—that is, across the tuning condenser C_2; and this arrangement is suggested as an alternative to the more usual one of loosely coupling an aerial when selectivity is required, since the moving plates of the aerial series condenser C_2 can now be at earth potential. The two circuits are contrasted in Fig. 12.

Data indicative of the results to be obtained with this simple arrangement are given below, for the transmitter 5GB received at Peterborough.

Tuning capacity $C_2 = 1{,}420\ \mu\mu$F. Aerial capacity $C_1 = 250\ \mu\mu$F. Aerial current produced by local oscillator = 9.3 mA. peak. Aerial resistance, including thermo-junction and coil = 92 ohms. Aerial effective height = 6 metres.

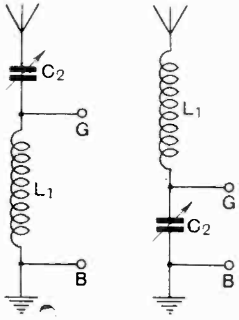


Fig. 12.—*Alternative ways of aerial series tuning.*

$$\text{Field strength} = \frac{9.3}{\sqrt{2}} \times \frac{250}{1{,}420} \times \frac{92}{6}$$

or 17.8 mV. per m. R.M.S.

The Calibrated Local Oscillator.

Finally, a few notes on the local oscillator may not be out of place. In measuring the amplification factor of sets over a range of wavelengths it is very convenient to have an oscillator which gives a uniform oscillatory output when the tuning is varied. Now, with the simple oscillator, having a tuned grid circuit and magnetic reaction from the anode circuit, the condition for oscillation, neglecting a number of factors, is

$$\frac{\mu}{R_a} \times M = C_1 R_1$$

where M is the mutual inductance between grid and anode coils,

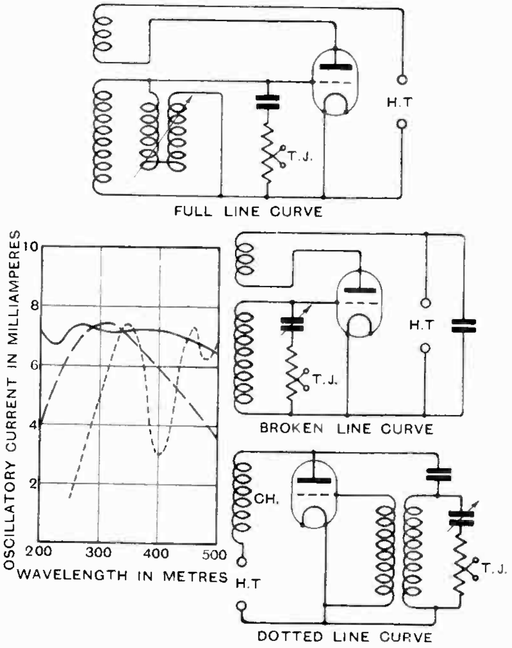
μ is the valve amplification factor and R_a its anode circuit resistance.

R_1 is h.f. resistance of the grid coil L_1 and

C_1 the grid tuning capacity.

So that if the frequency of oscillations is varied by increasing the capacity C_1, then the mutual inductance M must be increased if the valve is to remain oscillating. In practice this means that, with a fixed amount of magnetic reaction the oscillatory output will vary considerably with the tuning. Now, it is also possible to vary the frequency of oscillations by altering the grid tuning inductance, that is by using a variometer, and in this case, since L_1 does not appear in the condition for oscillation, the output should be constant over a large range of wavelengths. Unfortunately, there is one more variable, R_1, the H.F. resistance of the variometer, but it is possible to balance its increase of resistance with increase of frequency, by arranging that the natural period of the anode reaction coil shall be at the point where the variometer resistance is greatest, and then another neglected factor, the feed-back through the anode-grid capacity of the valve, should just neutralise the decrease in oscillatory output at the high-frequency end of the tuning scale.

An idea of the improvement to be obtained in securing a constant output is shown in Graph 3, where the oscillatory outputs of three types of oscillator are contrasted. In the case of the variometer circuit, magnetic reaction is obtained by connecting in parallel with the variable inductance a fixed one with which the anode coil is coupled; had the latter reacted directly on to the variometer, the amount of magnetic reaction would have varied with the position of the rotor coil.



Graph 3.—*Comparison of oscillatory outputs of three types of oscillator.*

In conclusion, it is hoped that these notes will discourage the idea that the measurement of field strengths is necessarily a very difficult art: on the lines indicated, it is possible to do a good deal with simple unshielded apparatus. The work described was carried out as a subsidiary experiment in the programme of the Radio Research Station, Peterborough, of the Department of Scientific and Industrial Research, to whom the author is indebted for permission to publish these notes.

Testing Radio Valves.*

The A.C. Bridge Method.

By C. S. Bull, B.Sc.(Hons.).

SUMMARY.—It is shown that in order to determine completely the performance of a valve it is necessary to measure two of the three characteristics M, g and R_a, and in addition to make tests on the uniformity of these characteristics over the range of conditions under which the valve may be operated. The accuracy and speed of various methods of test is discussed, and it is shown that an A.C. Bridge provides probably the quickest and most useful method of testing.

An A.C. Bridge test board is described in detail, to measure M values between 2 and 1,000, g values between 0.2 and 6.0 mA/volt, and R_a values between 500 and 50,000 ohms. In addition, it will measure the amplification given by a triode when used as a resistance coupled amplifier. Finally, a particular example of the utility of the test board indications is given.

Valve Characteristics.

1.1. The ideal triode radio valve has anode volts-anode current characteristics consisting of a group of parallel straight lines, as shown in Fig. 1. If the curves are drawn for one volt grid steps, the intercepts on the anode voltage axis are equal to M, and those on the anode current axis equal to g. Further, if ϕ is the angle between the anode volts axis and the characteristics

$$\cot \phi = R_a$$

A valve with such characteristics having a fixed load in its anode circuit will amplify without distortion provided its anode current is never reduced below zero or its grid potential is never positive. As an anode bend detector it will rectify modulated H.F. without distortion if it is biassed to the point of intersection between any characteristic and the anode voltage axis.

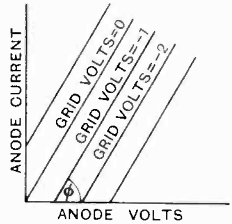


Fig. 1.

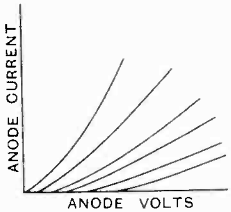


Fig. 2.

1.2. Actual triodes show departures from the above characteristics, even when ideally constructed, on account of two factors. The first factor is the space charge surrounding the cathode, which produces curvature of the characteristic, so that R_a and g vary from point to point, while the value of M is not affected. The second factor causing departure from the ideal characteristics is the gap between the wires of the grid, which causes M to become smaller as the anode voltage is increased, the grid voltage is made more negative and the anode current reduced. An exaggerated form of actual characteristics is shown in Fig. 2. Irregularities in manufacture intensify the variations in M, g and R_a.

1.3. These variations in M, g and R_a give rise to distortion when the valve is used either as an amplifier or a detector.

Methods of Testing.

2.1. To determine the quality of any triode as an amplifier or detector, it is therefore necessary to measure any two of the interdependent parameters M, g and R_a at some point of the characteristics, and to find the extent of their variation over the permitted operating range.

M, g and R_a can be determined by static readings, but it will be seen that the accuracy of the measurement depends on the accuracy of the meters and the range of current and voltage over which the test is made. Increasing the range to reduce measuring errors gives results which are the average values of the characteristics over the range. Thus the actual values of M, g and R_a at a point on the characteristics cannot be determined by static tests. Furthermore, static tests may give sufficiently false results to mask any variations in the characteristics between one point and another.

By drawing complete sets of characteristic curves the values of M, g and R_a can be

* MS. received by the Editor July, 1930.

determined at any point, and the variation noted, but this is obviously a laborious method.

2.2. The above argument on static testing methods applies to triode valves. The case of screened valves, on account of their much higher M and R_a values, is more difficult. Static tests are almost impossible unless sensitive back-balanced meters are used. Without very sensitive meters, errors of over 50 per cent. are common.

2.3. For the rapid testing of valves it is therefore necessary to devise a test that will measure the value of M, g or R_a over any chosen small region of the characteristic. A well-known method consists of applying a small A.C. voltage either between the grid and filament of the valve or in its anode circuit with suitable anode circuit loads, and (a) measuring the output, or (b) balancing the output against a known A.C. voltage.

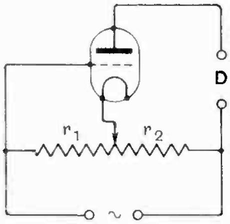


Fig. 3.

In the first method, (a), since the output must be small, its direct measurement will be difficult. If the output is amplified, the overall gain of the amplifier has to be determined. Both ways of making a direct measurement of small outputs lead to uncertainties, unless delicate instruments are used.

In the balancing method, (b), an amplifier can be used to detect the balance point, which will be quite independent of the gain in the amplifier. Thus, sensitivity can be combined with small input values, and the readings obtained can be taken to be the actual values of M, g or R_a at the operating point.

Van der Bijl gives on page 209 of his book, "The Thermionic Vacuum Tube," descriptions of bridge circuits for measuring M, g and R_a. These circuits, however, will be seen to be unsatisfactory for use in testing large power valves or screened grid valves when the considerations of paragraph 4.1 to 4.6 dealing with bridge design are taken into account.

The Theory of the A.C. Bridge.

3.1. The circuits commonly employed for measuring M, g and R_a will now be described.

In Fig. 3 is shown the circuit for M measurements. The bridge consists of a slide wire of resistance $(r_1 + r_2)$ r_1 and r_2 being the arms of the bridge. D is the detector by means of which the balance point is determined.

When no current is indicated by D, M is given by

$$M = \frac{r_2}{r_1}$$

It will be noted that the circuit virtually places an infinite impedance in the valve anode circuit, since no A.C. current flows in the anode circuit. The D.C. anode current of the valve flows through the slide wire and detector.

Fig. 4 shows the circuit for measuring g. Here, a resistance R is placed between the anode and filament, and the D.C. anode current is prevented from flowing through the slide wire by means of a condenser in series with the detector. The value of R is small compared with the impedance of the valve.

When the balance is obtained, *i.e.*, when there is no current in the detector

$$\frac{r_1 M R}{R + R_a} = r_2$$

which gives

$$g = \frac{1}{R}\Big/\left(\frac{r_1}{r_2} - \frac{1}{m}\right) \quad \ldots \quad \ldots (1)$$

This equation assumes that the H.T. battery resistance is small.

It is usually possible to select R, r_1 and r_2 so that $\frac{1}{M}$ is small compared with $\frac{r_1}{r_2}$. The equation for g then becomes

$$g = \frac{1}{R} \cdot \frac{r_2}{r_1} \quad \ldots (2)$$

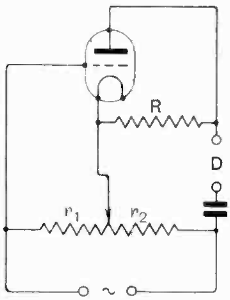


Fig. 4.

If now the slide wire is scaled in terms of g, from equation (2) a correction in accordance with equation (1) must be applied to the reading when M is low and g high. Actual correction curves will be given later.

Fig. 5 shows the circuit for measuring R_a.

This is a Wheatstone Bridge operated on A.C., the resistance r_1 and r_2 forming the calibrated slide wire, and P the comparison resistance. When there is a balance,

$$R_a = P \cdot \frac{r_2}{r_1}$$

In addition to M, g and R_a the A.C. bridge will measure the amplification given by triodes when resistance coupled. The circuit of Fig. 4 is employed, R having a high value. The resistance amplification, A, is given by

$$A = \frac{r_1}{r_2}$$

when there is a balance but

$$A = \frac{MR}{R + R_a}$$

and we can therefore make A nearly equal to M. Thus, by measuring M, then A, an indication of the amount of variation in M between two points of the valve characteristics can be obtained, without changing the anode and grid supply voltages.

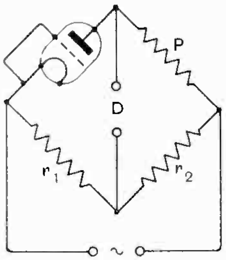


Fig. 5.

The Design of an A.C. Bridge.

4.1. Having set out the measurements required on valves and the reasons for adopting a bridge method of testing, we will describe the design of an A.C. bridge, and indicate briefly lines along which development has taken place.

4.2. After trials with buzzers, motor generators and oscillators, the mains, at 50 cycles, have been chosen as the source of A.C., for energising the bridge. Buzzers frequently refuse to buzz, have a very small power, and give a very unsatisfactory wave form. Motor generators and oscillators are high in first cost and maintenance.

4.3. In order to detect the balance point, a transformer primary winding is connected across the position D in Figs. 3, 4 and 5, the secondary feeding an L.F. amplifier followed by an anode-bend detector. The early transformers had a step-up ratio of 1 to 3 and a resistance of 1,000 ohms approximately. This resistance was a serious source of error in the case of screened valves and large power valves on account of the voltage drop in it. As transformer design improved, it has been found possible to increase the step-up ratio to 1 : 20, and to reduce the resistance to 50 ohms.

4.4. The amplifier following the transformer has also undergone changes in design. The first were high-gain transformer-coupled two-valve amplifiers preceding a detector valve. They were frequently quite insensitive at 50 cycles, and almost unstable at 500 cycles, and were therefore easily disturbed by microphonic effects in the valve under test and by the scratching noises set up by the slider on the slide wire forming part of the bridge resistances.

The latest amplifier consists of a single tuned transformer stage tuned to 50 cycles. It is followed by a high-M valve working as an anode-bend detector, and is practically unaffected by ordinary slider noises or microphonic noises.

4.5. Following the improvements in the amplifier and detector arising from advances in transformer and valve design, the resistance of the bridge has been reduced without loss of sensitivity. The effect of this change is to reduce the disturbance due to capacitative and inductive currents in the board. Since these currents are out of phase with those being balanced, they give rise to indefinite balance points, and consequent difficulty in reading. On this account the reading and the sharpness of the balance on the older A.C. bridges depended on the point at which the bridge was earthed. The earthing point had to be chosen after many tests, and depended on the lay-out and position of the board. The latest low-resistance bridge may be earthed at almost any point without affecting the reading more than 5 per cent. All the resistances are wound non-inductively, although this is not strictly necessary.

The inductance of the slide wire in the latest test bridges is reduced to its minimum value by winding it over empire cloth on a thick copper ring.

4.6. The circuit used after taking into account the considerations in paragraphs 4.1 to 4.5 is shown in Fig. 6. In Fig. 7 is shown a photograph of a bridge embodying this circuit. The numbers on the photograph correspond with those in the circuit diagram, Fig. 6. The lay-out has been considered from the point of view of avoiding capacity effects. Fig. 8 shows the correction curve to be used when measuring slope of valves with low M values. The correction is negligible for M greater than 5 and slope

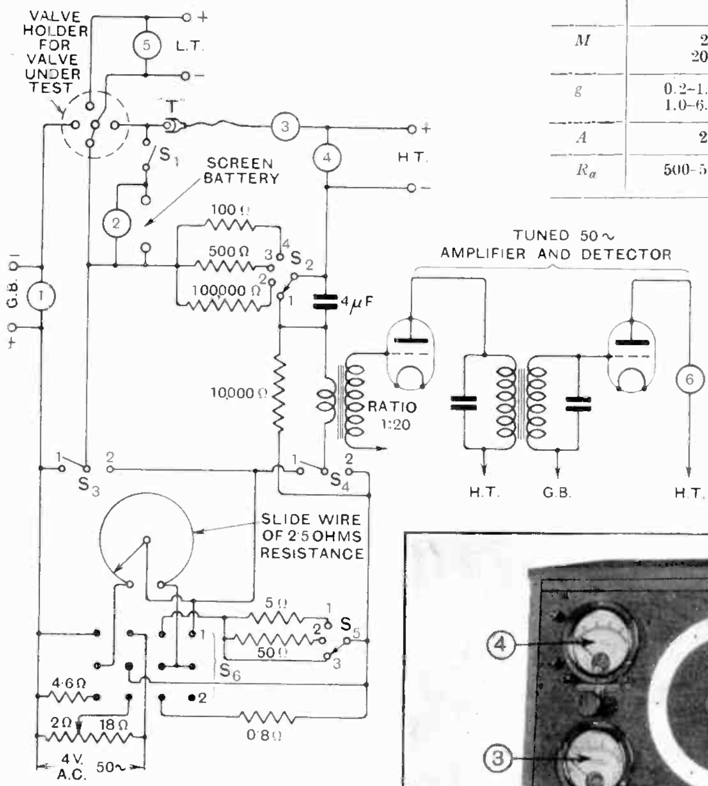


Fig. 6.—*Circuit of A.C. bridge for testing radio valves. Meters*:—1, *grid volts*; 2, *screen volts*; 3, *anode current*; 4, *anode volts*; 5, *filament volts*; 6, *detector-valve anode current*.

less than 2 mA/volt, unless results closer than 5 per cent. are required.

The A.C. voltage applied to the supply terminals of the bridge is 4.0, so that the excursion of the anode voltage during a test for "M" or "A" is less than 11.2 volts, while the voltage applied to the grid of the valve during "g" measurements is less than 0.4 volt A.C. The conditions approximate closely to those required when the considerations of paragraphs 2.1 to 2.3 are taken into account.

The switch combinations to obtain the various ranges is shown in the table below :—

Characteristic.	Range.	Switch positions.				
		S_2	S_3	S_4	S_5	S_6
M	2–50 20–1,000	1 1	2 2	2 2	2 1	1 1
g	0.2–1.2 mA/V 1.0–6.0 mA/V	3 4	2 2	2 2	— —	2 2
A	2–50	2	2	2	2	1
R_a	500–50,000 ohms	1	1	1	3	1

When testing screened grid valves, the tab "T" is joined to the anode of the valve, and switch S_1 is closed.

Use of A.C. Bridge.

5.1. A test board built with neither compensation nor shielding on the lines indicated by the above discussion of design, while it does not give results as accurate as those described by Hartshorn in *Proc. Phys. Soc.*, February, 1929, using a

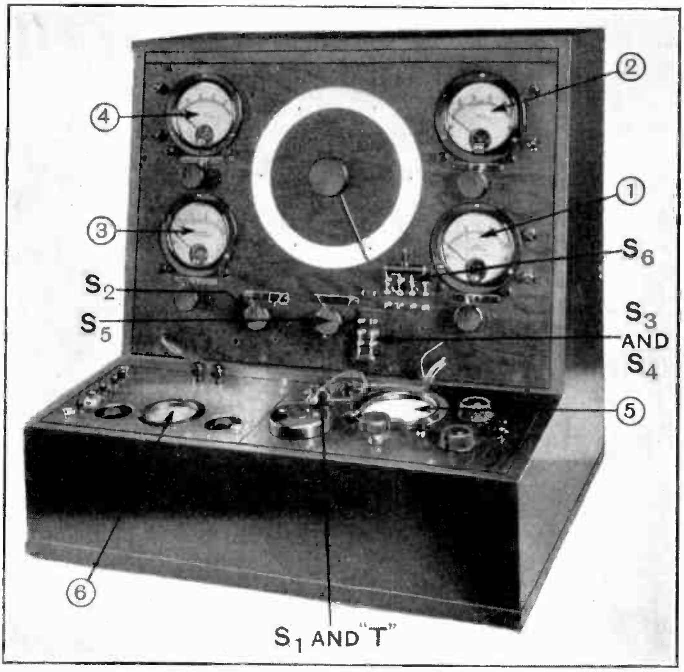


Fig. 7.—*The numbers correspond with those in Fig. 6.*

bridge energised at 1,000 cycles and having complete capacity compensation, gives readings to a far greater accuracy than is usually called for in testing radio valves. Furthermore, it is extremely rapid in use.

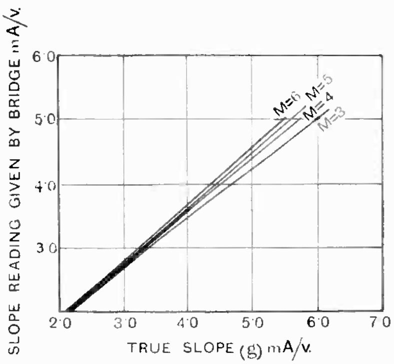


Fig. 8.—*Correction curves to be used when the slopes of valves of low voltage factor are measured on the A.C. bridge.*

5.2. Difficulty in obtaining a balance point is sometimes met with in the A.C. bridge. This is almost always due to one or more of three causes, (1) the valve under test may be extremely microphonic, (2) it may have unduly large variations in M over the range covered by the A.C. voltage in the bridge (Triodes only), or (3) it may be tested under unsuitable conditions. In case (2), the distortion produced by the variation in M produces harmonics which cannot be balanced out. Case (3) arises in screened valves, where, over certain parts of the characteristics, the values of M, g and R_a vary very rapidly, and again harmonics are produced.

5.3. A particular example of the speed and utility of tests with the A.C. bridge will now be given. Three valves, numbered 1, 2 and 3, of the "power" class, were tested. The anode voltage was 100 and grid voltage 0 during the A.C. tests.

The following results were obtained :—

Valve.	M.	A.	Quality of balance on "A" reading.
1	7.5	—	Very bad.
2	8.2	5.4	Bad.
3	8.5	6.3	Fair.

The distortion given during the determination of A for valve No. 1 was so bad that no balance was obtained between $A = 3.5$ and $A = 6.5$. The above results show that valve No. 3 is the only one that could be used successfully, Nos. 1 and 2 showing undue distortion when used as resistance amplifiers. Experience shows that this distortion will appear when the valve is used as a power valve. The time taken to obtain these results was about one minute.

From sets of characteristic curves drawn for valves Nos. 1 and 3, the following data was obtained, giving the distortion when the valves were used as power valves.

Valve No.	Percentage of second harmonic.	
	4,000 ohm load.	5,000 ohm load.
1	7%	13.7%
3	4%	6.2%

These figures confirm the conclusions drawn from the A.C. test results.

The characteristics of valve No. 2 were drawn at low anode voltages and currents, in order to check up the resistance amplification readings given by the board. The following table shows how the A.C. bridge results and the curves line up :—

Anode Battery Voltage.	Amplification—A.	
	A.C. Bridge.	From Curves.
100	5.4 Bad balance.	5.3 10% 2nd harmonic.
200	6.4 Fair balance.	6.2 4% 2nd harmonic.

The time taken to take the complete characteristics of these valves was about an hour. Static tests at various points would not have shown up clearly the variations in M, and would have taken up more than a quarter of an hour in any case.

5.4. Several bridges of the same pattern as that described have been working under production conditions for some time. They have proved to hold their calibration very well and to enable very high speeds of testing to be attained.

Acknowledgments.

6.1. The author desires to acknowledge permission granted to publish this paper by the Cosmos Lamp Works, Ltd., and the Gramophone Co., Ltd. (His Master's Voice), for whom portions of this work have been carried out.

The Alignment Representation of Valve Data.*

By W. A. Barclay, M.A.

§ 1. Introductory: The Need for more Adequate Valve Characteristics.

RECENT developments in the thermionic valve have kept well abreast of progress in other departments of wireless science, and there is no reason to think that the limit of the experimental field in this direction is yet in sight. In this age of specialisation, however, when so many valve types are designed for specific purposes, it is remarkable that comparatively little attention should be paid to the important matter of describing their performance. Indeed, when the manufacturer presents a group of grid voltage-anode current curves together with hypothetical figures for anode A.C. resistance and mutual conductance, he seems to consider that he has done all that could reasonably be expected of him in the way of "introducing" his wares.†

But there is a more serious aspect of the matter. With the arrival of the screened-grid and pentode valves, the difficulties of representing the valve performance by means of curves are increased many times over. We have now an extra potential to consider, and must find a means of showing how changes in it will affect the other three variables usually associated with the anode circuit of the triode. Most manufacturers frankly give up in despair, and merely illustrate the effect of a single change in the control grid potential for one single fixed value of screened grid voltage. This is, of course, a sad state of affairs, and gives very little information which is likely to be useful to the serious experimenter. It must also be remembered that the so-called valve constants, R_0, μ_0 and G_0 are really variable, and, in the newer valves, subject to very wide ranges of variation indeed. It cannot be too strongly insisted that detailed information regarding the magnitude and variation of all these quantities should be made available to the prospective user, both in order that he may make an intelligent choice to suit his requirements, and also that he may turn his purchase to the best possible account. This may appear to some to be a counsel of perfection. Nevertheless it will not be questioned that on the whole the information supplied remains lamentably incomplete, being practically the same to-day as was considered sufficient five years ago.

* M.S. received by the Editor, September, 1929.

† Since this was written, there are, happily, signs of an improvement in this respect.—Author.

§ 2. Some Fundamental Definitions.

Before proceeding to explore some new directions in the geometrical representation of valve performance, it will prove useful if, to fix ideas, we consider shortly the significance of some of the symbols employed. We shall take first the ordinary triode, and shall omit all considerations of filament temperature, which will be assumed constant throughout. We shall also neglect all grid current with its resulting effect on the sources of potential, together with all capacity effects in the valve. The relation between the three primary valve variables v_a, v_g and i_a may then be expressed geometrically as a curved surface in three-dimensional space, and analytically by the formal equation

$$i_a = f(v_a, v_g) \quad \ldots \quad \ldots \quad (1)$$

This is the static characteristic surface of the valve, from which the ordinary characteristic curves may be derived by taking series of sections perpendicular to the three fundamental axes of v_a, v_g and i_a. Of equal importance to these primary variables are their mutual rates of variation, which will be referred to as the secondary variables of the valve. These quantities are the partial derivatives $\frac{\partial v_a}{\partial i_a}$, $\frac{\partial i_a}{\partial v_g}$ and $\frac{\partial v_a}{\partial v_g}$. The first two of these, the anode A.C. resistance and mutual conductance respectively, are symbolised by R_0 and G_0. The third is numerically equal to the voltage amplification factor of the valve, but is of opposite sign, *i.e.*,

$$\mu_0 = -\frac{\partial v_a}{\partial v_g}$$

The quantities R_0, G_0 and μ_0 are thus true variables, depending on the values of v_a, v_g and i_a at every point of the characteristic surface. They are, however, connected by the relation $\mu_0 = G_0 R_0$, as may be easily shown by differentiation of (1). We have

$$di_a = \frac{\partial i_a}{\partial v_a} . dv_a + \frac{\partial i_a}{\partial v_g} . dv_g$$

$$= \frac{1}{R_0} . dv_a + G_0 . dv_g$$

If i_a is maintained at a constant value while v_a and v_g are allowed to vary,

$$0 = \frac{1}{R_0} . dv_a + G_0 . dv_g$$

Hence, $$\left[\frac{dv_a}{dv_g}\right]_{i_a = \text{const.}} = - G_0 R_0$$

i.e. $$\mu_0 = G_0 R_0 \quad .. \quad .. \quad (2)$$

It may be well to remark here that, for triode valves, each of the quantities R_0, G_0 and μ_0 is positive over the whole of the surface $i_a = f(v_a, v_g)$. (Care must be taken to distinguish between μ_0 and $\frac{\partial v_a}{\partial v_g}$ in sign.) For screened-grid valves, on the other hand, both R_0 and μ_0 assume negative values over part of the characteristic surface.*

§ 3. The Inverse Use of the Alignment Principle.

The use of practical alignment charts in simplifying calculation has become fairly widely known within recent years. The mathematical principles underlying their construction have also been co-ordinated and simplified so that it is now the simplest of matters for the amateur to design and construct charts for his own use. The writer believes, however, that for the physicist, and the wireless experimenter in particular, the chief value of alignment methods will be found in their inverse use, in which—that is to say—the principle is applied inversely to determine the actual "law" followed by the data of an experiment. Since the writer first called attention in 1925 to the possibilities offered by the inverse use of the alignment principle,† he has successfully elaborated the method and applied it to various fields of experimental research. In the examples which follow, no general exposition of principle is attempted: such an exposition would unduly swell the compass of a paper which is primarily concerned with valve performance, but it will be undertaken at a future date for the benefit of readers should sufficient interest render this desirable.

It is well known that an experimental relation between two variables may be illustrated by a Cartesian graph, the equation to which represents the "law" relating them. If we have to do with three variables all of which vary within fixed limits of experiment, we may draw a group of curves each of which represents the relation holding between two of the variables when the third is held at a constant value. To find the single algebraic law which relates the three quantities is then a matter of extreme difficulty in the general case, though often the procedure may be simplified by a suitable choice of scales and axes, when—for example—the curves may be made to assume the form of straight lines. The inverse use of the alignment principle depends upon the suitable selection of two scales or "supports" for two of the variables which may be called the "independent" variables. For any fixed value of the third or "dependent" variable, the straight "index" lines joining any corresponding values of the two independent variables taken on their respective supports will then pass through a fixed point to which may be assigned the fixed value of the dependent variable in question. Other points having been similarly ascertained for other values of the dependent variable, the locus of these experimentally determined points constitutes a scale of values of that variable. The geometrical position and nature of the three supports being now accurately measured from the diagram, the algebraic expression of their relationship can be obtained. From this it is a simple matter to apply the principle inversely to ascertain the actual law by which the variables themselves must be related. This statement of the procedure may appear complicated; actually, however, it is very simple in the practical case.

