THE

WIRELESS ENGINEER

AND

EXPERIMENTAL WIRELESS

NUMBER 105 VOLUME IX *JUNE 1932*

A JOURNAL OF

RADIO RESEARCH

AND

PROGRESS

2/6 NET

PUBLISHED BY

ILIFFE & SONS LTD.

DORSET HOUSE TUDOR STREET LONDON E.C.4

A3

The

WIRELESS ENGINEER

and EXPERIMENTAL WIRELESS

A Journal of Radio Research & Progress

Editor
HUGH S. POCOCK

Technical Editor
Prof. G. W. O. HOWE D.Sc., M.I.E.E.

VOL. IX No. 105

JUNE 1932

CONTENTS

Published Monthly on the first of each month

SUBSCRIPTIONS Home and Abroad : One Year, 32/-, 6 Months, 16/-. Single Copies, 2/8 post free

Editorial Offices
116-117 FLEET STREET, LONDON, E.C.4 Telephone: City 9472 (5 lines)

Advertising and Publishing Offices
DORSET HOUSE, TUDOR STREET, LONDON, E.C.4
Telegrams: "Experiwyr Fleet London" Telephone: City 2846 (15 lines)

Branch Offices

COVENTRY
19 Hertford Street
Telegrams: "Cyclist, Coventry."
Telephone: 5210 Coventry

BIRMINGHAM
Guildhall Bldgs., Navigation St.
Telegrams: "Autopress, Birmingham"
Telephone: Midland 2970 (3 lines)

MANCHESTER
260 Deansgate
Telegrams: "Iliffe, Manchester"
Telephone: Blackfriars 4412 (4 lines)

GLASGOW
26B Renfield Street, C2.
Telegrams: "Iliffe, Glasgow"
Telephone: Central 4857

The Editor invites the submission of articles with a view to publication. Contributions which are not exclusive should be so described when submitted. MSS. should be addressed to the Editor, "The Wireless Engineer and Experimental Wireless," Dorset House, Tudor Street, London, E.C.4. Especial care should be taken as to the legibility of MSS. including mathematical work.

HIGH VOLTAGE
SMOOTHING CONDENSERS

WITH the ever-increasing demand for real "quality" reception and the consequent use of higher voltages, condensers must, of necessity, be of unquestioned efficiency and reliability. Here are two types of T.C.C. Condensers truly worthy of the initials they bear—Guaranteed by the unique experience of over a quarter of a century to fulfil the needs of the most critical, for accuracy and dependability. Whatever the condenser — for whatever purpose, insist on the "condenser in the green case."

TYPE 95.

A 2 mfd. Type T.C.C. 95.
(1,000 V.D.C. Test. 500 V.D.C. working.)

Tested 1,000 V.D.C. for working up to 500 V.D.C.

Capacity.	Price each.
0·5 mfd.	4s. 0d.
1 ,,	5s. 0d.
2 ,,	7s. 0d.
4 ,,	12s. 6d.
6 ,,	18s. 0d.

TYPE 101.

Tested 1,500 V.D.C. for working up to 800 V.D.C.

Capacity.	Price each.
0·5 mfd.	6s. 3d.
1 ,,	7s. 6d.
2 ,,	10s. 0d.
4 ,,	19s. 4d.
6 ,,	28s. 6d.

A 2 mfd. Type T.C.C. 101.
(1,500 V.D.C. Test. 800 V.D.C. working.)

T.C.C.
ALL-BRITISH
CONDENSERS

The Telegraph Condenser Co., Ltd., Wales Farm Rd., N. Acton, W.3

PIVASPRING
PARK ROYAL
INSTRUMENTS

Tested on a special "dithering" machine which shakes and dumps the instrument continuously. A drastic test proving that the quality of material used and the workmanship is of the best.

Regd. Des. No. 759295

100% BRITISH
ALWAYS ACCURATE

SPECIFICATION

High-grade Cobalt Steel Magnet, accurately machined, giving excellent damping and accuracy. First quality Sapphire Jewel bearings. Will withstand heavy overloads without injury.

Zero correctors fitted to all instruments.

Each instrument separately calibrated and scaled.

Park Royal "Pivaspring" Instruments are used by Government Departments.

Full catalogue sent on request.

Type 1½" M.C.F.	List Price each.
VOLTMETERS 0-300 1,000 ohms per volt	33/9
MILLI-AMMETERS	30/-

PARK ROYAL

ENGINEERING COMPANY, LIMITED,
Cumberland Avenue, Park Royal, N.W.10.
Telephone: Willesden 2223, 2224 and 4715.

JOURNAL OF SCIENTIFIC INSTRUMENTS

produced by the Institute of Physics with the co-operation of the National Physical Laboratory. The principal English journal devoted exclusively to scientific instruments, their principles, construction and use. Essential to designers, makers and users.

CONTENTS OF THE MAY NUMBER.

The subscription rate for a yearly volume is £1 10s. net (post free) payable in advance. Separate parts 2s. 8d. (post free). Subscriptions should be sent to the publishers.

CAMBRIDGE UNIVERSITY PRESS
Fetter Lane, London, E.C.4 - - - England

THE
WIRELESS ENGINEER
AND
EXPERIMENTAL WIRELESS

VOL. IX. JUNE, 1932. No. 105

Acoustic Nomenclature and Definitions.

WITHIN the last few years the science of acoustics has developed from a rather neglected branch of physics into an important branch of electrotechnics—we might almost say of electrical engineering. There are, of course, a number of acoustic experts who would disclaim any connection with matters electrical, but it is noteworthy that in the list of draft reports on nomenclature, definitions, and symbols recently published by the German Elektrotechnischer Verein, there is one on Acoustic Nomenclature and another on the Unit of Loudness, sandwiched between Reports on Magnetic Units and Electrical Machinery nomenclature. We were also interested to notice a letter from M. Pomey in the *Revue Générale de l'Electricité* (26th March, 1932) headed "Terminologie acoustique," suggesting that the terms and conceptions should be drawn up on lines analogous to those in use in illumination.

The first of the two German Reports referred to above* defines the meanings to be attached to thirty of the most commonly employed terms, and although the actual German terms would only interest those who read German technical literature, the subject is of such general interest that we feel justified in outlining the suggestions which have been drawn up by a sub-committee of experts.

Sound (audible) is defined as mechanical vibrations and waves with frequencies within the range of the human ear; infra-sound and ultra-sound are self-explanatory. Depending on the medium through which the sound is being transmitted, it is designated air-sound, water-sound, or solid-sound (Körper-Schall). A tone is defined as a sinusoidal sound vibration, and a tone-mixture as a combination of different tones of unrelated pitches. The word "Klang," which is defined as a compound sound vibration, the individual tones of which are all exact multiples of a fundamental tone, is probably best translated by the word "note." A note-mixture is a combination of notes with independent fundamentals. Noise is defined as a sound consisting of a continuous tone-spectrum or of one made up of a large number of separate tones of various unrelated pitches. "Knall," a short sound impulse of great intensity, is equivalent to our "report" or "bang." We have no word exactly equivalent to "Lärm," which is defined as any sound which disturbs or interferes with a desired sound reception. Sound-power is defined as mechanical power in the form of sound; the strength or intensity of the sound as the mean value with respect to time of the energy flux density; the density of sound as the mean value with respect to time of the volume density of the sound energy. Loudness is not very helpfully defined as the strength of the sound sensation, but this subject is dealt with in detail in another Report to which we shall refer later.

In defining the sound pressure as either

* *Elektrotechniche Zeitschrift*, pp. 114, 138, 1932.

the instantaneous or the maximum or the root mean square value of the alternating pressure produced by the sound vibration, it is pointed out that this is the pressure in the wave itself and not the pressure on a surface which the sound wave strikes, although the term was formerly sometimes used in this way as being analogous to the pressure of light. To avoid any confusion between the velocity of propagation of the sound wave and what we would call the particle velocity, the German Committee has suggested a new word for the latter, *viz.*, Schallschnelle, which might be translated, " sound quickness or rapidity." Like the pressure and the displacement, it can be given as an instantaneous, as a maximum, or as a root mean square value.

Sound Resistance and Sound Hardness.

The definition of audibility as the acoustic relations in a room is very vague and might mean anything or nothing. For reverberation time the Committee has adopted Sabine's convention of the time required for the sound-density to fall to a millionth of its initial value.

In addition to the usual reflection, absorption and transmission coefficients, the Germans have introduced a term, " Schluckgrad," to denote the ratio of the energy which does not return to the total which falls on the surface, *i.e.*, it embraces both the absorbed and the transmitted energies.

In defining sound resistance as the ratio of the pressure to the velocity of the particles of the medium, and sound hardness as the ratio of the pressure to the displacement of the particles, it is pointed out that these may be complex quantities.

Receivers and Microphones.

Two types of sound receivers are defined, the velocity type, the hardness of which is equal to that of the surrounding medium, and the pressure type, the hardness of which is very great compared with that of the surrounding medium. Two types of microphones are also defined, *viz.*, the displacement microphone and the velocity microphone ; in the former the E.M.F. produced by the sound is proportional to the displacement of the vibrating element of the microphone, whilst in the latter it is proportional to its velocity.

The Report on the unit of loudness deals with a difficult subject. Like the candle-power of a lamp, the loudness of a sound is a physiological sensation, and as in the one case the human eye must be the ultimate judge, so in the other the human ear must be called in to say when two sounds are of equal loudness. The candle-power of a lamp is determined by subjective comparison with a standard lamp, and similarly the loudness of a sound must be determined by comparison with a standard source of sound. As the standard source the Report suggests a plane wave of pure sine form at a frequency of 1,000, which strikes the observer directly from the front, but acts only on one ear, the other ear being closed. In a plane wave the relations between pressure, displacement and power are simple. The frequency of 1,000 has been chosen because it lies at about the middle of the audible range. Experiment has shown that accurate results can readily be obtained by facing the source and using only one ear.

A New Standard of Loudness.

Having decided to measure loudness by subjective comparison with a standard, the results must then be expressed in terms of some physical constant of the standard, and the constant or unit chosen is the radiated power N per unit of area. Since the intensities with which the ear has to deal cover an enormous range (a ratio of about $10^{12} : 1$) the logarithm of the ratio is employed and the Report recommends the adoption of the American system, in which the common logarithm is used, in preference to the system based on the natural logarithm which has been largely used in Europe. It is recommended that the name " Phon " be given to what the Americans usually call a " Decibel," so that if N_1 and N_2 designate the intensities of two sounds (radiated power per unit of area) their difference of loudness will be equal to $10 \log_{10} N_1/N_2$ phons. One phon is about the smallest detectable difference of loudness, so that no decimal parts of a phon will occur. The whole range from the faintest sounds to painfully loud noises will be covered by 130 phons, and by arbitrarily fixing the 70 phon level to correspond to a root-mean-square sound pressure of 1 dyne per square centimetre, the zero of the phon scale corresponds very closely to the threshold of audibility. If P_{70} is the pressure corresponding to a loudness of 70 phons and P_0 that corresponding to a loudness of 0 phons and N_{70} and N_0 the corresponding intensities, then

$$10 \log N_{70}/N_0 \text{ or } 20 \log P_{70}/P_0$$

gives the difference in phons between the two loudnesses which is 70. Hence

$$P_{70}/P_0 = 10^{3.5} = 3160$$

and since P_{70} has been taken as 1 dyne per sq. cm., P_0 must be 1/3160 dyne per sq. cm., which agrees closely with the best determinations of the threshold pressure.

It is very desirable to obtain international agreement on the name of a unit which is certain to be employed in ever-increasing measure with the development of acoustic engineering. The name " Decibel " has been used to such an extent in America and in this country that it is hardly likely to be replaced by the name " Phon." It is very satisfactory, however, to note that the German Committee have definitely adopted the common logarithm system in preference to the other system with its somewhat awkward " neper." If the unit is the same the name by which it is called is a relatively unimportant matter so long as neither name is applied to anything else by the other side.

It should be specially noticed, however, that, whereas the decibel has only been used as a measure of the difference in loudness between two sounds, the phon can be used as a measure of the loudness of a single sound. The decibel could, of course, be used in the same way if one adopted the same convention with regard to the intensity to be taken as zero.

G.W.O.H.

" BROADCASTING HOUSE."

FOR the first time in its history the British Broadcasting Corporation now occupies a building specially constructed for broadcasting. In principle, the new headquarters in Portland Place, London, is a building within a building, the administrative offices being arranged round the outside of a large central tower, built of brick to minimise transmission of sound within the structure which contains the studios. There are three floors below and eight above street level.

The upper photograph gives a gallery view of the concert studio—the largest in this country—accommodating 750 persons. The control room, seen on the left, exemplifies the latest in broadcasting technique. Standby equipment is provided, while switching enables the chain of transmissions from studios to land-lines to be established with a minimum of delay.

A Valve Voltmeter Method of Harmonic Analysis.*

By W. Greenwood, B.Sc., D.I.C., A.C.G.I., A.M.I.E.E.

(Research Department, British Broadcasting Corporation.)

THE valve voltmeter method described in this article has been developed primarily for measuring the amount of harmonics produced by audio-frequency transformers. It has also been found useful for measuring the harmonics introduced by valves in audio-frequency amplifiers, and for analysing the wave-form of the output of tone sources. It has many other applications where the harmonic analysis of complex low-frequency oscillations is desired, and it has been used for the measurement of distortion introduced by radio-frequency broadcasting transmitters. Harmonics whose strength is as low as 0.1 % of the fundamental can be measured with sufficient accuracy for most purposes, and harmonics of greater strength can be measured with an accuracy of a few per cent. The apparatus can also be used for the measurement of very small voltages.

Principle of the Method.

The general principle is the same as that of a method described by C. G. Suits in *Proc. I.R.E.* for January, 1930. The complex wave-form to be analysed, together with the output from a tone source, is applied to the grid of a valve whose static characteristic follows a square law over the range employed. The only impedance in the anode circuit is that of a meter which reads the anode current, hence static conditions apply. The frequency of the tone source is adjusted until it is almost equal to that of the harmonic to be measured, thereby causing the needle of the meter in the anode circuit to oscillate slowly at the difference frequency. The amplitude of swing of the needle in milliamperes is then proportional to the amplitude of the harmonic. By adjusting the frequency of the tone source to be almost equal to that of the fundamental of the complex wave-form, the amplitude of the swing of the needle in milliamperes gives a measure of the amplitude of the fundamental. Hence the ratio of harmonic to fundamental is given by the ratio of the amplitude of the swing of the needle in the two cases, provided the output of the tone source is constant at the two frequencies. If actual voltages instead of ratios are required, these can be determined if the static characteristic is known.

The method has been considerably improved by using two identical valves with their grids in push-pull and their anodes in parallel, thereby overcoming a number of disadvantages present in the original arrangement employed by Suits, and extending considerably the possible applications of the method.

Theory of the Method.

On the assumption that the relation between change in anode current i and change in grid volts e of a valve is quadratic within the limits used, then $i = a_1 e + a_2 e^2$ where a_1 and a_2 are determined by the valve characteristic.

If the input voltage e is composed of the local oscillation $E_0 \cos \phi_0$ and the complex oscillation to be analysed, *viz.*,

$$E_1 \cos \phi_1 + E_2 \cos \phi_2 + \ldots$$

where $\phi_2 = 2\phi_1$ etc.,

$$\text{then } i = a_1(E_0 \cos \phi_0 + E_1 \cos \phi_1 + E_2 \cos \phi_2 + \ldots) + a_2(E_0 \cos \phi_0 + E_1 \cos \phi_1 + E_2 \cos \phi_2 + \ldots)^2$$

If this be expanded it will be found to contain terms in which

$$\omega t = \phi_0, \phi_1, \phi_2 \ldots (\phi_0 + \phi_1), (\phi_1 + \phi_2), \ldots$$

etc., but if ϕ_0 is made almost equal to ϕ_1, ϕ_2, ϕ_3, etc., in succession, then the only very low frequency component of i in each case will be $a_2 E_0 E_1 \cos \theta$, $a_2 E_0 E_2 \cos \theta$, $a_2 E_0 E_3 \cos \theta$, etc., respectively, where θ is

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

the beat frequency $(\phi_0 - \phi_1)$, $(\phi_0 - \phi_2)$, etc. The needle of the instrument will not respond to the higher frequencies. Hence the total amplitude I_b of the swing of the needle of the meter in the anode circuit

$= 2a_2E_0E_1$ for the fundamental.

$2a_2E_0E_2$,, second harmonic.

$2a_2E_0E_3$,, third harmonic.

etc.

The coefficient 2 takes into account the maximum positive and negative values of $\cos\theta$. Thus the peak amplitude of any harmonic

$$E_n = \frac{I_b}{2a_2E_0}$$

If E_0 is kept constant for all frequencies then the ratio of any harmonic to the fundamental is simply the ratio of the beat amplitude in each case, since a_2 is constant.

If absolute values are required they can be determined provided a_2 and E_0 are known. E_0 can be obtained by measuring the steady change in anode current obtained when the sine wave whose amplitude is E_0 is applied alone to the grid, *i.e.*, from the calibration as a voltmeter. The change in the current is given by the formula

$$\delta i = \frac{a_2}{2} \cdot E_0^2 = a_2E^2_{R.M.S.}$$

a_2 can be determined from the R.M.S. calibration or from the static characteristic. By plotting the square root of the static anode current in milliamperes against grid volts the slope of the curve gives $\sqrt{\text{m.a.}}$ per volt, and the square of this gives a_2 = milliamperes per volt squared. The static characteristic plotted in this way must be a straight line for a square law relation between grid volts and anode current. If the relation is not quite square law the coefficient a_3 (milliamperes per volt^3) can be found similarly by plotting the cube root of anode current against grid volts and cubing the slope of the curve.

If the local oscillator contains harmonics there is a possibility of obtaining beat notes between them and those of the complex oscillations to be analysed. Provided, however, that the local oscillator does not contain more than a few per cent of harmonics, the error can be shown by calculation to be negligible.

If the static characteristic be not entirely quadratic within the limits used, so that a term a_3e^3 appear in the equation to the characteristic, it can easily be shown that

$$I_b = 2a_2E_0E_2 + \frac{3a_3}{2}E_0E_1^2$$

when the second harmonic is being measured. Thus a spurious term $\frac{3}{2}a_3E_0E_1^2$ is introduced, but this can be made negligible by keeping E_1 small. This is not always convenient, however, as it reduces the sensitivity of the instrument by reducing E_2 at the same time. The difficulty is overcome by using two valves in push-pull, the voltage applied

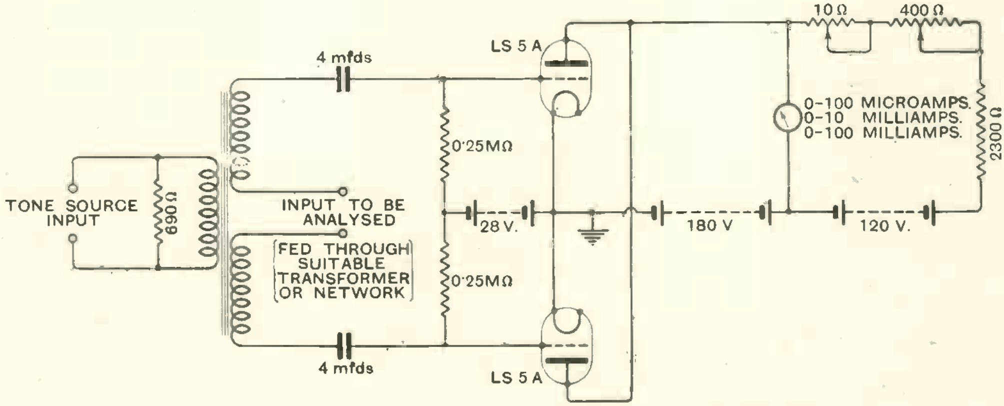


Fig. 1.—*Circuit diagram of harmonic analyser omitting switching arrangements.*

to one valve being

$$e = E_0 \cos \phi_0 + E_1 \cos \phi_1 + E_2 \cos \phi_2 + \ldots \text{ etc.}$$

and that applied to the other being

$$-e = -E_0 \cos \phi_0 - E_1 \cos \phi_1 - E_2 \cos \phi_2 - \ldots \text{ etc.}$$

The first valve gives a change in anode current of $a_1e + a_2e^2 + a_2e^3$ and the second gives a change of $-a_1e + a_2e^2 - a_3e^3$. If these changes flow through a common anode circuit the total change in current $= 2a_2e^2$, the changes due to the terms a_1e and a_3e^3 cancelling out.

Thus the possibility of error due to the term a_3e^3 is eliminated, and at the same time currents of the fundamental frequency are prevented from flowing through a D.C. meter connected in the common anode circuit.

General Arrangement of Apparatus.

A simplified circuit diagram of the apparatus in its final form is shown in Fig. 1. For accurate measurements it is important that the two grids of the push-pull valves should have exactly equal voltages applied to them. The input circuits have therefore been arranged symmetrically, and as the filaments are at earth potential there should be no other earth on the input circuit unless it is central. The tone source is fed through a screened transformer with the secondary in two halves. The complex input to be analysed is applied between the two halves of the secondary, either direct or through a screened transformer, depending upon the nature of the source from which the complex input is supplied. It is of course important that these transformers should introduce no amplitude or frequency distortion. The resistance of the grid leaks is sufficiently high to make the volts dropped across the secondary of the tone source transformer negligible, and to give a reasonably high input impedance. Grid blocking condensers are fitted to prevent discharging of the grid bias battery in the event of an earth on the input circuit. Switching arrangements are also provided so that the voltages of the various inputs as well as the standing feed to the valves can be measured on the anode current meter to ensure that correct conditions obtain. The anode current meter is provided with shunts to give ranges of 0–100 microamperes, 0–10 milliamperes, 0–100 milliamperes.

The standing current through the anode current meter is balanced out so that the beat amplitude can be read on the microammeter

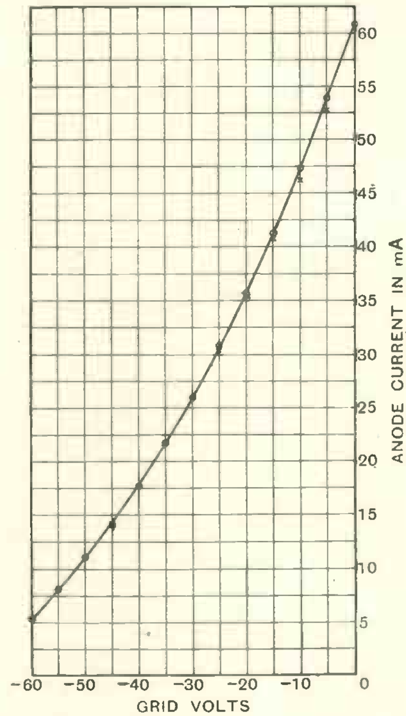


Fig. 2.—*Characteristics of LS5A valves, filament volts* 5.01, *anode volts* 202. *No.* 1 *valve shown* o, *No.* 2 *valve shown x.*

range to measure very weak harmonics, the fundamental being read on the 0–10 milliampere range. The 0–100 mA. range is used to check the standing feed.

By using the push-pull arrangement, currents of the fundamental frequency do not flow through the meter ; this is of considerable value when dealing with very low frequencies, as otherwise special filters would be necessary to prevent these low-frequency currents flowing through the meter and causing the needle to respond to them. These filters are difficult to arrange satisfactorily, particularly if the apparatus is to be suitable for a wide range of frequencies.

Valves.

No difficulty was experienced in finding valves whose grid-volts-anode current static characteristics follow a square law over an appreciable range. The valves actually adopted are LS5A's working on 180 volts, the standing current of about 55 mA. being balanced out by a separate 120-volt battery applied through a high resistance. Typical static characteristics of these valves are shown in Fig. 2, and it is seen in Fig. 3 that by plotting the square root of the anode current against grid volts a straight line is obtained for grid volts 0 to — 60, showing that the grid-volts-anode current curve is square law over this range. Thus with a steady bias of 30 volts a total input of 30 volts peak can be applied to each valve without exceeding the square law limits. Valves of greater sensitivity can be used, but LS5A's have been adopted on account of their wide square law limits and reliability.

For the majority of measurements it has been found most convenient to work with a total grid input to both valves of about 25 volts R.M.S. from the tone source. Possible errors are, however, introduced as already indicated, and are dealt with below.

Sources of Error.

If the equation representing the grid-volts-anode current characteristic contains a third order term as well as the square law term, a spurious second harmonic may be produced due to this if one valve only is used as already shown. As, however, the value of this is proportional to the square of the fundamental of the unknown source, it can be made negligible by keeping the input from the unknown source small when measuring the second harmonic, which is not always desirable when the latter is small. This difficulty, as we have seen, is overcome by using the push-pull arrangement. If, however, a fourth order term is present in the characteristic curve, a spurious third harmonic is produced in each valve, and these add together in the push-pull arrangement. In practical cases, however, no trace of this has been found.

It can be shown mathematically that no errors are produced by harmonics present in the tone source provided they are not greater than a few per cent. Suitable tone sources for this purpose are by no means difficult to make. When making measurements care must be taken to keep the beat frequency sufficiently below the natural frequency of the needle movement to prevent over-swinging of the needle and inaccurate readings.

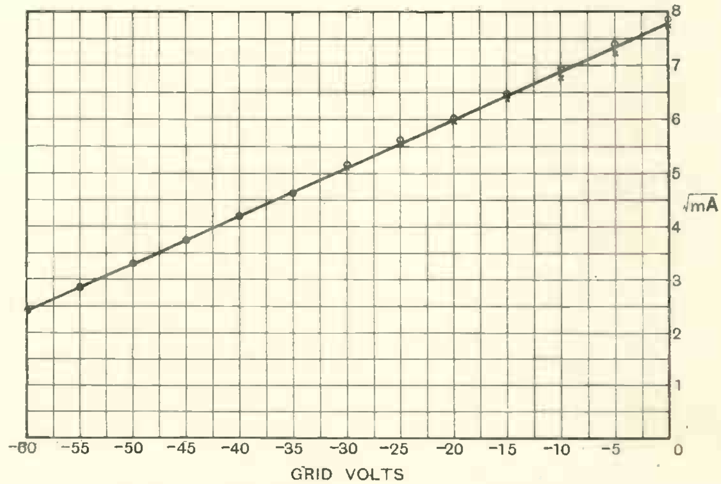


Fig. 3.—*Characteristics of LS5A valves, filament volts* 5.01, *anode volts* 202. *No.* 1 *valve shown* o, *No.* 2 *valve shown* x.

Conclusion.

The apparatus in its experimental form has been in use for over a year, and early measurements made with it agree remarkably well with those obtained after a year's working, and with the measurements made with the apparatus in its latest form.

Thanks are due to Mr. R. C. Patrick who has contributed very largely to the development of the apparatus.

Capacitive Output Coupling.*

By L. G. A. Sims, Ph.D., A.M.I.E.E.

IN amplification at acoustic frequency, using thermionic valves, it is customary to employ a coupling between the output valve and the acoustic load, as well as between the voltage amplifying stages of the amplifier. This coupling serves both as a matching device, whereby the effective load may be adjusted to a suitable multiple or sub-multiple of the impedance of the valve itself and as a means of isolating the steady component of the valve current from the load circuit. Both effects improve the efficiency of the output stage, while the isolation of the steady plate current from the windings of such load devices as loud speakers and telephones is frequently an incidental advantage.

The coupling may be a double-wound iron-cored transformer of suitable ratio or a tapped inductance and condenser. The general arrangement of these is illustrated in Figs. 1 and 2. The present paper is concerned with the value of the condenser C of Fig. 2, but it should be noted that, when C is very large, the circuit of Fig. 2 becomes electrically similar to that of Fig. 1.

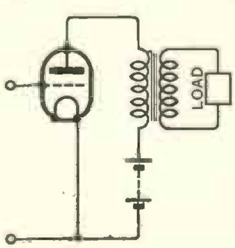


Fig. 1.

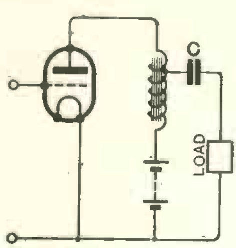


Fig. 2.

In order that the coupling shown in Fig. 2 may feed out only alternating current, it is necessary to insert the condenser C in series with the load. It is usual to regard the presence of this condenser as a disadvantage, upon the ground that it increases the impedance of the load branch, and so reduces therein the current and power, particularly at the lower acoustic frequencies. For this reason the capacity is usually made large in order that no appreciable loss may result. A value of 2 microfarads is very commonly employed.

The following notes show that, under certain conditions which obtain in practice, the condenser, so far from reducing the power output, may indeed increase it. Furthermore, it is shown that the large value of 2 microfarads may then be disadvantageous. The results appear to have practical importance, as they lead to an appreciable increase in the lower frequency power output of the stage under conditions which normally tend towards a reduction.

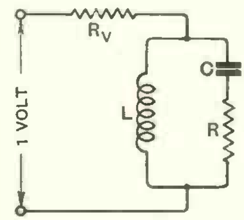


Fig. 3.

Considering Fig. 2, let the input to the valve grid be assumed to be such that 1 volt is passed to the anode circuit. As the voltage amplification factor of thermionic valves is constant with change of frequency, the effective driving voltage of the stage will be constant under all the conditions which follow. The equivalent circuit of Fig. 2 may then be as shown in Fig. 3.

R_v = Internal resistance of the valve.

L = Effective inductance in henrys of the coupling inductance with the steady component of valve current flowing in the winding.

C = Capacity of coupling condenser in farads.

R = Load impedance.

ω = $2\pi \times$ frequency.

V = Voltage developed across the load.

For the purpose of the preliminary analysis, it is advantageous to consider the load branch as connected across the whole inductance, and the load impedance as an ohmic resistance. Practical departures from the assumed conditions do not affect the general

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

conclusions, and can best be dealt with later.

The following analysis then applies :—

Current in R_v

$$= \frac{R + j\left(\omega L - \frac{1}{\omega C}\right)}{R_v\left[R + j\left(\omega L - \frac{1}{\omega C}\right)\right] + j\omega L\left(R - \frac{j}{\omega C}\right)}$$

Voltage developed across R_v

$$= \frac{R_v\left[R + j\left(\omega L - \frac{1}{\omega C}\right)\right]}{R_v\left[R + j\left(\omega L - \frac{1}{\omega C}\right)\right] + j\omega L\left(R - \frac{j}{\omega C}\right)}$$

Voltage developed across load

$$= \left[\frac{R}{R - \frac{j}{\omega C}}\right]\left[1 - \frac{R_v\left[R + j\left(\omega L - \frac{1}{\omega C}\right)\right]}{R_v\left[R + j\left(\omega L - \frac{1}{\omega C}\right) + j\omega L\left(R - \frac{j}{\omega C}\right)\right.}\right]$$

$$\text{or } V = \frac{j\omega LR}{R_v\left[R + j\left(\omega L - \frac{1}{\omega C}\right)\right] + j\omega L\left(R - \frac{j}{\omega C}\right)}$$

$$\text{or } V = \frac{j\omega L}{\left(R_v + \frac{L}{CR}\right) + j\left(\omega L\frac{R_v + R}{R} - \frac{R_v}{\omega CR}\right)} \qquad (1)$$

In scalar form this becomes

$$V = \frac{\omega L}{\left[\left(R_v + \frac{L}{CR}\right)^2 + \left(\omega L\frac{R_v + R}{R} - \frac{R_v}{\omega CR}\right)^2\right]^{\frac{1}{2}}} \qquad (1a)$$

The power delivered to the load is then

$$P = \frac{1}{R}\left[\frac{\omega^2 L^2}{\left(R_v + \frac{L}{CR}\right)^2 + \left(\omega L\frac{R_v + R}{R} - \frac{R_v}{\omega CR}\right)^2}\right] \qquad (2)$$

When C is very large, the power delivered to the load will tend towards the value given below :—

$$P = \frac{1}{R}\left[\frac{\omega^2 L^2}{R_v^2 + \left(\omega L\frac{R_v + R}{R}\right)^2}\right] \quad \dots \quad \dots \quad (2a)$$

This expression is therefore incidentally correct for a double-wound transformer of ratio unity, free from leakage reactance and winding resistance and having, on open circuit, a primary inductance of L henrys. (*See* Fig. 1.)

Re-arrangement of (1*a*) gives

$$V = \frac{\omega LR}{\left[\left(RR_v + \frac{L}{C}\right)^2 + \left\{\omega L(R + R_v) - \frac{R_v}{\omega C}\right\}^2\right]^{\frac{1}{2}}}$$

Writing $RR_v = A$, $(R + R_v) = B$, gives

$$V = \frac{\omega LR}{\left[A^2 + 2\frac{AL}{C} + \frac{L^2}{C^2} + \omega^2 L^2 B^2 - \frac{2LBR_v}{C} + \frac{R_v^2}{\omega^2 C^2}\right]^{\frac{1}{2}}}$$

Differentiation with respect to ω and substitution of $[d]$ for the denominator expression yields

$$\frac{dv}{d\omega} = \frac{[d]^{\frac{1}{2}}LR - \omega LR[d]^{-\frac{1}{2}}\left[\omega L^2 B^2 - \frac{R_v^2}{\omega^3 C^2}\right]}{[d]}$$

Whence maximum power in the load will occur at that frequency which makes

$$[d]^{\frac{1}{2}} = [d]^{-\frac{1}{2}}\left[\omega^2 L^2 B^2 - \frac{R_v^2}{\omega^2 C^2}\right]$$

$$\text{or} \qquad [d] = \omega^2 L^2 B^2 - \frac{R_v^2}{\omega^2 C^2}$$

Whence, by insertion of the component terms of $[d]$, we have

$$\omega = \left[\frac{2R_v^2}{2LBR_vC - (A^2C^2 + 2ALC + L^2)}\right]^{\frac{1}{2}}$$

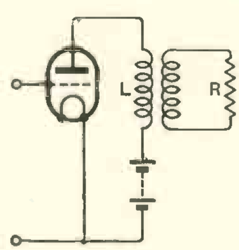


Fig. 4.

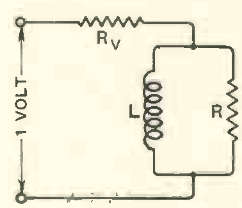


Fig. 5.

Substitution for A and B and simplification yield

$$\omega = \left[\frac{1}{C\left(L - \frac{R^2 C}{2}\right) - \frac{L^2}{2R_v^2}}\right]^{\frac{1}{2}} \quad \dots \quad \dots \quad (3)$$

This is the value of ω at which the power delivered to the load will reach an optimum value.

Inspection of the equation shows that, under certain conditions, ω may pass from a real to an imaginary value. These conditions occur when the magnitudes of the quantities are such as to make

$$2R_v^2C\left(L - \frac{R^2C}{2}\right) \gtreqless L^2.$$

It is scarcely possible by mere contemplation of these limiting conditions to say more than that both real and imaginary values of ω will occur in practice. In (3) all the four quantities must be regarded as variables, and it is necessary to plot the complete function for a range of values of each of these variables. The labour involved in this might become prohibitive unless limits to the range of two or more of them were fixed from practical considerations. This can be accomplished for R_v and L, and for the relations $\left(\frac{L}{R_v}\right)$ and $\frac{R_v}{R}$. We shall now proceed to show in a general way how such limits may be fixed.

The range of values of R_v may be taken as 1,000 ohms to 100,000 ohms, approximately. The lower limit applies to triode output valves and the upper limit to pentode valves.

