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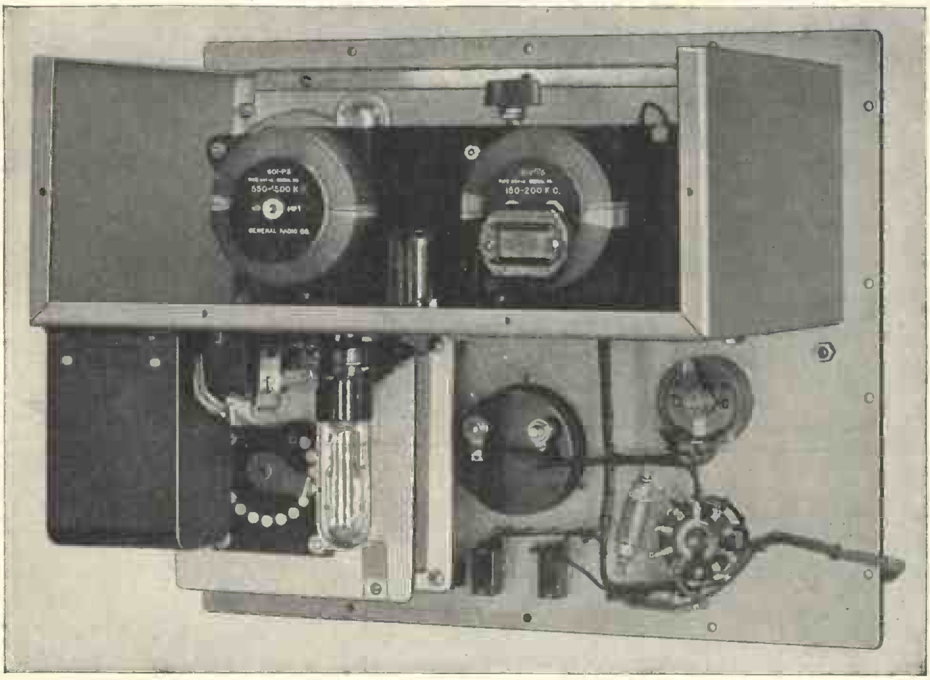

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The

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THE
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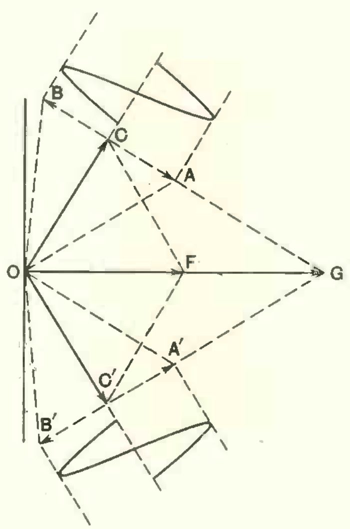
A New Method of Modulation.

THE January number of our French contemporary, *L'Onde Electrique*, contains an article by M. Henri Staut describing the new broadcasting station, "Radio-Paris," the transmissions from which are familiar to every listener who can tune in on the long wave band. The new station, which was opened in November, has a maximum antenna power of 100 kilowatts, whereas the former "Radio Paris" had a power of only 17 kilowatts. The new transmitter has been erected about 25 miles from Paris, with which it is connected by means of a lead-covered loaded cable designed to give no distortion between frequencies of 30 and 10,000, and to have a cut-off frequency of 17,000.

There are several points of interest about the equipment, such as the use of 12,000-volt mercury-arc rectifiers for the high-tension D.C. supply, but the most interesting feature is the use of a special method of modulation designed by M. Chireix, for which a great increase in efficiency is claimed. The principle underlying this so-called dephasing system of modulation is easily understood, but it is by no means so easy to form an opinion on the relative efficiencies of this and other methods of modulation. The explanation given in the article referred to is obviously based on a misunderstanding, but this by no means proves that the system does not do all that is claimed for it. The station has been so equipped that the ordinary choke-control method of modulation can be employed if desired, so that it is possible to make comparative tests of the two methods. The results given are very striking; using choke-control a carrier-wave power of 60 kW. required a supply to the last stage of 198 kW. when the modulation was 87.5 per cent., whereas with the new dephasing method of modulation the same result was obtained with a power supply of about 97 kW. The French engineers concluded from the results of the comparative tests that the efficiency of the final stage was about 30 to 33 per cent. with choke-control and about 60 to 63 per cent. with dephasing control.

With choke control and 100 per cent. modulation the steady carrier A.C. voltage applied to the grid must not exceed a half of the maximum allowable value, otherwise this maximum would be passed on the peaks of the 100 per cent. modulation. Since both the anode direct current and the antenna current are approximately proportional to the amplitude of the grid voltage, the D.C. power (VI) supplied to the valves will be a half of what it would be under the maximum conditions, whilst the antenna power (I_a^2R) will be a quarter of what it would be under those conditions. Hence the efficiency is, on an average, about a half of what it would be if it were possible to maintain the maximum amplitude of the grid voltage.

In the new system the last stage is duplicated; both valves are worked at their maximum grid voltage and they both act on the aerial system. If they are 180 degrees out of phase the aerial current will be zero, and each valve will be operating, as it were, on an infinite resistance and producing no current. If, now, the phases are shifted, so that they are no longer in exact opposition, current will be set up in the aerial system of a magnitude depending on the amount of phase shift. The modulation of the aerial current is thus produced by shifting the relative phases of the two electromotive forces. This is somewhat reminiscent of the early days of radio-telephony when a Poulsen Arc maintained a high-frequency current in the aerial, the resistance of which was varied by speaking into a battery of



microphones inserted between the aerial and earth.

We said above that the explanation given in the article referred to was based on a misunderstanding. If any reader refers to Fig. 5 in *L'Onde Electrique*, or Fig. 3 in the *Bulletin de la Société Française Radio-Electrique* for Sept.–Oct., 1931, he will note that in the arrangement there shown the reason why no current flows in the aerial resistance $R/2$ is because there is no P.D. between its ends, so that it is equivalent to a short-circuit and not to an infinite resistance as there stated.

The method of obtaining the desired variation of the phase relation between the two currents which induce the resultant modulated current in the aerial is illustrated in the diagram. Where there is no modulation the two currents are dephased as shown by OC and OC', giving a resultant OF which may be regarded as the carrier. Now these two currents OC, OC' are never varied in amplitude or phase. Modulation is produced by adding to them other currents in quadrature with them. Thus, at a given moment OC is compounded with a current CB, 90 degrees ahead of it, whilst at the same moment OC' is compounded with a current $C'B'$ 90 degrees behind it. The resultant of these four components is very nearly zero, and would be zero if B and B' were on the vertical line through O. The aerial current is then zero or a minimum. If, now, the amplitude of CB and $C'B'$ falls to zero and then reverses to CA and $C'A'$, the resultant will be OG. The resultant current is thus caused to vary between a very small value and some such value as OG. It is claimed that when valves are operated on constant grid voltage and variable load resistance, the efficiency is approximately constant, and by opposing the phases one obtains the same conditions as if the load resistance were increased. It would appear that the quadrature components have to be modulated in the usual manner, but we await with interest further particulars on this and many other points in this very ingenious and novel installation.

The frequency is stabilised by means of a quartz-crystal master oscillator, the crystal being maintained at constant temperature by means of a thermostat.

G. W. O. H.

Recording of Modulation Level of a Broadcast System.

By H. L. Kirke.

British Broadcasting Corporation.

SUMMARY.—The article describes apparatus which has been developed for indicating and recording the modulation level of a broadcast system. Such recording may take place at any convenient point in the chain of apparatus between the microphone and transmitter or may be used in conjunction with receiving apparatus. In the latter case, if the receiver is situated at a distance from the transmitter such that fading occurs, automatic gain control is provided to compensate for fading.

THE apparatus to be described has not reached finality and it is not suggested that there may be no better method of achieving the desired results, but it produces sufficiently satisfactory results to warrant its description.

The reason for the development of the apparatus is two-fold.

Firstly, to record and observe the level of modulation of our own stations in order to ensure that it is maintained as high as possible, having due regard to the preservation of light and shade in music, a reasonable balance of level values in other items, and freedom from distortion due to overloading.

Secondly, to record the level of modulation of foreign stations so that representations backed by definite evidence can be made to the necessary authorities in cases where these stations cause interference owing to an excessively high modulation level.

This paper is divided into six parts, as follows :—

1. The recorder.
2. The logarithmic rectifier for producing a decibel scale on the recorder.
3. The receiving apparatus.
4. Calibration of receiver and recording apparatus.
5. Automatic gain control apparatus.
6. Operation and results.

The Recorder.

This recorder has been developed by Messrs. Muirhead in conjunction with B.B.C. engineers. Previous recorders which have been tried have not been satisfactory because their moving parts were too sluggish and insufficiently damped. It was at one time proposed to use photographic recording apparatus with an arrangement for automatic developing. Such apparatus is, however, more costly and less easy to operate than the apparatus at present employed.

A syphon recorder is used with paper tape 2in. wide. The tape travels normally at a speed of 2in. per minute, and is pulled by a draw-off motor and fed on to a motor-operated re-rolling drum fitted with a slipping clutch. Both motors are D.C. motors wound for 6 volts, and are driven from the main filament battery. No interference from the motors has been observed unless any of the metal portions are touched by the hand or earthed, although no precautions have been taken to ensure freedom from interference. The current taken by the motors is between 0.3 and 0.4 ampere.

The movement consists of the usual moving coil, which has a resistance of 470 ohms and is suspended by a pair of phosphor bronze wires top and bottom. The tension and the effective length of the wires can be adjusted. This adjustment varies the natural frequency of the whole movement. The syphon is stuck to an aluminium bracket by beeswax, the aluminium bracket being attached to the coil. A second bracket carries the damping vane, which dips into an oil bath, the depth of the vane in the bath being variable giving variable damping. The sensitivity (to D.C.) varies with the adjustment of the tension on the phosphor bronze wires, and is made such that the syphon point is displaced by $1\frac{3}{4}$in. for a current of 2 milliamperes ; this with 2in. paper leaves a gap of $\frac{1}{8}$in. each side. The damping is preferably adjusted so that the movement is approximately critically damped. Under these circumstances the period (time taken for pen to come to rest) is of the order 1/5th secs. A certain amount of friction occurs between the pen and paper, but this is not serious, as the paper is so chosen that the friction is small, and, further, the ink acts as a lubricant.

The position of the pen and the angle of the paper must be carefully adjusted, however, to ensure minimum friction. An

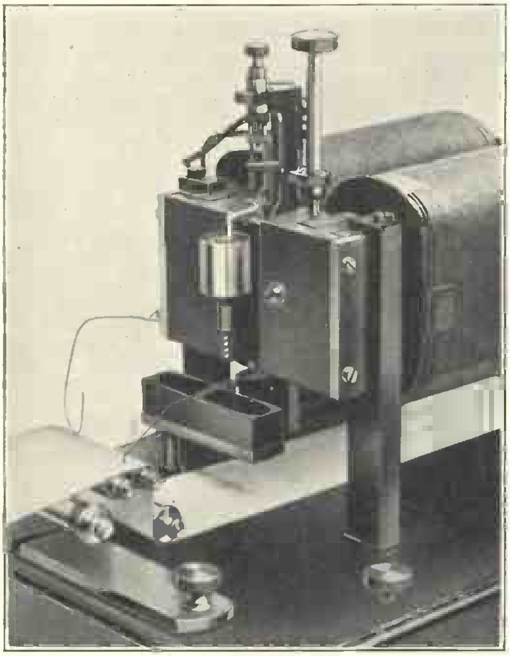


Fig. 1.—*Close-up of the recorder.*

through a system of roller guides (shown in the photograph). Considerable friction has to be provided to keep the paper taut. If this is not done the paper takes up a curve, as in Fig. 3, instead of lying flat, and, since the pen describes an arc in its travel across the paper, the pressure on the latter varies with the deflection. This is unsatisfactory. The method at present adopted to keep the paper flat is to omit one of the rollers as in Fig 3a.* Fig. 3a also shows the guide and brake, the latter consisting of folded paper placed between the paper tape and the base as shown. It is understood from those who have experience of syphon recorders that paper on paper is the best type of brake.

The paper record is divided into 8 spaces by ruling with 9 faint red lines. The calibration will be described later.

The Logarithmic Rectifier.

This apparatus has already been described,† but a brief description will be given here for completeness. Its purpose is to rectify acoustic frequency currents, the rectifier being so arranged that the output (D.C.) is proportional to the logarithm of the A.C. input. If this current is passed

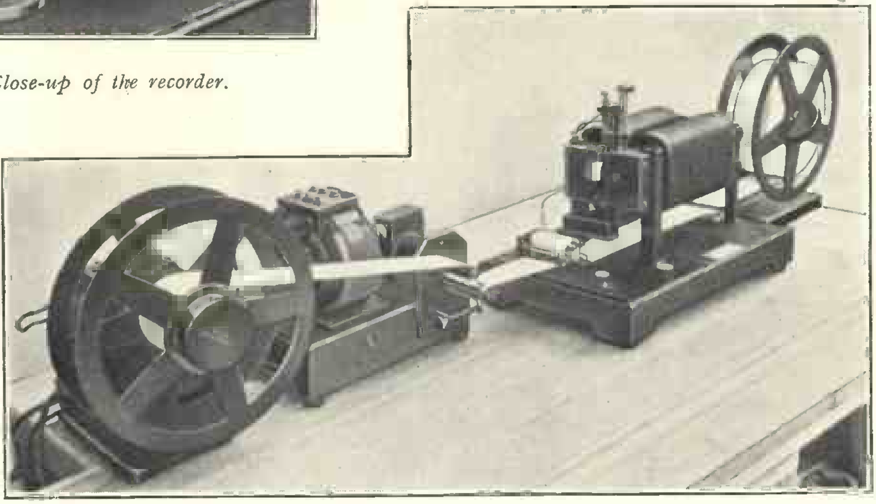


Fig. 2.—*General view of the equipment showing the arrangement of the recorder and the tape system of rollers.*

adjustment is provided for varying the height of the pen and the moving coil assembly. Photographs of the recorder are shown in Figs. 1 and 2.

The paper passes under a guide on the right of the recorder proper and thence

through a suitable D.C. meter or recorder, the scale of the D.C. meter or recorder can be calibrated in logarithmic units, *e.g.*,

* This method has another advantage in that it obviates smudging by the roller guide.

† See *World-Radio*, 26th February, 1932.

decibels. The reason for the use of a logarithmic rectifier is that other types of rectifier—square law or linear—do not readily give the necessary information regarding the level of acoustic frequency currents.

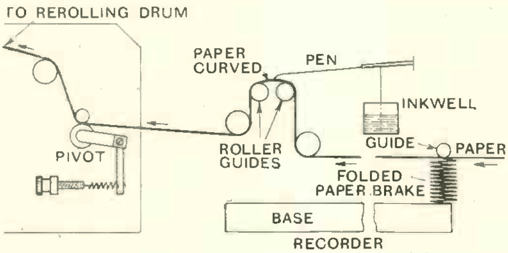


Fig. 3.

The logarithmic rectifier was developed originally for the monitoring and controlling of programme level.* It is preceded by a two-stage amplifier, the first stage being a single valve which is transformer-coupled to the second stage, which comprises two valves in push-pull. This stage is again transformer-coupled to the rectifier, which employs what are in effect two diodes in push-pull. The essential part of each diode is the anode filament path of a pentode. The control grid is connected to negative filament, while the second grid is connected to a source of H.T. voltage. The value of this voltage determines the shape of the rectifier characteristic. The H.T. to the amplifier rectifier unit is 300 volts, the second grids of the pentodes being supplied through a potential divider from the 300 volt supply. The potential divider is normally clamped in position after adjustment. The instrument used in the anode circuit of the rectifier for visual indication is a 0 — 1 mA. Ferranti milliammeter shunted to read 0 — 2mA. This arrangement gives the best conditions as regards damping. The meter scale is divided into eight equal portions, and each division between 1 and 7 represents normally a difference of level of 4 decibels; these 7 divisions correspond with the first 7 divisions on the recorder tape. The normal adjustment is such that a reading of 7 on the meter represents a sinusoidal potential difference between grid and filament of the first valve of approximately 2.5 volts R.M.S. A potential divider is normally provided in the latter position to vary the sensitivity.

The recorder is connected directly in series with the rectifier anodes and the 0 — 2 milliammeter; a battery, resistance and switch are provided for calibrating the sensitivity of the recorder. Actually the grid bias battery of the main receiver is used for this purpose.

A variable resistance of 400 ohms, connected in series with the common H.T. supply, is used to adjust the H.T. voltage to 300 and so to compensate for any variation in the voltage of the mains supply.

The Receiving Apparatus.

Two types of receiver have been used. The first embodies a straight circuit consisting of a screened-grid H.F. stage, a diode detector,† and three L.F. stages, the logarithmic rectifier unit being resistance capacity coupled to the anode of the first L.F. valve. A milliammeter is connected in the anode circuit of this valve, the change in current acting as a calibration of output and being a measure of the signal volts at the detector, to which the valve is directly coupled. The receiver is used for checking quality of local

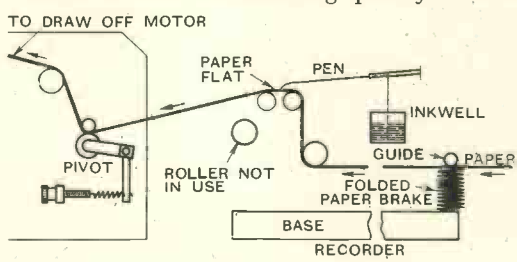


Fig. 3a.

transmissions, and for listening to those distant stations where interference is not severe. The essential circuits are shown in Fig. 4.

The second receiver was developed, or rather modified, for the particular purpose of recording modulation level. It is an Igranic Neutrosonic receiver modified as follows:

A variable conductance S.G. valve is used as the radio-frequency stage. The grid tuning circuits have been removed and placed outside the receiver to facilitate screening. The second detector circuits have been modified for the use of a diode. The last valve of the original receiver, now the 1st

* See the *B.B.C. Handbook*, 1932, page 355.

† See *The Wireless World*, 3rd February, 1932.

L.F. stage, is connected through a low pass filter to a resistance-capacity output circuit. The change in current through the resistance serves to calibrate the output of the receiver and is a measure of the output voltage of the detector. A suppressed zero milliammeter reading 7–12 mA. is provided for this purpose, the normal anode current being 11–12 mA., which is reduced by 1.6 mA. by a normal signal. The low pass filter circuit is described in *World Radio* of November 14th, *et. seq.*, 1930, and starts to cut off at 7,000 p.p.s., having maximum attenuation at 9,000 cycles. Its purpose is to remove the heterodyne note caused by the beating of the local station carrier and that of a station on an adjacent channel. It also removes some of the interfering sideband frequencies. A frequency characteristic is shown in Fig. 5. A second output is provided from the second detector (diode) output circuit through a 3 megohm resistance for operating the automatic gain control. The power amplifier for operating the loud speaker may be connected by means of a switch to either receiver. The essential circuit of the second receiver is shown in Fig. 6, which also shows the circuit of the automatic gain control. The mains supply unit and various decoupling arrangements are not shown, as they are of normal design, although it is to be noted that adequate decoupling must be provided. The filaments of the valves of the local receiver are all indirectly heated by A.C., whilst the superheterodyne receiver, logarithmic rectifier unit and D.C. amplifier employ 6-volt valves heated by a battery.

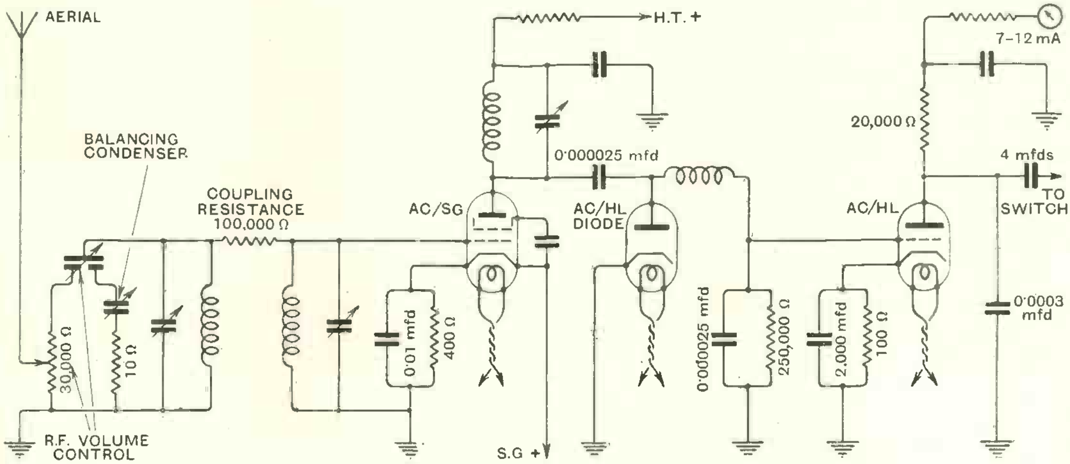


Fig. 4.

Calibration of Receiver and Recording Apparatus.

The logarithmic rectifier is calibrated in conjunction with a peak voltmeter used at the transmitter. This peak voltmeter will be the subject of another article in this journal. It is so arranged that modulation peaks, including those lasting only a very small fraction of a second, are indicated on a meter which shows directly the coefficient of modulation. It has been found by

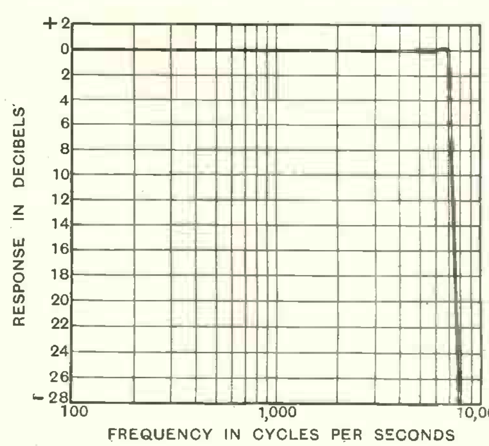


Fig. 5.

experiment that if the transmitter and logarithmic rectifier are calibrated on pure tone, the amplitude of the tone being adjusted so that the modulation at the transmitter is 30 per cent. (peak modulation), and the gain of the amplifier associated with the logarithmic rectifier being such that a reading of 7 is obtained for the same setting, then normal programme which produces a reading of 7 on the logarithmic rectifier will usually modulate the transmitter to about 70 per cent. or 80 per cent. This depends upon the actual wave form, which, of course, is continually varying as is also the amplitude.

The receiver and recorder can be calibrated in two ways. In the first case use is made of a transmitter—*i.e.*, the gain of the carrier. The pure tone is applied across the input of the logarithmic rectifier. This, of course, assumes that the detector and all preceding circuits have linear amplitude response, and that the H.T. voltage applied to the first L.F. valve and to its anode resistance does not change between the conditions of signal and no signal. This method cannot be used directly if the H.T. is from the mains, and if a decoupling resistance is used, unless the first L.F. valve anode circuit is previously calibrated. This can be done as follows. A variable resistance is substituted for the valve anode-filament path and the current noted for

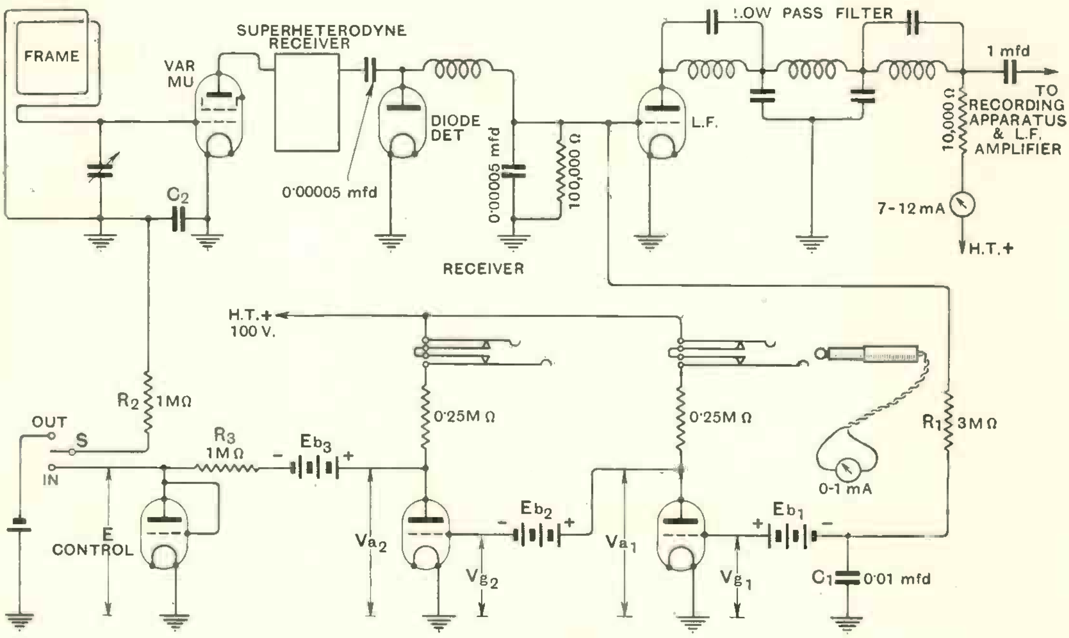


Fig. 6.

circuits is adjusted at the same time as the transmitter and its circuits are calibrated, so that 7 on the recorder represents a transmitter modulation of 30 per cent. for pure tone, the change in anode current of the first L.F. valve of the receiver being noted and kept constant.

Secondly, an absolute calibration is possible by the use of a pure tone having a peak voltage equal to 30 per cent. of the change in voltage drop in the anode resistance of the first L.F. valve due to the rectified carrier.

various values of resistance. If R is the total effective resistance, excluding the valve or the resistance substituted for it, R_1 and R_2 are two values of the substituted resistance and I_1 and I_2 two currents corresponding to resistances R_1 and R_2, we have

$$E \text{ (applied volts)} = R_1I_1 + RI_1 = R_2I_2 + RI_2$$

giving the value of R, which is made up of R_3 and R_4, R_3 being the anode resistance and R_4 the resistance of the remainder of the circuit. A change of direct current I_4, due to the rectified carrier, will take place through the R_3 and R_4, whereas alternating current I_3, due to modulation, will only pass through R_3. If R_a is the valve resistance, we have therefore

$$I_4 = \frac{\mu Eg_1}{R_a + R_3 + R_4}$$

where Eg_1 is D.C. change in grid voltage, and μ is the magnification factor of the valve,

$$I_3 = \frac{\mu Eg_2}{R_a + R_3}$$

where Eg_2 is the peak value of alternating grid voltage,

and $$\frac{I_4}{I_3} = \frac{R_a + R_3}{R_a + R_3 + R_4}$$

This provides a multiplier for the true value of calibrating voltage required. If I_4 is the current change through the anode resistance due to rectified carrier, then the peak value of A.C through R_3 required for calibration will be

$$I_3 = I_4 \frac{R_a + R_3 + R_4}{R_a + R_3} \kappa$$

where κ is the coefficient of modulation of the calibrating tone, *i.e.*, 0.3. Alternatively the calibrating tone can be applied to the grid of the first L.F. valve in series with a negative D.C. voltage equal to that due to the rectified carrier. The peak value of the calibrating voltage must be 0.3 times the D.C. voltage required to produce the same change of anode current as the rectified carrier.

Automatic Gain Control.

In order to compensate for the variations in field strength of distant stations due to fading, an automatic gain control circuit has been incorporated. It is operated by the rectified carrier voltage at the output of the diode detector, and its object is to keep this rectified carrier voltage practically constant irrespective of signal strength; this it does to within a few per cent.