§ 4. The Polygon of Error.

Two points demand attention. First, much depends on the suitability of the two

* "The Measurement of the Voltage Amplification Factor of Tetrodes," by W. Jackson, *E.W. & W.E.*, May, 1929.

† "The Alignment Principle in Calibration," by W. A. Barclay, *E.W. & W.E.*, December, 1925.

supports chosen for the independent variables. These may be either curves or straight lines—where possible, of course, the latter will be chosen. The selection of the supports is important, since, if these be not properly chosen, the index lines will not intersect approximately in fixed points. The method of choosing these supports affects also the limits and convenience of the diagram ; broadly speaking, they should be chosen so that all the scales—including that of the dependent variable—shall appear in convenient p…itions and to as large a scale
…he mode of selecting these
…s to the general theory of
…ay be said that it possesses
…nerality, and that the means
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…ider briefly the manner in
…ecting index lines determine
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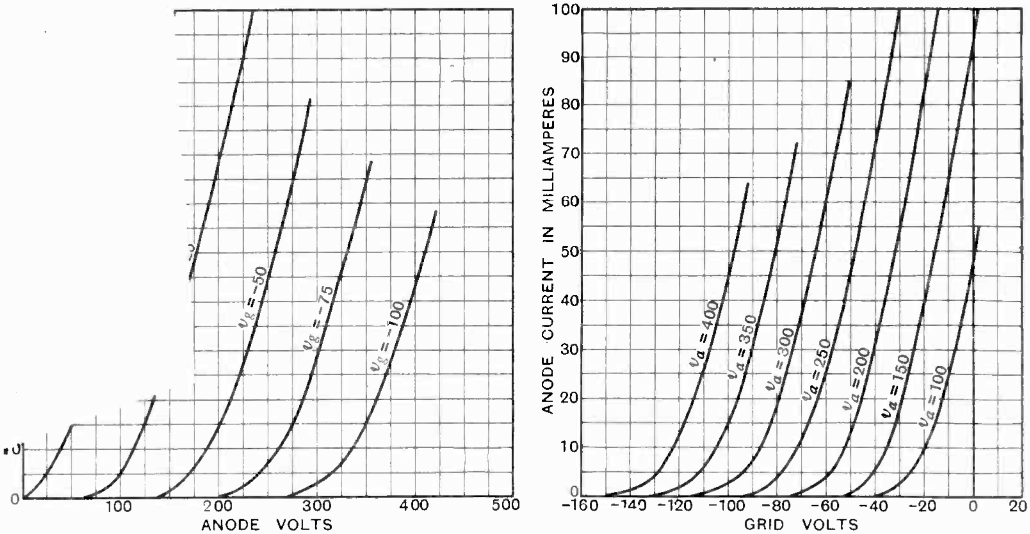
…le. It will usually happen
…variety of causes, these lines
…accurately in a fixed point, but will cross each other in a network of lines from which is to be selected an optimum point that will represent them all. Such a network may be termed a "polygon of error," and will be familiar to those whose duty it was to resect enemy gun positions during the War. Such polygons of error are due (*a*) to the unsuitability of the supports of the independent variables, and (*b*) to observational discrepancies in the experimental data. The apportionment of responsibility for any given polygon of error as between (*a*) and (*b*) is readily made, as the error in case (*a*) usually reveals itself in a systematic distribution of the lines as it does not with (*b*). The theory of the subject is interesting, but cannot be taken up here. Suffice it that, having obtained a series of polygons of error each of which may reasonably be ascribed to cause (*b*) above, nothing remains but to draw an optimum curve through each polygon, which curve is then regarded as the support of the third or dependent variable. From the nature of this curve, and the manner of the distribution of the numerical values upon it, the precise algebraic relation between the three variables is now deduced. The direct manner in which this relation is derived constitutes a striking advantage of this mode of correlating three variables.



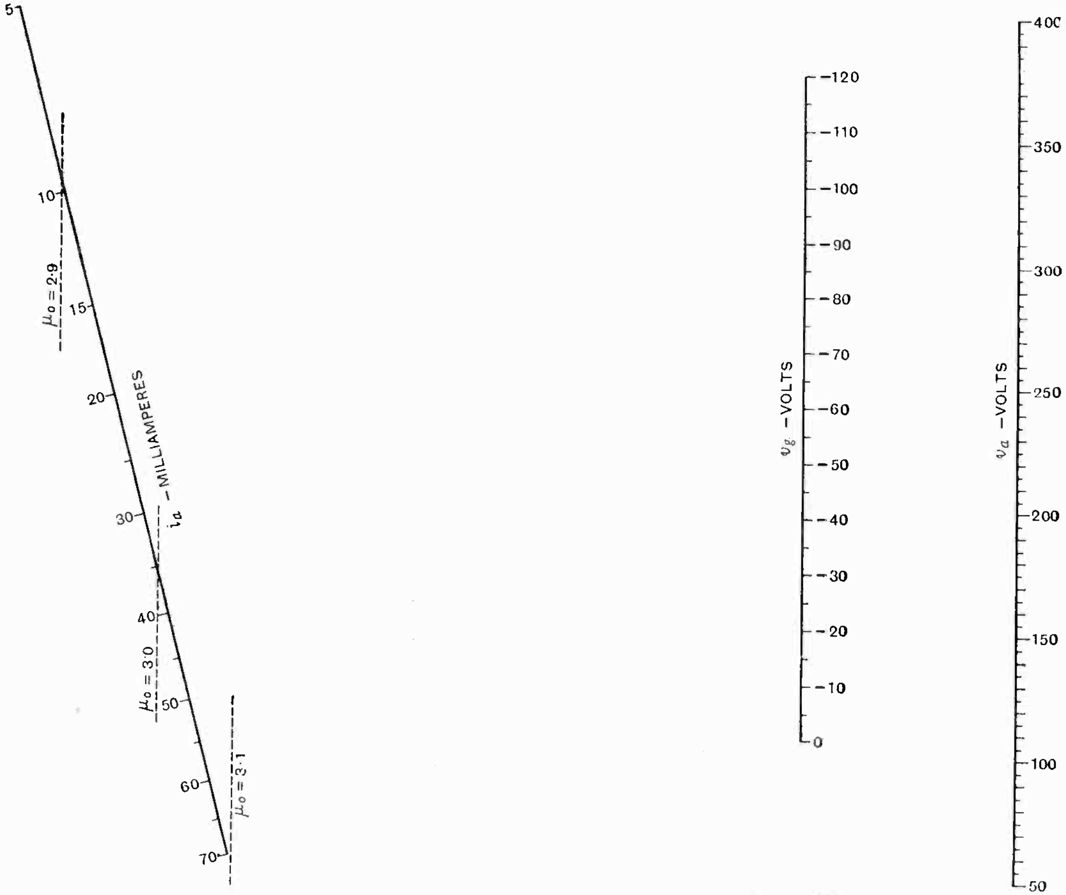
(a) (b)

Fig. 1.—*Average characteristics of Osram L.S.6A valve, (a) V_a/i_a characteristics. (b) V_g/i_a characteristics.*

§ 5. An Example—the Osram L.S.6A. Valve.

To illustrate the above remarks, the maker's average characteristics of the Osram L.S.6A. valve (reproduced in Figs. 1a—1b) were investigated in this manner over the limited range of values shown. It should be noted that outside this range and in the region of saturation current the equation which is deduced below will not apply. For the complete range, the anti-logarithmic analysis described in a previous issue would be preferable, although this has the disadvantage of assuming a constant value of μ_0.*

The complete alignment diagram corresponding to the L.S.6A. characteristics is shown in Fig. 2. The scales of v_a and v_g were taken on two vertical parallel supports, the graduations being linear, and the scales and distance apart being so chosen as to give the best disposition of the diagram. This is easily accomplished from a knowledge of the limiting values assumed by the variables. The different polygons of error for various fixed values of i_a were then drawn in, and it was found that these were all such as might be accounted for by errors in the readings of the original characteristics. Moreover, the polygons were all distributed in a regular sequence, all lying approximately on the sloping line shown to the left on Fig. 2. This sloping line is, therefore, the support of the i_a scale, and may be inscribed with the appropriate values of that variable.



[*Drawing copyright by W. A. Barclay.*

Fig. 2.—*Alignment characteristics of Osram L.S.6A valve. For convenience, values of* μ_0 *are shown by dotted vertical lines.*

* "The Method of Alignment Applied to Anti-logarithmic Triode Characteristics," by W. A. Barclay, *E.W. & W.E.*, December, 1930.

§ 6. The Variation in μ_0.

An interesting point here emerges. If the value of μ_0 were constant over the whole range of values shown, the theory of alignment indicates that the locus of the i_a points would be a straight line parallel to the other two supports. In other words, the value of μ_0 is dependent upon the distance of the i_a points from the other two scales. The fact that the locus of the i_a scale is actually at a slope points to the variation of μ_0 with i_a. In the case of the L.S.6A. valve this variation is very small over the range of current values shown, extending only from 2.9 to 3.1. Such a small change might well escape detection by other methods of investigation, and, indeed, it is fairly common practice to assume μ_0 to be constant. Using the alignment method, the variation in μ_0 " leaps to the eye," a useful feature, as with many valves the phenomenon is far more pronounced than in the case under consideration.

§ 7. The Equation of the Characteristic.

From the diagram of Fig. 2 we can now pass back to the algebraic relationship responsible for the particular configuration

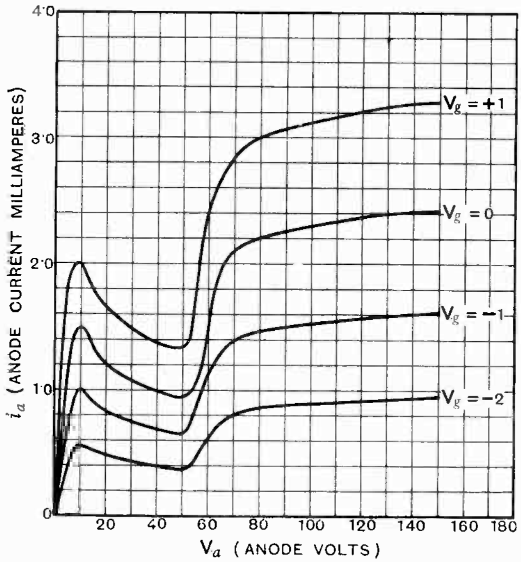


Fig. 3a.—V_a/i_a *characteristics of Marconi S.215 valve taken for screened-grid volts* = 60.

there shown. This involves a standard method of treatment, which will here be omitted as outside our present scope.

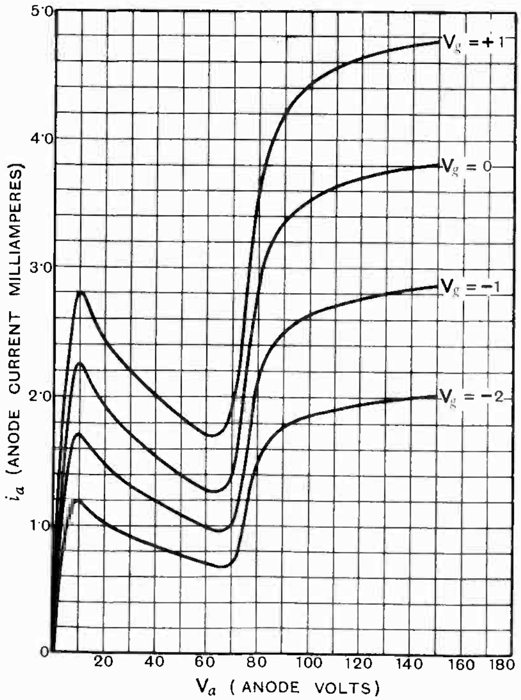


Fig. 3b.—*As Fig.* 3a, *but screened-grid volts* = 80.

As the result of measurements taken from Fig. 2 it is found that the relationship between i_a, v_a and v_g is expressible by the equation

$$\log_{10}(i_a+15)=3.76\times\frac{58.3+v_a+2.66v_g}{232+v_a+2.25v_g} \quad \ldots \quad (3)$$

The form of this equation is interesting. It will be seen that i_a is expressible as an anti-logarithmic function of v_a and v_g, although this function is more complex than that derived by the writer's previous analysis (*E.W. & W.E.*, April, 1929). It will be observed that the relationship of v_a and v_g depends on the value of i_a. Indeed, if we differentiate equation (3) partially with respect to v_g, we obtain

$$\frac{\partial v_a}{\partial v_g}=-\left\{2.25+\frac{1.54}{3.76-\log_{10}(i_a+15)}\right\} \quad (4)$$

thus expressing the numerical dependence of μ_0 upon i_a alone which was noted above in paragraph 6.

As a check on the work, the following values of i_a were calculated by means of equation (3) from various values of v_a and v_g as under :—

TABLE.

$v_a = 50$,	$v_g = 0$;	$i_a = 13$
$v_a = 100$,	$v_g = 0$;	$i_a = 47$
$v_a = 200$,	$v_g = -50$;	$i_a = 15$
$v_a = 250$,	$v_g = -50$;	$i_a = 46$
$v_a = 375$,	$v_g = -100$;	$i_a = 29$
$v_a = 425$,	$v_g = -100$;	$i_a = 63$

On comparing these figures with the curves of Fig. 1, it will be seen that equation (3)

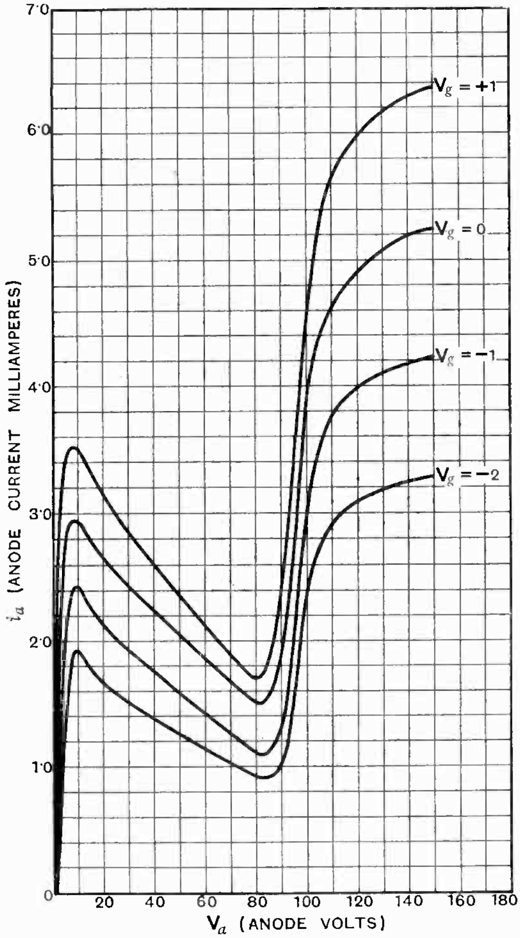


Fig. 3c.—*As Fig.* 3a, *but screened-grid volts* = 100.

reproduces the original characteristics with fair accuracy from i_a = 10mA. to i_a = 70 mA.

An important feature of the alignment process is that it provides not merely the values of the constants in an equation such as (3), *but actually gives the form of the equation itself.* This is a remarkable circumstance, and one which, in the writer's opinion, should do much to establish the method in favour with practical computors. He will venture to predict that this method, now for the first time published through the medium of *E.W. & W.E.*, will in after years play a not inconsiderable part in the equipment of the experimental physicist.

§ 8. Application to the Screened-grid Valve.

So far we have discussed the application of the inverse method of alignment to three variables. Under suitable conditions the number of variables may be extended to four or more. We shall take as an example of its application to four variables the case of the screened-grid valve. The laboratory of *The Wireless World* kindly placed at the disposal of the writer the four characteristics found for a Marconi S.215 valve shown in Figs. 3a—3d. The four diagrams are taken for the screened-grid voltages 60, 80, 100 and 120. Applying the inverse alignment process to these in a similar manner, the single diagram of Fig. 4 was obtained for the working range of the valve for all values of the variables concerned. In this case the two independent variables selected were i_a and v_g; adopting the linear and parallel scales for these shown on the right of the diagram, various polygons of error were obtained corresponding to various selected values of v_a and v_{sg}. The errors due to the experimental conditions in the data of Figs. 3a—3d were large enough to account for the maximum amount of "dispersion" occurring in the various polygons of error ; it became legitimate, therefore, to regard these as indicative of the positions of "ideal" points whose disposition on the diagram would indicate the trend of the variation of the variables in their vicinity. This idea of "trend of variation" is, indeed, fundamental to the whole alignment process. An experiment subject to errors of observation may be made to yield an approximation to the ideal relationship between the variables concerned, and it is this ideal "trend," stripped of the extraneous error, which the alignment process brings so beautifully to light. In the present case it was found possible to connect up the polygons of error by the network of curves shown, the point corresponding to any selected values of v_a and v_{sg} lying at the intersection of the respective curves shown for these values. This point (v_a, v_{sg}), of course, is then in alignment with corresponding values of v_g and i_a taken on their respective scales, so that a comprehensive conspectus of the variation of v_a, v_{sg}, v_g and i_a has been achieved on a single diagram.

§ 9. Variation of Mutual Conductance.

The diagram of Fig. 4 differs from that of Fig. 2 in the selection of the scales for the independent variables. In the case of Fig. 4, therefore, it is the mutual conductance for any specific working point that depends upon the distance of the point (v_a, v_{sg}) from the v_g and i_a scales. In other words, it is found that for the S.215 valve, G_0 is a function solely of the two variables v_a and v_{sg}. For convenience, values of G_0 from 0.5 mA. per volt to 1.0 mA. per volt have been included over the working range of the diagram, and are indicated by the vertical dotted lines. It is thus a simple matter to estimate the appropriate value of G_0 for any working point. As a practical example, the dotted index line shown on the diagram gives the following corresponding values for the variables of the valve :—

$v_a = 110$ volts, $v_{sg} = 100$ volts, $v_g = -1.3$ volts, $i_a = 3.5$ milliamps., $G_0 = 0.9$ milliamp. per volt.

The variations in R_0 and μ_0 may be easily traced by maintaining the index line at a constant value of the appropriate variable, while causing the others to vary in a manner which need not be detailed.

§ 10. Utility of the Alignment Process.

From the diagram of Fig. 4 many interesting facts regarding the performance of the screened-grid valve may be gleaned, and the writer hazards the suggestion that we may still be a long way from using such valves to the best advantage. There is considerable scope for the experimenter in studying the action of such a valve when the screened-grid potential is varied synchronously with that of the control grid. The manner of such variation is theoretically ascertainable by the aid of diagrams such as that now given, and it is possible to indicate the conditions which would require to be fulfilled in order to secure by such means a greater amount of theoretical amplification than is at present attainable. Naturally it would be unwise to place much trust in theory in this connection, as the practical danger of self-oscillation would doubtless assert itself in ever-increasing degree. The writer will not therefore say more on this head at present, beyond commending the idea as at least feasible within certain limits, and worthy

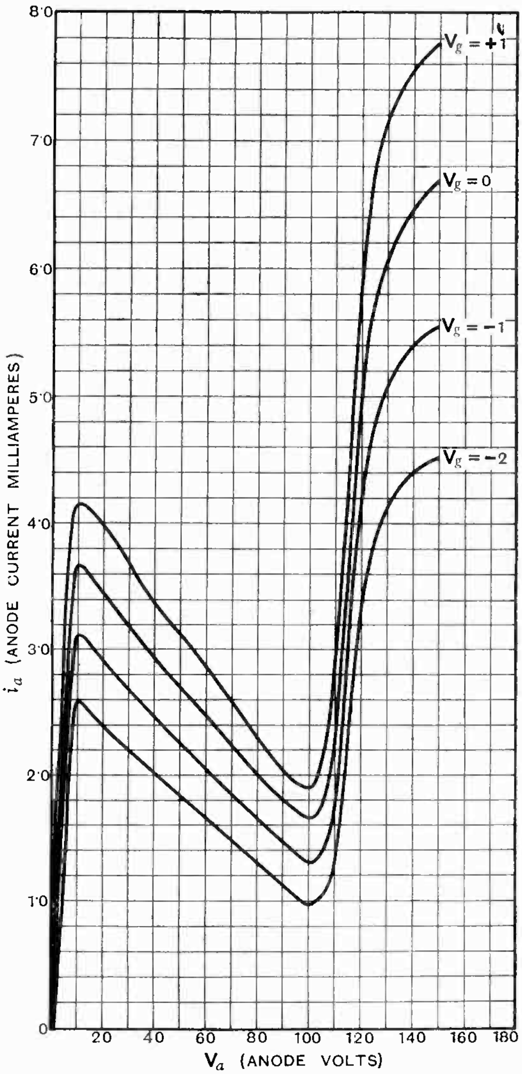
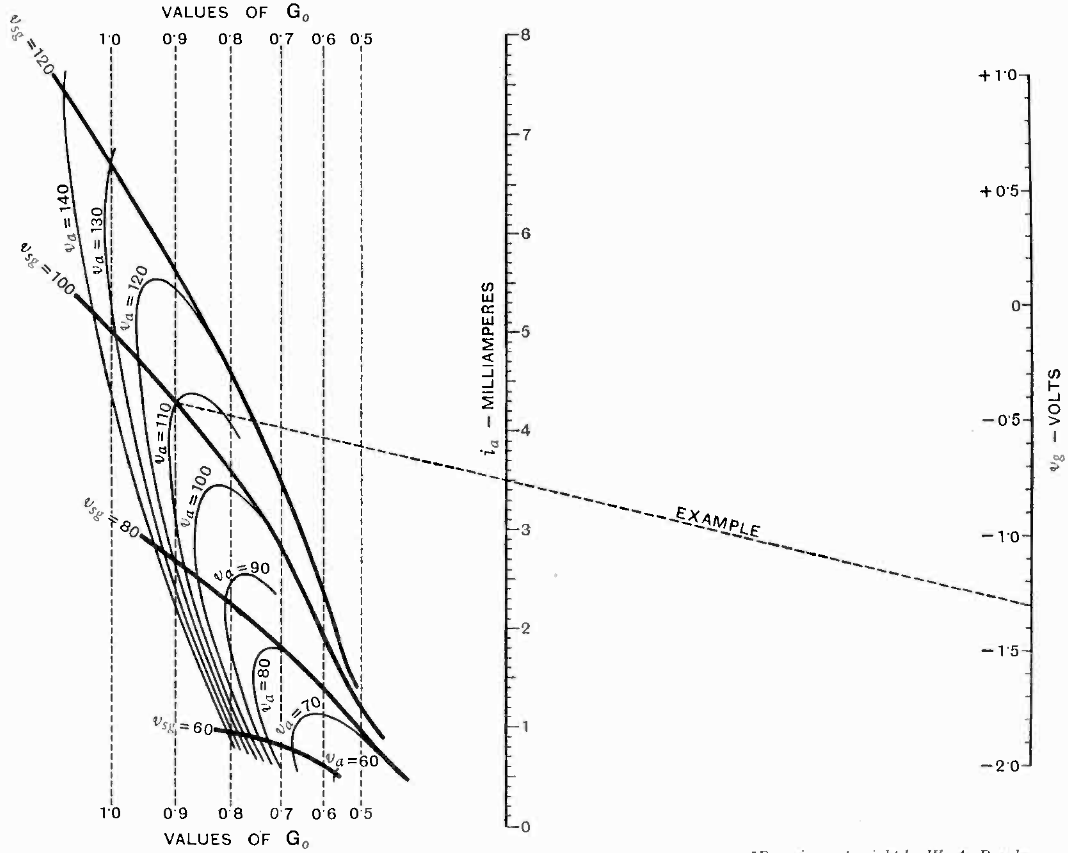


Fig. 3d.—*As Fig. 3a, but screened-grid volts* = 120.

of practical experiment. For such investigations the alignment method of portraying characteristics should prove invaluable.

A word of caution is, however, necessary. The application of the method of inverse alignment, like most inverse processes (of which integration is a fair example) is an art. Where it can be directly applied the results it can achieve are striking. But it does not always happen that experimental data are immediately amenable to the process. In such cases, theory indicates the method of selecting the functional scales for the independent variables, so that the construction may be carried out as before.

It will be realised that the foregoing description of the construction and use of these diagrams has been much handicapped by the necessity of avoiding the convenient symbolism which has been devised to facilitate the process. This symbolism, though essential to any practical utilisation of these methods, is purely mathematical. As such, any account of it is, for the reasons already stated, meantime omitted from these columns.



[*Drawing copyright by W. A. Barclay.*

Fig. 4.—*Alignment characteristic of Marconi S.215 valve.*

A New Method of Measurement of Resistance and Reactance at Radio Frequencies.

(Paper by F. M. Colebrook, B.Sc., and R. M. Wilmotte, M.A., A.M.I.E.E., read before the Wireless Section, I.E.E., on 7th January, 1931.)

ABSTRACT.

THE method is a development of one (due to P. W. Willans), illustrated in Fig. 1.* Circuits 2 and 3 represent valve-maintained h.f. oscillators, circuit 2 being set to the required frequency of measurement, circuit 3 is adjusted to beat with it at a suitable audio frequency. Circuit 1, which consists of the coil under investigation and a calibrated condenser, is then closed. As C_1 is varied the beat-frequency varies as shown in Fig. 2, in consequence of a corresponding variation of the frequency of circuit 2. The values of C_1' and C_1'' corresponding to the maximum and minimum beats are noted and the resistance R_1 is calculated from

$$R_1 = \frac{1}{2\omega}\left(\frac{1}{C_1'} - \frac{1}{C_1''}\right)$$

Difficulties of applying the method are discussed in the paper, when the authors describe the method now outlined.

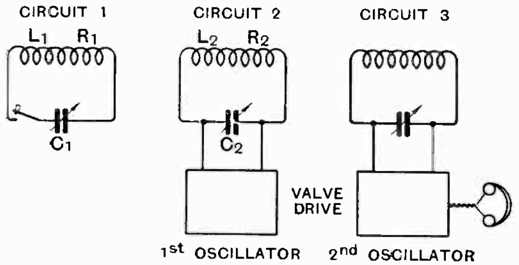


Fig. 1.

The new method has the advantages: (i) All measurements are made at the same frequency $\omega/2\pi$. (ii) The telephones carry an audio current of constant frequency from an auxiliary l.f. oscillator. The beat frequency is matched with this by the usual method of beats, giving an exceedingly sensitive method of synchronisation.

The procedure is as follows: (i) Open switch of circuit 1. Adjust frequency of 2 to required value and that of 3 till no beats are heard between the heterodyne-frequency and that of the audio source. (ii) Close circuit 1 and vary C_1 until the beats again disappear, i.e., the frequency of 2 is back to its original value. This gives the resonant value of C_1, i.e., $\omega L_1 = 1/(\omega C_1)$. (iii) Displace C_1 by a small amount. Beats are heard due to change in ω. Restore to synchronism with the audio source by changing C_2. If the process be repeated it will be found that the variation of C_2 required to balance the effect of variation of C_1 is of the same form as the variation of frequency in Fig. 2, i.e., it will be as shown in Fig. 2, the ordinates being values of C_2 in this case. Thus for a given setting of C_2 (e.g., corresponding to the line P_1P_2 of Fig. 2) there will be two values of C_1 (corresponding to P_1 and P_2) at which the original frequency $\omega/2\pi$ is restored and beats disappear. The critical values C_1', C_1, and C_1'' can be determined with good sensitivity and R_1 calculated by the same formula as before.

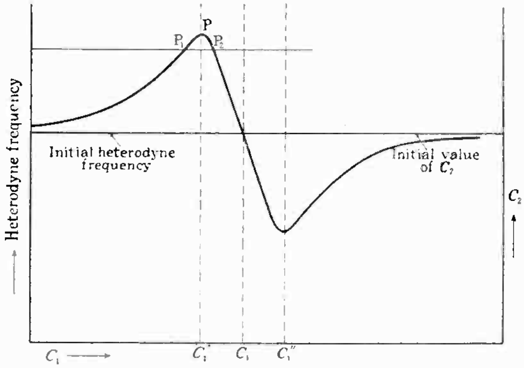


Fig. 2.

Details of the method are given in the paper. Briefly these are: (a) *The measurement circuit.* This consists of a stand with sockets and terminals for the coil and rigid leads connecting to the measurement condensers. The coil is screened from the measurement condensers, and a mercury link is included in the leads. The condenser system is shown in Fig. 3, C_a being a variable condenser with air dielectric and quartz insulation,

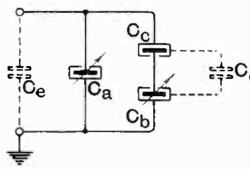


Fig. 3.

max. 600μF., C_b similar with max. 200μμF. C_c is one of a series of small fixed condensers of aluminium plates about 1¼in. square, contained in a screening case connected to one electrode, their capacities being of the order of 10, 25, 50, 150 and

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

200$\mu\mu$F. C_d and C_e (dotted) represent capacity of leads, etc.