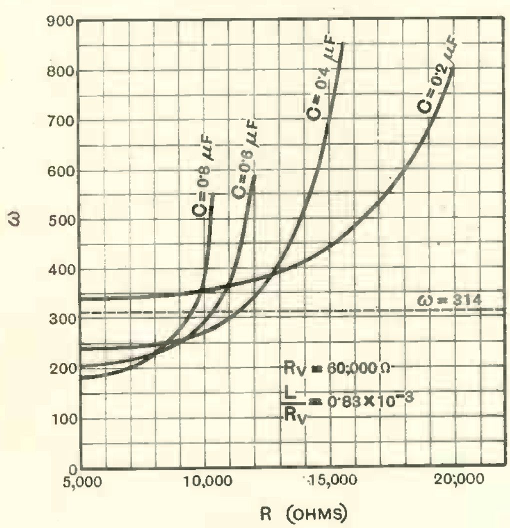


Fig. 6.—*Curves plotted from equation* 3.

Practical considerations fix an approximate upper limit of 100 henrys for L. This is, at least, certainly of the correct order.

It is desirable to correlate R_v and L approximately. For this, equation (1a) can be employed.

When C is very large this may be written

$$V = \frac{\omega L}{\left[R_v^2 + \left(\omega L \frac{R_v + R}{R}\right)^2\right]^{\frac{1}{2}}} \quad \ldots \quad \ldots \quad (4)$$

This is the voltage which would be developed across a resistance load of value R ohms, coupled to a valve of internal resistance R_v ohms by a loss-free coupling of primary (open circuit) inductance L henrys, independent of capacity. The circuit for this case is shown in Fig. 4, and the equivalent circuit in Fig. 5.

It is clear that the power developed in the load for this case will fall as the frequency becomes low due to the decreasing reactance of the inductance L. A practical limit to the extent to which this might be allowed to occur may reasonably be placed at a value which would be audible. Such a value is 3 Transmission Units. Furthermore, it can be seen from inspection of Fig. 5 that the voltage across R will approach, but cannot exceed, an upper limit given by

$$V = \frac{R}{R_v + R} \quad \ldots \quad \ldots \quad (5)$$

Combining (4) and (5), and inserting the condition that a 3 decibel loss may occur at some chosen lower value of ω, we have

$$*\log_{10} . R^2\left[\frac{R_v^2 + \left(\omega L \frac{R_v + R}{R}\right)^2}{\omega^2 L^2 (R_v + R)^2}\right] = 0.3,$$

or

$$\frac{R^2\left[R_v^2 + \left(\omega L \frac{R_v + R}{R}\right)^2\right]}{\omega^2 L^2 (R_v + R)^2} = 2 \text{ very nearly,}$$

whence

$$R^2 R_v^2 + \omega^2 L^2 (R_v + R)^2 = 2\omega^2 L^2 (R_v + R)^2$$

* For acoustic purposes, powers are compared upon a logarithmic basis. Thus any two powers P_1 and P_2, are said to differ by x Transmission Units or decibels, when

$$\left[10 . \log_{10} . \frac{P_2}{P_1}\right] = x.$$

If P_2 is greater than P_1 the acoustic gain in stepping from P_1 to P_2 is x decibels. Conversely, this will be the loss if the step is in the opposite direction and x will then be written as a negative quantity.

or $$L = \frac{RR_v}{\omega(R + R_v)} \quad \cdots \quad (6)^*$$

The lower value of ω, which is usually employed, is that corresponding to 50 cycles per second, namely, $\omega = 314$.

For triode valves it is usual to take the optimum matching condition $R = 2R_v$, the reasons for which are well known. In the case of pentode valves, this cannot be done on account of the bad wave-form distortion and high anode peak voltages which result. This effect was first pointed out by the author in a paper published in the *Wireless World and Radio Review*,† and it is now customary to take $R \doteq 0.2R_v$ with this type of valve.

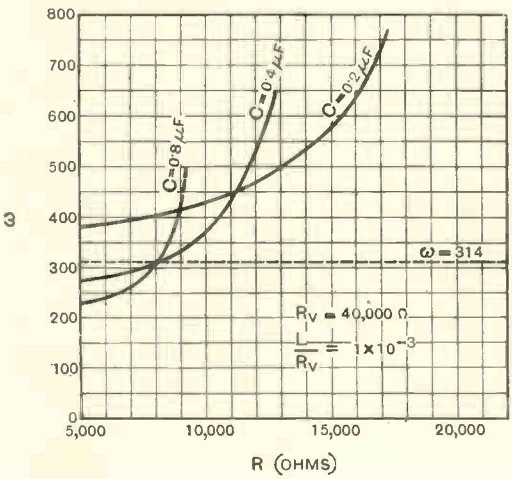


Fig. 7.—*Curves plotted from equation* 3.

Inserting these conditions in equation (6) enables practical limits to be determined for the ratio $\frac{L}{R_v}$.

For example, for a triode of 2,000 Ω internal resistance, we have

$$L = \frac{2R_v^2}{314 \times 3R_v} = \frac{8 \times 10^6}{1.884 \times 10^6}$$

$$= 4.25 \text{ henrys, whence } \frac{L}{R_v} = 2.13 \times 10^{-3}$$

Again, for a pentode of 60,000 Ω internal resistance, we have

$$L = \frac{0.2\, R_v^2}{314 \times 1.2\, R_v} = \frac{0.2 \times 36 \times 10^8}{2.26 \times 10^7}$$

$$= 32 \text{ henrys, whence } \frac{L}{R_v} = 0.53 \times 10^{-2}.$$

Thus rational values for the ratio L/R_v can be derived. It may be well to reiterate and comment on the basis upon which the derivation rests before proceeding to employ it. The value of L was obtained for different valve resistances upon the following reasonable assumptions :—

(1) The load resistance is matched to that of the valve according to the conventions employed in present practice for triode and pentode output valves.

(2) The reactance of L at 50 cycles per second may affect the output network not more than to cause a 3 decibel drop of power in the load resistance, at that frequency.

(3) The coupling condenser is large enough for its effect upon the calculations of (2) above to be unimportant.

Of these assumptions (1) will probably not be questioned : (2) gives a rational method of fixing lower limits for L and though practical experience may suggest slightly higher values in given cases, the differences will not be great : (3) is a necessary preliminary assumption because present practice is to employ values of C sufficiently large as not appreciably to affect the load

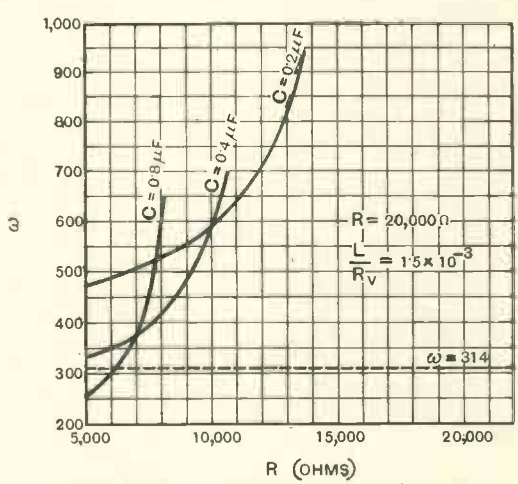


Fig. 8.—*Curves plotted from equation* 3.

* When R is small compared with R_v this may be written approximately

$$L = \frac{R}{\omega}$$

This result is helpful in pentode calculations where R_v is not known.

† "The Pentode and Power Amplification," *Wireless World*, Vol. XXIV, No. 3, p. 60, 1929.

current ; also because it is the object of the paper to investigate the effects produced in output circuits as the value of C is reduced. This will be accomplished by plotting curves from equation (3) which is an equation relating all the circuit constants with the frequency for optimum power conditions, and has been made possible by limiting the number of cases to those only which are practical.

Reverting to equation (3), families of curves can now be plotted showing the

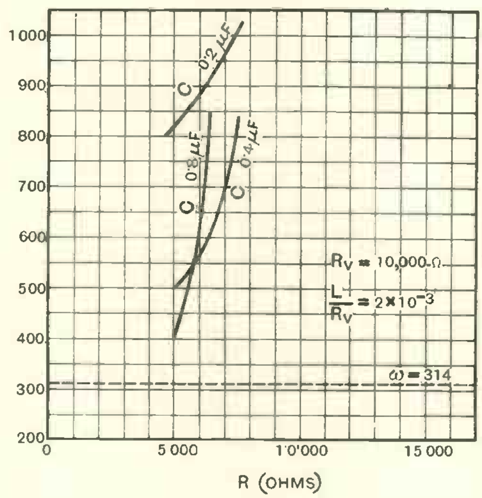


Fig. 9.—*Curves plotted from equation* 3.

ranges over which, in practice, ω will have real values. These are shown in Figs. 6, 7, 8 and 9, where four families have been plotted for four typical values of L/R_v with R as variable. Each family includes curves for several values of C. All the curves are discontinued at the point when the approach of imaginary values is imminent.

Comparison of Figs. 6 and 9 shows clearly that ω tends towards an imaginary value rapidly as R_v is reduced from 60,000 ohms to 10,000 ohms.

Inspection of the curves in any of the families shows that ω becomes imaginary as the load resistance approaches the value of the internal resistance of the valve to which it is coupled.

These results are of rather remarkable interest as they both mean that real values of ω can, in practice, only occur with pentode valves. The low internal resistance of the triode in conjunction with the ratio which

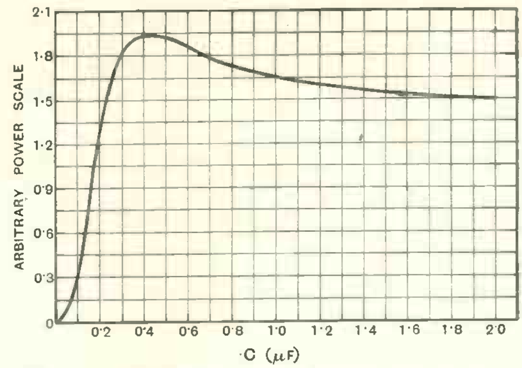


Fig. 10.—*Calculated curve for pentode* (R_t = 50,000 Ω) *choke coupled to load* (R = 10,000 Ω). *Variation of power with change of capacity.*

this bears to the load resistance when matched according to the usual convention, lead to imaginary values of ω. With the pentode valve, on the other hand, the conditions shown, for example, in Fig. 6, are both typical of common practical conditions and favourable to a real and stable value of ω. Moreover, they permit of a reasonable latitude in the values of C and R in the region $\omega = 314$ (50 cycles per second). This can only be interpreted as meaning that a suitable choice of coupling capacity will assist the low frequency power response of the pentode output valve—a result which is of practical value. In addition, the value of capacity required is very much smaller than the 2 microfarads usually employed.

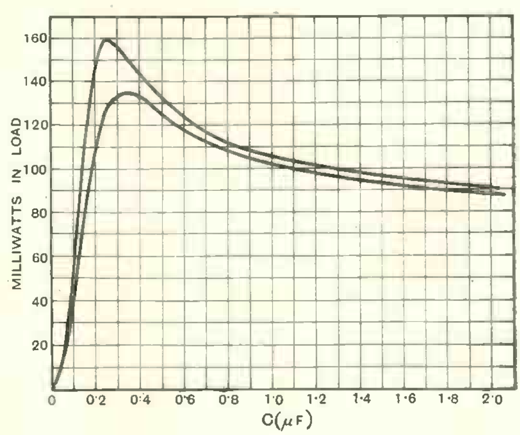


Fig. 11.—*Pentode* (R = 55,000 Ω) *choke coupled to* 10,000 Ω *resistance load. Variation of power to load with change of coupling c* (f = 50∼). *Experimental curves for two values of inductance.*

Fig. 10 shows a calculated curve of power with change of capacity. The small value of inductance assumed in this case results in a rather modest increase in power at the critical value of capacity. In Fig. 11 are shown two measured curves for different values of inductance. Fig. 12 demonstrates in a striking manner the improvement which actually results in the power response curve of a pentode output stage when the critical value of capacity is employed. The curves shown here are experimental curves obtained upon a commercial coupling unit consisting of an iron-cored choke and a 2-microfarad coupling condenser.

The reduction of this capacity to the critical value of 0.26 μF. lead to an almost

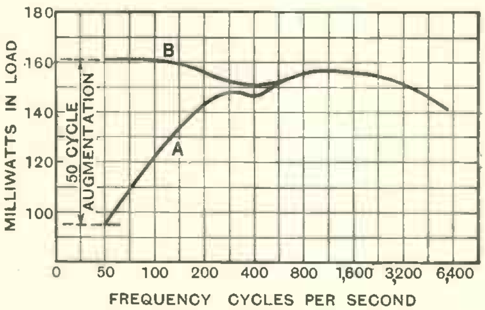


Fig. 12.—*Response curve of commercial coupling unit and* 10,000 Ω *load with* 55,000 Ω *pentode. A, as designed, viz., with* 2.0 μ*F. condenser. B, with coupling C reduced to* 0.26 μ*F.*

complete compensation of the response curve down to 50 cycles per second.

Numerous other curves confirming the theory have been obtained by calculation and experiment, but it is not considered necessary to show more than those above.

An extension of the analysis to cover other cases will probably be dealt with in a future paper.

Finally, a simple explanation for the result may be indicated. If reference is made to Fig. 3 it will be seen that the parallel circuit L, C, R is capable of resonance and then becomes the well-known "rejector" circuit of impedance given by $Z = \left(\frac{L}{C.R}\right)$ ohms, where C is in farads. This impedance may be very much greater than that possessed by the circuit when not resonant.

Suppose the valve resistance is very high, as in the case of the pentode, and that the load resistance R is comparatively low. Most of the available voltage will be lost in R_v under non-resonant conditions. But as resonance is approached, the L, C, R circuit may gain in impedance sufficiently to cause a large transfer of voltage with some increase of power in R. Inspection of the expression for the resonant impedance of this circuit shows that a low value of R will favour this condition.

Thus, at low frequencies, when the waning reactance of L normally causes increasing loss in R_v and falling power in the load R, resonance may restore the power level. This is most likely to occur if R_v is great and R comparatively small. The mathematical analysis shows that the effect actually occurs in the pentode output circuit if an appropriate value of C is chosen.

Correspondence.

Valve Resistance in Oscillation Generators.

To the Editor, The Wireless Engineer.

SIR,—In my article on Valve Oscillators in your March issue I do not think sufficient stress was laid on reduction of the negative resistance by an auxiliary positive resistance (inductionless) as described on p. 134, method C. Since reduction in ρ is the key to oscillation at very high frequencies, this method might be useful. If the oscillation is confined to the linear position of the characteristic, the problem can be treated analytically. I have not tested the resistance method of reducing ρ_e at very high frequencies. I think, however, it would be of general interest if someone with the necessary apparatus conducted a series of experiments and published the results. The influence of reduced ρ_e on frequency must not be overlooked. Near the critical condition expression (6) holds provided $\rho_e = (\rho - r)$ is substituted for ρ, unless of course r has a capacity effect.

In my letter on "optimum coil mass" in the same issue the first item in column 2 was centimated! It should read 22 gm. Also $\sqrt{k}$ vanished from the denominator of the constant A in expression (2).

London. N. W. McLachlan.
March 3rd, 1932.

Developments in the Testing of Radio Receivers.

We regret that, due to an error, the remarks made by Mr. W. D. Oliphant at the I.E.E. Discussion published last month, were attributed to Mr. W. B. Morrison.

The Analysis and Design of a Chain of Resonant Circuits.

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

Part II.

WHEN designing a system such as is shown in Fig. 1 it is necessary to adjust the value of M so that a compromise is effected between its overall amplification and selectivity. In a previous article by the author* it was shown that this can be done quite easily in the case of a system consisting of two coupled circuits; but when the methods given in that article are applied to a system consisting of 3 links, it is found that certain difficulties are encountered. In the case of the article quoted, the value of the coupling which gives maximum secondary current is obtained by equating dZ_{12}/dM to zero and solving the resulting equation, the impedances concerned being calculated at resonance. When this method is applied to equation (19) it is seen that

$$\frac{d}{dM}(Z_{13}) = \frac{2Z^3}{\omega^2 M^3}$$

thus giving no optimum value for M.

Reference to equation (21) of Prof. Mallett's paper† will show that this condition holds for all cases where the number of links is odd.

From equation (30) we have that

$$\frac{dZ_{14}}{dM} = j\left(\omega - \frac{3Z^2}{\omega M^2} - \frac{3Z^4}{\omega^3 M^4}\right) \quad \cdots \quad (59)$$

which gives an optimum value for M.

Equation (22) of Prof. Mallett's paper shows that, in general, a system consisting of an even number of links will have an optimum value for M.

We are, therefore, obliged to treat these two cases differently.

The reason for the difference between chains with two and three links will perhaps be seen more clearly from the following:—

In the case of two links the resonant frequency $f_0 = \frac{1}{2\pi\sqrt{LC}}$, for all couplings greater than the critical value, coincides with a trough on the resonance curve, whereas, in the case of three links, Fig. 4 shows that resonance always occurs on a crest of the curve. In the former case it is therefore possible, by reducing the coupling and thus moving from a trough to a crest, to obtain an optimum value for M at the point of inflexion. In the latter case resonance always occurs on a crest; therefore there is no optimum value for the coupling, and the only value which may be regarded as corresponding to the optimum value obtained for two links is the value of M at which the multiple "humps" commence. Fig. 10 illustrates this point.

We can therefore deduce, as a general conclusion, that in the case of an even

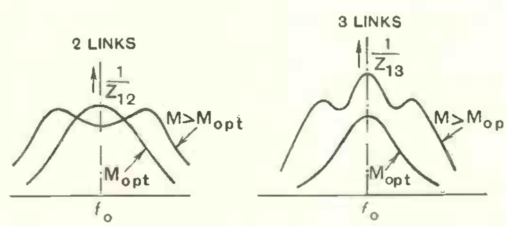


Fig. 10.

number of links we are able to use, as one factor in design, the value of M which gives maximum amplification at resonance, and in the case of an odd number of links we can utilise, as a practical working figure, the value of M at which the multiple "humps" first commence.

The design of the three systems will now be considered in detail. The following symbols will be employed:—

$\kappa_{opt.}$ = optimum value of the coupling factor.

κ = any given value of the coupling factor.

* "The Design of High Frequency Transformers." *Wireless Engineer*, July, 1931.

† *J.I.E.E.*, Sept., 1928, p. 972.

$A \quad = \dfrac{\kappa}{\kappa_{\text{opt.}}}$

$d \quad = \dfrac{R}{\omega_0 L}$ where $\omega_0 = \dfrac{1}{LC}$

V_n = voltage across the condenser of the final link.

$N = V_n/E$ = amplification.

$N_{\text{res.}}$ = value of N at the resonance frequency for any given value of κ.

$N_{\text{max.}}$ = value of $N_{\text{res.}}$ when the coupling has the optimum value.

$T_N = \dfrac{N_{\text{res.}}}{N}$ = selectivity. Where $N_{\text{res.}}$ and N are both obtained for the same value of κ, and N is calculated when the system is distuned by about 10 per cent.

$T_{\text{max.}}$ = Value of the selectivity obtained when the coupling has been adjusted to give a maximum value for T_N.

$T \quad = \dfrac{T_N}{T_{\text{max.}}}$ = selectivity factor.

1. Two Links.

This system has already been treated in a previous article,* but for the sake of completeness the results will be summarised here.

$$\kappa_{\text{opt.}} = d \qquad \ldots \quad (60)$$

$$N_{\text{max.}} = \frac{1}{2d} \qquad \ldots \quad (61)$$

$$N_{\text{res.}} = \frac{A}{(1 + A^2)} \cdot \frac{1}{d} \qquad \ldots \quad (62)$$

$$\frac{N_{\text{res.}}}{N_{\text{max.}}} = \frac{2A}{1 + A^2} \qquad \ldots \quad (63)$$

$$T_N = \frac{1}{(A^2 + 1)d^2} \frac{(1 - \omega_1^2/\omega_0^2)^2}{\omega_1^2/\omega_0^2} \qquad \ldots \quad (64)$$

$$T_{\text{max.}} = \frac{1}{d^2} \frac{(1 - \omega_1^2/\omega_0^2)^2}{\omega_1^2/\omega_0^2} \qquad \ldots \quad (65)$$

$$T = \frac{T_N}{T_{\text{max.}}} = \frac{1}{1 + A^2} \qquad \ldots \quad (66)$$

If the system is not distuned by more than 10 per cent., then we can assume, without great error, that $(\omega_0 - \omega_1)$ can be neglected when compared with ω_0. In the above, ω_0 corresponds to the frequency of the received signal, and ω_1 corresponds to the frequency to which the system is tuned.

If we put $(\omega_0 - \omega_1) = \triangle\omega$,

then $\omega_0 + \omega_1 = 2\omega_0 - \triangle\omega \approx 2\omega_0$

since $\omega_0 >> \triangle\omega$.

Equation (65) may be written

$$T_{\text{max.}} = \frac{1}{d^2} \frac{\{(\omega_0 - \omega_1)(\omega_0 + \omega_1)\}^2}{\omega_0^2 \omega_1^2} = \frac{1}{d^2} \frac{4(\triangle\omega)^2}{\omega_1^2}$$

Now $\omega_1 = \omega_0 - \triangle\omega$,

hence with the assumption that

$$\omega_0 >> \triangle\omega$$

we can replace, without appreciable error, ω_1^2 by ω_0^2.

Hence $T_{\text{max.}} = \dfrac{1}{d^2}\left(\dfrac{2\triangle\omega}{\omega_0}\right)^2$

$$\text{If we now put } z = \left(\frac{2\triangle\omega}{\omega_0}\right) \qquad \ldots \quad (67)$$

$$\text{Then } T_{\text{max.}} = (z/d)^2 \qquad \ldots \quad (68)$$

2. Three Links.

In this case we are concerned with the value of the coupling at which the multiple peaks just commence.

From equation (25) we have that this value is given by

$$s = \frac{R^2}{\omega_0^2 M_{\text{opt.}}^2} = \frac{1}{6}$$

We assume that $M_{\text{opt.}}$ can be regarded as an optimum value.

Now $M_{\text{opt.}}^2 = \kappa_{\text{opt.}}^2 L^2$

Hence $\dfrac{R^2}{\omega_0^2 L^2} = \dfrac{\kappa_{\text{opt.}}^2}{6}$

$$\text{or} \quad \kappa_{\text{opt.}} = d\sqrt{6} = 2.45d \qquad \ldots \quad (69)$$

We have that

$$\frac{1}{N} = \frac{E}{V_3} = \frac{j\omega CE}{I_3} = j\omega C Z_{13}$$

If we put $Z = p + jq$ in equation (19), then we obtain

$$\frac{1}{N} = -j\omega C\left[2p + \frac{p}{\omega^2 M^2}(p^2 - 3q^2) + jq\left\{2 + \frac{1}{\omega^2 M^2}(3p^2 - q^2)\right\}\right] \quad \ldots \quad (691)$$

* *Loc. Cit.*

at resonance $q = 0$, therefore

$$\left|\frac{1}{N_{res.}}\right| = \omega_0 C\left(2p + \frac{p^3}{\omega_0^2 M^2}\right)$$

$$= \frac{R}{\omega_0 L}\left(2 + \frac{R^2}{\omega_0^2 \kappa^2 L^2}\right) \text{since } \omega_0^2 = \frac{1}{LC}$$

$$= d\left(2 + \frac{d^2}{\kappa^2}\right)$$

Therefore $$|N_{res.}| = \frac{1}{d\left(2 + \frac{d^2}{\kappa^2}\right)}$$

Now $\kappa^2 = A^2 \kappa^2_{opt.} = 6\,A^2 d^2$

Hence $$|N_{res.}| = \frac{6A^2}{d(12A^2 + 1)} \quad .. \quad (70)$$

The maximum value of $N_{res.}$ for the single peak resonance curve, is obtained when the coupling has the optimum value, *i.e.*, when $A = 1$, therefore

$$|N_{max.}| = \frac{6}{13d} \quad .. \quad .. \quad .. \quad (71)$$

Hence $$\left|\frac{N_{res.}}{N_{max.}}\right| = \frac{13A^2}{(12A^2 + 1)} = \frac{13}{\left(12 + \frac{1}{A^2}\right)} \quad (72)$$

To determine the selectivity, it is assumed that we are concerned with the value of the ratio of the amplification at resonance and the value of the amplification when the system has been distuned by a certain amount. This amount is assumed to be of the order of about 10 per cent., so that it is reasonable to regard the value of the resistance of each link as small compared with the value of its reactance. It can also be assumed, without appreciable error, that we can neglect $(\omega - \omega_0)$ when compared with ω_0. Put $\omega - \omega_0 = \triangle\,\omega$, then

$$q = \omega L - \frac{1}{\omega C} = \omega L\left(1 - \frac{\omega_0^2}{\omega^2}\right)$$

$$= \frac{\omega L}{\omega^2}(\omega - \omega_0)(\omega + \omega_0) = 2L\triangle\omega \quad .. \quad (73)$$

First, assuming that $q >> p$, we obtain from equation (69a), that

$$\left|\frac{1}{N}\right| = \omega C q\left(\frac{q^2}{\omega^2 M^2} - 2\right)$$

Assuming $\omega_0 >> \triangle\omega$, and putting

$$q = 2L\,\triangle\omega$$

we obtain

$$\left|\frac{1}{N}\right| = 2LC\omega_0\triangle\omega\left\{\frac{4L^2}{M^2}\cdot\left(\frac{\triangle\omega}{\omega_0}\right)^2 - 2\right\}$$

after replacing ω by ω_0 as before

$$= 2\left(\frac{\triangle\omega}{\omega_0}\right)\left\{\frac{4}{\kappa^2}\left(\frac{\triangle\omega}{\omega_0}\right)^2 - 2\right\}$$

since $\omega_0^2 = \frac{1}{LC}$ and $M = \kappa L$

$$= z\left\{\left(\frac{y}{\kappa}\right)^2 - 2\right\}$$

after substituting from equation (67).

Equation (69) shows that κ is small, therefore we can assume that $\left(\frac{z}{\kappa}\right)^2 >> 2$.

Hence $$\left|\frac{1}{N}\right| = \frac{z^3}{\kappa^2} = \frac{z^3}{A^2\kappa^2_{opt.}} = \frac{z^3}{6A^2d^2}$$

or $$|N| = \frac{6A^2d^2}{z^3}$$

From equation (70), we have therefore that

$$T_N = \left|\frac{N_{res.}}{N}\right| = \frac{z^3}{d^3(12A^2 + 1)} \quad .. \quad (74)$$

This is a maximum when $A = 0$, hence

$$T_{max.} = \frac{z^3}{d^3} = \left(\frac{z}{d}\right)^3 \quad .. \quad (75)$$

and $$T = \frac{T_N}{T_{max.}} = \frac{1}{12A^2 + 1} \quad .. \quad (76)$$

Fig. 11 shows curves plotted for $\frac{N_{res.}}{N_{max.}}$ and $\frac{T_N}{T_{max.}}$, respectively, for different values of A. From these curves it is seen that, if a reasonable value of selectivity is required, we must be prepared to lose a fair amount of amplification. The curves indicate that it would not be good practice for the value of A to exceed 0.25. Also Fig. 5 shows that this value of A gives a resonance curve which does not contain more than one peak.

3. Four Links.

In this case we can obtain an optimum value for M at resonance. This value is given by equation (56) as

$$s_0 = \frac{R^2}{\omega_0^2 M^2_{opt.}} = 0.264$$

Therefore $$\kappa_{opt.} = 1.95\frac{R}{\omega_0 L} = 1.95d \quad .. \quad (77)$$

If V_4 is the voltage across the condenser of the last link, then

$$\frac{1}{N} = \frac{E}{V_4} = j\omega C Z_{14}$$

$$= -\omega^2 CM\left\{1 + \frac{Z^2}{\omega^2 M^2}\left(3 + \frac{Z^2}{\omega^2 M^2}\right)\right\}$$

From equation (30)

putting $Z = p + jq$, the equation reduces to

$$\frac{1}{N} = -\omega^2 CM\left[1 + \frac{(p+jq)^2}{\omega^2 M^2}\left\{3 + \frac{(p+jq)^2}{\omega^2 M^2}\right\}\right] \quad \ldots (78)$$

At resonance $q = 0$

Therefore

$$\frac{1}{N_{\text{res.}}} = -\omega_0^2 CM\left\{1 + \frac{p^2}{\omega_0^2 M^2}\left(3 + \frac{p^2}{\omega_0^2 M^2}\right)\right\}$$

or

$$\left|\frac{1}{N_{\text{res.}}}\right| = \kappa\left\{1 + \frac{R^2}{\omega_0^2 L^2 \kappa^2}\left(3 + \frac{R^2}{\omega_0^2 L^2 \kappa^2}\right)\right\}$$

$$= \kappa\left\{1 + \frac{d^2}{\kappa^2}\left(3 + \frac{d^2}{\kappa^2}\right)\right\}$$

Therefore

$$|N_{\text{res.}}| = \frac{1}{\kappa\left\{1 + \frac{d^2}{\kappa^2}\left(3 + \frac{d^2}{\kappa^2}\right)\right\}}$$

Now $\kappa = A\kappa_{\text{opt.}} = 1.95\, dA$

Therefore $|N_{\text{res.}}| =$

$$\frac{1}{1.95 dA\left\{1 + \frac{1}{3.8A^2}\left(3 + \frac{1}{3.8A^2}\right)\right\}} \quad \ldots (79)$$

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

$$|N_{\text{max.}}| = \frac{1}{1.95d\left\{1 + \frac{1}{3.8}\left(3 + \frac{1}{3.8}\right)\right\}}$$

$$= \frac{1}{3.63d} \quad \ldots \ldots (80)$$

Therefore

$$\left|\frac{N_{\text{res.}}}{N_{\text{max.}}}\right| = \frac{1.86}{A\left(1 + \frac{0.79}{A^2} + \frac{0.07}{A^4}\right)} \quad (81)$$

To determine the selectivity, we assume as before, that $q >> p$, that $\omega - \omega_0 = \triangle\omega$, and that we can neglect $\triangle\omega$ when compared with ω_0.

After replacing ω^2 by ω_0^2, we obtain from equation (78) that

$$\frac{1}{N} = -\omega_0^2 CM\left\{1 - \frac{q^2}{\omega_0^2 M^2}\left(3 - \frac{q^2}{\omega_0^2 M^2}\right)\right\}$$

From equation (73) we have that $q = 2L\triangle\omega$, therefore

$$\frac{1}{N} = -\kappa\left[1 - \frac{4}{\kappa^2}\left(\frac{\triangle\omega}{\omega_0}\right)^2\left\{3 - \frac{4}{\kappa^2}\left(\frac{\triangle\omega}{\omega_0}\right)^2\right\}\right]$$

$$= -\kappa\left\{1 - 3\left(\frac{z}{\kappa}\right)^2 - \left(\frac{z}{\kappa}\right)^4\right\} \text{where } z = \frac{2\triangle\omega}{\omega_0}$$

$$= \kappa\left(\frac{z}{\kappa}\right)^2\left\{3 + \left(\frac{z}{\kappa}\right)^2\right\}$$

Therefore $\left|\frac{1}{N}\right| = \kappa\left(\frac{z}{\kappa}\right)^4$

after assuming that $\left(\frac{z}{\kappa}\right)^2 >> 3$

Therefore $|N| = \frac{7.4A^3}{d}\left(\frac{d}{z}\right)^4$

and $T_N = \left|\frac{N_{\text{res.}}}{N}\right|$

$$= \frac{1}{14.4A^4\left\{1 + \frac{1}{3.8A^2}\left(3 + \frac{1}{3.8A^2}\right)\right\}} \cdot \left(\frac{z}{d}\right)^4 \quad \ldots (82)$$

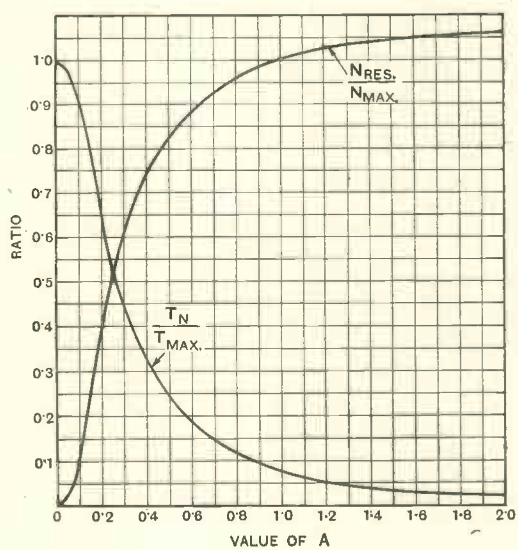


Fig. 11.

It is seen that T_N is a maximum when $A = 0$.

Hence $T_{\text{max.}} = \left(\frac{z}{d}\right)^4 \quad \ldots (83)$

and $T = \frac{T_N}{T_{max.}}$

$$= \frac{1}{14.4A^4\left\{1 + \frac{1}{3.8A^2}\left(3 + \frac{1}{3.8A^2}\right)\right\}}$$

$$= \frac{1}{14.4A^4\left(1 + \frac{0.79}{A^2} + \frac{0.07}{A^4}\right)} \quad .. \quad (84)$$

Fig. 12 gives the curves corresponding to Fig. 11 for four links. It is seen from these curves that in this case the selectivity falls off even more rapidly as the value of A is increased.

The curves indicate that in practice A should not exceed 0.2, if full advantage is to be taken of the selectivity offered by the use of 4 links. Fig. 9 shows that such a value for A would give a resonance curve consisting of one peak only.

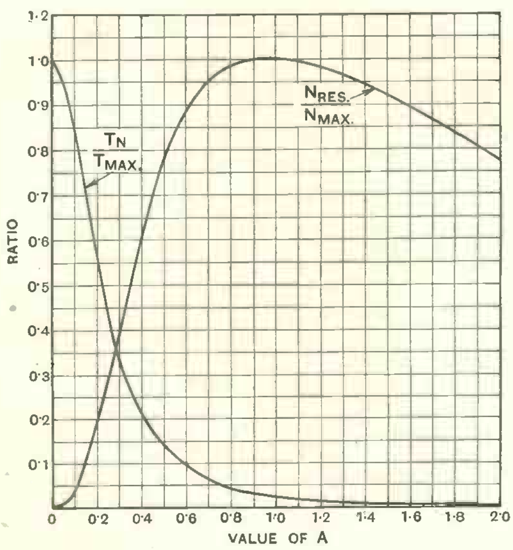


Fig. 12.

The corresponding curves for two links have already been given in a previous article.*

4. Choice of the Number of Links.

The number of links to be used in a given system depends on the degree of selectivity required. The choice can be determined very simply by a method which has been developed by Dr. W. Runge.† From equations (68), (75), and (83) it is seen that providing certain assumptions can be made about the magnitude of $\frac{z}{d}$, the maximum value of the selectivity factor for a system

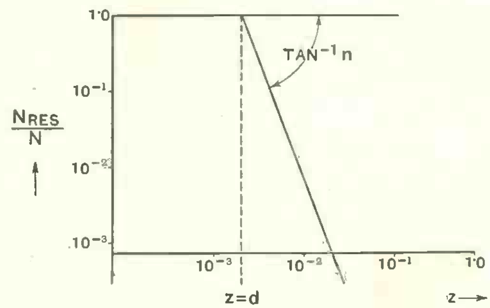


Fig. 13.

consisting of n links, is given by

$$T_n = \left|\frac{N_{res.}}{N}\right| = \left(\frac{z}{d}\right)^n$$

Therefore $\log T_n = n(\log z - \log d)$ (85)

When $\left|\frac{N_{res.}}{N}\right| = 1$ then $\log T_n = 0$

Therefore $\log z = \log d$ .. .. (86)

If we plot T_n against z on a logarithmic scale, we shall, therefore, obtain the curve shown in Fig. 13.

As we approach resonance, *i.e.*, $z \to 0$, then the assumptions made with reference to the magnitude of $\frac{z}{d}$ are no longer justified, and the actual resonance curve departs somewhat from the one shown in Fig. 13.