The autogain circuit is essentially a 2-stage battery coupled D.C. amplifier operating from a 100-volt dry battery with a total current consumption of 0.8 mA. The input is connected to the second detector output circuit, and the output is connected to the grid of the first H.F. valve. It might be thought that a stage could be saved by connecting the input of the autogain circuit to the anode of the first L.F. valve, which is itself directly coupled to the second detector. This valve, however, has its H.T. supplied from the mains, and the potential at the anode is therefore likely to fluctuate with mains variations; any such fluctuations would operate the autogain apparatus, which would therefore keep the voltage at the anode of the first L.F. valve constant, instead of the change in voltage. Furthermore, the voltage at this anode is of the order of 100 or more, and the first biassing battery voltage (E_{b_2} Fig. 6) would have to exceed this value.

The circuit is normally so adjusted, by means of battery voltages, etc., that, with a signal just sufficient to produce the required voltage at the detector output, the voltage applied to the grid of the gain control valve is slightly negative (about 1 volt). The voltage at the output of the detector will, of course, be negative with respect to the filament. Any increase of signal strength will tend to increase the detector output voltage, which will throw a considerably increased negative voltage on the grid of the gain control valve, reducing its magnification. The system adjusts itself to a stable condition such that the variation in magnification of the gain control valve compensates for the variation in signal strength.

The magnification of the D.C. amplifier is of the order of 100, and, since the maximum voltage required on the grid of the gain control valve is of the order 10 volts, the maximum fluctuation of signal on the detector output will be 1/10th of a volt.

The simple arrangement just described was the one first tried, which worked provided the detector output was not allowed to fall below the specified amount. If, however, the detector output became less than the value for which the voltage on the grid of the gain control valve was zero, the set became extremely insensitive, due to the fact that a positive voltage was applied to the gain control valve grid. The magnitude of the voltage can be estimated by considering the reduction of a normal detector output of 4 volts to zero in the absence of a signal. A change of 4 volts (positive) on the first grid will increase the negative bias on the second grid by 40 volts, which will reduce the anode current of the second valve to zero. The potential at the anode of the second valve will therefore be equal to the H.T. voltage, since there is no drop of voltage in the anode resistance. If the H.T. is 100 volts and E_{b_3} (Fig. 6) is 45 volts, a potential of + 55 volts will be applied to the grid of the gain control valve. Actually the voltage at the grid is somewhat less than 55, as it is fed through a resistance of 1 megohm, but nevertheless the positive voltage remaining is sufficient to reduce the sensitivity very considerably. The first endeavour to overcome this defect was to bias the grid of the first valve of the D.C. amplifier by a positive voltage equal to that of the detector output, fed through a high resistance of several megohms, so that for normal detector output the P.D. between the grid and filament of the first valve of the D.C. amplifier would be zero, the other batteries being adjusted to compensate. A reduction in the detector voltage would tend to make the first grid positive and grid current would occur, providing an E.M.F. across the resistance almost equal to the resultant applied positive voltage, so that in fact the grid would hardly become positive at all; whereas, if the detector output increased, the grid would become negative, no grid current would occur, and therefore the full negative voltage would be applied to the grid. This method was not very satisfactory, as the rate of change of grid current was not sufficiently great, with the result that grid current was in fact always present unless a relatively large signal was applied, the control of gain for small signal inputs being poor. It was found, however, that the use of this battery considerably reduced the value of H.T. required, and also the value of the next biassing battery E_{b_2}. (A volt on the grid is worth ten at the anode.) The difficulty was eventually overcome by using a diode after the D.C. amplifier, connected in shunt between the output circuit and earth, as shown in Fig. 6. The operation is similar to that of the grid of the first valve of the D.C. amplifier as described above, except that the voltage changes are one hundred times as great, due to the magnification of the D.C. amplifier; consequently the rate of change of current is, in effect, one hundred times as great. A high resistance is provided so that the drop of voltage, when the diode anode is positive, is as large as possible.

It is necessary to demodulate the carrier, as the modulation voltages at the detector are very large compared with the permissible variations in rectified carrier due to fading, etc. The modulation voltage would normally be applied to the D.C. amplifier, and fed back to the grid of the gain control valve with somewhat curious results. The writer has not tried to find out what the effect would be. Demodulation is effected here by a series resistance and shunt condenser

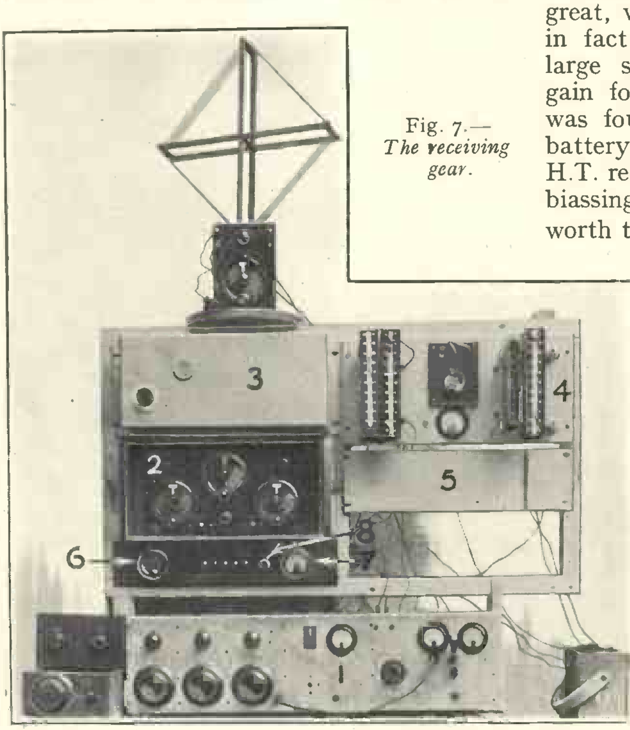


Fig. 7.—*The receiving gear.*

(1) *Local receiver and L.F. amplifier.* (2) *Superheterodyne receiver for distance.* (3) *L.F. amplifier and logarithmic rectifier.* (4) *Autogain amplifier.* (5) *Low pass filter circuit CO* = 7,000 *p.ps.* (6) 0–2 *milliammeter connected in series with recorder.* (7) *Suppressed zero meter* 7–12 *milliamps.* (8) *H.T. voltage regulation resistance for* (3).

the demodulation being $\dfrac{1}{\sqrt{\dfrac{R^2}{X^2}+1}}$ where R is the resistance and X the reactance of the condenser at the modulation frequency in question. When $X << R$ the demodulation is approximately $\dfrac{X}{R}$. In the first arrangement tried, practically the whole of the demodulation was carried out before the D.C. amplifier by a 5 megohm resistance and 1 mfd. condenser, giving a demodulation of 6×10^{-4} at approximately 50 pps. It is necessary to provide a by-pass condenser, C_2, across the gain control bias circuit to the gain control valve, and if the time constant of this condenser, and any resistances associated with it, is comparable with the time constant of the demodulating circuit, a very low frequency oscillation (normally damped) is set up every time any change in condition takes place. For good operation the one time constant must be much smaller than the other. With the above arrangement considerable difficulties were experienced due to induction from the A.C. mains supply, which could only be cured by using a much larger by-pass condenser for the gain control grid circuit, which meant that the time constant of this circuit was comparable with that of the demodulation circuit. The time constant of the latter circuit was then reduced to 3×10^{-2} ($R_1 = 3$ megohms and $C_1 = 0.01$ mfd.), giving a demodulation of only 0.1 at 50 pps., which appears to be satisfactory, the remainder of the demodulation being carried out by the second circuit, which has a time constant of 2 seconds ($C_2 = 1$ mfd., $R_2 + R_3 = 2$ megohms). (Fig. 6.)

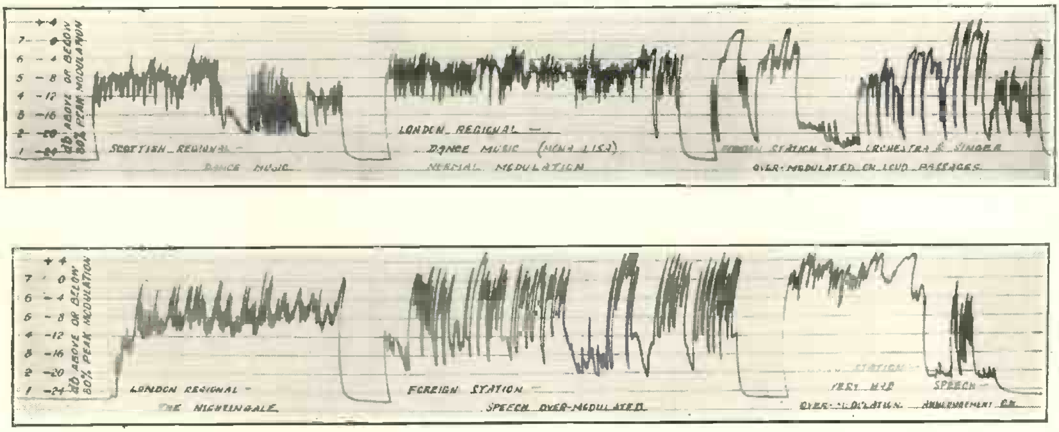


Fig. 8.—*Some modulation level records.*

Adjustment of D.C. Amplifier.

A signal is applied to the receiver, and adjusted by means of a manual gain control to give the desired value of detector output, the automatic gain control switch being in the "off" position. The second bias battery E_{b_2} (Fig. 6) is disconnected. If the voltage of the battery E_{b_1} is then varied it will be noticed that the anode current of V_1 decreases for values of E_{b_1} less than a certain amount, but scarcely increases at all for values greater than that amount; the correct voltage is one just less than that above which the anode current charge is small, *i.e.*, the voltage should be as high as possible consistent with the rate of change of anode current with grid voltage being high. The normal anode current with 250,000 Ω anode resistances, an Osram valve L610 and 100 volts H.T. is 0.3 mA. E_{b_2} is then adjusted so that the anode current to the second valve is about 0.25 mA. with an Osram DEL valve, 250,000 ohms anode resistance and 100 volts H.T. (E_{b_3} being disconnected). Alternatively, E_{b_2} can be adjusted until V_{g_2} is about 2 or 3 volts negative with respect to the point where grid current starts; this point is shown by connecting the meter in the first anode circuit, so as to read any grid current in the second valve. E_{b_2} should be increased

2–3 volts above the value required for zero grid current. E_{b_3} is then adjusted by removing V_3, connecting the meter in series with V_2 and finding a value of E_{b_3} which

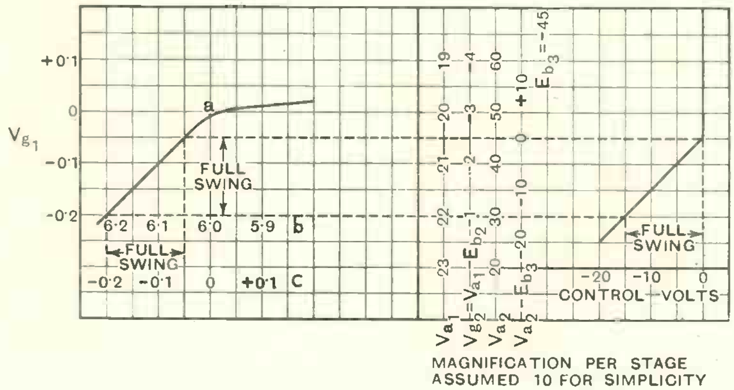
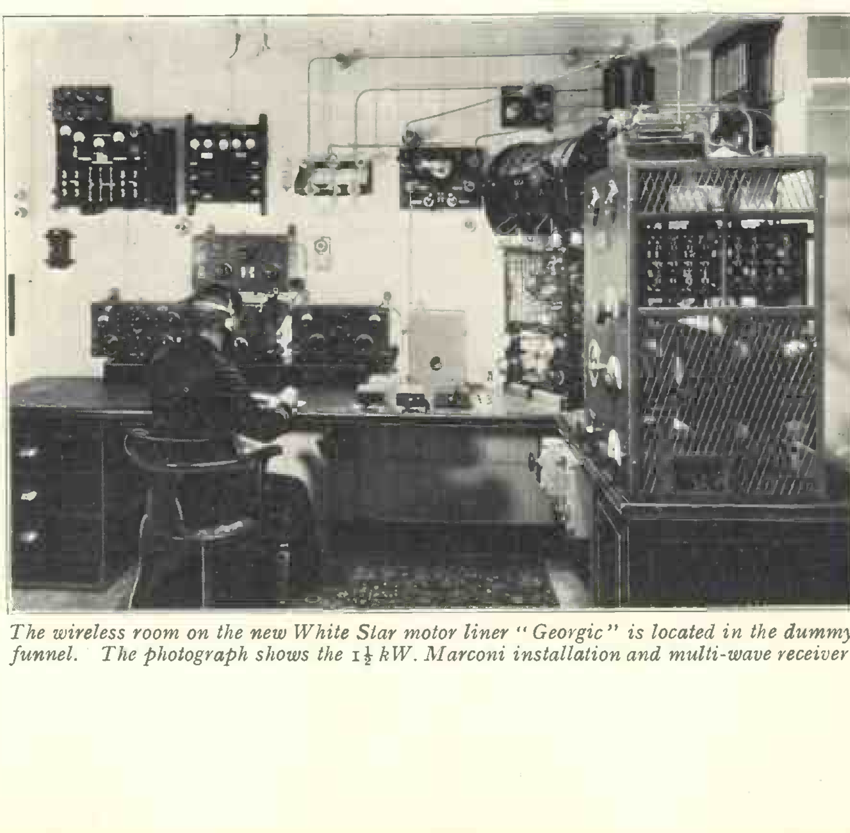


Fig. 9.—a *is point where grid current starts.* b *is rectified current* (E *detector*). c *is E det.* — E_{b_1} ($E_{b_1} = 6$).

gives the minimum change in the anode current of V_2 when the negative terminal of E_{b_3} is earthed. All the above adjustments must be made without any change in the detector output and with the gain control switch in the "off" position. This gives the correct adjustment, which can be tested by increasing the gain of the receiver by the manual gain control, when the detector output should remain constant for all values of receiver gain above the critical value where the autogain control comes into operation. The best adjustment for controlling the actual value of detector output which is to be maintained is the variation of the first grid battery E_{b_1}. Once the circuit has been adjusted it will be found that the detector output is determined by the voltage of the battery E_{b_1} plus a constant which depends upon the adjustment of the D.C. amplifier. This constant usually lies between 0 and 2 volts.

The autogain circuit is shown in Fig. 6. Fig. 7 shows photographs of the apparatus, and Fig. 8 some modulation level records obtained from various stations. Fig. 9 shows the potentials at various points of the D.C. amplifier for various conditions of normal operation.



The wireless room on the new White Star motor liner "Georgic" is located in the dummy funnel. The photograph shows the 1½ kW. Marconi installation and multi-wave receiver.

The Detection by a Straight Line Rectifier of Modulated and Heterodyne Signals.*

By E. B. Moullin, M.A., A.M.I.E.E.

IN this Journal there has been lately considerable discussion of the problem of a strong signal demodulating a weak. These articles have contained implicitly the whole solution of the problem, but do not seem to have pointed out explicitly certain things which seem to me essential to a clear understanding of the phenomenon.

If both stations are unmodulated the acoustic output will be a note of the difference frequency, because the amplitude of the detector voltage varies at this rate. If the interfering station is modulated the acoustic output should be the difference frequency modulated at the modulation frequency. The interfering programme should become the side bands of the difference frequency as carrier and we should expect this to sound very unlike the original. Thus if, for example, the carrier frequencies are separated by 7 k.c./s and the interfering station is modulated at 1 k.c./s we should not expect to hear a note of 1 k.c./s, but to hear notes of 6, 7 and 8 k.c./s. Every low note of the interfering station should be reproduced as a high note and vice versa. But experience shows that the interfering programme is in general recognisable, and we wish to understand why it should be. The problem to me is to understand why the interfering programme gets through in the presence of the strong signal and not to understand why the strong signal appears to reduce or "demodulate" the weak. The strong signal has in fact very little power to demodulate the weak, but it has the power of transferring the interfering programme to a modulation of the frequency difference between the two carriers. We will start by considering a steadily modulated voltage $v = V(1 + M \cos nt) \cos \omega t$, applied to a linear rectifier, then the current through the detector will have the wave form shown in Fig. 1. This can be decomposed into a current $i = \frac{kV}{\pi}(1 + M \cos nt)$ and a series of high frequency terms of frequency ω, 2ω, 3ω, etc. The current i is composed of a steady current $\frac{kV}{\pi}$ which will be indicated by a galvanometer and a slow frequency alternating current which will be indicated by a telephone.

The galvanometer deflection depends only on V and is independent of M: it will not change if the modulation is removed.

We will now suppose the applied voltage is $S\left\{\cos \omega t + \frac{W}{S}\cos(\omega + n)t\right\}$. Many people are accustomed to think of this as a sine curve of fluctuating amplitude: previous to Butterworth's paper (*Experimental Wireless*, 1929, p. 619) I had supposed the galvanometer deflection would be independent of W/S, just as it is independent of M. Since the amplitude of the detector voltage varies slowly between $(S + W)$ and $(S - W)$ it seems natural to suppose that the conditions will be the same as when it varied slowly between $V(1 + M)$ and $V(1 - M)$. But Butterworth has shown by straightforward analysis that the presence of W increases the galvanometer deflection, and I have had considerable difficulty in understanding how the effect comes about.

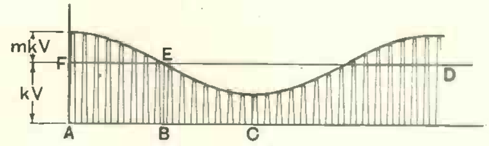


Fig. 1.

The mechanism of the effect was explained clearly in your leader of Aug., 1931, but will now be considered in more detail and from a slightly different angle.

(2) Rectification of a Heterodyned Signal.

Consider the two sine curves shown in Fig. 2, the larger of which has a frequency 0.9 of the smaller. At A, the starting time, they are in phase with one another, and the resultant voltage is substantially a sine curve of maximum value $(S + W)$: at C they are in antiphase and the voltage amplitude is

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

$(S - W)$. So far we are in complete agreement with the regime depicted in Fig. 1. At time B they are in phase quadrature and at this instant of time the instantaneous voltage is S. But the resultant voltage amplitude at this moment is not S, but is $\sqrt{S^2 + W^2}$, and the instantaneous voltage happens to be S only because it is on the descending side of a sine curve which has a maximum greater than S. The resultant amplitude will not fall to S until W has an appreciable antiphase component. Hence the current through the galvanometer and telephone will not fall to the value appropriate to S in the absence of W, until a time later than that shown by the point B in Figs. 1 or 2. Consequently this current will not have the wave form of the envelope in Fig. 1 and it will not cut the line FD until a time later than that shown by the point E in Fig. 1.

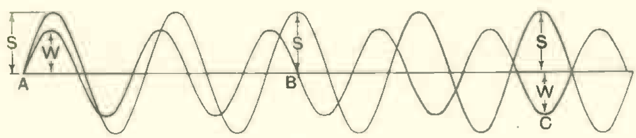


Fig. 2.

The current will be positive (greater than FD) for a longer time than it is negative, and since the positive and negative maxima are equal to one another the mean current is increased by the presence of W. Thus the first effect analysed by Butterworth owes its existence to the fact that the resultant is not S until after the two voltages are in phase quadrature.

By the trigonometrical process used in the previous articles on this subject, we can express the voltage as

$$V \equiv \sqrt{S^2 + W^2 + 2SW \cos nt} \cos (\omega t + \psi)$$
$$\equiv S\sqrt{1 + x^2 + 2x \cos nt} \cos (\omega t + \psi) \quad (1)$$

where ψ is a function of frequency such that

$$\tan \psi = \frac{W \sin . nt}{S + W \cos nt}.$$

Equation (1) is that of a sine curve of frequency $\omega/2\pi$ whose amplitude pulsates and whose phase also pulsates rhythmically. The pulsation of phase means only that each successive half sine curve, such as those shown in Fig. 1, starts from a slightly different place from where it would start if ψ was constant: the blank spaces are either a little more or a little less than half a period, but there are the same total number of half periods in a complete cycle of n as there would be if ψ was constant. We need, therefore, think no more of this slowly shifting phase.

The amplitude of V does not become equal to S until

$$\cos nt = -\frac{x}{2}, \text{ or } t \doteq \frac{\pi + x}{2n}$$

If $W = S$, $(x = 1)$ then

$$V = 2S \cos \frac{n}{2} t \cos (\omega t + \psi)$$

The shape of the envelope for $x = 0.1$, 0.25 and 1 is shown in Fig. 3, in which $(W + S)$ is kept constant at unity. The lines C_1D_1, C_2D_2, C_3D_3 show the current which would result from S in the absence of W, and it may be seen that the points E_1, E_2, E_3, where the respective curves cut these lines, are appreciably displaced from the vertical line at $x = \pi/4$. Therefore the mean current through the galvanometer is increased by an amount which is a function of the displacement of E_1, etc. The envelope curves for $x = 0.1$ and $x = 0.25$ are sensibly cosine curves drawn from a base line slightly above C_1D_1 and C_2D_2 respectively: but the envelope for $x = 1$ will not nearly conform to this representation. So we see that not only does the presence of W increase the galvanometer deflection, but also gives rise to alternating currents of frequency $2n$, $3n$, etc., which are not appreciable until x is verging on the value unity.

The increase of mean current could be found by graphical integration of curves such as those shown in Fig. 3, or, following Butterworth and Colebrook, by evaluating the elliptic integral expression for J, the mean current, where

$$\frac{J}{k} = \frac{2}{\pi} S(1 + x) \int_0^{\pi/2} \sqrt{1 - \frac{4x}{(1 + x)^2} \sin^2 \tfrac{1}{2}nt} \quad (2)$$

But the expression for V can be expanded in a Fourier series by a simple trigonometrical process and this series will give the mean current and also the fundamental component and its harmonics: the process is as follows:—

$$V = S\sqrt{1 + x^2 + 2x \cos nt}$$

Now

$$(1 + xe^{int})(1 + xe^{-int}) = 1 + x^2 + x(e^{int} + e^{-int})$$
$$= 1 + x^2 + 2x \cos nt$$

$$\therefore \quad \frac{V}{S} = (1 + xe^{int})^{\frac{1}{2}}(1 + xe^{-int})^{\frac{1}{2}}$$

$$\equiv (1 + X)^{\frac{1}{2}}(1 + Y)^{\frac{1}{2}}, \text{ where } XY = x^2$$
$$\text{and } (X + Y) = 2x \cos nt$$

$$= (1 + \tfrac{1}{2}X - \frac{1}{2^3}X^2 \ . \ . \ .)$$
$$(1 + \tfrac{1}{2}Y - \frac{1}{2^3}Y^2 + \ . \ . \ .)$$

$$= (1 + \tfrac{1}{4}XY + \frac{1}{2^6}X^2Y^2 + \ . \ . \ .) + \frac{(X+Y)}{2}\left(1 - \frac{1}{2^3}XY \ . \ . \ .\right) + \text{etc.}$$

$$= \left(1 + \frac{x^2}{2^2} + \frac{x^4}{2^6} + \ . \ . \ .\right) + x\left(1 - \frac{x^2}{2^3} \ . \ . \ .\right)\cos nt - \frac{x^2}{4}\left(1 - \frac{x^2}{2^2} \ . \ . \ .\right)\cos 2nt + \frac{x^3}{8}\left(1 - \frac{5x^2}{2^4} \ . \ . \ .\right)\cos 3nt - \text{etc.}$$

Each coefficient is a rapidly convergent series. In the limiting case when $x = 1$, $V = 2S \cos \frac{n}{2}t$ and the Fourier expansion for this is well known to be

$$V = \frac{4}{\pi}\left(1 + \frac{2}{3}\cos nt - \frac{2}{15}\cos 2nt + \frac{2}{35}\cos 3nt \ . \ . \ .\right)$$

So we have

$$\frac{J}{kS} = \left(1 + \frac{x^2}{4} + \frac{x^4}{64} + \ . \ . \ .\right) \quad (3)$$
$$= \frac{4}{\pi}, \text{ when } x = 1$$

The rate of convergence may be judged by stating that even when $x = 1$ the sum of the first three terms of (3) is less than $\frac{4}{\pi}$ by 1 part in 200. Accordingly we shall write

$$J = kS\left\{1 + \frac{x^2}{4}\left(1 + \frac{x^2}{16}\right)\right\} \quad . \ . \quad (3a)$$

Thus we find the increase of mean current is small: it has a limiting increase of 27 % when $x = 1$ and an increase of 6.3 % when $x = \frac{1}{2}$. Hence the expectation that the presence of W will not increase the mean rectified current is substantially correct until x is greater than, say, $\frac{1}{2}$. The graph of the function has been printed already (see *W.E. & E.W.*, 1931, August, p. 410, Fig. 2).

For the heterodyne notes we have,

$$\frac{i}{k} \equiv W\left\{\left(1 - \frac{x^2}{2^3} - \frac{x^4}{2^6} - \frac{5x^6}{2^{10}}\right)\cos nt - \frac{x}{4}\left(1 - \frac{x^2}{4} - \frac{5}{2^7}x^4\right)\cos 2nt + \frac{x^2}{8}\left(1 - \frac{5x^2}{2^4} - \frac{7}{2^7}x^4\right)\cos 3nt - \frac{5x^3}{2^6}\left(1 - \frac{7}{20}x^2 - \frac{21}{5 \cdot 2^6}x^4\right)\cos 4nt\right\} \quad (4)$$

to an accuracy of 1% when even $x = 1$.

We see from this that the acoustic output does not increase in proportion to W, and that all harmonic frequencies are present. But the fundamental term is proportional to W to an accuracy closer than 1% so long as x is less than $\frac{1}{4}$. (In the limit, when $x = 1$, the fundamental term is $i = 0.85kW$.) The fractional amplitude of the second harmonic is approximately $\frac{x}{4}$ with a limiting value of 20%, and of the third it is approximately $\frac{x^2}{8}$ with a limiting value of 8.5%. So long as x is less than 0.28, the acoustic output will be the fundamental note and its octave together with a third harmonic which is less than 1%.

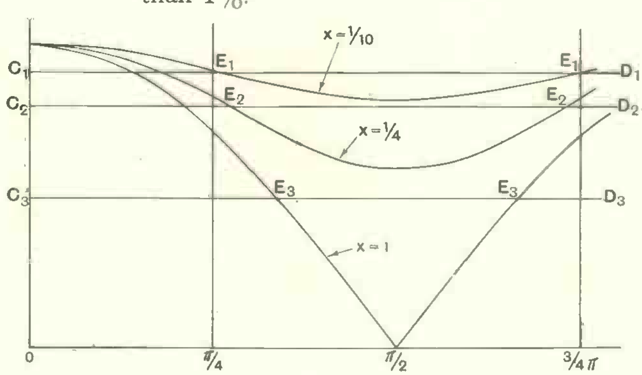


Fig. 3.

We have now considered fully the combination of two sustained voltages, and it remains to see what happens when one or both of them is modulated.

(3) Rectification when One Voltage is Modulated.

We have seen that, if the two voltages are notably unequal, there is no change of mean anode current: such change as does occur is a second order effect and will be ignored in a preliminary discussion. With this supposition the anode current consists of a simple harmonic current $i = kW \cos nt$, superposed on a steady current $J = kS$.

This is represented by Fig. 4, which shows four complete cycles of the beat frequency n. Now suppose the weak signal W is modulated to any depth, but at a frequency which is small compared with n. During any one cycle of n the change of amplitude is small, and that cycle of current will be sensibly the same as if the amplitude obtaining at that moment had obtained over many

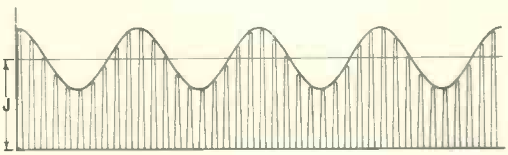


Fig. 4.

previous cycles. Accordingly the current of frequency n will now be modulated and this is shown in Fig. 5.