(b) *The first oscillator.* The chief requirement is that frequency shall be stable, and as far as possible independent of the resistance of the oscillating circuit. A series-fed Hartley circuit has been found satisfactory; fine adjustment of tuning capacity is necessary. (c) *Second or control oscillator.* Any simple oscillator with provision for headphones in the anode circuit can be used, although a more elaborate circuit is shown using an amplifier with facilities for coupling in the audio-frequency oscillator. This latter can be of any convenient type, a frequency of about 500 cycles per sec. having been found suitable.

In practice several points call for attention. To ensure stability of frequency in the first and second oscillators it is advisable that they should be switched on some hours before a measurement is made. Coupling between the measurement circuit and the first oscillator should be as close as is consistent with the regular behaviour of the latter. A suitable coupling is readily found by trial. Preliminary adjustments are best made with the audio source disconnected from the second oscillator, for which purpose a switch or link can be provided.

A suitable coupling having been found, the measurement circuit is opened and the first oscillator adjusted to give zero beats between the heterodyne and the audio source, the heterodyne-frequency rising with increase of tuning condenser in the first oscillator. The measurement circuit is closed and the setting of its capacity for zero beats is found by coarse adjustment of C_a and fine adjustment of C_b (Fig. 3). C_b is then decreased until the highest heterodyne-frequency is reached, then the first oscillator condenser is reduced to restore to zero beats. The second critical point C_1' is found in a similar manner, but in this case the heterodyne note falls.

An alternative method can be used, namely, the determination of the two zero beat points P_1 and P_2 (Fig. 2) for some given value of C_2 below the peak value. If C_{1a} and C_{1b} be the values of C_1 for any such pair of points and C_1 be the centre zero beat capacity, then :—

$$\frac{1}{\omega^2}\left(\frac{1}{C_1}-\frac{1}{C_{1a}}\right)\left(\frac{1}{C_1}-\frac{1}{C_{1b}}\right)=R_1^2$$

A table of measured results is given in the paper. This shows that the consistency is generally better than 2 per cent. The absolute accuracy does not appear to be so good as this, judged by measurement of inserted resistances of fine wire, but it is to be remembered that the self capacity of coil and leads will partially short-circuit a resistance inserted between coil and condenser. Measurements shown have been made down to a wavelength of 28.4 metres.

The work described was carried out as part of the programme of the Radio Research Board and is published by permission of the Department of Scientific and Industrial Research.

Appendices deal with the theoretical analysis of the original and the newer methods, while a further appendix discusses the application of the method to the measurement of impedance.

A Variable-capacitance Cylindrical Condenser for Precision Measurements, and a Wavemeter for Short Wavelengths.

(Paper by E. B. Moullin, M.A., A.M.I.E.E., read before the Wireless Section, I.E.E., on 7th January, 1931.)

ABSTRACT.

An accurately calibrated variable condenser is often required for plotting resonance curves. At frequencies of the order of 3×10^7 cycles per second, the total capacitance of the circuit is very small. A parallel-plate condenser does not seem very suitable for the purpose described, whereas a cylindrical condenser has much to recommend it, being self-screening and having a residual inductance of calculable value. The inside cylinder may be completely enclosed and the capacitance varied by moving the axis of the inside cylinder away from that of the outside cylinder, making them eccentric with one another but with their axes parallel. A cross-section of the arrangement is shown in Fig. 1.

The capacitance per unit length of such a system of indefinite length is exactly calculable from the formula

$$C=\frac{1}{2\log_e[\beta+\sqrt{(\beta^2+1)}]} \quad \cdots \quad (1)$$

where $\beta = (a^2 + b^2 - d^2)/(2ab)$

in which a and b are respectively the radii of the outside and inside cylinders and d is the distance between their axes. The capacitance changes very slowly with d so long as d is a good deal smaller than $(a - b)$, so that there is the possibility of large movement yielding a very small change of capacitance. If the change of capacitance is to be calculable, it is essential that the capacitance due to the ends of the cylinders should not be a function of d. This capacitance cannot be calculated exactly, but a rough approximation to it can be obtained.

The author then considers the theory of such a system and concludes that since the cylindrical condenser has a geometrical form for which the capacitance, inductance and resistance can be calculated it has much to recommend it provided that the mechanical construction can be arranged satisfactorily.

The next section of the paper deals with mech-

anical details of the cylindrical condenser. The distance between the axes of the cylinders may be varied by revolving the inner cylinder about an axis which is eccentric with respect to both the inner and the outer cylinder. In Fig. 1 the inner cylinder is supposed to revolve about a spindle through the point A. When the inner cylinder is

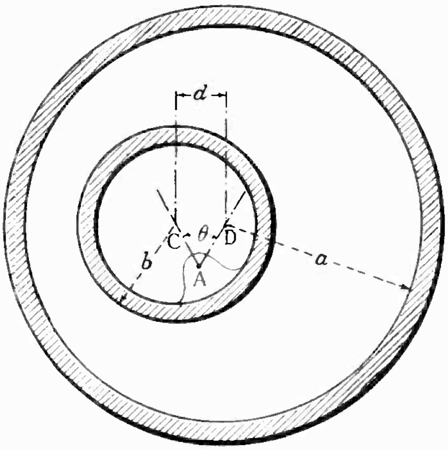


Fig. 1.

revolved about this axis there is an accompanying variation of the central distance CD, and we have

$$d = \sqrt{[(AC)^2 + (AD)^2 - 2AC \cdot AD \cos \theta]}$$

This method of altering d lends itself to robust mechanical construction, and it also has the convenience that d changes very slowly with θ when that angle is approaching 180°. It is then that d approaches $(a - b)$ and the capacitance is increasing at a rapid rate.

Fig. 6 shows a cross-sectional drawing of a completed condenser and illustrates the arrangement of the eccentric axle for the inner cylinder. Both cylinders are aluminium castings, accurately machined. The axle is carried in brass bearings mounted in mycalex bushes which fit into circular recesses, and these are machined in position so as to ensure that they are on a common axis. The lower bearing is of the footstep type and forms the electrical connection to the rotor. To make this connection more positive than a rubbing contact, a thin copper wire is passed up a central hole in the spindle and soldered to the rotor at one end and to the input terminal at the other. The index pointer is of ebonite and is fixed to a small brass bush which is pinned to the top of the spindle. The top end of the spindle is enclosed by a cylindrical brass cover connected to the outside case. The pointer passes through a slot in this cover and carries a metal ring which forms a door over the slot. The cylindrical cover and the door complete the shielding of the rotor system. The plunger switch mounted on the top of the screen cover (Fig. 6) is for converting the condenser into a variable inductance, and will be referred to later. The footstep bearing is connected to the input terminal by a brass rod passing through the base chamber and finally through a large cylindrical tube formed in the wall of the shell. The base chamber also carries two mica condensers for increasing the range of capacitance. Reference to Fig. 6 will make clear the arrangement of the terminals.

Capacitance measurements were made for a condenser almost identical with that of Fig. 6. The calculation and check of the minimum capacitance are shown in the paper, after which the author proceeds to trace the calculation of the change of capacity on rotation, giving the scale shown in Fig. 8. When the dial is correctly divided it is essential to set the pointer so that the zero of the scale corresponds precisely to the minimum capacitance. Since the capacitance passes through a maximum at exactly 180° from the position of minimum it suffices to find the true position of maximum, and the dial is scaled for the first three micro microfarads beyond that position. The experimental method of determining this maximum is discussed.

Each of the fixed mica condensers contained in the base chamber is made to have a capacitance of about 14 $\mu\mu$F, or at any rate something less than the maximum change of 16 $\mu\mu$F. Each of these can

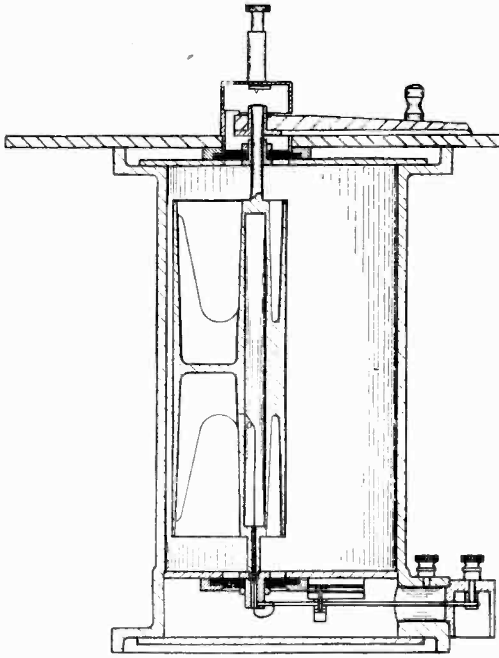


Fig. 6.

therefore be calibrated *in situ* by observing the increment of scale reading required to replace it when it is switched out of circuit. In this way the capacitance of each base condenser is consistent with the variable portion, and, moreover, this capacitance can be re-checked at any time. These base-chamber condensers give the instrument a continuous range from 28 to 72 $\mu\mu$F.

The outstanding use of the condenser in radio-frequency measurements is for plotting resonance curves, and for this purpose it may be used either as the variable condenser of a tuned circuit or as a means of varying the frequency applied to a fixed circuit. Examples of its use in this way at waves of 37 to 41.5 metres are shown in the paper.

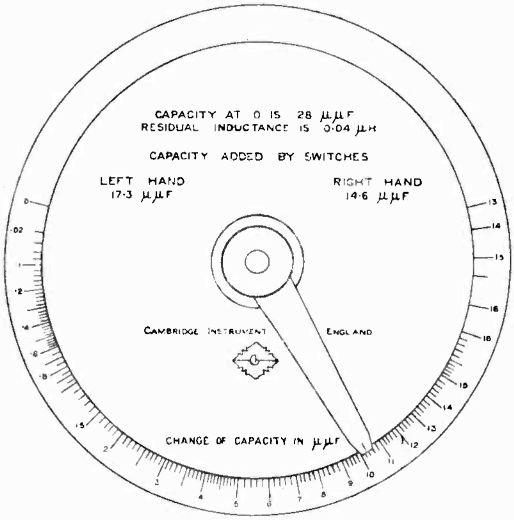


Fig. 8.

If the spring plunger shown in Fig. 6 is released, the top of the rotor is connected to the outside cylinder and then the current which enters the insulated terminal passes up the rotor and down the outside cylinder to the case terminal. The system then forms a self-screening inductance whose value can be varied by revolving the rotor. The calibration in terms of inductance change can be deduced from the capacitance calibration. The method of doing this is discussed in the paper and a resonance curve shown in which this was used as part of the circuit inductance.

Lastly the author describes the application of the condenser to a low-range wavemeter for short waves.

The tubular inductance and tubular condenser can be combined to form a robust and self-screening short-wave wavemeter of small range. One method of doing this is shown in the section drawing of Fig. 18. The circuit inductance is formed by a long rectangle of thick copper wire which is surrounded by a thick copper screen tube. A small loop at the end of the rectangle protrudes through the end of the screen tube and makes it possible for the wavemeter to absorb energy for the generator whose frequency is to be measured. The wavemeter capacitance is in two parts, one fixed and the other variable. The fixed portion is the capacitance between the screen tube and the outside surface of a copper cylinder concentric with the screen tube, and can be seen by reference to Fig. 18. The variable portion is formed by the capacitance between the inside surface of the concentric cylinder and the outside surface of a cylinder which revolves on an eccentric axle turning in bearings eccentric with the axis of the screen tube. Since the revolving cylinder is in electrical connection with the screen tube, it is at earth potential and consequently the dial handle need not be insulated. The whole of the capacitance is self-screening and all but a small fraction of the inductance is screened, so that the natural frequency of the circuit cannot be disturbed by surrounding objects. Since the whole wavemeter is enclosed in a thick copper tube the instrument is extremely robust and is suited to portable and field use. When suitably designed it must also be very permanent in calibration because small mechanical displacements make very small changes of capacitance or inductance.

Details of this use are discussed in the paper and it is shown that the instrument is capable of measuring a wavelength correct to about 0.07 per cent. In order to increase the inductance without appreciable increase of bulk, there is no objection to enclosing four or more wires in the screen tube.

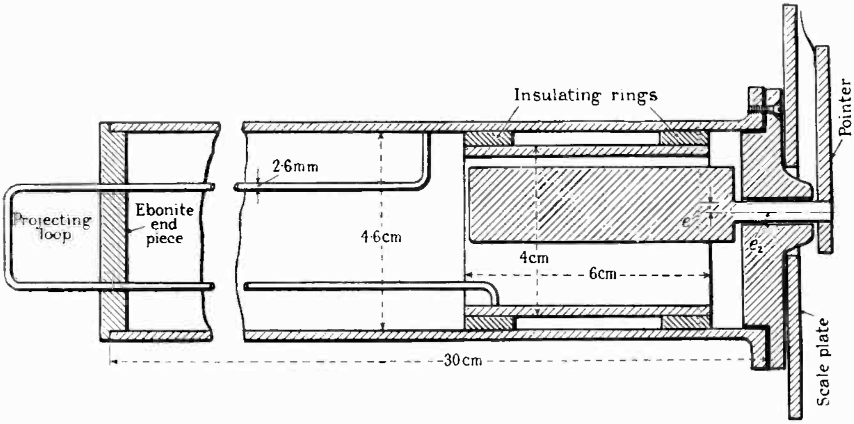


Fig. 18.

Discussion.

The discussion was a joint one on both the above papers.

Mr. P. W. Willans referred to early experimental work on the method. After using the first arrangement he had independently used the method now described by Mr. Colebrook and discussed some of the difficulties encountered, notably that of frequency-stability of the first oscillator.

Mr. P. K. Turner did not think the method was as accurate as other methods for the amount of apparatus involved. In particular he compared it with the reactance-variation method, pointing out that it required very accurate knowledge of the change of capacity. The method was suitable for use in the absence of facilities for measuring currents and voltages at radio frequencies, but he preferred the use of a valve voltmeter.

Mr. B. Williams said he had used the method considerably for resistance measurements and for accurate location of the resonance point of absorption wavemeters. In practice he preferred to employ another radio-frequency oscillator and use double beats. This had the advantage that the heterodyne note need not be kept at 1,000 cycles or any like value. He regretted the absence of more data as regards measurements of impedance, pointing out that in measuring the input impedance of screened valves running into grid current frequently vitiated results.

Mr. Bainbridge-Bell expressed a partiality for the use of a high-frequency bridge, but agreed that it was difficult to measure reference resistances for use with such a bridge. Colebrook's method was therefore suitable for this purpose, with the subsequent use of the bridge for measurement against these standards.

Mr. L. B. Turner considered that Mr. Colebrook's method was particularly good for short-wave work, and Mr. Moullin's condenser was very suitable as a means of measuring the capacity-change involved. He queried Mr. Moullin's views of the current path when the condenser was used as an inductance and sought further information on this point.

Mr. Wilkinson queried the use of additional fixed mica units in Mr. Moullin's condenser, and suggested that small air condensers would be much preferable.

The authors briefly replied to the discussion.

Book Reviews.

Testing Radio Sets.

By J. H. Reyner.

Pp. 178 + vi, with 88 Figs. Chapman & Hall. Price 10s. 6d.

As the author says in the Preface, "the best receivers break down at times and some systematic method of testing is necessary in order to discover in which department the trouble is located." We suppose that there are people with sufficient strength of character to adopt such a systematic method without wasting an hour or two making guesses at what may have gone wrong and finding each element in turn annoyingly in perfect order, but we believe that they are rare. Perhaps this book will act as a corrective and lead us all to substitute science for instinct in such emergencies. The first eight chapters deal with fault testing in finished receivers and the last four with special laboratory tests. After an introduction in which the necessary equipment is described, the chapters deal successively with general testing methods, low-frequency tests, tuning tests, high-frequency tests, mains apparatus, special tests and some curious faults. In discussing the methods suitable for fault testing the author naturally imparts a great deal of useful information concerning the principles of operation of the apparatus under test.

In the second part a chapter is devoted to the measurement of signal strength and another chapter to the subject of low-frequency testing and the production of telephonic frequency currents by such means as beat oscillators, etc.

The final chapter gives a number of extracts from the Year Book of the Institute of Radio Engineers for 1929, dealing with a standardisation report and the methods of testing sets to see if they are in accordance with the standards suggested.

The testing of separate components is discussed in an appendix. This involves ordinary laboratory measurements of resistance, inductance, etc. The index will enable one to turn at once to the section dealing with a particular trouble if one knows what it is.

The book is eminently suitable for the purpose for which it is written and should prove very useful.

G. W. O. H.

Funk-Empfangs-Technik.

By Manfred von Ardenne.

Pp. 352, with 330 Figs. Rothgiesser & Diesing, Berlin. R.M. 9.50.

This is a very comprehensive work embracing the whole field of radio reception, picture transmission, television, and sound reproduction from discs and films. It is a non-mathematical description of the present state of the art of radio reception, with a large number of diagrams and photographs of actual apparatus. When we say that it is non-mathematical, we do not mean that it is merely popular and qualitative, for it is not; the mathematical formulæ underlying the operation of the apparatus are given and discussed but are not established in detail. It is not confined to broadcasting but covers telegraphic reception of both long and short waves.

An appendix contains a large number of tables and alignment charts giving the data which a radio engineer is most likely to require in designing receiving apparatus.

The practical examples described and illustrated are, of course, mainly of German apparatus.

The book is one which, especially in view of the very reasonable price, can be unreservedly recommended.

G. W. O. H.

Abstracts and References.

Compiled by the Radio Research Board and reproduced by arrangement with the Department of Scientific and Industrial Research.

PROPAGATION OF WAVES.

ON SOME RADIO-FREQUENCY PROPERTIES OF IONISED AIR.—E. V. Appleton and E. C. Childs. (*Phil. Mag.*, December, 1930, Series 7, Vol. 10, No. 67, pp. 969–994.)

Authors' summary :—Experiments are described which confirm earlier work on the subject of the dielectric constant of ionised gases for radio-frequency electric forces, in that a dielectric constant less than unity has been observed under certain conditions. This result was obtained only with very low ionisation densities and low pressures. The existence of an apparent dielectric constant greater than unity at higher ionisation densities, which appears to have been observed by all workers on the subject, has been the subject of special study, and has been shown to be due to the formation of ionic sheaths round the experimental electrodes, which effectively increase the capacity of the experimental condenser, and so mask the true effect sought. The variation in the thickness of these sheaths with the potential across them has been examined by a wireless method, the result being in agreement with the theory of collectors developed by Langmuir and Mott-Smith.

The influence of an imposed magnetic field on the radio-frequency properties of ionised air has been studied, and the existence of an Inverse Zeeman effect for free electrons demonstrated. This effect was predicted in connection with the magneto-ionic theory of the atmospheric deviation of wireless waves. For a particular value of the imposed magnetic field a critical frequency is found for which pronounced absorption occurs. The relative magnitudes of the imposed magnetic field and the critical frequency yield a value of $\frac{e}{m}$ of 1.74×10^7 e.m.u. for the electric carriers, so that there is therefore no doubt that they are electrons.

The experiments therefore support the theory of Sir Joseph Larmor, according to which the refractive deviation of wireless waves in the upper atmosphere is due to the influence of free electrons.

FORTPFLANZUNG EINER ELEKTROMAGNETISCHEN WELLE IN EINEM IONISIERTEN MAGNETO-AKTIVEN MEDIUM (The Propagation of an Electromagnetic Wave in an Ionised, Magnetically Active Medium).—L. Schekulin [Zhekulin]. (*Zeitschr. f. hochf. Tech.*, Nov., 1930, Vol. 36, pp. 172–182.)

German version of the Russian paper dealt with at some length in 1930 Abstracts, pp. 447–448.

ZUR METALLREFLEXION (On Metallic Reflection).—J. Zahradníček. (*Zeitschr. f. Phys.*, No. 11-12, Vol. 65, 1930, pp. 814–823.)

The theory of the phenomena of reflection of a plane, linearly polarised electromagnetic wave at a metallic surface is developed from Maxwell's equations and the appropriate boundary conditions; formulæ for the refractive index and the index of absorption are given which are more general than those deduced by Drude for a normally incident wave. Suggestions for experiment at different angles of incidence are made and tables are given of Minor's measurements on silver, Drude's measurements, and measurements on *PbS* compared with the results of Drude, Macků and the author. Finally the special case $\sigma = 0$ is discussed.

KENNELLY-HEAVISIDE LAYER HEIGHT OBSERVATIONS FOR 4,045 AND 8,650 KC.—T. R. Gilliland. (*Bur. of Stds. Journ. of Res.*, November 1930, Vol. 5, No. 5, pp. 1057–1061.)

The Breit and Tuve " pulse " method was used. The report covers daytime observations (and two evening tests) between 16th January and 19th June, 1930. Curves are given comparing heights with sunspot numbers and magnetic character. " Although no conclusive correlation between magnetic character and height is evident from the curves, it will be noted that the disturbed period which began 12th February has been accompanied by a rise in height of considerable magnitude. . . . The existence of a close correspondence between sunspot numbers and virtual heights for 4,045 kc. such as is suggested by curves . . . can be demonstrated only by observations over a much longer period."

Records on 28th April, the day of the solar eclipse, give a morning height of only 202 km. for 4,045 kc., which is considerably lower than the lowest value (219 km.) obtained during this series of observations. The eclipse maximum occurred at 3.23 p.m., and at 3.52 p.m. a height of 317 km. was recorded.

The extreme heights beginning about 10th April (for 4,045 kc. a height of 406 km. was recorded on 17th April) " may suggest the disappearance of one layer permitting a higher one to come into view rather than the rise indicated in the curves."

CONDITIONS FOR THE PROPAGATION OF WAVES IN THE ATMOSPHERE.—S. Krütschkow. (*Journ. Appl. Phys., Moscow*, No. 3, Vol. 7, 1930, pp. 61–80.)

Various investigations point to the upper atmosphere being composed of oxygen, nitrogen and helium. In the regions where the aurora occurs (at a height of 80–130 km.) a certain portion of the oxygen molecules appears to be dissociated into atoms. From a discussion of various theories the writer concludes that the temperatures in the free atmosphere cannot be definitely stated; the most probable values are 215–300° abs. Calculation according to various formulæ suggest that from heights of 102–138 km. there is complete dissociation of the oxygen molecule. The electron concentration arrived at by the formulæ reaches its maximum (about 3×10^6 per cm.^{3}) at a height of 113–168 km.

Modellversuche mit sichtbaren Elektronenstrahlen zu Störmers Theorie des Polarlichtes und des "Weltraumechos" (Experiments on Model Apparatus with Visible Electron Beams Demonstrating Störmer's Theory of the Aurora and of the "World Space Echo").—E. Brüche. (*Naturwiss.*, 12th Dec., 1930, Vol. 18, No. 50, pp. 1085–1093.)

Experimente zu Störmers Polarlichttheorie (Experiments on Störmer's Aurora Theory).—E. Brüche: E. Brüche and W. Ende. (*Physik. Zeitschr.*, 15th Nov., 1930, Vol. 31, No. 22, pp. 1011–1015 and 1015–1016.)

The Diurnal and Seasonal Performance of High-Frequency Radio Transmission over Various Long Distance Circuits.—M. L. Prescott. (*Proc. Inst. Rad. Eng.*, Nov., 1930, Vol. 18, pp. 1797–1920.)

Author's summary:—This paper presents a quantity of radio wave propagation data that has been obtained during the past six years by the General Electric Company through the use of its developmental transmission facilities at South Schenectady, New York.

Nineteen radio circuits which radiate in various directions from Schenectady are treated. These circuits range in length from 2,300 to 11,400 miles. Data are given which will aid in determining the proper frequency to use in any high-frequency radio circuit from 1,000 to 10,000 miles in length.

It is shown that the daylight-darkness distribution over the path of propagation largely determines the diurnal and seasonal performance of high-frequency transmissions.

Ultra-Short wave Broadcasting.—German State P.O.: E. Rhein. (*Die Sendung*, 19th and 26th Dec., 1930, Vol. 7, pp. 823 and 839.)

A report from the German P.O. concerning Esau's recent tests in Chemnitz, with comments by Rhein, who calls attention to previous experiments by the P.O., the State Broadcasting Company, and Schröter, and also to the 3 m. work of Meissner and Apel in connecting the driver and the guard of goods trains. The present tests were with waves between 6 and 7 metres, and a 250 w. transmitter installed in a high-lying building, working on a simple 3.50 m. dipole. Reception was by means of various types of multi-valve receiver. "Systematic receiving tests in the town and its near environs gave in general adequate signal strength even in the most densely built-on parts of the town. Only in one direction was the strength markedly decreased, owing to intervening high ground. Strength depended greatly on the height of the receiver: in the upper storeys, good loud-speaker strength was obtained with no open aerial; on lower storeys the strength decreased to a marked degree, and on the ground floor and basement an aerial was necessary—a 1.5 m. wire being sufficient.

"In these tests the limit of range was 6–8 km. The farther from the transmitter, the greater the effect of the height of the receiver; but within limits the loss of strength could be made up for by a higher aerial. No appreciable difference between day and night results was found. Interference by electrical apparatus was less than usual in broadcast reception, but on the other hand the ignition noises of motor vehicles were noticeable. Similar interference has previously been observed at short wave stations when aeroplanes fly over."

"It would seem, therefore, that the ultra-short waves present—according to these Chemnitz tests—certain possibilities for broadcasting. On the other hand further experiments are necessary to find out how screening troubles can be overcome, what types of interference must be dealt with, what methods of modulation and what kind of receiving apparatus or adaptors are necessary to give distortionless broadcast reception."

Further P.O. tests have therefore been in progress since November, in Berlin, with a Lorenz transmitter and a dipole aerial elevated on a tower; and elsewhere by the Lorenz and Telefunken Companies.

Rhein states that the ignition interference referred to in the P.O. report occurs on 5, 6 and 7 m. waves *but is not met with on 8 metres*. The limit of reception lies at 6–8 km.; at any distance beyond about 2 km. it is apparently necessary to use strong reaction. He considers that raising the transmitter on a wireless tower and concentrating on the city by means of reflectors should greatly increase the range. Modulation only presents difficulties if multiple r.f. modulation is used (*see* v. Ardenne, Jan. Abstracts, p. 52; also, it is here stated, Andersen, *Radio World*, March, 1928). There is nothing to prevent 3 to 10 transmitters, on waves between 7 and 8 m., working simultaneously in Berlin each with its single programme.

Ultra-Short Wave Propagation.—Whitehead. (*See* abstract under "Transmission.")

Observations of the Amount of Ozone in the Earth's Atmosphere, and its Relation to other Geophysical Conditions. Part IV.—G. M. B. Dobson, H. H. Kimball and E. Kidson. (*Proc. Roy. Soc.*, Nov., 1930, Series A, Vol. 129, No. 811, pp. 411–433.)

Méthode nouvelle pour le Dosage optique de l'Ozone atmosphérique (New Method for Estimating by Optical Means the Amounts of Ozone in the Atmosphere).—A. I. Duninowski. (*Comptes Rendus*, 10th Nov., 1930, Vol. 191, pp. 859–861.)

A Theory of Upper-Atmospheric Ozone.—S. Chapman. (*Memoirs of the Roy. Meteorological Soc.*, June, 1930, Vol. 3, No. 26, pp. 103–125.)

Author's summary:—The main part of the paper consists of a discussion of the daily and annual variations of the ozone content of the atmosphere in any latitude up to about 50°. The ozone is treated as if it were uniformly spread through a layer of air 10 km. thick, having the same density as the air at the level of maximum ozone density. Convection and diffusion of ozone are neglected. The thermal decomposition of ozone ($2O_3 = 3O_2$) is discussed, and estimated to be negligible, except possibly in connection with an eleven-year (sunspot) variation of ozone. The ozone is supposed formed and decomposed in the 10 km. layer; formation is attributed ultimately to dissociation of O_2 by ultraviolet radiation (1300–1800 A.U.); the ozone is supposed decomposed by longer-wave radiation (2300–2900 A.U.); the intensities of radiation in these bands are supposed to be not greatly different from those that would occur in the spectrum of a black body at 6000°; the photo-electric efficiency of the radiations is supposed *not* to be very low. Then, by day, the dissociation of ozone would seriously reduce its amount, were it not compensated by rapid re-formation $(O + O_2 = O_3)$. The fact that the daily variation of ozone is inconspicuous is used to estimate a lower limit for the rate of this recombination.

In so far as dissociation $(O_3 = O + O_2)$ and re-formation $(O + O_2 = O_3)$ balance one another, they have no ultimate effect on the amount of ozone; but new O atoms are formed by dissociation of O_2, and this tends to increase the amount of ozone. This rate of increase is supposed held in check by reactions which cause the reversion of some of the O (formed from O_2 and O_3) and O_3 to O_2, by the reactions $2O = O_2$, $O + O_3 = 2O_2$. These reactions occur mainly by day; most of the O atoms then present have been formed from O_3. It is shown that the varying rates of these reactions can explain the observed annual variation of ozone, provided that the coefficients of reaction have suitable values. [*Cf.* November Abstracts, 1930, p. 623.]