From Fig. 13 it is seen that, if the value of d is made the same for all the links, it is a simple matter to determine the value of n which will satisfy the required selectivity conditions. If the value of n does not exceed four, then the data given in this article can be used to complete the design. For values of n exceeding four, the methods of this article can be extended, after reference to Prof. Mallett's paper.

* *Loc. Cit.*

† *Telefunken Zeitung*, Oct., 1927, p. 55.

An Aperiodic Impedance Measuring Set.*

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

THE proposed method uses only two variable resistances, it gives the impedance in a form which is independent of the frequency, so that the frequency need be known only if a frequency characteristic is to be plotted. In any case, however, the accuracy of the measurement is not affected by the accuracy with which the frequency can be measured or is known. Also the magnitude and phase angle of the impedance are given without any irksome calculation. The only apparatus needed is two variable resistances and a valve voltmeter, such as the Moullin voltmeter, which most wireless experimenters either possess already or can construct without any difficulty. We avoid the use of a costly variable condenser standard. The voltmeter need not be calibrated at all. In fact, any valve detector will do. There are also certain advantages of operation which can be better discussed later, after the proposed method has been described.

Proposed New Method.

The essential circuit of the method is shown in Figs. 1*a* and 1*b*. Consider the circuit of Fig. 1*a*. The current from the oscillator passes through the resistance R_1 and the impedance Z in series. The valve voltmeter can be connected across either the resistance or the impedance by means of a simple switch S. The resistance R_1 can be varied. When the reading of the voltmeter is the same for both positions of the switch S, the magnitude of the impedance Z is given by

$$z = R_1 \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

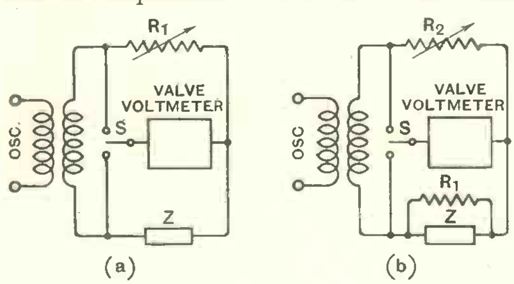


Fig. 1.

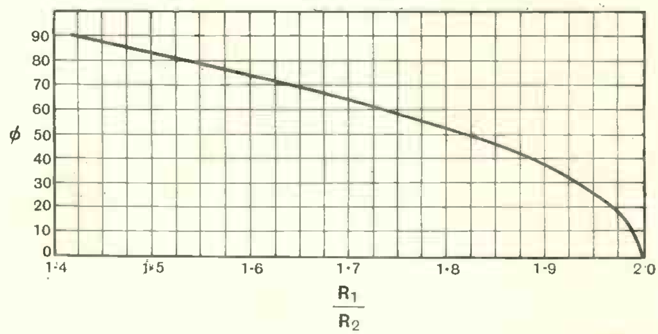


Fig. 2.

This is an extremely simple operation and the result needs no calculation whatever. Also it does not depend upon the calibration of the voltmeter. The resistance R_1 is then placed across the impedance Z, as shown in Fig. 1*b*, and the same operation is performed for the combination of R_1 and Z in parallel as was done before for Z alone. The resistance required for equal voltages is now R_2, say. It can then be shown that the phase angle of the impedance Z is given by ϕ where

$$\phi = \pm 2 \cos^{-1} \frac{(R_1)}{(2R_2)} \quad \ldots \quad \ldots \quad (2)$$

All that is necessary to find ϕ is to perform a simple division sum and then to look up trigonometrical tables. Even this can be avoided by plotting a curve of ϕ against (R_1/R_2), which is done in Fig. 2.

It will be seen that the sign of ϕ is not given. This can be found very simply in the following way. Suppose the first operation has been performed, so that we have the condition shown in Fig. 1*a*, when the voltmeter gives equal readings for both positions. Let then a large condenser, 1 or 2 μf, be placed across Z. If now the voltmeter

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

reads less on Z than it does on R_1, then Z has a capacitive reactance and ϕ is negative, whereas if the voltmeter reads more on Z than on R_1, Z has an inductive reactance and ϕ is positive. It is only necessary that the reactance of the condenser be small compared with the reactance of Z. The value of the condenser is immaterial so long as it satisfies this condition, which should be easily met.

The large condenser is then removed and the second operation is performed. This method of determining the sign of ϕ does not take any time, as it does not involve a balance, but merely a pair of observations. A proof of this method is given in Appendix I.

A Modification of the Method.

If the impedance varies with the current it carries, it is essential that the current passing through the impedance should be that when in ordinary use. This method of measurement possesses the advantage that this condition can be easily arranged. The arrangement to allow of this is shown in Fig. 3. In this case R_1 is that part of the resistance tapped off by T. The current is adjusted to the correct amount by varying R_0, which need not be known, and then measuring the voltage drop across the initial value of R_1. For this, one must have an approximate calibration of the voltmeter. The process is as follows. R_0 is varied until the current through R_0, R_1, and Z in series is of the right value, which is found by measuring the voltage drop across any convenient value of R_1, 1,000 ohms, say. For example, if the current through Z is to be 2mA, R_1 is adjusted to 1000 ohms and then R_0 is varied until the voltage drop across R_1 is 2 volts, as indicated by the voltmeter. R_0 is then kept constant and R_1 is varied for the first operation. R_1 is then placed across Z and R_2 takes its old place. R_0 is varied so that the current again assumes the value of 2mA *through* Z, and this is known by measuring the voltage drop across R_1 (now in parallel with Z), the voltage drop now being the desired current times R_1, not 1000 ohms. R_2 is then varied for the second operation. An error of 10% or even 20% will be permissible in the voltmeter readings, as the effect on the impedance will be small.

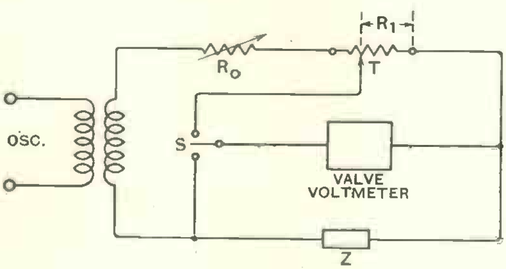


Fig. 3.

Some Operating Advantages.

It is sometimes required to obtain by quick inspection an idea of the successive maximum and minimum points on an impedance frequency curve. The maximum and minimum points are then chosen for more detailed measurements. The present method admits of a rapid inspection for such maxima and minima, since it is necessary to find only R_1, at each frequency. A suitable example for the method is finding the impedance-frequency characteristic of a loud speaker.

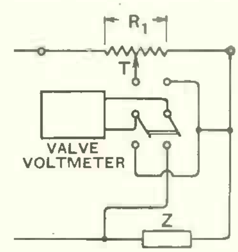


Fig. 3a.

Another point of importance is that the proposed method can be used almost in an unlimited range of frequencies, provided non-inductive resistances are used and self capacities are kept reasonably small.

In other methods, excessive condenser values must be used at low frequencies, for example near 50 cycles. At very high frequencies, such as are coming into common use in superheterodyne receivers, the condenser will have to take very small values, and the effect of the accuracy of the frequency will affect considerably the value of the reactance as calculated from the formula $(1/2\pi fC)$. The present method, however, avoids these inconveniences, as a good resistance can be made to read accurately over a very wide range of frequencies, provided the resistance is not so high that unavoidable shunting capacities will affect it materially.

Precautions to be Taken.

It is essential for accurate results that the oscillator should not contain large harmonics, especially of the even orders, otherwise an effect, known as " turn-over," will upset the accuracy of measurement. " Turn-over " is the name applied to the phenomena that, if a complex wave is applied to a rectifier, the rectified current may change when the leads supplying the wave to the rectifier are reversed. The reason for this is given in Appendix 2. In an actual case, the harmonics were purposely increased and an inaccuracy of 10 per cent. was obtained. On reducing the harmonics to their normal level, the accuracy was within 1 per cent., and better results could have been obtained with special arrangements. If the oscillator consists of an oscillating valve plus an amplifier, the best results will be obtained if the amplifier is supplied from the grid of the oscillating valve, and, if possible, a push-pull amplifier should be used. This will result in the reduction of the second and fourth harmonics, and in such a case the " turn-over " effect is rendered negligible. This is discussed in Appendix 2.

APPENDIX 1.

Proof of the Method.

A vectorial proof of the method is illustrated in Fig. 4. Let $OA = Z$ and $OB = R_1$, the angle

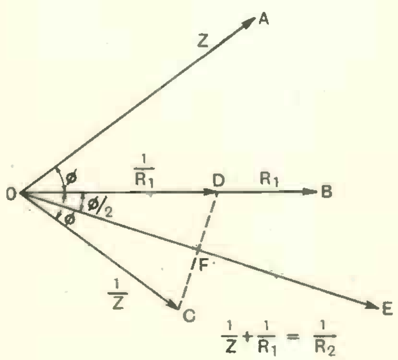


Fig. 4.

between them being ϕ. OC is the reciprocal of OA and represents the admittance $1/Z$. OD is $1/R_1$. When the first balance is achieved $OA = OB$, and hence $OC = OD$. R_1 is then placed across Z and so we have to add the admittances $1/Z$ and $1/R_1$, obtaining the admittance $(1/Z) + (1/R_1)$, shown by OE. By the second balance this is equal to $1/R_2$. Since $OC = OD$, the vector sum of OC and OD, which is OE, bisects the angle between OC and OD, and $OE = 2OF$, where F is the point of intersection of OE and CD. Therefore $OF = \frac{1}{2}(1/R_2)$, *i.e.*, $OF = 1/2R_2$.

Then $\cos(\phi/2) = OF/OD$

$$= (1/2R_2) \div (1/R_1) = (R_1/2R_2)$$

giving $\phi = 2\cos^{-1}(R_1/2R_2)$.

R_1 can be put in series with Z and then

$$\phi = 2\cos(R_2/2R_1).$$

This has the disadvantage that R_2 must have twice the range necessary in the shunt method.

APPENDIX 2.

The Effect of Harmonics in the Oscillator.

In an oscillating valve circuit of the tuned-anode type, the a.c. voltage on the grid is an almost pure wave of the fundamental frequency, although the anode voltage may contain a large proportion of harmonics. This is especially the case if a feed-back resistance is used. (See " A Single-valve Multi-frequency Generator," *The Wireless Engineer*, September, 1931.) If this voltage is then amplified by a balanced push-pull amplifier, the output of the amplifier will contain very small amounts of even harmonics, and fairly small odd harmonics.

Suppose the output of the amplifier is then applied to the impedance set and let the input to the detector be represented by

$$V = V_1 \sin \omega t + V_2 \sin(2\omega t + \theta_2) + V_3 \sin(3\omega t + \theta_3) \quad \ldots \quad (1)$$

Let the rectifier have the anode-current characteristic

$$i_a = f(V) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Expanding i_a by Maclaurin's theorem we get

$$i_a = f(0) + Vf'(0) + \tfrac{1}{2}V^2 f''(0) + \tfrac{1}{6}V^3 f'''(0) + \ldots \quad (3)$$

Substituting for V from equation (1) we see that the rectified current is

$$I_0 = f(0) + \tfrac{1}{2}a_2 f''(0) + \tfrac{1}{6}a_3 f'''(0) \quad \ldots \quad (4)$$

where $a_2 = \frac{1}{2}(V_1^2 + V_2^2 + V_3^2)$,

and

$$a_3 = \tfrac{3}{4}[V_1^2 V_2 \sin(-\theta_2) + 2V_1 V_2 V_3 \sin(\theta_2 - \theta_3)]$$

If the leads to the voltmeter are reversed the rectified current is

$$I_0' = f(0) + \tfrac{1}{2}a_2 f''(0) - \tfrac{1}{6}a_3 f'''(0) \quad \ldots \quad (4')$$

causing a difference in reading of

$$I_0 - I_0' = \tfrac{1}{3}a_3 f'''(0) \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

If there is no second harmonic, this vanishes. If $V_2 = 0$, the third harmonic does not cause " turn-over," but as soon as a second harmonic appears, the third harmonic contributes to the " turn-over " effect. The " turn-over " vanishes if the rectifier characteristic is parabolic, for then $f'''(0) = 0$. It is therefore clear that a second harmonic will cause an error, due to the " turn-over " effect, since, in the simple method of switching assumed in the diagrams, the voltages across R_1 and Z are applied in the opposite directions to the rectifier. Professor Howe has suggested the switching arrangement of Fig. 3*a*, which eliminates this error to a large extent.

Another error is caused for the following reason. The current through R_1 and Z is the same, but the voltage drops across R_1 and Z for harmonics are different, for R_1 is a constant resistance, whilst the impedance of Z varies with frequency. Even if the rectifier characteristic is purely parabolic so that "turn-over" is absent, the rectified current for the voltage drop across R and Z will be different if V_1 is the same for both, since V_2, V_3, etc., will be different for the two impedances, and the rectified current is given by

$$\tfrac{1}{2}(V_1^2 + V_2^2 + V_3^2 + \ldots)f''(0).$$

Two extreme cases make this clear. Suppose R_1 and Z have equal impedances at the fundamental frequency, but that Z is infinite at the second harmonic. Then V_1 will be the same for R_1 and Z, but V_2 will be zero across R_1 whilst its value across Z will be the full value of the second harmonic e.m.f. output of the generator. The result will be that the impedance at the fundamental frequency will be overestimated by the measurement. If, on the other hand, Z is zero at the second harmonic, V_2 across Z will be zero, and the impedance at the fundamental frequency will be underestimated. In the former case R_1 will give $z\left(1 + \frac{V_2^2}{V_1^2}\right)^{\frac{1}{2}}$, whereas in the latter case R_1 will give $z\left(1 + \frac{V_2^2}{V_1^2}\right)^{-\frac{1}{2}}$

It is clear from this that the maximum error that can be caused in this way by all harmonics is an error of $\pm \frac{1}{2}(V_h^2/V_1^2) \times 100\%$, where V_h^2 is the sum of the squares of the harmonics, *viz.*:

$$V_h^2 = V_2^2 + V_3^2 + V_4^2 + \ldots\ldots$$

In order that this error be less than 1%

$$\tfrac{1}{2}(V_h^2/V_1^2) \times 100 < 1,$$

i.e. $$(V_h^2/V_1^2) < \frac{2}{100},$$

or $$(V_h/V_1) < .141.$$

Thus the error will be within 1% if the total harmonic content of the oscillator is less than 14% of the fundamental. This is not a difficult requirement to meet. If the harmonic content of the oscillator is less than 5% the error is less than $\frac{1}{8}$%, resulting in an accuracy which is perhaps excessive.

NEW BOOKS.

Thermionic Vacuum Tubes and their Applications.

By Professor E. V. Appleton, M.A., D.Sc., F.R.S.

Pp. vii + 117 with 68 figures. Messrs. Methuen & Co., Ltd., London, 1932. Price 3s. net.

This small volume is a welcome addition to Messrs. Methuen's collection of Monographs on Physical Subjects. The author deals in characteristically lucid fashion with the internal action of diode and triode valves, deriving the space-charge equations for planar and cylindrical electrodes. The characteristic curves and their differentiates are then considered, and such topics as the effects of secondary emission and "soft" valves are briefly discussed. The main uses of the triode as amplifier, rectifier and oscillator are described, reference being made to various practical applications.

Owing to space limitations, many parts of the subject have necessarily had to be omitted, but a useful feature of the book is the copious supply of references which are conveniently given at the end of each chapter. In his preface the author disclaims any intention of covering a wider field than the behaviour of thermionic tubes in various typical physical and electrical applications.

The reviewer would suggest that, in a subsequent edition, the symbol m should not, as on p. 39, have two entirely different connotations within a few lines of each other. The further appropriation of the symbol μ to represent degree of modulation is also, perhaps, a little disconcerting to those who are accustomed to connect it with valve magnification. These are, of course, matters of opinion, though one cannot help feeling that it is unfortunate that more uniformity in the use of such symbols cannot be secured.

As a compendium of up-to-date information on valve "mechanics" this book can be cordially recommended to all wireless engineers.

First Principles of Television.

By A. Dinsdale, M.I.R.E.

The principles and practice of Television, with descriptions of typical systems and notes on the present state of the art in various countries. Pp. 241+xv, with 130 illustrations and diagrams and 38 full-page plates. Published by Chapman & Hall, Ltd., London. Price, 12s. 6d.

Physics in Sound Recording.

By A. Whitaker, M.A., F.Inst.P.

The 17th Lecture in the "Physics in Industry" series given before the Institute of Physics, November, 1931. A brief account of the various methods of recording and reproducing sound, including photographic recording and "Talkie" films. Pp. 24, with 12 illustrations and diagrams. Published by the Institute of Physics, London. Price, 1s. 2d., post free.

Les Unités Electriques.

By J. Sudria, with preface by M. A. Blondel.

A text-book for students giving the definitions of the various units and formulae required in electrical problems, with 11 typical examination questions and their solutions. Pp. 86. Published by Libraire Vuibert, Paris. Price, 10 francs.

The Recording and Reproducing of Sound.

By A. G. D. West, M.A., B.Sc.

A series of cantor lectures delivered before the Royal Society of Arts, March, 1931. Including the various methods of obtaining gramophone and phonograph records and their manufacture, reproducing apparatus, loud-speaker horns, measurements of sound, etc. Pp. 95 with 78 illustrations and diagrams. Issued by the Royal Society of Arts, London. Price, 3s.

Electro-Mechanical Rectification.*

A Moving-coil L.S. Phenomenon.

By N. W. McLachlan.

DURING the course of experiments with moving-coil loud speakers in 1928, a peculiar effect was observed with a freely suspended diaphragm having little axial constraint. As the frequency of the constant voltage oscillator applied to the L.S. amplifier was reduced, the amplitude of vibration of the diaphragm increased and a point was reached when it moved axially out of the magnet. An appreciable force had to be applied to restore the diaphragm to its original position in the magnet. On removal of this force, the diaphragm shot out again. Also the lower the frequency and the greater the current the farther the diaphragm came out. At this time (1928) an electro-mechanical rectifying action seemed rather mysterious.† However, some measurements of the distribution of gap flux along the axis of the magnet had been made previously and these suggested an explanation of the phenomenon. The gap distribution was published in the *Wireless World*, November 26th, 1930, and the rectification effected reported in the same issue. The axial flux distribution of a certain electro-magnet is given in Fig. 1. The outward axial motion of the coil is due to the variation in flux within and without the magnet.

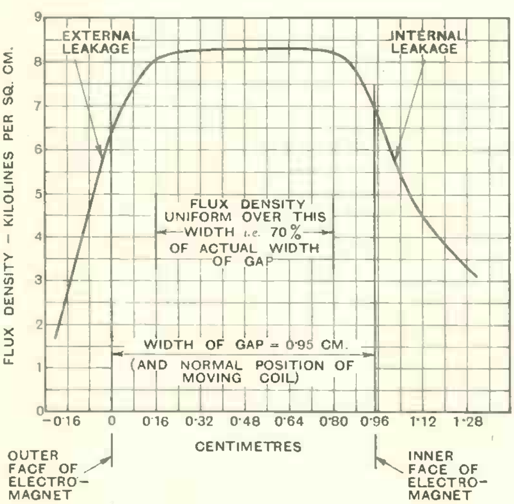


Fig. 1.—*Diagram showing axial distribution of flux in a moving-coil loud speaker magnet. The approximate linear decay outside the magnet should be noted.*

In explaining this result it is preferable to consider a simple hypothetical case. Fig. 2 represents a circular coil situated in a radial field whose strength varies linearly from the point O (*see* field distribution on left-hand side of Fig. 1). The coil is supplied with current from a source whose resistance is so high that neither the reactance of the coil nor the back e.m.f. due to its motion in the magnetic field have any appreciable influence. In other words, the phase of the current remains unaltered with reference to the driving e.m.f.

If A is the extreme position of the coil at any particular instant, it is convenient to consider the current to have its maximum value $I_{max.}$. This means that our initial conditions postulate zero motion, but maximum force on the coil in the direction X_1. Thereafter the coil moves with gradually increasing velocity but decreasing acceleration until B is reached, when the current and, therefore, the axial force is zero. At B the kinetic energy $\frac{1}{2} M_0V_0^2$ is a maximum and the coil proceeds on its way, reversed current meanwhile causing it to decelerate. It will ultimately stop when the work done upon it is equal to $\frac{1}{2} M_0V_0^2$. Since the field strength gradually decreases as the coil moves to the left past B, the velocity at C will not be zero when the current is $-I_{max.}$. Consequently the coil moves beyond C and comes to rest at D, when the current is $-I$, this being less than the maximum. The coil now starts on its return journey in the direction X_2 the current and field strength

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

† There is also electro-mechanical rectification in telephones and reed driven instruments. *See Wireless World*, p. 584, October 31st, 1928.

being smaller than those at A. The acceleration time period is now reduced to PQ, which is a fraction of RS. Obviously the coil cannot reach its initial position at A, and in the long run it experiences an axial displacement in the direction of the arrow

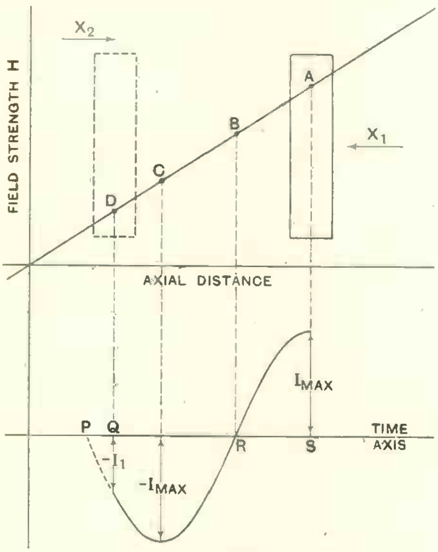


Fig. 2.—*Diagram illustrating rectification effect due to reaction between alternating current in circular coil and non-uniform radial magnet field.*

X_1. Hence, the effect can be described as electro-mechanical rectification.

In problems of this nature, it is usual to crystallise the explanation in an analytical expression. All one requires is a formula containing a unidirectional component (not necessarily constant in value) and a periodic component. The differential equations are very easy to construct but impossible to solve. For example, if we take the simplest case where a coil *alone* is driven by a sine wave source of extremely high resistance, the differential equation of motion is

$$mD^2x = Ax \sin wt$$

where m = mass of coil

D^2x = acceleration

$Ax \sin wt$ = force on coil.

Owing to the existence of x on the right-hand side, this equation defies solution unless one resorts to a multiplicity of pages of infinite series from which no physical explanation can readily be derived. The difficulty is that the acceleration of the coil is implied not only in point of time, but also in that of the displacement x. If these three factors were not interdependent, the problem could be solved by graphical integration of the acceleration and velocity curves.

The phenomenon can be demonstrated in an elegant fashion if the magnet is mounted with its axis vertical. A large diaphragm, *e.g.*, a disc or a flat cone is arranged to have a powerful radial mode at a certain frequency. Alternating current of this frequency is supplied to the coil. As the current is increased the amplitude of vibration is adequate to bring the coil into the leakage field outside the magnet. The coil rises accompanied by the flapping and noise (use stiff Whatman paper) of the diaphragm whilst executing its radial mode. Although the spectacle is reminiscent of a soaring bird or a helicopter, I have not yet applied for letters patent with the intention of inaugurating electroacoustic flight!

As a last word, we may consider the significance of this effect in the operation of loud speakers. The annular surround and the centring device impose adequate constraint which prevents the diaphragm disappearing into space when the bass drum is beaten or the pedal organ is played. Nevertheless, if these instruments are reproduced properly in a large room or in a cinema, the axial motion is adequate to introduce a unidirectional component—unless a specially long magnet is used. This is concomitant with the above form of rectification due to the decreasing strength of the magnetic field beyond the magnet. Also the unidirectional component drives the diaphragm to a position where the surround limits the axial motion outwards but not inwards, *i.e.*, another form of rectification. The effect is only evinced seriously when the axial amplitude is large, *i.e.*, at low frequencies,* although, of course, the amplitude at any frequency depends upon the output. However, this is obviously limited by heating of the moving coil. For ordinary household purposes the amplitude is usually inadequate to introduce serious alien frequencies.

* *See Phil. Mag.*, 11, 38 (1931), for amplitudes required to radiate 1 watt at various frequencies.

Studies in Radio Transmission.

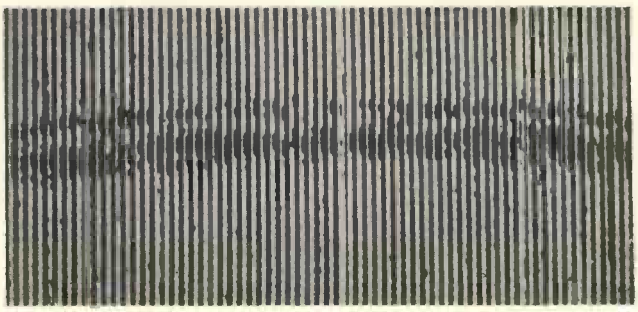
Paper by T. L. Eckersley, B.A., B.Sc., read before the Wireless Section, I.E.E., on 23rd March, 1932.

Abstract.

THE paper is a very lengthy one, dealing largely with determinations of layer height, density, recombination, etc., made on facsimile transmissions on long-distance channels and from measurements of received signal-strength made on similar routes.

Facsimile Measurements.

After discussing the facsimile method, the author refers to the now accepted existence of two layers, the upper of which was discovered by Prof. Appleton some years ago at heights of 200 to 350 km. The two regions are designated by the descriptions *E* for the region at about 100 km. and *F* for the upper region mentioned.



(1) *Montreal* (32 *m.*). 2045 *G.M.T.*, 10*th May*, 1921. *Scanning speed* 57.6 *in. per sec.*

The facsimile records disclose in general a series of 1, 2, 3, 4 or more separated marks corresponding to the arrival, by different paths, of a single transmitted impulse. Examples are shown in Plates 1 and 3. The differences of time can be measured with considerable accuracy, and ray angles, effective height and maximum electronic density can be calculated. The analysis is based on the theorem that the time taken by a pulse projected along a ray at an angle of elevation θ to traverse the actual paths *TP′ QS′* . . . . *R* (see Fig. 3)* is equal to the time taken by light to traverse the equivalent path *TYQS* . . . . *R*, and is

$$\frac{d}{c\cos\theta} \quad \cdots \quad \cdots \quad (1)$$

where $TR = d$.

The difference in time of any two echoes, or "echo spread" as we may call it, is

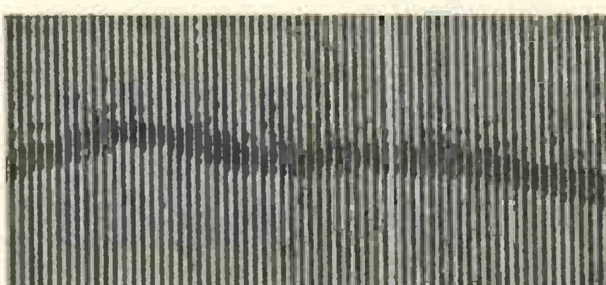
$$\tau_{12} = \frac{d}{c}\left(\frac{1}{\cos\theta_2} - \frac{1}{\cos\theta_1}\right) \quad \cdots \quad \cdots \quad (2)$$

where θ_1 and θ_2 are the corresponding angles of projection of the two rays. τ_{12} is measured. It is the time separation between any two echoes of the record. d being known, it is possible to find $1/(\cos\theta_2) - 1/(\cos\theta_1)$.

Results for the New York-Somerton route provide most material for the estimation of equivalent heights, values shown by the author ranging from 286 to 359 km. Other echo times taken during daytime conditions contribute towards a determination of the complete diurnal curve of N, the electronic density. The values are represented in Fig. 7. This result seems to indicate considerable secular reduction in densities as between 1928 and 1931. This is in accordance with other radio observations, in particular those which indicate that a longer wave is necessary for a given night communication in 1931 than that required in 1928.

Scattering is shown in many of the records, and is particularly intense on 60 m. after sunset. The scattered signal lasts in certain cases for 20 milliseconds after the original signal has arrived, implying an increase of path of the scattered signal of 6,000 km. in extreme cases. The average scatter is of the order of 10 to 12, milliseconds representing a scattering source from 1,500 to 2,000 km. distant. Results on 120 metres are similar in most respects to those on 60 m. except that there is no measurable echo in the daytime and very little sign of scattering.

Discussing results as to the constitution of the two regions of ionisation, the author concludes that in the case of the *F* region densities fall off in a regular manner from sunset to dawn. On the assumption that the reduction is due to the recombination of the electrons with atoms of one species, the relation between $1/N$ and t should be a linear one. This is confirmed by the results. After sunset the density behaves as if the ionising agent were removed and the layer settles down towards equilibrium by recombination. No deter-



(3) *South Africa* (16 *m.*). 0920 *G.M.T.*, 2*nd June*, 1931. *Scanning speed* 57.6 *in. per sec.*

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

mination is attempted of the layer gradients or distribution of N in the layer. Measured values of effective height are not sufficiently accurate. With waves of 45 to 100 m., the effective heights appear to cluster round the value of 210 to 220 km., while with shorter waves of 22–30 m., the measurements cluster round values of 300 to 340 km. This is suggested as akin to the abrupt change at 100 m. or so from the E to the F layers and suggests the possibility of three layers.

Evidence with respect to the E layer is very confused. It appears definite that in the daytime this lower layer is so attenuating and probably so dense that no 120 m. ray survives the passage through it to the upper layer and down again. There is evidence, however, that some energy is reflected from the E layer and produces fading and interference. With regard to the ionising agent, Milne's theory of corpuscular emission from the sun fits well into existing hypotheses.

Signal Measurement.

In the second part of the paper, the material discussed consists of a continuous series of measurements made between October 1930 and October 1931, the measurements being made at Chelmsford. It is stated that signal intensity may vary from 10 to 1 or more during the few minutes required for measurement. The choice of a representative figure is thus to some extent arbitrary. The stations measured were as far as possible those with well-defined c.w. carriers.

From these results, taken in conjunction with the facsimile results, it is concluded that each one of the sheaf of rays transmitted is differently attenuated, and with the help of the facsimile results we conclude that high-angle rays are more attenuated than low-angle rays. The field intensity of a single ray was found to depend on two factors—attenuation and the focusing factor. Facsimile results and other theoretical considerations show that the focusing factor was practically proportional to the inverse distance.

The extreme variation of signal intensity could not be accounted for by variations in the focusing factor, and it is concluded that the main factor in daylight transmission was attenuation.

Eliminating the magnetically disturbed routes (transatlantic) the overall attenuation $\underline{a}_0$ is found proportional to the square of the wavelength, and the overall attenuation on the disturbed routes was greater.

There was also some evidence of residual attenuation even at night, although in the 75 m. "Leviathan" transmission it was small. The low-angle attenuation $\underline{a}_0$ was identified as the attenuation of the rays passing through the E layer, both for the reason that it varied in proportion to λ^2 and for the reason that the calculated E layer attenuation agreed well with the observed. The high-angle attenuation and the excess of attenuation in transatlantic transmissions was attributed to F layer attenuation. Skip effects on wavelengths greater than 35 m. show that residual F layer attenuation should exist. This F layer attenuation is shown to be more important on short than on long waves.

The secular changes in transmission between 1927–28 and 1930–31 are partly disclosed by the comparison of recent results and those compiled from R strength observations in 1928.

These changes comprise an increase of limiting wavelength, a decrease of E layer attenuation, and an increase of F layer attenuation between sunspot maximum and sunspot minimum.

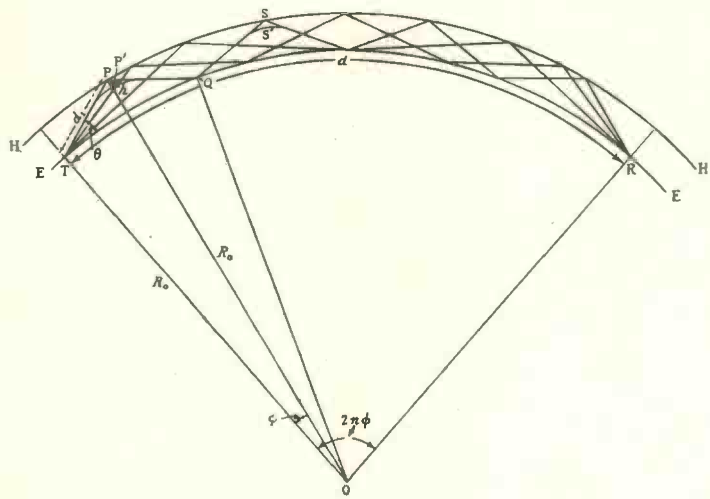


Fig. 3.

The practical consequences of some of these considerations is important.

Low-angle rays are least attenuated and long-distance transmission is practically wholly effected by these. The use of a high beam aerial with a low projection angle (especially for the shorter waves) is therefore justified. If additional evidence of the effect of the angle of projection in the vertical plane were required, the evidence obtained by Bruce* would be convincing. Differences of the order of 15 to 20 decibels were obtained on two aerial arrays, one sharply directive at an angle of about 25° of projection and the other with a low angle of about 10° of projection.

Skip effects have not been discussed, but the evidence is conclusive that day skip-effects on wavelengths greater than about 30 m. cannot be due to electron limitations. For this region the theory of high-angle attenuation as outlined in the author's 1927 paper holds good, though the model of the Heaviside layer then used was entirely wrong.

Arising out of these measurements the author has devised a system of charts marked with contour lines, like the isobars of a weather chart, which, for the night regions, gives approximately the lines of equal maximum electronic density in the F layer. If the transmission characteristics on any given route and at a given time are required the chart drawn on tracing paper is adjusted on the

* *Bell System Technical Journal*, 1931, Vol. 10, p. 661, Fig. 3B.

top of a Mercator projection showing the great circle to be examined so as to represent the conditions in the layer at the given local time. Radio conditions along the route can be read off at a glance. Separate charts for the various seasons are required.

Both facsimile and signal measurement results throw some light on the difficult subject of scattering. Although the author has no doubt as to its existence, the origin, mechanism and distribution of such scattering are still matters for speculation.

Some of the facsimile records show cases of a single short impulse being spread out into a long trail of, may be, 20 milliseconds' duration.

The author suggests that although it is perhaps generalising on insufficient evidence, one cannot help being impressed by the fact that the shorter-wave scatter-echoes show a much more well-defined and more distance scatter source, and that where the receiver is beyond the edge of the skip distance the scatter signals do not, in general, start until after the first main reflection. These results may throw some light on the regions where the scatter signals originate.

The last part of the paper is devoted to detailed theoretical discussion. The following can be summed up as the conclusions reached :—

(1) The attenuation is some inverse function of the gradient of electronic density, so that the less the gradient the greater the attenuation.

(2) The attenuation is in every case inversely proportional to the height of the layer above the earth.

(3) The attenuation in each case varies inversely

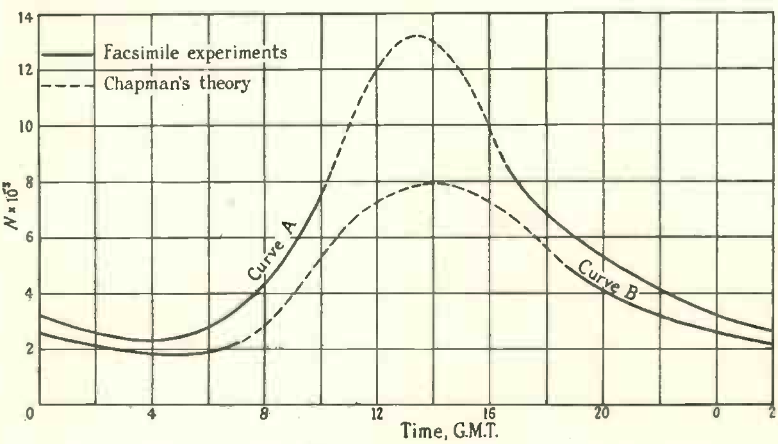


Fig. 7.—*Curve A.—New York-Somerton, 21st–22nd October*, 1928 ; $-11°$; *latitude* 45° ; I_0 317 ; *a* 7×10^{-11} ; 0.495 ; n_0 21.3×10^5. *Curve B.—Montreal-Somerton 10th–11th May*, 1931 ; 17° 45′ ; *latitude* 45° ; I_0 80 ; 10^{-10} ; 0.816 ; n_0 8.94×10^5

as some power of λ. The longest waves are least attenuated.