The form of anode current is now

$$i = kW(1 + M \cos mt) \cos nt$$

where m is the frequency of the modulation. This current cannot be split into a component of frequency m, but only into three components having frequencies $(m + n)$, n and $(m - n)$.

Thus to the present degree of approximation there is no current of frequency m and the weak signal is said to have been completely demodulated. But perhaps the effect is more suitably described by the term derectified, for if this current passes through an anode circuit impedance and the P.D. across it is applied to a second rectifier, then we shall obtain a current of frequency m and its depth of modulation will be unaffected by the process. Just as it is necessary to rectify the modulated high frequency current in order to obtain a current of modulation frequency, so it is necessary to rectify the modulated acoustic current of frequency n to recover a current of the modulation frequency of the original high frequency voltage.

We are familiar with this result in the superheterodyne system of reception: there an unmodulated voltage is combined with a modulated signal to produce a beat note of very high frequency. The beat frequency current is always assumed to be modulated like the original carrier: after the modulated beat frequency current has been amplified it is rectified again so as to produce a current of acoustic frequency.

When an interfering station acts alone on a receiver, the rectifier produces a current of the modulation frequency, but when the carrier of the desired signal operates simultaneously, then the output of the rectifier is a modulated current of the difference frequency and is no longer a current of modulation frequency.

But because there is a second order effect on the magnitude of J, there is a small output current of frequency m, which can be calculated readily from equation (3a).

Instead of $\frac{W}{S}$ being a constant x, we now have

$$w = W(1 + M \cos mt) \text{ and so } \frac{W}{S} = x(1 + M \cos mt).$$

Substituting in (3a) yields

$$\frac{J}{kS} = 1 + (1 + 2M^2)\frac{x^2}{4} + \left(\frac{Mx^2}{2} + \frac{4Mx^4}{64}\right)\cos mt + \left(\frac{M^2x^2}{2}\right)\cos 2mt + \frac{M^3x^4}{64}\cos 3mt + \frac{x^4M^4}{512}\cos 4mt \quad (5)$$

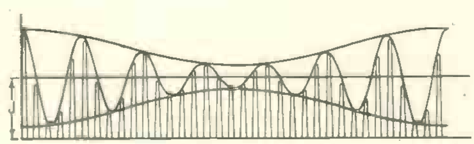


Fig. 5.

The acoustic frequency output is

$$\frac{J}{k} = \frac{Mx}{2} W\left[\left\{1 + \frac{x^2}{8}\right\}\cos mt + \frac{M}{2}\cos 2mt + \frac{M^2x^2}{32}\cos 3mt\right] \quad .. \quad (5a)$$

Hence, in the presence of S the output current of frequency m is approximately $\frac{x}{2}$ of what it would have been in the absence of S. This result is in agreement with formula (12) of the paper in the March issue by Professor Appleton and Mr. Boohariwalla, but it now appears that their formula is probably valid to a higher degree of accuracy than they indicated. It also appears now that an octave is produced whose fractional amplitude is sensibly proportional to $\frac{M}{2}$.

Formula (5a) shows that the acoustic output in the presence of S should be a little greater than the value calculated by Professor Appleton, but the increment is only about 4% when $x = \frac{1}{2}$: since the rectifier is not truly linear, it is not worth applying the correction to the tables in his paper.

If both signals are modulated, we have

$$\frac{W}{S} = x \cdot \frac{(1 + M_1 \cos m_1 t)}{(1 + M_2 \cos m_2 t)}$$

and so using (3a) we have

$$\frac{J}{k} \doteq S\left\{(1 + M_2 \cos m_2 t) + \frac{x^2}{4} \cdot \frac{(1 + M_1 \cos m_1 t)^2}{(1 + M_2 \cos m_2 t)}\right\}$$

$$\doteq S + SM_2\left(1 - \frac{x^2}{4}\right)\cos m_2 t + \frac{M_1 x W}{2}\cos m_1 t - \tfrac{1}{4} \times WM_1M_2\{\cos . \overline{m_1 + m_2 t} + \cos . \overline{m_1 - m_2 t}\} \quad .. \quad (6)$$

Hence S is demodulated by an amount which agrees with Professor Appleton's formula and also two small sum and difference tones are produced whose amplitudes are approximately $\frac{M^2}{2}$ of the amplitude of the unwanted signal.

We see from (4) that there are also supersonic currents of frequency $(n \pm m)$, $(n \pm 2m)$, etc., and $(2n \pm m)$, etc. The effect of the weak on the strong is a true demodulation, but the main effect of the strong on the weak is a displacement of the acoustic frequencies. It should be realised that the expansion given by equation (3) has no restriction that m should be small compared with n, but only that both m and n shall be small compared with p. It is not necessary that n should be supersonic: if it is audible, then the main effect of the modulation of the weaker signal is to produce modulated currents of frequency n, that is to say, currents of frequency $n + m$ and $n - m$.

If the receiver is a superheterodyne, the intermediate frequency amplifier will be tuned to frequency n and the terms $2n$, etc., can be ignored: then it follows from (4) that

$$\frac{i}{k} = W(1 + M\cos mt)\left\{1 - \frac{x^2}{8}(1 + M\cos mt)^2\right\}\cos nt$$

$$= W\left[1 - \frac{x^2}{8}\left(1 + \frac{3}{2}M^2\right) + M\left\{1 - \frac{3}{8}x^2\left(1 + \frac{M^2}{4}\right)\right\}\cos mt - \frac{3}{16}M^2x^2\cos 2mt - \frac{M^3x^2}{32}\cos 3mt\right]\cos nt \quad .. \quad (7)$$

This shows that the modulation depth is slightly increased by the heterodyne and that modulation frequencies $2m$, $3m$, etc., are introduced. If M is unity, the greatest value x can have is $\frac{1}{2}$, and then

$$\frac{i}{k} = \frac{59}{64}W\left[1 + \frac{113}{118}\cos mt - \frac{3}{59}\cos 2mt - \frac{1}{118}\cos 3mt\right]$$

(4) The Combined Effect of Circuit and Detector.

If an E.M.F. $e = E(1 + M\cos nt)\cos \omega t$ acts on a simple resonant circuit, it will apply to the rectifier a voltage which is a function of F, the power factor of the circuit. If the circuit power factor is very small, so that $F << \frac{2n}{\omega}$, and if the circuit is tuned to frequency ω, then the detector voltage can be shown to be (see *Wireless Engineer*, May, 1931, p. 257)

$$v = \frac{E}{F}\left(1 - \frac{MF}{2a}\sin nt\right)\sin \omega t, \text{ where } a \equiv \frac{n}{\omega}$$

With a linear rectifier, the acoustic output will be

$$\frac{i}{k} = \frac{ME}{2a}\sin nt$$

If the circuit is not tuned to the carrier frequency, the two side bands will not produce equal voltages, and we then have the combination of a modulated voltage and an unmodulated heterodyne, which is one of the conditions we have been considering. Thus, suppose the circuit is tuned to the lower side band, then it may readily be shown that

$$\frac{2v}{E} = -\frac{M}{F}\left(\sin \overline{\omega - n}t + \frac{f}{4a}\sin \overline{\omega - n}t\right) + \frac{1}{a}\left(1 + \frac{M}{2}\cos nt\right)\cos \omega t$$

$$\doteqdot -\frac{M}{F}\sin \overline{\omega - n}t + \frac{1}{a}\left(1 + \frac{M}{2}\cos nt\right)\cos \omega t$$

$$= \frac{M}{F}\sqrt{1 + \frac{F^2}{M^2a^2}\left(1 + \frac{m}{2}\cos nt\right)^2 + \frac{2F}{Ma}\left(1 + \frac{M}{2}\cos nt\right)\sin nt \sin(\omega t + \psi)}$$

When M is so small that $F/Ma >> 1$, this envelope takes the form

$$v \doteqdot \frac{EM}{2F}\,\frac{F}{Ma}\left(1 + \frac{M}{2}\cos nt\right)$$

and then

$$i/k = \frac{EM}{4a}\cos nt$$

If M is not vanishingly small, $F/Ma << 1$, and then

$$v \doteqdot \frac{EM}{2F}\left(1 + \frac{F}{Ma}\sin nt + \frac{F^2}{Ma^2}\cos nt + \frac{F}{2a}\sin 2\,nt\right)$$

$$\therefore \frac{i}{k} = \frac{E}{2a}\left(\sin nt + \frac{F}{a}\cos nt\right) + \frac{EM}{2a}\sin 2\,nt \qquad \ldots \ldots (8)$$

The acoustic output now consists of a fundamental term whose amplitude is independent of M and an octave which is proportional to M: hence if the decrement is very small it is important to tune the circuit to the carrier frequency, or the result will be very confused.

(5) Immunity from an Interfering Station.

Let the two stations have carrier frequencies ω and $\omega + n$, where we suppose n is scarcely audible, say, 8 k.c./s: let each be modulated with a frequency of about 1 kc/s.

We have seen that the weaker station of frequency $\omega + n$ produces a 1 k.c./s note only by a second order effect and the main result of its modulation is to produce a modulated note of 8 k.c./s: in other words its main effect is to produce notes of 7, 8 and 9 k.c./s. Let each station have the same field strength E and the same modulation depth M and let both be modulated to approximately the same frequency m. Let

$$\frac{n}{\omega} = a \text{ and } \frac{m}{\omega} = \gamma$$

The interfering station produces a voltage at the detector.

$$W \doteqdot \frac{E}{2a}(1 + M\cos mt)\cos(\omega + n)t$$

whereas $S = \dfrac{E}{F}\left(1 - \dfrac{MF}{2\gamma}\sin m_2 t\right)\sin \omega t$

$$\therefore \qquad x = \frac{W}{s} = \frac{F}{2a}$$

If by means of a quartz crystal or by valve retroaction the effective value of F is of the order 1/2000 and a is of the order 8×10^{-3}, then $F/2a \doteqdot 1/32$.

Substituting in equation (6), we have

$$\frac{J}{k} \doteqdot SM_2\cos m_2t + \frac{M_1x}{2}W\cos m_1t - \tfrac{1}{4}xWM_1M_2(\cos \overline{m_1 + m_2}t + \cos \overline{m_1 - m_2}t)$$

$$= \frac{EM}{2\gamma}\left\{\cos m_2t + \frac{F\gamma}{4a^2}\cos m_1t - \frac{F^2}{16a^2}M(\cos \overline{m_1 + m_2}t + \cos \overline{m_1 - m_2}t)\right\}$$

Thus the immunity ratio for the note m_1 is $\dfrac{F}{2a}\,\dfrac{\gamma}{2a}$, making

$$\frac{F}{2a} = \frac{1}{32} \text{ and } \frac{\gamma}{2a} = \frac{1}{16}, \text{ this ratio is } \frac{1}{512}$$

The small decrement circuit scores largely because it makes the mean value of the wanted signal very great indeed compared with the mean value of the interfering signal, and this is the condition for the unwanted signal to be almost completely displaced in acoustic frequency.

A New Valve Characteristic.*

By P. K. Turner, M.I.E.E.

A means is suggested by which the performance of a valve as a grid rectifier can be judged as easily as its performance as an amplifier is at present.

(1) Introduction.

FOR a long time the writer has been dissatisfied with the data available on the performance of valves as detectors. It is so easy, given the I_a/E_a curves of a valve, to design any desired audio-frequency stage round it; and with the curves and the values of the electrode capacities to design a radio-frequency stage round a given screened-grid valve: but corresponding methods for detectors have not hitherto been available. True, the makers give I_g/E_g curves in a few cases, but they are not very useful, for in most cases some attempt is made in design to get linear detection, and as this involves some rectification in the anode circuit as well as grid rectification, the I_g/E_g curve will only give results after a considerable amount of rather awkward analysis.

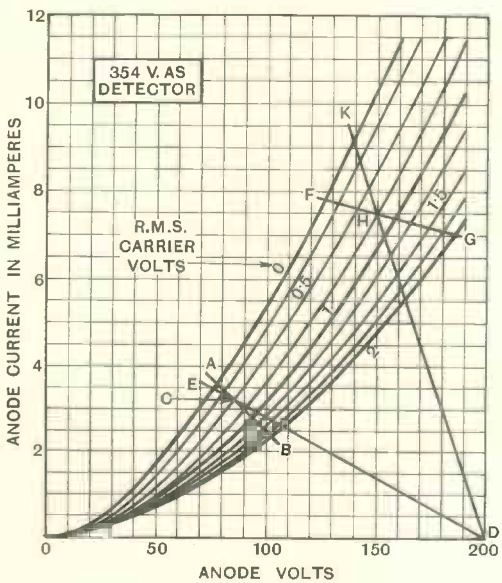


Fig. 1.—*Rectifying curves for Mullard 354V. Conditions as shown in Fig. 2.*

This dissatisfaction has led to the invention of a new kind of valve characteristic, which seems to solve the problem completely. It is claimed as new simply because the author has not seen it anywhere: but it is so simple and satisfactory that he has been metaphorically kicking himself for not having seen it three years ago, and possibly someone else did so and published it. If this is so the author will be very grateful for news of it.

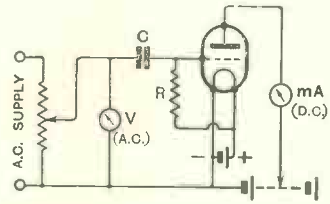


Fig. 2.—*The circuit used for the measurements. For A.C. valves, R and the grid and anode returns were connected to the cathode. In all cases the frequency was 50 ∼ and C 2 μF. R was 0.25 MO except where otherwise stated.*

(2) The Proposed Curves.

A sample curve-sheet for a well-known valve—the Mullard 354V—is shown in Fig. 1. The curves are simply I_a/E_a characteristics, taken with varying amounts of A.C. input to a grid rectifying circuit. In the particular case of the measurements made for Fig. 1, the circuit was as in Fig. 2, and the applied A.C. was at 50 ∼: the validity of assuming that the results hold good at radio frequencies will be discussed later.

Assuming for the moment that the curves are valid at R.F., one then simply uses them as one would the ordinary I_a/E_a curves.

For example, the line *AB* in Fig. 1 is that of a 20,000 ohm load, on a total anode supply voltage of 150. The condition for linear rectification is of course that the intersections of *AB* and the various curves shall be equally spaced along *AB*, since they represent a regular increase of 0.25 v r.m.s. input. It is obvious at once that the best working point is at *C*, representing 0.5 v carrier: also it appears that 50 per cent. modulation will give no distortion, but that

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

100 per cent. will give some. We see also that in the absence of a carrier the anode current will be represented by the point A, or 3.65 mA; while the optimum input will reduce this to 3.25 mA. This enables one to draw up practical instructions for the use of the circuit under best conditions, without direct measurement of the R.F. input. We have only to specify that the input shall produce a definite current drop, in this case 0.4 mA.

The curves give the useful output: in the above case, assuming an input of 0.5 v r.m.s. and 50 per cent. modulation, the carrier swings from 0.25 to 0.75 v, and the corresponding swing on the load is 90 − 81 = 9 v.

If, as is usual, it is proposed to use a decoupling circuit, we proceed quite simply (Fig. 1). Assuming 200 v in all, other conditions as above, we draw CD, and find that its slope corresponds to 36,000 ohms, of which 20,000 is already accounted for by the load; so that the "stopper" will be 16,000 ohms. The steady D.C. in the absence of input will now be at Point E, or 3.5 mA, so that the D.C. drop for the optimum carrier will be from E to C or 0.25 mA, though for audio-frequency modulation the working line will still be AB.

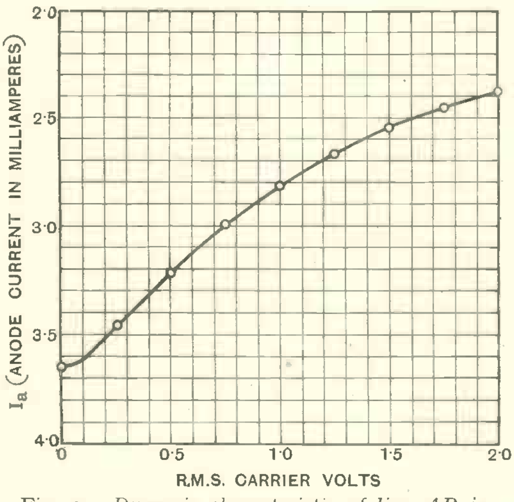


Fig. 3.—*Dynamic characteristic of line AB in Fig. 1, for harmonic analysis.*

Although one can estimate by eye the approximate optimum input, it is easy to be more accurate if desired. All that is necessary is to plot the intersections of curves and load line as in Fig. 3, and draw in the "dynamic" characteristic, which

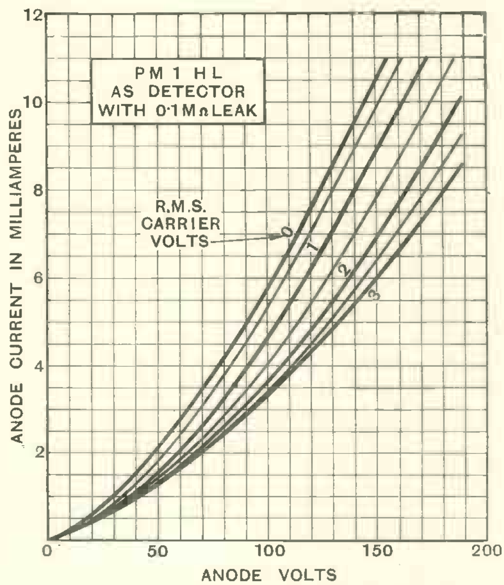


Fig. 4.—*Rectifying curves of Mullard PM1HL, with "leak" of 0.1 MO, for comparison with Figs. 5 and 6.*

is then analysed in the usual manner: the results for this particular case are (all for 100 per cent. modulation):—

R.m.s. carrier (volts).	Fundamental output (swing).	Effective magnification.	2nd Harm. per cent.	3rd Harm. per cent.
1.0	26	26	15	2
0.75	22.5	30	9	4.5
0.50	17	34	0	6

(3) Validity of the Curves.

Considering now the validity of these curves as a basis for design. Those of Fig. 1 were taken at 50 ~, with a grid condenser of 2 μF. If, therefore, the impedance of the detector itself were a pure (variable) resistance, the input conditions would correspond exactly with those of the same grid resistance and a 0.0001 μF condenser at 1,000 kc. Although of course the input impedance of the rectifier is actually in part capacitive, this appears not to affect the use of the curves, since its effect is only to cause a slow progressive loss of overall efficiency as the frequency increases: it simply means that rather more R.F. energy must be provided to get the requisite input at the rectifier itself, which may still be estimated by the drop in the D.C. anode current.

Another question as to the validity of the curves arises from the fact that in linear detection part of the rectification is carried out in the anode circuit. The curves are naturally drawn from measurements with no external impedance on the anode circuit, and it may be held that as there is rectification in the anode circuit the effect of any external impedance cannot be accurately represented in the usual way by load-lines. This objection is, I believe, correct in principle; but two facts make it unimportant in practice:—

(a) The external impedance to radio frequencies is always low, owing to the presence of a by-pass condenser.

(b) Under good working conditions the proportion of rectification done in the anode circuit is small.

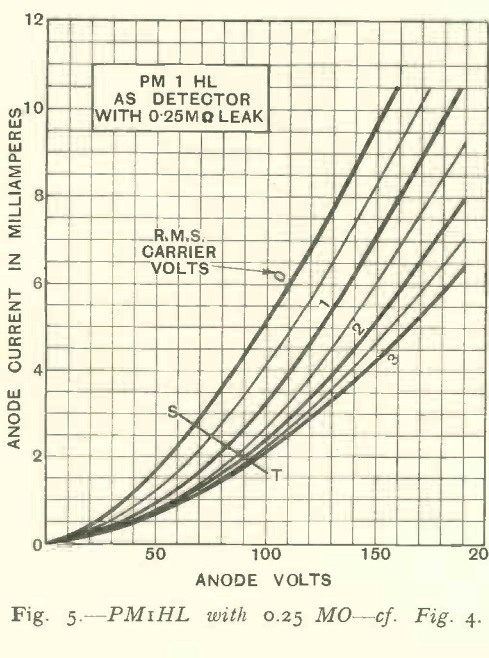


Fig. 5.—*PM1HL with* 0.25 *MO—cf. Fig.* 4.

The practical fact is that detecting circuits designed on the basis of these curves give results whose departure from prediction is no greater than that caused by the commercial variation between valves of the same nominal rating.

(4) Noticeable Points in the Results.

An interesting point is the large variation

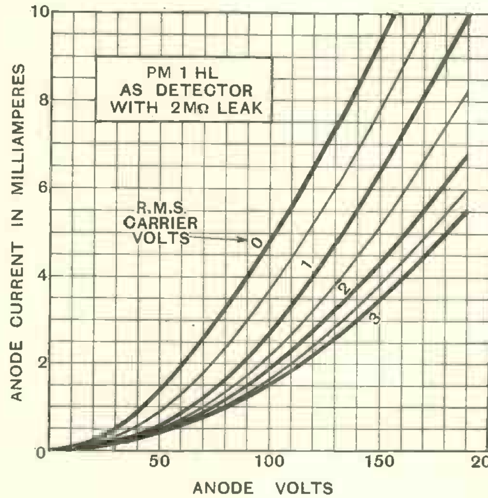


Fig. 6.—*PM1HL with* 2.0 *MO—cf. Fig.* 4.

in the optimum D.C. drop due to the carrier under different conditions. Taking the valve already mentioned, we found with resistance coupling a D.C. drop of 0.25 mA from 3.5 mA, or appr. 7 per cent. The lines *FHG*, *KHD*, on the same curves, show conditions for transformer coupling, estimating the transformer as a working load of 75,000 ohms, and with a "stopper" of about 7,000 ohms. In this case the optimum input is 0.75 V r.m.s., and the D.C. drop is from 9.2 to 7.5 mA, *i.e.* 1.7 mA or 18 per cent. In fact, the optimum D.C. drop is so much a function of the ratio (for D.C.) of decoupling resistance to load resistance that curves of this type seem the only simple means of finding it.

Another interesting result is obtained on comparing curves taken with varying values of grid resistance. Such curves are shown in Figs. 4, 5, and 6, for the Mullard PM1HL valve, with "leaks" of 0.1, 0.25, and 2.0 *MO* respectively. It will be seen that the lowest value is not enough to approach perfect "voltage" rectification, so that the output is low: but there is the unexpected result that the linearity is poor also. But at 0.25 *MO* the results are much better, and there is little improvement for grid resistance above

0.25 *MO* (confirmed by curves, not shown, taken with 0.5 and 1.0 *MO*). A careful analysis of the circuit shows that this is consistent with an apparent slope resistance of the rectifying circuit itself of about 20,000 or 30,000 ohms, which is typical. This valve is interesting, as may be seen from the curves, as giving a quite low amount of distortion for small inputs of the order of 0.25 v carrier; as a rule 0.5 v or 1 v is called for to avoid a considerable 2nd harmonic.

(5) The Valve Manufacturer and the New Curves.

These points, however, are by the way. The author's main thesis is to present a means by which detectors can be compared, and their circuits designed, just as is done for amplifiers with the normal I_a/E_a curves.

Further, since it is not so easy for the user to take these curves as to take purely D.C. ones, it is highly desirable that they shall be issued by the manufacturers. Now here readers can help. The various manufacturers will not issue curves of a new type unless their Association approves them; and this approval depends on a majority of the manufacturers being impressed by a public demand for such curves. If they are persistently asked for, they will in the end be given, as has been the case with the normal I_a/E_a curve.

The exact conditions for taking the new curves should of course be standardised, and are a matter for discussion; but I would suggest that the form shown here is reasonable, which leads to the following preliminary suggestions for standard conditions :—

(1) Curves to be taken at 50 ~ or any other convenient frequency.

(2) The grid condenser reactance to be 1,500 ohms, corresponding to 0.0001 μF at 1,000 kc.

(3) The grid resistance to be 0.25 *MO* except where some other value is definitely called for to get efficient working: and then the non-standard value to be stated on the curves.

(4) Curves to be drawn for such values of r.m.s. input that they lie about 10 v apart on the E_a scale at their widest separation.

Cossor Cathode Ray Oscillograph.

WE are happy to note the introduction of yet another cathode, ray oscillograph of British manufacture. This oscillograph, which is made by A. C. Cossor, Ltd., Highbury Grove, London, N.5, is of an improved Braun tube type, in which the conductance of the deflector plates has been considerably reduced by extending the anode to surround the deflector system. The tube operates with high tension voltages between 300 and 3,000 volts, and has the following electrical characteristics :—

Filament Current	**0.7 to 1.1 amps.**
Filament Voltage	**0.4 to 0.8**
Gun Voltage	**300 to 3,000** } **relative to filament.**
Shield Voltage	**0 to — 200** }
Gun Current	**10 to 200 microamps.**
Capacities (inclusive of socket) :—	
Each deflector plate to gun	**6.0 μμF. approx.**
Each deflector plate to opposite plate	**1.5 μμF. approx.**

Two types of fluorescent screen are available: Type A for visual observations, and Type B for photographic work.

The prices are as follows: Oscillograph Tube (Type A or B, including sockets) £7 10s. 0d.; extra sockets, 6s. Half-wave rectifier valve for H.T. supplies up to 3,000 volts, £1. Bright emitter valves for time bases, 5s.

An excellent handbook (B15) setting forth the properties of the Tube, with suggestions for its use, is available on application.

A Carrier Interference Eliminator.*

By W. Baggally.

WHEN a broadcast receiver capable of reproducing with good fidelity is being operated in the presence of an interfering telephony transmission, three types of interference may be produced if the frequency of the interfering station is within about 10 Kc. of the wanted station :—

(1) Direct interference ; both transmissions being heard together.

(2) Carrier interference ; a whistle of steady amplitude and frequency.

(3) Side-band interference, manifested as high-pitched twittering noises, due to beating

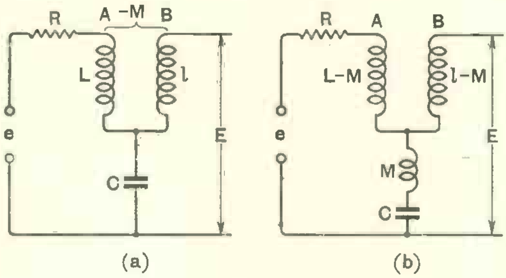


Fig. 1.

of the wanted carrier with the interfering side-bands, and as alien tones accompanying the wanted transmission, and due to beating of the wanted side-bands with the interfering carrier.

The methods of preventing direct interference are well known and will not be discussed here.

Side-band interference is not easy to deal with except by the sacrifice of the upper register in the reproduction, but is always less powerful than carrier interference, which will now be considered.

Clearly, what is required is a means of strongly attenuating one narrow band of frequencies without upsetting the response of the receiver to frequencies lying outside this range ; it is then to be expected that the suppression of the carrier whistle will cause but slight deterioration in the fidelity, since all frequencies above and below the whistle frequency will be reproduced as before.

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

A simple circuit which may be made to have the desired properties by a suitable choice of constants is the Campbell sifter shown in Fig. 1 (*a*).

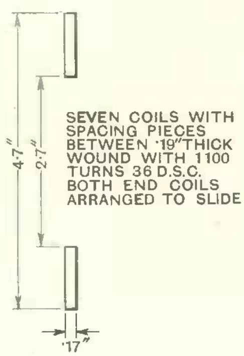
The two coils are so connected that the E.M.F. $I\omega M$ induced in l is in opposition to the voltage $I/\omega C$ across the condenser.

Then for the frequency $f_0 = 1/2\pi\sqrt{MC}$ the two E.M.F.s will be equal and E will be zero.