OBSERVATIONS ON FADING OF RADIO SIGNALS.—A. N. Shtchukin. (*Westnik Elektrot., Moscow*, No. 5, 1930, pp. 163–172.)

Author's summary:—Observations carried out by the Radio Section of the State Physico-Technical Laboratory, Leningrad, on the intensity of signals received from several radio stations are described. The quantitative part of the work includes the measurement of absolute radio field intensity and the value of fading. The qualitative part of the work includes the investigation of different methods of measurement, the study of the periodicity of fading and the investigation of fading due to polarisation. The simultaneous reception of different wavelengths radiated by the same transmitter, and the simultaneous reception on two equal directional antennas, were also investigated.

NOTE ON THE ACCURACY OF ROLF'S GRAPHS OF SOMMERFELD'S ATTENUATION FORMULA.—W. H. Wise. (*Proc. Inst. Rad. Eng.*, Nov., 1930, Vol. 18, pp. 1971–1972.)

The writer points out that Sommerfeld's formula is arrived at by a number of approximations not mentioned by Rolf in his papers (1930 Abstracts, pp. 29 and 388) and that one of these,

$$[i(k_1 - s)r \approx \tfrac{1}{2}qe^{ib}],$$

leads to considerable error if Rolf's graphs are employed for short waves and for poorly conducting grounds.

THE DIFFRACTION OF A CIRCULARLY SYMMETRICAL ELECTRO-MAGNETIC WAVE BY A COAXIAL CIRCULAR DISC OF INFINITE CONDUCTIVITY.—J. Bardeen. (*Phys. Review*, 1st Nov., 1930, Series 2, Vol. 36, No. 9, pp. 1482–1488.)

A mathematical investigation which may be applied in the determination of the power flow into the earth below a vertical antenna which is grounded by a circular disc lying on its surface.

ZUR PHASENANOMALIE BEI EINER KUGELWELLE (On the Phase Anomaly in a Spherical Wave).—J. Picht. (*Zeitschr. f. Phys.*, No. 1-2, Vol. 65, 1930, pp. 14–17.)

Author's summary:—It is shown that, for points on the axis of a spherical wave bounded by a right circular cone, the phase anomaly has not the value π, but varies between 0 and 2π.

ÜBER DIE ELEKTRISCHE WELLENAUSBREITUNG IN METALLEN (On the Propagation of Electric Waves in Metals).—F. Walter. (*Elektrot. u. Masch : bau*, 16th Nov., 1930, Vol. 48, pp. 1034–1035.)

Long summary only, of a paper from the Siemens Laboratories.

EFFECTS OF SHORT LENGTHS OF CABLE ON TRAVELLING WAVES.—McEachron, Hemstreet and Seelye. (*Gen. Elec. Review*, Nov., 1930, Vol. 33, pp. 634–636.)

A NEW FIELD STRENGTH MEASURING EQUIPMENT.—v. Ardenne. (*See* under "Measurements and Standards.")

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

SUR LES RÉLATIONS DES ORAGES MAGNÉTIQUES AVEC LES COURANTS TELLURIQUES (The Relations between Magnetic Storms and Earth Currents).—J. Bosler. (*Comptes Rendus*, 17th Nov., 1930, Vol. 191, pp. 961–963.)

Observations during the past few years at Tortosa (Spain) indicate that it is the earth current which is the primary phenomenon, and that this produces the magnetic disturbance according to Ampère's law: this forms a complete reversal of the earlier view.

THE ULTRA-VIOLET LIGHT THEORY OF AURORÆ AND MAGNETIC STORMS. (CONTINUED.)—E. O. Hulburt. (*Phys. Review*, 15th Nov., 1930, Series 2, Vol. 36, No. 10, pp. 1560–1569.)

THE ULTRA-VIOLET "FLARE" THEORY.—E. O. Hulburt. (*Sci. News-Letter*, 18th Oct., 1930, Vol. 18, p. 253.)

Extracts from a recent lecture on this theory (*cf.* 1930 Abstracts, pp. 34–35 and elsewhere). ". . . . The effects of the absorbed [ultra-violet] radiation are interesting. The ionization in the upper atmosphere is increased and a million ampères or so are suddenly added to the three million ampères encircling the earth. The magnetic effects of the additional current are simultaneous over the earth and constitute the magnetic storm. The solar flare heats the high atmosphere in the day-time, causing it to expand outward. Calculation showed that the ionized layer should be lifted up about 50 miles during an average storm, and measurements with radio signals showed that this was so, increases in height of 30 to 70 miles being observed during magnetic storms." *See* also above.

ÜBER DIE KOAGULATION VON WOLKEN UND NEBEL (On the Coagulation of Clouds and Mist.)—E. Frankenberger. (*Physik. Zeitschr.*, 15th Sept., 1930, Vol. 31, No. 18, pp. 835–840.)

CINÉMATIQUE DES ÉLÉMENTS DE LIGNES ET DE SURFACES D'ÉGALE COTE APPLIQUÉE À LA MÉTÉOROLOGIE (Kinetics of the Elements of "Iso" Lines and Surfaces applied to Meteorology).— –. Mezin. (*Comptes Rendus*, 6th Oct., 1930, Vol. 191, pp. 555–557.)

L'ÉTÉ 1930 ET LES VARIATIONS SOLAIRES (The Summer of 1930 and Solar Variations).—H. Mémery. (*Comptes Rendus*, 22nd Sept., 1930, Vol. 191, pp. 495–497.)

STÖRMER'S AURORA THEORY: DEMONSTRATION OF ELECTRON RAY ENTERING A MAGNETIC FIELD.—Brüche.

(*See* under "Propagation of Waves"; also under "Miscellaneous," Convention in Königsberg.)

NOISE ASSOCIATED WITH LIGHTNING.—M. H. D. Gunther and E. R. Gunther. (*Nature*, 27th Sept., 1930, Vol. 126, p. 472.)

An account of phenomena noticed at Petersfield during the thunderstorms of Aug. 29–30 for which the explanation is suggested that an electrical current, induced in the mains, jumped a switch and illuminated an electric light bulb.

HOLES PRODUCED IN GROUND BY LIGHTNING FLASH.—W. Hall. (*Nature*, 6th Sept., 1930, Vol. 126 p. 352.)

BALL LIGHTNING.—R. W. Wood. (*Nature*, 8th November, 1930, Vol. 126, p. 723.)

An account of a case of globular or ball lightning. *See* also *Nature*, 22nd Nov., 1930, Vol. 126, p. 809.

BALL LIGHTNING.—C. M. Botley. (*Nature*, 13th Dec., 1930, Vol. 126, p. 919.)

A reference to a quotation from Flammarion referring to the undesirability of touching ball lightning globes.

COMPARISON OF LIGHTNING WAVES AND LABORATORY WAVES.—F. W. Peek.

(*See* abstract under "General Physical Articles.")

THE INFLUENCE OF POLARITY ON HIGH-VOLTAGE DISCHARGES [LICHTENBERG FIGURES].—F. O. McMillan & E. C. Starr. (*Journ. Am. I.E.E.*, Oct., 1930, Vol. 49, pp. 859–863.)

LE PARAFOUDRE UNIVERSAL "CORONA" À CHAMBRE D'IONISATION (The "Corona" Universal Lightning Protector with Ionisation Chamber [and Radio-active Salts]).—C. Franck. (*Rev. Gén. de l'Élec.*, 20th Sept. 1930, Vol. 28, pp. 441–447.)

LE RONFLEMENT DES LIGNES AÉRIENNES ET LES PERTURBATIONS ATMOSPHÉRIQUES (The Humming of Aerial Lines, and Disturbances in the Atmosphere).—A. Nodon. (*Comptes Rendus*, 17th Nov., 1930, Vol. 191, pp. 959–961.)

Valuable meteorological information can be obtained from the humming of aerial lines, and two such lines, at right angles, are being installed at the Biarritz Observatory; microphones and valve amplifiers will be used. The humming, which as a rule occurs in a calm atmosphere, is attributed to electrostatic attractions provoked by successive small masses of highly charged air passing rapidly over the line in a direction at right angles to it.

LA COURONNE SOLAIRE ÉTUDIÉE EN DEHORS DES ÉCLIPSES (The Solar Corona Studied apart from Eclipse Times).— –. Lyot. (*Comptes Rendus*, 10th Nov., 1930, Vol. 191, pp. 834–837.)

THUNDERSTORMS AND THE PENETRATING RADIATION—B. F. J. Schonland. (*Proc. Roy. Soc.*, Dec., 1930, Series A, Vol. 130, No. 812, pp. 37–63.)

See January Abstracts, p. 34.

INVESTIGATION OF THE RELATION OF COSMIC RADIATION TO TERRESTRIAL MAGNETIC DISTURBANCES.—W. M. H. Schulze. (*Physik. Zeitschr*, 15th Nov., 1930, Vol. 31, No. 22, pp. 1022–1025.)

PROPERTIES OF CIRCUITS.

THE VAN DER POL FOUR-ELECTRODE TUBE RELAXATION OSCILLATION CIRCUIT.—R. M. Page and W. F. Curtis. (*Proc. Inst. Rad. Eng.*, Nov., 1930, Vol. 18, pp. 1921–1929.)

Authors' summary:—"Relaxation oscillations of an electrical nature are defined, and the operation of a tetrode relaxation circuit is described in detail. The mechanism of frequency division is explained, and oscillograms of the oscillations in this circuit are shown, both of the free oscillation and of the oscillation as controlled in frequency division.

"The characteristics of the oscillator are discussed with reference to frequency drift and stability of frequency division. The period of the oscillator is shown to be approximately $RC \log V_1/V_2$, where V_1 and V_2 are initial and final voltages on the condenser, respectively, during the discharge. V_1/V_2 is shown to change very steeply with average internal grid resistance.

"Modifications are shown for increasing the frequency stability and over-all efficiency of the system, and for controlling the ratio of charging time to discharging time of the condenser. A further modification is suggested for making the internal grid resistance independent of filament voltage when the grid is positive."

One modification suggested involves a change in valve design. The current flow could be limited by a third grid interposed between the filament and the present inner grid. Such a grid, if biased so as to allow only sufficient current to sustain oscillations, would effect a marked increase in valve life, a reduction of drift in filament emission, and the elimination of the dependence of internal resistances on filament voltage. The result would be a more nearly constant frequency, far greater stability for frequency division, and greater over-all efficiency. It is hoped that such three-grid valves, suitable for this circuit, will be available in the near future.

OSCILLATIONS DE RELAXATION PRODUITES PAR UN OSCILLATEUR À QUARTZ PIÉZOÉLECTRIQUE (Relaxation Oscillations produced by a Quartz Oscillator).—P. T. Kao. (*Comptes Rendus*, 17th Nov., 1930, Vol. 191, pp. 932–934.)

In a triode circuit containing a quartz crystal and an oscillatory circuit, the writer has obtained relaxation oscillations quite different from the Fromy type (due to excessive grid polarisation). This new type has a period of the order of half a second, and the writer explains that the two factors necessary for the production of relaxation oscillations (a reservoir for storing up energy and a mechanism for returning the system to its initial condition) are here represented by the quartz itself—which can gradually work up to quite a large amplitude—and by the sudden change in phase of the oscillating circuit as it passes through resonance; such passage being produced automatically by the quartz—since several circuit factors, such as the internal resistance of the valve and even the frequency of the quartz itself, vary with the vigour with which the latter vibrates.

THE DEVELOPMENT OF NEW METHOD FOR THE SUPERPOSITIONS OF ELECTRIC WAVES [RELAXATION OSCILLATION TRIODE CIRCUITS FOR C.-R. OSCILLOGRAPH].—Y. Miyamoto. (*Res. Electrot. Lab., Tokio*, No. 286, 1930, 27 pp.)

In Japanese, with short English synopsis. The writer has designed two types of circuit for improving the synchronisation of the sweeping magnetic field.

DIE STABILITÄT UND SELBSTERREGUNG ELEKTRISCHER KREISE MIT ORGANEN FALLENDER CHARAKTERISTIK (The Stability and Self-Excitation of Electrical Circuits containing Organs with Falling Characteristics [Negative Resistance]).—K. Steimel. (*Zeitschr. f. hochf. Tech.*, November, 1930, Vol. 36, pp. 161–172.)

A re-investigation of this old problem in the light of our present knowledge of the behaviour of the Dynatron and the reactively-coupled valve (Turner Kallirotron, magnetrons, etc.). These organs of negative resistance may be divided into two classes A and B. Class A, which contains the arc and certain valve circuits—including one form of the Abraham multivibrator, can only excite a series circuit; class B (dynatron-type circuits) can only excite a flywheel circuit. The reverse combinations refuse to oscillate even when the Duddell conditions are satisfied. This difference is carefully examined by investigating the processes leading to the negative resistance, with the help of equivalent circuits. The essential difference between the two classes is found to lie in the nature of the reactive coupling, class A being of the current-coupled type and class B of the potential-coupled type.

FREQUENCY DIVISION.—J. Groszkowski. (*Proc. Inst. Rad. Eng.*, Nov., 1930, Vol. 18, pp. 1960–1970.)

English version of the paper referred to in 1930 Abstracts, p. 210. "It is demonstrated that the division of frequencies, that is, the inverse process from frequency multiplication, is possible by using a triode arrangement. The requirements of such a circuit are analyzed theoretically and the conditions resulting from this study are tested experimentally. Curves are included showing the results of these experiments when the initial frequency bears a ratio to the final frequency equal to a small integer number."

SELECTIVITY AND DAMPING OF A REGENERATIVE RADIO RECEIVER.—E. S. Antseliovitch. (*Westnik Elektrot., Moscow*, No. 5, 1930, pp. 194–196.)

"Some considerations and conclusions on the definition of the terms 'damping' and 'selectivity' in connection with regenerative radio receivers. The dependence of these quantities on the intensity of the received signals. A graphical illustration of the conclusions."

THE ESTIMATION OF THE SENSITIVITY OF THE GRID RECTIFIER FOR LARGE INPUTS.—C. D. Hall. (*E.W. & W.E.*, Dec., 1930, Vol. 7, pp. 668–670.)

Measurements on the sensitivity of the grid rectifier, using low impedance valves with high anode voltages and resistance coupling, gave much smaller outputs than those calculated by Barclay's method using measured valve characteristics. This discrepancy was found to be due to the small time constant of the grid condenser and leak circuit, necessary in order to follow the modulation. The results are here investigated and the calculation of the necessary correction factor described.

THEORIE DER NIEDERFREQUENZ-VERSTÄRKERKETTEN (Theory of Chains of Low Frequency Amplification Stages).—R. Feldtkeller and F. Strecker. (*Arch. f. Elektrot.*, 7th Nov., 1930, Vol. 24, No. 4, pp. 425–468.)

Authors' summary:—This paper discusses input amplifier chains for distortionless amplification of broad low-frequency bands; the sections are of the same or similar construction and are used with alternating voltages sufficiently small for the sections to be considered as linear systems as far as alternating current is concerned. This means that the position of the working point in the field of non-linear valve characteristics does not depend on the alternating currents but on the mean grid and anode potentials relative to the cathode; these are functions of the battery voltages and of the direct current resistances of the system.

Use is made of the relations connecting the field of non-linear characteristics and the constants of the linear system of alternating currents to determine in diagrammatic form the working voltages and anode resistances with which the valve will deliver the largest alternating voltage to the following stage, the alternating voltage on the grid and the permissible linear distortion being given.

In the discussion, the valve is regarded as being connected with the dynamic capacity of the next valve by means of a coupling connection in the anode circuit; this allows the effect of the subsequent sections of the amplifier chain to be estimated.

For higher frequencies (*e.g.*, those occurring at the upper limit of the acoustic range) the effect of the succeeding valves can no longer be represented by a constant dynamic capacity. A rigid calculation of the amplification factors of the whole chain of amplifiers is thus necessary and has been carried out by means of the circuit equations of the system.

It is found that these systems may be considerably simplified when the frequencies considered are limited to the range below about one megacycle p.s.

The amplification factors of the chain have been approximated to by the products of the chain transmission factors of the sections, for which comparatively simple expressions may be found from the theory of quadripoles. These are shown in diagrams, from which the most favourable dimensions for the coupling connections can be deduced for prescribed frequency bands and permissible distortion. In this connection it is found that, in contrast to the resistance coupling used when coupling is effected with repeaters with finite leakage coefficients, the coupling elements are subject to an important limitation, since the amplification can be increased to the point of self-oscillation by the inductances in the anode circuits and the negative effective values of the input resistances thus produced in the grid circuits. The limiting values which are permissible for the circuit elements may be determined by means of the diagrams given.

The two capacities (1) of the valve and (2) of the circuit elements, which influence the grid, have a very great effect on the character of the amplification curves. A method is deduced, from considerations of impedance, by which these capacities may be determined exactly from impedance measurements at a fixed low frequency.

The chain impedances of the sections of the amplifier chain are closely connected with the chain transmission factors. They may be determined from the chain transmission factors without the necessity of solving quadratic equations. Using the chain impedances, the amplifier chain may be calculated for arbitrary terminal impedances; the appropriate method is shortly indicated.

Finally, a comparison is made to determine whether resistance coupling or resistance repeater coupling gives the greater possible amplification. It is found that the resistance repeater coupling is superior to the resistance coupling when the upper limit of frequency is below a definite value, and vice versa. The frequency for which the two are approximately equal is about one megacycle p.s. for the input amplifier valves commonly used.

IMPEDANCE CORRECTION OF WAVE FILTERS. DEVELOPMENT OF IMPEDANCE REQUIREMENTS.—E. B. Payne. (*Bell Tech. Journ.*, Oct., 1930, Vol. 9, No. 4, pp. 770–793.)

A METHOD OF IMPEDANCE CORRECTION.—H. W. Bode. (*Bell Tech. Journ.*, Oct., 1930, Vol. 9, No. 4, pp. 794–835.)

MUTUAL IMPEDANCES OF GROUND RETURN CIRCUITS. SOME EXPERIMENTAL STUDIES.—A. E. Bowen and C. L. Gilkeson. (*Bell Tech. Journ.*, Oct., 1930, Vol. 9, No. 4, pp. 628–651.)

TRANSIENTS IN PARALLEL GROUNDED CIRCUITS, ONE OF WHICH IS OF FINITE LENGTH.—L. C. Peterson. (*Bell Tech. Journ.*, Oct., 1930, Vol. 9, No. 4, pp. 760–769.)

STROOMVERDEELING IN EEN EENLAGIGE SPOEL MET INACHTNAME VAN DE WEDERKEERIGE INDUCTIE TUSSCHEN ELK PAAR SPOELELEMENTEN (The Current Distribution in a Single Layer Bobbin, taking into consideration the Mutual Induction between Each Pair of Elements).—K. Posthumus. (*Tijdschr. Nederl. Radiog.*, No. 6, Vol. 4, 1930, pp. 165–188.)

Theoretical, confirmed by experiment. From the latter it appears that cylindrical metallic screens diminish the mutual induction between neighbouring elements but increase that between more distant elements. This effect can be avoided by using non-metallic screens covered with strips of tin-foil. In this way the theoretical wavelength can be obtained for wavelengths down to 50 metres.

THE "GRID" DYNATRON CIRCUIT.—Ito. (*See* under "Valves and Thermionics.")

TRANSMISSION.

UNTERSUCHUNGEN ÜBER SCHWUNDERSCHEINUNGEN BEI KURZEN WELLEN (Investigations on Short-Wave Fading Phenomena).—K. Krüger and H. Plendl. (*Physik. Zeitschr.*, 1st Dec., 1930, Vol. 31, No. 23, pp. 1057–1058.)

A short notice only of a method of decreasing fading on short waves (about 50 m.) at the receiver by using an emitter with two perpendicular horizontal antennæ (one in the N.-S., one in the E.-W. direction) excited alternately in step with a frequency of modulation. Typical records of reception at points south of the emitter are given and compared with those due to a normal emitter. *See also* 1930 Abstracts, p. 452.

AN INTERESTING SIDEBAND PROBLEM.—G.W.O.H. (*E.W. & W.E.*, Dec., 1930, Vol. 7, pp. 651–652.)

A conundrum whose solution shows that if an oscillatory circuit is slightly detuned, one incoming sideband may produce a much larger current than the carrier and other sideband combined—"a fairly conclusive proof of its reality." It also emphasises the importance of splitting up a modulated e.m.f. into its constituent components of constant amplitude before attempting to predict its action on an oscillatory circuit.

ÜBER MODULATION, SENDERBANDBREITE UND DEMODULATION (Modulation, Band Width and Demodulation).—W. Runge. (*Telefunken Zeit.*, October, 1930, Vol. 11, No. 55, pp. 28–34.)

The only possible forms of modulation are amplitude-, frequency- and phase-modulation. The writer investigates each form mathematically and shows that there are no disadvantages in amplitude-modulation but great advantages—the smallest necessary transmitting power and the simplest receiver.

In amplitude- and phase-modulation, the amplitudes of the sidebands are proportional only to the modulating amplitudes, while in frequency-modulation they are also inversely proportional to the modulating frequencies. It is often maintained, therefore, that frequency-modulation causes less interference, since the sideband amplitudes sink at the higher frequencies. But this result can also be obtained with amplitude-modulation by a suitable arrangement of frequency-dependence prior to the transmission, this being compensated for in the receiver in a very simple manner.

PHASENMODULATION (Phase-Modulation).—W. Loest. (*Zeitschr. f. hochf. Tech.*, Nov., 1930, Vol. 36, pp. 188–190.)

The hope of reducing the width of the wavebands in telephony, by the substitution of frequency-modulation for amplitude-modulation, has been shown by Carson, Salinger, Roder and van der Pol to be unfounded. The writer examines the possibilities of a third type of modulation, phase-modulation, and finds that here also sidebands are formed on either side of the carrier at intervals equal to the modulating frequency. Whereas in the case of frequency-modulation van der Pol's "modulation index" m depends on the modulating frequency, in phase-modulation it is governed only by the magnitude of the phase displacement.

THE GENERATION OF [ULTRA-] SHORT WAVES.—W. W. Maslennikoff. (*Journ. Appl. Phys., Moscow*, No. 3, Vol. 7, 1930, pp. 81–91.)

Experiments are described with the Russian Type R 5 valve connected to a Lecher wire system. With the circuit employed, the generated wavelength is regulated entirely by the position of the bridge, *i.e.*, by the natural wavelength of the external circuit. The optimum anode voltage, *i.e.*, that which gives oscillations of the greatest energy, is found to be related to wavelength by the empirical formula $\lambda E^{3/2}_{a\,\max.} = \text{const.}$ Further, if l is the length of the external oscillatory circuit, then $l + d = \lambda/4$, where d is the so-called "oscillatory circuit shortening" determined by Drude's theory: from this relation it is possible to calculate the internal dynamic capacity of the valve.

SENDER FÜR ULTRAKURZE WELLEN (Ultra-Short Wave Generator).—W. Kroebel. (*Zeitschr. f. Phys.*, 1930, Vol. 65, Nos. 11/12, pp. 726–729.)

"A transmitting arrangement for short undamped waves (λ about 10–20 cm.) is described. The transmitter may be tuned in a simple way to the desired wave-length." For previous work by the writer, using Russian valves, *see* 1930 Abstracts, p. 505.

PRACTICAL EXPERIMENTS IN ULTRA-SHORT WAVE COMMUNICATION.—C. C. Whitehead. (*E.W. & W.E.*, Oct. and Nov., 1930, Vol. 7, pp. 542–551 and 612–620.)

The wavelength used was just below 3 m. Points of interest on the transmitting side include:—(1) the abandonment of push-pull circuits in favour of the single-valve circuit first used by Gill and now called the "Huxford" circuit in the U.S.A. (2) Screening of valve envelopes—not "ordinary" screening, the conductor must be in close contact; *cf.* 1930 Abstracts, p. 211. (3) Power conversion efficiency was about 12 %; loss due to time period being comparable with transit time of electrons is estimated at about 40 % of input energy; feeder loss at about 35 %, mainly dielectric losses.

Points in reception:—As a low capacity valve was desired, the V.24 type was adopted and adhered to; the same Gill circuit was used; super-regeneration produced such an increase in range [something like 10 : 1] that it was permanently adopted. About 30 kc. was found to be a good quenching frequency, for reasons given.

Both transmitter and receiver were easy to handle, a change of valve or a variation of H.T. causing no trouble.

Results of range tests, *at ground level*, are given. H.T. input to transmitter was nearly 20 w., and the greatest range recorded is 8,000 yds. (later improved to 10 miles). As regards propagation, the writer concludes that a definite and limited zone exists around the transmitter wherein signals are invariably audible; that within this region the horizontally polarised wave is the more efficient, but that its plane becomes rotated (owing to the influence of the ground) so that within a wavelength of the ground it becomes vertical at extreme ranges; that the vertically polarised wave suffers more from attenuation, over difficult ground, than the horizontally polarised, but that no trace of change in *its* plane of polarisation can be found under any circumstances or at any range so far obtained; and that the pure space wave does not undergo any change in plane of polarisation, whether emitted horizontally or vertically, or at any range. The influence of conditions local to the receiver seems to have more effect on the strength of received signals than similar conditions local only to the transmitter. Even in thunderstorms not a single atmospheric was noticed.

ÜBER FREIE SCHWINGUNGEN EINER ELEKTRONENRÖHRE MIT LECHER-SYSTEM. BARKHAUSEN-KURZ-SCHALTUNG (Free Oscillations of a [Flat Electrode] Valve with Lecher Wire System, B.-K. Circuit).—R. Wundt. (*Zeitschr. f. hochf. Tech.*, Oct., 1930, Vol. 36, pp. 133–146.)

Sahanek's theoretical conclusion that B.-K. oscillations cannot be obtained with flat plate electrodes is here disproved (*cf.* also Gerber, January Abstracts, pp. 38–39). In the valves employed, the cathode takes the form of 14 oxide-coated filaments stretched between two parallel "bus-bars," and the grid and plate are similarly flat. On the assumption that the electron oscillations and the oscillatory circuit are coupled through the valve capacity, the dependence of the wavelength and damping of the oscillations on the length of the Lecher wires is calculated: the results are confirmed by experiment. The experimental results agree with those of Hollmann, obtained with cylindrical electrodes.

The B.-K. equation $\lambda_0^2 E_g$ = const. is not fulfilled exactly, because in addition to the grid potential the space charge has an effect on the electron movements, and with these particular valves the space charge is particularly large owing to the grid lying on one side only of the cathode.

ÜBER DIE FREQUENZ DER BARKHAUSENSCHWINGUNGEN (The Frequency of the B.-K. Oscillations).—H. G. Möller. (*E.N.T.*, Nov., 1930, Vol. 7, pp. 411–419.)

A continuation of the work dealt with in 1930 Abstracts, pp. 627–628.

Formulae are derived for the dependence of frequency upon (*a*) heating current, (*b*) amplitude, and (*c*) tuning of the Lecher wire system.

DER BARKHAUSEN-KURZ-EFFEKT NACH DER WELLENMECHANIK (The Barkhausen-Kurz Effect according to Wave Mechanics).—K. Schuster. (*Ann. der Physik*, 1930, Ser. 5, Vol. 7, No. 1, pp. 54–64.)

Author's summary :—A discussion of the Barkhausen-Kurz effect is given on the principles of wave mechanics with simplifying assumptions. It is found that, starting from the fundamental level, the distances apart of neighbouring energy levels first decrease, reach a minimum and then increase again. This gives a system of spectral lines which has a certain similarity to a band system. The band edge of lowest frequency corresponds to the wave-length calculated by Barkhausen and Kurz.

A METHOD OF OBTAINING QUARTZ-CONTROLLED OSCILLATIONS OF SOME HUNDRED WATTS, USING A SCREEN-GRID VALVE.—Y. Kusunose. (*Journ. Inst. Tel. & Teleph. Eng., Japan*, June, 1930, p. 515.)

In Japanese. The writer's previous circuit could not be used above 1.5 megacycles owing to the plate/grid capacity of the valve. He now uses a screen-grid valve and obtains the same power output at much higher frequencies. Curie-cut crystals are better than 30 degree-cut ones. Both types undergo considerable heating during operation.

FREQUENCY STABILISATION OF HETERODYNE OSCILLATORS THROUGHOUT A WIDE CONTINUOUS FREQUENCY RANGE.—A. Wainberg and N. Titoff. (*Journ. Appl. Phys., Moscow*, No. 3, 1930, Vol. 7, pp. 37–60.)

An analytical examination of the conditions for frequency-independence (for varying filament and anode voltages) shows a whole series of conditions to be fulfilled, but experiments prove that the fulfilment of only 4 of these gives good results: these 4 are :—a minimum ratio L_a/C_a (λ = const.); maximum internal resistance of the triode; the presence of a large non-inductive resistance in the anode circuit (100,000–200,000 ohms); a grid leak in the grid circuit. For considerable changes of filament and anode voltages, frequency variations can in this way be kept down to less than 0.001 %; this percentage can be reduced still further by fulfilling other of the conditions obtained analytically. The above refers to l.f. and ordinary h.f. oscillations; short waves are being investigated separately.