(4) High-angle waves are in general much more attenuated than glancing-angle waves.

(5) The attenuation decreases with increasing ionic density (increasing everywhere in the same proportion).

(6) The attenuation increases with increasing collision frequency.

Discussion.

Mr. L. B. Turner, who opened the discussion, criticised the facsimile method, and compared it with the Breit and Tuve pulse method for determining layer height at a particular place. The facsimile method was of direct practical importance, but as a method of research into the height and density of the layer it was open to many objections. What part of the globe were the author's data examining ? What is the first ray recorded and which the last ? In connection with the author's reference to the accepted existence of two layers he reminded the meeting that Prof. Appleton had disclosed the existence of the second layer in 1927.

Prof. S. Chapman referred to the gratifying results from the material. The results gave good agreement with the measurements of Prof. Appleton in the *F* region. With regard to results differing from one year to another, this agreed with inferences from terrestrial magnetism. The sun's radiation changes greatly in the 11 years' circle.

Mr. Wellington referred to the difficult material with which the author had had to work. As regards the variation of ionic density with local time, correlation appeared to be good within certain limits, especially in the tropics. Conditions, however, were different in higher latitudes. A slide was shown illustrating polar distribution, and general comparison drawn between tropical and polar conditions.

Dr. J. Hollingworth referred to the need of considering the effect of the earth's magnetic field, and showed a slide illustrating discrepancies from the author's figures due to this omission. He also described measurements with crossed closed coils and indication by cathode ray oscillograph. These showed rapid variation of conditions and of steep-angle incidence.

Mr. G. Builder spoke of the complexity of pulse images, even at short distances, and of the increased difficulties of interpreting the facsimile data. Recent short-distance work had shown that the echo was sometimes split into two components giving different velocities, with effects numerically comparable to the author's scattering.

Mr. J. F. Herd preferred the short-distance pulse methods as giving the ground ray as a rigorous datum point, compared with the inferential datum of the long distance facsimile method. The forthcoming "polar year" observations included systematic measurements of layer height within the Arctic circle and it was hoped also to be able to determine the polarisation of the downcoming components.

Mr. T. L. Eckersley briefly replied to several of the points raised in the discussion, and the meeting concluded with a vote of thanks to the author on the motion of the Chairman, Lt.-Col. A. S. Angwin.

Abstracts and References.

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

PROPAGATION OF WAVES.

SOME STUDIES OF RADIO TRANSMISSION OVER LONG PATHS MADE ON THE BYRD ANTARCTIC EXPEDITION.—L. V. Berkner. (*Bur. of Stds. Journ. of Res.*, Feb., 1932, Vol. 8, No. 2, pp. 265–278.)

Reference has already been made to a preliminary notice of this paper (May Abstracts, p. 276) on field intensity measurements of high-frequency signals (9 000 to 15 000 kc/s) over long paths, taken at Dunedin, New Zealand, during 1929–30. The experimental data are given in the form of curves showing typical daily variations of field intensities and monthly averages of signal intensity measurements made on various stations in North America and Europe. The data are discussed with reference to the nature of the daylight-darkness path traversed. Charts of the daylight-darkness path are used based on a special projection of the earth with Dunedin, New Zealand, as a centre and the antipodal point as the boundary circle. Diurnal and seasonal variations of relative field intensity are illustrated by a three-dimensional surface.

The author summarises the repeated occurrences observed through the frequency ranges and paths considered as follows :—" 1. In general, a signal minimum occurs over a wholly light path. 2. A rise in signal intensity generally occurs as the path becomes partially dark, higher frequencies rising and reaching a maximum progressively before the next lower frequency. 3. A steady fall in signal intensity occurs after the maximum has been reached, starting progressively down from the higher frequencies and becoming most pronounced after the path has become wholly dark. The transmission conditions do not appear to become fixed or steady either during daylight or darkness. A secondary rise and maximum is frequently observed as daylight approaches the transmitting end of the path.

" 4. An apparent diminution in signal intensity takes place generally for a given daylight-darkness path, when the darkness portion is prolonged. 5. A decrease in signal intensity appears to take place when the darkness wall is advancing so slowly as apparently to allow the attenuation along the prolonged daylight portion of the path to increase more rapidly than the diminution in attenuation at the advancing darkness wall. 6. A shift of the signal path may take place under certain conditions, as suggested." Correlation of weakened signal intensity with magnetic disturbances was noted when the signal path passed near a magnetic pole.

INVESTIGATIONS OF KENNELLY-HEAVISIDE LAYER HEIGHTS FOR FREQUENCIES BETWEEN 1 600 AND 8 650 KILOCYCLES PER SECOND.—Gilliland, Kenrick and Norton. (*Proc. Inst. Rad. Eng.*, Feb., 1932, Vol. 20, pp. 286–309.) *See* April Abstracts, p. 216.

PRELIMINARY NOTE ON AN AUTOMATIC RECORDER GIVING A CONTINUOUS HEIGHT RECORD OF THE KENNELLY-HEAVISIDE LAYER.—Gilliland and Kenrick. (*Proc. Inst. Rad. Eng.*, March, 1932, Vol. 20, pp. 540–547.)

See February Abstracts, p. 87. For rumours as to the application of the apparatus to automatic transmission control giving fading-free transmission, *see* May Abstracts, p. 283. No suggestion of such use is made in the present paper.

THE SPREADING OF ELECTROMAGNETIC WAVES FROM A HERTZIAN DIPOLE.—Ratcliffe, Vedy and Wilkins: G.W.O.H. (*See* under " Aerials and Aerial Systems.")

CONCERNING THE INFLUENCE OF THE ELEVEN-YEAR SOLAR ACTIVITY PERIOD UPON THE PROPAGATION OF WAVES IN WIRELESS TELEGRAPHY.—H. Plendl. (*Proc. Inst. Rad. Eng.*, March, 1932, Vol. 20, pp. 520–539.)

English version of the paper dealt with in January Abstracts, p. 29.

TRANSFERENCE CURVES FOR THE GEOGRAPHICAL REPRESENTATION OF LIGHT AND DARK AREAS, AT ANY DATE AND TIME, AT THE EARTH'S SURFACE AND AT THE IONISED LAYER, ASSUMING 100 KILOMETRES FOR ITS MEAN HEIGHT: ALSO, APPROXIMATE TIME OF SUNRISE OR SUNSET FOR EITHER LEVEL AT ANY PLACE.—J. Williamson. (*British Radio Annual*, Vol. 1, 1931, Frontispiece.)

In a paper entitled " Geography's Applications to Radio."

DIE DRAHTLOSE NACHRICHTENÜBERMITTELUNG IN DEN POLARGEBIETEN (Wireless Communication in the Polar Regions [and the Causes of its Difficulties]).—K. Krüger. (Summary in *Hochf:tech. u. Elek:akus.*, March, 1932, Vol. 39, p. 107.)

The difficulties experienced in maintaining good communication may be attributed to four factors :—(i) the low temperature ; this can only affect the actual apparatus, for instance by reducing the output of dry batteries and accumulators. (ii) The ice coating of the earth's surface ; large expanses of ice may exert considerable damping on the propagation of long and medium waves, for ice has a comparatively low conductivity and a small dielectric constant. Thus a transmitter on these wavelengths is found to have a distinctly smaller range over the inland ice of Greenland than over land. (iii) The low position of the sun ; on account of this and the consequent reduction of ultra-violet ionisation, short-wave communication normally requires rather longer wavelengths than elsewhere. But even during the complete darkness of the polar winter there may be enough reflection for short and the shorter medium waves. (iv) The proximity of the magnetic pole; this results in the regions being particularly exposed to the effects of solar activity. It is thought that this is the main reason for the occasional complete breakdowns of short-wave communication in these latitudes. The writer illustrates by examples the connection between such breakdowns and magnetic anomalies.

SOME EFFECTS OF TOPOGRAPHY AND GROUND ON SHORT-WAVE RECEPTION.—Potter and Friis. (*See* under " Reception.")

CONTOUR DIAGRAMS OF FIELD STRENGTHS IN SHIP-SHORE TELEPHONY.—Anderson and Lattimer. (*See* abstract under " Stations, Design and Operation.")

TRANSMISSION EXPERIMENTS WITH [ULTRA-SHORT] 1.3 METRE WAVES.—Pfetscher and Beck. (*See* under " Transmission.")

COMMUNICATION TESTS FOR RADIO TELEPHONY BY MEANS OF ULTRA-SHORT [4.6 AND 5.8 METRE] WAVES BETWEEN NIIGATA AND SADO.—Uda. (*See* under " Stations, Design and Operation.")

SUR LA CONSTANTE DIÉLECTRIQUE ET LA CONDUCTIBILITÉ DES GAZ IONISÉS (The Dielectric Constant and Conductivity of Ionised Gases).—T. V. Jonescu and C. Mihul. (*Ann. Scient. Univ. Jassy*, Special Number, Vol. 17, No. 1/2, 1931, pp. 78–110.)

Working with a density round 2×10^7 electrons/cm³, the conclusion is reached that the ionised air has a natural frequency, independent of electron density, of 3.16×10^7 c/s; and that the two kinds of electron, free and bound, act differently on the dielectric constant and conductivity. For previous work on ionised gases, by the same authors and Jonescu alone, *see* Abstracts, 1931, pp. 144, 204 and 315: 1932, pp. 92 and 157.

TABLES OF THE IONISATION IN THE UPPER ATMOSPHERE.—E. O. Hulburt. (*Phys. Review*, 15th March, 1932, Series 2, Vol. 39, No. 6, pp. 977–992.)

Author's abstract :—" The present paper continues the work on the ionisation of the upper atmosphere due to the ultra-violet light of the sun, developed in a series of papers in this Journal, and takes into account as far as possible the entire meteorology of the upper atmosphere and the effects of recombination, temperature diffusion and the motions of the ions and electrons in the gravitational, electric and magnetic fields of the earth. Tables are presented of the ion and electron densities over the earth. The ionisation at night is worked out more completely than was done previously. After sunset as a result of temperature diffusion and electric-magnetic drift, the ionised region separates into two banks, one with a maximum of ionisation at about 110 km and one with a maximum at about 140 km. Quantitative agreement is found with the skip distances and other phenomena of wireless waves and with various facts of terrestrial magnetism." For the series of papers referred to, *see* Abstracts, 1930, pp. 34–35, 95, 208, 328, 450, 564, 564–565, 622; 1931, pp. 90, 90–91, 207.

SUR LA RÉPARTITION DE L'OZONE DANS L'ATMOSPHÈRE TERRESTRE (On the Distribution of Ozone in the Earth's Atmosphere).—D. Chalonge. (*Journ. de Phys. et le Rad.*, Jan., 1932, Vol. 3, pp. 21–42.)

Cf. 1931 Abstracts, p. 317. " Experimental results so far obtained, too few in number and too lacking in accuracy, allow it merely to be said that the ozone in the atmosphere behaves roughly (as regards the absorption exercised on the solar radiation) as an imaginary thin layer at about 50 km would behave; they are, however, quite insufficient to indicate whether the centre of gravity of the distribution is at that height or higher. Moreover, the ozone seems to exist in notable quantity from a height below 20 km to one above 80 km, its concentration increasing with altitude. There is, in fact, no 'ozone layer.' "

ON THE CAUSE OF THE CLOSE CORRELATION BETWEEN ATMOSPHERIC OZONE CONTENT AND METEOROLOGICAL CONDITIONS.—H. Petersen. (Summary in *Physik. Ber.*, 15th Feb., 1932, Vol. 13, p. 494.)

THE PHOTOCHEMICAL OZONE EQUILIBRIUM IN THE ATMOSPHERE.—Mecke: Faraday Society (*See* abstract under " General Physical Articles.")

ANWENDUNG DER HILLSCHEN DIFFERENTIALGLEICHUNG AUF DIE WELLENFORTPFLANZUNG IN ELEKTRISCHEN ODER AKUSTISCHEN KETTENLEITERN (Application of the Hill Differential Equation to the Wave Propagation in Electrical or Acoustic Filter Networks).—F. Noether. (Summary in *Physik. Ber.*, 15th Feb., 1932, Vol. 13, p. 418.)

CONTRIBUTIONS ON THE SUBJECT OF SOUND PROPAGATION, PARTICULARLY BENDING AND ANOMALOUS PROPAGATION.—B. Sandmann. (*Gerlands Beitr.*, No. 1/3, Vol. 28, pp. 241–278.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

CORRELATION OF RADIO ATMOSPHERICS WITH METEOROLOGICAL CONDITIONS.—T. Nakai. (*Res. Electrot. Lab. Tokyo*, No. 322, 1931, 14 pp. and plates.)

In Japanese, with English synopsis. Two periods are covered, between 1927 and 1929. " The following are the main points of interest :—(1) Atmospherics seem to be associated with a low-pressure area or a cyclone and a line of discontinuity when these are moving rapidly. (2) A typhoon seems to produce atmospherics when the reading of barometric pressure is low. When it takes a value higher than 740 mm Hg, roughly speaking, atmospherics are scarcely produced. (3) In general, atmospherics due to a cyclone prevail in autumn and winter, those due to a cyclone and a line of discontinuity in a period including spring and early summer, and those due to a thunderstorm, a typhoon and a cyclone in the seasons of from early summer to autumn. (4) In the seasons of from spring to autumn, the average direction of atmospherics varies, generally speaking, as the altitude of the sun, so that atmospherics seem to be related indirectly with the sun." For other Japanese papers *see* March Abstracts, p. 158.

IONISATION BY PENETRATING RADIATION AS A FUNCTION OF PRESSURE AND TEMPERATURE.—A. H. Compton, R. D. Bennett and J. C. Stearns. (*Phys. Review*, 15th March, 1932, Series 2, Vol. 39, No. 6, pp. 873–882.)

For a preliminary note *see* February Abstracts, pp. 89–90. Authors' abstract:—"To account for the experimental fact that the ionisation of a gas exposed to γ-rays or cosmic rays is not proportional to the pressure, but approaches a limiting value for pressures of about 140 atmospheres, the hypothesis is suggested that at these high pressures the initially formed ions may remain so close together that they frequently reunite under their mutual electrostatic attractions. The probability is calculated for the ions to become separated by diffusion, and formulas are thus obtained for the saturation ionisation current as a function of pressure. The most satisfactory formula is based upon an arbitrary but reasonable assumption regarding the ranges of the secondary electrons ejected by ionising beta particles. Knowing the variation of ionisation with pressure, this diffusion theory predicts a definite variation of ionisation with temperature. Such a temperature variation is experimentally discovered and is in good accord with the theoretical prediction. The temperature coefficient is negligible for pressures less than 10 atmospheres, but at pressures over 100 atmospheres the ionisation approaches proportionality to the absolute temperature."

TESTS TO DETERMINE THE NATURE AND SOURCE OF THE COSMIC RAYS.—A. H. Compton. (*Science*, 25th March, 1932, Vol. 75, pp. 329–330.) *See* also April Abstracts, p. 219 (Swann: Compton).

ÜBER DAS SPEKTRUM DER ULTRASTRAHLUNG. I.—DIE MESSUNGEN IM HERBST 1928 (On the Spectrum of Cosmic Radiation. I.—The Measurements in Autumn, 1928).—E. Regener. (*Zeitschr. f. Phys.*, 1932, Vol. 74, No. 7/8, pp. 433–454.)

This paper contains a full account of measurements on the absorption of cosmic radiation in Lake Constance, which have already received preliminary notice in several places (Abstracts, 1929, p. 463; 1931, pp. 207, 264—two; also *Verh. d. Deutschen Physik. Gesellsch.*, Series 3, Vol. 12, 1931, p. 45). The most penetrating component was found to be probably homogeneous at depths of 80 metres and more, and its absorption coefficient 1.9×10^{-4}/cm H_2O. Its wavelength probably corresponds to the transformation of the mass of a helium atom into radiation.

ON THE SOLAR PERIOD OF COSMIC RADIATION.—W. Messerschmidt. (*Physik. Zeitschr.*, 15th March, 1932, Vol. 33, No. 6, pp. 233-234.)

A short account of investigations already referred to (May Abstracts, p. 278) which show that the solar period of cosmic radiation is due to meteorological influences and not to direct radiation from the sun.

ÜBER DEN LUFTDRUCKKOEFFIZIENTEN DER HARTEN ULTRASTRAHLUNG (On the Atmospheric Pressure Coefficient of the Hard Cosmic Radiation).—W. Messerschmidt and W. S. Pforte. (*Zeitschr. f. Phys.*, 1932, Vol. 73, No. 9/10, pp. 677–680.)

The authors find the mean value of the atmospheric pressure coefficient of hard cosmic radiation (after passage through lead screens 10 cm thick) taken over a period of six months to be very constant, as also the radiation intensity. Quickly-moving barometric depressions give rise to deviations from the mean pressure coefficient.

COSMIC RAY PARTICLES.—G. L. Locher. (*Phys. Review*, 15th March, 1932, Series 2, Vol. 39, No. 6, pp. 883–888.)

The specific ionisation along cosmic ray particle tracks is found not to exceed 36 ion-pairs per cm, in air at 1 atmosphere pressure. "This is less than one third the ionisation calculated by Kolhörster and Tuwim [May Abstracts, p. 278], whose value is believed to be erroneous, at least for individual tracks, for reasons set forth in this paper." Groups of tracks are believed to be made by secondary electrons ejected by one photon.

THE PRODUCTION OF ARTIFICIAL COSMIC RAYS [FROM BERYLLIUM BOMBARDED BY ALPHA RAYS].—W. Bothe and H. Becker. (*Science*, 26th Feb., 1932, Vol. 75, p. 8.)

NEUTRON, ATOMIC BRICK, MAY SOLVE MYSTERY OF COSMIC RAYS.—(*Sci. News Letter*, 5th March, 1932, Vol. 21, p. 143.)

SOME NEW THEORETICAL AND EXPERIMENTAL RESULTS ON THE AURORA POLARIS [ELECTRON RAY TESTS AND PERIODIC SPACE PATHS].—E. Brüche: Störmer. (*Terrestr. Magn.*, March, 1931, pp. 41–52.)

ÜBER MAGNETISCHE STÖRUNGEN, DIE AN SÜDNORWEGISCHEN NORDLICHTTAGEN IN POTSDAM BEOBACHTET WURDEN (Magnetic Disturbances observed in Potsdam on Days of S. Norwegian Aurora).—A. Röstad. (*Geofys. Publ. Oslo*, No. 3, Vol. 9, 31 pp.)

Relations between auroral distance from magnetic axis and the intensity of the magnetic disturbances: special characteristics of the latter.

BROADCASTING AND [ITS SUGGESTED EFFECT ON] THE WEATHER.—E. V. Newnham: Humphreys. (*Sci. Progress*, April, 1932, pp. 685–687.)

Summary of Humphreys' paper entitled "The Weather and Radio," written as a result of many appeals in the U.S.A. for the suppression of radio broadcasting on the ground that it has a disturbing effect on the weather.

Do Meteors cause Static ?—J. Cage. (*Radio News*, Feb., 1932, Vol. 13, p. 669.)

A note on the simultaneous observation of atmospherics and flashes of light from meteorites.

Terrestrial and Solar Coronae and their Relation to Cosmic Phenomena.—L. Vegard. (Summary in *Sci. Abstracts, Sec. A*, March, 1932, Vol. 35, No. 411, p. 199.)

The Electrical Properties of the Sun.—A. Dauvillier. (*Rev. Gén. de l'Élec.*, 5th March, 1932, Vol. 31, pp. 303–311.)

The Electromagnetic Phenomena produced on the Earth by the Electron Emission from the Sun.—A. Dauvillier. (*Rev. Gén. de l'Élec.*, 2nd and 9th April, 1932, Vol. 31, pp. 443–455 and 477–488.)

Continuation of the above work.

Variazione del Potenziale elettrico dell' Atmosfera duranti un Temporale (Variation of the Electrical Potential of the Atmosphere during a Storm).—R. Di Maio. (*L'Elettrotec.*, 15th March, 1932, Vol. 19, pp. 209-211.)

Die stationäre Geschwindigkeitsverteilung von in einem elektrischen Felde diffundierenden Elektronen (The Stationary Velocity Distribution of Electrons Diffusing in an Electric Field).—M. Didlaukis. (*Zeitschr. f. Phys.*, 1932, Vol. 74, No. 9/10, pp. 624–630.)

Short Report on the Meteorological-Aerological Observations on the Graf Zeppelin Arctic Trip.—Weickmann and Moltchanoff. (*Meteorol. Zeitschr.*, No. 11, Vol. 48, pp. 409–414.)

See April Abstracts, p. 220, for a part of the work here dealt with.

New Radiometeorological Methods [for Sounding Ballons].—P. Duckert and B. Thieme. (Summary in *E.T.Z.*, 24th March, 1932, Vol. 53, pp. 297–298.)

New Meteorographs with Wireless Distant Recording [for Balloon Work, etc.].—L. Heck and G. Sudeck: Moltchanoff. (*Gerlands Beitr.*, No. 1/3, Vol. 31, pp. 291–314.)

Cf. April Abstracts, p. 220. The present paper describes two types of equipment, that of the Askania Company and that of the German Aircraft Research Establishment. For a long summary, illustrated, see *Hochf:tech. u. Elek:akus.*, March, 1932, Vol. 39, pp. 108–110.

Luftdurchschlag bei Niederfrequenz und Hochfrequenz an verschiedenen Elektroden (Air Breakdown at Low and High Frequencies with Various Electrodes).—F. Miseré. (*Archiv f. Elektrot.*, 23rd Feb., 1932, Vol. 26, No. 2, pp. 123–126.)

The result of this investigation shows that, from a certain critical breakdown distance, which tends to smaller values as the frequency increases, the breakdown voltage is about 20 % smaller at high frequencies (a few hundred kc/s) than at low ones (about 50 c/s).

Funkenkonstante für Funkenbildung aus verschiedenen Grenzspannungen (Spark Constant for Spark Formation with Various Boundary Voltages).—M. Toepler and T. Sasaki. (*Archiv f. Elektrot.*, 23rd Feb., 1932, Vol. 26, No. 2, p. 111–114.)

Messung der beim elektrischen Luftdurchschlag übergegangenen Elektrizitätsmenge (Measurement of the Amount of Electricity Flowing during Electrical Breakdown).—P. Rosenlöcher. (*Archiv f. Elektrot.*, 23rd Feb., 1932, Vol. 26, No. 2, pp. 115–117.)

An oscillographic record of the voltage across a spark gap with series condenser makes it possible to measure the quantity of electricity flowing during a spark breakdown. During the actual breakdown process about 10^{13} electrons were found to pass between electrodes 1 mm apart (plate spark gap); the arc discharge then began.

The Kindling of Electric Sparkover.—C. E. Magnusson. (*Elec. Engineering*, Feb., 1932, Vol. 51, pp. 117–118.)

" Experimental evidence is presented which tends to prove that electrons and not protons or positive ions are the active carriers in the spark kindling mechanism, and that Lichtenberg figures form the initial step in the process."

Lightning Arrester Grounds.—H. M. Towne. (*Gen. Elec. Review*, March and April, 1932, Vol. 35, pp. 173–177 and 215–221.)

Recent Progress in Protecting Buildings against Lightning.—A. Boutaric: Schaffers. (*Génie Civil*, 19th March, 1932, Vol. 100, pp. 289–291.)

PROPERTIES OF CIRCUITS.

Wattless Retroaction.—H. Braude (Leningrad). (Long summary in *Hochf:tech. u. Elek:akus.*, March, 1932, Vol. 39, pp. 110–112.)

From the differential equation of a mechanical or electrical oscillatory system it can be seen that if the retroactive force is not proportional to the *first* derivative of the displacement (current), *i.e.*, to velocity, but to its second derivative, *i.e.*, to acceleration, then it will not be the damping but the equivalent mass or self inductance which changes, and with it the natural frequency of the system. If the retroactive force is proportional to the displacement (current), then the equivalent elasticity or capacity of the system will alter—and the natural frequency again. For a certain critical value of retroactive force the natural frequency will tend towards infinity.

In order that the retroactive force shall be proportional to displacement (current) or to its second derivative, it must lead or lag by a quarter period with respect to the first derivative of the displacement (current); *i.e.*, the vector of the force must be displaced $\pi/2$ to left or right with regard to the velocity vector. Such a phase displacement can easily be obtained by displacing by $\pi/2$ the amplification phase of the amplifier producing the retroaction. Thus in a 2-stage amplifier it can be done by introducing into the anode circuit of the first valve a wattless (capacitive or inductive) resistance small in comparison with the internal valve resistance.

If the usual case of retroaction, in which the damping is decreased, and the opposed case, where it is increased, are together designated "wattish" retroaction, the special case above mentioned may be called a wattless retroaction. The generalised case, in which the retroactive force vector is displaced by an angle other than $\frac{n\pi}{2}$ with respect to the velocity of the system, may be called "complex retroaction": here the damping *and* the frequency are altered. It is impossible to obtain either "wattish" or wattless retroaction in the pure form. Hence the discrepancy between "natural" frequency and frequency actually generated, in a valve transmitter; hence also the inconstancy of frequency during operation; both are due to "complex retroaction" owing to a wattless component produced by working conditions, *e.g.*, the slope of the valve characteristic.

This generalised theory of retroaction can also be applied to aperiodic systems: here, wattless retroaction produces changes in the equivalent mass or elasticity (equivalent self inductance or capacity) of the system.

The paper contains a theoretical and experimental examination of wattless retroaction in simple electrical oscillatory systems. The results may be applied to electro-mechanical systems such as tuning forks, magnetostrictive-, quartz-, and string-resonators, by using the equivalent circuits for these. They are of importance also in connection with the stabilisation of generators, frequency division, etc.

Optical Retroaction [for Generation of Sinusoidal and Relaxation Oscillations].—Sewig. (*See* under "Transmission".)

Sur un Montage à Réaction indépendante de la Fréquence (A Circuit whose Retroaction is Independent of Frequency [for Audio-frequencies 20 to 20 000 Cycles per Second]).—L. Brillouin and M. Lévy. (*Comptes Rendus*, 4th April, 1932, Vol. 194, pp. 1151–1153.)

A resistance-coupled amplifier whose first valve has two grids. The plate circuit of the last valve contains the primaries of two transformers: the secondary of one of these serves as the output, while that of the other feeds a bridge circuit composed of three resistances, r_1, r_2 and r', and a series oscillating circuit LCr. The potential provided by the diagonal of the bridge is applied to one of the grids of the first valve, and supplies the retroaction.

The circuit will act either as an oscillator or as a selective amplifier, the change being effected by adjustment of the bridge resistance r', which is variable. The large number of parameters and the compensating action of the bridge circuit allow r to be high in value while keeping the effective resistance of the oscillatory circuit at the desired value. Thus no iron core is needed for L and the wire can be thin enough for the resistance r to be independent of frequency. In this way all the factors are independent of frequency—neglecting the losses in the mica condensers—so that the characteristics vary very little with frequency. In a specimen circuit L was 4 henries, r about 2 000 ohms, and the frequency range 20 to 15 000 or 20 000 c/s. Using chokes with iron cores and a few hundred henries inductance, frequencies of 3 or 4 c/s can be reached. As a selective amplifier, the selectivity is adjustable by the variable resistance r': the time constant may reach several seconds: the voltage amplification varies with the selectivity and may easily reach 10^5.

The Mutual Interference of Wireless Signals in Simultaneous Detection [Apparent Demodulation].—Appleton and Boohariwalla. (*See* under "Reception.")

Further Notes on the Detection of Two Modulated Waves which Differ Slightly in Carrier Frequency.—Aiken. (*See* under "Reception.")

An Examination of Selectivity.—Langley. (*See* under "Reception.")

The Magnification of the Tuned Circuit.—Sowerby. (*See* under "Reception.")

The Amplification Ratio of Resistance-Coupled Valve Combinations.—P. Kapteyn. (*Hochf:tech. u. Elek:akus.*, March, 1932, Vol. 39, pp. 78–86.)

Second and final part of the paper dealt with in May Abstracts, p. 278. Resistance-coupled r.f. amplifiers receded into the background at the introduction of broadcasting, because of their comparatively small amplifications below 1 000 metres, the development of tuned amplifiers, and the capacitive effects of the resistances available at the time. They have, however, regained importance in the form of "multiple" valves, giving at 200 metres an amplification of about 10 per valve. "As the writer's researches show, these amplifications can, by suitable dimensioning, be increased to about 100 to 300 per valve." These researches are now described.

Section IVa, on the influence of the valve capacity, discusses the limitations of success of various attempted methods of reducing the grid/anode capacity while keeping to one grid only. The introduction of the screen grid reduces the effective capacity practically to the sum of the static capacities; it increases these, however, and if this increase is to be kept as small as possible the following relation should be observed:

$r_{sg} = \sqrt{r_a \cdot r_{cg}}$, where r stands for radius. *This leads to interelectrode spacing increasing from the* *centre outwards;* Fig. 14 shows the spacing in the writer's 3-grid valve (referred to later in Section IVd) designed on this plan. But in an amplifier circuit such as Fig. 15, it is best to use valves in which the available space is so distributed that only the capacities *actually detrimental in each stage* are reduced by the wide spacing (Fig. 16, i and ii).

Section IVb, on the influence of steepness of slope, recalls that for short waves even a great reduction of detrimental capacity does not allow the external resistance to be pushed up to the required value unless the slope of the valve is sufficiently steep, and then shows that what is required is not maximum *absolute* steepness but the optimum ratio slope/capacity. The simple paralleling of two systems (as with loud speaker valves) is useless, as the ratio remains unchanged; the mere lengthening of a cylindrical electrode system is also ineffective. Figs. 17 and 18 show effective grid designs: in Fig. 18 the spacing of the filament wires is large compared with the filament/grid interval, to reduce space-charge effect. A big capacity grid-cathode (thus involved) would be harmless in the first stage of the Fig. 15 amplifier. The introduction of a space-charge grid would be effective in increasing the slope, but by necessitating an increase in the control-grid and anode diameters would increase the grid/anode capacity and prevent any important increase in amplification. This defect in its turn can be countered by the introduction of a screen grid, although the use of 3 grids naturally leads to rather large dimensions, particularly as research has shown that *the larger the diameter of the space-charge grid, the better is the suppression of space-charge effect;* the effective diameter of the cathode becomes practically that of the space-charge grid, and the electron density at the "emitting" surface becomes so small that the secondary space charge between space-charge grid and control grid is reduced to insignificance.

Working on these lines, and using a space-charge grid diameter of 5 mm with directly heated metal-vapour cathode, a slope of 10 mA/v was reached—about 10 times the value without the space-charge grid. In the final model, for reasons of size, the slope was reduced to 2 to 3 mA/v, quite enough for broadcasting wavelengths where too great a slope is liable to introduce instability, especially in multiple valves. Excellent results are also obtained with indirectly heated cathodes, where the increased mechanical stability allows the grid-cathode spacing to be made very small. Using a control grid sufficiently closely wound to avoid "island formation," multiple-valve amplifications of 10 *per stage* at 200 metres can thus be obtained without the use of a space-charge grid—about as much as with the above described 3-grid valves with directly-heated filaments.

Section IVc deals with the optimum penetration coefficient and optimum anode resistance for r.f. amplifiers, as was done for l.f. amplifiers in the first part of the paper. Section IVd gives examples of three types of double-circuit valves actually constructed and tested. The first (Figs. 22 and 23) has 3 grids in both systems; the anode resistance here (and apparently also in the other types) is 30 000 ohms, and the space-charge grid of the second system is connected through a similar resistance to the anode supply. Both screen grids and the space-charge grid of the first system are connected to a common terminal, so that the outside connections are not more complicated than in the ordinary double-circuit valve. The amplification per valve is about 100, or about 300 with specially good oxide cathodes.

Neither of the other two types uses the space-charge grid; both use a screen grid, and the type shown in Fig. 24 employs the special grid spacing of Fig. 16 (*see* end of Section IVa, above). This, using a tuned anode circuit in the second stage, gives a total amplification of about 1 000. The type shown in Fig. 25 uses a special indirectly heated cathode and a tuned-anode second stage, *giving a total amplification ranging from* 1 000 to 3 000 according to wavelength and to the damping of the oscillatory circuit. "As tests on a large number of such valves have shown, such r.f. amplifications per double valve can be controlled faultlessly."

Section V deals with the prevention of reaction effects and howling in both r.f. and l.f. amplifiers.

CHAMP ÉLECTROMAGNÉTIQUE PRODUIT PAR UN FIL PARCOURU PAR UN COURANT ALTERNATIF SINUSOÏDAL AU-DESSUS D'UNE COUCHE CONDUCTRICE (The Electromagnetic Field produced by a Wire Traversed by a Sinusoidal Alternating Current above a Conducting Layer).—Dubourdieu. (*Comptes Rendus*, 7th March, 1932, Vol. 194, pp. 848–850.)

"Let $Oxyz$ be a system of rectangular co-ordinates. Space is supposed to be filled with a medium of conductivity σ_0, of dielectric constant ϵ_0 and permeability $\mu_0 = 1$ except in the region $-\delta \leq z \leq 0$ which is filled with a medium whose electromagnetic constants have the values σ, ϵ, $\mu = 1$. Also let $y = 0$, $z = d$ be the equation of the infinite wire F traversed by a current $I = I_0 e^{-i\omega t}$." By a solution of the Maxwellian equations, three expressions may be found for Π, which is a function of y and z, according to which of the three regions ($z \geq 0$, $-\delta \leq z \leq 0$, and $z \leq -\delta$) the field is to be calculated in. Thus in the first region $\Pi = \Pi_0 - \Pi_0' + \Pi''$. Here Π_0 corresponds to the "incident" field which would be produced by the wire if the layer ($-\delta \leq z \leq 0$) did not exist. Expressions are given for this and for Π_0' and Π''; the former corresponds to the "reflected" field, the latter supplies a third superposed field. Analogous expressions exist for the two other regions.

If the first medium is air, and the layer is conductive,

$$\Pi_0 - \Pi_0' = 2I_0 \log \frac{\sqrt{y^2 + (z+d)^2}}{\sqrt{y^2 + (z-d)^2}}$$

If the layer is *very* conductive, total reflection takes place, Π'' becoming negligible. "The study of these expressions gives rise to an interesting theoretical discussion closely bound to the nature of the singular points of the nucleus figuring in the integral Π''. One is thus led, according to respective orders of magnitude of the quantities $\sqrt{\sigma}\delta$, $\sqrt{\sigma}d$, $\sqrt{\sigma}y$ and $\sqrt{\sigma}z$, to asymptotic expressions for the electromagnetic field." If $\delta = \infty$ the case becomes that studied by Pollaczeck

(*E.N.T.*, 1926). If the layer is infinitely thin, tending toward zero, and the conductivity increases so that $\sigma\delta$ tends towards a final limit equal to the superficial conductivity, the formulae given by Levi-Civita are obtained.

CONTRIBUTION TO THE EXPERIMENTAL STUDY OF ELECTRICAL INDUCTION.—Turpain and Sabatier. (*See* under "Aerials and Aerial Systems.")