It will also be observed that resonance occurs in the primary circuit when $\omega^2 LC = 1$, which would give rise to a peak in the output.

This may be obviated by making $L = M$ and so causing the resonant and zero points to coincide.

It is shown in the Appendix that under these conditions $E \rightarrow e$ for frequencies differing from f_0 and that the attenuation becomes small outside a band of frequencies containing f_0 ; the width of the band in cycles per second being given by $\delta = R/2\pi M$.



A further advantage to be gained by making $L = M$ is that since the voltages across L and l are thereby made equal, the points A and B are brought to nearly the same potential and the effects of capacity

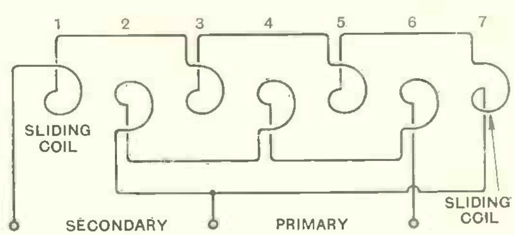


Fig. 2.

between the coils much reduced, though there is, of course, a residual $P.D.$ between A and B due to the primary coil resistance and impurity in the mutual inductance, so that it is as well to keep the coil capacities and resistances as small as practically convenient.

A form of construction fulfilling these conditions is shown in Fig. 2; the seven coils are each wound with 1100 turns of No. 36 double silk covered wire, and with the dimensions shown the primary and mutual inductances are each about one henry, so that when tuned with a variable air condenser of 1500 $\mu\mu$F capacity, the frequency range is from about 4,500 to 12,000 cycles per second.

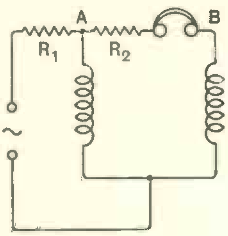


Fig. 3.

The mutual is brought to exact equality with the primary inductance by sliding the two end coils (both of which are secondary coils) axially or transversely and then clamping them in any convenient manner.

A simple means of making this adjustment is to connect the coil to an A.C. source and a telephone, as shown in Fig. 3, where R_1 and R_2 may both be about 20,000 ohms. The sliding coils are moved till the minimum sound is heard in the telephone, in which case the reactive voltages across primary and secondary cancel each other, giving $L = M$.

The resistances R_1 and R_2 are for the purpose of swamping the resistance of the primary coil and so increasing the sensitivity of the method.

It remains to decide the best band width to meet practical requirements and hence the A.C. resistance of the valve preceding the filter.

First it is to be noted that the band width ($\delta = R/2\pi M$) does not depend on the tuning capacity, so that if, as in the present case, the tuning is done by a variable condenser, the band width is a constant of the circuit and independent of f_0.

If the band is too wide, the fidelity will suffer owing to the virtual elimination of a good slice of the upper register, but as a compensation, a good deal of side-band interference as well as the carrier whistle will be cut out.

On the other hand, if the band width is insufficient, the circuit will be very difficult to tune, there will be no reduction of side-band interference, and the slightest wandering of either transmission will necessitate retuning the filter; the fidelity, however, will leave nothing to be desired.

A satisfactory compromise is usually arrived at by making the band width about 1500 cycles, which with a one henry coil requires the impedance of the source to be about 9500 ohms.

The valve may conveniently be resistance capacity coupled to the filter as shown in Fig. 4, and this arrangement works excellently in practice.

Using the above arrangement, and with the filter tuned to any frequency above about 6000 cycles per second, it is not possible to tell by ear whether the filter is in or out of circuit when receiving a transmission free from interference.

That this is not due to high note loss in the receiver and loud speaker is testified by the fact that when receiving 5 XX without the filter, the heterodyne whistle accompanying the transmission (frequency 9600 cycles per second) is quite painfully loud, although the filter, when carefully tuned, reduces it to virtual inaudibility.

If the filter is tuned much below 6000 cycles, one realises, when it is put in circuit, that "something" has happened to the reproduction, though the distortion is by no means severe, and is, of course, not nearly so bad as that produced by the expedient, advocated by some writers, of cutting off the entire upper register.

This is due to the fact that even when

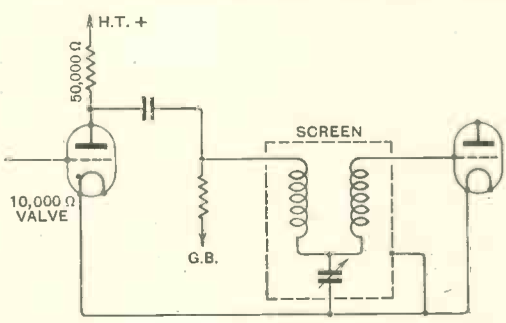


Fig. 4.

quite low-pitched whistles are being dealt with, the extreme upper register is retained at full strength, so that the reproduction never sounds "muffled" as it does if a conventional low-pass filter cutting at 3500 cycles or so is used.

There should be no difficulty in operating the filter followed by an A.F. transformer if so desired, since at 8000 cycles or so the primary impedance would probably be too high to upset the working of the filter, although the writer has not himself used this arrangement.

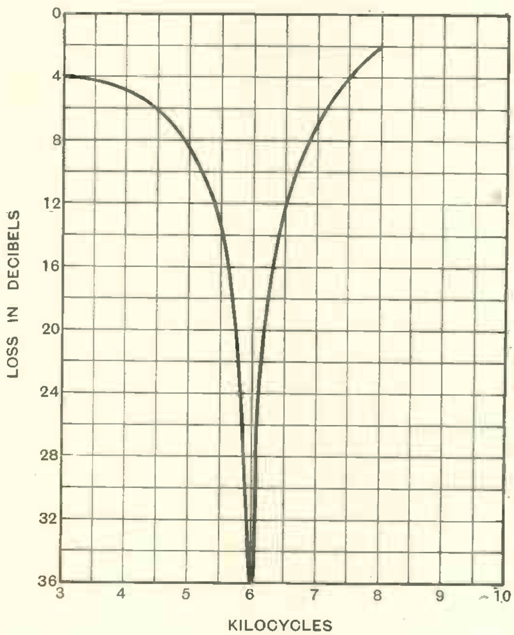


Fig. 5.

In any case the determining factor in deciding the A.C. resistance of the preceding valve would be the filter band width ; a transformer would then have to be selected to work with this valve.

The attenuation characteristic of the arrangement of Fig. 4 was plotted and is hown in Fig. 5 ; it agrees well with the calculated curve except that the attenuation is not infinite at f_0.

This is due to the residuals in the coil and condenser, and also to the fact that the wave form of the oscillator used in the measurements contains a small percentage of harmonics, which would, of course, seriously reduce the apparent attenuation at f_0.

APPENDIX.

By a well-known circuit transformation the systems shown in Figs. 1 (*a*) and 1 (*b*) may be shown to be equivalent.

From Fig 1 (*b*) we have at once

$$\frac{E}{e} = n = \frac{j\omega M + 1/j\omega C}{R + j\omega L + 1/j\omega C} \quad \ldots \quad \ldots \quad (1)$$

Putting

$$L = M,\ \omega_0^2 MC = 1,\ P = \frac{f}{f_0} - \frac{f_0}{f},\ Q = R/\omega_0 M$$

where $f = \omega/2\pi$, $f_0 = \omega_0/2\pi$, equation (1) becomes

$$n = \frac{jP}{Q + jP} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

the scalar form of which is

$$|n| = P/\sqrt{Q^2 + P^2} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

It is seen that n is zero for $P = 0$ and that it approaches unity for other values of P.

To investigate the breadth of the frequency band within which the attenuation is appreciable, we may define the cut-off frequencies as those for which $n = 1/\sqrt{2}$, in which case $P^2 = Q^2$ and we have

$$\frac{f}{f_0} - \frac{f_0}{f} = \pm Q \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

or

$$f^2 \mp f f_0 Q - f_0^2 = 0 \quad \ldots \quad \ldots \quad (5)$$

of which the two positive roots give the desired cut-off frequencies, *viz.* :

$$\text{Lower cut-off, } f_c = \frac{f_0}{2}\left(\sqrt{Q^2 + 4} - Q\right) \quad \ldots \quad (6)$$

$$\text{Upper cut-off, } f_c' = \frac{f_0}{2}\left(\sqrt{Q^2 + 4} + Q\right) \quad \ldots \quad (7)$$

Calling the band width δ, we have

$$\delta = f_c' - f_c = f_0 Q = R/2\pi M \quad \ldots \quad \ldots \quad (8)$$

The Flash-Arc in High-power Valves.

Paper by B. S. Gossling, M.A., read before the Wireless Section, I.E.E., on 6th April, 1932.

ABSTRACT.

THE paper is a communication from the Staff of the Research Laboratories of the General Electric Co., Wembley. It deals with the sudden type of discharge in high-power transmitting valves (sometimes known as the " Rocky Point effect "), to which the author gives the name of " flash-arc." This name is chosen as giving expression to the two most prominent features of the phenomena, first the extreme suddenness of the breakdown following an interval here referred to as the time-lag, and secondly, the fact that when the breakdown occurs the current is limited only by the power-supply and external circuit, a property characteristic of arc-like discharges. The breakdown does not, in general, follow immediately upon the application of the voltage but occurs after an interval or time-lag of widely variable duration. Time-lags of several thousands of hours have been observed. Provided the power supply is interrupted soon enough—as by the usual protective devices—the electrodes suffer no damage, nor is the vacuum necessarily impaired. The insulation restores itself completely for the time being, and a valve which has had a flash-arc can be brought into operation again.

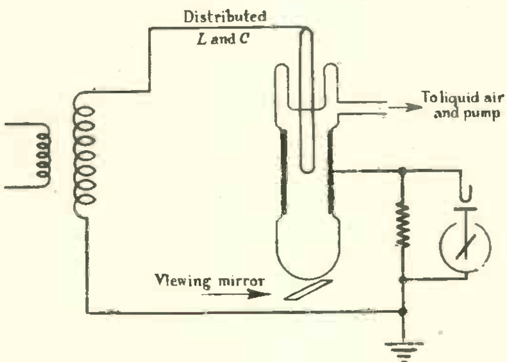


Fig. 1.—*Experimental circuit* (*in its first form*).

General Experimental Study of the Properties of the Flash-Arc.

There is, in general, though not always, something to be seen when a flash-arc occurs. The transitory nature of the phenomenon frequently results in the visible evidence being missed. Sometimes single or repeated flashes of fluorescence are seen widely distributed over the surface of the glass-work. A characteristic sign of flash-arc is the appearance of one or more minute star-like scintillations on the surface of the cathode. It is only very violent breakdowns that show any continuous bridging of the gap between the electrodes.

After discussing these effects, the author describes experiments on flash-arcs obtained by the discharge of condensers (capacities of 0.0001 to 0.0016 μF.) through inductances of 3.1 to 40 μH. in series with the discharge tube and with a device for measuring the peak current. Experimental circuits are shown in Figs. 1 and 2.* The electrodes of the discharge-tube consisted of a copper cylinder and a loop of stout molybdenum wire. The indicating device was a quick-acting peak-voltmeter responding in a very small fraction of a micro-second to the voltage developed across a non-inductive resistor. The completeness of the breakdown with the larger condensers is shown by the small damping of the oscillatory current. With the smallest condenser, however, the oscillation is heavily damped. The maximum amplitude of the oscillations is generally much less than the value to be expected from the charging voltage. It follows that energy is expended in building up the arc-path and it is shown that 1 to 3 watt-seconds will give an arc of high conductivity, whereas 0.2 watt-second will not.

From recorded values of condenser-charge and current-maximum, it is possible to make an estimate of the minimum duration of the initial building-up stage. This is found to be of the order of 2×10^{-7} to 4×10^{-7}, and is compared by the author with the time of flight of positive ions, approaching 10^{-7} second. The discharge is easily transferred from one electrode to another, *e.g.*, in a triode the grid and filament both take their share of the current.

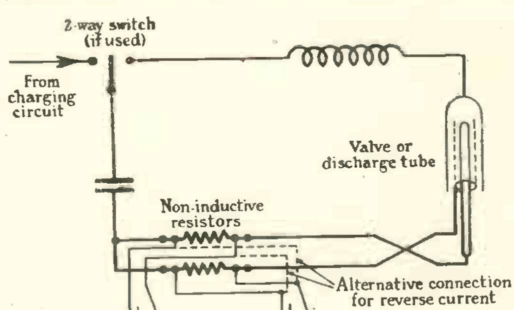


Fig. 2.—*Condenser-discharge and current-measuring circuits.*

The author finds that residual gas in the tube only affects the flashing voltage indirectly. A considerable rise of gas pressure has no effect, but a subsequent clean-up of the gas lowers the flashing

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

voltage. "Auto-electronic" or "cold-cathode" electron currents were evident at voltages well below the flashing voltage, but appeared to have little effect on flash-arc voltage. A flash-arc may be artificially encouraged by pilot discharges across loose contacts. It is then found that no great initial expenditure of energy is demanded and that the flashing voltage may be very low. Of visible after-effects, the chief is that widespread, tree-like markings appear on the grid and filament supports, showing the great mobility of the arc. The fine wires of the active grid are, however, never damaged. Visible markings are produced on the anode, but these are too vague for significance.

The Flash-Arc in Practical Operation.

The operation of similar valves in different kinds of installations has shown that the tendency to produce flash-arcs varies considerably with the circuit conditions. Considering the simple circuit of Fig. 5, it is shown that the anode stopping condenser *C* has a certain approximately steady charge. When the condenser *B* has its maximum charge, as shown, the voltage between the valve electrodes is a maximum and the probability of flash-arc is greatest. The valve short-circuit joins *C* and *B* in parallel and their charges tend to neutralise, performing a damped oscillation of relatively high frequency. Generally there will be a residue representing the excess of one charge over the other. This, shared between *B* and *C* in parallel, dissipates itself through *L* in a second damped oscillation of lower frequency. This keeps the arc active while the extra current in the high-frequency choke is being built up. There might thus be an advantage in so proportioning the voltages and capacities of *C* and *B* that their charges are equal when the latter is charged to the maximum.

The author then proceeds to consider various circuits, (*a*) these including high-power telegraph transmitters at Carnarvon and Rugby, (*b*) medium-power broadcast transmitters modulated by anode voltage in the last stage (Daventry 5XX and Motala), (*c*) two versions of the 5GB experimental broadcast transmitter with low-power modulation. It is stated that at Carnarvon, Motala, 5XX and at short-wave stations flash-arc has seldom or never occurred. At Daventry 5GB (two circuits) and at Rugby GBR (two circuits) it occurred frequently in the earlier circuits a few years ago, but is rare with the circuits now in use.

From the examinations quoted it is concluded that (1) direct paralleling of anodes is dangerous if it permits concentration on the flashing valve of currents exceeding 5 to 10 amperes; (2) the smaller the h.f. output-condenser the safer is the circuit; (3) the larger the inductance between each valve and the high-tension supply, the safer is the circuit; (4) individual anode resistances are a good safeguard, but they cannot be used for valves above 10 kW. size; (5) resistances in the high-tension supply are useful.

Where several valves are used, subdivision of the circuit by providing separate input chokes and output condensers gives marked improvement. Recent larger valves of 100 kW. size have been found to compare well with the earlier smaller valves, although the circuit conditions are necessarily less advantageous.

As regards rectifier valves, information is more speculative, but it is concluded that it appears better to distribute such valves among a larger number of phases rather than to increase the current in each of a small number of valves.

Time-lag of the Flash-Arc.

Lastly, the paper describes and discusses the time-lag of the flash-arc. The available data are divided between two ranges: (*a*) short time-lags of a few seconds or minutes, and (*b*) long time-lags of tens, hundreds or thousands of hours.

Short time-lags—of the order of a few minutes—are found to be sensitive to voltage, a 3 % increase of which decreases the lag in the ratio of 10 or more to 1. Two theories are given. One suggests the detachment of surface fragments by slow yielding and the resulting violent "auto - electronic" emission from newly formed points. The other suggests "Schrot-effect" variation of a pre-existing auto-electronic emission.

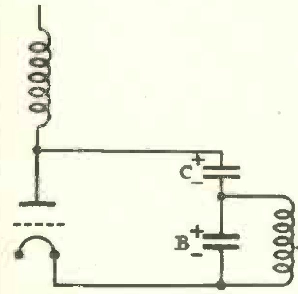


Fig. 5.—*Suppression of the flash-arc in the high-frequency stage.*

Long time-lags range in time from a few hours to over 10,000 hours. Information on this type of time-lag is therefore only to be obtained from valves in operation. Long time-lags recorded at Rugby are analysed statistically. They are shown to have a regular, but not, in general, a simple distribution up to 15,000 hours. It is also found that there exist sub-groups of valves having different intrinsic tendency to flash and that the flashing tendency of all valves decreases the longer they are in operation. After once flashing-over a valve may be replaced in operation for a "second life." No correlation, however, is found between the lengths of first and second lives. Survivor curves for each life are shown in Fig. 16.

Continuous operation, or even merely continuous heating of the filaments in early life, is found to reduce the flashing tendency. Gas-wandering, which is encouraged by intermittent operation, is therefore held to assist flashing, but it is considered that continuous pumping is not likely to prevent it.

Discussion.

Prof. C. L. Fortescue, who opened the discussion, referred to the practical importance of the author's contribution. Was the effect due to actual metal-vapour arc? He did not understand the time-lag of a large number of hours. The conditions in operation could not be compared with a d.c. system. Values of twice the apparent peak-voltage could be exceeded due to other modes of oscillation, and such voltages might be an explanation.

Mr. H. Faulkner referred to early experiences in the installation and testing of the Rugby transmitter, quoting very short lives in the first place. From these experiences they had come to the conclusion that flash-arc was definitely attributable to the valves. As a means of locating the fault they had used spark-gaps between the valves and found that they only got sparks when flash occurred. As regards comparison of machine *versus* rectifier as h.t. supply, he pointed out that the machine can give greater outputs under the load of these discharges. The case of long time-lag might be due to evaporation of the filament disclosing impurities. Had water-cooled valves ever been tried with molybdenum anodes as used in glass valves ?

MR. WALKER suggested that flash-arc might be started due to local overheating on electrodes, for example, scale on the anode due to deposit from the cooling water. Any grid overheating would most probably be due to parasitic oscillation. Flash-arc appeared chiefly in amplifying valves, as compared, for example, with modulating valves.

MR. BURCH referred to the case of continuously evacuated valves, which were subject to somewhat varying conditions of vacuum. Their (Metrovick)

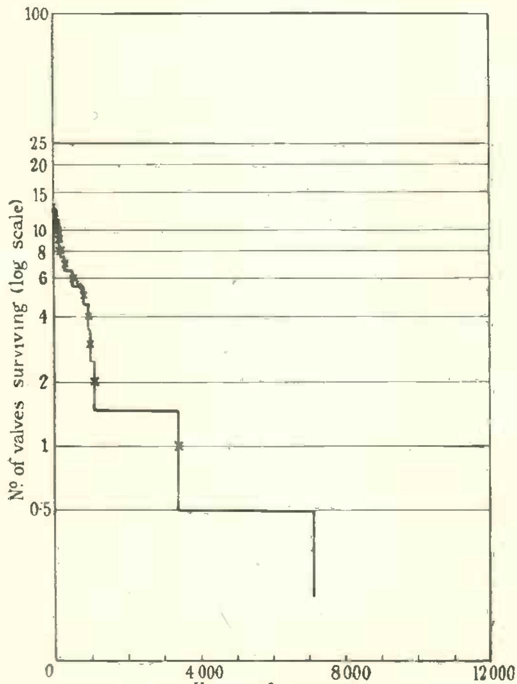


Fig. 16a.—*First-life survivor curve for 13 valves at Rugby GBR.*

experience confirmed that of the author, that mere pressure had little to do with the tendency. They had found that assembling a new filament and grid into an old anode, the valve took very little time to condition, as compared with an old filament and grid assembled with a new anode.

MR. MCPHERSON said that improvements which had been effected in the performance of water-cooled valves were due chiefly to detail and cleanliness in making. The flash-arc appeared to be due

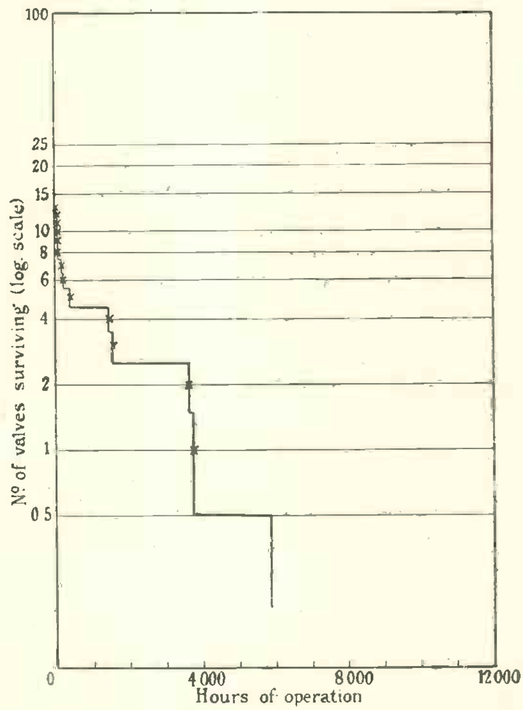


Fig. 16b.—*Second-life survivor curve for 13 valves at Rugby GBR.*

to valve and circuit combined. Spurious oscillations might have a trigger effect. The author had not mentioned critical voltage. As power increased, safe voltage decreased. The Prague broadcasting station working at 20,000 volts had given very little trouble due to flash-arc.

MR. W. J. DAVIS briefly raised a few points. Changes of gas might be due to metallic fragments vapourising.

MR. H. L. KIRKE referred to early experiments at 5GB. Troubles increased when they went from four valves to six. Spurious oscillations were very hard to trace. Difficulties of data on the performance of 5GB had arisen because of other changes made about the same time. An interesting effect was that if, in the course of morning tests, they used deep modulation of steady tone, a flash-arc frequently occurred later in the day.

After a brief reply by MR. B. S. GOSSLING, a cordial vote of thanks was accorded to the author on the motion of the Chairman, LT.-COL. A. S. ANGWIN.

Correspondence.

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

"Demodulation."

To the Editor, The Wireless Engineer.

SIR,—I feel that I need not apologise for asking you to find space for a further letter on the subject of the "demodulation" of a weak transmission by a stronger one, for this matter is one of which the importance is only now becoming fully realised, and I wish to point out that even now it is not yet fully understood.

In the first place, the name by which this phenomenon is generally known is unfortunate, for although it is in a sense descriptive of the result, it is misleading as to the mechanism. I observe that in the recent contribution by Appleton and Boohariwalla (*W.E.*, March, 1932) the word "demodulation" was carefully avoided; but it crept back again in the letter from Professor Appleton on the same subject published in your April issue, which only shows how difficult it is to get rid of an unsuitable name once it has gained currency.

The new fact which seems to be emerging in connection with this effect is the part played by the carrier beat frequency in relation to the time constant of the detector load (*i.e.*, the "grid-leak" and condenser in a grid rectifier).

Butterworth's original paper (*E.W.*, Vol. 6, p. 619) and my own later amplification of this (*E.W.*, Vol. 8, p. 409) implied that the carrier beat frequency should be supersonic with respect to the load. The Editorial note in the same issue also contained the same stipulation. In a letter referring to my article, Mr. W. B. Lewis (*W.E.*, Vol. 8, p. 538) tried to take the effect of the load more explicitly into account, but based his version on the erroneous statement that the analysis given by Butterworth and myself was only true for zero load resistance. His statement that with a very high resistance load the response to two signals of amplitudes S and W would approach $S + W$ is not quite correct as stated, for the significant feature of the load is not its resistance but its time constant. It was, however, a step nearer to what now appears to be the truth of the matter.

A paper by C. B. Aiken (*Bell Syst. Tech. J.*, Vol. 10, pp. 1–19) on simultaneous rectification gave a very complete account of this subject, but his analysis contains no stipulation with regard to the carrier beat frequency and implies that the "demodulation" effect is independent of the output circuit load, provided this is capable of reproducing the *modulation* frequencies involved.

Finally, the letter by Professor Appleton, already referred to, states, with acknowledgment to Mr. M. V. Callender, that if the time constant of the load is high (relative to the period of the carrier beat) the response will tend to be proportional to the peak value $S + W$, and there will consequently be no "demodulation" effect due to interaction. In other words, the effect will only occur fully if the load is capable of following the carrier beat frequency.

Thus, summarising the changes that have occurred in the stipulations—first, it was thought necessary that the carrier beat frequency should be supersonic (relative to the load); then later, that it need not be; and finally, that it must not be. It is an interesting object lesson in the necessity for a close scrutiny of analytical processes.

One looks forward to a more complete analysis which shall represent quite clearly the effect of the carrier beat frequency. As Professor Appleton's letter indicates, it will be necessary to modify the initial assumption, that the response is proportional to carrier amplitude, by representing the dependence of this response on the rate of change of carrier amplitude. This is likely to complicate the analysis very considerably.

F. M. COLEBROOK.

Teddington, Middlesex.

The Mutual Interference of Signals in Simultaneous Detection.

To the Editor, The Wireless Engineer.

SIR,—In the March, 1932, issue of this journal there was published an account of a theoretical and experimental investigation of the mutual interference of signals in simultaneous detection by Mr. Boohariwalla and myself. The theory worked out (which was satisfactorily verified experimentally) showed that, if strong and weak signals ($S \cos w_1 t$ and $W \cos w_2 t$ respectively) are simultaneously received with a linear detector, the acoustic response due to the weaker signal, when modulated, is, in the presence of the stronger signal, reduced to $\frac{1}{2}\frac{W}{S}$ of its value when the stronger signal is absent. These results were interpreted as deciding in favour of Butterworth's analysis as opposed to that of Beatty.

In a supplementary letter in April, 1932, the conditions under which the analysis was valid were stated (the need for this having been pointed out to me by Mr. M. V. Callendar), and it was mentioned that, for example in the case of the cumulative grid rectifier, the theory would only be valid in its simple form if the time constant of the grid circuit were sufficiently low to permit the mean grid potential to follow faithfully changes of the difference frequency $\left(\frac{w_1 - w_2}{2\pi}\right)$. (Such conditions had, of course, been satisfied in the experimental work in which the theory had been confirmed.) If the time constant of this circuit is high the mean signal current tends to be that corresponding to the signal peak voltage ($S + W$) in which case the signals do not mutually interfere. In other words, a high grid circuit constant and a high frequency difference are unfavourable to what has been, perhaps somewhat loosely but certainly with readily recognisable connotation, termed the "demodulation effect." It so happened, however, that in the same issue there was an article by Mr. F. M. Colebrooke (see, in particular, page 201) in which somewhat different conclusions were arrived at so that it seemed worth while to examine the question again in a wider series of experiments.

The experiments carried out by Mr. Boohariwalla and myself have therefore been repeated in this laboratory with the valuable assistance of Mr. D. W. Fry, special attention being paid to the effect of increasing the value of the grid condenser of a cumulative grid rectifier. In all other respects the experimental conditions were as previously described. The results very definitely confirm those of the earlier series of experiments and, moreover, show that as was anticipated, the mutual interference of signals tends to disappear with increasing grid circuit time constant. As an example the following results may be quoted. The grid leak was in each case 3 megohms.

Grid condenser μF.	$\frac{1}{2}\frac{W}{S}$	$\frac{\text{Acoustic signal of } W \text{ in presence of } S}{\text{Acoustic signal of } W \text{ in absence of } S}$
0.0003	0.14	0.14
0.01	0.14	0.28
0.1	0.14	0.33

It will be seen that good agreement with theory was obtained, as previously, only when the time constant of the grid circuit is sufficiently low, and that the effect of the suppression of the acoustic output due to the weaker signal becomes smaller as this time constant is increased.

Wheatstone Laboratory, E. V. Appleton.
King's College, London.