ELIMINATION OF HARMONICS IN VALVE TRANSMITTERS.—Y. Kusunose. (*Journ. Inst. Tel. and Teleph. Eng., Japan*, May, 1930, p. 433.)

In Japanese. The paper includes the description of a method of eliminating the strongest harmonic by introducing into the plate circuit a parallel resonant circuit having a slightly lower natural frequency than the harmonic, and coupled to the main oscillatory circuit. The method has been found effective experimentally.

RECEPTION.

ÜBER DIE MÖGLICHKEIT, SENDER ZU TRENNEN, DEREN SEITENBÄNDER SICH ÜBERLAPPEN (The Possibility of Separating Two Stations whose Sidebands Overlap [with a comment on the Stenode Radiostat]).—W. Runge. (*Telefunken Zeit.*, Oct., 1930, Vol. 11, No. 55, pp. 34–35.)

A short investigation of the question whether a receiver can be so designed as to receive only such frequencies as are symmetrical with regard to the carrier frequency. Assuming such a receiver to be receiving a carrier t and two symmetrical side-frequencies b_1 and b_2, the writer imagines an interfering frequency s on the outside of b_2 and then brings it nearer to the carrier till finally it coincides with b_2. Then if its amplitude is supposed to equal that of b_2 and its phase is opposed, the receiver will find itself dealing with the carrier t and one asymmetrical frequency b_1: it will therefore be silent. Such a receiver is therefore impracticable: it is quite possible to build one which will be insensitive to interference *on one side of the carrier* [*cf.* David, Jan. Abstracts, p. 40], but then it will receive only the sideband on the other side of the carrier and will be susceptible to interference on that side.

AN IMPROVED PRE-SELECTOR CIRCUIT FOR RADIO RECEIVERS.—E. A. Uehling. (*Electronics*, Sept., 1930, Vol 1, pp. 279–281 and 309.)

In combinations of inductive and capacitive coupling seeking to obtain uniformity in the transmission characteristic, it is usually found that, in spite of adjustment of constants, the rate of variation of the width of the band with change of frequency is greater than that for purely inductive or purely capacitive coupling. In the circuit here given, however, the mutual impedance is so arranged that an e.m.f. induced in the second circuit by a current in the first circuit is of the same sign for a capacitive element as for an inductive element. By a suitable adjustment it can be arranged that the transmission characteristic is rectangular in form and the selectivity characteristic very nearly uniform throughout the broadcast range.

DIE FUNKABSCHIRMUNG AN FLUGMOTOREN (Spark Screening of Aircraft Engines).—W. Dorn. (*E.T.Z.*, 20th Nov., 1930, Vol. 51, pp. 1610–1613.)

An article based on German and American technique, dealing not only with ignition screening but also with the screening of the charging dynamo, etc.

NEUES ÜBER STÖRUNGSSCHUTZ IM RUNDFUNK (Recent Methods of Eliminating Interference [from Dynamos, etc.] with Broadcast Reception).—G. Büscher. (*Die Sendung*, 10th Oct., 1930, Vol. 7, pp. 651–652.)

BESEITIGUNGSMASSNAHMEN BEI RUNDFUNK-EMPFANGSTÖRUNGEN (Methods for the Elimination of Interference with Broadcast Reception).—W. Hasenberg. (*E.T.Z.*, 30th Oct., 1930, Vol. 51, pp. 1523–1524.)

DEVICE FOR ELIMINATION OF ATMOSPHERICS AND INTERFERENCE.— —. Bruni. (*Europ. Fernsp:dienst*, Nov., 1930, No. 20, p. 402.)

Paragraph on Bruni's reported invention which is apparently being tested by the Italian Broadcasting authorities and watched by Army and Navy representatives. No details are given.

NEW METHODS OF ELIMINATION OF PARASITIC CURRENTS IN RADIO RECEIVERS.—S. Manczarski. (*Wiadomości i Prace, Inst. Radjotech., Warsaw*, No. 5, Vol. 2, pp. 117–184.)

Author's summary :—The author deals with the following questions : (i) The elimination of parasitic currents in broadcast reception. (ii) Analysis of frequency of parasitic currents. (iii) Frame and antenna effect of coils. (iv) Inductive-capacity coupling. (v) Elimination of atmospherics. (vi and vii) Elimination of parasitic currents caused by transmitters and by power lines. From mathematical considerations he derives various methods of elimination of parasitic currents in radio receivers. Among the other methods, new methods of elimination of the disturbances caused by power lines are given.

RECORDING BY ELECTRO-OSMOSIS.—(French Pat. 688017, Volmer, pub. 18th Aug., 1930.)

Other methods of recording often fail when the signals take the form of a series of short impulses in rapid succession. The present method converts these current impulses into impulses applied to liquids by the use of electro-osmosis. The liquid, emerging from a nozzle, moistens the passing slip so that a local current can flow and cause a change of colour in the chemical with which the slip is impregnated.

SHORT WAVE RECEIVER TYPE R.C.25 [FOR COMMERCIAL STATIONS, BEAM OR NON-BEAM TYPE AERIAL SYSTEMS].—J. A. Smale. (*Marconi Review*, Nov., 1930, No. 26, pp. 1–14.)

A double heterodyne receiver with amplification at three different frequencies including the fundamental, using screen-grid valves in the high frequency amplifier.

TYPE R.G. 29C RECEIVER (particularly suitable for Duplex Telephony Services).—Marconi Company. (*Marconi Review*, Nov., 1930, No. 26, pp. 20–24.)

In the course of this article, reasons are given for not making use here of the " valve-heart " for obtaining its cardioid diagram [*i.e.*, a comparatively small vertical aerial coupled through a valve to the frame aerial circuit]. The receiver is designed to combine sensitivity with extreme selectivity ; it employs one screen-grid r.f. stage, a detector capable of self-oscillation, and a l.f. stage ; wave-range is 500–1,200 m.

DIE EMPFANGSSTATION AUF DAMPFER " BREMEN " (The Receiving Station on board the " Bremen ").—E. Zepler. (*Telefunken Zeit.*, Oct., 1930, Vol. 11, No. 55, pp. 50–51.)

A short article on this equipment, which had to fulfil the conditions (i) reception on various receivers simultaneously, on one aerial only, and (ii) reception during working of the ship's transmitter.

NEUTRODYNE AND SUPERHETERODYNE RECEIVERS AND THEIR DERIVATIVES : AN ANALYSIS OF THEIR OPERATION.—F. Vilbig. (*T.F.T.*, April and May, 1930, Vol 19, pp. 109–120 and 141–145.)

UN NOUVEAU MONTAGE DE DÉTECTION PAR LA COURBURE PLAQUE (A New Detection Circuit using Anode Bend).—L. G. Veyssière. (*T.S.F. Mod.*, August, 1930, Vol 11, pp. 384–393.)

To avoid the step-by-step adjustment of an anode-bend detector by means of the grid bias, the writer uses a screen-grid or multi-grid valve and displaces the plate-current curve parallel to itself without varying the grid potential, by a variable resistance in the circuit of the second grid. The principle has been applied to a three-grid power valve.

" A CRITICAL REVIEW OF LITERATURE ON AMPLIFIERS FOR RADIO RECEPTION."—J. Zenneck. (*Zeitschr. f. hochf. Tech.*, Nov., 1930, Vol. 36, p. 200.)

Review of the recently published Radio Research Special Report No. 9 of the Department of Scientific and Industrial Research. The reviewer ends by expressing strongly his hope that the methods of the present volume may be applied to other branches of Wireless.

AERIALS AND AERIAL SYSTEMS.

BERECHNUNG DER STRAHLUNGSCHARAKTERISTIKEN UND STRAHLUNGSWIDERSTÄNDE VON ANTENNENSYSTEMEN (The Calculation of the Radiation Characteristics and Radiation Resistances of Aerial Systems).—R. Bechmann. (*Zeitschr. f. hochf. Tech.*, Nov., 1930, Vol. 36, pp. 182–188.)

This first instalment begins with a general consideration of radiation resistance, leading to a formula for the radiation resistance of an aerial system of uniform components which was given by Pistolkors (1929 Abstracts, p. 329) for the special case when all the current amplitudes are assumed equal. *See also* Bechmann, 1930 Abstracts, p. 455. It then goes on to the calculation of the Hertz vector and the electric and magnetic field strengths, for a single linear radiator.

The final instalment will give the summation of the expressions thus obtained, to give the directional characteristics of aerial systems built up of parallel radiators, and will end by a calculation of the radiation resistance for any desired distribution of current in the individual wires. The greater part of the paper, including as an example the calculation of the radiation resistances of the individual wires of a 6 × 6 dipole system, is given in *Telefunken Zeit.*, Oct., 1930, Vol. 11, No. 55, pp. 52–63.

On the Calculation of the Radiation Resistance of an Antenna.—A. E. Suzant. (*Westnik Elektrot., Moscow*, No. 5, 1930, pp. 196–198.)

A short paper to demonstrate the equivalence of the two methods (integration of the Poynting vector, and Brillouin's method based on the induced e.m.f.) as both are based on integrating Maxwell's equations with the same assumptions.

Résistance de Rayonnement d'une petite Antenne oscillant en Demi-Onde (Radiation Resistance of a Small Aerial Oscillating to a Half-Wave).—S. Sonada. (*L'Onde Élec.*, Nov., 1930, Vol. 9, pp. 511–519.)

See 1930 Abstracts, p. 570.

Om Sändareantenners Effektivitet med särskild hänsyn till Rundradions Våglängder (The Efficiency of Transmitting Aerials, especially for Broadcasting Wavelengths).—E. T. Glas. (*Tekn. Tidskr.* (*Elek.*), Nos. 5 and 9, Vol. 60, 1930, pp. 21–28 and 51–59.)

Deals with current distribution, aerial resistance, the effects of masts, etc., etc.; fading, field strength at the surface of the earth, radiating efficiency and its improvement.

On the Efficiency-rating of Transmitting Aerials for Broadcasting Distribution.—E. T. Glas. (*E.W. & W.E.*, Dec., 1930, Vol. 7, pp. 665–668.)

The writer shows how a simple efficiency formula can be deduced according to the definition which he proposes for the percentage efficiency of an aerial, taking the no-loss half-wave aerial as a standard.

Mathematical Notes on Receiving Aerials.—Y. Kato. (*Journ. I.E.E. Japan*, Oct., 1929.)

In Japanese. By equating the energy flowing into the closed surface enclosing a doublet, of length h and ohmic resistance R_0, to the energy dissipated in the doublet, the current produced by a plane electromagnetic wave of intensity E is found to be $Eh\Big/\frac{80\,\pi^2h^2}{\lambda^2} + R_0$. Similar treatment is given to the straight wire aerial of half-wavelength and to the Marconi type beam aerial. For an m-stage beam aerial with n wires, the received current is given by

$$I_0 = \frac{mn^2E\,.\,\frac{\lambda}{\pi}}{R + mnr_0\,.\,\frac{\lambda}{4}},$$

where R is the radiation resistance and r_0 the ohmic resistance of each wire.

Transmission on Two Aerials at Right Angles to Avoid Fading.—Krüger & Plendl. (*See* under "Transmission.")

VALVES AND THERMIONICS.

Method of Alignment Applied to Anti-Logarithmic Triode Characteristics.—W. A. Barclay. (*E.W. & W.E.*, Dec., 1930, Vol. 36, pp. 671–675.)

In a former paper (*ibid.*, April, 1929, pp. 178–183) the writer obtains an antilogarithmic formula for the "lumped" characteristic of a triode, namely $i_a = I_s\{1 - 10^{a(1-10^{bv})}\}$, where $v = v_a + \mu v_g$ in the usual way. [This formula may also be employed to represent the ordinary triode characteristics with variable grid and anode voltages.] In determining the constants a and b from a given characteristic, and in the reverse process of deriving the characteristic from the formula, the Principle of Alignment provides material assistance, as the present paper shows.

Shot Effect of the Emission from Oxide Cathodes.—H. N. Kozanowski and N. H. Williams. (*Phys. Review*, 15th Oct., 1930, Series 2, Vol. 36, No. 8, pp. 1314–1329.)

Authors' abstract :—Experimental procedure in the study of fluctuations in the space current of a thermionic emitter is outlined. A new method of measuring *shot-circuit impedance* is introduced. Conditions under which the observed fluctuations may be applied to determine the electronic charge are pointed out. A method is described whereby the frequency of oscillating circuits used in this investigation may be determined and controlled. An investigation has been made of the fluctuations associated with the emission from barium-strontium oxide cathodes, particularly in the space charge region. The presence of positive ions in the emission from oxide coatings has been experimentally verified. These positive ions moving in an electron space charge cause abnormally high shot-fluctuations in an aperiodic circuit at high amplifier frequencies. The characteristic fluctuations associated with the emission from oxide cathodes have been reproduced in a vacuum tube of special design in which positive ions from an independent Kunsman potassium ion emitter interact with electron space charge about a metal emitter. This is taken as evidence that the same process goes on in the emission from barium-strontium oxide cathodes. Some results obtained in a study of the shot effect of films evaporating from a tungsten wire are included.

VORLESUNGSVERSUCH ZUR DEMONSTRATION DER WIRKUNG EINER MONOATOMAREN NATRIUMSCHICHT AUF DIE GLÜHELEKTRONENEMISSION EINES WOLFRAMDRAHTES (Lecture Experiment Demonstrating the Effect of a Monatomic Sodium Layer on the Thermionic Emission of Tungsten Wire).—R. Suhrmann and F. Breyer. (*Physik. Zeitschr.*, 15th Sept., 1930, Vol. 31, No. 18, pp. 823–824.)

THERMIONIC EMISSION OF OXIDE COATED CATHODES CONTAINING AN NI-BA ALLOY CORE.—N. C. Beese. (*Phys. Review*, 15th Oct., 1930, Series 2, Vol. 36, No. 8, pp. 1309–1313.)

HIGH EFFICIENCIES OF EMISSION FROM OXIDE-COATED FILAMENTS.—B. J. Thomson. (*Phys. Review*, 15th Oct., 1930, Series 2, Vol. 36, No. 8, pp. 1415–1417.)

Very high efficiencies of electron emission were observed from filaments of nickel, coated with barium and strontium carbonates.

ÜBER DIE LEISTUNGSVERSTÄRKUNG DER ELEKTRONENRÖHREN (On the Power Amplification of Electron Tubes).—N. Vermes. (*Ann. der Physik*, 1930, Series 5, Vol. 7, No. 3, pp. 257–266.)

"In continuation of a former paper [*cf.* 1930 Abstracts, p. 456], the variation factors of grid and anode voltage and current are calculated. These are then used to calculate the variation factors of the power produced."

DAS GITTERDYNATRON (The "Grid" Dynatron Circuit).—Y. Ito. (*E.N.T.*, Nov., 1930, Vol. 7, pp. 419–426.)

In the usual dynatron circuit an oscillatory circuit is inserted in the anode lead, and oscillation is produced by the negative resistance occurring in the anode circuit owing to secondary emission in the presence of high positive *grid* potential. Such an arrangement is here called an "anode dynatron" to distinguish it from the "grid dynatron" circuit, in which a second oscillatory circuit is introduced into the grid circuit and oscillation is caused by the negative resistance in the grid circuit due to secondary emission in the presence of high positive *anode* potential.

In the grid dynatron circuit, the grid circuit oscillations are communicated to the anode circuit, but their frequency remains chiefly dependent on the grid circuit constants. The arrangement therefore gives a generator whose frequency is only slightly altered by loading the anode circuit; the influence of the latter circuit is only visible when its natural frequency is almost the same as that of the grid circuit, when a pulling-into-tune effect occurs.

The oscillations may be strengthened by the use of a second, space-charge grid with reaction from the grid circuit so that the a.c. potentials on the two grids are kept in phase. The paper investigates the behaviour of the single and double grid circuits.

G.E.C. VALVE "CAPABLE OF MEASURING 10^{-17} A."—B. J. Thompson. (*Electronics*, Sept., 1930, Vol. 1, pp. 290–291.)

The development and construction of the valve referred to in January Abstracts, p. 43. The design was arrived at by combining a number of steps for reducing grid current; *e.g.*, reduction of the photoelectric emission by using a thoriated tungsten filament operating at a low temperature. The grid current and input resistance are of the order of 10^{-15} A. and 10^{16} ohms respectively. *See also* below.

A LOW GRID-CURRENT VACUUM TUBE.—G. F. Metcalf and B. J. Thompson. (*Phys. Review*, 1st Nov., 1930, Series 2, Vol. 36, pp. 1489–1494.)

Authors' abstract:—The various factors that may cause a current to flow to the control grid of a high vacuum tube are outlined. The magnitudes of the separate components are experimentally determined, and methods are given by which these currents may be greatly reduced. A tube is described which has a grid current of 10^{-15} ampère and a mutual conductance of 25 microampères per volt. As an input resistance of 4×10^{11} ohms may be used, a current of 10^{-17} ampère may be detected when a galvanometer having a sensitivity of 10^{-10} ampère per millimetre is used in the plate circuit. Under this condition the sensitivity is 250,000 millimetres per volt. *See also* above.

DIE AUSSENSTEUERRÖHRE ALS AUDION UND WIDERSTANDSVERSTÄRKERRÖHRE (The External-Grid Valve as Audion and Resistance-Amplifier Valve).—G. Jobst, J. Richter and W. Wehnert. (*Telefunken Zeit.*, Oct., 1930, Vol. 11, No. 55, pp. 38–47.)

A very complete account of the development of the Telefunken "rod" valves. The effects of the nature of the glass employed and of the shape of the container, and the influence of the gas filling on the rectification and on the suppression of the low frequencies, are dealt with in considerable detail.

DI ALCUNI TUBI TERMOIONICI A PIÙ DI TRE ELETTRODI (Some Thermionic Valves with more than Three Electrodes).—U. Ruelle. (*Reg. Accad. Nav. Livorno*, No. 50, 1930, 9 pp.; *Rass. d. Poste, d. Teleg. e d. Telef.*, No. 4, April, 1930.)

ÜBER VERSTÄRKERRÖHREN MIT PHOTOELEKTRISCHER EMISSION (Amplifier Valves with Photoelectric Emission).—M. v. Ardenne. (*Zeitschr. f. hochf. Tech.*, Oct., 1930, Vol. 36, pp. 146–151.)

A paper on the valves dealt with in the *Wireless World* article (1930 Abstracts, pp. 631–632). After a historical introduction, the writer amplifies somewhat the information given in that article and then deals at length with methods of obtaining illumination of sufficient constancy.

VERGLEICH ZWEIER VERFAHREN ZUR BESTIMMUNG VON KONTAKTSPANNUNGEN ZWISCHEN METALLEN (Comparison of Two Methods of Determination of Contact Voltages between Metals).—G. Mönch. (*Zeitschr. f. Physik*, 1930, Vol. 65, No. 3-4, pp. 233–243.)

DIRECTIONAL WIRELESS.

SUR UN PROCÉDÉ DE GUIDAGE DES AVIONS (A Method of Guiding Aircraft).—M. Biot. (*L'Onde Élec.*, Nov., 1930, Vol. 9, pp. 520–526.)

The writer explains that in its simplest form the system is not so much a true " guiding " as a means of allowing the aircraft to gather its position from an exact knowledge of the path it has traversed. A zone of interference produced by synchronised transmissions from two stations is created along the route; the aircraft is supplied with a " counter " which registers the number of maxima and minima passed through; the distance travelled can be obtained, since the wavelength is known.

By employing two pairs of transmitters, each pair on a different wavelength, a further development is possible. If the pairs are situated at right angles, a cross-system of nodal lines is obtained, and if the aircraft counts algebraically the nodal lines traversed in each group, it can determine its exact position. The need for two different wavelengths can be avoided by the plan of transmitting alternately, in rapid succession, from the two pairs.

A RADIOBEACON AND RECEIVING SYSTEM FOR BLIND LANDING OF AIRCRAFT.—H. Diamond and F. W. Dunmore. (*Bur. of Stds. Journ. of Res.*, Oct., 1930, Vol. 5, pp. 897–931.)

The improved system is made up of three elements, the runway localising beacon, the boundary marker beacon, and the landing beam (ultra-short wave)—see diagram.

Each of these elements is described in some detail, including the receiving apparatus. The 3.2 m. landing beam equipment is given most attention. The Uda system of wave-directors and wave-reflectors is here employed. A horizontal dipole is used for the receiver, which has only two valves without regeneration and requires no adjustment—not even volume control, since the path followed constitutes a line of constant field intensity and the indications are furnished by a d.c. micro-ammeter mounted on the instrument board.

Along the centre of the beam is the line of greatest signal strength; if, therefore, the pilot hits the beam head-on near the centre and then starts to drop, approaching the field as he does so, the signal will remain at the same strength because the approach to the transmitter compensates for the greater distance from the centre of the beam. " The curve along which the signal maintains a constant strength is just about the same as the best landing curve " (*Sci. News-Letter*, 22nd Nov., 1930, pp. 324–325).

In a preliminary section the writer discusses various schemes for landing altimeters such as leader-cable altimeters, sonic, capacity and radio-reflection methods. " It is doubtful at the present time whether any of these instruments will be sufficiently sensitive or accurate for making normal landings in dense fog. These instruments when available will, however, be exceedingly valuable in maintaining a safe altitude during point-to-point flying, and may prove of some service during landing operations " (for determining the altitude from which the glide should be started).

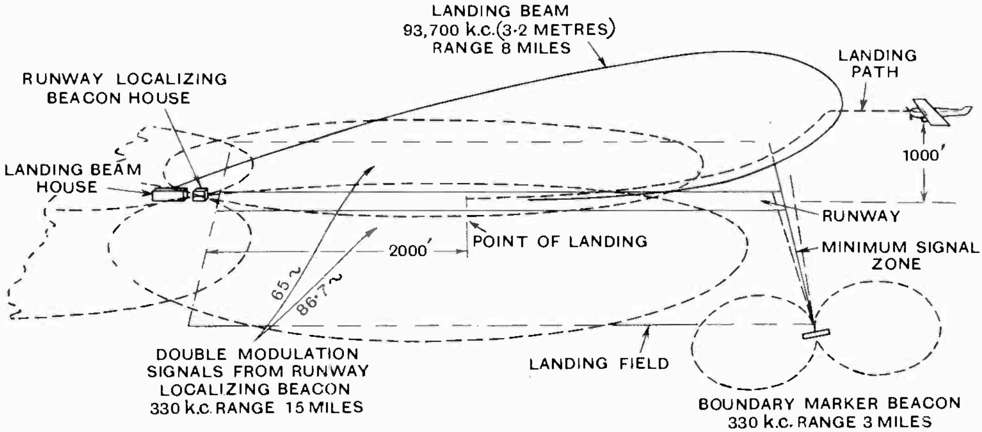
A short paper on the subject, by the same writers, is in *Proc. Nat. Ac. Sci.*, Nov., 1930, Vol. 16, pp. 678–685.

AERONAUTICAL RADIO COMMUNICATIONS.—E. Sibley. (*Journ. Am. I.E.E.*, Nov., 1930, Vol. 49, pp. 918–920.)

A short survey of the system due to the U.S.A. Federal Radio Commission. *Cf.* above abstract.

DIRECTION FINDER FOR EXTREMELY SHORT WAVES BELOW ONE METRE.—S. Uda. (*Journ. I.E.E. Japan*, March, 1930.)

In Japanese. In an earlier paper (1930 Abstracts,



Radiobeacon System for Blind Landing.

p. 568) the writer refers briefly to the application of the Yagi-Uda wave canal formed of their wave-reflectors and wave-directors, and the present paper is devoted to the use of this as a direction finder. The apparatus used is very similar to, or identical with, that shown in Fig. 6 of the *I.R.E.* paper of the earlier abstract. Wave-director rods are used, in front of a parabolic reflector made up of about 12 rods.

RADIO DIRECTION FINDING AT POST OFFICE COAST STATIONS.—G. H. Farnes and F. Hollinghurst. (*P.O. Elec. Eng. Journ.*, Oct., 1930, Vol. 23, Part 3, pp. 211–215.)

CONSTANT SPEED CONTROL ON ROTATING BEACON.—Hecht and Alexander. (*See* abstract under "Subsidiary Apparatus.")

ACOUSTICS AND AUDIO-FREQUENCIES.

ABSORPTION OF SOUND AT OBLIQUE INCIDENCE.—E. T. Paris. (*Nature*, 6th Dec., 1930, Vol. 126 p. 880.)

The writer explains that the disagreement mentioned by Heyl (*cf.* 1930 Abstracts, p. 340) between Larmor and the writer concerning the absorption of sound by porous bodies at oblique angles of incidence is due to an invalid approximation in Larmor's calculation.

MEASUREMENT OF ABSORBING POWER OF MATERIALS BY THE STATIONARY WAVE METHOD.—A. H. Davis and E. J. Evans. (*Proc. Roy. Soc.*, Vol. 127 A, 1930, pp. 89–110.)

ÜBER DAS DÄMPFUNGSPROBLEM DER MATHEMATISCHEN PHYSIK, MIT EINER ANWENDUNG AUF DIE AKUSTIK GROSSER RÄUME (The Damping Problem of Mathematical Physics, and an application to the Acoustics of Large Rooms).—M. J. O. Strutt. (*Math. Ann.* No. 5, Vol. 102, 1930, pp. 671–684.)

RESULTS OF NOISE SURVEYS. PART I. NOISE OUT OF DOORS. PART II.—NOISE IN BUILDINGS.—R. H. Galt: R. S. Tucker. (*Journ. Acoust. Soc. America*, July, 1930, Vol. 2, pp. 30–58 and 59–64.)

THE END-CORRECTIONS OF AN OPEN ORGAN FLUE-PIPE; AND THE ACOUSTICAL CONDUCTANCE OF ORIFICES.—A. E. Bate. (*Phil. Mag.*, Oct., 1930, Series 7, Vol. 10, No. 65, pp. 617–632.)

ON THE SOUND FIELD DUE TO A CONICAL HORN WITH A SOURCE AT ITS VERTEX.—K. Satô. (*Jap. Journ. Phys.*, No. 3, Vol. 5, pp. 103–109.)

The theoretically derived values are compared with the experimental values, with which they agree qualitatively.

VELOCITY OF SOUND IN TUBES: ULTRA-SONIC METHOD.—R. W. Boyle and D. Froman. (*Nature*, 18th Oct. 1930, Vol. 126, pp. 602–603.)

A description of a method of investigation of the velocity of sound in tubes by means of stationary waves at ultrasonic frequencies whose wave-lengths are comparable to the diameter of the column. A velocity-frequency curve is found which is like the selective absorption curve of optics.

ON THE VELOCITY OF SOUND IN SOFT AND BRITTLE SUBSTANCES.—E. J. Irons. (*Journ. Scient. Instr.*, Oct. 1930, Vol. 7, pp. 323–326.)

THE VELOCITY OF PROPAGATION OF LONGITUDINAL WAVES IN LIQUIDS AT AUDIO-FREQUENCIES.—L. G. Pooler. (*Phys. Review*, No. 7, Vol. 35, Series 2, pp. 832–847.)

STRUKTURBESTIMMUNG DURCH AKUSTISCHE EIGENSCHWINGUNGEN (Structure Determination by Characteristic Acoustic Vibrations).—A. Meissner. (*Zeitschr. f. Phys.*, 1930, Vol. 65, No. 3-4, pp. 145–157.)

An investigation of the molecular structure of quartz by determining its characteristic acoustic vibrations. These are excited by means of high frequency electrical vibrations, acting on a quartz plate cut perpendicular to the electrical axes. The acoustic vibrations are correlated with definite structure planes in the crystal, from which an approximately cubic structure is deduced.

These measurements confirm and complete the structural dimensions deduced from X-ray measurements. Two characteristic vibrations are found to be present in a quartz plate; their frequencies have the ratio $1 : \sqrt{2}$.

EINE NEUE METHODE ZUR ERZEUGUNG SEHR KURZER AKUSTISCHER WELLEN (A New Method of Generating Very Short Acoustic Waves).—H. Mülwert. (*Arch. f. Ohren-, Nas.- u. Kehlkopf.*, Sp. Number, Vol. 125, 1930, pp. 266–275.)

Frequencies from 20,000 to 220,000 cycles/sec. are obtained by the use of a very thin membrane traversed by alternating currents in a strong magnetic field.

MÉTHODE D'OBSERVATION D'ONDES SONORES NON STATIONNAIRES (A Method of Observing Non-stationary Sound Waves).—E. P. Tawil. (*Comptes Rendus*, 24th Nov., 1930, Vol. 191, pp. 998–1000.)

A procedure which avoids both the stroboscopic method and the formation of standing waves. It is a further development of the work referred to in 1930 Abstracts, p. 515.

SICHTBARMACHUNG KURZER SCHALLWELLEN (Making Short Sound Waves Visible).—H. Kröncke. (*Physik. Zeitschr.*, 15th Oct., 1930, Vol. 31, No. 20, pp. 908–909.)