GÜNSTIGE ABSTIMMUNG VON HOCHFREQUENZANLAGEN (Optimum Tuning Conditions for High Frequency Plant [to Satisfy Various Requirements]).—M. Osnos. (*Hochf:tech. u. Elek:akus.*, March, 1932, Vol. 39, pp. 101–105.)

The various separate requirements are:—small kVA consumption in the condensers; constancy of ratio of useful secondary voltage to primary voltage; constancy of internal e.m.f. of the transformer for varying loads, so that the iron losses may remain constant; constancy of ratio of secondary to primary terminal voltages under varying loads; and constancy of useful secondary voltage when only one circuit contains a condenser.

ÜBER DIE ABHÄNGIGKEIT DES SCHEINWIDERSTANDES EINES SYMMETRISCHEN VIERPOLS VON DER BELASTUNG (The Variation of the Apparent Resistance of a Symmetrical Quadripole with the Load).—H. König. (*Helvet. Phys. Acta*, No. 5, Vol. 4, pp. 281–289.)

DER VIERPOL UND SEINE SPEZIELLEN SCHALTUNGEN (The Quadripole and its Special Modes of Connection).—H. König. (*Ibid.*, pp. 303–336.)

Dealing with the 33 different ways in which a quadripole can be connected as a link between two dipoles.

CALCULATION OF HEEGNER'S NETWORK.—U. B. Kobzarev. (*Westnik Elektrot.*, No. 9, 1931, Sec. I, pp. 281–285: in Russian.)

Giving formulae for the displacement of the resonance point, the transmission coefficients of the filter acting on the quartz plate, the transformation ratio, and the resonance curve. From the general formulae for complex loads, formulae are derived for two limiting cases, a purely dissipative resistance and a pure reactance. In the first case the condition for the best efficiency possible with the circuit (0.25) is only fulfilled for two values of the load resistance: the resonance resistance R_q and the capacity of the dielectric polarisation C_p must fulfil the inequality $2R_qC_p\omega < 0.5$. If $2R_qC_p\omega > 0.5$, the maximum efficiency is less than 0.25 and can only be obtained for one single value of load resistance.

STUDIES OF THE CURRENT IN A CIRCUIT IN WHICH R, L OR C ARE SUBJECTED TO HARMONIC VARIATIONS.—J. B. Pomey. (*Rev. Gén. de l'Élec.*, 20th Feb. and 9th April, 1932, Vol. 31, pp. 235–241 and 475–477.)

"It is remarkable that in general no permanent periodic régime is established. The case of the vibrating condenser is governed by an equation known as the Mathieu equation, about which the writer gives some facts. He applies this theory in particular to lines of periodic composition, *i.e.*, to pupinised lines and to filters." In the second part, dealing with a varying inductance, the circuit is compared to a telephone circuit containing a battery and a microphone.

ZUR THEORIE DER FREQUENZABHÄNGIGKEIT EINES WECHSELSTROMMESSKREISES MIT GLEICHSTROMGERÄT UND TROCKENGLEICHRICHTER (On the Theory of the Frequency Variation of an Alternating Current Measuring Circuit with Direct Current Apparatus and Dry-Plate Rectifiers).—L. Cremer. (*Archiv f. Elektrot*, 23rd Feb., 1932, Vol. 26, No. 2, pp. 75–94.)

POTENTIAL STABLE D'UNE ÉLECTRODE ISOLÉE DANS UNE LAMPE TRIODE (Stable Potential of an Insulated Electrode in a Triode).—G. A. Beauvais. (*L'Onde Élec.*, Feb., 1932, Vol. 11, pp. 83–88.)

It is found that an insulated electrode in a triode can maintain in a stable manner a potential different from zero on condition that the other electrode is raised to a high potential. Two possible explanations, one based on secondary emission and the other on ionisation of the residual gas, are discussed; the second is thought to be the more probable. *See* also April Abstracts, p. 221.

THE EXPERIMENTAL INVESTIGATION OF PARASITIC REACTIVE COUPLINGS IN RESONANCE AMPLIFIERS.—V. I. Siforov and E. V. Viland. (*Westnik Elektrot.*, No. 9, 1931, Sec. I, pp. 285–294: in Russian.)

From the data of the amplifier it can be calculated how near it is to the oscillation point. The parasitic grid/anode capacity is given, for practical purposes, by

$$C_0 = \frac{K-1}{K} \cdot \frac{2}{\mu\omega_0 Z_1}\left(\frac{2}{Z_2/R_i} + 2\right),$$

where C_0 is the static grid/anode capacity; K a number which gives how many times the damping of the oscillatory grid circuit is reduced by retroaction; ω_0 the angular frequency of the signals; Z_1 and Z_2 the equivalent resistances of the grid and anode circuits, and R_i the impedance of the valve. A method of measuring K, and other auxiliary measurements, are described. Measurements on triodes and screen-grid valves are given and agree with the above formula.

INVESTIGATION OF THE OSCILLATION THRESHOLD IN TRIODE CIRCUITS.—Giovanni. (*See* abstract under "Transmission.")

CALCULATION OF A VALVE OSCILLATOR WITH DETUNED OSCILLATING CIRCUIT.—Berg. (*See* under "Transmission.")

SIMPLE TELEPHONE BROADCASTING NETWORKS.—Apanasenko. (*See* under "Stations, Design and Operation.")

Papers dealing with Poincaré's Law that of All Bodies of Equal Volume the Sphere has the Smallest Capacity.—G. Szegö. (Summaries in *Hochf:tech. u. Elek:akus.*, Feb., 1932, Vol. 39, p. 76.)

On Periodic Movements of the Negative Glow in Discharge Tubes.—W. A. Leyshon. (*Proc. Physical Soc.*, 1st March, 1931, Vol. 44, Part 2, No. 242, pp. 171–189.)

The full paper referred to in May Abstracts, p. 281.

TRANSMISSION.

Modulation et Bandes latérales : Relation entre la Modulation "en Amplitude" et la Modulation "en Fréquence" (Modulation and Sidebands : Relation . . . etc.).—N. F. S. Hecht. (*L'Onde Élec.*, March, 1932, Vol. 11, pp. 101–128.)

French version of the *Wireless Engineer* paper dealt with in 1931 Abstracts, p. 613.

Übertragungsversuche mit der 1.3 m-Welle (Transmission Experiments with [Ultra-Short] 1.3 Metre Waves).—O. Pfetscher and R. Beck. (*Physik. Zeitschr.*, 15th March, 1932, Vol. 33, No. 6, pp. 242–244.)

This paper contains a description of experiments on a wavelength of 1.3 m over an optical path of 55 km between the Inselsberg in the Thuringian Forest and the Wasserkuppe in the Rhön. The emitter used is briefly described. The emitting antenna was placed along the focal line of a parabolic cylindrical reflector.

The polarisation of the field received was determined and was practically the same as that emitted. The received intensity increased with the height of the receiving antenna above the ground and did not become constant until a height of 5 m was reached. Buildings round the receiver had a marked reflecting power, though they held no particular iron constructions. Atmospheric conditions had no effect on propagation. Much disturbance was caused by unscreened sparking from motors within 50 m of the receiver.

A Note on the Ultra-Short-Wave Oscillation by the Back-Coupling Connection [Diodes and Triodes].—K. Morita. (Long English summary in *Journ. I.E.E. Japan*, No. 10, Vol. 51, pp. 94–95 : full paper in Japanese, pp. 708–710.)

An investigation [on 4.4 m waves] of a discrepancy between calculated and experimental values of the threshold potential for oscillation, probably due to the effect of space charge. "From these experiments the author suggests that still, for the ultra-short-wave oscillator, the tube must be designed so as to give the most suitable value of amplification constant ; and for a given tube a much shorter wave may be obtained by shortening the distance between the parallel wires which construct the outer part of the oscillation circuit."

On the Production of Ultra-Short Waves of 12 Centimetres.—S. Sonada and T. Takayama. (Long English summary in *Journ. I.E.E. Japan*, No. 1, Vol. 52, pp. 10–12 : full paper in Japanese, pp. 69–72.)

Electron Oscillations [Ultra-Short Waves round 35 Centimetres in Wavelength] in Four-Electrode Tubes.—K. Morita. (English summary and curves in *Journ. I.E.E. Japan*, No. 9, Vol. 51, p. 80.)

" In conclusion . . . a four-electrode tube has a wider range of available grid potential and produces more intense waves than a triode which has the same grid and filament dimensions."

Outline of a Possible Interpretation of the Barkhausen-Kurz Electronic Oscillations : The Interpretation of Electronic Oscillations.—A. Rostagni. (Summaries in *Hochf:tech. u. Elek:akus.*, Feb., 1932, Vol. 39, pp. 66–67.)

Long summaries by Hollmann of the two Italian papers referred to in April Abstracts, p. 223.

The Generation of [Ultra-] Short Waves.—W. W. Maslennikoff. (Summary in *Hochf:tech. u. Elek:akus.*, Feb., 1932, Vol. 39, pp. 67–68.)

Long summary by Hollmann of the Russian paper dealt with in 1931 Abstracts, p. 94.

Investigation of Oscillators for Wavelengths of the Order of a Decimetre [Valves with Spiral Grids and Anodes, for Ultra-Short Wave Generation].—U.S.S.R. Electrotechnical Institute. (*Westnik Elektrot*, No. 9, 1931, Sec. I, pp. 297–304 : in Russian.)

Improvements in Frequency Multipliers [for Crystal-Controlled Aircraft Transmitters].—E. G. Watts. (*Electronics*, April, 1932, pp. 124–125.)

The unique advantages of piezo-control are especially desirable for aircraft, but transmitters thus controlled have not been widely used because of their complication and inflexibility compared with the tuned-circuit controlled type. The writer shows that commonly used amplifier neutralisation systems (Hazeltine, Rice) can be used in an improved frequency-doubling circuit, thanks to which a more reasonably efficient and flexible piezo-controlled transmitter for aircraft becomes practicable.

A Method for the Approximate Calculation of a Thermionic Frequency Changer [based on Anode Dissipation].—Joffe. (*See* under "Subsidiary Apparatus and Materials.")

Principal Electrical Relations in an Oscillating Triode [Graphical and Analytical Treatment].—S. I. Zilitinkevitch. (*Westnik Elektrot.*, No. 9, 1931, Sec. I, pp. 271–280 : in Russian.)

Calculation of a Valve Oscillator with Detuned Oscillating Circuit.—A. I. Berg. (*Westnik Elektrot.*, No. 8, 1931, Sec. I, pp. 234–241 : in Russian.)

Investigation of the working conditions in a valve oscillator whose oscillatory circuit is detuned with respect to the frequency of the grid potentials. In this frequently occurring case, an increase of the applied power is accompanied by a corresponding increase of anode loss and a decrease of output power. The shape of the anode current curve remains the same as in a tuned oscillator, and therefore the effects can be calculated by formulae of the same character as those serving for the latter.

ELIMINATION OF HARMONICS IN VACUUM TUBE TRANSMITTERS.—Y. Kusunose. (*Proc. Inst. Rad. Eng.*, Feb., 1932, Vol. 20, pp. 340–345.) *See* 1931 Abstracts, p. 496.

OPTISCHE RÜCKKOPPLUNG (Optical Retroaction [for Generation of Sinusoidal and Relaxation Oscillations]).—R. Sewig. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 13, 1932, pp. 180–182.)

A note, prompted by a reference to British Patent No. 326 498, on previous researches by the Osram Gesellschaft on optical retroaction circuits, in which a photoelectric cell was connected in the grid circuit of a triode whose anode circuit contained a glow discharge tube. This tube was kept continuously alight by the steady anode current and was arranged to work on a nearly straight part of the current/light characteristic. The optical connection between lamp and cell could be varied by a screen, and the amplitude of the sinusoidal oscillations set up by the optical retroaction could thus be controlled from a maximum to vanishing point. The oscillations, moreover, could be modulated in various obvious optical ways.

A similar circuit, employing a valve with small grid current (" Dosimeter " valve, Osram T 113), was useful for generating relaxation oscillations with linear time course—*e.g.*, for oscillograph time-base purposes. A second photoelectric cell was used to control the rate of condenser discharge, by the regulation of its small incandescent lamp.

ÉTUDE DES FAIBLES OSCILLATIONS DES GÉNÉRATEURS À LAMPES (Study of Weak Oscillations in Valve Oscillator Circuits).—B. Giovanni. (*L'Onde Élec.*, Feb., 1932, Vol. 11, pp. 89–100.)

A theoretical investigation to determine (*a*) the relations connecting the amplitude and frequency of the oscillations with the resistance introduced into the oscillating circuit, when this resistance is varied in a narrow range round the value R corresponding to the oscillation threshold; and (*b*) the conditions which decide whether the setting-in of oscillation shall be gradual or abrupt. The investigation is limited to cases where the grid current is practically zero, *i.e.*, where grid potentials are zero or negative; but Section VII deals with the effect of grid current.

ON THE INFLUENCE OF VALVE RESISTANCE IN OSCILLATION GENERATORS [AND THE STABILISATION OF FREQUENCY BY SERIES ANODE INDUCTANCE].—N. W. McLachlan: Mallett. (*Wireless Engineer*, March, 1932, Vol. 9, pp. 130–135.)

The writer begins with a criticism of Mallett's results (1930 Abstracts, p. 463). " It follows, therefore. that deductions from his frequency equation must be erroneous, and no general proof has been given that an inductance L' will counteract variation in the valve parameters." Then, turning to screen-grid valves as oscillators (as used in his modulated c.w. wavemeter), he arrives at the various conditions which should be observed for the sake of frequency constancy.

LA STABILITA' DI FREQUENZA DEL TRIODO GENERATORE (The Frequency Stability of the Triode Oscillator).—C. Matteini. (*L'Elettrotec.*, 15th Feb., 1932, Vol. 19, pp. 121–129.)

The frequency instability is attributed to the existence of out-of-phase relations between the alternating components of the plate and grid potentials. The analytical and experimental study leads to certain practical conclusions as to the design of stable frequency oscillators: thus the resonance coefficient $\left(\epsilon = \omega_0 CR = \frac{R}{\omega_0 L}\right)$ should be high in value, the triode should be chosen to have a high internal resistance with a low amplification factor, the ratio L/C should be comparatively low, and the grid bias resistance should be high.

FREQUENCY STABILISATION OF RADIO TRANSMITTERS.—Y. Kusunose and S. Ishikawa. (*Proc. Inst. Rad. Eng.*, Feb., 1932, Vol. 20, pp. 310–339.) *See* 1931 Abstracts, pp. 496–497.

THE [TETRODE] DYNATRON OSCILLATOR.—E. C. S. Megaw: Colebrook. (*Wireless Engineer*, March, 1932, Vol. 9, pp. 152–153.)

For previous correspondence on Colebrook's paper *see* April Abstracts, p. 222. The present letter deals with the mechanism of the Colebrook circuit, and ends by comparing the principle with that of Van Ryn's " Numans " oscillator: the difference is that in the latter the dynatron (*i.e.*, secondary emission) region of the outer grid characteristic is used.

OPERATING MECHANISMS OF NEGATIVE RESISTANCE OSCILLATORS [MATHEMATICAL AND GRAPHICAL INVESTIGATION].—R. Usui. (Long English summary in *Journ. I.E.E. Japan*, Nos. 7 and 12, Vol. 51, pp. 64–67 and 115–116: full paper in Japanese, *ibid.*, pp. 393–402 and 869–877.)

A REVERSED-CURRENT FEED-BACK OSCILLATOR [RETAINING CONVENIENCE OF DYNATRON OSCILLATOR BUT OSCILLATING UP TO 10 OR 15 MEGACYCLES].—W. van B. Roberts. (*QST*, Feb., 1932, Vol. 16, pp. 32–33.)

Using a type '24 valve with 90 v on screen and between 30 and 40 v on the plate.

A DIRECT-COUPLED AMPLIFIER FOR THE DYNATRON OSCILLATOR.—E. G. Fraim. (*QST*, Feb., 1932, Vol. 16, pp. 37–38.)

Description of an oscillator and r.f. amplifier designed to reduce the frequency drift of the dynatron, to be stable in operation, and to give sufficient output in harmonics for frequency measurements. The data given are for a range 1 700 to 2 050 kc/sec.

THE OPERATION OF VACUUM TUBES AS CLASS B AND CLASS C AMPLIFIERS.—Fay. (*Proc. Inst. Rad. Eng.*, March, 1932, Vol. 20, pp. 548–568.) *See* May Abstracts, p. 283.

AN INSTRUMENT FOR MEASURING MODULATION RATIO.—V. N. Lepeshinskaja-Krakau. (*Westnik Elektrot.*, No. 9, 1931, Sec. I, pp. 314–318 : in Russian.)

By means of a moving coil instrument combined with a copper-oxide rectifier it is possible to measure not only the mean value but also the amplitude of an alternating current, the amplitude being found by compensation of the rectified current by a direct current. A pyrometric voltmeter is used as the indicating instrument.

BROADCAST TRANSMITTER MEASUREMENT USING A COMMON WAVEMETER.—E. A. Laport. (*Electronics*, March, 1932, pp. 88–89 and 114.)

A FREQUENCY INDICATOR FOR [BROADCASTING] TRANSMITTERS.—(*Gen. Radio Exper.*, Jan., 1932, Vol. 6, pp. 6–7.)

This frequency-deviation meter is a 1 000-cycle instrument with a scale reading 100 cycles on either side of the central zero, working in conjunction with a very constant piezo-oscillator with a frequency 1 000 cycles above that of the transmitter.

RECEPTION.

THE MUTUAL INTERFERENCE OF WIRELESS SIGNALS IN SIMULTANEOUS DETECTION.—E. V. Appleton and D. Boohariwalla. (*Wireless Engineer*, March, 1932, Vol. 9, pp. 136–139.)

Authors' summary :—" The theoretical investigations of Beatty and Butterworth . . . have been extended and tested experimentally. In cases where the theoretical results obtained by these authors diverged, the experimental results are found to decide in favour of Butterworth's analysis. A simple result of the work, which is of importance in practice, can be stated as follows :—If strong and weak signals of carrier wave intensities S and W respectively are simultaneously received with a linear detector, the modulation of the weak signal is reduced to a fraction $\frac{1}{2} \cdot \frac{W}{S}$ of its original value. At the same time the modulation of the strong signal is reduced slightly to $\left\{1 - \frac{1}{4}\left(\frac{W}{S}\right)^2\right\}$ of its original value." With reference to the first statement, the writers add that this result has been previously announced, together with their suggestion that the demodulation effect plays a very important part in the behaviour of the Stenode Radiostat receiver (*Wireless World*, 17th June, 1931, p. 661).

AN EXAMINATION OF SELECTIVITY.—R. H. Langley. (*Proc. Inst. Rad. Eng.*, April, 1932, Vol. 20, pp. 657–673.)

Author's summary :—A review of the literature on selectivity including the important recent contributions shows the necessity for co-ordination of the results and clarification of the definitions. The present selectivity requirements are developed and a simple mathematical treatment is expanded to meet them. The criterion for uniform ability to reject undesired signals, for both condenser and inductance tuning, results from this calculation. The relation of the selectivity curve, as now taken and presented, to the actual performance of the receiver is discussed, and the central portion is compared mathematically with the fidelity characteristic. Possible improvements in the definition, method of measurement, and presentation of data, are suggested.

FURTHER NOTES ON THE DETECTION OF TWO MODULATED WAVES WHICH DIFFER SLIGHTLY IN CARRIER FREQUENCY.—C. B. Aiken. (*Proc. Inst. Rad. Eng.*, March, 1932, Vol. 20, pp. 569–578.)

Further development of the work dealt with in 1931 Abstracts, p. 208. Author's summary :—" The present paper deals with the analysis of the detection of two modulated waves of slightly different carrier frequency under the conditions that the carrier amplitude of one wave is much smaller than that of the other and that the modulation of the larger wave is low. These conditions apply in determining the interference which arises during the operation of two broadcast stations on the same frequency assignment when the stations are non-isochronous and transmit different programmes. A discussion of the characteristics of shared channel interference is given, and it is shown that there are only two important components of this interference, one being the carrier beat note and the other being what has been designated as side-band noise. This latter consists of two frequency spectra, one of which is similar to the spectrum of the modulating frequencies of the undesired station but is shifted upward by a constant amount equal to the difference between the carrier frequencies. The other spectrum is of a similar type but is shifted downward in frequency by the same amount."

THE STENODE RADIOSTAT.—P. G. Davidson : Robinson. (*Wireless Engineer*, March, 1932, Vol. 9, pp. 150–151.)

A criticism of Robinson's letter referred to in April Abstracts, p. 225 ; the point particularly stressed is the necessity of the 10 kc interval between stations. " The function of the detector is only to transfer the unwanted modulation to a new frequency band, thus producing a wave having as many components as the original interfering transmission " : if interference is to be avoided, these unwanted components must all lie within the range of operation of the filter.

SUPER-SELECTIVITY *versus* SIDEBANDS [ADVANTAGES OF GREAT SELECTIVITY WITH AUDIO COMPENSATION].—(*Electronics*, March, 1932, pp. 100–101.)

" No matter how this selectivity is obtained . . . the advantages of such circuits are several, especially when worked into linear detectors. In the first place, such selectivity decreases the modulation with respect to the carrier. Then if selective fading is experienced such that the carrier under normal circumstances would become weaker than the sidebands, with resultant bad mushing, in the highly selective receiver the carrier would still be stronger than the stronger sideband and good quality would not suffer." A second advantage mentioned is the demodulation of the weak carrier.

THE *WIRELESS WORLD* "AUTOTONE": HIGH CIRCUIT SELECTIVITY WITH TONE CORRECTION.—(*Wireless Engineer*, March, 1932, Vol. 9, p. 135.)

THE MODULATED CURRENT IN THE RESONANCE CIRCUIT, THE SIDE BAND COEFFICIENT, AND THE RADIO RECEIVER CHARACTERISTICS RELATED TO THEM.—S. Takamura. (*Journ. Inst. T. and T. Eng., Japan*, Jan., 1932, pp. 60–82: in Japanese.)

i.–Introduction. ii.–The modulated current in the resonant circuit. iii.–The side band coefficient: (*a*) theoretical, (*b*) experimental observations. iv.–The detection of the modulated wave and the receiver output. v.–The relations between selectivity and fidelity. vi.—The variation of fidelity by de-tuning. vii.–Conclusion.

BASS DRUM AND TYMPANI—THE 5 000 CYCLE LIMIT.—(*Electronics*, March, 1932, p. 101.)

"Advertising claims to the contrary, very few radio receivers now on the market, or in the home, transmit faithfully up to 5 000 cycles. The majority of them are practically dead at this frequency, especially those equipped with tone controls." Bell Laboratories' tests with trained and untrained observers show that for all musical instruments very little transmission below 60 c/s is necessary, but that only the tympani and bass drum could be transmitted faithfully through a receiver cutting off at 5 000 c/s.

ZERO-BEAT TUNING USED IN HIGHLY SELECTIVE (OSCILLATING) BROADCAST RECEIVER.—F. Reimann. (*Rad., B., F. f. Alle*, March, 1932, pp. 100–101.)

Editorial comments on reports of a receiver specially designed to make use of the pull-in ("mitnahme") effect. When there is no need of super-selectivity the receiver can be used in the normal manner. Re-radiation, when the receiver is employed in the oscillating condition, is prevented by a very high resistance in the audion anode circuit (keeping the oscillation amplitude very low) and by a preliminary screen-grid r.f. stage.

PROBLEMS OF PUSH-PUSH AMPLIFICATION.—C. E. Kilgour. (*Electronics*, March, 1932, pp. 82–83 and 112.)

"The term push-push is used when a two-tube, parallel, out-of phase stage of amplification is so biased as to cause first one tube to 'push' and then the other, in distinction to the case where the tubes are so biased that one 'pushes' while the other 'pulls,' as in the well-known push-pull amplifier." A push-push stage is, in fact, a push-pull circuit in which "Class B" bias is used (bias at about the cut-off point) instead of "Class A" as in a push-pull stage: *cf.* McLachlan, Abstracts, 1929, p. 391, and Barton, 1931, p. 560, and January, pp. 44; also Farrar, May Abstracts, p. 283. Examination of a valve characteristic shows that with full grid swing the power output is twice as large for the push-push case as for the push-pull, while the power required of the supply source is 27% greater: making the anode dissipation equal, the Class B bias would yield 3.7 times the output of Class A. But push-push amplification has certain important input requirements, if distortion is to be avoided. For this reason and because of the particular suitability of the system for battery receivers, the Type 230 valve has received considerable attention in connection with it. More than a watt output, with low harmonics, can be obtained from a pair of these valves in push-push, driven by a third 230; whereas the valve is rated at only 16 milliwatts for standard Class A operation.

THE AMPLIFICATION RATIO OF RESISTANCE-COUPLED VALVE COMBINATIONS: FINAL PART.—Kapteyn. (*See* under "Properties of Circuits.")

OUTPUT AMPLIFIERS FOR 110-VOLT D.C. RECEIVERS. J. R. Nelson. (*Electronics*, April, 1932, pp. 128–129 and 148.)

"The power output of d.c. receivers with a reasonable amount of distortion, using about 110 volts supply, has been somewhat limited in comparison with a.c. receivers . . . This paper will give the results of an experimental study of the output and distortion obtained using various tubes and combinations."

SOME EFFECTS OF TOPOGRAPHY AND GROUND ON SHORT-WAVE RECEPTION.—R. K. Potter and H. T. Friis. (*Proc. Inst. Rad. Eng.*, April, 1932, Vol. 20, pp. 699–721.)

Authors' summary:—This paper contains some results of an experimental study of the effects which ground and ground irregularities have upon short-wave signal reception. The results illustrate the signal strength advantage to be gained in the selection of suitable ground or topographical conditions and show the influence of antenna types, and vertical angle of signal arrival, upon such an advantage. Although the tests were confined to reception, the conclusions are probably applicable in general to the case of transmission. The agreement between measurement data and theory seems to justify the application of plane wave optical theory to the calculation of vertical plane directivity of antennas. Such an application suggests, according to the data obtained, that signals from South America are normally received at much lower vertical angles than those from England.

SENSITIVITY CONTROLS—MANUAL AND AUTOMATIC. —D. D. Israel. (*Proc. Inst. Rad. Eng.*, March, 1932, Vol. 20, pp. 461–477.)

From the Grigsby-Grunow Laboratories. Author's summary :—" Control of sensitivity is a problem that must go hand in hand with improvement in sensitivity. A highly sensitive receiver requires a total attenuation of as much as 160 db. Of this 80 db may be called ' sensitivity control ' which is that portion of control that permits a one-volt carrier to be received without demodulator overload. The remaining 80 db may be called ' level control ' with which the loud speaker response is attenuated to the proper level.

" The various basic manual control methods are discussed. Generally, manual control is accomplished in one or both of two ways ; viz., 1. Attenuate r.f. input. 2. Alter vacuum tubes' characteristics. The requirements for an ideal automatic sensitivity control are set down and the various basic systems discussed. High carrier level demodulator distortion as it affects certain systems is pointed out."

DEVELOPMENTS IN BROADCAST RECEIVERS DURING 1931.—(*Gen. Elec. Review*, Jan., 1932, Vol. 35, pp. 49–51.)

Including a diagram of the new type of automatic volume control in which the amount of r.f. and i.f. amplification is controlled entirely by the automatic volume control valve : the manual volume control has no effect on the sensitivity up to this point. Another point dealt with is the embodying of " tone equalisers," practically closed compartments on either side of the cabinet interior, each provided with an opening near the loud speaker cone. These openings are covered with acoustic absorbing materials, and the effect is that the " tone equalisers " absorb energy throughout the frequency range in which normal cabinet resonance occurs, and therefore decrease the " boominess."

THE BATTERY V-M THREE.—W. I. G. Page. (*Wireless World*, 30th March and 6th April, 1932, Vol. 30, pp. 314–318 and 341–343.)

A three-valve battery-operated receiver for the amateur constructor. A variable-mu valve is employed in the r.f. stage.

ONE KNOB CONTROL FOR SUPERHETERODYNES.—A. L. M. Sowerby. (*Wireless World*, 30th March, 1932, Vol. 30, pp. 320–324.)

In a superheterodyne in which one knob is used for controlling the tuning of the oscillator and signal frequency circuits, it is necessary to arrange for the former to be kept adjusted, over the whole of the tuning range, to a frequency differing by a constant amount from that of the latter. The author deals with the employment of tracking condensers for this purpose.

SUPERHETERODYNE IMPROVEMENTS.—W. T. Cocking. (*Wireless World*, 6th April, 1932, Vol. 30, pp. 338–340.)

The author summarises the tendencies in modern design. In order to reduce background noises to a minimum it is desirable to employ a preliminary stage of signal-frequency r.f. amplification, using a variable-mu valve. To attain a high degree of selectivity and quality it is necessary to employ several selective tuning circuits in conjunction with a tone correction valve.

WIRELESS WORLD MONODIAL A.C. SUPER.—W. T. Cocking. (*Wireless World*, 13th, 20th and 27th April, 1932, Vol. 30, pp. 364–368, 391–396 and 428–432.)

A seven-valve a.c. mains-operated superheterodyne receiver for the amateur constructor. The principal features are :—a preliminary stage of r.f. amplification at signal frequency, special band-pass filters with a total of eight tuned circuits, one stage of tone correction, volume control by variation of the grid bias of the signal-frequency and intermediate-frequency amplifiers, in which positions variable-mu valves are employed.

POLYDOROFF [IRON] CORES FOR SUPERHETERODYNES [EITHER IN PRE-SELECTOR STAGE OR OSCILLATOR].—Langley : Polydoroff. (*Electronics*, April, 1932, p. 131.)

See 1931 Abstracts, p. 498. " Because of the characteristics of the coils, whose inductance is varied by moving in or out the cores of ' polyiron,' an oscillator of constant output is possible, and a selector of constant gain over the broadcast band could easily be made." Constants for such an oscillator are given.

AUTOMATIC GRID BIAS.—M. G. Scroggie. (*Wireless World*, 13th April, 1932, Vol. 30, pp. 369–373.)

The author discusses various precautions necessary to avoid instability and attenuation of the bass when obtaining grid bias from voltages developed across resistances deliberately inserted for that purpose in various parts of the circuit.

THE MAGNIFICATION OF THE TUNED CIRCUIT.—A. L. M. Sowerby. (*Wireless World*, 13th and 20th April, 1932, Vol. 30, pp. 378–380 and 408–410.)

The author discusses the advantages to be gained by expressing the properties of a coil in terms of magnification rather than by the more general method of stating the series or parallel resistance. This alternative has a number of merits, notably in connection with selectivity measurements.

SHOULD RADIO RECEIVERS BE FUSED ?—(*Electronics*, April, 1932, p. 136.)

" Introduction of mercury vapour rectifiers to the home receiver market will bring into the open the question if sets shall be fused or not. . . . Even today, replacements of the transformer seem all too prevalent. A survey by *Radio Retailing* shows that roughly a half million power transformers and a quarter million filter chokes were replaced by service men in the year 1930."

A HIGHLY SELECTIVE AUDIO-FREQUENCY TRANSFORMER (VIBRATING REED TYPE) FOR RADIOTELEGRAPHIC CHANNELS SPACED ONLY 75 CYCLES.—Gunn. (*See* abstract under " Subsidiary Apparatus and Materials ".)

MORE ABOUT AUDIO SELECTIVITY [AND ITS USE IN RADIOTELEGRAPHY].—L. W. Hatry : Hull. (*QST*, March, 1932, Vol. 16, pp. 34–35.)

A practical addendum to Hull's paper (April Abstracts, p. 224.)

AERIALS AND AERIAL SYSTEMS.

Réflecteurs et Lignes de Transmission pour Ondes ultra-courtes (Reflectors and Feeders for Ultra-Short—18 Centimetre—Waves [Dover–Calais Service]).—R. Darbord. (*L'Onde Élec.*, Feb., 1932, Vol. 11, pp. 53–82.)

In the original Dover-Calais demonstrations the valves were mounted close to the dipoles in front of the spherical mirrors which directed the radiation on to the large parabolic mirrors. This plan had two objections: the valves and their connections were exposed to the weather, and the dipoles induced oscillations in the internal connections of the valves, which not only interfered with the functioning of the valves, but interacted with the dipole radiation and made it less pure. Later, as here described, these effects were avoided by separating the valves from the dipoles and using feeders. These are discussed theoretically in Appendix 2, while their design and advantages are dealt with in the later part of this paper (pp. 69–73). They are of the concentric type, of very special construction (Fig. 14) which allows valve and dipole to be easily matched.

The first part deals with the spherical and parabolic reflectors, first (and in Appendix 1) theoretically, using the Huyghens principle, and then practically. "The efficiency of a parabolic mirror is maximum when the focus lies in the plane of the aperture. Then, thanks to the transmitting parabolic mirror, the field reaching the receiving station is multiplied by a factor equal to the ratio of the half-perimeter of the aperture to the wavelength. Thanks to the receiving parabolic mirror, the field received by the receiving aerial is multiplied by the same factor." In the section on the spherical mirror it is mentioned that reflection at the mirror was found to produce a phase change of π and that a similar change was produced when the reflected rays passed through the centre of the sphere, so that a total change of 2π (equivalent to zero change) was obtained. Thus in order that the direct and reflected rays should agree, it is necessary that twice the radius should equal a whole number of wavelengths. This phase change of π on passing through a focus was proved by Gouy for sound waves and light, and by Tatarinov for Hertzian waves.

The wavemeters originally used were of the Lecher wire type and were not quite satisfactory, the resonance curves being somewhat flat. This was due to the fact that, at resonance, the r.f. current was limited by the dipole radiation resistance and by the resistance of the thermo-couple heater; as resonance was departed from, the reactance of the line did not take up sufficiently quickly a value large in comparison with these resistances. A satisfactory wavemeter has now been designed and tested, based on the concentric feeder system, and is described in pp. 73–77.

Note on a One-Wire Feeder for Travelling Waves.—G. A. Uger. (*Westnik Elektrot.*, No. 9, 1931, Sec. I, pp. 294–297: in Russian.)

Derivation of the equation for the electric field vector at a feeder of length l on the passage of a wave of length λ, and calculation of the radiation distribution as a function of l/λ. Using the Poynting method, the radiated power and radiation resistance are determined as functions of $2\pi l/\lambda$.

Reflectievrij Maken van Hoogfrequentleidungen (Elimination of Reflection in H.F. Feeders). — K. Posthumus. (*Tijdschrift Nederland. Radiogenoot.*, April, 1932, Vol. 5, No. 5, pp. 149–153.)

Author's summary:—A simple method is derived by which it is possible to eliminate standing waves on a symmetrical feeder by inserting only one correcting impedance. This can be done in four different ways, *i.e.*, either a choke coil or a condenser, both either in parallel or in series. Instead of a coil or a condenser, sections of transmission line may be used (*cf.* Roosenstein, 1931 Abstracts, pp. 147–148.)

Broadcasting Aerial System for the Suppression of Fading.—C. Lorenz Company and German P.O. (*Rad., B., F. f. Alle*, March, 1932, pp. 98–100.)

Editorial comments on the aerial system referred to in March Abstracts, pp. 166–167.

Characteristics of Airplane Antennas for Radio Range Beacon Reception.—H. Diamond and G. L. Davies. (*Proc. Inst. Rad. Eng.*, Feb., 1932, Vol. 20, pp. 346–358.) *See* 1931 Abstracts, p. 441.

Receiving Frame Aerials for Low-frequency Alternating Magnetic Fields [for Loth System].—Bourgonnier and Durepaire. (*See* under "Directional Wireless".)

The Vertical Polar Diagram of a Marconi Beam Aerial.—T. L. Eckersley. (*Marconi Review*, Jan.–Feb., 1932, No. 34, pp. 26–29.)