To the Editor, The Wireless Engineer.

SIR,—I was interested to see the note in your June issue on "Electro-Mechanical Rectification," for I observed the same phenomenon—curiously enough at about the same time as did Dr. McLachlan—in the Amplion laboratory in 1928.

But, contrary to his opinion (expressed in his last paragraph), I found the effect quite important in any attempt to get first-class reproduction. This is not so much on account of the obvious effect on the low notes—though this may be annoying to a sensitive ear—as from the effect which is produced if a low and a high note occur simultaneously. The high note is then modulated by the low one, and the result is very distressing.

Dr. McLachlan's analysis, however, does not bring out very clearly one important point. The phenomenon only occurs (at any rate noticeably) when the leakage fields behind and in front of the gap are different, as shown in his example. This is, of course, the normal case. But in all the loud speakers I build now I shape the poles so that the leakage fields are symmetrical, at any rate within the extreme range of movement of the coil, and this cures the trouble.

Windsor. P. K. Turner.

[Dr. McLachlan, in a contribution to the *Phil. Mag.*, Vol. xiii, January, 1932, p. 140, states: "In the reproducer used for these tests the coil always moved out of, but not into, the magnet. This is due to the leakage field being less outside than inside the magnet. Doubtless, by starting with the coil well inside the magnet it would move inwards." The title of the contribution in which this appeared was "Additional Experiments on Moving-Coil Reproducers and on Flexible Disks." Mr. Turner may possibly have overlooked this statement.—ED.]

New Books.

Les Unités Électriques.

By J. Sudria, pp. 85. Published by Librairie Vuibert. Paris.

The subject of the fundamental basis of the various systems of electric and magnetic units is of great importance at the present time and is being considered by various national and international committees and commissions. This book, to which M. Blondel has written a preface, is intended for the use of students, but it will appeal to a much wider circle. It is an admirably written critical examination of the underlying principles of the various systems of units. It emphasises the conventional character of all systems, the danger of overlooking the fact that the dimensions of a quantity depend largely on arbitrary assumptions, and the absence of any grounds for assuming that all electric and magnetic units must necessarily be expressible in terms of length, mass and time. On page 55 there is a useful table giving the dimensions of the electric and magnetic units in terms of L, M, T, and Q, a quantity or charge of electricity, and it is interesting to see how the electrostatic system of units can be obtained from this by making the unjustifiable assumption that displacement has the same dimensions as electric force (*i.e.*, permittivity a mere number), or the electromagnetic system by making the equally unjustifiable assumption that magnetic induction has the same dimensions as magnetising force (*i.e.*, permeability a mere number).

The author points out that if one confines one's attention to geometry, the only dimension required is L, but that on extending one's researches into kinematics it is convenient to introduce a new dimension, *viz.*, T; if one goes further and considers dynamics it is convenient, but not essential, to add another dimension M. Those who think that M is essential, but have doubts about Q, should read the book.

G. W. O. H.

Wireless Receivers, The Principles of Their Design.

By C. W. Oatley, M.A., M.Sc., with a preface by O. W. Richardson, F.R.S.

The fundamental principles involved in the design of wireless receivers (superheterodynes excepted) and with a useful bibliography giving references to articles on the subject which have appeared in *The Wireless Engineer*, *The Wireless World*, and other technical publications. Pp. 103 + viii, with 41 diagrams. Published by Methuen & Co., Ltd., London. Price, 2s. 6d. net.

Abstracts and References.

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PROPAGATION OF WAVES.

REFLECTIEMETINGEN OP RADIOGEBIED (Reflection Measurements on Radio Waves).—G. J. Elias and C. G. A. von Lindern. (*Tijdschr. Nederl. Radiogenoot.*, April, 1932, Vol. 5, No. 5, pp. 133–145.)

This paper discusses curves of field strength of wireless signals from near emitters registered at Delft on wavelengths of just over 80 m and 54 m respectively. Two receiving antennae were used, one a "vertical" one, in the vertical plane Delft-Rotterdam, whose vertical part extended from 3 m to 27 m above the ground and whose horizontal part was 5 m long at a height of 3 m above the ground, the other a "skew" antenna with vertical part of length 9 m and horizontal part 10 m long at a height 11 m above the ground. The emitters were situated at Rotterdam (11 km from receiver), Dordrecht (30 km) and the Hague (10 km). Details of the emitting antennae are given; they were chiefly horizontal. The records shown each extended over a quarter of an hour. For reception, the methods of high-frequency amplification and intermediate-frequency amplification with local generator were used; the results obtained by them were in good agreement.

Conclusions were drawn from the curves taken during daylight hours, which show regular interference effects between the ground wave and that reflected at the ionised atmospheric layers. The effective surface of reflection must then be in vertical motion with uniform velocity. An approximate value of the reflection coefficient ρ is obtained by estimating theoretically the magnitude of the vertically polarised ground wave to be expected from an emitter containing a vertical and a horizontal part over a semi-conducting earth, and also the horizontally polarised force radiated upwards. The fact that part of the reflected energy reaches the receiver after a second reflection at the earth's surface is also taken into account. Comparison of the theory with the reception curves showing regular interference effects, assuming the reflecting layer to be at a height of 120 km, gives a reflection coefficient of 0.07 for $\lambda = 81$ m at 13.15 h on November 21st, 1931.

Reception curves are reproduced which show that the reflection coefficient increases when the sun is lower in the sky. This is explained by the increased height of the layer with the same electron density, which follows from previous theoretical work of one of the authors (1931 Abstracts, pp. 373 and 373–374). The reflection coefficient for short waves is found as a function of the angle η made by incident rays from the sun with the vertical, in the form $\rho = e^{-c_1 \cos \eta}$, where c_1 is a function of the wavelength. The reflection should thus be very strong at sunset. The reflecting layer should rise 50 km between noon and sunset. From previous work (see above reference) a reflection coefficient 0.7 is calculated for sunset conditions, ten times as great as that observed above. The value actually given by the records was only eight times as great. The discrepancy is explained by assuming that the temperature of the atmosphere has been given too low a value in the calculations and that the ionisation lags behind the value it would have if it followed the sun's position instantaneously.

From the records obtained with $\lambda = 54$ m, it is concluded that the reflection coefficient for this wavelength must be smaller than for $\lambda = 81$ m, the ratio being about 1 to 2.5 or 3. The very disturbed records obtained at night are attributed to the presence of ionic clouds.

SUGGESTED WIRELESS OBSERVATIONS DURING THE SOLAR ECLIPSE OF AUGUST 31, 1932.—E. V. Appleton and S. Chapman. (*Nature*, 21st May, 1932, Vol. 129, pp. 757–758.)

The agents principally responsible for the production of the atmospheric ionised layers are known to travel rectilinearly, and thus may be ultra-violet light, swiftly moving neutral particles, or both. These travel with different velocities and so during a solar eclipse there are important differences in the incidence in time and place of the "optical eclipse" and the "corpuscular eclipse." This letter reproduces a map made by J. C. P. Miller of the tracks of these two eclipses in the forthcoming solar eclipse of August 31, 1932, and shows that wireless observations made on that date may decide between alternative hypotheses as to the cause of the atmospheric ionisation. Anyone who is able to make observations of a simple or more ambitious character (in 1927 a simple galvanometric record of signal intensity was obtained) is asked to communicate with the first-named writer at King's College, London.

QUELQUES PROGRÈS RÉCENTS DANS LE DOMAINE DES ONDES ÉLECTRIQUES ULTRA-COURTES (Some Recent Progress in the Field of Ultra-Short Waves).—J. Marique. (*Bull. de la Soc. belge des Élec.*, April, 1932, 23 pp.)

Among the papers and tests referred to in this survey are the following:—(i) Beverage, Peterson and Hansell (Abstracts, 1931, pp. 550–551), mention being made of the tests to a dirigible which showed a refraction effect analogous to that reported by Jouaust in the France-Corsica service (1931, p. 317), signals on a 6-metre wave at a distance of 160 km being inaudible on the dirigible at 300 m height but perfectly received at a height of 650 m; whereas the "optical range" would demand a height of 2 000 m. (ii) Schröter's work on the absorption in towns, leading to a formula for the received e.m.f. (1932, p. 30); also Sohnemann's measurements and formula (1932, p. 30) and his observations on the different polarisation under different weather conditions and the consequently suggested superposition of a space ray on the direct ray. (iii) Bergmann's researches to test the effects of

28-cm waves at much higher powers than are obtainable by ordinary methods on this wavelength, by submerging the aerial of a comparatively powerful 2.5-metre transmitter *in water*, in which the propagation velocity is about 9 times as small as in air. He thus obtains 28-cm waves at great strength. (iv) The Philips Company's tests with a transmitter at the top of the Carlton Hotel in Amsterdam, on a wavelength of 7.85 m, giving very strong reception more than 6 km outside the town and at some hundreds of metres in the town itself. " Several amateurs in Harlem reported comfortable reception, giving a range of about 20 km. The quality was as good as that given by the best broadcasting stations on normal waves."

Section II deals with frequency stabilisation: crystal control with frequency multiplication (Amsterdam transmitter and the writer's Air Service transmitter): direct crystal control using tourmalin (Straubel, April, p. 235): stabilisation by long lines (Conklin, Finch and Hansell, February, p. 93).

Section III deals with recent developments in transmitting valves. The writer mentions that when using as the output stage two screen-grid Philips valves type QB 3/500 placed side by side, those halves of the plates facing each other grew red hot while the outer halves remained dark: care in placing is obviously necessary. Describing the 1–2 kw water-cooled G.E.C. valve for 2–5 m waves (February, pp. 93—McArthur and Spitzer—and 98) the writer states that only a 40 hours' life is guaranteed, " but it is certain that lives of the same order as those of longer-wave valves will be attained." The 18-cm wave (electronic oscillation) valve of the Standard Laboratories in Paris is described briefly (1931, pp. 500–501): it is stated that systematic studies were made to determine the influence of the pitch of the helical grid on the functioning of the valve, but " if my information is exact no conclusions could be drawn from these studies."

Section IV deals with receivers—" this is, it would seem, the least developed part of the technique." As regards super-regeneration, the Russian work of Gorelik and Hintz (March, p. 164) is specially mentioned. In superheterodyne reception, the avoidance of the need for the usual local oscillator, by modulating the ultra-short wave with a high frequency which is itself modulated at low frequencies, is referred to: " it does not however give all the advantages of superheterodyne reception with the local oscillator, whose large amplitude improves the detection." A Lorenz experimental transmitter employed the system and the writer believes it was also used on 18-cm communication. Section V deals with " decimetre " waves, particularly with the Dover–Calais 18-cm service, concerning which a number of facts furnished by Embrechts are given, including data as to gains due to reflectors. The received field is 75 mv/m. The writer points out that apparently 175 watts are employed to radiate 0.25 w, so that the system is not so economical as it seems at first sight: it is probable that longer waves with simpler equipment could compete with it except from the point of view of secrecy and absence of interference.

Zur Frage der Wellenausbreitung in der Grossstadt (The Propagation of Waves in Cities [Mathematical Investigation, on Optical Lines, of the Effect of Broadcast Receiving Aerials]).—F. Ollendorff. (*E.N.T.*, April, 1932, Vol. 9, pp. 119–131.)

Author's summary:—The propagation of electromagnetic waves in a city is seriously affected not only by the influence of individual buildings but also by the presence of numerous tuned receiving aerials [*cf.* Barfield, 1929 Abstracts, p. 262]. For a quantitative representation of this effect, the whole antenna area is considered as a uniaxially polarisable crystal whose dielectric constants are calculated from the data of the individual aerials and of the arrangement of these aerials in combination [the spacing of the aerials being as a rule small compared with the wavelength, and the aerial conglomeration being only polarisable in the vertical direction, a horizontally oriented electric field having no effect on it].

The natural frequency of an individual aerial is not inconsiderably increased [as much as 20 %] by the presence of neighbouring tuned receivers; as a result, different receiving conditions are produced according to whether a receiver is pre-calibrated and adjusted to its calibration or is tuned to the existing conditions in the conglomeration of aerials. The effect of the conglomeration on the transmitted wave expresses itself as an influence on the wave number [the complex wave number k of a ground wave exponentially damped along the direction of propagation—see equation 35] which is determined in the form of a transcendental equation [equation 37] by appropriate solution of the field equations from the border conditions. This equation is approximately solved for the two adjustments of receiver [above mentioned]; in particular, simple formulae are developed for the value of the absorption [equations 62a and 66].

In addition to this effect on the transmitted wave, the influence of the conglomeration is also seen in a local decrease in signal strength: this is also treated for the two adjustments. It is found that as a rule the reception given by tuning-in with the conglomerated aerials should be the stronger, but that this is opposed by an increased absorption of the transmitted wave. The numerical results agree to a certain extent with experience, within the probable limits of error. But the existing experimental results are insufficient to decide all the questions connected with the subject: new and systematic tests are required.

Beitrag zum Studium der Ausbreitung elektromagnetischer Felder in unterirdischen Hohlräumen (Contribution to the Study of the Propagation of Electromagnetic Fields in Subterranean Caves and Tunnels [Short Wave Tests, and the Reception of Broadcasting Signals]).—V. Fritsch. (*Hochf: tech. u. Elek:akus.*, April, 1932, Vol. 39, pp. 136–139.)

As the geological constitution of the region tested is known to be uniform, the results indicate the existence of undiscovered caves. As regards medium-wave broadcast reception, this was impossible at some points in the cave system and possible at others.

At the one spot for which comparative strengths are given, Brünn and Budapest both gave strength 6, though at the surface the former was 20 times as strong as the latter. The much greater weakening of the Brünn signals is attributed to their shorter wavelength: weak amateur short-wave stations, however, were well received, so that it seems that the absorption coefficient β is different at medium and high frequencies—which agrees with the author's previous results in gorges of the Danube and in tunnels.

DISTANCE RANGES OF RADIO WAVES [FROM 10 KILOCYCLES TO 30 MEGACYCLES/SEC.].—J. H. Dellinger. (*Rad. Engineering*, April, 1932, Vol. 12, pp. 18–19.)

"The graphs give average distance ranges [limits for reliable reception] as observed by a number of experimenters—see references listed at end—to occur most frequently over a number of transmission paths. Through certain frequency ranges, available data were so incomplete as to require extrapolation which may be considerably in error. Wide variations of distance range and skip distance must be accepted as normal." Distance along scale is proportional to cube root of numbers: this cubical scale was chosen because it spaces the data satisfactorily. Two graphs are given, one for day and the other for night. The limits of field strength used are not such as to give, in the broadcast band, satisfactory programme reception: they range from 10 microvolts/metre, for frequencies up to 2 000 kc, to 1 microvolt/metre for 20 000 kc.

TABLES OF NORTH ATLANTIC RADIO TRANSMISSION CONDITIONS FOR LONG-WAVE [15–23 KC] DAYLIGHT SIGNALS FOR THE YEARS 1922–1930.—L. W. Austin. (*Proc. Inst. Rad. Eng.*, April, 1932, Vol. 20, pp. 689–698.)

DISCUSSION ON "SOME EXPERIENCES WITH SHORT-WAVE WIRELESS TELEGRAPHY."—N. H. Edes: J. C. Coe. (*Proc. Inst. Rad. Eng.*, April, 1932, Vol. 20, pp. 740–743.)

Coe compares Edes' results in China (1931 Abstracts, p. 145) with his own observations in the south-western parts of the United States, showing points of agreement and of difference; the range of latitudes in the two regions was approximately the same. Edes replies, commenting on these comparisons and urging Coe to publish his valuable data in full. Judging from Edes' China results, a discontinuity in the distance/wavelength characteristics would be expected in Coe's tests at about 450 miles at night in summer. No discontinuity at this (or any other) distance was found. Edes suggests that the low-lying (10 km) layer of small ionisation, to which he attributes the discontinuity noted by himself (1931 Abstracts, pp. 605–606), may be present in China—owing perhaps to the high humidity along the China coast—and not in America.

Coe's modification of Edes' best daylight wavelength formula, to fit conditions in the American area, gives wavelengths greater than Edes' by about 6 metres at 200 miles and 18 metres at 800 miles. This might be due either to permanent differences between the two regions or to a general variation in conditions during the interval (unknown) between the two sets of observations. If the skip-wavelength curves conform somewhat similarly to the best-wavelength curves, it may be deduced that the layer ionisations in the two regions are of the same order of magnitude but that the layer in the States is at a greater height.

Coe found that transmissions of from 30 to 200 metres wavelength at distances up to 40 miles, well within the ground ray range, showed that the distance at which fading usually became pronounced increased approximately as the square of the wavelength; and further, that these short distances were entirely different from those at which the useful sky ray returned to earth. Edes can only explain this by (a) fluctuation in strength of the ground ray, or (b) interference between ground ray and a ray that has encircled the earth: "yet neither explanation seems probable."

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

THE COLLISIONAL FRICTION EXPERIENCED BY VIBRATING ELECTRONS IN IONISED AIR.—E. V. Appleton and F. W. Chapman. (*Proc. Physical Soc.*, 1st May, 1932, Vol. 44, Part 3, No. 243, pp. 246–254.)

Authors' abstract:—"The variation of the radio-frequency conductivity of ionised air with pressure has been studied experimentally at frequencies of the order of 10^9 c/s. From the measurements of the critical pressure at which such conductivity is a maximum the magnitude of the collisional frictional forces experienced by vibrating electrons has been estimated."

Incidentally, evidence of a dielectric constant less than unity was obtained, as in previous investigations at lower frequencies (1931 Abstracts, p. 88). The writers refer to Gutton's researches and his conclusion that electrons in an ionised gas are subjected to quasi-elastic forces (1930 Abstracts, pp. 207–208 and 267), and they mention some tests, carried out in their laboratory and soon to be published, which confirm Gutton's experimental results but refute his deductions. "All the quasi-resonance effects are to be explained, both qualitatively and quantitatively, as due to the fact that the dielectric constant of the ionised gas under the experimental conditions assumes negative values. We therefore shall assume the restoring force coefficient [in the expression for the high-frequency conductivity used in the theoretical part of the present paper] to be zero." *Cf.* Hasselbeck, below.

COLLISIONAL FRICTION ON ELECTRONS MOVING IN GASES.—E. C. Childs. (*Phil. Mag.*, May, 1932, Series 7, Vol. 13, No. 87, pp. 873–887.)

In the equation of motion of an electron moving in a gas under the influence of electric fields there is usually included a term representing a force of frictional type in the form $g\dot{x}$ where $\dot{x}$ is the velocity of the electron and g a constant. In the case of free electrons it can be shown theoretically, on the assumption that directed momentum is completely destroyed at each impact, that $g = \frac{m}{\tau}$

where m is the mass of the electron and τ the average time between two consecutive collisions; the velocity acquired due to the field between collisions is assumed small compared with the random velocity due to thermal agitation. The present paper describes an experimental confirmation of the theoretical value of this frictional force. The property of ionised gas chosen for study was the electrical conductivity in high-frequency alternating electric fields. This and the electron concentration determine g. Langmuir's probe-current analysis method was used to obtain information as to the electron concentration and electron temperature. To find the electrical conductivity, resistances of known value were substituted for the leak-resistance of the ionised gas. Great care was taken to eliminate the effects of positive ion sheaths. The increase in resonant frequency on increase of leak-resistance was first measured: the theory of the effect is given. The results showed that the observed value of g was of the same order of magnitude as the theoretical value. For more accurate determination, the effect of change of capacity on the impedance of the ionisation-condenser circuit was minimised by comparing the current passed by the ionisation condenser with that passed by various high resistances of sputtered type. The experimental procedure is described. The numerical results obtained show that "the frictional coefficient of electrons moving in air is not very different from the value calculated from kinetic theory" and "any calculation of the behaviour of the Heaviside layer based on this assumption is not appreciably incorrect." The deductions of Ponte and Ricard (1929 Abstracts, p. 500) are discussed.

ÜBER DAS VERHALTEN ELEKTRISCHER WELLEN BEIM DURCHGANG DURCH IONISIERTE GASE (On the Behaviour of Electric Waves when Passing Through Ionised Gases).—W. Hasselbeck. (*Ann. der Physik*, 1932, Series 5, Vol. 12, No. 4, pp. 477–502.)

This paper describes an investigation of the absorption of damped electromagnetic waves of length 2–6 cm by ionised gases and the effect of electron density and frequency thereon. Monatomic gases were chiefly used, on account of the greater absorption effect they produce. The waves from the emitter passed through the absorption tube to fall on a receiver where their intensity was measured. The emitter, receiver, and optical system used are described. The apparatus was tested by measuring the reflection and absorption at glass plates. A special tube, which is described, was used to obtain a layer of gas ionised homogeneously; the electron densities were of the order 10^{10} to 10^{11} per cc. The wavelengths were determined by an interferometer method. Electron densities and temperatures were determined by means of Langmuir probes of considerable length.

In a mixture of neon and helium the absorption coefficient for 3 cm waves was found to be proportional to the electron density for pressures of the order of 0.1 mm Hg. At higher pressures the absorption increased much more rapidly. Measurements of the absorption as a function of frequency were carried out with a neon-helium mixture. The results for low and high pressures again differed. For low pressures the absorption coefficient increased with the wavelength. For higher pressures (up to 21 mm Hg) a maximum value of the absorption coefficient was found. For higher electron densities this maximum was displaced in the direction of shorter wavelengths.

The experimental results are compared with the two theories of absorption which assume (1) that the electrons are subjected to no elastic force binding them to their equilibrium position, and (2) that such a force exists. The low pressure curves showed that theory (1) was approximately valid for the experimental conditions they represented; this was not so however for the higher pressures. A possible explanation of the experimental results on the basis of theory (2) is discussed. An attempt is made to estimate the electron densities present in the discharge from two absorption measurements with two different frequencies, both large compared with the natural frequency assumed to be caused by the elastic bond; this estimate is of the same order as that given by the probe measurements.

GASENTLADUNGEN BEI SEHR HOHEN FREQUENZEN (Gas Discharges at Ultra-High Frequencies). L. Rohde. (*Ann. der Physik*, 1932, Series 5, Vol. 12, No. 5, pp. 569–599.)

This paper describes an investigation of the behaviour of various gases in high-frequency alternating electromagnetic fields (wavelengths chiefly 4.32 and 2.16 metres). The dependence on pressure of the minimum sparking voltages and the voltage required to keep the discharge just going was determined. The electrodeless ring discharge could be generated using wavelengths down to 2.30 m. A list of literature references is appended.

LES ÉLECTRONS LIBRES DES GAZ IONISÉS DANS LE CHAMP MAGNÉTIQUE (The Free Electrons of Ionised Gases in a Magnetic Field).—Th. V. Jonescu and C. Mihul. (*Comptes Rendus*, 18th April, 1932, Vol. 194, pp. 1330–1332.)

Continuation of the work dealt with in March Abstracts, p. 157. Air and hydrogen were both tested, at pressures ranging from 10^{-5} to 1.5×10^{-1} mm Hg. Applying Pedersen's formula to the results, the writers have calculated ν, the number of collisions between the free electrons and the gas molecules. Limiting the application of this formula in each case to that part of the curve which is not affected by the electrons attached to the molecules, it is found to confirm the experimental curves $\sigma = f(H)$.

Table I (obtained from a series of constant pressure measurements already published—*loc. cit.*) shows how ν decreases as the wavelength increases (from 14×10^7 at 234 cm to 8.6×10^7 at 670 cm). Table II shows (for air and for hydrogen) how the mean velocity of the electrons decreases with increase of the magnetic field: the total proportion of the number of positive ions to that of electrons increases with the field. Finally, Table III gives the results of the tests at various pressures, for air and hydrogen. It shows how the electron velocity (measured by the Langmuir method) varies with the pressure: for air it passes through a minimum at about 3×10^{-2} mm Hg, for hydrogen it decreases with increasing pressure. "Our researches have also shown that resonance occurs for weaker fields when the pressure increases. For air, this displacement passes through a minimum for a pressure of 3×10^{-2} mm. It may be noticed that ν similarly passes through a *maximum* at a pressure of 5×10^{-2} mm for hydrogen, and 3×10^{-2} mm for air. At these pressures the mean free path passes through a minimum. Everything occurs as if the diameter of the molecules entering into these phenomena were variable with the pressure. Comparing the values of ν and ν_m [the latter being the number of collisions calculated from the velocities deduced from the Langmuir method tests, divided by the mean free paths according to the kinetic theory] it is seen that they are of the same order of magnitude, whereas the classical theory gives values 5 to 250 times smaller."

Measurement of Current in Electrodeless Discharges by Means of Frequency Variations. — J. Tykocinski - Tykociner. (*Phil. Mag.*, May, 1932, Series 7, Vol. 13, No. 87, pp. 953–964.)

The full paper, an abstract of which was dealt with in 1931 Abstracts, p. 284.

Theory of Electromagnetic and Electrostatic Induction in Electrodeless Discharges. —J. Kunz. (*Ibid.*, pp. 964–975.)

This paper contains the theory of the experiments referred to in the preceding abstract ; expressions are given for the conductivity and coefficient of self-induction of the glass bulb containing the ionisation, and the frequency of the discharge is determined.

Winter in the Ionosphere.—R. A. Watson Watt. (*Nature*, 21st May, 1932, Vol. 129, pp. 761–762.)

Coincidences in the annual variations of received long- and short-wave signals have already led the writer to suggest that there is evidence of a close connection between the mechanisms of ionisation of the Kennelly-Heaviside and Appleton regions of the ionosphere. Hollingworth found an abrupt change in signal strength of long waves at the end of October, the winter values being maintained until the beginning of May. These waves were returned from the lower regions of the Kennelly-Heaviside layer. Wilkins, observing at the Radio Research Station, Slough, received no signals from the Rome-Sardinia telephone service on wavelengths of about 10 m between Nov. 1, 1931, and May 2, 1932. This was due to electron limitation effect in the upper part of the Appleton region. This points to a similarity in the mechanism of ionisation of the two regions, which clearly both involve agencies of solar origin and have curves suggesting a twelve-monthly variation, though this is displaced relative to the astronomical reference points of solstice and equinox.

Automatic Recording of Heaviside Layer Heights.—E. L. C. White. (*Nature*, 16th April, 1932, Vol. 129, p. 579.)

This letter is a preliminary note of continuous automatic records of the effective height of the Heaviside layer. The "echo" method is used and the signals and echoes give a stationary pattern on a cathode-ray oscillograph screen at the receiver. The tips of the peaks representing the signal and echoes are photographed on a film moving at about three inches per hour. Sample records show a jump from *E* layer to *F* layer and splitting of echo from *F* layer.

Electromagnetic Waves and Pulses.—W. E. Sumpner. (*Phil. Mag.*, May, 1932, Series 7, Vol. 13, No. 87, pp. 1049–1075.)

This investigation deals with the principle of independence of waves, the rate of transfer of energy and the energy available for transfer. In order to reconcile the phenomena of interference with the independence principle, it is suggested that "a compound ray of light may exist in what may be called a neutralised state, such that the ray has no observable effect on matter, although it conveys electromagnetic energy." This state occurs when the vector sum of the electric fluxes in the component waves is zero. The connection between waves and pulses and the reflection and refraction of pulses are considered. The suggestion is made that "a single pulse may consist of a group of distinct physical entities associated in some way represented by the polarisation."

Über die bei der Totalreflexion im zweiten Medium strömende Energie (On the Energy Flowing in the Second Medium in Total Reflexion).—A. Rostagni. (*Ann. der Physik*, 1932, Series 5, Vol. 12, No. 8, pp. 1011–1014.)

Remarks on a paper by F. Noether (April Abstracts, p. 217).

Dispersion of Explosion Waves in the Atmosphere.—P. Duckert. (Summary in *Sci. Abstracts*, *Sec. A*, April, 1932, Vol. 35, No. 412, p. 332.)