The sound vibrations in a Kundt's tube may be made visible from a long distance by using glowing wire, treated electrically, instead of the usual fine powder. The nodes appear as bright points; at the antinodes the wire is cooled by the air movements. The effect shows best at high frequencies.

ÜBER DAS FECHNERSCHE GESETZ UND SEINE BEDEUTUNG FÜR DIE THEORIE DER AKUSTISCHEN BEOBACHTUNGSFEHLER UND DIE THEORIE DES HÖRENS (On Fechner's Law and its Bearing on the Theory of Acoustic Errors of Observation and the Theory of Hearing).—G. v. Békésy. (*Ann. der Physik*, 1930, Series 5, Vol. 7, No. 3, pp. 329–359.)

THE EFFECT OF NOISE ON THE ARTICULATION OF A TELEPHONE CIRCUIT.—J. Collard. (*P.O. Elec. Eng. Journ.*, Oct. 1930, Vol. 23, Part 3, pp. 187–192.)

THE "HALLFORMANTEN" THEORY OF TONE QUALITY.—F. Trautwein. (*Electronics*, Sept., 1930, Vol. 1, pp. 298–299.)

"The physiological effect of musical quality is in the main produced by the presence of one or more 'Hallformanten' which are heard simultaneously with the fundamental. These are damped oscillations of a definite frequency which is invariably higher than that of the fundamental, and which may be in any relation to this, not necessarily a multiple. The 'Hallformant' invariably dies out during each period of the fundamental, or is suppressed by the beginning of the next. The frequency of a 'Hallformant' may remain unchanged for a considerable range of frequency of the fundamental. Should the fundamental reach a higher frequency than that of a 'Hallformant,' the latter disappears. 'Hallformanten' are in general caused by variations in strength occurring during each period of the fundamental. . . . Certain instruments (especially the flute) have no 'Hallformanten.'"

See also below.

THE ELECTRICAL SYNTHESIS OF MUSICAL AND SPEECH SOUNDS.—F. Trautwein.

(*See* under "Miscellaneous," Convention in Königsberg : also *cf.* above.)

ELECTROMAGNETIC VIOLIN FOR USE WITH LOUD SPEAKER.—(French Pat. 686683, Dimitriu, pub. 29th July, 1930.)

For summary, *see Rev. Gén. de l'Élec.*, 29th Nov., 1930, Vol. 28, p. 190 D.

L'ORGE ÉLECTRONIQUE (The Electronic Organ).—E. Coupleux and A. Givelet. (*Rev. Gén. de l'Élec.*, 6th Dec., 1930, Vol. 28, pp. 895–900.)

Cf. Jan. Abstracts, p. 45. In the present paper, practical details are added of this organ, which—unlike other types which depend on beat notes—produces the musical frequencies directly.

THE SPIELMAN PHOTOELECTRIC PIANO.—E. Weiss. (*La Nature*, 1st July, 1930, No. 2836, pp. 8–10.)

AN OBJECTIVE METHOD OF EVALUATING MUSICAL PERFORMANCE.—C. E. Seashore and J. Tiffin. (*Science*, 7th Nov., 1930, Vol. 72, pp. 480–482.)

The performances of two singers are here compared by means of the graphs (pitch and time) recorded by an improved Metfessel strobophotograph camera.

LOUD SPEAKER TESTS AND PERFORMANCE FACTORS.—D. A. Oliver. (*E.W. & W.E.*, Dec., 1930, Vol. 7, pp. 653–664.)

From the G.E.C. Laboratories. Proposals for the basis of standard response tests to be applied to reproducers under controlled conditions. It is admitted that more work will have to be done before a complete correlation can be made between scientific laboratory tests and the subjective impressions as described by selected observers, but "provided accurate comparisons can be made under simple, artificial, but quite definite conditions, some reasonable attempt can be made to correlate observed and calculated effects." Typical experimental results are given in support of the recommendations put forward.

LOUD SPEAKER USING MAGNETOSTRICTION.—(French Pat. 688658, Thomson-Houston Co., pub. 27th Aug., 1930.)

For summary, see *Rev. Gén. de l'Élec.*, 29th Nov., 1930, Vol. 29, p. 191 D. The Company's researches in connection with this design have shown that an alloy of 40–70% cobalt with iron or nickel gives an expansion of 0.00084 mm. per cm. length for a field increase of 100–200 gauss. Nickel contracts in about the same proportion.

ZUR THEORIE ELEKTROMAGNETISCHER TONABNEHMER (The Theory of the Electromagnetic Pick-Up).—A. Forstmann. (*E.N.T.*, Nov., 1930, Vol. 7, pp. 426–434.)

A theoretical investigation of the amplitude- and frequency-dependence of such pick-ups. It is shown that a decrease in frequency-dependence can readily lead to an increase in amplitude-dependence; this may be avoided by keeping the armature movement small by maintaining a low level of amplitude at the record and by decreasing the mechanical efficiency. Equations representing the conditions for independence of frequency and amplitude are obtained and an equivalent circuit for the moving system is given. The equivalent circuit given by Maxfield and Harrison (*Bell Tech. Journ.*, 1926) is criticised adversely.

GROUND NOISE IN SOUND PICTURES: A STUDY OF NOISE DUE TO DISC RECORDING.—H. G. Tasker. (*Electronics*, Sept., 1930, Vol. 1, pp. 273–275 and 312.)

DESIGN AND TESTING OF MOTION PICTURE SCREENS FOR SOUND PICTURE WORK.—H. F. Hopkins. (*Journ. Soc. Motion Picture Engineers*, Sept., 1930, Vol. 15, pp. 320–328.)

A TWO-DIMENSIONAL BOUNDARY VALUE PROBLEM FOR THE TRANSMISSION OF ALTERNATING CURRENTS THROUGH A SEMI-INFINITE HETEROGENEOUS CONDUCTING MEDIUM [MATHEMATICAL THEORY APPLICABLE TO TELEPHONE LINES].—H. P. Evans. (*Phys. Review*, 15th Nov., 1930, Series 2, Vol. 36, No. 10, pp. 1579–1588.)

THE TRANSMISSION CHARACTERISTICS OF OPEN-WIRE TELEPHONE LINES.—E. I. Green. (*Bell Tech. Journ.*, Oct., 1930, Vol. 9, No. 4, pp. 730–759.)

THE TREND IN THE DESIGN OF TELEPHONE TRANSMITTERS AND RECEIVERS.—W. H. Martin and W. F. Davidson. (*Bell Tech. Journ.* Oct., 1930, Vol. 9, No. 4, pp. 622–627.)

DIE VORTEILE DER WIEDERGABE VON SCHALLPLATTEN ÜBER DEN LAUTSPRECHER (The Advantages of Gramophone Reproduction by Loud Speaker).—M. v. Ardenne. (*Die Sendung*, 19th Dec., 1930, Vol. 7, pp. 816–817.)

DIE BERECHNUNG DER VERSTÄRKERTRANSFORMATOREN (The Calculation of [L.F.] Amplifier Transformers).—F. Lang. (*E.T.Z.*, 27th Nov., 1930, Vol. 51, pp. 1637–1642.)

PHOTOTELEGRAPHY AND TELEVISION.

SYSTÈME DE TÉLÉVISION COMPORTANT, EN PARTICULIER, UN DISPOSITIF DE SYNCHRONISATION ET DE MISE EN PHASE AUTOMATIQUE (A Television System, including in particular Automatic Synchronisation and Phasing).—R. Barthélemy. (*Comptes Rendus*, 1st Dec., 1930, Vol. 191, pp. 1051–1053.)

The synchronisation and phasing arrangements which form the chief novelty of the system here described have led to perfectly stable reception of animated pictures of good quality, both from life and from films, by line and by Wireless.

Instead of synchronising the receiving disc by the transmission of an auxiliary frequency, a very short signal—a "top" of the order of 1/10,000 sec. —is sent at the beginning of each sweep of the scanning beam, *i.e.*, every 1/16 sec.; this "top" releases, with an accuracy of 1/10,000 sec., an oscillatory phenomenon at the receiver: *i.e.*, it illuminates a neon lamp maintained near, but clear of, the relaxation oscillation condition. The oscillation has a duration defined by the circuit constants and about equal to the interval between two consecutive "tops," and it only renews itself under the action of a fresh signal; a series of pulsating currents is thus obtained whose *phase* is exactly governed by the transmitter, but whose amplitude is a function only of the conditions at the receiver. This pulsating current is used to control a special "motor-relay" in which a triode acts as the commutator (*see* Barthélemy patent, under "Subsidiary Apparatus").

NEW METHODS IN TELEVISION.—H. E. Ives. (*Science*, 31st Oct., 1930, Vol. 72, pp. x and xii.)

Colour television from Kodacolor moving films: division of the frequency band into three bands each of which is transmitted separately and re-combined in the receiver: two-way television using a red and blue scanning beam in place of the blue originally employed—a red-sensitive caesium oxide cell is here used in conjunction with the blue-sensitive potassium cell, the booth itself being illuminated with yellow-green light to which neither cell is sensitive.

DIE BILDABTASTUNG BEIM FERNSEHEN (Scanning in Television: a Survey).—F. W. Winckel. (*Zeitschr. f. Fernmeldetech.*, No. 6, Vol. 11, 1930, pp. 92–95.)

A THREE-ELECTRODE PHOTOELECTRIC CELL WITH GREAT SENSITIVITY.—T. Asada. (*Proc. Phys. Math. Soc., Japan*, June, 1930, Vol. 12, pp. 145–155.)

A central filament of nickel wire coated with salts of calcium, barium and strontium is surrounded by a spiral grid, of tungsten or molybdenum wire 0.13 mm. in diameter and about 70 cm. long. When the filament is heated, the salts evaporate and are deposited on the grid, which becomes photo-sensitive and shows no fatigue since the deposit is continually being removed. There is an iron anode, and the emission of photoelectrons from the grid changes the potential of the latter and thus controls the anode current.

An 8 w. lamp at 10 cm. distance produced a current of 0.5 mA., whereas a gas-filled potassium cell (Pressler) gave only 3×10^{-7} A. For small light intensities the anode current is proportional to these, but for greater intensities it increases rather less. The sensitivity is greater for yellow and green light, and extends into the infra-red. Intermittent illumination up to 10^{-7} sec. brought out no signs of inertia.

ÜBER EIN NEUES, LICHTELEKTRISCHES PHOTOMETER (On a New Photoelectric Photometer).—H. Teichmann. (*Naturwiss.*, 10th Oct., 1930, Vol. 18, No. 41, p. 867.)

A preliminary note on the use as a photometer of the copper-cuprous oxide cell in combination with a mirror galvanometer. The cell consists of a copper plate coated on both sides with cuprous oxide.

OSCILLATIONS IN PHOTOELECTRIC CELLS.—R. Ruedy. (*Television*, Nov., 1930, Vol. 3, p. 391.)

Referring to Rosing's work (1930 Abstracts, pp. 273 and 515) the writer points out that this phenomenon was described by Norman Campbell in 1927: "If . . . a moderate illumination is applied to the cell, the oscillations cease, because the current which lies on the unstable portion of the dark characteristic lies on the stable portion of the illuminated characteristic." The stopping of the oscillations is governed by space-charge conditions in the cell, and the effect is therefore not entirely reversible in all cases. Campbell mentions the possible use of the phenomenon for the transmission of pictures.

UNTERSUCHUNGEN ZUR FRAGE DER TRÄGHEIT GASGEFÜLLTER PHOTOZELLEN (Investigations on the Inertia of Gas-Filled Photocells). —F. Schröter and G. Lubszynski. (*Physik. Zeitschr.*, 15th Oct., 1930, Vol. 31, No. 20, pp. 897–904.)

PHOTOELECTRIC EFFECT AND THE J-PHENOMENON.—T. H. Osgood. (*Phys. Review*, No. 11, Vol. 35, 1930, p. 1407.)

A comparison between Marx's results (see Marx, and Marx and Meyer, 1930 Abstracts, p. 460) and Barkla's result that a heterogeneous X-ray beam greatly increases its ionising effect on a gas if some of the longer wavelengths are removed.

DER KRISTALL-DETEKTOR ALS PHOTOZELLE (The Crystal Detector as Photoelectric Cell).—M. Grützmacher. (*T.F.T.*, Sept., 1930, Vol. 19, p. 283.)

A crystal detector, connected through an amplifier to a loud speaker and subjected to intermittent illumination, makes the loud speaker emit a note corresponding to the frequency of the illumination: this is explained by the effect of absorbed light quanta on the two contact-surfaces possessing different work functions. Advantages offered by such a form of photoelectric cell are: The smallness of the working surface, a high absolute sensitivity, a considerable independence of frequency, and comparatively small internal resistance and capacity.

INFRA-RED SENSITIVITY OF CESIUM OXIDE PHOTOELECTRIC CELLS.—J. W. Ballard. (*Journ. Opt. Soc. Am.*, Nov., 1930, Vol. 20, pp. 618–623.)

For the region 5,000 to 8,000 A.U. the results agree with those of Koller and of Vedder; the response is found to decrease gradually from the maximum at about 7,750 A.U. to approximately zero at 12,000 A.U.

ELECTROSTATIC SURFACE FIELDS NEAR THORIATED TUNGSTEN FILAMENTS BY A PHOTOELECTRIC METHOD.—L. B. Linford. (*Phys. Review*, 15th Sept., 1930, Series 2, Vol. 36, No. 6, p. 1100.)

THE EFFECT OF SYSTEMATIC SURFACE TREATMENT ON THE PHOTOELECTRIC EMISSION FROM METALS.—R. F. Hanstock. (*Phil. Mag.*, Nov., 1930, Series 7, Vol. 10, No. 66, pp. 937–944.)

The research was undertaken "to examine the photoelectric emission from metal surfaces in a vacuum at intervals during the process of polishing, the surface being initially in an annealed state." Details of the experimental arrangement and typical curves of photoelectric current plotted against the number of polishing rubs are given. All the metals tested (Cu, Ag, Au and Pt) gave curves of similar shape.

"The main characteristics of the curves may be summarised as follows:—1. The photoelectric current is increased when the metal surface is polished. 2. The increase of the photoelectric current with rubbing is approximately a linear function of the number of rubs until just before the maximum value is reached. 3. The ratio $\frac{i_m}{i_o}\left[\frac{\text{Current from surface in polished state}}{\text{Current from annealed surface}}\right]$ shows no regular dependence on the pressure of the gas in the tube. 4. The effect appears for radiation of a restricted range of wavelength as well as for the full spectrum. 5. By heating to above 150°C. the metal can be reduced to its less active state."

DIE BEEINFLUSSUNG DER LICHTELEKTRISCHEN EIGENSCHAFTEN DES CÄSIUMS DURCH ADSORPTION AN SALZSCHICHTEN (The Effect of Adsorption at Salt Layers on the Photoelectric Properties of Caesium).—J. H. de Boer and M. C. Teves. (*Zeitschr. f. Phys.*, 1930, Vol. 65, No. 7/8, pp. 489–505.)

ÜBER SPERRSCHICHTPHOTOZELLEN (I. MITTEILUNG) (On Suppressor Layer Photoelectric Cells (Part I)).—O. v. Auwers and H. Kerschbaum. (*Ann. der Physik*, 1930, Series 5, Vol. 7, No. 2, pp. 129–175.)

Authors' summary:—With a view to explaining the phenomena observed in a copper-cuprous oxide cell, the theory of a two-terminal resistance is discussed in the case where the resistances are non-linear.

It is shown that the non-linearity of the two-terminal resistance indicates a possible way of deciding whether a cell may be regarded as electrically equivalent to a source of voltage or to a source of current.

Experiments show that in the case of suppressor layer photoelectric cells formed of copper and cuprous oxide the source of *current* should be chosen as the electrical equivalent.

Further, the influence of the distance of the point of incidence of the light from the electrode is theoretically and experimentally explained with the aid of the theory of a homogeneous artificial line; and a case, already discussed by W. Schottky with simplifying assumptions, is extended by taking into account the non-linearity of the shunt element.

Finally, experiments on the influence of an external impressed voltage on the behaviour of a suppressor layer photoelectric cell are communicated. Work on these problems is being continued.

ON THE PLACE OF ORIGIN OF THE PHOTOELECTRONS IN THE COPPER-CUPROUS OXIDE PHOTOELECTRIC CELL.—W. Schottky. (*Physik. Zeitschr.*, 1st Nov., 1930, Vol. 31, No. 21, pp. 913–926. Discussion p. 970.)

For an abstract of the paper itself, *see* January Abstracts, p. 46.

ÜBER EINE AN KUPFER-KUPFEROXYDULZELLEN BEOBACHTETE TEMPERATURABHÄNGIGKEIT DES SPERRSCHICHTPHOTOEFFEKTES (On a Temperature Variation of the Boundary Layer Photoelectric Effect observed in Copper-Cuprous Oxide Cells).—H. Teichmann. (*Zeitschr. f. Phys.*, 1930, Vol. 65, No. 9/10, pp. 709–713.)

Experimental results are given which show that the boundary layer photoelectric effect [*cf.* Duhme and Schottky, and Kerschbaum, 1930 Abstracts, p. 636, and Jan. Abstracts, p. 46] has a negative temperature coefficient.

ÜBER EINE NEUE ART VON PHOTOZELLEN. 2. MITTEILUNG (On a New Type of Photoelectric Cell. 2nd Communication).—B. Lange. (*Physik. Zeitschr.*, 1st Nov., 1930, Vol. 31, No. 21, pp. 964–969.)

A continuation of the first paper recorded in 1930 Abstracts, p. 578. In discussing the practical applications of his "oxide-cell," the writer describes a differential form for the comparison of two light sources in photometry. In the subsequent discussion, he mentions that the internal resistance of the oxide-cell is of the order of 500 ohms per cm².

INFRAROTEMPFINDLICHE ZELLEN (Infra-Red Sensitive Photoelectric Cells).—F. Michelssen. (*Zeitschr. f. tech. Phys.*, Dec., 1930, Vol. 11, pp. 511–515.)

Telefunken researches in connection with Schröter's work on the use of Hertzian and infra-red rays for communication (*see* 1930 Abstracts, p. 333). Since the selenium cell fails for wave-lengths greater than 0.9μ, Schröter—on atomic physical grounds—added tellurium, and thus extended the range to 1.2μ. The slight penetration of light (5×10^{-5} mm.), and the low specific resistance of the selenium-tellurium alloy, call for very thin layers, and the writer describes the method of construction by cathode sputtering on to a graphite "grid" formed on a glass plate.

Thallium sulphide cells, thin-layered and with a (dark) resistance of only 5×10^6 ohms (compared with the $100–500 \times 10^6$ of the Case cell) were also constructed by the use of grids—here formed of gold deposited on quartz glass. Their curves lie in about the same region but are much flatter at the top, so that between 0.7 and nearly 1.0μ they are almost horizontal.

The paper ends by giving some range results. With a d.c. arc of 600 w. input, ranges of 28 km. were easily obtained. Mist and light fog were readily penetrated by rays above 1μ, but in very thick, wet fog (view limited to 20 metres) all rays between 0.75 and 1.2μ failed in less than 1 km.; in such a fog, where the particles are relatively large compared with the wavelength, it seems that only waves of several μ wavelength can succeed, and since these can only be detected by bolometers, thermo-piles and the like, it appears impossible to transmit high signal frequencies through dense fogs.

THE ADAPTATION OF GLASS-ENCLOSED PHOTO-ELECTRIC CELLS TO VERY SHORT WAVE-LENGTHS.—J. and J. F. Thovert. (*Comptes Rendus*, 1st Dec., 1930, Vol. 191, pp. 1058–1059.)

By the interposition of a thin layer of fluorescent material which acts as a frequency changer.

ZUM PHOTOEFFEKT AN METALLEN (On the Photo-electric Effect for Metals).—H. Fröhlich. (*Ann. der Physik*, 1930, Ser. 5, Vol. 7, No. 1, pp. 103–128.)

"On the basis of Sommerfeld's electron theory, a theory of the photoelectric effect for thin metallic sheets is given which is connected with Wentzel's treatment. The theory agrees in all important points with the results of experiments on thin layers."

NAVA-PHOTOZELLEN (The "Nava" Photoelectric Cell of the Tungsram Co.).—G. Lohrmann. (*Bull. d. l'Assoc. Suisse des Élec.*, No. 18, Vol. 21, 1930, pp. 608–611.)

PHOTO-IONIZATION OF CÆSIUM VAPOR BY ABSORPTION BETWEEN THE SERIES LINES.—C. Boeckner and F. L. Mohler. (*Bur. of Stds. Journ. of Res.*, Oct., 1930, Vol. 5, pp. 831–842.)

MEASUREMENTS AND STANDARDS.

CHARACTERISTICS OF PIEZO-ELECTRIC QUARTZ OSCILLATORS.—I. Koga. (*Proc. Inst. Rad. Eng.*, Nov., 1930, Vol. 18, pp. 1935–1959.)

An investigation of the behaviour of quartz oscillators, as regards both frequency and amplitude, on the basis of the Barkhausen equation. Conclusions arrived at include the following:—(i) the frequency as an oscillator is always higher than the response frequency as a resonator; (ii) increase in length of air gap reduces the amplitude and increases the frequency; the product of the quartz thickness and the rate at which the frequency is varied by the air gap is nearly constant with the same kind of quartz; (iii) air resonance occurs in the air gap of the holder: the characteristic features in frequency and amplitude are explained by the theory of reaction of a dependent system.

The treatment is applied to the push-pull connection and the advantages of this circuit are explained.

QUARTZ-CONTROLLED OSCILLATIONS OF SOME HUNDRED WATTS POWER, BY USE OF A SCREEN-GRID VALVE.—Kusunose.

See under "Transmission."

DESIGN AND MANUFACTURE OF OSCILLATING QUARTZ PLATES.—S. Matsumura and K. Takahashi. (*Electrot. Lab., Tokio, Circ.* 72, 1930, 37 pp.)

In Japanese, with short English synopsis.

INFLUENZA DEL DECREMENTO DEL QUARZO SULLA FREQUENZA DI OSCILLAZIONE DEI PIEZO-OSCILLATORI (Influence of the Quartz Decrement on the Frequency of Piezo-oscillators).—M. Boella. (*L'Elettrotec.*, 15th Nov., 1930, Vol. 17, pp. 734–736.)

PIEZOELEKTRISCHE VERSUCHE NACH DEM PRINZIP DER METHODE VON GIEBE UND SCHEIBE (Piezoelectric Experiments on the Principle of the Method of Giebe and Scheibe).—A. Hettich. (*Zeitschr. f. Phys.*, 1930, Vol. 65, No. 7/8, pp. 506–511.)

COMPARISON OF THE OSCILLATION CHARACTERISTICS OF CRYSTAL MOUNTINGS WITH AND WITHOUT AIR GAP, FOR SHORT WAVE USE.—S. Matsumura and K. Hatakeyama. (*Journ. Inst. Tel. and Teleph. Eng., Japan*, June, 1930, p. 575.)

In Japanese. The oscillation characteristics, for medium high frequencies, are better for mountings without air-gaps than for those with air-gaps.

SUL FUNZIONAMENTO DEL PIEZOOSCILLATORE IN RELAZIONE CON LA CURVA DI RISONANZA DEL QUARZO (The Behaviour of a Piezo-Oscillator in relation to the Resonance Curve of the Quartz).—M. Boella. (*L'Elettrotec.*, 15th Oct., 1930, Vol. 17, pp. 672–678.)

Followed by an article by Angrisano on the methods employed in plotting the resonance curves.

STRUCTURE OF QUARTZ INVESTIGATED BY ACOUSTIC METHODS.—Meissner.

See abstract under " Acoustics."

AN INTERNATIONAL COMPARISON OF FREQUENCY BY MEANS OF A LUMINOUS QUARTZ RESONATOR.—S. Jimbo. (*Proc. Inst. Rad. Eng.*, Nov., 1930, Vol. 18, pp. 1930–1934.)

Author's summary :—" The international comparison of frequency standards made with the luminous quartz resonator shows the different laboratories—Physikalischtechnische Reichsanstalt, National Physical Laboratory, Bureau of Standards, and Electrotechnical Laboratory—to be in agreement to one part in 10^5 when used to calibrate the resonator at its flexual fundamental of about 10 kc., due allowance being made for the temperature coefficient of the resonator in this mode, namely, about 1 part in 10^5 and negative. The observed agreement seems limited by the luminous glow resonator used rather than by any difference between the laboratory standards compared."

The writer considers that although this good agreement (better than ever attained before) is largely due to the superiority of the luminous quartz resonator, there are still some difficulties in determining precisely the response frequency, owing to the unsteadiness of the glow. The resonator in question appears to be the one described by Giebe and Scheibe (1930 Abstracts, p. 462).

LE FRÉQUENCEMÈTRE ÉTALON ABSOLU DU LABORATOIRE NATIONAL DE RADIOÉLECTRICITÉ (The Absolute Standard Frequency Meter of the French National Laboratory of Radioelectricity).—B. Decaux. (*L'Onde Élec.*, Oct., 1930, Vol. 9, pp. 449–466.)

An elinvar tuning fork, with a frequency about 1,024 p.p.s., is driven without contact by means of a microphone circuit, and its deformed current shock-excites a circuit tuned to one of its harmonics; after amplification, this harmonic synchronises an oscillating circuit with a range 10,000 to 100,000 p.p.s. The current from this, deformed by anode circuit rectification and amplified, shock-excites a second oscillator with a range 100,000 to 3,000,000 p.p.s. (quartz controlled for the very high frequencies). The tuning fork does not require thermostatic control, for the accuracy desired (of the order of 1/100,000). It is calibrated by frequency demultiplication, using neon tube and phonic wheel. The paper deals with the apparatus and procedure in considerable detail. The writer ends by foreshadowing the need of still greater accuracy : " it is possible that a high-class piezoelectric oscillator such as that of Marrison (very low temperature coefficient, quartz under constant pressure, etc.) may provide a constancy better than that of a tuning fork ; moreover, the free tuning fork of quartz (Holweck and Lejay) demands great attention " [1929 Abstracts, p. 457].

INTERPOLATION METHODS FOR USE WITH HARMONIC FREQUENCY STANDARDS.—J. K. Clapp. (*Proc. Inst. Rad. Eng.*, Sept., 1930, Vol. 18, pp. 1575–1585.)

Author's summary :—Interpolation methods for determining the value of an unknown frequency in terms of harmonic standard frequencies are discussed under the following classifications: I. Direct beating methods, wherein the beat between known and unknown frequencies is utilised directly to operate frequency indicators or measuring devices. II. Direct interpolation methods in which the fundamental frequency of an interpolation oscillator is adjusted to zero beat in turn with the unknown frequency and the adjacent known harmonic frequencies. The unknown frequency is then found from the oscillator dial readings. III. Harmonic interpolation methods which are an extension of the principles of (II) permitting an interpolation oscillator of limited fundamental frequency range to be employed in the measurement of frequencies lying both above and below this range. IV. The principles of (III) point to a means for covering a wide range of unknown frequencies through the use of a low-frequency narrow-range oscillator fitted with harmonic producing circuits. A greatly opened-out interpolation scale may be obtained.

Some disadvantages and limitations of the various methods are considered, as well as some advantages.

APPAREILS DE MESURES ÉLECTRIQUES S'ADAPTANT AUX ELECTRO-AIMANTS (Electrical Measuring Instruments adapted to Electro-magnets).—L. Quevron. (*Comptes Rendus*, 13th Oct., 1930, Vol. 191, pp. 604–606.)

Experiments in combining a moving-coil galvanometer with a powerful electromagnet enabled a spot deflection of 1–2 mm. to be obtained for a power of 3.2×10^{-16} watt ; this sensitivity could be still further increased.

AN ELECTRON TUBE WATTMETER AND VOLTMETER AND A PHASE SHIFTING BRIDGE.—H. M. Turner and F. T. McNamara. (*Proc. Inst. Rad. Eng.*, Oct., 1930, Vol. 18, pp. 1743–1747.)

Description of a balanced modulator type of thermionic wattmeter for measuring a few microwatts or more, a phase-shifting bridge for controlling the angular relation of two potentials without changing their amplitudes, and a balanced modulator type voltmeter for measuring potentials of a few millivolts, without amplifying, in conjunction with the bridge.

PRECISION MEASUREMENTS WITH A MODIFIED LARSEN A.C. POTENTIOMETER.—(*Génie Civil*, 1st Nov., 1930, Vol. 97, p. 448.)

Summary of a description of an improved

arrangement in which the measurement at the balancing point is amplified by a microphone, and leakage current errors are reduced by special winding of the transformers and by a reduction of the capacities to earth.

A COMPENSATED VACUUM TUBE VOLTMETER WITH BALANCED BRIDGE OUTPUT.—W. G. Hayman. (*E.W. & W.E.*, Oct., 1930, Vol. 7, pp. 556–559.)

After discussing various thermionic voltmeter circuits due to other workers, the writer describes a balanced bridge circuit whose main features are high input impedance, stability of zero, independence of calibration on anode voltage over a range of potentials likely to be experienced on any laboratory accumulator battery, and immunity of galvanometer from damage by accidental unbalance.