"The calculation is one of considerably greater difficulty than that required for the horizontal plane, and the reason for this lies in the uncertainty introduced by the finite conductivity of the earth," which has a profound effect with regard to the distribution of energy in the vertical plane. The method of calculation consists in taking account of the sum of the elements of field strength due to the direct waves and the reflected waves from the earth's surface. The calculation is based on the analysis given by the writer in *Proc. I.E.E.*, June, 1927, Vol. 65, where it is shown that an extension of Sommerfeld's analysis of the transmission of electric waves over the earth's surface may be made to yield the vertical polar diagram of a small aerial at a height h above the surface.

In a Franklin uniform aerial the effective current in the aerial is nearly a constant. In the calculation, the effective radiating current is assumed as constant; the reflector is taken into account by multiplying by a factor, σ is taken as $1/2 \times 10^{12}$, ϵ as 5, and aerial height as 3λ (= 66 m). Fig. 2 gives the calculated diagrams, curve 2 being on a larger scale so as to show the back radiation. "Perhaps the most striking result is the extraordinary concentration of energy in the lower angle directions. The maximum radiation occurs at only

2° elevation and practically the whole of the energy is radiated below 20°." The zero radiation along the horizontal direction implies that at great enough distances the radiation projected horizontally is negligible compared with that at a finite angle (*cf.* curves given by Strutt and by Howard Wise). As regards back radiation, the main loops are at 35° and 50°, and the maximum amplitude ratio is only 1/142.

APPLICATION OF PLANE WAVE OPTICAL THEORY TO CALCULATION OF VERTICAL PLANE DIRECTIVITY OF AERIALS.—Potter and Friis. (*See* abstract under " Reception.")

A METHOD FOR DETERMINING THE EFFECT OF THE EARTH ON THE RADIATION FROM AERIAL SYSTEMS.—J. S. McPetrie. (*Journ. I.E.E.*, March, 1932, Vol. 70, No. 423, pp. 382–390.)

Author's summary :—In an earlier paper [1931 Abstracts, pp. 211–212] the author described a graphical method for determining the magnitude and phase of the electric field in the neighbourhood of an aerial carrying a current of known distribution. The major portion of that paper neglected the effect of the earth, although an indication was given of a method for taking account of the image of the aerial in the earth. The first part of the present paper elaborates this explanation and shows how the results given in the earlier paper may be modified in order to take account of the electrical constants of the earth's surface. A formula is deduced for the field at any point near the earth's surface due to a given doublet, and it is shown how this formula may be extended in order to determine the field at various distances from an aerial carrying a current of known distribution. The second part of the paper shows how the field at any distant point may be found directly for any number of equal aerials and reflectors from a knowledge of the field at the same point due to one aerial and reflector alone. The current in the reflector wire need not be equal in magnitude or in phase to that in the aerial, and the components of the array may be either vertical or horizontal.

THE SPREADING OF ELECTROMAGNETIC WAVES FROM A HERTZIAN DIPOLE.—J. A. Ratcliffe, L. G. Vedy and A. F. Wilkins. (*Wireless Engineer*, March, 1932, Vol. 9, pp. 140–142.)

Long abstract of I.E.E. paper. The theoretical investigation is confirmed by experiments on wavelengths of 1 000 and 1 554 m. The variation of field with distance, re-radiation from an aerial, and the absolute value of field intensity due to an aerial with its lower end earthed, are dealt with.

THE FIELD IN THE IMMEDIATE NEIGHBOURHOOD OF A TRANSMITTING AERIAL.—G.W.O.H. : Ratcliffe, Vedy and Wilkins : Zickendraht. (*Wireless Engineer*, March, 1932, Vol. 9, pp. 119–122.)

An editorial on the papers dealt with above and in April Abstracts, p. 239.

STUDY OF THE HARMONICS OF SYMMETRICAL AND ASYMMETRICAL DIPOLE OSCILLATORS.—K. F. Lindman. (*Acta Åbo*, No. 7, Vol. 6, 130 pp.)

Continuation of the work dealt with in 1929 Abstracts, p. 574. With Hertz rod oscillators of fundamental wavelength about 1.5 m, it was found that when the dipole was excited by a spark gap in the middle, the odd harmonics were absent ; but these were all present in a secondary resonator without any spark gap. By earthing, or feeding the potential at a point where an antinode was desired, the various harmonics could be suppressed or brought up. Dielectrics near the ends of the dipole increased the wavelength. If the exciting spark gap was arranged asymmetrically, the intensities and lengths of the first harmonics were different in the two halves of the dipole.

FELDVERTEILUNG UND ENERGIEEMISSION VON RICHTANTENNEN (Field Distribution and Energy Emission of Directive Aerials).—E. Siegel and J. Labus. (*Hochf:tech. u. Elek:akus.*, March, 1932, Vol. 39, pp. 86–93.)

Authors' summary :—On the basis of van der Pol's solution for the electric radiation field produced by a dipole and for the energy emitted by such a dipole, the field distribution and energy emission are investigated from aerials excited to harmonics and from combinations of dipoles excited in the same phase (series of dipoles, groups of dipoles, and Telefunken beam systems). Formulae are given for the calculation of the field distribution in space, and of the radiation resistance, for the most important arrangements.

CONTRIBUTION TO THE EXPERIMENTAL STUDY OF ELECTRICAL INDUCTION.—A. Turpain and H. Sabatier. (*Comptes Rendus*, 7th March, 1932, Vol. 194, pp. 853–855.)

" When two wireless stations, a transmitter and a receiver, each with a single-wire aerial, are in communication, it is assumed that the transmitting aerial plays an inducing rôle with respect to the ' induced ' receiving aerial. The transmission from one to the other, since Hertz' experiments, has been considered to be an extension of the action which, in the phenomenon of induction, the ' inducing ' circuit produced on the ' induced.' Now in the case of two single-wire aerials, fixed with regard to each other, there can be no question of invoking a variation of the induction flux ϕ which is of a value essentially composed of the product of a field H and a surface S ; $\phi = HS$. In the case of single-wire aerials with a wire diameter of the order of a millimetre, the aerials being separated by many tens of kilometres, the surface S of the ' induced ' conductor is zero. The purely experimental question arises : *is a variation of the field H, by itself, sufficient to create induction ?* Is it enough that the lines of force striking a wire conductor should vary with time, for this conductor to be the seat of an inductive effect ? "

Experiments are described, both with open and closed " induced " circuits at close quarters, in which no induction effect whatever could be detected as due only to the " shock " of the lines of force of the field on a wire conductor, either at the make or break of the inducing circuit. The strength of the inducing current ranged from 2 to 10 and 30 amperes, and the galvanometers could detect currents of 10^{-7} and 10^{-9} ampere.

Graphical Method of Calculating the Mechanical Design of an Aerial.—I. S. Gonorovsky. (*Westnik Elektrot.*, No. 8, 1931, Sec. I, pp. 241–246: in Russian.)

The formulae serving for the mechanical calculation of power lines do not give satisfactory results for aerials. The writer gives a complete method of solution using graphical statics, and applies it to the calculation of the most important types of transmitting aerial systems.

The Electromagnetic Field produced by a Wire [of Infinite Length] Traversed by a Sinusoidal Current above a Conducting Layer.—Dubourdieu. (*See* under "Properties of Circuits.")

A Simple Non-polarising Earth for Curing "Noisy Grounds" [Daniell Cell Porous Pot, Copper Sulphate Solution and Copper Rod].—W. Butz. (*QST*, March, 1932, Vol. 16, pp. 43–44.)

VALVES AND THERMIONICS.

Über die Elektrizitätsleitung von Bariumoxyd in Zusammenhang mit der Elektronenemission (The Electrical Conduction of Barium Oxide and its connection with Electronic Emission [the Actions in the Activating Process and in Actual Working]).—W. Meyer and A. Schmidt. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 13, 1932, pp. 137–144.)

Of the three interpretations of the activating process for barium-oxide cathodes (thermal, electrolytic, and the reducing action of the binding material or of the core), the last-named can certainly only have an effect which is limited in time. Hitherto it has been generally assumed that the processes in the actual working conditions of an oxide-coated cathode represent a state of dynamic equilibrium, in which the quantity of barium forming is equal to the quantity evaporated; the question arises whether this state of equilibrium is based on thermal or electrolytic action.

The writer has therefore investigated the resistance of the unformed and formed BaO, in order to get as clear an idea as possible of the transition between the two and to decide the above question. The conclusions reached are as follows:—The change of the oxide into its electron-emitting form cannot take place through a purely thermal treatment up to 1 000° C. without the presence of a reducing factor. A direct-current treatment, on the other hand, produces the change electrolytically; as a result, the shape of the current/voltage curve is altered, the electrolytic formation of metallic filament disappears, and the temperature coefficient and the absolute value of the resistance become considerably smaller. The measurements lead to the supposition that *the electrolytic action produces a barium suboxide with high electronic conductivity*, of unknown composition but apparently corresponding to the subchloride found by Haber and Tubandt. The results can *not* be explained by assuming a mixture of Ba and BaO in place of this suboxide Ba_xO. The latter appears to play an important rôle in both the activating and the emitting processes.

Die Kennlinie der Elektronenröhren (Thermionic Valve Characteristics).—A. Gehrts. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 13, 1932, pp. 117–122.)

Author's summary:—Our calculation of the characteristic curve of the [old Telefunken] valve RE 16 and the comparison with the measured characteristic lead to the following conclusion:

In incandescent-cathode single-grid valves with cylindrical electrodes, when the grid bias is negative, the electron current flowing can be calculated according to the Langmuir-Schottky space-charge law ($V^{3/2}$ law). With equipotential cathodes which are at a uniform temperature, the active voltage is to be taken as the algebraic sum of the effective voltage, the Volta potential, the threshold potential [$-V_m = \frac{T}{11\,600} . ln\left(\frac{I_s}{I_a}\right)$, where I_s is the saturation current. This value, given by Schottky, was for plane electrodes, but holds approximately for cylindrical electrodes if— as is usually the case —the distance of the threshold surface from the cathode is only small] and the correction factor for the natural velocities of the electrons. The effect of the potential drop along the cathode can be allowed for by the addition or subtraction of half the heating voltage (Greinacher, Kato) but is most easily dealt with, together with the variation of temperature along the cathode, by graphical integration.

In calculating the effective voltage, allowance must be made for the influence on it of the space charge field, pointed out by Schottky. Slight discrepancies between the measured and calculated current values are due to inexactness of the correction factor for the initial velocity of the elctrons. As constant in the $V^{3/2}$ law the Langmuir-Schottky constant $G = 14.65 \times 10^{-6} \frac{l}{r_a \beta^2}$ is to be taken.

Raumladeströme von Oxydkathoden (Space-Charge Currents in Oxide-Coated Cathodes).—A. Gehrts. (*Zeitschr. f. tech. Phys.*, No. 4, pp. 192–195.)

Continuation of the work dealt with above. The comparison of the calculated and measured space-charge characteristics of the Telefunken indirectly heated a.c. valve REN 904 enables the influence of the transverse resistance of the oxide layer on the shape of the characteristic to be determined. This transverse resistance flattens the curve and, varying exponentially with the reciprocal of the cathode temperature, causes a marked dependence of the steepness of slope of the characteristic on that temperature. Space-charge current measurements give values for the transverse resistance which agree well with the measured values arrived at by Lübcke and Kroczek (1931 Abstracts, p. 270), namely 5 000 decreasing exponentially to 100 ohms/cm as the temperature changes from 800 to 1 000° C.

Characteristics of the UV-858 Power Tube [Radiotron Triode, Water-Cooled] for High-Frequency Operation.—M. A. Acheson and H. F. Dart. (*Proc. Inst. Rad. Eng.*, March, 1932, Vol. 20, pp. 449–460.)

Authors' summary:—"This paper indicates

the need for high power vacuum tubes for high-frequency transmission, and discusses new factors most important in the design of a tube for this usage. Older types of tubes were built with high efficiency, low-frequency use in view, with the result that when applied to high frequencies they were severely limited by allowable operating voltage and by large internal capacities and inductances. However, by operating class B amplifiers and thus dispensing with the power modulator, and by minor sacrifices in efficiency in class B or class C operation, it is possible to design a tube having greatly increased high-frequency rating, although it has no usual advantage at low frequency. The actual design of such a high-frequency tube and the resulting characteristics and ratings are given for the UV-858 Radiotron. From these data some of its important uses are indicated and its possibilities in such uses may readily be estimated.

Results of special tests involving new phenomena, possible for the first time with this tube, are given." These special tests were at ultra-high frequencies. At 50 megacycles it was estimated that 5 to 10 kw were radiated : an arc would form on the end of the half-wave aerial, extending 12 or 15 inches into space. The valve was also made to generate considerable power as a B.-K. oscillator. Other results refer to space currents and heating effects.

500 KILOWATT DEMOUNTABLE VALVES.—Metropolitan-Vickers Company. (*P.O. Elec. Eng. Journ.*, April, 1932, Vol. 25, Part 1, pp. 61–64.)

Illustrated description of the valve referred to in February Abstracts, p. 98.

NEW TUBES—DETECTORS, RECTIFIERS, AMPLIFIERS [TRIPLE-TWIN, CLASS B AMPLIFIER VALVE, WUNDERLICH DETECTOR, ETC.].—(*Electronics*, April, 1932, pp. 118–120 and 148.)

"Class B amplification talk has crystallised suddenly with the announcement and introduction of a new tube (the 46) designed primarily for this purpose. It will deliver upwards of 10 watts, more or less undistorted. . . . The attendant difficulties of poor regulation seem to be partially solved by the development and introduction of a new rectifier, a double-wave mercury vapour tube (the 82) with low internal voltage drop." This RCA 46 valve is discussed later in the article, together with the Triple-Twin (*see* May Abstracts, p. 285), both in simple and push-pull circuits. "It looks as though Class B amplifiers, or the Triple-Twin, may provide the way out of the pentode situation."

As regards the Wunderlich detector, this is said to have "definite advantages. The input so far as r.f. is concerned is push-pull ; the a.f. output is normal." The valve has two grids arranged in a co-cylindrical fashion about the cathode. The circuit yields at a certain point a negative potential of amplitude depending on the incoming signal : this potential can be applied to the automatic volume control. After detection, the valve acts as an audio-frequency amplifier with the two grids in parallel. "It is reported that as much as 20 volts can be available for volume control without severe distortion on heavy modulation." *See* also Terman, below.

Triple grid valves are also mentioned, of peculiar shape owing to an internal shield which reduces the interelectrode capacity. "One of the new tubes not yet publicly announced is a triode of greater amplification than the 227, of a mutual conductance of about 1 500 and specially adapted to economical set construction."

NOTES ON THE WUNDERLICH TUBE [FOR GRID LEAK POWER DETECTION].—F. E. Terman : Wunderlich. (*Electronics*, April, 1932, p. 148.)

See preceding abstract. The new valve "can be thought of as a triode with a second grid wound between the meshes of the usual grid." It gives "full-wave grid rectification in a balanced circuit in which negligible r.f. currents flow in the plate circuit. This feature has two important advantages—it approximately doubles the output voltage by eliminating simultaneous plate and grid rectification, and makes unnecessary the r.f. filter in the detector plate circuit." Other properties, and the working conditions, are discussed.

POWER DETECTION CHARACTERISTICS OF PENTODE TUBES.—H. A. Brown and C. T. Knipp. (*Electronics*, April, 1932, pp. 126–127 and 150.)

The writers conclude that pentodes show quite highly desirable detection characteristics : "the pentode type of tube seems to be not merely a tube functioning satisfactorily on power detection, but it really seems to be a *power detector*, putting out, roughly estimating, ten times as much power as any other type of detector with which the writers are familiar."

THE OPERATION OF VACUUM TUBES AS CLASS B AND CLASS C AMPLIFIERS.—Fay. (*Proc. Inst. Rad. Eng.*, March, 1932, Vol. 20, pp. 548–568.) *See* May Abstracts, p. 283.

THE POSITIVE-GRID TUBE [WORKING AS A CLASS B AMPLIFIER AND GIVING 20 WATTS UNDISTORTED OUTPUT].—L. Martin. (*Radio Craft*, March, 1932, Vol. 3, p. 523.)

THE OUTPUT POWER OF THE FINAL STAGE.—Benz. (*See* abstract under "Acoustics and Audio-frequencies.")

CHOOSING A SCREEN-GRID TUBE [AND THE FAILURE OF TRANSCONDUCTANCE AS AN INDEX TO THE OPERATING CHARACTERISTIC].—R. de Cola. (*Rad. Engineering*, Dec., 1931, Vol. 11, pp. 15–16.)

WHICH TUBE FOR THE CRYSTAL OSCILLATOR ?—G. Grammer. (*QST*, Feb., 1932, Vol. 16, pp. 24–26 and 88.)

VALVE WITHOUT FILAMENT OR VACUUM.—A. Hund. (*Rad., B., F. f. Alle*, March, 1932, p. 98.)

Editorial comments on American reports of Hund's new valve : "no filament, no vacuum, performance equal to that of a triode, very simple construction, consequent cheapness, universal application not only for reception but also for transmission."

CONTROL CONDITIONS OF GRID-CONTROLLED GAS DISCHARGES—ION CONTROL VALVES [E.G., THYRATRONS].—Klemperer and Lübcke. (*See* under "Subsidiary Apparatus and Materials.")

AN AUTOMOBILE TUBE OF INCREASED OUTPUT [EVEREADY RAYTHEON TYPE LA].—M. Bareiss. (*Electronics*, March, 1932, p. 96.)

VACUUM TUBE PERFORMANCE *versus* MANUFACTURING TOLERANCES.—W. Charton. (*Electronics*, Feb., 1932, pp. 44–45 and 74.)

CAN RADIO TUBES BE SOLD ABROAD?—S. E. Laszlo. (*Electronics*, March, 1932, pp. 92–93.)

A METHOD OF MEASURING EMISSION CURRENT OF AN ELECTRON TUBE [SHORT-PERIOD APPLICATION OF ANODE-VOLTAGE TO AVOID DAMAGE IN OVERLOADING].—E. Iso and H. Ikushima. (*Journ. Inst. T. and T. Eng. Japan*, Dec., 1931, p. 1549: in Japanese.)

Using a condenser discharge through a spark gap or a thyratron.

DIRECTIONAL WIRELESS.

A SIMULTANEOUS RADIOTELEPHONE AND VISUAL RANGE BEACON FOR THE AIRWAYS.—F. G. Kear and G. H. Wintermute. (*Proc. Inst. Rad. Eng.*, March, 1932, Vol. 20, pp. 478–515.) *See* 1931 Abstracts, p. 619.

LE SONDAGE ACOUSTIQUE PAR ÉCHOS À BORD D'AÉRONEFS BRUYANTS (Acoustic Sounding by Echoes on board Noisy Aircraft).—C. Florisson. (*Comptes Rendus*, 4th April, 1932, Vol. 194, pp. 1149–1150.)

By the methods here described the writer has made a successful acoustic altimeter in spite of the usual aircraft noises. The nature of the echoes actually gives interesting information as to the subjacent earth—thus different effects are noted above flat ground, villages, sea and woods.

ECHOES FROM DANGER POINTS GUIDE BOAT THROUGH FOG [SONIC LOCATOR, USING 3 000-CYCLE WHISTLE].—C. W. Rice. (*Sci. News Letter*, 13th Feb., 1932, Vol. 21, p. 103.)

LANDING BLIND [USE OF A SERIES OF CONCENTRIC CABLES TO GIVE POSITION AND APPROXIMATE HEIGHT].—F. Celler. (*Aviation*, Dec., 1931, Vol. 30, pp. 699–700.)

LES CADRES DE RÉCEPTION POUR CHAMPS MAGNÉTIQUES ALTERNATIFS À BASSE FRÉQUENCE (Receiving Frame Aerials for Low-frequency Alternating Magnetic Fields [for Loth Systems]).—C. Bourgonnier and M. Durepaire. (*Rev. Gén. de l'Élec.*, 26th March, 1932, Vol. 31, pp. 403–410.)

The authors give a mathematical analysis to determine the optimum number of turns for such a frame, basing the analysis on certain hypotheses which are later confirmed by experiment.

PREVENTION OF AIRCRAFT COLLISIONS BY INFRA-RED RAYS AND THE FOURNIER-CÉMA CELL.—(*See* abstract under "Miscellaneous.")

ELECTRONIC DIRECTION FINDER [COMPASS].—P. Schwerin, Perriman Electric Company. (Summary of British patent in *Electronics*, March, 1932, p. 111.)

"A vacuum tube with an anode and two auxiliary electrodes, arranged so that by means of four pieces of high magnetic permeability and low permanent magnetism, the earth's magnetic field will draw the electrons to one or the other of the electrodes."

DIRECTIONAL OBSERVATION OF LOW-FREQUENCY WAVES.—E. Yokoyama, T. Nakai and I. Tanimura. (*Res. Electrot. Lab. Tokyo*, No. 315, 1931, 55 pp. and plates: in Japanese.)

ACOUSTICS AND AUDIO-FREQUENCIES.

ACOUSTIC ALTIMETER FOR AIRCRAFT.—Florisson. (*See* abstract under "Directional Wireless".)

ON THE EQUIVALENT MASS OF DRIVEN LOUD SPEAKER CONES.—M. J. O. Strutt. (*Wireless Engineer*, March, 1932, Vol. 9, pp. 143–150.)

The method employed for measurement is one of direct substitution; a stretched steel band carrying the cone is vibrated by an electromagnetic driving system, the resonance frequency determined, and the cone replaced by an adjustable mass until the same resonance frequency is obtained. The mass of the cone can thus be determined as a function of frequency between 20 and 2 000 c/s. The mass is much smaller when the driving point movement is at right angles to the cone axis than when it is along the axis. The variation of mass with frequency is much more abrupt in the former than in the latter case. This agrees with the fact that there are always, at a given frequency and with appropriately driven cones, many more radial nodes than circular ones. The final section deals with measurements *in vacuo* and the determination of the additional mass due to air-motion.

EXTENSION DU DOMAINE DES FRÉQUENCES ACOUSTIQUES REPRODUITES AVEC FIDÉLITÉ PAR HAUT-PARLEURS (Extension of the Frequency Range faithfully reproduced by Loud Speakers [Combination of Several Loud Speakers with Different Characteristics, Several Amplifiers and Corresponding Filters, for Sound Film Reproduction]).—P. Toulon: Établissements Charlin. (*L'Onde Élec.*, March, 1932, Vol. 11, pp. 139–156.)

The final arrangement consists of one high frequency speaker in the middle, surrounded by a circle of five medium frequency speakers, with an external square of four low frequency speakers. All the speakers are Charlin modifications of the Rice-Kellog type, and the three frequency ranges are approximately 10 to 300, 500 to 2 000, and 2 000 to well over 10 000 c/s.

ÜBER DEN EINFLUSS VON QUELLENWIDERSTAND UND PARALLELKAPAZITÄT AUF DIE FREQUENZKURVE VON LAUTSPRECHERN (The Influence of the Resistance of the Current Source [Output Valve Stage] and Parallel Capacity on the Frequency Characteristic of a Loud Speaker).—F. Söchting and W. Nowotny. (*Elektrot. u. Masch:bau.*, 28th Feb., 1932, Vol. 50, pp. 135–138.)

Fig. 1 shows the frequency curves of a loud speaker, obtained by the use of a Gerlach sound pressure meter (Wolman and Kaden, January Abstracts, p. 41), for the cases $R_i = 0$ (constant voltage at the terminals of loud speaker) and $R_i = 50\,000$ ohms (three-grid valve). For equal strengths at the highest frequencies, the sound pressures of the lower notes are reduced to about one-tenth (acoustic power 1/100) in the second case. This illustrates the importance of a thorough understanding of the effect, for in many cases for one reason or another the valve resistance is not small compared with the impedance of the loud speaker.

The paper therefore first investigates the effect of the valve internal resistance on the frequency characteristic, which is shown to be principally a discrimination in favour of the higher frequencies. Attempts to remove this effect by connecting a condenser in parallel with the loud speaker do not always meet with the success expected, as is shown in the second half of the paper.

THE LOUD SPEAKER COIL OF OPTIMUM MASS.—N. W. McLachlan: Strafford. (*Wireless Engineer*, March, 1932, Vol. 9, p. 151.)

Strafford's letter on the importance of coil mass in midget design loud speakers, dealt with in May Abstracts, p. 290, " comes at an opportune moment. I have been studying the problem analytically and experimentally, and what follows may be of interest."

CALCULATION OF LOUDSPEAKER EFFICIENCY.—I. Wolff. (*Electronics*, Feb., 1932, pp. 52–53 and 76.)

Owing to the conditions under which a loud speaker is used, a special definition of efficiency, the " absolute efficiency," is more useful than the usual definition of power delivered/power supplied. " The general definition which the I.R.E. has given for the absolute efficiency of electro-acoustic apparatus, when applied to loud speakers, can be interpreted as follows :—the absolute efficiency of a loud speaker, for a given speaker not of the relay type, is given by the following formula :

$$Eff. = \frac{\frac{4z_r}{|z^2|}\left|M^2\right|R_s}{\left|\frac{M^2}{z} + Z + R_s^2\right|}."$$

The symbols in this formula are defined, and an illustration is given of the use of the formula to calculate the absolute efficiency of a m.c. loud speaker. Certain simplifying assumptions are made which no longer hold when the frequencies are such that the depth of the cone becomes comparable with the wavelength, so that the calculation is not carried above 1 600 c/s. For calculation of efficiency where the more complex phenomena take place, reference is made to Strutt's paper (March Abstracts, pp. 169–170).

The determination of the response in any direction, by means of the calculated efficiency values and the directional radiation curves, is also discussed.

BASS DRUM AND TYMPANI—THE 5 000 CYCLE LIMIT.—(*See* under " Reception ".)

THE VOLF RESONATOR AND MODULATOR.—(*Electronics*, March and April, 1932, pp. 102 and 144.)

" The principle of the Helmholtz resonator, with many tuned tubes, echoing on to water, is used." A small model has a dynamic unit and 65 resonating tubes, all of different lengths and diameters and appropriate to different notes and overtones. Water in a container at the bottom changes a surface sound wave into a compressional wave—" the only wave-form which progresses by simple radiation and is therefore not distorted by obstructions such as walls and objects in a room or auditorium."

" TONE EQUALISERS " IN BROADCAST RECEIVERS.—(*See* " Developments in Broadcast Receivers" under " Reception.")

AMPLIFIER TONE CONTROL CIRCUITS [SUGGESTION OF SIMPLIFIED MATHEMATICAL TREATMENT].—R. H. Nisbet: Scroggie. (*Wireless Engineer*, March, 1932, Vol. 9, p. 153.)

On Scroggie's paper dealt with in April Abstracts, p. 230.

THE VIBROMETER.—H. Subra. (*Rev. Gén. de l'Élec.*, 19th March, 1932, Vol. 31, pp. 371–376.)

Including a section on the application of this device to acoustic measurements, such as measurements of the acoustic impedance of a loud speaker and the efficiency of a microphone. *Cf.* Kobayasi, 1931 Abstracts, p. 329.

WATTLESS RETROACTION [AND ITS APPLICATION TO ELECTRO-MECHANICAL SYSTEMS SUCH AS TUNING FORKS AND VARIOUS RESONATORS].—Braude. (*See* under " Properties of Circuits.")

RECORDING OF LONG PROGRAMMES OR BOOKS: AN AUSTRIAN DEVICE.—I. J. Saxl: Thirring and Richtera. (*Electronics*, March, 1932, p. 85.)

An article based apparently on the Selenophon sound-on-paper system dealt with in 1930 Abstracts, p. 512. The importance of " talking books for the blind " is emphasised.

A NEW METHOD OF RECORDING SOUND AND VIBRATIONS [PHOTOGRAPHIC VERSION OF THE HYDRAULIC MICROPHONE].—H. Greinacher. (*Schalltechnik*, No. 6, Vol. 4, pp. 94–96.)

La Reproduction des Enregistrements inscrits sur Pellicule cinématographique (The Reproduction of Sound-on-Film Records [particularly the "Stellor" Reproducing Equipment].—P. Toulon. (*L'Onde Élec.*, March, 1932, Vol. 11, pp. 129–138.)

Über die Bestimmung der Ausgangsleistung von Verstärkern (The Determination of the Output Power of Amplifiers).—F. Benz. (*Mitteil. Tech. Versuchsamtes, Vienna*, No. 1/4, Vol. 20, pp. 84–89.)

Among the various expressions for power connected with an amplifier, a very important one, from the point of view of output, is the anode power capacity of the final stage. This anode power capacity (anodenaufnahmeleistung) must not be confused with the power delivery (leistungsabgabe) of the valve itself, which is connected with the maximum power obtainable from the valve *as an oscillator*. This power, a multiple of the anode dissipation, is also the theoretical maximum derivable at all from the valve without regard to fidelity. It must never be used as the basis for calculating an amplifier: the writer estimates the maximum undistorted output power for an ordinary output stage at *one-eighth* of the anode dissipation, or *one-fifth* for a push-pull stage. In actually designing an amplifier, *one-tenth* should be taken to replace the maximum one-eighth.

A table gives examples of the calculated and observed values for a simple and for a push-pull output: the output valve in each case has an anode dissipation of 100 watts, so that the undistorted powers delivered to the loud speaker, calculated for the two amplifiers, are 12.5 and 20 watts respectively. The corresponding measured powers are 10 and 15 watts.

Sulle Unità pratiche in Acustica e sulle Misure fonometriche. Un nuovo Fonometro per Tutte le Frequenze (Practical Units in Acoustics, and Phonometric Measurements. A New Phonometer for All Frequencies [using a Neon Tube Generator]). —A. Bernini. (*Nuovo Cim.*, No. 9, Vol. 8, 1931, pp. 321–330.)

Correction to "Measuring Frequency Characteristics with the Photo-Audio Generator."—J. H. O. Harries: Schäffer and Lubszynski. (*Proc. Inst. Rad. Eng.*, Feb., 1932, Vol. 20, p. 363.)

Correction of an error in the Schäffer-Lubszynski paper (1931 Abstracts, p. 563) in the calculation of the screen area exposed by the perforated disc. *See* also Lubszynski, below the above-named abstract.

Over Isoleering van het Geluid (The Insulation of Sound [Tests on Cork, Kapok, Bamboo Tissue, Newsprint, etc.]).—R. Moens. (*Natuurwet. Tijdschr.*, No. 6, Vol. 12, pp. 200–206.)

A Circuit whose Retroaction is Independent of Frequency.—Brillouin and Lévy. (*See* under "Properties of Circuits.")

Frequency Characteristics in Film Recording and Reproducing.—G. Lewin. (*Electronics*, Feb., 1932, pp. 40–42.)

Application of Norris-Andree Method of Reverberation Measurement to Measurements of Sound Absorption.—R. F. Norris. (*Journ. Acous. Soc. Am.*, No. 3, Vol. 3, 1932, pp. 361–370.)

Transmission of Sound through Apertures [Confirmation of Lamb's Predictions].—E. Ritchie. (*Journ. Acous. Soc. Am.*, No. 3, Vol. 3, 1932, pp. 402–414.)

The Determination of Absorption Coefficients for Frequencies up to 8 000 Cycles.—F. L. Hopper. (*Journ. Acous. Soc. Am.*, No. 3, Vol. 3, 1932, pp. 415–427.)

The Apparent Reduction of Loudness.—D. A. Laird, E. Taylor and H. H. Wille, Jr. (*Journ. Acous. Soc. Am.*, No. 3, Vol. 3, 1932, pp. 393–401.)

On the Loudness of Noise.—H. B. Marvin. (*Ibid.*, pp. 388–392.)

The Noise Survey of the Rapid Transit Lines of New York City.—G. T. Stanton and J. E. Tweeddale. (*Ibid.*, pp. 371–387.)

The New Music of Electronic Oscillations: the Latest Instruments of Theremin, Ranger and Miessner.—(*Electronics*, March, 1932, pp. 86–87 and 114.)

Electrical Music.—O. Vierling. (*E.T.Z.*, 18th Feb., 1932, Vol. 53, pp 155–159.)

A survey, leading up to the latest ideas in producing the sound mechanically and controlling timbre, etc., electrically (*see* also 1931 Abstracts, p. 621).

PHOTOTELEGRAPHY AND TELEVISION.

Television on a Light Beam.—E. F. W. Alexanderson: G. E. C. (*Elec. World*, 30th Jan., 1932, Vol. 99, p. 217.)

Paragraph on a recent demonstration. "The work thus far is highly experimental, yet some day we may see television broadcast from a powerful arc lamp, mounted atop a tower high above the city. The modulated light waves will be picked up in the houses by individual photoelectric tubes instead of by the present type wire antennas." An arc lamp was used in which the light came from the arc rather than from the crater.

New Scanning Method [Irregular Strip Sequence].—Toulon. (Summary in *Electronics*, March, 1932, p. 105.)

By the resulting rapid covering of the whole object, the eye receives a rough impression which is then made more precise as the other intervening strips are scanned. A reduction is claimed of 50% in the number of points per second for equal definition, together with absence of flicker. *Cf.* Browne, end of next abstract.

MULTI-CHANNEL TELEVISION.—C. O. Browne. (*Journ. I.E.E.*, March, 1932, Vol. 70, No. 423, pp. 340–349 : Discussion, pp. 349–353.)

The full paper referred to in April Abstracts, p. 231. In the discussion, Dowsett mentions that the Marconi Company is experimenting with a Kerr cell with a gap around 1.1 mm and a maximum voltage about 3 800 v. As an alternative to sweeping one-fifth of the picture over each photocell, he suggests that the lens should sweep the whole picture over the five photocells, so that the picture would be sent along each channel with a phase difference of one-fifth of the total time. W. D. Wright stresses the importance of the author's method of calculating the attenuation due to the finite aperture of the scanning spot: "hitherto there has been much confusion of thought as to the connection between size of scanning spot, amount of detail in received image, frequency band, and the dot analogy of newspaper photographs. It should now be clear that the detail transmitted and received depends solely on the frequency characteristic of the system, provided that this includes the attenuation due to the size of the scanning aperture. . . ."

Bailey, dealing with certain amplifier difficulties, suggests that a band amplifier from (say) 1 000 to 1 025 instead of from zero to 25 kc/sec. would be a less difficult achievement: the final rectification of the high-frequency currents might take place either in the last stage of the amplifier or possibly even in the Kerr cell itself. "Since the latter has an approximately bi-quadratic law, it would rectify and demodulate a high-frequency signal. This leads to other interesting possibilities such as the use of a solution in nitrobenzene of one or more bi-polar substances, which are known to resonate at the higher frequencies and to give a very much increased Kerr effect. This phenomenon is probably due to an actual rotation of the molecule at a frequency of the order of 10 to 20 mc/sec. The resonant effect, if sufficiently broad, might be used to increase the amplification of the Kerr cell in the final stage."

Replying to Wright, the author mentions that he has found empirically that with the comparatively feeble illumination of a television image the angular resolving power of an average eye amounts to 5 minutes of arc, so that the received image, 24″ × 16″, should be viewed from a distance of 29′. Replying to Angwin, he has found no better scanning sequence than that of a uniform progression across the picture: irregular scanning sequences, in practically every case, produce an illusion of a number of lines moving slowly across the screen. *Cf.* Toulon, preceding abstract.

HIGH VOLTAGE KERR CELL.—H. M. Dowsett. (*See* above abstract.)

RESONANCE EFFECTS IN KERR CELLS USING BI-POLAR SUBSTANCES IN NITROBENZENE.—C. E. G. Bailey. (*Ibid.*)

SUGGESTED SLOW-SPEED SURVEY OF OBJECT SUPERIMPOSED ON USUAL DETAIL SCANNING [MAKING USE OF CONTINUITY OF PARTIAL OBSERVATION].—G. E. Land. (*Television*, Feb., 1932, Vol. 4, p. 482.)