"Duckert's calculations give an average speed of sound at 296 m/s in the stratosphere up to a height of 30 km. The speed then increases rapidly to 360 m/s for heights up to 40 km. The increase is not uniform, but takes place chiefly in two layers situated respectively 31 and 37.5 km above the ground. Possible explanations of the increased speed in the upper stratosphere are discussed."

On the Transparency of the Lower Atmosphere —Buisson, Jausseran and Rouard. (*Comptes Rendus*, 25th April, 1932, Vol. 194, pp. 1477–1479).

Extension of the work referred to in 1930 Abstracts, p. 331, to light wavelengths ranging from 2 313 to 1 855. For the former the optical density of 1 km of air is 1.37 ; for the latter, 445.

On the Reflection at the Surface of the Ground of a Spherical and Isotropic Seismic Wave.—L. Cagniard. (*Comptes Rendus*, 14th March, 1932, Vol. 194, pp. 1005–1008.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

VARIATION DIURNE DES ATMOSPHÉRIQUES À PARIS DE 1928 À 1931. INFLUENCES RESPECTIVES DES SOURCES ET DE LA PROPAGATION (The Diurnal Variation of Atmospherics at Paris, from 1928–1931. The Respective Influences of the Sources and of Propagation). —R. Bureau. (*Comptes Rendus*, 18th April, 1932, Vol. 194, pp. 1369–1370.)

A set of curves derived from the Saint-Cyr recorder is given: wavelength 11 000 m, in the middle of a band of about 4 kc/s. The writer draws conclusions as to the relative influence of the sources and of propagation, dealing in separate sections with night atmospherics, afternoon atmospherics, and migratory cold fronts, near and distant. Finally the writer states that a first approximation for the evaluation of the activity of *near* sources is given by the height of the curves at times when propagation conditions are unfavourable to distant sources: "the level of the minimum following sunrise thus gives an estimate of the mean activity of the migratory atmospherics (due to cold fronts), while the level of the sunset minimum gives an estimate of the mean activity of the 'stagnant' atmospherics (due to quasi-stationary storm systems)."

THE IONISING EFFICIENCY OF ELECTRONIC IMPACTS IN AIR.—J. Thomson. (*Proc. Roy. Soc. Edinburgh*, Vol. 51, 1930/31, pp. 127–141: *Sci. Abstracts, Sec. A*, April, 1932, Vol. 35, pp. 346–347.)

The poor agreement between previous measurements of the total ionisation produced by an electron of a given energy has led the writer to attack the problem in a new way. He has measured the energy consumed in producing one pair of ions, when electrons in the range 50 to 270 volts are completely absorbed in air. This value changes with the initial velocity of the electrons, but for high velocities approaches asymptotically to the value 37 ± 2 volts. A relation between range, ionisation per unit path, and total ionisation is established; it is concluded that, except for very rapid cathode- and beta-rays, the ionisation per unit path, as determined with ionisation chambers, has no meaning.

ESPERIENZE DI DEFLESSIONE MAGNETICA SUI RAGGI PENETRANTI (Tests on the Magnetic Deflection of the Cosmic Rays).—B. Rossi. (*Nuovo Cimento*, No. 8, Vol. 8, pp. 189–190.)

See also Abstracts, 1931, p. 609, and March, p. 160. Either the cosmic ray particles possess much greater energy than that corresponding to their penetration, or they are something different from all known corpuscular radiation; or, finally, the coincidences in the two counter tubes must be due to two different components coming from the same gamma ray—a hypothesis demanding an unknown property of such rays.

ZERTRÜMMERUNG VON BLEI DURCH ULTRASTRAHLUNG (Disintegration of Lead by Cosmic Radiation).—E. G. Steinke and H. Schindler. (*Zeitschr. f. Phys.*, 1932, Vol. 75, No. 1/2, pp. 115–118.)

The authors show that the spontaneous ionising impulses observed in ionisation chambers used for the investigation of cosmic radiation are really set free in the lead in which the chamber is enclosed. The high specific ionisation points to their being hydrogen nuclei; their range is estimated at 10 cm lead. The frequency of collision gives the sum of the diameters of the two particles taking part in a collision as 3×10^{-16} cm; this also corresponds to hydrogen nuclei and cannot be reconciled with the assumption that electrons are primary corpuscles of cosmic radiation.

NACHWEIS EINER SEKUNDÄRSTRAHLUNG DER DURCHDRINGENDEN KORPUSKULARSTRAHLUNG (Proof of a Secondary Radiation Caused by the Penetrating Corpuscular Radiation). —B. Rossi. (*Physik. Zeitschr.*, 1st April, 1932, Vol. 33, No. 7, pp. 304–305.)

The existence of a secondary radiation excited in the lead shields surrounding the ionisation chambers used for measuring cosmic radiation is proved by counting the coincidences of ionising particles passing through three ionisation chambers, only two of which could be intersected by any one straight line.

VERTICAL TUBE COUNTER- AND BAROMETRIC-EFFECTS OF COSMIC RADIATION AT SEA-LEVEL.—W. Kolhörster. (*Nature*, 26th March, 1932, Vol. 129, p. 471.)

The vertical tube counter effect, first observed by Tuwim (*Berliner Ber.*, 1931, Vol. 91, p. 360: *see* also 1931 Abstracts, p. 552) has now been measured more precisely and found to be in accordance with his theory of the phenomenon. Repetition of the experiments in the open air at different barometric pressures shows the barometric effect, and gives a second method for the accurate measurement of the absorption coefficient of cosmic radiation with the same apparatus at the same time, without the use of a special screen: the absorption coefficient from the vertical tube counter effect is found to be $(\mu/\rho)_{H_2O} = 1.69 \times 10^{-3}\, cm^2\, gm^{-1}$ in the open air.

THE VARIATION OF PENETRATING RADIATION WITH ZENITH DISTANCE.—G. Bernardini. (*Nature*, 16th April, 1932, Vol. 129, pp. 578–579.)

The writer has measured the angular distribution from the zenith of penetrating radiation; the intensity curve "seems to be somewhat sharper than would be expected from absorption by the atmosphere."

KONDENSATOREN UND WANDERWELLEN (Condensers and Surges [Application of Heaviside Operational Methods to Surges—particularly of Non-Rectangular Form—on Lines]).—J. L. Miller. (*Elektrot. u. Masch:bau*, 8th May, 1932, Vol. 50, pp. 281–286.)

MEASUREMENTS OF LIGHTNING SURGES ON TRANSMISSION LINES IN SWEDEN.—H. Norinder. (Summary in *Sci. Abstracts, Sec. B*, April, 1932, Vol. 35, No. 412, pp. 203–204.)

"Relatively slow lightning discharges may show individual rapid field changes of the duration of some 10 to 20 microsec. The field force in such rapid variations may reach as much as 75 volts/metre/microsec. at a lightning distance of 1 km."

THE INFLUENCE OF THE STRATOSPHERE ON THE DYNAMICS OF THE WEATHER (Review of the Relations between Events in the Stratosphere and in the Troposphere).—H. Ertel. (*Meteorol. Zeitschr.*, No. 12, Vol. 48, pp. 461–475.)

THE RELATIVE NUMBERS OF SUNSPOTS.—M. Omschansky. (Summary in *Physik. Ber.*, 1st April, 1932, Vol. 13, p. 760.)

THE ELEVEN-YEAR THERMAL WAVE AT THE EARTH'S SURFACE.—F. Dilger. (Summary in *Physik. Ber.*, 1st April, 1932, Vol. 13, pp. 762–763.)

THE MOBILITIES OF ATMOSPHERIC LARGE IONS.—R. K. Boylan. (*Proc. Dublin Acad.*, *A*, No. 4, Vol. 40, pp. 76–85.)

Tests of Dublin City air by two methods, both of which show the existence of groups with higher and lower velocities than the Langevin ions.

PROBLEM OF THE AURORA.—C. Störmer. (Summary in *Sci. Abstracts, Sec. A.*, April, 1932, Vol. 35, No. 412, pp. 339–340.)

TERRESTRIAL MAGNETISM: RECENT WORK OF THE CARNEGIE INSTITUTION: POLAR YEAR PLANS.—J. A. Fleming. (*Electrician*, 22nd April, 1932, Vol. 108, p. 567.)

ÜBER DEN UNTERSCHIED IN DER BLITZGEFAHR DER EICHE UND DER BUCHE (On the Difference between Oak and Beech as regards Danger of Being Struck by Lightning).—B. Walter. (*Physik. Zeitschr.*, 1st April, 1932, Vol. 33, No. 7, pp. 306–307.)

The author concludes that there is no fundamental difference between oak and beech as regards the danger of being struck by lightning.

ÜBER DAS ANWACHSEN DER RAUMLADUNGEN BEIM ELEKTRISCHEN DURCHSCHLAGE EINER GASSTRECKE (On the Growth of the Space Charges in the Electrical Breakdown of a Gaseous Path).—N. Kapzov. (*Zeitschr. f. Phys.*, 1932, Vol. 75, No. 5/6, pp. 380–390.)

DURCHSCHLAGFELDSTÄRKE DES HOMOGENEN FELDES IN LUFT (The Breakdown Field-Strengths of the Homogeneous Field in Air).—H. Ritz. (*Archiv f. Elektrot.*, 21st April, 1932, Vol. 26, pp. 219–232.)

THE ELECTRODELESS DISCHARGE AS MEASURED BY THE CATHODE-RAY OSCILLOGRAPH (Number of Initiating Electrons, etc.): *also* THE STEP-BY-STEP DISCHARGE (AND KRUG'S DENIAL).—Buss. (*See* under "General Physical Articles.")

PROPERTIES OF CIRCUITS.

ERWEITERUNG DER SIEBKETTENTHEORIE (Extension of the Filter Network Theory).—M. J. O. Strutt. (*Archiv f. Elektrot.*, 21st April, 1932, Vol. 26, pp. 273–278.)

Author's summary:—"The wave propagation along lines with periodic structure is treated generally, and it is shown that the formula obtained contains as special cases the formulae of filter chain theory, if it is assumed:—(*a*) that only concentrated self-inductance and capacity are present, and (*b*) that the meshes of the periodic line are small compared with the wavelength on the line.

"The important difference between a filter with meshes finite compared with the wavelength, and with distributed or only partially concentrated self-inductance and capacity, and one with infinitely small meshes and concentrated constants is that in the first case an infinite succession of pass and stop zones exists as a function of frequency, whereas in the second case the number is limited." The investigation was undertaken because of the difficulty encountered in constructing satisfactory filters for undamped waves below 1 metre: the writer therefore illustrates the application of the formulae obtained by the case of a filter for a narrow pass band in this region of wavelength.

A NOTE ON THE FREQUENCY ANALYSIS OF THE HETERODYNE ENVELOPE: ITS RELATION TO PROBLEMS OF INTERFERENCE.—F. M. Colebrook: Vigoureux. (*Wireless Engineer*, April, 1932, Vol. 9, pp. 195–201.)

Author's summary:—The exact form of the envelope of the heterodyne combination of two sine waves, and its comparison with a pure tone modulated continuous wave, is a matter of some importance in connection with selective reception of radio communication.

The frequency analysis of the envelope is described in detail. It is shown that it can be represented as a Fourier series with a fundamental frequency equal to the difference of the frequencies of the constituent sine waves, and with appreciable harmonic content. The maximum equivalent amplitude modulation is just under 70 per cent., which is given by equal amplitudes of the two sine waves. A brief experimental verification of the analysis is given.

As a means of producing the equivalent of a single tone modulated wave of known characteristics, the heterodyne combination of two continuous waves is only satisfactory for small modulation percentages.

The modulation frequency output produced by the perfect rectification of a heterodyne combination is, in energy, less than a quarter of that given by a tone modulated continuous wave with similar constituent amplitudes.

The frequency analysis of the heterodyne envelope illustrates the effect known as the apparent demodulation of a weaker station by a stronger one. It is due to the difference between the partial derivatives of the constant term in the analysis, with respect to the constituent amplitudes.

The analysis also shows that a single side band system of broadcast transmission would not give, on rectification, a faithful reproduction of the original modulation, but would give rise to a number of extraneous difference frequencies, in addition to the introduction of harmonics.

QUELQUES EXEMPLES D'OSCILLATIONS NON LINÉAIRES (Some Examples of Non-Linear Oscillations).—N. Kryloff and N. Bogoliuboff. (*Comptes Rendus*, 14th March, 1932, Vol. 194, pp. 957–960.)

In the treatment of non-linear circuits, particularly of those involved in radio technique, the writers consider that sufficient attention has not been paid to the possible existence of oscillations whose frequencies are the linear combinations $n_1\omega_1 + n_2\omega_2 + \ldots n_r\omega_r$ of the different so-called "principal" frequencies, so that the functions of time t which represent the oscillations are essentially what (in Analysis) are called quasi-periodic, in the sense used by Bohl. Consequently, Poincaré's methods, based on the developments of the functions representing the oscillations according to the powers of the parameters, are here inadequate and may lead to wrong results, apart from the fact that the developments do not converge uniformly on a real axis, since they contain polynomials in t.

The writers have therefore adopted another procedure, developing not the required function itself (representing the stationary oscillations) but the amplitudes, phases and frequencies directly. They thus obtain the following results :—

(i) The stationary oscillations are composed of natural oscillations, forced oscillations, and also (contrary to the case of linear oscillations) *combined* oscillations. (ii) The so-called "natural" frequency ω depends not only on the constants of the circuit but also on the amplitude of the external force, and this last dependence is proportional—for small values of the parameter ϵ — to ϵ^2 ; with the result that this natural frequency is the more stable the smaller the value of ϵ (ϵ occurs in the non-linear radio equation

$$\frac{d^2}{dt^2}I(t) + \dot{\omega}^2 I(t) = \epsilon f\left(\frac{dI}{dt}\right) + E\sin at, \text{ where } \dot{\omega} = \frac{1}{LC}\Big).$$

(iii) Besides the resonance represented by $\dot{\omega} \sim a$, there are other resonances, of demultiplication of $\dot{\omega}$, near to $n/m \,.\, a$, such as for $a/2$, $a/3$, and $2a/3 \ldots$

SUR LE PHÉNOMÈNE DE L'ENTRAÎNEMENT EN RADIOTECHNIQUE (The "Pull-In" Effect in Radio Technique).—N. Kryloff and N. Bogoliuboff. (*Comptes Rendus*, 21st March, 1932, Vol. 194, pp. 1064–1066.)

Using the notation and an equation of the work dealt with above, the writers arrive at the conditions for the occurrence of the "pull-in" effect and the consequent production of a silent zone. In the general case, the critical value is given by

$$\int_0^{2\pi} f'\left(\frac{Ea}{\dot{\omega}^2 - a^2}\cos y\right)dy = 0 ;$$

for the special case considered by van der Pol it is $\left(\frac{Ea\gamma}{\dot{\omega}^2 - a^2}\right)^2 = 2$. The first of these equations shows, among other things, the absence of any threshold for the effect : this is confirmed by the most recent researches—however small the impressed force, a and $\dot{\omega}$ can always be taken near enough to resonance for the pull-in effect to occur. Among other results obtained, it is found that when $a^2 = \dot{\omega}^2$ (exact resonance) then $\phi = \pi/2$, that is to say, the phase of the forced oscillation is displaced by 90° with respect to the phase of the impressed force. Moreover, resonance is the sharper the smaller the value of ϵ (*see* preceding abstract) : this follows from equation 6, which also gives a means of constructing graphically the resonance curves expressing the dependence of N (amplitude of the forced oscillation) and $a^2 - \dot{\omega}^2$. Examination of these curves shows that the maximum value of N does not occur for $a^2 = \dot{\omega}^2$, but is displaced from this point.

LES PHÉNOMÈNES DE DÉMULTIPLICATION DE FRÉQUENCE EN RADIOTECHNIQUE (The Phenomena of Frequency Division in Radio Technique).—N. Kryloff and N. Bogoliuboff. (*Comptes Rendus*, 29th March, 1932, Vol. 194, pp. 1119–1122.)

Further application of the writers' methods of dealing with non-linear processes referred to in the two preceding abstracts, in this case to the question of resonance in frequency division. Among the results obtained are the following :—A silent zone exists, produced by the disappearance of the beats, and in this zone the relation exists

$$I(t) = P\sin at + N\cos\left(\frac{a}{2}t + \phi\right).$$

The conditions governing the width of this zone and the stability of the oscillatory régimes occurring can be derived. The calculations have been applied to the case of van der Pol function : it is seen that for external forces sufficiently large, no division phenomenon occurs.

The writers conclude by pointing out that their methods are applicable and effective in dealing with a number of other problems—such as the longitudinal stability of aircraft. They may, it is thought, open the way to the creation of a general Non-linear Mechanics.

ON THE "RETARDATION NETWORKS" (PART III).—K. Nagai. (English summary in *Journ. I.E.E., Japan*, No. 1, Vol. 52, p. 10 : full paper in Japanese, pp. 60–63.)

ON A METHOD FOR THE DETERMINATION OF ROOTS OF AUXILIARY EQUATIONS OF THE 3RD AND 4TH DEGREE IN CONNECTION WITH THE INVESTIGATION OF ELECTRICAL OSCILLATIONS IN COMPLEX CIRCUITS.—L. Mirlas. (*Westnik Elektrot.*, No. 9, 1931, Sec. I, pp. 309–314 : in Russian.)

The roots of the algebraic auxiliary equations of the 3rd and 4th degree are simply found by means of special equations derived from the mathematical and physical conditions of the system. Examples are given.

TRANSMISSION.

UNTERSUCHUNGEN AN ULTRAKURZWELLENRÖHREN (Investigations on Valves Producing Ultra-Short Waves).—H. Collenbusch. (*Ann. der Physik*, 1932, Series 5, Vol. 13, No. 2, pp. 191–211.)

This paper describes the results of an extensive series of investigations on the production of ultra-short waves by characteristic valves with filament, grid and anode in the Barkhausen-Kurz circuit and by diodes with an auxiliary magnetic field. Three of the valves used had spiral grids, short-circuited by a metallic bar supporting the windings; the others had spiral grids without the bar but with ends connected outside the anode by a nickel strip. This closed grid circuit could be excited to give its fundamental oscillation and in one case in a magnetic field to give a harmonic. If the spiral was broken in the middle, a wave approximately twice as long was produced. Undamped oscillations of length down to 4.7 cm were obtained. The wave produced was linearly polarised in the plane defined by the axis of the grid and the nickel strip, and the wavelength was not changed by altering the length of the leads. Besides these short waves due to the closed grid circuit, longer ones were obtained whose length depended on the length of the connections and the inter-electrode capacities. These waves were mostly polarised in a plane perpendicular to that described above. Oscillations were also found due to coupling between the above two types of circuit.

The oscillations of greatest energy were those in which the effective capacity was that between grid and anode. The effective self-induction was the Lecher wire system of connections to these two electrodes. These oscillations were studied in detail. One valve, in which the anode radius was five times as large as that of the grid, could be made to produce waves of all lengths between 28 and 120 cm. A sharp maximum of the energy radiated was found at $\lambda = 45$ cm. Oscillation regions in the (e_g, e_a) plane for a given wavelength and various constant emission values were determined.

These regions were also determined for the other type of oscillations, generated by the spiral grid circuit. Experiments were made with valves whose filament lay between the grid and anode. Tests made with diodes in a magnetic field gave results the same in principle as those with the oscillating spiral grid circuit. The same valve gave nearly the same wavelength when used as a diode in a magnetic field as when used as a triode, and in both cases the working conditions had very little effect upon the wavelength produced.

The times of flight of the electrons between the electrodes and the oscillation periods are calculated; when oscillations are taking place the latter are found to be connected with the former by linear relations with small integral coefficients. In general the conclusions reached by other authors are verified.

ON THE ULTRA-HIGH-FREQUENCY OSCILLATION OF THE MAGNETOSTATIC VACUUM TUBE.—W. Dehlinger. (*Phys. Review*, 1st April, 1932, Series 2, Vol. 40, No. 1, pp. 120–121.)

Abstract only:—" A physical picture of the phenomena during the electronic oscillation in the magnetostatic oscillator is given. The notion of a critical radius for plate voltages varying between a larger and a smaller value than the critical voltage for a given constant magnetic field is developed. The value of the critical radius is calculated as a function of the voltage differences and the potential distribution. The flying time of the electrons is discussed in its relation to the voltage distribution, and the falling angle is expressed in a simple way."

SUL MAGNETRON DI HULL (On the Hull Magnetron [Calculation of Wavelength]).—L. Pincherle. (Summary in *Physik. Ber.*, 15th April, 1932, Vol. 13, p. 821.)

A theoretical treatment of the case where the magnetic field is parallel to the direction of the electrons, leading to the formula $\lambda = 4\pi mc/\sqrt{3} \,.\, eH = 12\,300/H$, where c is the velocity of light. The constant 12 300 is in good agreement with Okabe's experimentally found value of 13 000. H must be very large.

GILL-MORRELL AND BARKHAUSEN-KURZ OSCILLATIONS.—E. C. S. Megaw and R. Cockburn. (*Nature*, 9th April, 1932, Vol. 129, pp. 542–543.)

Megaw's letter criticises results described by Cockburn (April Abstracts, p. 223); Cockburn replies.

INCREASED POWER FOR ULTRA-SHORT WAVES.—H. N. Kozanowski: Westinghouse Company. (*Sci. News Letter*, 16th April, 1932, Vol. 21, p. 244.)

Paragraph on a new development (reported to the I.R.E.) making possible " an output of at least 5 watts from a 60-centimetre wave transmitter, while—according to published literature—the energy available in this range has been only a fraction of a watt." In bringing a piece of metal near the valves of an ordinary transmitter, Kozanowski found that in certain very exact positions its presence increased the output: as a result, in his new set he has set up a sliding coupling of metal tubing between the plate and filament circuits of his valves.

THE GERMAN P.O. ULTRA-SHORT-WAVE TRANSMITTER FOR BROADCASTING AND TELEVISION.—(*Rad., B., F. f. Alle*, May, 1932, pp. 194–196.)

An outline of this Telefunken 6 to 8-metre transmitter which is said to put 15 kw into the aerial at 7 metres—compared with the hitherto-achieved maximum of 3 kw. There are seven stages, starting with a 0.1 watt crystal stage (56 m), and modulation is by grid bias control.

THE DYNATRON OSCILLATOR.—F. P. Basto: Colebrook. (*Wireless Engineer*, April, 1932, Vol. 9, pp. 213–214.)

Another contribution to the discussion dealt with in June Abstracts, p. 342. " It seems to me that the circuit can oscillate at higher frequencies because the 'static' curve $I_a - V_a$ is replaced by a 'dynamic' one having a steeper slope and consequently with a lower negative resistance, which will balance an oscillatory circuit having a lower dynamic resistance." The American result, that sometimes the insertion of a $\frac{1}{2}$ megohm resistor in the grid return is necessary to make the valve oscillate, is discussed, as is also the chance of the new circuit introducing 2nd harmonic distortion.

SUR LES OSCILLATEURS À LAMPE RÉGLÉS PRÈS DE LA LIMITE D'ENTRETIEN (Valve Oscillators adjusted near to the Oscillation Threshold [Mathematical Investigation]).—Y. Rocard. (*Comptes Rendus*, 18th April, 1932, Vol. 194, pp. 1325–1327.)

In a Meissner triode circuit, if r is small compared with $L\omega$, the equation

$$i + A\frac{di}{dt} + B\frac{d^2i}{dt^2} = C\left(\frac{di}{dt}\right)^2 + D\left(\frac{di}{dt}\right)^3 + \ldots$$

can replace the usual more complex equation. It can be shown that when the circuit is worked near the oscillation threshold this simplified equation is of as general application as the more complex, and the writer here makes use of it to obtain expressions for the amplitudes of fundamental and third harmonic, the variation of frequency with the proportion of third harmonic, and the time constant for the setting up of oscillation. The simple character of these expressions can be illustrated by quoting the last two, namely :—

$$\omega = \frac{1}{\sqrt{Lc}}\sqrt{1 + \frac{r}{\rho} - \left(\frac{4H_3}{H_1}\right)^2},$$

where ρ is the internal valve resistance and H_1 and H_3 are the amplitudes of fundamental and third harmonic respectively ; and time constant

$$\theta = \frac{1}{\omega}\cdot\frac{H_1}{4H_3}.$$

MULTIPLEX TRANSMISSION AND SECRET RADIOTELEPHONY.—Chireix : Villem. (*Bull. S.F.R.*, Jan., 1932, Vol. 6, pp. 1–10.)

"A system composed of a single transmitter and a single receiver enables one to establish simultaneously two radiotelephone communications and one radiotelegraph communication on the same wavelength. This result is obtained by modulating the transmitter carrier wave by a combination of three frequency bands, each one corresponding to one of the communications." The first speech band is inverted with the point of inversion at 2 700 c/s, so that the frequencies included in it (300 to 2 400 c/s) become 2 400 to 300 c/s ; the second speech band is inverted with the point of inversion at 3 200 c/s, so that its same frequencies are transposed to 3 500 to 5 600 c/s. Telegraphy is carried out on a frequency between these bands, namely 3 100 c/s. "It is easy to understand that communications thus obtained are practically unintelligible and consequently secret." Tests of the system, for the Paris–Buenos Ayres route, are progressing satisfactorily.

EEN ANALOGIE TUSSCHEN DE ABBESCHE THEORIE VAN DE MICROSCOPISCHE BEELDVORMING EN DIE VAN DRAAGGOLF EN ZIJBANDEN BIJ HET MODULATIEPROCES IN DE RADIO (An Analogy between Abbé's Theory of the Formation of Microscope Images and the Theory of Carrier Wave and Sidebands in the Modulation of Wireless Waves).—W. F. Einthoven. (*Tijdschr. Nederl. Radiogenoot.*, April, 1932, Vol. 5, No. 5, pp. 147–148.)

THEORY OF MODULATION AND ITS PRACTICE.—Y. Fukuta. (*Circ. Electrot. Lab. Tokyo*, No. 84, 64 pp. : in Japanese, with bibliography of 108 items, chiefly English and German.)

RECEPTION.

BROADCAST RECEPTION IN A CITY : TUNING TO THE "CALIBRATED" OR THE "COMMON" TUNING POINT.—Ollendorff. (*See* abstract under "Propagation of Waves.")

BROADCAST RECEIVERS : I.E.E. DISCUSSION ON THE TREND OF DESIGN.—C. F. Phillips and others. (*Electrician*, 22nd April, 1932, Vol. 108, p. 562.)

Short summary only. The most definite trend was towards reduced prices and simplicity of control—two factors utterly opposed to each other technically : the trend would seem likely to lead to a concentration of design and production into fewer hands. Was there any real tendency on the part of the designer to comply with the I.E.E. Regulations for mains-driven sets—except perhaps by some of the larger manufacturers ? Among users, ignorance of good reception was remarkable : could not the B.B.C. provide a demonstration room where the public might learn what proper reception really was and perhaps obtain advice ?

THE SELECTIVITY OF BROADCAST RECEIVERS : I. E. E. DISCUSSION.—(*Wireless Engineer*, April, 1932, Vol. 9, pp. 208–212.)

For Howe's long editorial on this Discussion *see* pp. 183–185. It includes a diagram "which will throw considerable light on the principle underlying those systems which seek to reduce interference by super-selectivity and tone-correction. It will also show what such systems can do and what they cannot do."

PUTTING BACK THE HIGH NOTES.—W. T. Cocking. (*Wireless World*, 11th May, 1932, Vol. 30, pp. 470–472.)

There are many receivers in use to-day in which a good measure of selectivity is obtained without the use of band pass filters ; as a result of this, sideband cutting and high-note loss must inevitably take place. The author discusses various simple compensating circuits whereby the higher audible frequencies can be restored in their correct proportion.

THE MUTUAL INTERFERENCE OF SIGNALS IN SIMULTANEOUS DETECTION.—E. V. Appleton : Callendar. (*Wireless Engineer*, April, 1932, Vol. 9, p. 214.)