A MULTI-RANGE VACUUM TUBE VOLTMETER.—L. Tulauskas. (*Electronics*, July, 1930, Vol. 1, pp. 170–172.)

A compact thermionic voltmeter using two valves operated from a 45 v. battery, said to be accurate at audio- and radio-frequencies and covering a range up to 12 v. peak value.

THE MEASUREMENT OF HIGH VOLTAGES, WITH SPECIAL REFERENCE TO THE MEASUREMENT OF PEAK VOLTAGES.—R. Davis, G. W. Bowdler and W. G. Standring. (*Journ. I.E.E.*, Sept., 1930, Vol. 68, pp. 1222–1230.)

LOW POWER-FACTOR MEASUREMENTS AT HIGH VOLTAGES.—E. H. Rayner, W. G. Standring, R. Davis and G. W. Bowdler. (*Journ. I.E.E.*, Sept., 1930, Vol. 68, pp. 1132–1148.)

APPARATUS FOR THE MEASUREMENT OF HIGH CONSTANT OR RIPPLED VOLTAGES.—L. S. Taylor. (*Bur. of Stds. Journ. of Res.*, Sept., 1930, No. 3, Vol. 5, pp. 609–618.)

Description of a compact and portable voltmeter multiplier which consumes but 1 mA. per 100 kv. and hence can be kept in continuous connection without interfering with the operation of the h.t. system.

ÜBER EINE NEUE FELDSTÄRKE-MESSEINRICHTUNG (A New Field Strength Measuring Equipment).—M. v. Ardenne. (*E.N.T.*, Nov., 1930, Vol. 7, pp. 434–443.)

Description of a direct-reading, portable equipment designed to conform with present requirements in connection with fading curves, etc., especially of broadcasting stations :—simple operation, sufficient accuracy (±10 %), the possibility of using with an automatic recorder and the power of quickly changing the scale-range for all wavelengths. The method adopted is that of the calibrated receiver : such a method demands the utmost constancy in the valve circuits, and former attempts have failed for this reason. In the equipment here described an 8-stage r.f. amplifier is used, giving a magnification of 5,000–10,000 ; " only the latest developments in valve construction " make it possible to get this with the necessary constancy—three double and one triple valve aperiodically coupled being used, leading up to a thermionic voltmeter of 2 triode stages.

A screened frame aerial is employed as a rule, but a variable coupling is provided for an open aerial. A special capacitive volume control (*see* Schlesinger, below) working on the first double-circuit r.f. valve, varies the magnification between the limits 1 : 1,000 and is independent of frequency to 1 % [for the range of wavelength of the set here described—200–600 m.]. The valve voltmeter has a range of 1 : 5, so that the equipment can deal with very varied tasks.

EIN KAPAZITIVER SPANNUNGSTEILER MIT LASTAUSGLEICH UND SEINE ANWENDUNGEN (A Capacitive Potentiometer with Automatic Load Compensation).—K. Schlesinger. (*Zeitschr. f. hochf. Tech.*, Nov., 1930, Vol. 36, pp. 190–196.)

A device which possesses the 5 properties required in high frequency test-room technique :—independence of frequency [complete between 10^4 and 10^7 cycles/sec.], large range of voltage reduction [1 : 15,000], small initial reduction, continuous adjustment, and constancy of generator load [by a compensating capacity]. The air gap between stator and rotor plates is reduced to 0.2 mm., without the calibration varying after many thousand revolutions, thanks to the use of steel bearings. The necessary small minimum capacity of 0.01 cm. is obtained by the combination of an earthed plate on the rotor and a fixed screen which approaches within 0.1 mm. of it.

Among the various applications described are the measurement of amplification and sensitivity, dielectric constants, decrements, resonance resistance (the compensating device keeping the tuning unaltered), and as a wide-range, frequency-independent volume or amplification control—used by von Ardenne in his field strength measuring apparatus (*see* preceding abstract) ; the same device was presumably used in his arrangement for reaction adjustment without de-tuning—1930 Abstracts, p. 568.

EINE EINFACHE ANORDNUNG ZUM MESSUNG KLEINER KAPAZITÄTEN (A Simple Apparatus for the Measurement of Small Capacities).—K. Schlesinger. (*Zeitschr. f. tech. Phys.*, Dec., 1930, Vol. 11, pp. 537–538.)

Description of the employment of the capacitive potential divider, dealt with above, in a radio-frequency bridge circuit for measuring capacities of the order of 0.1 cm.

EINE MESSBRÜCKE FÜR SEHR KLEINE KAPAZITÄTEN (A Capacity Bridge for Very Small Capacities).—G. Zickner. (*E.N.T.*, Nov., 1930, Vol. 7, pp. 443–448.)

With the bridge here described, a 1.0 μμF. capacity can be measured with an accuracy of 1 %, and a 0.1 μμF. capacity with an accuracy of 10 %. The standard variable condenser is so designed as to have no zero capacity : the two semi-circular plates are insulated from the container and are separated by a screening wall which divides this container into two parts. The part of the wall between the plates has an aperture, of the same shape and size as the plates, which can be covered or uncovered by the movement of a conducting vane (connected to the case) carried by the spindle.

Each of the resistance arms of the bridge is shunted by a variable phasing condenser (max. 1,000 $\mu\mu$F.) so geared together that one increases as the other decreases. In addition, several values of fixed condenser can be thrown in by means of jack switches. The whole bridge, including the telephones and the leads to the apparatus under test, is carefully screened and earthed.

PRÄZISIONS-MESSKONDENSATOREN UND MESSBRÜCKEN (Precision Test Condensers and Bridges).—(*Zeitschr. f. hochf. Tech.*, Oct., 1930, Vol. 36, pp. 159–160.)

This description of Selinger's products includes the standard condensers referred to in 1930 Abstracts, pp. 640–641; also the Zickner condenser with no zero capacity and the special bridge for very small capacities embodying this (*see* above).

THERMOWATTMETRISCHE VERLUSTMESSUNGEN AN GROSSEN KAPAZITÄTEN (Loss Measurements on Large Condensers by the Thermo-Wattmeter).—G. Zickner and G. Pfestorf. (*E.T.Z.*, 4th Dec., 1930, Vol. 51, pp. 1681–1684.)

FASOMETRI A TRIODI (Triode Phasemeters).—F. Vecchiacchi. (*L'Elettrotec.*, 5th Nov., 1930, Vol. 17, pp. 713–719.)

MEASURING THE ACCURACY OF WAVEMETERS IN COMMON USE.—H. Mimura. (*Electrot. Lab., Tokio*, Circ. 73, 1930, 40 pp.)

In Japanese. Lamp or telephones as indicator, accuracy rarely 1 %, sometimes only 10 %; hot-wire ammeter, 1–2 % over whole range; galvanometer, 0.1 to 0.3 %. With heterodyne wavemeters, 0.1 % for 200 kc. upwards, 0.5 % for 50 kc. upwards, and 1.5 % for 15 kc. upwards. The wavemeters included in this series of tests include neither those using quartz nor the narrow-band type.

EIN WECHSELSTROMGALVANOMETER (A Galvanometer for A.C.).—H. Mukherjee. (*Zeitschr. f. Phys.*, No. 3-4, Vol. 64, 1930, pp. 286–291.)

A sensitivity of 6×10^{-7}A. is obtained with this current balance instrument.

THE MAINTENANCE [TO WITHIN ONE OR TWO PARTS IN A MILLION] OF A STANDARD OF ELECTROMOTIVE FORCE: NOTES ON STANDARD WESTON CELLS.—A. N. Shaw and H. E. Reilley. (*Canadian Journ. of Res.*, Nov., 1930, Vol. 3, pp. 473–489.)

THE MUTUAL INDUCTANCE OF SHORT COAXIAL AND CONCENTRIC SOLENOIDS.—H. B. Dwight and P. W. Sayles. (*Journ. of Math. and Physics*, July, 1930, Vol. 9, pp. 162–165; Summary in *Rev. Gén. de l'Élec.*, 25th Oct., 1930, Vol. 28, p. 650.)

THE PRACTICAL MAGNETIC UNITS: ON A SYSTEM OF MECHANICAL, ELECTRICAL AND MAGNETIC UNITS.—A. Blondel: E. Brylinski. (*Comptes Rendus*, 17th Nov., 1930, Vol. 191, pp. 899–903 and 931–932.)

SUBSIDIARY APPARATUS AND MATERIALS.

A SIMPLE METHOD OF PRODUCING LOW FREQUENCY CURRENTS OF SINUSOIDAL SHAPE AND THEIR MEASUREMENT.—J. G. Bedford and H. Josephs. (*P.O. Elec. Eng. Journ.*, Oct., 1930, Vol. 23, Part 3, pp. 181–186.)

"To measure the electrical parameters of lines and apparatus at telegraph frequencies, that is, between 5 and 100 cycles per second, it became necessary to develop a portable generator which would produce an e.m.f. of sinusoidal shape and also be capable of an output up to at least 60 volts." A motor-driven Baudot distributor, with governor removed to increase the range of speed, was used to supply square-topped waves of negligible transit time, and suitable low-pass filters converted these into sinusoidal waves. An adaptation of Maxwell's Commutator Bridge method was used for the measurement of the frequencies.

OSCILLATORE DI ELEVATA STABILITÀ PER FREQUENZE ULTRAACUSTICHE (A Supersonic Oscillator with Frequency Stabilisation of a High Order).—M. Boella. (*L'Elettrotec.*, 25th Sept., 1930, Vol. 17, pp. 629–630.)

For a range 18,600–19,100 cycles/sec., with an accuracy greater than $1 : 10^4$. The stabilising circuit is piezoelectrically governed, and the heterodyning circuit is designed to have great frequency stability; in both cases the oscillatory circuit lies between grid and plate, and the feed is through an intermediate point on the inductance (Hartley). In the stabilising circuit the quartz is between the oscillatory circuit and the grid, "according to a new system which allows the quartz to vibrate exactly on its series resonance frequency (74,500 cycles/sec.)."

NEUE BRAUNSCHE RÖHREN MIT WECHSELSTROMHEIZUNG (A New C.-R. Tube with A.C. Heating of Cathode).—H. Reibedanz: v. Ardenne. (*Zeitschr. f. hochf. Tech.*, Nov., 1930, Vol. 36, pp. 196–197.)

The von Ardenne-von Hartel tube referred to in the *E.W. & W.E.* article (1930 Abstracts, p. 228) had a mains unit designed to supply its anode and Wehnelt cylinder voltages, but its cathode required heating current from an accumulator, since a.c. heating caused deflections of the ray up to 1 cm. in extent. The modified tube here described avoids this difficulty and can be driven entirely from the mains. The disturbances were produced by variations not in the filament temperature but in the magnetic field surrounding the cathode, and are avoided by twisting the cathode loop into a kind of figure-of-eight.

This special filament is also being fitted in the new, small type of tube which has only one pair of deflecting plates and is thus meant for visual observation only; the screen is coated with a material which gives a white light, visible in bright daylight, for a voltage as low as 1,000 V. Owing to its rather longer deflecting plates, the sensitivity is somewhat greater than that of the larger tube intended for photographic recording.

SMALL TYPE VON ARDENNE C.-R. TUBE FOR VISUAL OBSERVATION IN DAYLIGHT.—V. Ardenne.

(*See* end of preceding abstract.)

L'OSCILLOGRAFO A RAGGI CATODICI E L'ASSE DEI TEMPI (The C.-R. Oscillograph and Its [Argon Discharge Tube] Time Base).—C. Calosi. (*L'Elettrotec.*, 15th Nov., 1930, Vol. 17, pp. 737–738.)

NOUVEAUX OSCILLOGRAPHES BLONDEL ET LEURS APPLICATIONS (New Blondel Oscillographs and their Applications).—J. Vassillière-Arlhac. (*Bull. d. l. Soc. franç. d. Élec.*, Nov., 1930, Vol. 10, pp. 1152–1162.)

ELEKTROMETRISCHE MESSUNGEN SEHR KLEINER HOCHVAKUUMDRUCKE MIT HILFE VON IONISATIONSSTRÖMEN: DAS RAUMLADUNGSMANOMETER (Electrometer Measurements of Very Small High-Vacuum Pressures with the help of Ionisation Currents: the Space Charge Manometer).—W. Molthan. (*Zeitschr. f. tech. Phys.*, Dec., 1930, Vol. 11, pp. 522–529.)

For pressures as low as 10^{-10} mm.

EIN NEUES HOCHSPANNUNGSELEKTROMETER. 2. MITTEILUNG (A New High-Voltage Electrometer. 2nd Communication).—T. Wulf. (*Physik. Zeitschr.*, 15th Nov., 1930, Vol. 31, No. 22, pp. 1030–1032.)

Continuation of the work referred to in 1930 Abstracts, p. 345.

A DEVICE FOR MAINTAINING ISOCHRONISM IN LOW-POWER ELECTRIC MOTORS.—N. F. S. Hecht and D. P. Alexander. (*Journ. I.E.E.*, Dec., 1930, Vol. 69, pp. 83–88.)

Authors' summary:—In connection with the driving of a wireless direction-finding rotating beacon it was found necessary to devise means of controlling a motor so as to obtain accurate constancy of speed over wide ranges of mains variation.

In the first instance experiments were made with a governor such as that used in the Baudot printing-telegraph system, but it was found that it did not absorb sufficient power to enable it to be used on the beacon. With a view to diminishing the amount of power that need be absorbed by the governor, an electric circuit arrangement for the supply of power to the electric motor was devised, and finally an eddy-current governor with clock control was designed. The clock control is intended to enable two beacons to be run with alternate periods of transmission, without the possibility of serious overlapping of these periods. The accuracy of the governor control is of the order of 0.05 per cent. with 30 per cent. mains-voltage fluctuations, while the clock control limits the cumulative error to less than 1 degree of azimuth.

THE VERSATILITY OF APPLICATION OF SELSYN EQUIPMENT.—R. A. Corby. (*Gen. Elec. Review*, December, 1930, Vol. 33, pp. 706–711.)

A D.C. MOTOR USING A TRIODE AS COMMUTATOR.—R. Barthélemy. (*Rev. Gén. de l'Élec.*, 27th Sept., 1930, Vol. 28, p. 112 D.)

Summary of a patent. The driving magnet is energised by the anode current, and the toothed-disc rotor—by its action on a second magnet with windings on its poles—influences the grid potential and thus controls the driving current. The absence of brushes and the lightness of the rotor enables a jewelled movement to be used and leads to high speeds such as are required in television.

L'AMÉLIORATION DE L'ISOLEMENT DES MACHINES À HAUTE TENSION (Improving the Insulation of H.T. Generators).—Brown-Boveri Company. (*Génie Civil*, 29th Nov., 1930, Vol. 97, pp. 544–545.)

VOLTAGE IRREGULARITIES IN D.C. GENERATORS.—J. T. Fetsch. (*Journ. Am.I.E.E.*, June, 1930, Vol. 49, pp. 436–440.)

IMPROVED IRON-HYDROGEN BARRETTER COMBINATION.—(French Pat. 684118, La Radiotechnique, pub. 21st June, 1930.)

For a summary of this combination of two barretters with a bi-metallic contact and auxiliary relay, such that the second barretter comes into action automatically when the voltage across the first becomes too great for its proper functioning, see *Rev. Gén. de l'Élec.*, 25th Oct., 1930, Vol. 28, p. 146 D.

DIE ELEKTRISCHE SPANNUNGSREGELUNG MITTELS KOHLEDRUCK-WIDERSTÄNDEN (Voltage Regulation by Varying-Pressure Carbon Resistances).—H. Grob. (*E.T.Z.*, 11th Dec., 1930, Vol. 51, p. 1717–1720.)

ISOLATOREN AUS KIESELSÄUREGLAS-QUARZISOLATOREN (Insulators of Silicate-Glass — Quartz Insulators).—F. Skaupy. (*E.T.Z.*, 18th and 25th Dec., 1930, Vol. 51, pp. 1745–1747 and 1768–1772.)

The first part of this paper on the nature, production and application of quartz glass (transparent and opaque), of various brands such as Vitreosil, ends with a section on its particular value for high-frequency insulation, especially for short waves. It remains unchanged in a 20 m. field in which porcelain becomes red hot, most glasses melt, and Bakelite warps. The second part deals with actual types of insulator for various purposes, *e.g.*, for transmitting valves.

A STUDY OF TELEPHONE LINE INSULATORS.—L.T. Wilson. (*Bell Tech. Journ.*, Oct., 1930, Vol. 9, No. 4, pp. 697–729.)

DIËLECTRISCHE VERLIEZEN (Dielectric Losses).—Th. J. Weijers. (*Tijdschr. Nederl. Radiog.*, No. 6, Vol. 4, 1930, pp. 143–164.)

A theoretical and experimental investigation of dielectric loss and dielectric residual effect in condensers. The experimental work includes tests between 500 cycles and 1.5 megacycles per second on a large number of dielectrics including mica, glass, celluloid, paper and various oils. Results conform, at any rate qualitatively, with the inhomogeneity theory. The paper also deals with the theories due to Pellat, von Schweidler, Wagner and Rogowski.

DIELEKTRISCHE VERLUSTE IN ÖLEN (Dielectric Losses in Oils).—A. Gemant. (*Zeitschr. f. tech. Phys.*, Dec., 1930, Vol. 11, pp. 544–545.)

Proof that the losses in oil at low frequencies are due to a different process (Wagner effect) from that causing them at high frequencies (Debye effect).

EINE SCHWEBUNGSMETHODE ZUR BESTIMMUNG DER DIELEKTRIZITÄTSKONSTANTEN LEITENDER FLÜSSIGKEITEN (A Beat Method for Determination of the Dielectric Constant of Conducting Fluids).—W. Graffunder and R. Weber. (*Zeitschr. f. Phys.*, 1930, Vol. 65, No. 11–12, pp. 723–725.)

"The method of superposition hitherto used is only reliable for almost perfect insulators. By means of a device which compensates for conductivity and uses wireless valves connected in parallel, the method may be applied to the case of conducting fluids."

GRAPHICAL CALCULATION OF ELECTRO-MAGNET WINDINGS.—S. Leviev and M. G. Tsimbalisty. (*Westnik Elektrot., Moscow*, No. 5, 1930, pp. 188–193.)

ZUR DEFINITION DER ELEKTROMAGNETISCHEN STREUUNG (On the Definition of Electromagnetic Leakage).—E. Weber. (*Elektrot. u. Masch:bau*, 19th Oct., 1930, Vol. 48, pp. 941–949.)

TRANSFORMER CORES OF WOUND STRIP.—(French Pat. 688301, Swendsen, pub. 21st Aug., 1930.)

For summary, *see Rev. Gén. de l'Élec.*, 29th Nov., 1930, Vol. 28, p. 191 D.

HERSTELLUNG VON THERMOELEMENTEN AUS DÜNNEN DRÄHTEN (The Construction of Thermo-Elements from Thin Wires).—O. Kantorowicz and R. Reinecke. (*Zeitschr. f. tech. Phys.*, Dec., 1930, Vol. 11, p. 547.)

SOLDERING TUNGSTEN.—R. d'E. Atkinson. (*Nature*, No. 3168, Vol. 126, 1930, p. 97.)

A gold-palladium alloy is recommended, with borax as flux.

THE TESTING OF CHOKES FOR MAINS-OPERATED RECEIVERS.—F. Dohnal. (*Elektrot. u. Masch:bau*, 11th May, 1930, Vol. 48, pp. 430–436.)

THE TESTING OF DRY CELLS.—R. W. W. Sanderson. (*G.E.C. Journ.*, Nov., 1930, Vol. 1, No. 3, pp. 115–122.)

THE CADMIUM BATTERY TESTER.—(*World Power*, Oct., 1930, Vol. 14, p. 297.)

ON THE THEORY OF THE LEAD ACCUMULATOR.—L. Jumau: Denina and Frates. (*World Power*, Oct., 1930, Vol. 14, pp. 303–304: *Rev. Gén. de l'Élec.*, 30th Aug., 1930, Vol. 28, pp. 311–312.)

DAS MIKROPORÖSE GUMMIDIAPHRAGMA FÜR AKKUMULATOREN (The Microporous Rubber [Separator] Diaphragm for Accumulators).—H. Beckmann. (*E.T.Z.*, 20th Nov., 1930, Vol. 51, pp. 1605–1607.)

LES ACCUMULATEURS ÉLECTRIQUES D'APRÈS LES BREVETS RÉCENTS (Electric Accumulators according to Recent Patents).—L. Jumau. (*Rev. Gén. de l'Élec.*, 25th Oct., 1st, 8th and 15th Nov., 1930, Vol. 28, pp. 651–663, 696–709, 744–751, and 786–796.)

A VARIABLE CONDENSER WITH NO ZERO CAPACITY.—Zickner.

(*See* abstract under "Measurements and Standards.")

ZUR FRAGE DER ABRUNDUNG EBENER KONDENSATOREN IN NORMALER LUFT (On the Question of Rounding-off [the Edges of] Flat Plate Air Condensers.—W. Schilling. (*Arch. f. Elektrot.*, 27th Sept., 1930, Vol. 24, No. 3, pp. 383–396.)

MAGNETISIERUNG UND MAGNETISCHE ALTERUNG VON DAUERMAGNETEN FÜR ELEKTRISCHE MESSINSTRUMENTE (The Magnetisation and Magnetic Ageing of Permanent Magnets for Electrical Measuring Instruments).—E. Schramkow and B. Janowsky. (*Zeitschr. f. tech. Phys.*, Oct., 1930, Vol. 11, pp. 429–432.)

Small air-gap horse-shoe magnets can be magnetised to complete saturation by an a.c. field of high intensity superposed on a comparatively weak d.c. field. The method leads also to a means for artificially ageing the magnet thus formed.

HOW TO DETERMINE WIRE SIZES FOR ELECTRO-MAGNETS.—H. B. Brooks. (*Indust. Engineering*, July, 1929, Vol. 87, pp. 349–350.)

Shows how to determine the size of wire necessary for successful operation on a given constant voltage, for a given iron structure, by a single experiment with a trial winding on a variable voltage.

AN ELECTRICAL IMPULSE RATE INDICATOR AND RECORDER.—W. W. Macalpine. (*Review Scient. Instr.*, Sept., 1930, Vol. 1, pp. 523–526.)

A circuit is described which is operated by impulses and in which the reading of a meter is a function of the rate of the impulses. A continuous record of the rate can also be obtained.

GENERAL THEORY, DESIGN, AND CONSTRUCTION OF SENSITIVE VACUUM THERMOPILES.—C. H. Cartwright. (*Review Scient. Instr.*, Oct., 1930, Vol. 1, pp. 592–604.)

THE PROPERTIES OF SPUTTERED METAL RESISTORS.—L. C. Van Atta. (*Review Scient. Instr.*, Nov., 1930, Vol. 1, pp. 687–690.)

Satisfactory high resistances (10^{10}–10^{13} ohms) changing only slowly with age can be made by sputtering platinum on soft glass rods and embedding the rods in paraffin in glass tubes. They have no trace of polarisation, and a negligible temperature coefficient ; Ohm's law is obeyed. *See* also Perucca, 1930 Abstracts, p. 170.

A VACUUM-TUBE VOLTAGE REGULATOR FOR ALTERNATORS.—L. C. Verman and L. A. Richards. (*Review Scient. Instr.*, Oct., 1930, Vol. 1, pp. 581–591.)

Description of an arrangement, on the lines of the writers' d.c. generator regulator (1930 Abstracts, p. 171), for use with an alternator.

COPPER-OXIDE DETECTORS.—V. N. Lepeshinskaja-Krakau.

(*See* under " Miscellaneous.")

NOUVEAUX REDRESSEURS À OXYDE CUIVRIQUE (New Copper-Oxide Rectifiers).—H. Pélabon. (*L'Onde Élec.*, Nov., 1930, Vol. 9, pp. 497–510.)

A fuller exposition of the work dealt with in the *Comptes Rendus* note (1930 Abstracts, pp. 641–642).

STATIONS, DESIGN AND OPERATION.

DICHTE DER KOMMERZIELLEN KURZWELLENSTATIONEN ([World] Density of Commercial Short Wave Stations).—E. Quäck and H. Mögel. (*Telefunken Zeit.*, Oct., 1930, Vol. 11, No. 55, pp. 22–25.)

Already referred to in 1930 Abstracts, p. 644.

BETRIEBSKONTROLLE VON KURZWELLENSENDERN (The Monitoring of Short Wave Transmitters).—H. Mögel. (*Telefunken Zeit.*, Oct., 1930, Vol. 11, No. 55, pp. 8–21.)

See January Abstracts, p. 52.

DER GEGENWÄRTIGE STAND DER KURZWELLENTECHNIK (The Present Position of Short Wave Technique).—E. Wolf. (*Elektrot. u. Masch:bau*, 21st Dec., 1930, Vol. 48, pp. 1126–1133.)

RADIO TELEPHONY AT THE RUGBY STATION.—(*Nature*, 11th Oct., 1930, Vol. 126, p. 574.)

A short account of recent progress in the development of the Post Office radio transmitting station at Rugby.

RUGBY G.P.O. RADIO STATION.—(*Electrician*, 3rd and 10th Oct., 1930, Vol. 105, pp. 405 and 439–440.)

RECENT DEVELOPMENTS IN RADIO TELEPHONY [The Rugby Short Wave Equipment].—(*Engineering*, 31st Oct., 1930, Vol. 130, pp. 541–543.)

Particular attention is paid in this first instalment to the quartz oscillators controlling the Transatlantic 16.38, 24.69, 33.26 and 43.45 m. waves, the containing ovens and their bi-metallic strip thermostats.

LATEST DEVELOPMENTS OF SERVICE AND TECHNIQUE IN TELEPHONY IN THE U.S.A.—K. Höpfner. (*E.T.Z.*, 13th Nov., 1930, Vol. 51, pp. 1573–1580.)

Including sections on broadcasting and short wave telephony.

LA LIAISON RADIOTÉLÉPHONIQUE MADRID BUENOS-AIRES (The Madrid-Buenos Aires Telephone Service).—E. M. Deloraine. (*L'Onde Élec.*, Oct., 1930, Vol. 9, pp. 467–483.)

THE RCA WORLD-WIDE RADIO NETWORK.—A. A. Isbell. (*Proc. Inst. Rad. Eng.*, Oct., 1930, Vol. 18, pp. 1732–1742.)

After a history of events leading to the foundation of the RCA, a list of its international and domestic radio circuits (at the end of 1929) is given, followed by a number of facts concerning the plant and methods involved. The methods of handling the traffic, in particular, are described.

TERMINAL EQUIPMENTS FOR SHORT WAVE POINT TO POINT RADIO LINKS.—F. de Fremery and P. R. Thomas. (*Elec. Communication*, No. 4, Vol. 8, 1930, pp. 242–248.)

FUNKTECHNIK UND LUFTVERKEHR (Wireless Technique and Aviation).—H. Schmidt-Reps. (*Telefunken Zeit.*, Oct., 1930, Vol. 11, No. 55, pp. 48–50.)

A very short account, with illustrations, of some recent Telefunken aircraft apparatus.

TYPE A.V.M.5 SET FOR MILITARY AEROPLANES.—Soc. Franç. Radio-Élec. (*Bull. de la S.F.R.*, Oct., 1930, Vol. 4, pp. 143–152.)

ULTRA-SHORT WAVE EQUIPMENT FOR TANKS AND ARMOURED CARS.—Marconi Co. (*Marconi Review*, Nov., 1930, No. 26, pp. 15–19.)

See also January Abstracts, p. 53.

THE STRASBURG BROADCASTING STATION.—(*Bull. de la S.F.R.*, Nov., 1930, Vol. 4, pp. 162–169.)

DER DEUTSCHE KURZWELLEN-WELTRUNDFUNKSENDER (The German Short Wave " World " Broadcasting Station [Zeesen, near Königswusterhausen]).—W. Meyer. (*Telefunken Zeit.*, Oct., 1930, Vol. 11, No. 55, pp. 25–27.)

VON ARDENNE'S SCHEME FOR DISTANT BROADCAST RECEPTION IN CITIES.—W. Runge. (*Die Sendung*, 1st Nov., 1930, Vol. 7, p. 700.)

An adverse criticism of the first plan referred to in January Abstracts, p. 52.

RUNDFUNK AUF KURZWELLEN (Broadcasting on [Ultra-] Short Waves).—F. Meissner and M. Libau. (*Die Sendung*, 21st Nov., 1930, Vol. 7, pp. 748–749.)

A short article on the Esau-Leithäuser tests on the possibilities of broadcasting in Berlin on 9 m. and such ultra-short waves.

ULTRA-SHORT WAVE BROADCASTING.—German State P.O. : E. Rhein. (*See* under "Propagation of Waves.")

WIRELESS DEVELOPMENTS IN CANADA.—(*Engineer*, 21st Nov., 1930, Vol. 150, pp. 561–563.)

DAS POLIZEI-FUNKNETZ UNGARNS (The Hungarian Police Wireless Network).—A. Szentirmay. (*Telefunken Zeit.*, Oct., 1930, Vol. 11, No. 55, pp. 36–38.)