PROGRESS IN TELEVISION : TELEVISION PROGRESS FROM AN ENGINEERING VIEWPOINT.—J. Dunsheath : P. G. Weiller. (*Rad. Engineering*, March, 1932, Vol. 12, pp. 11–13 : 16–17 and 37.)

SUBMARINE TELEVISION.—Hartmann. (*Funk, Berlin*, 1st Jan., 1932 : short summary in *Electronics*, March, 1932, p. 105.)

SUBMARINE TELEVISION [FOR EXPLORING THE DEPTHS OF THE SEA].—(*La Nature*, 1st Feb., 1932, pp. 101–102.)

TELEVISION RECEIVER WITH BRIGHTER IMAGE.—W. H. Peck. (*Electronics*, April, 1932, p. 144.)

Employing a lens system claimed to utilise 80% of the available light "instead of 0.02777 of 1% obtained with the usual punched-hole scanning disc." All the light from a neon-crater tube is concentrated into a beam through a condenser lens and is focused on to a prismatic reflector. Recently demonstrated, the receiver gave well-lighted images on a 12 × 14 inch screen.

PECK SCANNING SYSTEM FOR TELEVISION.—W. H. Peck. (*Rad. Engineering*, March, 1932, Vol. 12, p. 21.)

In the usual lens disc system the spot must be large enough to cover several lenses, if it is to be undistorted over the whole image—unless highly corrected lenses are used. In the Peck system cheap lenses may be used; the light from the neon tube is focused to a small spot on each lens in turn; the lenses are spherical on one side and flattened and silvered on the other, so that the light passes into them and is reflected back, giving an image two feet square at a distance of two feet. *See* also preceding abstract.

TELEVISION PROJECTOR WITH TRANSPARENT SCANNING DISC USING SPARK DECOMPOSITION OF ACID FILM.—C. F. Jenkins. (*Sci. News Letter*, 19th March, 1932, Vol. 21, p. 175.)

The transparent disc is horizontal, with wire spokes running radially from the centre and terminating where the holes would be in a Nipkow disc. Immediately below these is a glass plate containing a thin film of acid. As sparks take place between the spoke ends and the acid, a bubble is formed in the latter and causes a dark spot on the screen. "The new method puts 3 600 times more light on the screen than the old pin-hole scanning system."

A NEW SYNCHRONISING SYSTEM FOR TELEVISION.—T. Sone. (*Journ. Inst. T. and T. Eng. Japan*, Dec., 1931, p. 1560 : in Japanese.)

LONG DISTANCE TELEVISION TESTS WITH THE CATHODE RAY RECEIVER [LONDON AND BERLIN TO DRESDEN : COMPARISON OF CATHODE RAY AND NIPKOW DISC RECEIVERS].—E. Busse. (*Fernsehen*, No. 4, Vol. 2, 1931, pp. 252–253.)

EMPFINDLICHE LICHTSTEUERUNG MITTELS SPIEGELMEMBRAN (Sensitive Light Control by Mirror Membrane).—C. Müller: Mey. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 13, 1932, pp. 171–180.)

Description of a method of light control claimed to be many times as sensitive as the older methods and to be free from variation with frequency (50–10 000 c/s), colour and temperature, and from non-linear distortion. The reflecting, perfectly flat metal membrane is only 1 to 2 ten-thousandths of a millimetre thick, and is deformed either directly by the sound waves or indirectly by electro-static or -magnetic control. The changes in shape of this membrane alter the focusing of an image of a grating, reflected from the membrane, on a grating in a screen, and thus vary the amount of light passed by the screen. Compared with a Kerr cell, the device requires a dry-battery auxiliary voltage of 70 and a control voltage of 7 volts, with a 3-watt lamp, instead of 450 and 300 volts and a 30-watt lamp, respectively. It is thus particularly advantageous for portable work such as sound-film recording. Other applications are acoustic research and measurement, phototelegraphy and television, and infra-red telephony. The paper deals in detail with the various characteristics of the device.

NEW SODIUM LIGHT SOURCE OF HIGH LUMINOUS INTENSITY.—M. Reger. (Summary in *Sci. Abstracts*, *Sec. A*, March, 1932, Vol. 35, No. 411, p. 210.)

THE OPTICAL PROPERTIES OF NITROBENZENE IN THIN LAYERS SUBMITTED TO AN ELECTROSTATIC POTENTIAL.—A. Cotton and H. Mouton. (*Comptes Rendus*, 14th March, 1932, Vol. 194, pp. 924–926.)

CHARACTERISTIC CONSTANTS OF PHOTOELECTRIC CELLS.—S. N. Kakurin. (*Westnik Elektrot.*, No. 3, 1931, Sec. I, pp. 83–89: in Russian.)

The characteristic properties of cells are investigated for constant illumination L, [$i = f(U)$, where U is the accelerating potential] and for constant U, [$i = f(L)$]. The curves can be represented analytically over a wide zone by the equation $\log i = n \log L + gU + k$, and give straight lines when plotted to double logarithmic co-ordinates. Hence the following three characteristic constants for photoelectric cells may be derived :—

$$n = \frac{\Delta \log i}{\Delta \log L},\ g = \frac{\Delta \log i}{\Delta U},\ \text{and}\ t = \frac{g}{n};$$

these are analogous to the parameters of a three-electrode valve, and can be used for the representation and calculation of the working conditions of photoelectric cells. The paper includes a list of parameters of 20 cells investigated by the writer.

EINE BEEINFLUSSUNG DES PHOTOELEKTRONENSTROMES IN SPERRSCHICHTZELLEN DURCH MAGNETISCHE FELDER (Magnetic Control of the Photoelectric Current in Attenuating Layer Cells).—E. Rupp. (*Naturwiss.*, 1st April, 1932, Vol. 20, No. 14, pp. 253–254.)

This letter is a preliminary notice of a decrease found in the photoelectric current from an attenuating layer cell when placed in a strong magnetic field ; the effect increases with decreasing angle between the lines of magnetic force and the surface of the attenuating layer, and is greatest when the latter makes an angle of 45° with the beam of light and − 45° with the lines of force. A proposed explanation of the observations, neglecting after effects, is a change of the free path of the electrons in the magnetic field.

SILVER-SELENIUM (ON IRON-NICKEL ALLOY) PHOTOELECTRIC CELL.—Western Elec. Instrument Company. (*Sci. News Letter*, 27th Feb., 1932, Vol. 21, p. 128.)

Giving " 200 times as much current for a given amount of light as the best caesium vacuum cell at present in use " : unlimited life and low cost are claimed, and a relay to actuate electrical machinery can be operated direct from the cell without other source of current.

PROGRESS IN THE CONSTRUCTION OF SELENIUM PHOTOELECTRIC CELLS.—S. German Apparatus Works. (*See* abstract under " Subsidiary Apparatus and Materials.")

THE FOURNIER-CÉMA PHOTOELECTRIC CELL.— (*See* abstract under " Miscellaneous.")

PHOTO CELLS : THE VALVES WHICH OPERATE BY LIGHT.—C. C. Paterson. (*Journ. Scient. Instr.*, Feb., 1932, Vol. 9, pp. 33–40.)

Discourse given at the Physical and Optical Societies' Exhibition.

SPEKTRALE LICHTELEKTRISCHE EMPFINDLICHKEIT DÜNNER ALKALIMETALLHÄUTE BEI ZIMMERTEMPERATUR UND BEI DER TEMPERATUR DER FLÜSSIGEN LUFT (Spectral Photoelectric Sensitivity of Thin Alkali Metal Films at Room Temperature and at the Temperature of Liquid Air).—R. Suhrmann and H. Theissing. (*Zeitschr. f. Phys.*, 1932, Vol. 73, No. 11/12, pp. 709–726.)

The purpose of this work on thin invisible sodium films was to find whether any influence of temperature on the photoelectric sensitivity can arise from the effect of temperature on double layers or from variation of the absorption coefficient of the surface for light. The result of the investigation was as follows :—

" 1. In the case of layers of average thickness, less than monatomic, the effect of cooling is to decrease the action of the double layer, and the work function is thereby increased (by not more than 0.3 to 0.4 volt) compared with its value at room temperature, by an amount corresponding to that by which (at room temperature) it was diminished by the action of the double layer. Further, cooling causes an increase in the steepness of the sensitivity curve and also in the spectral sensitivity for short waves ; this increases not only ψ [the work function] but also the constant M in Richardson's equation for total photoelectric emission. 2. In the case of layers of selective sensitivity, where the effect of the double layer is naturally smaller than in monatomic layers, the increase of the work function due to cooling is smaller ($\Delta\psi = 0.2$ volt). The selective maximum is displaced by cooling by about 10 mμ towards shorter waves."

THE SURFACE-ELECTRONS [APPLICATION TO PHOTOELECTRIC EFFECT].—J. E. Nyrop. (*Phys. Review*, 15th March, 1932, Series 2, Vol. 39, No. 6, pp. 967–976.)

Author's abstract:—The theory regarding the degenerate electronic gas inside an electron-conductor producing an electronic gas, *i.e.*, the surface-electrons, covering the surface of the conductor is applied to the ordinary and the selective photo-effect and the evaporation from heated metals. Further, it is explained how the adsorption caused by metallic surfaces and the catalytic effect produced by them can be calculated when surface-electrons are considered and that the potential barrier which accounts for the work function also can be estimated.

SULLA NATURA DI UN EFFETTO FOTO-TERMOIONICO DOVUTO ALLE RADIAZIONI ROSSE E INFRAROSSE (On the Nature of a Photo-thermionic Effect due to Red and Infra-Red Radiation).—I. Ranzi. (*Nuovo Cim.*, No. 9, Vol. 8, 1931, pp. 331–337.)

DI ALCUNI NUOVI FATTI CONSTATABILI CON LE COMUNI CELLULE FOTOELETTRICHE (Some New Facts observable with Ordinary Photoelectric Cells).—Q. Majorana. (*Lincei Rendic.*, No. 7, Vol. 13, 1931, pp. 463–469.)

The writer finds, with a great number of commercial cells (K, Na, gas-filled and vacuum), a decrease of current, measured with electrometer and galvanometer, with increasing wavelength as far as into the red, and thereafter an increase again towards the infra-red. With a suitably chosen voltage on the cell, the minimum sinks below zero, *i.e.*, illumination by red light produces a negative charging of the alkali metal. The phenomenon is not explained: the effect of the surface condition of the electrodes will first be investigated.

PHOTOIONISATION PROBABILITIES OF ATOMIC POTASSIUM.—M. Phillips. (*Phys. Review*, 15th March, 1932, Series 2, Vol. 39, No. 6, pp. 905–912.)

SEKUNDÄRERSCHEINUNGEN, DIE AUF DEN PRIMÄREN PHOTOELEKTRISCHEN EFFEKT BEI AN SALZSCHICHTEN ADSORBIERTEN CÄSIUMATOMEN FOLGEN (Secondary Phenomena Following the Primary Photoelectric Effect in Caesium Atoms Adsorbed by Salt Layers).—J. H. de Boer and M. C. Teves. (*Zeitschr. f. Phys.*, 1932, Vol. 74, No. 9/10, pp. 604–623.)

MEASUREMENTS AND STANDARDS.

DISSYMMETRICAL MULTIVIBRATORS.—F. Vecchiacchi. (*Nuovo Cim.*, No. 9, Vol. 8, 1931, pp. 352–359.)

Possessing the following advantages over the classical symmetrical circuit:—the oscillation frequency can be adjusted within wide limits by varying one condenser, or one resistance, only; varying the condenser, the frequency alters in an inverse proportion and the form and amplitude remain sensibly constant; and finally, it is possible to obtain oscillations of rectangular form and adjustable ratio of length for the two half-waves, within wide limits. The circuit may be used for various purposes, including the production of a linear time base for c.-r. oscillographs.

THE FREQUENCY STABILITY OF THE TRIODE OSCILLATOR.—Matteini. (*See* under "Transmission.")

FUNDAMENTAL CRYSTAL CONTROL FOR ULTRA-HIGH FREQUENCIES: TOURMALINE OSCILLATORS FOR WAVELENGTHS DOWN TO 1.2 METRES.—H. Straubel. (*QST*, April, 1932, Vol. 16, pp. 10–13.)

English version of the paper dealt with April Abstracts, p. 235.

PIEZOELECTRIC QUARTZ: ITS APPLICATIONS TO WIRELESS TELEGRAPHY AND TELEPHONY [A SURVEY].—A. Houot. (*Rev. Gén. de l'Élec.*, 6th Feb., 1932, Vol. 31, pp. 177–186.)

PIEZOELEKTRISCHE EIGENSCHAFTEN VON SEIGNETTESALZKRISTALLEN (Piezoelectric Properties of Rochelle Salt Crystals).—R. D. Schulwas-Sorokin. (*Zeitschr. f. Phys.*, 1932, Vol. 73, No. 9/10, pp. 700–706.)

SILVERING ELECTRODES ON QUARTZ CRYSTALS [BRASHEAR PROCESS].—G. S. Parsons. (*QST*, March, 1932, Vol. 16, p. 20.)

ÜBER DIE DÄMPFUNG VON MAGNETOSTRIKTIONSRESONATOREN (The Damping of Magnetostriction Resonators).—E. A. Kopilowitsch. (*Ukrain. Phys. Abh.*, No. 3, Vol. 2, pp. 49–53.)

Measurements of the logarithmic decrements of a number of nickel rod resonators lead to the conclusions that the decrement varies according to the thermal and mechanical history and increases with the strength of the exciting alternating field; further, that it has a strong dependence on the magnetic polarisation, showing a hysteresis effect as the magnetisation is increased and decreased. This is attributed to a lag in the difference between the magnetisation of the deformed rod and its original magnetisation.

SUR LA DÉTERMINATION EXPÉRIMENTALE DU COUPLE D'AMORTISSEMENT D'UN OSCILLATEUR (The Experimental Determination of the Damping Couple of an Oscillator).—J. Haag. (*Comptes Rendus*, 7th March, 1932, Vol. 194, pp. 838–840.)

"It is generally assumed that the damping couple of an oscillator is composed of a viscous friction and a constant friction. The only *raison d'être* of this hypothesis is that it allows the easy integration of the differential equation of the motion. Unluckily, the results of this integration do not agree with experiment. Here is a procedure which rests on much less restrictive hypotheses . . ."

RADIO FREQUENCY STANDARD ESTABLISHED AT THE ELECTROTECHNICAL LABORATORY.—S. Kanzaki. (*Res. Electrot. Lab. Tokyo*, No. 319, 1931, 36 pp.: in Japanese.)

The equipment includes a valve-maintained tuning fork, phonic motor and multivibrators, and has an accuracy of the order of 1 part in 100 000. Results of international comparisons are given.

TALKING CLOCKS FOR THE DISTRIBUTION OF TIME OVER TELEPHONE NETWORKS (SOUND-ON-FILM SYSTEM).—E. Esclangon. (*Comptes Rendus*, 14th March, 1932, Vol. 194, pp. 921–924.)

A NEW TYPE OF VALVE VOLTMETER [USING SPACE-CHARGE GRID VALVE].—L. Medina. (*Funk, Berlin*, 26th Feb., 1932.)

No anode or compensation battery is required; a variable 1 000-ohm resistance sets the pointer to zero, and this and the adjustment of the filament voltage to the value used in calibration are the only adjustments necessary. Readings from 0.1 to 1.5 v are possible. At higher voltages the galvanometer reading tends to decrease, providing an automatic protection against overloading. Frequencies from 50 to 300 000 c/s can be measured without compensation.

ELECTRON TUBE VOLTMETER.—F. N. Trotsevitch. (*Westnik Elektrot.*, No. 8, 1931, Sec. I, pp. 255–261: in Russian.)

Some properties of a valve voltmeter are examined theoretically and experimentally: *e.g.*, rectification, characteristic curves and energy consumption. Single- and two-grid valves with thoriated tungsten filaments are used in the tests. Discrepancies between calculation and measurement are less than 1.5%

COMPOSITE-COIL ELECTRODYNAMIC INSTRUMENTS.—F. B. Silsbee. (*Bur. of Stds. Journ. of Res.*, Feb., 1932, Vol. 8, pp. 216–264.)

For the precise measurement of alternating current, voltage or power at power frequencies. The basic idea is the close intermingling of the windings which carry alternating current with those carrying direct current. In an appendix some suggestions are given as to the winding of coils so that two independent windings will have very nearly equal magnetic effects.

THE WENNER POTENTIOMETER [REDUCING EMFS AND RESISTANCE VARIATIONS AT THE CONTACTS].—L. Behr: Wenner. (*Review Scient. Instr.*, March, 1932, Vol. 3, pp. 109–120.)

RECTIFIER CIRCUITS FOR MEASUREMENT OF SMALL ALTERNATING CURRENTS [RIPPLE IN AN H.T. CIRCUIT].—J. A. Darbyshire. (*Journ. Scient. Instr.*, April, 1932, Vol. 9, pp. 123–127.)

RILIEVO, MEDIANTE DIODI, DELLA FORMA DI UNA TENSIONE ALTERNATIVA (Plotting the Form of an Alternating Voltage by means of Diodes [a Simple Method for Certain Cases]).—F. Vecchiacchi. (*L'Elettrotec.*, 5th March, 1932, Vol. 19, pp. 179–180.

NUOVO METODO PER LA DETERMINAZIONE DEL RAPPORTO FRA I VALORI EFFICACE E MEDIO DI UNA TENSIONE ALTERNATIVA (New Method of Determining the Ratio of the R.M.S. to the Mean Value of an Alternating Voltage [Form Factor]).—F. Vecchiacchi. (*L'Elettrotec.*, 25th March, 1932, Vol. 19, pp. 237–238.)

Making use of diode circuits. For previous work on these lines by the same writer, *see* April Abstracts, p. 235 (two).

ON THE THEORY OF THE FREQUENCY VARIATION OF AN A.C. MEASURING CIRCUIT WITH D.C. APPARATUS AND DRY-PLATE RECTIFIERS.—Cremer. (*See* under "Properties of Circuits.")

MOVING-COIL METER AND COPPER OXIDE RECTIFIER FOR MEASURING MODULATION RATIO.—Lepeshinskaja-Krakau. (*See* abstract under "Transmission.")

I TRIODI E LA MISURA DEGLI ANGOLI DI FASE DEI CONDENSATORI CON IL METODO DI SOSTITUZIONE NEI CIRCUITI RISUONANTI (The Triode and the Measurement of the Phase Angles of Condensers by the Method of Substitution in the Resonant Circuit).—F. Vecchiacchi. (*L'Elettrotec.*, 5th Feb., 1932, Vol. 19, pp. 93–99.)

MISURE AD ALTA FREQUENZA DELL' ANGOLO DI PERDITA DI DIELLETTRICI (Measurement at High Frequencies [10 to 6 400 kc/s] of the Loss Angles of Dielectrics).—M. Boella. (*Ibid.*, pp. 99–103.)

UN NUOVO METODO PER LA MISURA DELL' ANGOLO DI PERDITA DEI DIELETTRICI CON PARTICOLARE RIGUARDO AGLI ISOLATORI (A New Method of Measuring the Loss Angles of Dielectrics, particularly Insulators in Series).—A. M. Angelini. (*L'Elettrotec.*, 5th April, 1932, Vol. 19, pp. 261–263.)

ELECTRODYNAMIC ARRANGEMENT FOR THE MEASUREMENT OF SMALL MUTUAL INDUCTANCES.—Guillet. (*See* under "Miscellaneous.")

HIGH RESISTANCE MEASUREMENT [WITH THE G.E.C. LOW GRID CURRENT VALVE TYPE FP-54].—F. A. Lidbury. (*Electronics*, March, 1932, p. 94.)

HIGH FREQUENCY COIL MEASUREMENTS.—W. D. Oliphant. (*Journ. Scient. Instr.*, April, 1932, Vol. 9, pp. 121–123.)

Author's abstract:—The paper describes a simple, rapid and accurate method for determining from a single series of experimental observations the inductance, self-capacity and resistance of a coil at radio frequency. The method is essentially one applicable to routine experimentation and to meet that end a special table for entering results has been devised. As far as the measurement of resistance is concerned, the method is due to P. W. Willans, but as can be seen it can be effectively extended to cover measurement of inductance and capacity. The paper concludes with a brief note on the measurement of the self-capacity of such coils as high frequency chokes.

THE MEASUREMENT OF ELECTRICAL RESISTANCE IN TERMS OF A MUTUAL INDUCTANCE AND A PERIOD.—H. R. Nettleton and F. H. Llewellyn. (*Proc. Physical Soc.*, 1st March, 1932, Vol. 44, Part 2, No. 242, pp. 195–219.)

A CATHODE-RAY OSCILLOGRAPHIC METHOD OF MEASURING INDUCTANCE.—G. I. Finch and R. W. Sutton. (*Proc. Physical Soc.*, 1st March, 1932, Vol. 44, Part 2, No. 242, pp. 190–194.)

The full paper, with Discussion, dealt with in May Abstract, p. 293.

THE ELECTROSCOPE CAPACITY BALANCE [FOR MEASURING CAPACITIES OF A FEW MICRO-MICROFARADS]. — E. S. Brown. (*Proc. Physical Soc.*, 1st March, 1932, Vol. 44, Part 2, No. 242, pp. 220–223.)

Two electroscopes are connected in series with a source of e.m.f. and shunted by variable condensers. The crossed images of the gold leaves, projected on to a vertical screen, give intersections whose locus is a straight line so long as the capacities are equal. The unknown capacity is shunted across one condenser, the capacity of which is then adjusted to give equality again.

A METHOD OF MEASURING SMALL CAPACITANCE [*e.g.*, 5 $\mu\mu$F].—R. Barton. (*Review Scient. Instr.*, March, 1932, Vol. 3, pp. 123–132.)

Resembling Faraday's method of repeated sharings, in which the unknown capacity is alternately charged from a large condenser and discharged ; but differing in that instead of allowing the potential of the large condenser to decrease with decreasing charge during the sharing, the potential is restored after each sharing by the capacity being gradually and continuously decreased (variable air condenser). By thus keeping the potential constant, variations in the capacity of the potential indicator associated with the condenser are eliminated, the necessary leakage correction can be determined and applied with great accuracy, and the resulting expression for calculating the capacity is simplified. Accuracy of measurement is limited mainly by the precision with which the variable condenser may be adjusted and read.

DIE MESSUNG DER SELBSTINDUKTIVITÄT VON EISENDROSSELN (The Measurement of the Self-Inductance of Iron-Cored Chokes [with or without D.C. Polarisation : a Simple Method]).—H. Teuchert. (*E.T.Z.*, 4th Feb., 1932, Vol. 53, pp. 103–104.)

SUBSIDIARY APPARATUS AND MATERIALS.

ELEKTRODYNAMISCHER BANDVERSTÄRKER ALS ERSATZ FÜR SIEBKETTEN UND RÖHRENVERSTÄRKER BEI TONFREQUENZTELEGRAPHIE (An Electrodynamic Band Pass Magnifier as a Substitute for Filters and Valve Amplifiers in Note-Frequency Telegraphy).—M. Wald. (*E.N.T.*, March, 1932, Vol. 9, pp. 91–111.)

The principle of the device is as follows :—A special form of field magnet, fed by alternating current, has pivoted in its parallel and uniform field a small moving coil with practically no controlling force (the leads to the moving coil being very weak spirals) and a fixed internal core to reduce the air gap as much as possible. As long as it is open-circuited, the moving coil will remain in equilibrium at any angle. If its circuit is closed through an impedance Z, it will take up such a position that the electrical torque is zero. Assuming first that Z contains no e.m.f., the plane of the coil will lie parallel to the field, and the coil will be linked with no lines of force : it will be in equilibrium and free from current.

If now the moving coil circuit has an external (signal) e.m.f. impressed on it, of frequency equal to that of the alternating magnetic field, and in phase with this, the coil will rotate on its axis until the current generated in it, as a result of the impressed e.m.f. and of the e.m.f. produced by the a.c. field, is displaced 90° with respect to this field : the torque then becomes zero and the coil is in equilibrium. The energy then in the moving coil circuit is greater than that of the e.m.f. producing the coil deflection : the latter energy merely controls the energy taken out of the locally generated a.c. field, *and the device acts as a magnifier*. In practice, two independent moving coils side by side are employed : these are connected through such a bridge circuit that they are fed by components of the signal current with a phase difference of 90°. In this way it is no longer necessary for the signal current to be in phase with the alternating magnetic field, as was assumed above. The bridge circuit (Fig. 8) also serves to de-couple the two moving coils and prevents the bad effect on the magnification which their interaction would produce. The total available current output of the two coils is equal to the root of the sum of the squares of the magnified currents in the separate coils, and is independent of the phase angle between signal and field.

If the signal currents are *not* of the same frequency as the magnetic field, the two moving coils will take up an oscillatory motion of frequency equal to the difference frequency. It is shown on p. 95 that the magnified output current agrees in frequency not with the magnetic field but with the signal frequency, *so that the action is not a relay action but a true amplification*. As the difference frequency between signal and field is increased, the inertia of the coils comes into play to reduce the resulting deflections : it is on this fact that the selectivity of the device depends. This selectivity is investigated in Section B on pp. 95–96.

For note-frequency telegraphy a two-stage version of the device is used, not only to increase selectivity and magnification but also to prevent the appearance of the magnified currents in the line—as would occur with a single stage owing to the identity of the input and output circuits.

A MECHANICALLY RESONANT [AUDIO-FREQUENCY] TRANSFORMER.—Ross Gunn. (*Proc. Inst. Rad. Eng.*, March, 1932, Vol. 20, pp. 516–519.)

This very selective transformer device is particularly suitable for use in control work and can be modified so that it is useful in telegraphy if the transmitted and received heterodyne frequencies can be held sufficiently constant; radiotelegraphic channels could be spaced only 75 cycles. If the selectivity is defined as $S = f_r/(f_1 - f_2)$, where f_1 and f_2 are the frequencies, above and below the resonant frequency f_r, where the oscillating current is 70.7% that at resonance, then the selectivity of a typical example at 1 500 c/s is 115; on the low-frequency side of the resonance curve peak, a frequency change of only 0.33% will double the response voltage.

In its simplest form, the diaphragm of a telephone receiver is replaced by a tuned reed of magnetic material. The motion of this reed is made to generate potentials in another receiver adjacent to the reed.

THE IMPORTANT FIRST CHOKE IN HIGH-VOLTAGE RECTIFIER CIRCUITS.—F. S. Dellenbaugh, Jr., and R. S. Quimby. (*QST*, Feb., 1932, Vol. 16, pp. 14–19.)

A choke must precede the first condenser in the filter circuit used with a high-voltage rectifier, and this paper shows that the inductance of this first choke has a definite critical value depending on the load resistance (or more accurately, total circuit resistance) and frequency only. The *optimum* value for full load operation is twice this critical value. Several tests are described illustrating what happens when this inductance is varied. An example of the design of the first choke for a filter to meet certain specifications is given. The method of testing to determine whether a choke is properly limiting the peak value of the current is discussed. For a continuation of this paper, *see* "The First Filter Choke—Its Effect on Regulation and Smoothing" (*ibid*., March, 1932, pp. 26–30).

REMARK ON THE PAPER "GLASS OR METAL DISCHARGE TUBE" [FOR CATHODE-RAY OSCILLOGRAPH].—M. Knoll and H. Knoblauch: Dicks. (*Archiv f. Elektrot.*, No. 12, Vol. 25, 1931, p. 853.)

Criticism of Dicks' paper dealt with in 1931 Abstracts, p. 571. If $i > 1$ mA and $E = 70$ to 80 kv, glass tubes are not satisfactory for prolonged runs, and the pre-concentrating coil necessary for small currents involves longer length and reduced sensitivity. The leak discharge found by Dicks can only have been due to unsuitable insulation or other causes named. The intermediate electrode described by him has often been used by the writers, but is not needed for metallic discharge tubes for voltages up to 80 kv. Dicks replies on pp. 854–855, defending the use of the intermediate electrode and denying that the pre-concentrating coil demands much increase in tube length and decrease in sensitivity.

THE CATHODE-RAY OSCILLOGRAPH. LITERATURE TO THE MIDDLE OF 1931: DEVELOPMENT UP TO THE MIDDLE OF 1931.—M. Knoll. (*Archiv tech. Mess.*, Nov., 1931, Vol. 1, p. 75: pp. 76–77.)

In the first article, papers are classified as general summarising, design and construction, and technique of operation of tubes and associated circuits.

ON POTENTIAL DIVIDERS FOR CATHODE RAY OSCILLOGRAPHS.—F. P. Burch. (*Phil. Mag.*, April, 1932, Series 7, Vol. 13, No. 86, pp. 760–774.)

Author's summary:—In Gábor's oscillographic method [*Forschungshefte der Studiengesellschaft für Hochstspannungsanlagen*, Heft 1 (1927)] a known fraction of the voltage to be measured has to be transmitted over a long line and reproduced without distortion, the division of voltage being effected by condensers or condensers and resistances. If the low voltage impedance of the system is divided between the two ends of the line, the condensers may be made from six to eight times smaller than when it is concentrated at one end only. The field of application of the method is thus greatly extended.

VORSAMMELSPULE UND ELEKTRONENDICHTE BEIM KATHODENOSZILLOGRAPH (Pre-concentrating Coils and Electron Density in the Cathode-Ray Oscillograph).—F. Malsch. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 13, 1932, pp. 136–137.)

Measurements on the electron density in the axis of the ray attainable at the screen by means of the pre-concentrating coil of Rogowski, Flegler and Tamm. In the tube used, with a total emission of 1 mA the density was already 7 mA/mm² at 18 kv. At 40 kv it rose to 12 mA/mm². When this is compared with Knoll's result that a density of 0.1 to 10 mA/mm² is sufficient for external recording for all practical purposes, it is seen that the pre-concentrating coil does all that is necessary.

DIE KONZENTRIERUNGSSPULE ALS VERGRÖSSERUNGSLINSE (The Focusing Coil [in the Cathode Ray Oscillograph] as a Magnifying Lens).—F. Hamacher. (*Archiv f. Elektrot.*, 22nd March, 1932, Vol. 26, No. 3, pp. 215–218.)

The inhomogeneity of the field due to a coil can be used to increase the dimensions of the cross-section of an electron beam.

DISSYMMETRICAL TWO-VALVE MULTIVIBRATOR CIRCUITS [FOR LINEAR TIME BASE, ETC.].—Vecchiacchi. (*See* abstract under "Measurements and Standards.")

DISCUSSION ON "A SIMPLE METHOD OF HARMONIC ANALYSIS FOR USE IN RADIO ENGINEERING PRACTICE."—J. R. Ford: Roder. (*Proc. Inst. Rad. Eng.*, Feb., 1932, Vol. 20, pp. 359–362.)

Referring to Roder's method (1931 Abstracts, p. 629) Ford questions its correctness as regards even harmonics, and gives an alternative procedure. Roder points out a possible error in this, and shows that the condemnation of his own method is due to an error in applying it.

A NEW VOLTAGE QUADRUPLER.—W. W. Garstang. (*Electronics*, Feb., 1932, pp. 50–51.)

Satisfactory commercial voltage doublers are now available using the principle of condensers charged in parallel and discharged in series; the introduction of the dry-plate rectifier and the "truly dry" type of electrolytic condenser have made these a practical proposition. The writer has now succeeded in overcoming certain circuit difficulties in combining two such doublers in series to give a practical voltage quadrupler.

A METHOD FOR THE APPROXIMATE CALCULATION OF A THERMIONIC FREQUENCY CHANGER [BASED ON ANODE DISSIPATION].—A. I. Joffe. (*Westnik Elektrot.*, No. 9, 1931, Sec. I, pp. 304–309 : in Russian.)

Application of the writer's "anode dissipation" procedure (May Abstracts, p. 283) to the calculation of frequency doublers and treblers.

THE ADVANTAGES OF THE NICKEL-BAND CATHODE IN RECTIFIERS.—Telefunken Company. (*Rad., B., F. f. Alle*, March, 1932, pp. 135–136.)

A CORONA TUBE VOLTAGE REGULATOR [REGULATING THE OUTPUT OF A FULL-WAVE RECTIFIER AND THUS CONTROLLING THE EXCITATION OF A GENERATOR].—H. W. Dodge and C. H. Willis. (*Elec. Engineering*, Feb., 1932, Vol. 51, pp. 112–114.)

PROGRESS IN THE CONSTRUCTION OF SELENIUM RECTIFIERS.—S. German Apparatus Works. (*E.T.Z.*, 3rd March, 1932, Vol. 53, p. 214.)

Larger dimensions of selenium plate can now be made, passing 0.5 A per plate (*i.e.*, useful supply of 4.5 W per plate). The paragraph also describes the same firm's new selenium photoelectric element, using the external photoelectric effect instead of the internal effect as in the older selenium cell.

STEUERBEDINGUNGEN VON GITTERGESTEUERTEN GASENTLADUNGEN — IONENSTEUERROHRE (Control Conditions of Grid-Controlled Gas Discharges—Ion Control Valves [*e.g.*, Thyratrons]).—H. Klemperer and E. Lübcke. (*Archiv f. Elektrot.*, 23rd Feb., 1932, Vol. 26, No. 2, pp. 67–74.)

This paper gives a general account of the development, control conditions and applications of grid-controlled gas discharge tubes.

HOT CATHODE THYRATRONS [INCLUDING THE USE OF INDIRECTLY HEATED, HEAT-SHIELDED CATHODES].—L. J. Davies. (*Engineer*, 1st April, 1932, Vol. 153, pp. 364–365.)

From the B.T.H. Engineering Laboratory.

SELBSTTÄTIGE FREQUENZREGULIERUNG (Automatic Frequency Regulation).—H. Martin. (*Physik. Zeitschr.*, 15th March, 1932, Vol. 33, No. 6, pp. 239–242.)

Author's summary :—A description is given of a simple method [using two tuning forks and a mirror] of demonstrating Lissajous' figures with variable phase difference, and of a further application of the photoelectric relay to frequency control [by illuminating a photoelectric cell at the centre of the Lissajous' figure].

A RESISTANCE THERMOSTAT WITH LIGHT-SENSITIVE CELL [RADIOVISOR SELENIUM BRIDGE] OPERATION.—E. J. C. Dixon. (*P.O. Elec. Eng. Journ.*, April, 1932, Vol. 25, Part 1, pp. 65–67.)

Author's abstract :—"A method of using a resistance thermostat with a reflecting galvanometer and a light-sensitive cell to control the operation of the heater relay is described, and practical circuits are given for working from a.c. or d.c. mains. The sensitivity of the device as used in practice [for ovens for crystal oscillators] is $\pm$ 0.1%, but can be increased by using a more sensitive galvanometer", or by the use of an a.c. input and a push-pull valve rectifier across the output (McNamara, 1931 Abstracts, p. 448).

STEEL-COPPER ALLOYS FOR DYNAMOS AND TRANSFORMERS.—Kussmann, Scharnow and Messkin. (Summary in *E.T.Z.*, 25th Feb., 1932, Vol. 53, p. 181.)

TROLITUL : A SYNTHETIC MATERIAL, TRANSPARENT, NOT BRITTLE, AND HIGHLY INSULATING. —(*E.T.Z.*, 11th Feb., 1932, Vol. 53, p. 132.)

ON THE DIELECTRIC LOSS OF INSULATING MATERIALS AT HIGH [AND ULTRA-HIGH] FREQUENCIES.—H. Irino. (*Circ. Electrot. Lab. Tokyo*, No. 80, 1931, 27 pp.)

In Japanese, with short English synopsis.

NEW STEATITE AS AN INSULATING MATERIAL FOR HIGH FREQUENCIES.—E. Albers-Schönberg and J. Gingold. (*E.T.Z.*, 3rd March, 1932, Vol. 53, pp. 205–207.)

Including tests with ultra-short waves (7 m).