In the paper by the writer and Boohariwalla dealt with in June Abstracts, p. 343, in discussing the effect of various types of detector use was made of a static characteristic relating mean signal current to amplitude of input voltage. The present letter points out that this type of characteristic can only be used in interpreting dynamic effects when certain conditions are fulfilled. One of these is that, in cumulative grid rectification, the time constant of the grid circuit should be sufficiently small for changes of the difference frequency to be followed : when the time constant is too high there is no interaction of signals and thus no demodulation. "This means that the demodulation effect tends to be most marked when the difference of carrier frequencies is low, and it is a mistake to call such a frequency difference 'supersonic' without further qualification."

THE FREQUENCY ANALYSIS OF THE HETERODYNE ENVELOPE: ITS RELATION TO PROBLEMS OF INTERFERENCE.—Colebrook. (*See* under "Properties of Circuits.")

THE GRAPHICAL SOLUTION OF DETECTOR PROBLEMS.—G. S. C. Lucas. (*Wireless Engineer*, April, 1932, Vol. 9, pp. 202–207.)

The writer's method is applicable to problems in anode bend or grid detection with diode, triode, s.g. and pentode valves, and "fairly accurate" results can be obtained in a few minutes if the standard valve curves are available. The method is first applied to grid rectification. The solution of problems in anode bend detection is dealt with in the second instalment (*ibid.*, May, 1932, pp. 253–258) and makes use of a new characteristic known as the $E_p/m - I_p$ characteristic, first given by L. J. Davies in 1928.

TESTS ON FIVE ULTRA-SHORT WAVE RECEIVERS [7 TO 13 METRES: TWO-STAGE WITH RETROACTIVE DETECTOR; SUPER-REGENERATIVE; AND SUPERSONIC HETERODYNE].—R. L. Smith-Rose and H. A. Thomas. (*Wireless Engineer*, April, 1932, Vol. 9, pp. 186–194.)

"The tabulated results . . . show that the overall voltage amplification, under the conditions given above, may rise from about 860 for the simple retroactive detector type to 100 000 for the super-regenerative type, and to nearly three million for the supersonic heterodyne type." Where a high sensitivity is required over the range of wavelengths in question, the advantage appears to lie quite definitely with the supersonic heterodyne type of receiver "which, it is contemplated, may be developed to a higher degree than is represented in the two receivers used for these tests." Even the least sensitive of the five receivers was used successfully for reception and d.f. at distances up to 20 miles from a half-wave aerial with a maximum current of half an ampere.

SUPER-REGENERATION AND SHORT [AND ULTRA-SHORT] WAVES.—H. B. Dent. (*Wireless World*, 18th May, 1932, Vol. 30, pp. 502–505.)

In view of the possibilities offered by the forthcoming ultra-short wave tests to be undertaken by the B.B.C., the author not only treats the subject theoretically, but gives details of an experimental four-valve receiver.

ZWEI EMPFÄNGER ZUR FADINGMILDERUNG ([The Construction of] Two Receivers for the Reduction of Fading).—R. Schadow. (*Funkmagazin*, Feb., 1932, Vol. 5, pp. 109–114.)

Both based on the simultaneous reception of the same programme on two different wavelengths, or else—where practicable—on the reception of one transmission on two spaced aerials. One type uses aperiodic, the other tuned, radio-frequency amplification.

EIN SELBSTTÄTIGES GERÄT ZUR AUSWAHL DES JEWEILS LAUTEREN ÜBERTRAGUNGSWEGES (An Automatic Device for the Selection of the Temporarily Strongest Receiver Output [in Spaced-Receiver Reception for Combating Fading]).—H. E. Kallmann. (*E.N.T.*, April, 1932, Vol. 9, pp. 137–142.)

Description of an entirely thermionic device in which two amplifiers are rendered mutually dependent by the use of the Kallirotron method of connection and are controlled by a two-valve differential relay. By its use the stronger of the two audio-frequency outputs is automatically selected and switched in, while the other is cut off. It works rapidly, without a break, and noiselessly, even for small differences in strength.

STABILISING SUPERHETERODYNE PERFORMANCE: ELECTRON-COUPLED OSCILLATORS USING HEATER-TYPE TUBES.—J. J. Lamb: Dow. (*QST*, April, 1932, Vol. 16, pp. 14–17.)

Modifications of the "electron-coupled" types of oscillator described by Dow (April Abstracts, p. 222) have been successfully applied to the oscillator of superheterodyne receivers, as is here described.

DER SUPERHET ALS FERNEMPFÄNGER DER ZUKUNFT (The Superheterodyne as the Long-Distance Receiver of the Future).—S. Brüller. (*Rad., B., F. f. Alle*, May, 1932, pp. 197–205.)

A constructional article based on the previous paper dealt with in 1931 Abstracts, pp. 615–616.

[PREVENTION OF] ACOUSTIC FEEDBACK IN SUPERHETERODYNE RECEIVERS.—E. Messing. (*Rad. Engineering*, March, 1932, Vol. 12, p. 14.)

One of the most valuable steps was to put a steel cover over the oscillator tuning condenser to insulate it acoustically; another (where it was impossible to float the chassis) was to float the loud speaker by a sponge rubber strip under its periphery. *See* also Bouck, Brooke, April Abstracts, p. 225.

A CIGAR-BOX SUPER-REGENERATIVE RECEIVER [550–1 000 kc, USING A 4.5 V ANODE BATTERY AND ONE TRIODE].—W. van B. Roberts. (*QST*, March, 1932, Vol. 16, pp. 11–12.)

A SIX-VALVE MOTOR-CAR RECEIVER MOUNTED ON STEERING COLUMN AND USING CONDENSER AERIAL UNDER RUNNING BOARDS.—J. W. Berge. (*Radio News*, Feb., 1932, Vol. 13, pp. 667–668.)

RECEIVER FOR SUBMARINES: RECEPTION UNDER WATER [3 000–20 000 METRE WAVES].—Soc. Franç. Rad:élec. (*Bull. S.F.R.*, Jan., 1932, Vol. 6, pp. 11–15.)

SCHULFUNKANLAGEN (Receiving Equipment for Schools Broadcasting).—H. Fasal. (*Funkmagazin*, March, 1932, Vol. 5, pp. 187–192.)

Discussing the technical requirements of such apparatus. Among the important points are:—universal suitability for broadcast, gramophone, *and microphone*; protection against interference; expert laying of leads, suitably earthed at various spots; suitability of amplifier for the number and nature of the "points" (a 3-watt output is considered capable of dealing with a maximum of 5 electromagnetic or 1 m.c. loud speaker: for 6 watts the numbers are 8–10 and 2 respectively: for 10 watts, 20 and 3–4, and for 16 watts, 35 and 5); volume control at input as well as at each "point"; and the possibility of introducing remote start-stop control. In the specimen installation diagram a tone regulator is included between the receiver and the output amplifier; this is not considered essential. As regards loud speakers, the electromagnetic type is thought to be satisfactory except in special cases.

What Should the Ideal Schools Broadcasting Receiver Look Like? Construction of a Battery-driven Receiver for Schools. The Detection of Faults in School Receivers. The Most Suitable Installation of a School Receiving Equipment. (*Ibid.*, pp. 196–208.)

The Saic "Filter-Aerial," and a Comparison with Ordinary Filters.—Saic. (*Rad., B., F. f. Alle*, May, 1932, pp. 223–225.)

A description of the latest form of this device (*see* 1931 Abstracts, pp. 385–386) and of the results obtainable with it.

Radio Inductive Interference.—H. O. Merriman. (*Dom. of Canada Dept. of Marine, Bull. No.* 2, 1932, 104 pp.)

"Since the publication of Bulletin No. 1 [in 1925] the Radio Branch of the Department of Marine has investigated over thirty thousand sources of radio interference and has arranged for the elimination of the major portion thereof. Special tests are required, in many instances, and new methods have to be adopted to deal with sources of interference arising from conditions not hitherto encountered. The department, therefore, solicits the co-operation of all who are interested in the suppression of radio inductive interference, and will be pleased to receive reports of special or difficult cases. Multigraphed circulars, dealing with the location and elimination of interference caused by specified types of electrical apparatus, are published from time to time, and will be sent, on request, to those who desire to prevent interference from a stated source. There remain, however, many cases of interference for which no economic cure has yet been found, but research work being conducted at present is progressing favourably."

The Bulletin deals with this work in detail. The investigation of interference with and without special detection apparatus is described: the installation of a receiver to ensure minimum "radio inductive susceptiveness" (including the use of a shielded lead-in and of an underground or grounded aerial) is discussed. A long chapter deals with various types of surge trap for insertion in the power lines supplying the interfering apparatus, or in exceptional cases in the wiring in the vicinity of the receiver. Certain types of apparatus likely to cause interference are then considered one by one, together with their suitable treatment. Public utilities' lines and apparatus are similarly dealt with, and the final chapter describes some investigations of special interest. One of these was a case where induced sparking from an unused telegraph line caused interference: in another, interference originating on a distribution system was carried by trolley lines for many miles.

Radio Inductive Interference: Methods Employed [in Canada] to Locate and Suppress the Interference at its Source.—H. O. Merriman. (*Trans. Eng. Inst. Canada*, Vol. 36, 1926–1930, pub. 1932, pp. 242–247.) *See* also 1931 Abstracts, p. 457.

Protecting Devices against Local Interference, for Connection at the Receiver.—E. Nesper. (*Funkmagazin*, March, 1932, Vol. 5, pp. 217–220.)

Electrical Interference in Motor Car Receivers.—L. F. Curtis. (*Proc. Inst. Rad. Eng.*, April, 1932, Vol. 20, pp. 674–688.)

Author's summary:—In the high tension and low tension ignition circuits of present-day motor cars there are three sources of high-frequency transients in time and space. In the lighting generator there is another. These radiations and their reduction to acceptable levels to avoid pick-up by the supply and antenna leads to the receiver and the best form of antenna are discussed.

Eliminating Interference Caused by Electrical Equipment.—A. Larsen. (*QST*, March, 1932, Vol. 16, pp. 16–19 and 23.)

From the Danish paper referred to in 1931 Abstracts, p. 616.

The Importance of Volume Level.—R. Raven-Hart. (*Wireless World*, April 6th, 1932, Vol. 30, pp. 345–346.)

The author discusses an important aspect of intensity of reproduction in relation to the original performance which is broadcast, leading to the conclusion that changes in volume level effected at the receiver must inevitably mar quality, except under the conditions where reproduction is at the same intensity as the original, and that the only satisfactory alternative is to develop a new technique for broadcasting where the conductor himself makes the corrections necessary, and not the control engineer or the listener at his receiver.

Circuits to Obtain Detection and Delayed AVC [Automatic Volume Control: Variations of the Farnham Circuit].—J. R. Nelson: Farnham. (*Rad. Engineering*, April, 1932, Vol. 12, pp. 13–14.)

Farnham's circuit for detection and AVC is first given (Fig. 1) and is stated to have a serious defect from a valve standpoint, in that the cathode is at high a.c. potential, so that difficulty may be found with valves having considerable heater-cathode leakage. The writer gives two alternative circuits in which the cathode is at zero a.c. potential. They give better AVC action than a single diode.

AUTOMATIC SUPPRESSION OF INTERCARRIER NOISE IN RADIO RECEIVERS [WITH AUTOMATIC GAIN CONTROL].—P. O. Farnham. (*Rad. Engineering*, April, 1932, Vol. 12, pp. 21–23.)

For aerial inputs below the point where normal automatic gain control begins, the audio voltage output is related to the input by a first or second power law, depending on the law of the detector. At very weak inputs, the total audio output drops off much less rapidly, most of this output being furnished by the fluctuation noise within the receiver, together with interference such as that caused by electrical disturbances on the power line. The writer shows how this undesirably high noise level can be reduced by the use of a second bias-developing agency connected at a suitable point. " In view of the superiority of the diode over most types of rectifier from the standpoint of harmonic distortion, particular attention is devoted to gain control systems in which one diode serves as a demodulator furnishing audio output while another operates as a rectifier with delayed action to furnish a control bias. Experimental data are included to show how closely the performance of an actual receiver embodying the noise suppression principle approaches the conditions set up as ideal."

VOLUME CONTROLS: A REVIEW OF THE DEVELOPMENT OF VOLUME CONTROL SYSTEMS, INCLUDING DESIGN TO MEET PRESENT-DAY REQUIREMENTS.—W. S. Parsons. (*Rad. Engineering*, April, 1932, Vol. 12, pp. 25–28.)

MORE ABOUT THE DIODE.—H. L. Kirke. (*Wireless World*, 20th April, 1932, Vol. 30, pp. 388–389.)

The article deals with some practical applications of principles outlined previously (1932 Abstracts, p. 224).

VISUAL TUNING OF BAND-PASS AMPLIFIERS [USING DYNATRON OSCILLATOR].—R. De Cola. (*Electronics*, Feb., 1932, p. 58.)

CHANGING A TUNED R.F. TYPE OF RECEIVER TO A SUPERHETERODYNE [" SUPERHETERODYNE CONVERTER WITH REMOTE CONTROL "].—General Motors Radio Corporation. (*Rad. Engineering*, March, 1932, Vol. 12, p. 21.)

The converter is built to resemble a portable smoking stand, with an illuminated dial and two knobs for tuning and volume control, connected to the receiver by a 30-ft. cord.

AUTOMATIC DEVICE FOR TUNING-IN TO DIFFERENT STATIONS AT DIFFERENT TIMES.—G. Frantz. (*Rad., B., F. f. Alle*, March, 1932, p. 97.)

Editorial comments on Frantz' invention reported to have created a " sensation " in the U.S.A.

PERSONNEL AND EQUIPMENT FOR THE SMALL MANUFACTURER.—Z. Bouck. (*Rad. Engineering*, March, 1932, Vol. 12, pp. 19–20.)

CONTINUITY TESTS OF RADIO RECEIVERS.—J. F. Rider. (*Rad. Engineering*, March, 1932, Vol. 12, pp. 26–32.)

" An analysis of comments received relative to published information covering continuity testing to be found in radio service manuals."

AUS DER PRAXIS DER EINKNOPFABSTIMMUNG (Practical Points in Connection with Single-Knob Tuning).—H. Fasal. (*Funkmagazin*, Feb., 1932, Vol. 5, pp. 129–134.)

QUICK-ACTING FUSES FOR RADIO RECEIVERS.—Sundt: Littelfuse Laboratories. (*See* abstract under " Subsidiary Apparatus and Materials.")

RADIO RECEPTION AND SUNSPOTS.—H. T. Stetson. (*Electronics*, April, 1932, pp. 122–123.)

See February Abstracts, p. 95, and elsewhere. " The result of these investigations may suggest that during years of sunspot maximum when long-distance reception is relatively poor, sales pressure should be brought to bear upon the placing of receiving sets for successful reception within a 30- to 50-mile radius, whereas during periods of depressed solar activity, such as we are approaching at present, long distance reception should be one of the selling features for the radio market."

AERIALS AND AERIAL SYSTEMS.

THE SPREADING OF ELECTROMAGNETIC WAVES FROM A HERTZIAN DIPOLE.—J. A. Ratcliffe, L. G. Vedy, and A. F. Wilkins. (*Journ. I.E.E.*, May, 1932, Vol. 70, No. 425, pp. 522–536: Discussion, pp. 536–544.)

The full paper referred to in June Abstracts, p. 347 (two). Authors' summary:—" The previous experimental work on the spreading of a wave from a Hertzian dipole is discussed and is shown to be incomplete. An experimental investigation of the variation of the electric and magnetic fields with distance, in a wave from a source which approximates to a Hertzian dipole, is described. A long wavelength (1000 m) is used, and the results agree with theory up to distances of 0.01 λ. The field re-radiated from a receiving aerial is investigated, using long waves, and is found to be in accordance with the ordinary theory.

" Finally it is shown, experimentally, that the field due to an aerial with its lower end connected to earth is, at a nearby point on the earth's surface, equal to twice the field which the aerial alone would give in free space. The theoretical significance of this fact is discussed."

OVERCOMING " SKIP DISTANCE " EFFECT [NEW SINGLE-MAST SHORT WAVE AERIAL SYSTEM AT ZEESEN].—(*Wireless Engineer*, April, 1932, Vol. 9, p. 194.)

SHORT WAVE DIRECTIVE AERIALS AT BANDOENG.—W. F. Einthoven. (*Tijdschr. Nederland. Radiogenoot.*, March, 1932, Vol. 5, No. 4, pp. 129–132.)

PORTABLE APPARATUS FOR THE ADJUSTMENT OF BEAM AERIALS.—Soc. Franç. Rad:élec. (*Bull. S.F.R.*, Feb.-March, 1932, Vol. 6, pp. 29–35.)

ERFAHRUNGEN MIT EMPFANGSANTENNEN (Tests with Receiving Aerials).—Neckenbürger. (*Rad., B., F. f. Alle*, May, 1932.)

Summary of the *AEG-Mitteilungen* paper dealt with in April Abstracts, p. 226.

WHAT CAN THE "SCREENED AERIAL" DO? [POSSIBILITY OF CUTTING-OUT LOCAL DISTURBANCES BY SCREENING THE DOWN-LEAD].—E. Nesper. (*Funkmagazin*, March, 1932, Vol. 5, pp. 184–186.)

German Electricity undertakings are apparently inclined to say that there is no need for precautions to prevent interference being generated, since a properly screened down-lead will avoid all trouble from it. The writer examines this statement.

REDUCING "RADIO INDUCTIVE SUSCEPTIVENESS" OF BROADCAST RECEIVERS BY USE OF SHIELDED LEAD-IN OR UNDERGROUND OR GROUNDED AERIALS.—Merriman. (*See* abstract under "Reception.")

VALVES AND THERMIONICS.

A GIANT TUBE FOR RADIO TRANSMISSION.—A. Dinsdale. (*Rad. Engineering*, April, 1932, Vol. 12, pp. 17 and 28.)

Illustration and data of the Marconi-Osram 500 kw valve "said to be the largest hard-pumped tube in the world"; and a short description of the Metropolitan-Vickers demountable 500 kw valve already dealt with in these Abstracts.

INVESTIGATIONS ON VALVES PRODUCING ULTRA-SHORT WAVES.—Collenbusch. (*See* under "Transmission.")

FLASH-ARC PHENOMENON ("Rocky Point Effect" in High Power Valves).—B. S. Gossling. (*Electrician*, 15th April, 1932, Vol. 108, p. 536.)

Summary of I.E.E. paper. Part I.—General experimental survey: duration of building-up stage, etc. Part II.—Comparison of the incidence of flashing in operation at various installations: conclusions drawn from this: particular behaviour of three-phase circuits, etc. Part III.—Time lag: two theories: no correlation between lengths of "first" and "second" lives, etc.

A NEW HIGH QUALITY DETECTOR TUBE.—Wunderlich. (*Rad. Engineering*, April, 1932, Vol. 12, pp. 33–34.)

"Simple tube and system, designed by N. E. Wunderlich, combines full-wave detection, audio amplification and full automatic volume control . . . is entirely non-microphonic . . . requires no magnetic or electrostatic shield about it, as the elements are all balanced to ground." Data are given. *Cf.* June Abstracts, p. 349 (two).

A NEW INDUSTRIAL AMPLIFIER TUBE FOR PHOTOTUBE CIRCUITS [WESTINGHOUSE RJ-550].—L. Sutherlin. (*Rad. Engineering*, April, 1932, Vol. 12, p. 24.)

The RJ-553, much used for photoelectric devices such as smoke indicators, light control relays, etc., has an exceptionally long life. The new valve is smaller and less expensive, and its life, though not quite as long, is very long compared with the recognised life of radio valves. At the test point the maximum allowable grid current is 0.01 μA, the mutual conductance is 1 650 and the average plate current is 6 mA.

A NEW LOW NOISE VACUUM TUBE.—G. F. Metcalf and T. M. Dickinson. (*Phys. Review*, 1st April, 1932, Series 2, Vol. 40, No. 1, p. 134.)

Abstract only, containing no description of the tube. The reduction or removal of the various causes of noise is said to permit the amplification of low-frequency voltages of less than 1 microvolt over the whole frequency band below 100 c/s.

PENTODE WITH EXTRA ELECTRODE FOR DETECTION.—(French Pat. 701 700: *Funk, Berlin*, 26th Feb., 1932.)

The functions of detection and amplification are separated, the former being performed by the diode composed of the extra electrode and the filament.

VARIABLE-MU RADIO-FREQUENCY PENTODE TYPE 39 [6-VOLT D.C. HEATER-TYPE].—L. Martin. (*Radio Craft*, Feb., 1932, Vol. 3, pp. 458–459.)

DISTORTION IN SCREEN-GRID VALVES: WITH SPECIAL REFERENCE TO THE VARIABLE CONDUCTANCE TYPE.—R. O. Carter. (*Wireless Engineer*, March, 1932, Vol. 9, pp. 123–129.)

Distortion in the r.f. valves has generally been assumed to be negligibly small: lately, however, it has been shown that under certain conditions, and especially when the amplifier gain is controlled by variation of grid bias on the r.f. valves, the distortion introduced may be quite large. "As this is probably in many ways the best method of gain control, it is highly desirable to know the conditions which must be fulfilled if quality is to be unimpaired. The present article describes some measurements made to determine the limits for distortionless operation both of a standard type of screen-grid high-frequency amplifying valve and also of . . . the 'variable-mu tetrode' . . ."

THE CHARACTERISTICS OF TWO SCREEN-GRID VALVES COUPLED DIRECTLY TO EACH OTHER.—T. Amishima. (English summary in *Journ. I.E.E. Japan*, No. 10, Vol. 51, pp. 93–94; full paper in Japanese, pp. 705–707.)

The synthetic characteristics of the resulting circuit are different from those of a single s.g. valve. For example, in one circuit given the V_{cg1}/A_2 curve (A_2 being second anode current) changes its steepness on change of anode voltage V_2 of the second valve, and at some value of V_2 the curve becomes perpendicular. If V_{sg1} is changed, the V_{cg1}/A_2 curve changes its working point and (as in the ordinary connection) moves to the minus side of V_{cg1} as V_{sg1} is increased.

MORE ABOUT THE DIODE.—Kirke. (*See* under "Reception.")

DYNAMIC ARRANGEMENT FOR COMPARING THE CONSTANTS OF TWO TRIODES.—C. Dei. (Summary in *Sci. Abstracts, Sec. B*, Feb., 1932, Vol. 35, No. 410, p. 376.)

An *Accad. Lincei* paper. The arrangement described determines ρ and *k* of one triode by comparison with another. "The terminals of an alternator are connected by three commutators either to the two plates or the two grids of the two valves to be compared."

IONISATION IN VACUUM TUBES [AND THE ADVANTAGE OF THE BUCKLEY METHOD OF CHECKING GAS CONTENT].—R. de Cola: Buckley. (*Rad. Engineering*, April, 1932, Vol. 12, pp. 15–16.)

ÜBER DEN AUSBRENNVORGANG DER IM VAKUUM GEGLÜHTEN DRÄHTE. II. (On the Burning Out Process of Wires Heated in Vacuo. II). —L. Prásnik. (*Zeitschr. f. Phys.*, 1932, Vol. 75, No. 5/6, pp. 417–420.)

This paper completes a former one (Abstracts, March, p. 168; *see* also 1931, p. 501) and gives numerical applications to tungsten wires.

THERMIONIC EMISSION AND SPACE CHARGE.—N. H. Frank. (*Phys. Review*, 15th Jan., 1932, Series 2, Vol. 39, No. 2, pp. 226–236.)

Author's abstract:—The theory of thermionic currents for a plane parallel electrode arrangement including space charge effects is developed by using Fermi-Dirac statistics and by taking into account the wave-mechanical nature of the electron. The use of the Wentzel-Kramers-Brillouin approximate solution of the Schrödinger equation leads to results quite analogous to those of the classical calculations. The current-voltage characteristic is but slightly different, but the expressions for potential distribution (and hence space charge, field, energy density, etc.) are appreciably modified by wave mechanics.

ON THE REDUCTION OF SHOT EFFECT FLUCTUATIONS BY ELECTRON SPACE CHARGE.—E. W. Thatcher. (*Phys. Review*, 1st April, 1932, Series 2, Vol. 40, No. 1, pp. 114–115.)

Further evidence is presented in support of the theory given in a previous paper (May Abstracts, p. 286).

ON THERMAL ELECTRONIC AGITATION IN CONDUCTORS.—N. H. Williams and E. W. Thatcher. (*Phys. Review*, 1st April, 1932, Series 2, Vol. 40, No. 1, pp. 121–122.) Abstract only.

THE USE OF THERMIONICS IN THE STUDY OF ADSORPTION OF VAPOURS AND GASES.—J. A. Becker. (*Bell Tel. System Reprint* B-649; to be published in *Transactions of the Faraday Society*.)

A THEORY OF THE EMISSION OF POSITIVE IONS FROM GLOWING METALS.—N. Morgulis. (Summary in *Physik. Ber.*, 15th April, 1932, Vol. 13, p. 814.)

TOTAL SECONDARY EMISSION OF ELECTRONS FROM METALS AS A FUNCTION OF PRIMARY ENERGY. —P. L. Copeland. (*Phys. Review*, 1st April, 1932, Series 2, Vol. 40, No. 1, p. 122.)

VERSTÄRKUNG DER INTERFERENZFARBEN DÜNNER OXYDSCHICHTEN (Strengthening of Interference Colours of Thin Oxide Layers [on Valve Metals]).—A. Güntherschulze and F. Keller. (*Zeitschr. f. Phys.*, 1932, Vol. 75, No. 9/10, pp. 597–598.)

ACCOMMODATION COEFFICIENT OF HYDROGEN: A SENSITIVE DETECTOR OF SURFACE FILMS [ON TUNGSTEN FILAMENTS].—K. B. Blodgett and I. Langmuir. (*Phys. Review*, 1st April, 1932, Series 2, Vol. 40, No. 1, pp. 78–104.)

SURFACE HEATING BY NEUTRALISED POSITIVE RAYS BEFORE AND AFTER RETURN TO NORMAL STATE.—M. C. Johnson. (*Proc. Physical Soc.*, 1st May, 1932, Vol. 44, Part 3, No. 243, pp. 255–266.)

DIRECTIONAL WIRELESS.

DIRECTION FINDER TYPE D.F.G. 9A [PARTICULARLY FOR NAVAL WORK].—Marconi Company. (*Marconi Review*, March–April, 1932, No. 35, pp. 22–27.)

Designed chiefly for use with the small type of shielded frame aerial, this equipment uses the aperiodic Bellini-Tosi system, and gives a sharply defined zero (a small vertical aerial is used for the dual purpose of "zero-sharpening" and sense), simple tuning and rapid wave-range change. The total wave-range covered by the four stages is 300–4 000 metres. A modified version (Type D.F.G. 9b) in the "general purpose" category will be described in a later issue.

S.F.R. COMPENSATED NIGHT EFFECT RADIOGONIOMETER [ADCOCK AERIALS WITH AIR-CORE TRANSFORMERS].—Soc. Franç. Rad: élec. (*Bull. S.F.R.*, Dec., 1931, Vol. 5, pp. 181–191.)

AIRPLANE RECEIVING EQUIPMENT FOR VISUAL RADIO RANGE-BEACONS.—Note from the U.S. Bureau of Standards. (*Journ. Franklin Inst.*, May, 1932, Vol. 213, No. 5, pp. 568–570.)

This note gives information on literature published by the Bureau of Standards and obtainable from the Superintendent of Documents, Washington, D.C., giving practical details as to the construction and use of the radio range-beacon devices developed by the Bureau.

PROGRESS IN AERONAUTIC RADIO RESEARCH [EQUISIGNAL BEACON RECEIVERS, ETC.].—(*Bur. of Stds. Tech. News Bull.*, No. 176, 1931, pp. 132–133.)