GENERAL PHYSICAL ARTICLES.

THE DISTRIBUTION OF ELECTRONS IN THE ATOM.—L. Goldstein. (*Comptes Rendus*, 3rd Nov., 1930, Vol. 191, pp. 766–768.)

ON A GENERALISED PROBLEM OF DIRICHLET.—M. Brelot. (*Comptes Rendus*, 27th Oct., 1930, Vol. 191, pp. 697–699.)

ON A POSSIBLE CONCEPTION OF NUCLEAR PHENOMENA.—M. de Broglie. (*Comptes Rendus*, 27th Oct., 1930, Vol. 191, pp. 689–690.)

THE CONDUCTION OF ELECTRICITY IN LIQUID DIELECTRICS.—D. H. Black and R. H. Nisbet. (*Phil. Mag.*, Nov., 1930, Series 7, Vol. 10, No. 66, pp. 842–862.)

UNTERSUCHUNGEN ÜBER DEN EINFLUSS STARKER ELEKTRISCHER FELDER AUF DIE DIELEKTRIZITÄTSKONSTANTE VON FLÜSSIGKEITEN ([Experimental] Investigations on the Influence of Strong Electric Fields on the Dielectric Constant of Liquids).—H. Gundermann. (*Ann. der Physik*, 1930, Series 5, Vol. 6, No. 5, pp. 545–573.)

THE DIELECTRIC CONSTANT OF CARBON DIOXIDE AS A FUNCTION OF TEMPERATURE AND DENSITY.—F. G. Keyes and J. G. Kirkwood. (*Phys. Review*, 15th Aug., 1930, Series 2, Vol. 36, No. 4, pp. 754–761.)

EFFECT OF MAGNETIC FIELDS ON DIELECTRICS.—P. L. Burns. (*Nature*, 12th July, 1930, Vol. 126, p. 59.)

"Experiments . . . show clearly that when a constant magnetic field is superimposed on a dielectric, which is being subjected to an alternating electric stress, so that magnetic and electric fields are normal to one another, then the presence of the magnetic field causes a change in the power factor of the dielectric and hence in the losses occurring therein. The nature of the results indicates that the effect of the magnetic field is to decrease the power factor."

EFFECT OF MAGNETIC FIELDS ON DIELECTRICS.—S. Whitehead : J. B. Miles. (*Nature*, 26th July and 20th Sept., 1930, Vol. 126, pp. 133 and 438.)

Comments on the above. Miles points out that the power factor may be either increased or decreased by a magnetic field, according to the side of the peak of the frequency/power factor curve on which the power factor is being measured. Whitehead remarks that on Smouroff's theory an increase of power factor in magnetic fields is to be expected and has been observed experimentally by Monkhouse (1929 Abstracts, p. 344).

ÜBER DEN DURCHSCHLAG FLÜSSIGER ISOLIERSTOFFE (On the Breakdown of Liquid Insulators).—F. Koppelmann. (*Naturwiss.*, 11th April, 1930, Vol. 18, No. 15, p. 333.)

A preliminary account of experimental investigations of the breakdown voltages of pure paraffin oil and hexane.

DIPOLES IN RELATION TO THE ANOMALOUS PROPERTIES OF DIELECTRICS.—S. Whitehead. (*Phil. Mag.*, May, 1930, Series 7, Vol. 9, No. 60, pp. 865–880.)

A report on the mathematical application of the Dipole Theory of Debye to anomalous properties of dielectrics. The paper is intended to show the analogies and differences between the dipole theory and other theories (*e.g.*, Pellat, Schweidler, Wagner and Décombe) of the anomalous properties of dielectrics. Curves are given showing the fall of absorption current with time and the variation with frequency of (1) specific power loss, (2) power factor, (3) permittivity.

A SEARCH FOR THE SOURCE OF DIELECTRIC POLARIZATION.—R. D. Bennett. (*Phys. Review*, 1st July, 1930, Series 2, Vol. 36, No. 1, pp. 65–70.)

ÜBER DEN ALLGEMEINEN CHARAKTER UND DIE GESTALT DER FORMEL FÜR DIE DIELEKTRIZITÄTSKONSTANTE UNHOMOGENER MISCHUNGEN (On the general Character and the Form of the Formula for the Dielectric Constant of Inhomogeneous Mixtures).—A. Piekara. (*Physik. Zeitschr.*, 15th June, 1930, Vol. 31, No. 12, pp. 579–584.)

THE COMPLEX NATURE OF DIELECTRIC ABSORPTION AND DIELECTRIC LOSS.—E. J. Murphy and H. H. Lowry. (*Journ. Phys. Chem.*, March, 1930, Vol. 34, pp. 598–620.)

"An investigation of dielectric absorption and dielectric loss with particular reference to the influence of ions adsorbed on inner surfaces."

THEORIE DER INTERMITTIERENDEN WIRKUNG UND ULTRAROTES BANDENSPEKTRUM (The Theory of Intermittent Action, and the Infra-red Band Spectrum).—K. C. Kar and B. Biswas. (*Zeitschr. f. Phys.*, 9th Jan., 1930, Vol. 59, No. 7/8, pp. 570–572.)

DURCHGANG DES ELEKTRISCHEN STROMES DURCH FESTES PARAFFIN IM DUNKELN UND BEI RÖNTGENBESTRAHLUNG (Passage of Electric Current through Solid Paraffin (1) Unilluminated and (2) under X-ray Illumination).—W. M. Tutschkewitsch. (*Ann. der Physik*, 1930, Series 5, Vol. 6, No. 5, pp. 622–636.)

ELEKTRISCHE MOMENTE EINIGER MOLEKÜLE (Electrical Moments of Some Molecules).—H. Müller and H. Sack. (*Phys. Zeitschr.*, 15th Sept., 1930, Vol. 31, No. 18, pp. 815–822.)

WAS IST EIN ISOLATOR? (What is an Insulator?).—A. Meissner. (*Zeitschr. f. Phys.*, 1930, Vol. 65, No. 3/4, pp. 158–166.)

Starting from the structure of quartz (*cf.* under "Acoustics") a discussion is given of the properties which appear to characterise insulators in general.

THE EFFECT OF TRANSIENT VOLTAGES ON DIELECTRICS. IV.—LAW OF IMPULSE SPARK-OVER AND TIME LAG.—F. W. Peek. (*Journ. Am. I.E.E.*, Oct., 1930, Vol. 49, pp. 868–871.)

Relative effects of different wave shapes: comparison of lightning waves and laboratory waves: co-ordination of line insulation. Abridgment only.

THE RECOMBINATION OF IONS IN AIR AND OXYGEN IN RELATION TO THE NATURE OF GASEOUS IONS: THE RECOMBINATION OF IONS IN ARGON, NITROGEN, AND HYDROGEN.—O. Luhr. (*Phys. Review*, 15th Aug., 1930, Series 2, Vol. 36, No. 4, p. 787; pp. 788–789.)

Abstracts only. *See* also 1930 Abstracts, p. 585.

THUNDERSTORMS AND THE PENETRATING RADIATION.—Schonland.

See under "Atmospherics."

MISCELLANEOUS.

COPPER-OXIDE DETECTORS.—V. N. Lepeshinskaja-Krakau. (*Westnik Elektrot., Moscow*, No. 5, 1930, pp. 179–188.)

Experiments on the application of the rectifying effect of oxidised copper to radio detection. The dependence of the behaviour of such detectors on their area, temperature, and time of heating during oxidation, etc., was investigated; static and dynamic characteristics were plotted, and the values of resistance, rectifying ratio, voltage, and power efficiency, etc., were studied as functions of the applied a.c. voltage. The influence of room temperature and of biasing voltage was also investigated, and the dependence of the rectified current on frequency—as compared with the galena detector. Fields of application are discussed.

THE ELECTRICAL CONDUCTIVITY OF THE EARTH.—I. Königsberger. (*Physik. Zeitschr.*, 15th May, 1930, Vol. 31, pp. 487–498.)

INFRA-RED RAY COMMUNICATION.—Michelssen: Schröter.

(*See* abstract under "Phototelegraphy.")

APPARATUR FÜR STARKES ULTRAVIOLETTES UND ULTRAROTES LICHT UND ÜBER DAS PHOTOGRAPHIEREN MIT WÄRMESTRAHLEN (Apparatus for Strong Ultra-violet and Infrared Light, and Photography with Heat Rays).—J. Plotnikow. (*Zeitschr. f. Elektrochem.*, No. 7, Vol. 35, 1929, pp. 434–438.)

THYRATRON STABILIZER FOR X-RAY TUBES.—W. K. Kearsley. (*Gen. Elec. Review*, Oct., 1930, Vol. 33, pp. 571–572.)

An arrangement by which the X-ray tube current itself adjusts the average filament current on each cycle so that the former current is kept constant.

FREQUENZABHÄNGIGKEIT DER FUNKENSPANNUNG IN LUFT. VORLÄUFIGE MITTEILUNG (How the Spark Potential in Air Depends on Frequency. Preliminary Communication).—H. Lassen. (*Physik. Zeitschr.*, 1st Oct., 1930, Vol. 31, No. 19, pp. 868–870.)

A QUANTITATIVE EXPERIMENTAL METHOD OF MAPPING EQUIPOTENTIAL LINES, AND ITS APPLICATION TO ELECTRIC PRECIPITATOR PROBLEMS.—A. W. Simon and L. C. Kron. (*Review Scient. Instr.*, Sept., 1930, Vol. 1, pp. 527–536.)

RADIO CHARTS THE UPPER AIR.—J. D. Van Brakle. (*Scient. American*, Nov., 1930, Vol. 86, pp. 350–351.)

Illustrated article on the U.S.A. Signal Corps' method of charting the direction and velocity of winds at high altitudes by the use of balloons carrying small wireless transmitters (wavelength 130 m.), and direction-finding loops on the ground. A method of determining the upper-air temperatures is now being tried: a bi-metallic plate whose capacity varies with the temperature is included in the transmitting circuit so that it controls the length of the emitted wave.

TELEPHONING FROM TRAINS: THE CANADIAN NATIONAL RAILWAYS SYSTEM.—J. C. Burkholder. (*Discovery*, Dec., 1930, Vol. 11, pp. 297–399.)

The Canadian method here described and illustrated differs from the one employed in Germany in that no "switching-over" from speaking to listening is necessary. The car aerial consists of seven strands of copper wire strung on insulators about 12in. above the roof. The three centre strands are used for transmitting and the other four for receiving. The carrier frequencies are 102 and 152 kc.

THE GERMAN PHYSICISTS AND MATHEMATICIANS' CONVENTION IN KÖNIGSBERG, 1930.—(*E.T.Z.*, 18th Dec., 1930, Vol. 51, pp. 1748–1749.)

Short accounts of certain events, including a demonstration by Brüche of a constricted electron ray entering the magnetic field of a dipole and behaving in accordance with Störmer's aurora theory (*see also* under "Propagation of Waves"); a paper by Jacobs on the development of a copper-block thermostat for piezo-electric oscillators, giving a constancy of 1–2 cycles in a wavelength of 300 m., and on its application to common-wave broadcasting: and a paper and demonstration by Trautwein on the electrical synthesis of musical and speech sounds (*see also* under "Acoustics").

THE GERMAN RADIO AND PHONO EXHIBITION.—G.W.O.H. (*E.W. & W.E.*, Oct., 1930, Vol. 7, pp. 533–535.)

THE 1930 GERMAN RADIO EXHIBITION.—(*Rad., B., F. f. Alle*, Oct., 1930, pp. 433–437 and 457–471.)

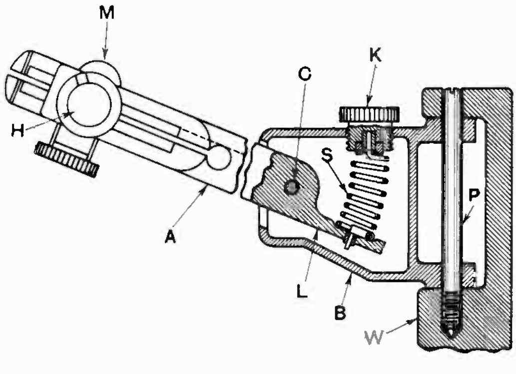
Some Recent Patents.

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each

GRAMOPHONE PICK-UPS.

Application date, 25th April, 1929. *No.* 332613.

Relates to means for controlling the pressure of the pick-up on a gramophone record. The pick-up arm *A* is pivoted at *C* in a casing *B* mounted on a pivot *P* carried by the base-piece *W*. A com-



No. 332613.

pression spring *S* is arranged to bear on a rearwardly-extending lug *L* and is controlled by a knob *K* so as to lessen the effective weight of the free arm. The outer end of the arm *A* is split both vertically and horizontally. This allows the pick-up carrier *H* to be moved laterally so as to adjust the effective length of the arm, and also to rotate slightly about a clamping bolt *M* as pivot, so as to secure the proper tracking angle.

Patent issued to M. Glasscoe, G. M. Daines and F. J. Glasscoe.

GRAMOPHONE AMPLIFIERS.

Convention date (U.S.A.) 28th April, 1928. *No.* 310519.

A number of different coils, designed to respond to different frequency bands, are wound around the armature of a gramophone pick-up. Each coil is connected to a separate chain of amplifiers through a circuit comprising a variable resistance, inductance and capacity. The impedances in each circuit are adjusted to resonate say to different frequency bands in the audible scale, thus ensuring an efficient and balanced overall response.

Patent issued to Dominion Gramophone Records, Ltd.

GANGED CONDENSERS.

Application date, 25th April, 1929. *No.* 332941.

In a condenser of the rotary type, an additional semi-fixed plate is provided and is adapted to be warped or bent towards or away from the other plates by means of control screws, so as to allow the overall capacity to be finely adjusted for any particular setting of the condenser. The adjustment is particularly useful for regulating the capacity curve of each condenser to the requirements of individual circuits in gang-tuning systems.

Patent issued to Dubilier Condenser Co., Ltd.

SHORT-WAVE SIGNALLING.

Convention date (Germany) 27th March, 1929. *No.* 331667.

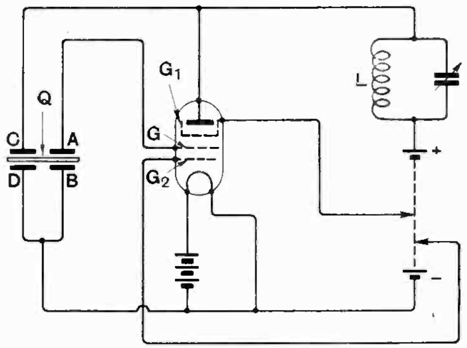
When working on wavelengths well below ten metres, the effective range of transmission is limited by the curvature of the earth, since such waves travel, like light, in a straight line. The actual range is of course determined by the elevation of the transmitting aerial above the ground. According to the invention long-range transmission is effected by arranging elevated relay stations at intervals along the track of the message. These intercept the travelling waves and then retransmit them, so that they travel in a series of straight lines well above the earth's surface.

Patent issued to C. Lorenz Akt.

VALVE GENERATORS.

Convention date (U.S.A.), 31st July, 1928. *No.* 316576.

A pentode tube comprising a control grid *G*, screening grid G_1, and a space-charge grid G_2 is used in combination with a piezo-crystal *Q* as a short-wave generator. The input electrodes *A*, *B* between control grid and filament are adjustable, relatively



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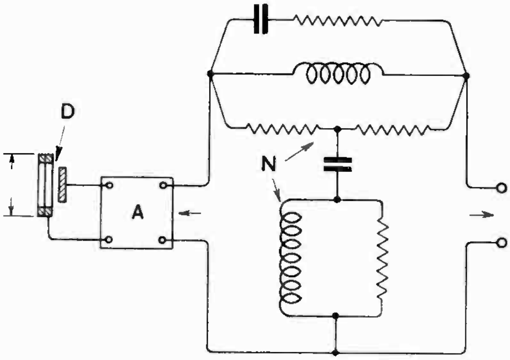
to the output electrodes *C*, *D* between the anode and filament, in order to control the regenerative coupling. The circuit *L* is tuned approximately to the crystal frequency. By regulating the biasing potentials on the two auxiliary grids, the parameters of the tube and its internal impedance can be adjusted to optimum values.

Patent issued to Wired Radio Inc.

SOUND-REPRODUCTION.

Convention date (*U.S.A.*) *4th May*, 1928. *No.* 310959

In practice the response of a diaphragm is not uniform with frequency, because high-frequency impulses exert approximately twice the incident sound pressure, whereas low-frequency impulses exert the actual incident pressure. This arises from the fact that practically complete reflection occurs at the diaphragm for waves shorter than twice the diameter of the diaphragm. The figure shows a



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pick-up device *D* of the condenser-transmitter type feeding an amplifier *A*, in the output circuit of which is an impedance network *N* designed to compensate for the frequency distortion introduced by the diaphragm *D*.

Patent issued to Electrical Research Products Inc.

GAS-FILLED RECTIFIERS.

Convention date (*France*) *17th April*, 1928. *No.* 309921.

When using a gas-filled rectifier for charging HT batteries there is some risk of "arcing" when the mains supply is suddenly stopped, which, in turn, may cause a complete discharge of the battery. To avoid this a high resistance of 100,000 ohms, in series with a condenser, is inserted in shunt with the rectifier, *i.e.* across the plate and filament. This damps out any oscillations which may be started in the secondary circuit when the supply is suddenly cut off, and which are the primary cause of the "arcing."

Patent issued to Soc. Anon. E. C. Grammont et A. Grammont.

WIRING-UP RECEIVERS.

Application date 18th May, 1929. *No.* 331991.

In order to simplify assembly for mass production a sheet of thin metal is placed upon an insulated base, and the complete wiring-circuit, including the collars and all connections from collar to collar, is stamped out in one operation. Simultaneously the insulated base and metal sheet are perforated to enable them to be passed over and attached to the vertical terminals of the previously arranged component parts forming the complete receiver.

Patent issued to J. P. Laker.

TELEVISION APPARATUS.

Convention date (*Germany*) *16th April*, 1929. *No.* 331765.

When circular holes are used for the scanning disc, the received picture has a "striped" appearance due to the fact that the largest amount of light passes only through the centre of each hole, the intensity falling-off towards the edges. If square or oblong holes are used, the changes of intensity occur too suddenly and tend to widen the permissible frequency band due to modulation. According to the invention, small and well-spaced circular or diamond-shaped apertures are used at the transmitting end, whilst in reception the apertures are made square or oblong in shape, and larger and arranged closer together, so as to reassemble the picture elements in a tessellated manner.

Patent issued to Telehor Akt.

REFLEX CIRCUITS.

Application date 23rd March, 1929. *No.* 331191.

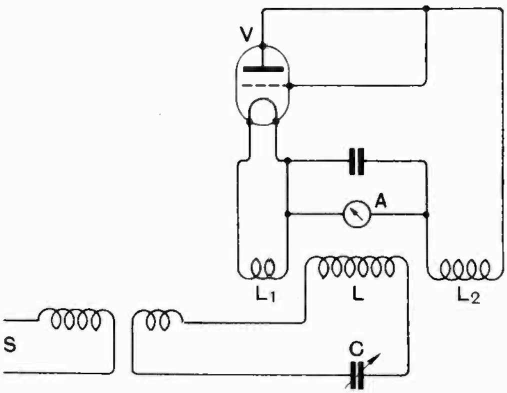
The stability of a "reflexed" broadcast receiver is enhanced (*a*) by neutralising the inter-electrode capacity effect of the dual-purpose amplifier for high-frequency currents, and (*b*) by feeding-back the rectified signals to the grid through an impedance designed to prevent the passage of any radio frequencies.

Patent issued to H. Green and Celebritone Ltd.

RESONANCE METERS.

Application date 9th April, 1929. *No.* 331865.

The valve *V* which operates as a diode (the grid and anode being connected) is coupled to the tuned circuit *L*, *C* of a wave meter through a filament-energising coil L_1 and an anode coil L_2. When the



No. 331865.

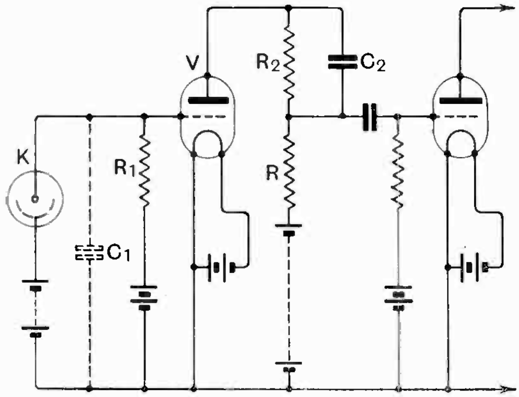
valve is energised it acts as a rectifier, so that a direct-current milliammeter *A* inserted as shown will give a maximum reading when the circuit *LC* is adjusted to resonance with any external source such as *S*.

Patent issued to Capt. J. S. C. Salmond, R.N., A. Wilkinson, and A. Symonds.

LIGHT-SENSITIVE AMPLIFIER CIRCUITS.

Convention date (U.S.A.) 20th November, 1928. No. 331462.

When a photo-electric cell K is coupled to a thermionic amplifier, the distributed capacity of the cell and leads shunted across the input (as



No. 331462.

indicated by the dotted line condenser C_1) causes a comparative falling-off in the higher frequencies. According to the invention, this is corrected by inserting a resistance R_2 shunted by a capacity C_2, in series with the coupling resistance R, in the plate circuit of the valve V. It is shown mathematically in the Specification that in order to neutralise the effect of the shunt capacity C_1, the ratio of the conductance of R_2 to the capacity of C_2 should be the same as the ratio of the conductance of R_1 to the capacity C_1.

Patent issued to British Thomson-Houston Co. Ltd.

AUTOMATIC VOLUME CONTROL.

Application date 4th January, 1929. No. 331541.

The amplification factor and internal resistance of a screened-grid valve vary considerably with change of biasing voltage on the control grid. This fact is utilised to ensure an automatic volume-control. In one arrangement a resistance inserted in the plate circuit applies a negative voltage to the control grid. Any increase in plate current automatically increases this negative bias, and so reduces the amplification factor of the valve. A similar arrangement is described as applied to an indirectly heated SG amplifier.

Patent issued to A. Hall and Ferranti Ltd.

PREVENTING FADING.

Convention date (Germany) 25th June, 1928. No. 314343.

A "wobble" frequency of several thousand cycles per second is sometimes imposed on a carrier wave in order to minimise the effect of fading. In order to stabilise the "wobble" frequency in short-wave transmission, it is first applied to a glow cathode tube inserted in shunt across an impedance in the grid circuit of the main oscillator valve. The shunted impedance is in series with the main frequency-control crystal, but serves to introduce a sufficient fluctuation in the electrical constants of the grid circuit to pass the "wobble" frequency on to the output.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie, m.b.h.

SHORT-WAVE GENERATORS.

Convention date (Germany) 21st April, 1928. No. 310043.

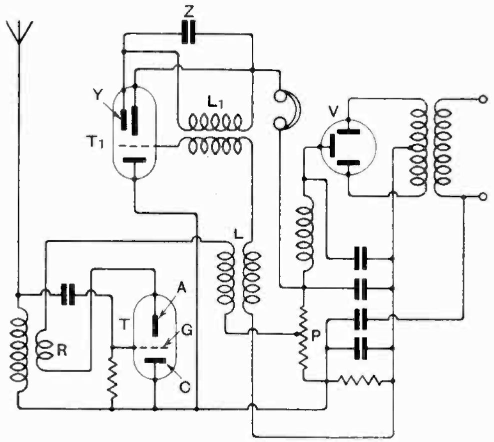
For generating ultra-short wavelengths, extraneous capacities and inductances due to the leads, etc., are avoided by enclosing the whole of the circuit elements, including the oscillating circuits, in an evacuated glass bulb, any required adjustment of the working frequency being effected by inductive action from outside the bulb.

Patent issued to Telefunken Ges. für Drahtlose Telegraphie, m.b.h.

GLOW-DISCHARGE TUBES FOR WIRELESS RECEPTION.

Convention date (Germany) 31st December, 1927. No. 303371.

Relates to a radio receiver using discharge tubes with unheated cathodes both for rectification and amplification. The necessary high-tension is drawn from the supply mains. As shown, the signals are applied across a control grid G and the cathode C of the glow-discharge tube T, the HT supply to the anode A being derived from the mains through a rectifier valve V and a potentiometer P. Reaction is applied through a coil R in the anode circuit. The



No. 303371.

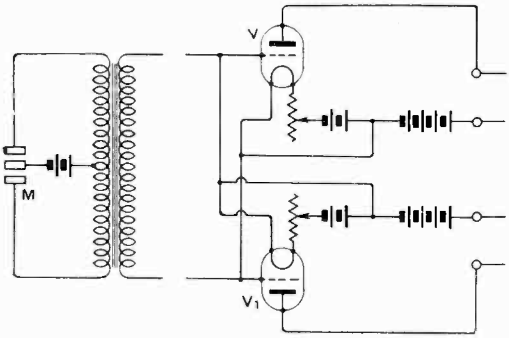
output from the rectifier is fed through a coupling L to the control grid of a second discharge tube T_1, which is fitted with an auxiliary anode Y coupled to the main anode through a condenser Z. A coupling L_1 between the control grid and anode introduces a further reaction effect.

Patent issued to Dubilier Condenser Co. Ltd.

AMPLIFYING CIRCUITS.

Convention date (U.S.A.), 1st May, 1928. No. 310857.

A high amplification ratio is secured without the use of grid bias. The figure shows the application of the method to the input from a microphone *M*. Two valves *V*, V_1 are arranged in push-pull, the grid of each valve being directly connected to the filament of the other. Separate loud-speakers may be connected to each valve, or the outputs may be combined. No leak resistance is necessary as the grid current of one valve discharges through the grid circuit of the other, the discharge path so provided acting as an ordinary ohmic resistance. By avoiding any variable grid impedance, distortion is eliminated.



No. 310857.

Patent issued to W. H. Bristol Talking Corporation.

Application date, 3rd August, 1929. No. 333390.

The output from a preceding valve is applied through a blocking condenser to an adjustable tapping on a low-frequency choke connected across the grids of two push-pull amplifiers. The condenser and choke are designed to form a resonant circuit to the lower frequencies, so as to give these notes a rising amplification factor.

Patent issued to H. Clarke & Co. (Manchester), Ltd., and H. Ingham.

TRANSATLANTIC TELEPHONY.

Convention date (U.S.A.), 5th February, 1929. No. 332687.

In operating a long-distance wireless telephony channel it is desirable to be able to transmit telegraphic signals either as a preliminary to setting-up the "thorough" telephony connection or for general supervisory purposes between the operators at the transmitting and receiving ends. According to the invention, means are provided for allowing printer telegraphic messages to be transmitted during such times as the radio link is not being employed for telephony. Morse printing equipment is provided both in the control and operating rooms. The equipment comprises two units one of which is a combined sending and receiving set, the other being a receiver only. The receiver is maintained continuously in circuit with the receiving channel, whilst the sender is connected at will to the outgoing channel, echo-suppressing devices being inserted in each path.

Patent issued to Standard Telephones & Cables, Ltd.

PIEZO-CRYSTAL CONTROL.

Application date, 12th September, 1929. No. 332451.

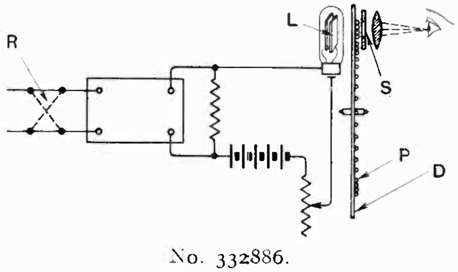
The invention is designed to minimise frequency-variation due either to the gradual change in thickness of the piezo-crystal resulting from friction against the electrodes, or to temperature fluctuations in the crystal. With this object in view, a stream of gas is passed between the crystal and its electrodes, and the temperature of the gas is itself regulated so as to compensate for any heat insulation between the crystal and its housing and also for the heat dissipated by the crystal when under vibration. Preferably, a rarefied stream of hydrogen or helium gas is drawn past the crystal and electrodes by suction derived from the cooling-water supplied to the anode of the generating-valve.

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

TELEVISION APPARATUS.

Convention date (U.S.A.), 15th February, 1929. No. 332886.

In order to increase the brilliancy of the received image the scanning-disc *D* is made of transparent or translucent material, such as glass or bakelite, upon which a spiral series *P* of opaque spots is formed, either by painting or by inserting opaque filings in openings drilled into or through the disc. In rotation, the opaque spots trace out a succession of lines across the glow-lamp *L*, which are merged together in the viewing screen *S* in the ordinary way, except that the resultant effect is a "negative" of the true image. This is converted into a positive by means of a reversing switch *R* in the input to the amplifier. Since the major portion of the glow-lamp electrode is always visible, the intensity of the received image is considerably greater than that obtainable with the ordinary or opaque type of scanning disc.



No. 332886.

Patent issued to Westinghouse Electric & Manufacturing Co.