A SOLDER FOR ALUMINIUM (ALUMAWELD). (*Electronics*, Feb., 1932, p. 71.)

ASPECTS OF STANDARD-SIGNAL GENERATOR DESIGN.—J. D. Crawford. (*Electronics*, Feb., 1932, pp. 46–47 and 74.)

A NEW A.C. POTENTIAL COMPARATOR.—D. C. Gall. (*Journ. Scient. Instr.*, April, 1932, Vol. 9, pp. 132–134.)

TWO BILLION OHMS [GLASS ROD HELIX SURROUNDING STRAIGHT CARBON ROD AND SPUTTERED WITH THIN FILM OF CARBON].—(*Elec. Journal*, Jan., 1932, Vol. 29, p. 42.)

Cf. Rentschler and Henry, May Abstracts, p. 297.

BORIC ACID FUSES [EXTINGUISHING ARC BY WATER VAPOUR GENERATED IN THE FUSE]. (*Electric Journal*, Jan., 1932, Vol. 29, pp. 41–42.)

STATIONS, DESIGN AND OPERATION.

OPERATION OF A SHIP-SHORE RADIOTELEPHONE SYSTEM [NORTH ATLANTIC SERVICE].—C. N. Anderson and I. E. Lattimer. (*Proc. Inst. Rad. Eng.*, March, 1932, Vol. 20, pp. 407–433.)

From authors' summary :—"Problems encountered in establishing and operating this service are discussed, together with measures applied for their solution. The most difficult problems have arisen in connection with adapting the ship terminal for operation under the limited space conditions encountered on shipboard. These conditions impose undesirable proximities between units of equipment and between antennas. . . . Considerable data have been collected during the past two years. . . . Of interest are the contour diagrams indicating the variation of signal fields with time of day and with distance. . . ."

THE COMMUNICATION SYSTEM OF THE RADIOMARINE CORPORATION OF AMERICA.—I. F. Byrnes. (*Proc. Inst. Rad. Eng.*, March, 1932, Vol. 20, pp. 434–448.)

Including the newly developed "combination" transmitter, for medium and short waves, with its special motor-car spring suspension (*see* April Abstracts, p. 223, Pannill).

COMMUNICATION TESTS FOR RADIO TELEPHONY BY MEANS OF ULTRA-SHORT [4.6 AND 5.8 METRE] WAVES BETWEEN NIIGATA AND SADO.—S. Uda. (Long English summary in *Journ. I.E.E. Japan*, No. 1, Vol. 52, pp. 2–5 : full paper in Japanese, pp. 9–12.)

Continuation of the tests dealt with in May Abstracts, pp. 298–299. As a result of these later tests the writer concludes that if a horizontal aerial is used it must be located at a sufficient height, otherwise signals will often be missed even in direct-vision range ; the vertical type "is preferable, in most cases, for point to point communication, because of its reliability, especially for communications beyond the optical range."

ULTRA-SHORT-WAVE [42 CENTIMETRE] SIGNALLING.—Westinghouse Company. (*Rad. Engineering*, March, 1932, Vol. 12, p. 22.)

A short note on recent Westinghouse tests, using parabolic mirrors, over a distance of over one mile.

REFLECTORS AND FEEDERS FOR ULTRA-SHORT WAVES [DOVER–CALAIS SERVICE].—Darbord. (*See* under "Aerials and Aerial Systems.")

WIRELESS COMMUNICATION IN THE POLAR REGIONS [AND THE CAUSES OF ITS DIFFICULTIES].—Krüger. (*See* under "Propagation of Waves.")

OPTIMUM TUNING CONDITIONS FOR HIGH FREQUENCY PLANTS [TO SATISFY VARIOUS REQUIREMENTS].—Osnos. (*See* under "Properties of Circuits.")

TYPE TESTING OF FREQUENCY-CHECKING APPARATUS FOR BROADCAST STATIONS.—Bureau of Standards. (*Bur. of Stds. Tech. News Bull.*, No. 178, Feb., 1932.)

A note on the testing, at the request of the Federal Radio Commission, of several types of special frequency-checking equipment offered by manufacturers to broadcasting stations.

A FREQUENCY INDICATOR FOR [BROADCASTING] TRANSMITTERS. (*See* under "Transmission.")

SIMPLE TELEPHONE BROADCASTING NETWORKS.—A. D. Apanasenko. (*Westnik Elektrot.*, No. 9, 1931, Sec. I, pp. 318–320 : in Russian.)

The writer shows that the output power of a primary line on which n receivers are connected in every kilometre, with uniform distribution, is given by :

$$W_r = \frac{|\bar{E}_0|^2}{Z_r^2} \cdot nR_r \cdot \tfrac{1}{2} \left| \frac{\sin h2\bar{\gamma}l}{2\bar{\gamma}} + l \right|.$$

The efficiency is :

$$\eta = W_r : W_a = 0.5 \frac{\cos \phi_r}{\cos \phi_a} \left| 1 + \frac{2\bar{\gamma}l}{\sin h2\bar{\gamma}l} \right|,$$

and $\bar{\gamma}$ is given by

$$\bar{\gamma} = \frac{\sqrt{n}}{Z_r} \sqrt{(R + j\omega L)R_r - j\left(\omega L_r - \frac{1}{\omega C_r}\right)}.$$

A comparison between the efficiencies of open and closed networks is examined.

WIRED BROADCASTING IN SWITZERLAND.—(*Rad., B., F. f. Alle*, March, 1932, pp. 102–103.)

Editorial comments on the developments referred to in April and May Abstracts, pp. 240 and 299, and also on the Philips Radio Company's announcement of successful simultaneous multi-programme distribution over a power network.

FEASIBILITY OF BROADCASTING WITH CARRIER CURRENT APPLIED TO LIGHTING AND POWER LINES.—I. Tanimura. (*Journ. Inst. T. and T. Eng., Japan*, Dec., 1931, p. 1521 : in Japanese.)

Points investigated include :—selection of feeding systems ; effects of "on" and "off" of the lines feeding certain quarters ; the minimum separation of adjoining receivers ; and the relation of power transmitted to service area.

THE NEW RADIOELECTRIC STATIONS OF PONTOISE AND NOISEAU.—E. Picault. (*Rev. Gén. de l'Élec.*, 9th and 16th April, 1932, Vol. 31, pp. 491–497 and 534–540.)

LEAGUE OF NATIONS RADIO : SOME PARTICULARS OF THE TRANSMITTING AND RECEIVING STATIONS AT GENEVA. (*Electrician*, 18th March, 1932, Vol. 108, p. 407.)

RADIO SETS IN THE FOREST SERVICE [FOR FIRE FIGHTERS]. (*Science*, 11th March, 1932, Vol. 75, Supp. p. 12.)

GENERAL PHYSICAL ARTICLES.

A POSSIBLE EXPLANATION OF THE DIFFERENCE IN MASS BETWEEN THE PROTON AND THE ELECTRON.—Al. Proca. (*Journ. de Phys. et le Rad.*, Feb., 1932, Vol. 3, pp. 83–101.)

ABSOLUTE VALUES FOR THE MOBILITIES OF GASEOUS IONS IN PURE GASES.—N. E. Bradbury. (*Phys. Review*, 1st Feb., 1932, Series 2, Vol. 39, No. 3, pp. 546–547.) Abstract only.

ANWENDUNG VON AHNLICHKEITSBETRACHTUNGEN AUF DIE STRÖMUNG DER ELEKTRIZITÄT IN GASEN (Application of the Principles of Similarity to the Flow of Electricity in Gases).—H. Mache. (*Physik. Zeitschr.*, 1st Jan., 1932, Vol. 33, No. 1, pp. 43–46.)

ÜBER DIE VOLLE DIFFERENTIALE SEKUNDÄRSTRAHLUNG IN LUFT FÜR ELEKTRONEN MITTLERER GESCHWINDIGKEIT (On the Complete Differential Secondary Radiation in Air for Medium Velocity Electrons).—E. Kipphan. (*Ann. der Physik.*, 1931, Series 5, Vol. 12, No. 4, pp. 401–432.)

THE CHANGES WHICH GASEOUS IONS UNDERGO WITH TIME.—J. Zeleny. (Summary in *Physik. Ber.*, 15th Dec., 1931, Vol. 12, p. 2915.)

EINE METHODE ZUR BESTIMMUNG DER BEWEGLICHKEIT VON EDELGASIONEN MIT HILFE DER NEGATIVEN SCHICHTEN (A Method for Determining the Mobility of Ions of the Rare Gases by means of the Negative Layers).—M. J. Druyvesteyn. (*Zeitschr. f. Phys.*, 1931, Vol. 73, No. 1/2, pp. 33–44.)

THE STEP-BY-STEP DISCHARGE IN GASES.—W. Rogowski: Krug. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 13, 1932, pp. 97–99.)

Krug has asserted that the step-by-step discharge oscillograms sometimes obtained by Rogowski were fictitious and due to oscillation in the measuring circuit. Rogowski now refutes this.

PAPERS ON PHOTOCHEMICAL PROCESSES.—Faraday Society. (Summaries in *Sci. Abstracts, Sec. A*, Jan., 1932, Vol. 35, pp. 66–73.)

Including a paper on the photochemical ozone equilibrium in the atmosphere, by Mecke.

MISCELLANEOUS.

GENERAL FERRIÉ: A TRIBUTE.—R. Jouaust. (*L'Onde Élec.*, Feb., 1932, Vol. 11, pp. 45–52.)

AUSTRALIAN CARRIER SYSTEM.—(*P.O. Elec. Eng. Journ.*, April, 1932, Vol. 25, Part 1, pp. 1–7.)

A VOICE FREQUENCY MULTI-CHANNEL TELEGRAPH SYSTEM.—J. M. Owen and J. A. S. Martin. (*Ibid.*, pp. 8–16.)

INDUSTRIAL USES OF ELECTRONIC DIFFRACTION [STUDY OF SURFACES, *e.g.* OF PHOTOELECTRIC OR X-RAY CATHODES].—C. J. Phillips. (*Electronics*, March, 1932, p. 84 and 114.)

STATISTICS OF RADIO AND SOUND-PICTURES.—(*Electronics*, March, 1932, p. 79.)

THE VIBROMETER.—Subra. (*See* under "Acoustics and Audio-frequencies.")

ELECTRODYNAMIC ARRANGEMENT FOR THE MEASUREMENT OF SMALL MUTUAL INDUCTANCES: APPLICATION TO THE EXAMINATION OF [ULTRA-] MICROMETERS.—A. Guillet. (*Comptes Rendus*, 29th Feb., 1932, Vol. 194, pp. 777–779.)

Devised to employ alternating current (mains, if sufficiently constant in voltage and frequency) but without the necessity of using auxiliary apparatus such as contact or valve detectors, rectifiers, etc. For previous work on ultra-micrometer circuits by the same author, *see* April Abstracts, p. 242.

ULTRA-MICROMETER CIRCUITS FOR STUDYING THE VIBRATIONS AT THE SURFACE OR IN THE INTERIOR OF A SOLID, PARTICULARLY THE FRAMEWORK OF A BRIDGE [ABSORBOMICROMETER].—P. Santo Rini. (*Comptes Rendus*, 14th March, 1932, Vol. 194, pp. 955–957.) *Cf.* January Abstracts, p. 53. For the same writer's special exploring condenser, *see* 1931 Abstracts, p. 287.

THE GRID GLOW MICROMETER.—R. W. Carson. (*Amer. Mach.*, No. 11, Vol. 75, p. 407.)

Description of the use of the grid-glow tube as a very satisfactory indicator in the micrometry of thin wires and soft materials.

VALVE METHOD FOR THE MEASUREMENT OF THE MODULUS OF RIGIDITY OF MATERIALS.—L. N. Tomilina. (*Westnik Elektrot.*, No. 5/6, 1931, Sec. I, pp. 161–164.)

THE "INVISIBLE BARRAGE" AND THE PREVENTION OF ACCIDENTS BY MEANS OF INFRA-RED RAYS.—Fichet-Céma Company. (*Génie Civil*, 9th April, 1932, Vol. 100, p. 371.)

For marine or aerial navigation and many other purposes. The detector employed is the Fournier-Céma photoelectric cell, in which an exhausted bulb contains a strip of quartz covered with the photosensitive substance and placed between two polarised electrodes. Working at potentials not exceeding 40 v., it seems to preserve its sensitivity for many years.

MAKING NEW EMULSIONS AT 300 000 CYCLES.—(*Electronics*, March, 1932, p. 95.)

PHOTOELECTRICALLY CONTROLLED HUMIDIFIER GOVERNED BY MOISTURE ON WINDOW PANE.—B. S. Havens. (*Electronics*, Feb., 1932, p. 61.)

CONTINUOUS WEIGHING WITH LIGHT-SENSITIVE "TELEPOISE."—E. J. White. (*Electronics*, Feb., 1932, p. 60.)

PHOTOELECTRIC CONTROL OF THE WEIGHING OF BATCHES.—(*Electronics*, March, 1932, p. 98.)

PHOTOCELL CONTROLLED ELEVATOR DOORS.—C. E. Ellis. (*Electronics*, Feb., 1932, pp. 54–55.)

THE LATEST IN HIGH-INTENSITY X-RAYS AND "FEVER MACHINES" [ULTRA-SHORT WAVE TREATMENT].—(*Electronics*, Feb., 1932, pp. 56–57 and 76.)

EXPERIMENTS ON THE BIOLOGICAL EFFECTS OF D'ARSONVALISATION ON ULTRA-SHORT (10-METRE) WAVES.—H. Bordier. (*Comptes Rendus*, 4th April, 1932, Vol. 194, pp. 1191–1193.)

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.

CONDENSERS.

Convention date (U.S.A.), 11th *February*, 1930. *No.* 363717.

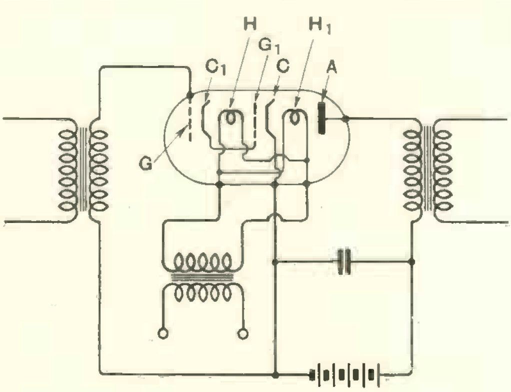
A fixed condenser, specially suitable for by-passing radio-frequency currents, is made by lapping alternate sheets of tin-foil and paraffin paper around a central core. The core contains a conducting post, which is in metallic connection with one of the tinfoil sheets and forms one terminal of the condenser. The consequence is that a small but definite amount of inductance is introduced, and this is so related to the capacitance that the condenser possesses zero or negligible impedance at a given frequency.

Patent issued to Sparks-Withington Co.

VALVE AMPLIFIERS.

Convention date (*U.S.A.*), 16*th December*, 1929. *No.* 363430.

An amplifier designed to give an undistorted output without the use of a negative grid bias comprises a valve with two cathodes, C, C_1 and two grids G, G_1 co-operating with a single anode A. The cathode C, grid G and anode co-operate in the ordinary way, but are influenced by the action of the auxiliary cathode C_1 and grid G_1. The two latter are electrically connected together but are independent of the other electrodes. H, H_1 are heating elements for the cathodes. Signals impressed from the input transformer on the grid G influence the electron emission from the cathode C_1, and since this is directly connected to the grid G_1, the latter also controls the main electron stream between the cathode C and anode A. So long as



No. 363430.

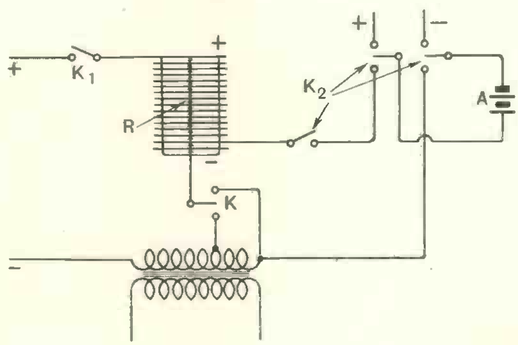
the grid G_1 is negative the amplifying action is normal. When the grid G_1 becomes positive, electrons flowing to that grid from the cathode C cause a current to flow between the grid G_1 and the cathode C_1. The result is that when the grid G is negative no current flows in the input circuit, whilst when it is positive the normal grid current is offset by the action of the grid G_1 and cathode C_1.

Patent issued to Revelation Patents Holding Co.

RECTIFIER UNITS.

Application date, 25*th February*, 1931. *No.* 365845.

A high-tension unit, which can also be used as a trickle charger, consists of a multiple dry-contact rectifier R, all the sections being utilised for the



No. 365845.

supply of H.T., but only the two lower sections for charging the accumulator A. In the latter case a part of the transformer secondary is tapped off by means of a switch K, the associated switches K_2 being closed and K_1 opened. Alternatively two or more sections of the rectifier may be connected in parallel with the L.T. load. The method is also applicable to circuits of the voltage-doubling type.

Patent issued to F. L. W. Dean.

CATHODE-RAY INDICATORS.

Convention date (*Germany*), 9*th October*, 1929. *No.* 365073.

A cathode-ray tube is mounted, say, on an aeroplane, so that it can swing about a single axis under the influence of gravity. The action of the earth's magnetic field then deflects the ray from its normal point of impact upon a fluorescent screen to an extent dependent upon the inclination of the aeroplane. Two such tubes can be mounted so as to swing about axes mutually at right-angles, an optical system being used to combine the resulting deflections in such a way as to give a direct indication of the plane's horizontal direction as well as its inclination or "dip."

Patent issued to International General Electric Co., Ltd.

SHORT-WAVE GENERATORS.

Application date, 8th October, 1930. *No.* 364637.

To diminish interelectrode capacity losses in a valve generating oscillations of the order of 3 metres, the main oscillatory circuit, comprising the valve capacity and external inductance, is shunted by an auxiliary Lecher-wire circuit tuned to a wavelength longer than but less than twice that of the generated wave. The auxiliary circuit builds up large " flywheel " currents which are isolated from the valve capacities and serve to increase the effective output.

Patent issued to Marconi's Wireless Telegraph Co., Ltd., and E. W. B. Gill.

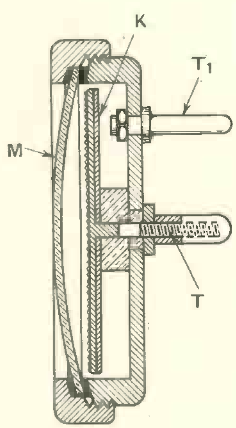
H.F. COUPLINGS.

Convention date (*U.S.A.*), *3rd December*, 1929. *No.* 364777.

A circuit of the band-pass type, used either as an input or intervalve coupling, comprises an absorption element, such as a split copper ring, which is closely coupled to some of the inductance windings in each of the two circuits to be linked together. The ring is moved relatively to the windings, so as to vary the eddy-current induction, and therefore the effective coupling, as the tuning is altered, the movement being " ganged " with the main tuning control.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

LIGHT-SENSITIVE CELLS.



No. 365838.

Convention date (*U.S.A.*), *25th March*, 1930. *No.* 365838.

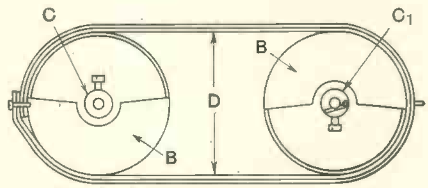
The cell is constructed in the general shape of a watch case. The active electrode of copper-cuprous oxide is mounted on a flat disc *K*, disposed directly in front of the window *M* and made in one piece with a shank *T* forming one of the output terminals. The second terminal is shown at T_1. When ready for use the cell is filled with a solution of glacial acetic acid mixed with cobalt chloride.

Patent issued to Arcturus Radio Tube Co.

GANGED CONDENSERS.

Application date, 16th March, 1931. *No.* 364431.

Each of the condensers C, C_1 consists of a shallow metal drum with one end open, and half the circumference cut away. The cut-out part is replaced by a segment *B* of insulating material, so that the outer periphery of each drum is partly metal and partly insulated. The two condensers are coupled by a band *D* formed of two layers, one of metal and the other of an insulating material, so that the " overlap " of the band determines the effective capacity in each case. The condensers are so



No. 364431.

arranged that, as they are rotated, their capacities increase or decrease simultaneously and to an equal degree.

Patent issued to General Electric Co., Ltd., and W. H. Peters.

AUTOMATIC " STAND-BY " CIRCUITS.

Convention date (France), 18th September, 1930, *No.* 363981.

The receiving aerial is coupled to a circuit, the tuning of which is continuously varied, for instance, by a rotating condenser driven through reduction gearing from a small motor. When a sufficiently powerful signal is received, a valve amplifier first cuts out the motor, so that the tuning is stabilised for a definite interval of time. If during this period a predetermined sequence of signal impulses are received, a series of relays are closed to operate an alarm. Otherwise the rotating condenser is again set into motion.

Patent issued to L. L. E. Chauveau.

ELIMINATING DISTURBANCES.

Application date, 3rd February, 1931. *No.* 365813.

In order to cut out the effect of local induction, the aerial is raised above the " spread " of the disturbing field, and the down-lead is screened by an earthed metallic tube of comparatively large cross-section, the space between the tube and the lead-in wire being filled by an insulating material impervious to water.

Patent issued to W. C. Fairweather.

TUNING-DIALS.

Application date, 12th December, 1930. *No.* 366212.

The control knob of the tuning-condenser is geared to an indicator which moves over a large-sized dial on which the names of the principal broadcasting stations are printed in their proper sequence, so as to allow tuning to be effected by direct reading instead of by " degrees." The upper part of the dial is devoted to the medium-wave, and the lower to the long-wave stations. A flash-lamp is arranged to illuminate either the upper or lower dials, as desired, the lighting being controlled by the automatic wave-change switch.

Patent issued to E. K. Cole, Ltd., and E. J. Wyborn.

PHOTO-ELECTRIC AMPLIFIERS.

Application date, 6th November, 1930. No. 365682.

A screened-grid amplifier, designed for use with a photo-electric input, is transformer-coupled to the output, or to a succeeding stage of amplication. The transformer is iron-cored, or of the high-mu type, and has a step-down ratio, the primary being of high inductance. The advantage claimed over the known use of choke and resistance-capacity couplings is that the apparatus following the amplifier may be located at a considerable distance without suffering from attenuation losses.

Patent issued to S. G. Brown.

PENTODE AMPLIFIERS.

Application date, 6th November, 1930. No. 366572.

Instead of earthing the outermost grid, or biasing it from a point on the common H.T. supply, it is connected to the anode through an independent battery so that it is always anchored at a definite potential, preferably 30 volts below that of the anode.

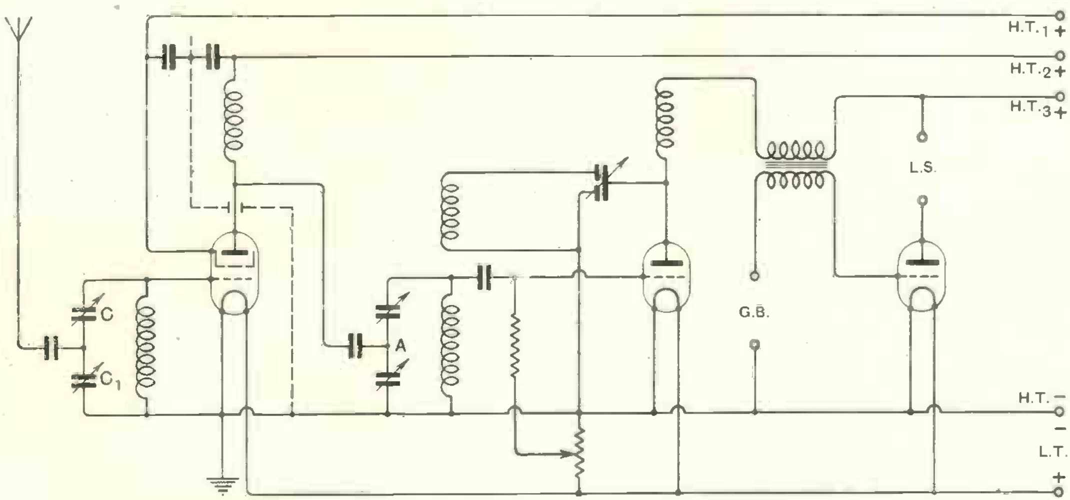
Patent issued to Lissen, Ltd., and M. V. Callendar.

COUPLING CIRCUITS.

Application date, 7th January, 1931. No. 365306.

The two condensers C, C_1 are ganged together, and the aerial is coupled to a point between them, so that although the whole of the tuning capacity is in the closed circuit, only a part of it is in the aerial-earth circuit. The effective aerial coupling is therefore maintained constant throughout the tuning range, because the natural tendency for the coupling to increase with frequency is offset by the simultaneous decrease in the value of the capacity C_1. A similar arrangement is shown at A as an intervalve coupling.

Patent issued to J. F. Sudder.



No. 365306.

VALVE AMPLIFIERS.

Application date, 31st January, 1931. No. 367150.

A resistance or impedance is inserted in the anode circuit of a screen-grid or pentode valve, and specified voltages are applied to the grids, in order to secure a working characteristic having a gradual slope with a sharp upper bend followed by flat-topped saturation limit. When so connected the valve may be used as a limiter or rectifier. The specification describes a method of deriving the value of the appropriate anode impedance, as well as the necessary biasing voltages, from the characteristic curves of a commercial type of valve.

Patent issued to W. B. Mackenzie and H. R. Cantelo.

EARTHING-SWITCHES.

Application date, 9th October, 1930. No. 366913.

A safety earthing-switch is so arranged that the normal path from the aerial to set includes a fuse wire which, in the event of a lightning discharge, fuses and frees a spring contact to connect the aerial directly to earth.

Patent issued to F. E. Harmer.

MAINS-ELIMINATORS.

Application date, 11th December, 1930. No. 366209.

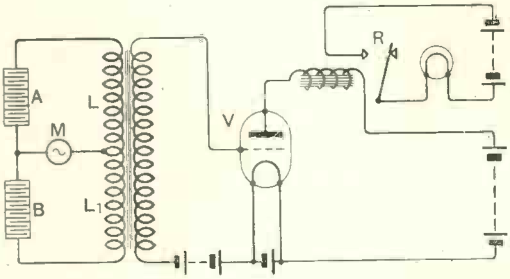
To avoid the necessity for large-sized chokes and high-capacity condensers in the smoothing circuit, use is made of short-circuited transformer windings which serve to separate and remove any A.C. components. One or more chokes or tuned rejector circuits are inserted in series in the positive main, and one or more L.F. transformers are shunted across the mains. The secondaries of these transformers are short-circuited by resistances, in which any fluctuating energy is dissipated.

Patent issued to Kolster-Brandes, Ltd.

LIGHT-SENSITIVE BRIDGES.

Application date, 13th December, 1930. No. 366213.

To compensate for extraneous fluctuations in light and heat, a balancing cell *A* is arranged in parallel with the operative cell *B*, and the respective outputs from both cells are fed to coils *L*, L_1 wound



No. 366213.

in opposition. Any change of light or heat common to both cells is thus balanced out, whilst the effect of an impulse directed solely on to the cell *A* is transferred to the amplifier *V*, and operates a relay *R*. As shown, the cells *A*, *B* are energised from an A.C. source *M*.

Patent issued to E. S. Clouderay and Radiovisor Parent Ltd.

CATHODE-RAY INDICATORS.

Application dates, 5th August, 1930, and 11th May, 1931. No. 366989.

The anode of a cathode-ray tube is divided into two halves or four quadrants, each being connected to separate amplifiers. The ionic beam normally strikes the centre of the anode, where it is spread equally over the divided segments, but if it is deflected, say by the earth's magnetic field, or by any other deliberately applied electrostatic or magnetic field, then one or other of the associated amplifiers is energised and sets into operation a motor which rotates the platform carrying the cathode-ray tube until the ionic beam again falls exactly in the centre of the anode. The amount of angular rotation is a measure of the strength or direction of the applied field. The angular rotation may be repeated by telemotor apparatus to control the synchronous movement of a distant apparatus. The cathode-ray system may for instance be used, in conjunction with the earth's magnetic field, as a bank or tilt indicator in an aeroplane; or it may be used in direction-finding to react automatically to impulses received from a beacon transmitter, the response being free from the usual 180° ambiguity.

Patent issued to R. A. Watson-Watt and L. H. Bainbridge-Bell.

AUTOMATIC GAIN CONTROL.

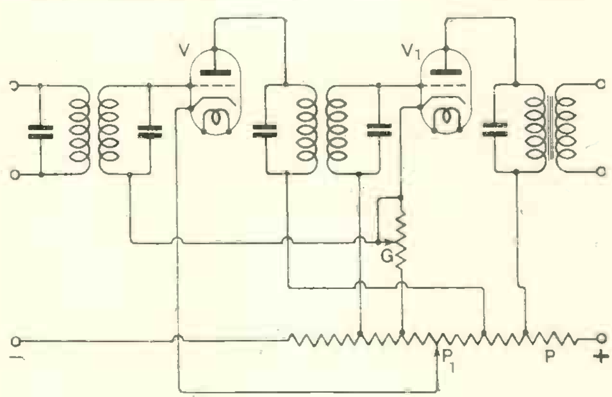
Convention date (U.S.A.), 12th November, 1929. No. 366937.

The volume of sound in an orchestral performance may vary by as much as 100,000 to 1, whereas the maximum ratio obtainable in a gramophone record ordinarily does not exceed one-fifth this amount. Moreover, the intensity of the high and low notes, whether in a gramophone amplifier or a radio receiver, does not maintain the correct relation to the intermediate notes. The invention provides means for varying the amplification in accordance with the strength of the impressed signal (*a*) so that the volume ratio is maintained substantially the same as the original production; and (*b*) so that the higher frequencies are attenuated when the output is small, and the lower frequencies when the output is large. The first object is attained by means of a resistance which automatically varies the effective grid bias in accordance with the average intensity of the impressed signal, and the second by means of a tone-compensating filter included in the input circuit of the amplifier.

Patent issued to J. H. Hammond, Jr.

Convention date (U.S.A.) 29th August, 1930. No. 366875.

In an anode-bend rectifier the anode current increases with signal strength, and advantage is taken of this fact to control the degree of amplification over wide limits so as to maintain a constant output-volume. The valve voltages are tapped off from the supply potentiometer *P*, as shown. Bias for the grid of the H.F. amplifier *V* is taken from a point *G* on a resistance in the output circuit of the detector valve V_1, so that the applied grid voltage varies with the received signal. If the cathode return tapping P_1 for the valve *V* is brought opposite to the cathode return from the detector V_1, the applied grid bias will be positive, instead of negative as usual, and increasing signal strength will result in a more positive bias. With the tapping P_1 in the position shown, a negative biasing resistance is



No. 366875.

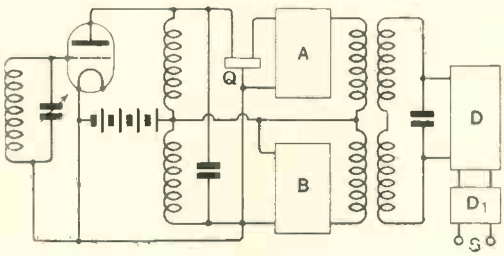
applied to the detector valve in combination with a positive biasing-voltage on the H.F. amplifier.

Patent issued to British Thomson-Houston Co., Ltd.

SELECTIVE RECEPTION.

Application date, 6th November, 1930. No. 366568.

The received signals are passed through two separate channels, one sharply tuned to the carrier frequency and the other more broadly tuned to take the sidebands. By adjusting the relative



No. 366568.

amplification in the two channels, the percentage modulation can be regulated to any desired degree prior to detection. As shown in the figure, a piezo-electric crystal *Q*, tuned to the carrier frequency, limits the width of the band applied to the H.F. amplifier *A*. The sidebands are simultaneously fed to a parallel amplifier *B*, and the combined output is transferred first to a detector *D* and then through L.F. stages D_1 to the loud speaker *S*. The differential amplification of the carrier and sideband components permits the use of a high-percentage modulation in transmission without producing distortion in the receiver.

Patent issued to Standard Telephones and Cables, Ltd.

SECRET TELEPHONY SYSTEMS.

Convention date (U.S.A.), 8th November, 1929. No. 366921.

Relates to secret systems of the kind in which the speech or signal waves are sub-divided into a series of frequency bands, which are then transposed or inverted in a pre-arranged order before transmission, and subsequently reassembled in the correct sequence at the receiving station. According to the invention the order in which the various frequency bands are transposed is automatically varied from time to time under the control of timing-cams driven synchronously at each station. Other cams pre-select the new combination ready for each change-over.

Patent issued to Electrical Research Products, Inc.

MOUNTING PIEZO CRYSTALS.

Convention date (U.S.A.), 24th January, 1930. No. 366252.

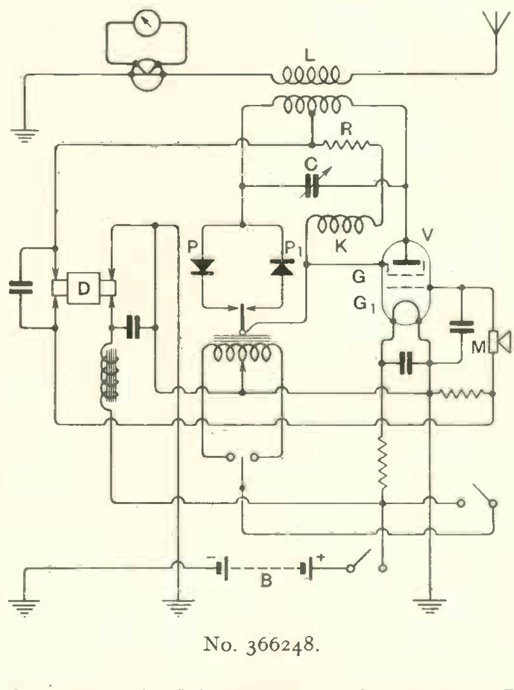
A solution of dry Canada balsam and Xylol is spread over the surface of a Rochelle salt crystal, and is allowed to dry to a " tacky " state. Tinfoil is then applied and rubbed down with a hard cloth. The prepared unit is next baked in an oven at 55° C. to evaporate the Xylol, and, before the balsam has had time to harden, is again rubbed down with a hard cloth until the balsam cement between the active crystal and the tinfoil electrode is reduced to a layer of approximately five ten-thousandths of an inch. The method is stated to reduce the electrode impedance to a minimum, and to ensure constant frequency in operation.

Patent issued to Cleveland Trust Co.

AIRCRAFT SETS.

Convention date (U.S.A.), 31st January, 1930. No. 366248.

Relates to a light-weight fool-proof set suitable for aircraft use. A screen-grid valve *V* serves as a combined oscillator, amplifier, and modulator. High tension and grid bias are taken from a wind-screw generator *D*, whilst the filament is energized from the battery *B* supplying the plane lighting-system. The main oscillatory circuit *L*, *C* is centre-tapped to the H.T. supply, and is connected to the grid *G* through one or other of the piezo-electric crystals *P*, P_1 which stabilise the C.W. frequency. One frequency is used for calling and the other for working. Modulation is effected through a high-voltage microphone *M* inserted between the control grid G_1 and filament. Biasing voltage for



No. 366248.

the screen grid *G* is taken from the generator *D* through a dropping resistance *R*, a choke *K* being inserted to protect the generator windings from any radio-frequency feed-back.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

Printed for the Publishers, Iliffe & Sons Ltd., Dorset House, Tudor Street, London, E.C.4,
by The Cornwall Press Ltd., 1-6, Paris Garden, Stamford Street, London, S.E.1.
Sole Agents for Australasia—Gordon & Gotch (Australasia), Ltd.
Sole Agents for South Africa—Central News Agency, Ltd.