For simultaneous radiophone and radio-beacon reception, the receivers are being improved: an undistorted output of 400 mw has been found desirable for satisfactory service during severe atmospherics: a uniform response for frequencies from 50 to 3 000 c/s has also been found desirable. A direct copper connection for ground return is being used. An improved method of calibrating the reed indicators has been developed. Only one loop aerial is now necessary if the zero-centre pointer type indicator is employed.

TWO-WAY FIVE-METRE TELEPHONY AEROPLANE TESTS.—Lyman and Keily. (*QST*, April, 1932, Vol. 16, p. 13.)

Note on some amateur tests taking place in April.

THE "ASKANIA" TELECOMPASS FOR AIRCRAFT [WITH AIR TRANSMISSION].—(*Génie Civil*, 30th April, 1932, Vol. 100, pp. 443–446.)

ACOUSTICS AND AUDIO-FREQUENCIES.

BERECHNUNG DER ERFORDERLICHEN LEISTUNGSABGABE DER ENDSTUFE EINER SCHALLWIEDERGABEAPPARATUR (Calculation of the Necessary Power Output of the Final Stage of a Sound Reproducing Apparatus [for Any Given Room]).—F. Aigner. (*Zeitschr. f. tech. Phys.*, No. 5, 1932, Vol. 13, pp. 218–221.)

The writer first obtains the relation between energy density E of the sound field and the corresponding number of phons ψ received by a listener:—$E = 7.3 \times 10^{\frac{\psi - 140}{10}}$ erg/cm³. From this he derives the radiation output L of the loud-speaker necessary to deliver ψ phons to a listener in a room of V cm³ content with a reverberation time of τ sec. (for a filled room, assuming the validity of the Sabine-Jäger formulae) :—$L = \frac{V}{\tau} \times 10^{\frac{\psi - 190}{10}}$ watt. Then, if η is the loud-speaker efficiency and ϕ the electric phase angle in the loud-speaker circuit, the electrical power L_e of the output stage, measured in a matched pure ohmic resistance, is given by $L_e = \frac{L}{\eta \cdot \cos\phi} = \frac{V}{\tau \cdot \eta \cdot \cos\phi} \times 10^{\frac{\psi - 190}{10}}$ watt.

In discussing (Section 3) the application of the formula, it is assumed (Janovsky, March Abstracts, p. 172) that a fortissimo of a philharmonic orchestra yields 80 phon, and that $\frac{1}{\eta \cdot \cos\phi}$ for modern m.c. loud-speakers with the usual magnetic field-strengths is about 100, while for horn loud-speakers and m.c. loud-speakers with a magnetic field above 15 000 gauss it is about 10. Taking the first class of loud-speaker and the value of 80 phon, L_e comes out at $\frac{V}{\tau} \times 10^{-9}$ watt, which for a room of 1.3×10^{10} cm³ (audience of about 2 000) and a τ of 1.3 sec. gives $L_e = 10$ watts for the electrical power of the output stage.

In Section 4 it is pointed out that for the loudest noises such as the roar of an aeroplane (say 130 phon) the power on this basis would require to be 100 kw even for horn loud-speakers: even if $\frac{1}{\eta \cdot \cos\phi}$ were brought down to 1, L_e would still have to be 10 kw! Luckily the true reproduction of such noises is not very important: the formula gives the correct values for a faithful reproduction of speech and music. In Section 5 the writer deals with the background noise levels of apparatus and auditorium, hitherto assumed to be zero. Owing to unevenness and limitations in size, the available range of intensity is about 40 phon for gramophone discs; owing to Barkhausen effect and the bending of the characteristic, it is about 26 phon for steel wire records; for sound-on-film records, owing to grain-size effect and the limitation of contrast between black and white on the film, it is about 23–26 phon; special devices such as those used in "noiseless" systems can raise this to 60 phon.

ON THE SYMMETRICAL MODES OF VIBRATION OF TRUNCATED CONICAL SHELLS; WITH APPLICATIONS TO LOUD-SPEAKER DIAPHRAGMS.—N. W. McLachlan. (*Proc. Physical Soc.*, 1st May, 1932, Vol. 44, Part 3, No. 243, pp. 408–420: Discussion, pp. 420–425.)

Author's abstract :—"It is shown that in general the stresses in a vibrating conical shell are so complicated that the problem is unsuited to analytical treatment. If the stress were purely extensional, the frequency would be independent of the thickness t and vary inversely as the major radius a. This, however, would necessitate a much larger potential energy at the small end than practice indicates. The expression for the frequency of a shell of constant minor radius is of the form $f = kt^{n_1}a^{-n_2}$ where, for certain conditions, $n_1 = 0.22$ and $n_2 = 0.67$.

"Experimental work with paper, glass and aluminium shells is described. The modes crowd together as compared with the segregation which occurs in the case of a disc. With thick glass or aluminium of comparatively low loss, the nodal frequencies are very clearly defined peaks. In the case of paper cones driven by coils of small mass, the peaks disappear and the nodal region is indicated by a broad rounded contour. The influence of thickness, apical angle and the mass of the driving coil is considered. Vibrations of the air column within the shell and the general requirements for loud-speaker diaphragms are discussed and illustrated by practical examples." In the final Section 9 on the suitability of various materials, the writer remarks that "as was stated in Section 8 [Section 6 ?], for comfortable audition the main frequency group should lie between certain limits. This is accomplished by using a coil of suitable mass or some equivalent artifice. The output in the upper register must be properly proportioned to that at lower frequencies. In fact, a curve of the form shown recently in the *Philosophical Magazine* [Jan. Abstracts, p. 41] is desirable. So far as the investigation has been pursued, such results have only been achieved by the use of paper of low density and suitable transmission loss. It is hardly necessary to state that glass shades and aluminium are quite beyond the pale, so far as the reproduction of speech and music is concerned." But in his reply to the Discussion he remarks that quality is a matter of personal taste and is not amenable to the laws of physics; if perfect reproduction could be obtained there would still be dissentients, "so bizarre is the psychology of musical appreciation."

EFFECTIVE MASS OF LOUD SPEAKER CONES.—G. A. V. Sowter: Strutt. (*Wireless Engineer*, April, 1932, Vol. 9, pp. 214–215.)

Referring to Strutt's paper dealt with in June Abstracts, p. 350, the writer calls attention to McLachlan's papers (Abstracts, 1931, p. 561, and 1932, p. 169) and makes certain criticisms of Strutt's methods.

THE LOUD SPEAKER COIL OF OPTIMUM MASS.—F. R. W. Strafford : McLachlan. (*Wireless Engineer*, April, 1932, Vol. 9, p. 214.)

In response to McLachlan's letter dealt with in June Abstracts, p. 351.

UN MICROFONO ED UNA ALTOPARLANTE ELETTRODINAMICI DI TIPO SPECIALE (Moving Coil Microphone and Loud Speaker of Special Type). — G. Giulietti. (*Rendic. Lomb.*, Special No. 16/18, Series 2, Vol. 64, pp. 1197–1200.)

The design is based on the principle of the moving coil pick-up and is such that the coil can only move in one plane and is set perpendicular to a uniform magnetic field. Thus in the case of the microphone there is an exact agreement between the e.m.f. set up in the coil and the displacement of the diaphragm attached to the latter : an analogous result is obtained with the loud speaker. Simultaneous oscillograms confirm these statements.

A TACHOMETER-TYPE FREQUENCY METER FOR LOUD SPEAKER TESTING AND OTHER PURPOSES.—E. Thielmann : Dornig : Lenzola Company. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 13, 1932, pp. 204–205.)

The instrument embodies a small high-frequency generator driven by a motor and provided with a tachometer reading from zero to above 6 500 c/s (or if required, up to 20 000 c/s). The motor-generator is run up to speed and the motor switched off : it takes more than a minute to run down, during which time the performance of the loud speaker (excited from the generator) is compared with the tachometer dial readings. Fig. 3 gives specimen curves showing the progress since 1928 in obtaining loud speaker diaphragms with flat frequency characteristic. The 1931 curve "shows that the 'calyx radiator' of the Lenzola Loud Speaker Works is practically free from overtones."

The instrument can obviously also be used for determining resonance points in mechanical structures.

A DEVICE FOR RAPIDLY PLOTTING LOUD-SPEAKER RESPONSE CURVES.—F. H. Brittain. (*Journ. Scient. Instr.*, May, 1932, Vol. 9, pp. 169–170.)

Designed to correct for the departure from uniformity of the overall frequency response of the capacity microphone, amplifier, meter and associated circuits, and for those inaccuracies of the a.c. output meter which remain constant. A standard sheet of semi-logarithmic paper is used, with the logarithmic scale along the abscissae and a uniform scale of decibels as ordinates. The paper is held on a drawing board or (for a semi-automatic arrangement) on a drum coupled to the variable-frequency oscillator : in the latter case the frequency correcting base line would take the form of a cylindrical cam against which a roller end-fitting to the adjustable ruler scale is pressed.

LOUD SPEAKERS IN OPERA PRODUCTION.—R. Raven-Hart. (*Wireless World*, 25th May, 1932, Vol. 30, p. 547.)

A system is described which is in use in the Berlin City Opera House, whereby loud speakers are hidden in the wings and above the proscenium arch to give the effects of the "ghostly choruses" which appear in certain operatic works. Previously it was necessary for performers to be perched insecurely in the flies, but with this new system they can be accommodated in a special studio ; not only is this more convenient but the necessary effects are more realistically produced.

ÜBER EINE EICHMETHODE DES KONDENSATORMIKROPHONS MIT PERIODISCH VERÄNDLICHER ERSATZKAPAZITÄT (A Method of Calibrating the Condenser Microphone by the Use of a Periodically Varying Substitution Condenser).—W. Lange. (*Hochf:tech. u. Elek:akus.*, April, 1932, Vol. 39, pp. 133–136.)

The amplitude of the pressure changes is measured by the amplitude of the diaphragm vibrations : this amplitude is measured by the consequent changes of capacity between diaphragm and opposed electrode : finally the changes of capacity are measured (by the de-tuning they cause in an r.f. circuit induced into by an r.f. generator circuit) with the help of an oscillograph (directly calibrated in dynes/cm^2) and of a periodically varying condenser, the "modulation condenser," which can be connected in place of the microphone. This modulation condenser consists of two glass discs, each with 100 tinfoil sectors with intervals the same size as the sectors. One disc is rotated, and the capacity then varies approximately sinusoidally with a frequency a hundred times the speed of rotation. The amount of capacity change is a function of the air-gap, which is adjustable with a vernier scale. The total circuit capacity is kept constant, when microphone and modulation condenser are interchanged, by the adjustment of a variable condenser. The frequency of the modulation condenser variations is synchronised with the frequency of the sound exciting the microphone.

TECHNIQUE OF MICROPHONE CALIBRATION.—S. Ballantine. (*Journ. Acous. Soc. Am.*, No. 3, Vol. 3, 1932, pp. 319–360.)

A NEW METHOD OF BLOCKING OUT SPLICES IN SOUND FILM : THE SURFACE TREATMENT OF SOUND FILM : PHOTOGRAPHIC CHARACTERISTICS OF SOUND RECORDING FILM : THE MEASUREMENT OF DENSITY IN VARIABLE DENSITY SOUND FILM : APPARATUS FOR THE ANALYSIS OF PHOTOGRAPHIC SOUND RECORDS.—Crabtree, Ives, Sandvik, Jones, Tuttle, McFarlane. (*Kodak Publications* : summaries in *Physik. Ber.*, 15th April, 1932, Vol. 13, pp. 825–827.)

THE RAPID RECORD OSCILLOGRAPH IN SOUND PICTURE STUDIES.—Curtis, Shea and Rumpel. (*See* under "Subsidiary Apparatus and Materials.")

SOME OVERLOOKED OPPORTUNITIES FOR ELECTRICAL PHONOGRAPHS.—V. Karapetoff. (*Electronics*, April, 1932, p. 121.)

Based on a recent lecture and demonstration. The author urges manufacturers to make records of accompaniments, to which the gramophone owner could sing or play ; of vocal and instrumental solos, unaccompanied, so that the owner could accompany them on his own piano ; to provide an attachment whereby speed and volume could be regulated at a distance ; to improve home recording attachments, and to provide studios where an owner could have records made for his personal needs.

DAS STAHLBAND ALS SCHALLPLATTE (The Steel Band [Insulated and Wound into a Spiral] as Gramophone Disc).—F. Noack : Stille. (*Rad., B., F. f. Alle,* May, 1932, pp. 235–236.)

Short article on the latest development of the Stille steel band.

ELECTRONIC ORGAN, COUPLEUX-GIVELET SYSTEM, AT THE CHURCH OF VILLEMOMBLE, NEAR PARIS.—(*Génie Civil,* 5th March, 1932, Vol. 100, pp. 244–246.)

LA " SONDE PHONIQUE " POUR LA MESURE DES INTENSITÉS MÉCHANIQUES DES SONS (The " Phonic Tester " for the Measurement of the Mechanical Intensity of Sounds).—J. F. Cellerier. (*Comptes Rendus,* 21st March, 1932, Vol. 194, pp. 1067–1069.)

The equipment consists of a highly sensitive bi-cone microphone, a single triode between this and a variable attenuator, then a series of filters, an amplifier (two stages are shown in the diagram), a copper-oxide rectifier and finally a milliammeter. The procedure is that the attenuator is adjusted so that the milliammeter reading is always the same. Various applications are described, one being the determination of the vocal power of a singer and its variation at different notes. Another use is the investigation of the acoustic properties of an auditorium, the entire equipment consisting only of four light boxes so that it can easily be set up at different points of the room. The testing of sound-insulating materials is another important application.

ACOUSTICAL AND ELECTRICAL POWER REQUIREMENTS FOR ELECTRIC CARILLONS [AND THE USE OF THE SOUND MEASURING METER].—A. N. Curtiss and I. Wolff. (*Proc. Inst. Rad. Eng.,* April, 1932, Vol. 20, pp. 626–646.)

Authors' summary :—The importance is shown of making noise level measurements in order to determine the acoustical or electrical power necessary to blanket any given area with satisfactory music. Measurements were made on the bells of the Valley Forge carillon, over a wide area using a sound meter and a local variable noise-making machine. These data gave the necessary relations between noise level and satisfactory music and were used to calculate the acoustical and electrical power requirements. Two methods of making noise-level measurements particularly suitable for acoustical surveys of this kind are mentioned. With the measured and calculated data, curves have been drawn up which permit rapid calculation of the audio power requirements for any given noise level and for various coverages.

SOME ACOUSTIC AND TELEPHONE MEASUREMENTS.—H. R. Harbottle. (*Electrician,* 15th April, 1932, Vol. 108, p. 537.)

Short summary of I.E.E. paper.

A VOICE AND EAR FOR TELEPHONE MEASUREMENTS.—A. H. Inglis, C. H. G. Gray and R. T. Jenkins. (*Bell S. Tech. Journ.,* April, 1932, Vol. 11, No. 2, pp. 293–317.)

A SIMPLE HARMONIC ANALYSER.—Nicholson and Perkins. (*See* under " Subsidiary Apparatus and Materials.")

HEULTON-GENERATOREN (" Howl " Generators).—H. von Hartel. (*Funkmagazin,* Feb., 1932, Vol. 5, pp. 106–108.)

Description of two generators, one avoiding the use of a motor-driven rotating condenser by employing a spring-mounted condenser plate moved at mains frequency by an electromagnet, the other using the interrupted light-ray method.

GENERATOR OF ELECTRICAL OSCILLATIONS AT MUSICAL FREQUENCIES [MUSICAL HETERODYNE].—Soc. Franç. Rad:élec. (*Bull. S.F.R.,* Feb.–March, 1932, Vol. 6, pp. 36–39.)

SAITENOSZILLATOR (String Oscillator).—J. Zahradníček and Z. Žák. (*Ann. der Physik,* 1932, Series 5, Vol. 12, No. 6, pp. 662–664.)

A circuit, analogous to that used by Eccles and Jordan for a tuning fork (*Electrician,* 1919, Vol. 82, p. 704), is given for the continuous excitation of a steel wire in any harmonic.

PRECISION METHODS USED IN CONSTRUCTING ELECTRIC WAVE FILTERS FOR CARRIER SYSTEMS.—Harris. (*See* under " Subsidiary Apparatus and Materials.")

A TERMINOLOGY FOR ACOUSTICS : A SUGGESTION FOR A PROPER SYSTEM ANALOGOUS TO THAT OF OPTICS.—J. B. Pomey. (*Rev. Gén. de l'Élec.,* 26th March, 1932, Vol. 31, p. 402.)

ZUR THEORIE DES HÖRENS BEI DER SCHALLAUFNAHME DURCH KNOCHENLEITUNG (On the Theory of Hearing with Sound Received by Conduction through Bone).—G. v. Békésy (*Ann. der Physik,* 1932, Series 5, Vol. 13, No. 1, pp. 111–136.)

This paper discusses the connections and differences between hearing through the air and through the skull bones.

SOUND AND HEARING.—N. F. Cave-Brown-Cave. (Summary in *Sci. Abstracts, Sec. B,* April, 1932, Vol. 35, No. 412, p. 219.)

NOISE.—N. W. McLachlan. (*Wireless World,* 18th May, 1932, Vol. 30, pp. 514–516.)

Unmusical noises which may soothe, musical sounds which may irritate, noises that may reduce psychological activity to zero, together with the peculiarities of the human ear, are dealt with.

NOISE RECORDER FOR COMPARING STREET-CAR SOUNDS.—(*Electronics,* March, 1932, p. 99.)

SOUNDPROOF PARTITIONS [OF CINDER BLOCK AND CLAY TILE].—(*Bur. of Stds. Tech. News Bull.,* No. 176, 1931, p. 131.)

Echo Sounding for Aircraft and Ships: A Direct-Reading Chronograph for the Exact Measurement of Short Time Intervals.—Dubois and Laboureur. (*See abstract under "Subsidiary Apparatus and Materials."*)

Einige Beobachtungen an Schwingenden Rohren (Some Observations on Vibrating Tubes [and Their Use in Detecting and Measuring High Audio-Frequencies]).—H. Kröncke. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 13, 1932, pp. 196–198.)

Researches on the transverse vibrations of glass tubes, observed by means of sand inside them which marks the position of the nodes. Frequencies up to about 30 000 c/s were measured.

Die erzwungenen Schwingungen der Kreisplatten (The Forced Vibrations of a Circular Plate).—W. Flügge: Elsas. (*Ibid.*, pp. 199–204.)

Working with light discs excited by a central thread connected to a tuning fork, Elsas showed that an elastic disc can carry out forced vibrations at any frequency and that the resulting sound figures are continually changing from one to the other. The present paper deals mathematically with the problem and confirms Elsas' results. The ordinary Chladni figures are special cases of the more complex figures due to forced vibration.

The Mathematical Theory of Chladni Plates.—R. C. Colwell. (*Phys. Review*, 1st April, 1932, Series 2, Vol. 40, No. 1, p. 125.)

The Vibrations of a Circular Plate.—R. C. Colwell. (*Journ. Franklin Inst.*, April, 1932, Vol. 213, No. 4, pp. 373–380.)

Photographs are given of nodal systems of a circular plate predicted by theory and produced by the use of a triode oscillator; some of the pictures show nodal curves which are not accounted for by Kirchhoff's equation.

PHOTOTELEGRAPHY AND TELEVISION.

Some Principles governing the Design of Kerr Cells.—W. D. Wright. (*Proc. Physical Soc.*, 1st May, 1932, Vol. 44, Part 3, No. 243, pp. 325–335.)

From the Gramophone Company's laboratories. Author's abstract:—"The paper describes some principles that were employed in designing a Kerr cell for use in a television system. The volts/intensity characteristic of the cell is developed and the theory is extended to apply to the case when an optical bias is used. The chromatic effects obtained with high potentials are discussed and finally the treatment of the cell as an integral part of an optical system is given. It is shown that from this aspect the most efficient form of cell is one using shaped plates. The frequency-response is briefly discussed." The shaped plates referred to are designed to fit the cone of light used, so that the separation between the plates is at each point the narrowest that will still allow the cone to be transmitted. In the cells used, the ratio of the end diameters of the double-cone plates to the mid-point diameter is about 4 : 1, "and only one-half the biasing and modulating voltages were necessary compared to those required if parallel plates had been used." A calculation shows that little is to be gained by increasing this ratio.

The Electrostriction of Benzene.—M. Pauthenier and P. Delahaye. (*Comptes Rendus*, 25th April, 1932, Vol. 194, pp. 1465–1466.)

A New Crater-Tube Development. (*Television*, May, 1932, Vol. 5, No. 51, pp. 94–95.)

Description of a point-source lamp which is said to have a true "crater" source. The entire light available is concentrated to a point or "ball" which is largely *outside* the hole in the anode, with the ionised gas coming from the cathode within the tube, "a design method of both electrical and mechanical novelty." Both the type of gas used and the pressure must be controlled carefully. The hole in the cathode is about 0.07 inch in diameter and ¼ inch deep. The cathode may be made in whole or in part from one of the alkali metals, for the sake of lower striking potential. Beryllium and magnesium have the added advantage of cleaning up the gas impurities.

Sperrschicht-Photozellen (Stop-Layer Photoelectric Cells [Siemens and Halske Copper Oxide Cell and Its Use in Photometry]).—A. Dresler. (Summary in *E.T.Z.*, 7th April, 1932, Vol. 53, p. 342.)

After discussing the properties of the cell as regards practical photometry, the writer points out that if pointer instruments are to be employed the cell sometimes requires to be used in conjunction with an amplifier, of as simple a type as possible. Instead of valve methods he recommends his system of amplification depending on the simultaneous existence of the "external" and "internal" photo-effects: thanks to the latter, the resistance of the cell decreases with illumination, the change being particularly great for small values of illumination. If an auxiliary source of e.m.f. is connected in series with the cell and the measuring instrument, and the consequent repose current through the cell is compensated by a counter-e.m.f., then on illumination the balance is destroyed and a difference current flows, to which the true photoelectric current adds itself. The meter deflection depends on the strengths of the illumination and of the auxiliary current, which is kept not above 1 mA. Magnifications of from 5 to 20 can thus be reached: meter current and illumination are no longer proportional, the magnification factor being greater at low light intensities, so that values of 0.05 lux can thus be measured.

In the subsequent discussion, Bloch discusses the variation (from positive, through zero to negative) of the temperature coefficient of the cell with the total circuit resistance, and the consequent existence of an optimum resistance, for the instrument associated with the cell, at which the temperature coefficient vanishes. Reference is also made to a paper by H. Sell on "a mechanically controlled bolometer and its use as a quantitative d.c. amplifier [amplification factor up to about 10 000] and as a highly sensitive relay."

A MECHANICALLY CONTROLLED BOLOMETER AND ITS USE AS A QUANTITATIVE D.C. AMPLIFIER AND SENSITIVE RELAY.—H. Sell. (*See* end of preceding abstract.)

ON THE COMPOSITION OF THE OXIDE IN COPPER OXIDE RECTIFIERS AND PHOTOELECTRIC CELLS.—Dubar. (*See* under "Subsidiary Apparatus and Materials.")

A NEW INDUSTRIAL AMPLIFIER TUBE FOR PHOTO-TUBE CIRCUITS [WESTINGHOUSE RJ-550].—Sutherlin. (*See* under "Valves and Thermionics.")

RESISTANCE-CAPACITANCE COUPLED AMPLIFIER IN TELEVISION.—H. M. Lane. (*Proc. Inst. Rad. Eng.*, April, 1932, Vol. 20, pp. 722–733.)

A method is given of obtaining the transient or complete solution of the amplifier performance under the excitation of typical television signal impulses. The analysis shows that "the amplifier response to the unit impressed voltage is of an oscillatory nature. The amplifier performance will be good provided the duration of the first positive swing of its response to unit impressed voltage is long compared with the duration of the actual signal impulse. In general, the greater the time constant of the amplifier, the better. The indication is that the greater the scanning speed the better is the amplifier performance."

LA PARTICIPATION DES SAVANTS RUSSES AU DÉVELOPPEMENT DE LA TÉLÉVISION ÉLECTRIQUE (The Part Played by Russian Workers in the Development of Electrical Television).—B. L. Rosing. (*Rev. Gén. de l'Élec.*, 6th April, 1932, Vol. 31, pp. 507–515.)

French version of the Russian paper referred to in 1930 Abstracts, p. 577. Wolfke's modification of the Nipkow disc principle (1898): the writer's use of cathode rays for reception and polyhedric mirrors for transmission (1907 onwards): Boutch-Brouevitch and his multi-cell screen and commutator for transmitting (1922), with cathode-ray reception: Tscherníscheff's cathode-ray tube inventions (1924) including (Fig. 11) modulation of the spot intensity by a triode "relay" and (Fig. 12) the production of luminous discharges between a number of small metal cylinders, packed side by side but insulated from each other, and a screen, these discharges being produced by the charges due to the cathode ray; also a c.-r. transmitter with a special means of synchronisation between transmitting and receiving ray (end of Sec. 1, p. 511): and another modification of the Campbell-Swinton principle, by Grabovsky, Popoff and Piskounoff (1925) in which the photosensitive layer is no longer mosaic but continuous.

The paper next deals with the writer's improvements to his earlier system, using a rotating polyhedric mirror combined with a plane mirror with oscillating motion (Fig. 13) and a two-commutator method of synchronisation (Figs. 14 and 15); also his improvements to the c.-r. tube itself (Fig. 16), particularly the use of one pair of long deflecting plates running the whole length of the tube, and of an equally long concentrating coil: deflection in the second direction is produced by a solenoid at right angles to the tube axis. Reference is made to his method of obtaining high-tension d.c. (6 000 to 8 000 v) from 110 v a.c., by a battery of condensers and rotating contacts. His discovery of "ballistic photoelectric signalling," in which a photoelectric cell is used in an oscillating condition, is mentioned (1930 Abstracts, p. 515).

The last part of the paper deals with Russian *mechanical* methods, including Adamian's scheme for indirect transmission after recording the results of the scanning as curves on a photographic or other strip; Rtscheouloff's vibrating spring device (after Leblanc) and Kakourine's complete system (Fig. 18) using Nipkow discs. Gouroff's proposals, on the lines of the systems of Mihaly and Jenkins, are outlined, and finally the successful work of Termen is referred to.

TELEVISION IN AMERICA.—A. Dinsdale. (*Electrician*, 22nd April, 1932, Vol. 108, p. 572.)

Summary of paper read before the Television Society. Developments in cathode ray transmission and reception, and in increased size of image (particularly Sanabria) are mentioned. "The National Broadcasting Company propose building a television studio on the 85th floor of the Empire State Building, with a short-wave transmitting aerial on the top of the airship mooring mast, 1 250 ft. above the street."

NOUVEAU PROCÉDÉ D'ÉTUDE ET DE RÉGLAGE D'UNE TRANSMISSION DE TÉLÉVISION (A New Method of Studying and Regulating a Television Transmission).—M. Robert. (*Comptes Rendus*, 14th March, 1932, Vol. 194, pp. 965–967.)

Assuming a stationary object to be scanned with a picture frequency of 12 p.s., the luminous flux ϕ received by the photoelectric cell may be represented by a function of period 1/12 sec. For the transmission to be correct, it is sufficient that at each instant the luminous intensity of the neon lamp at the receiver should be proportional to ϕ. ϕ may be considered as the sum of a flux with sinusoidal variation as a function of time, of frequency $F = 12$ and various harmonic frequencies lying between $F = 12$ and the limiting frequency F_1 corresponding to the smallest transmissible detail.

Since it is assumed that the system works on the straight-line parts of the various characteristics, a sinusoidal flux variation at the start will give a sinusoidal variation of the luminous intensity of the neon lamp at arrival. Thus good reception will be obtained if the fundamental frequency and each of the harmonics are reproduced with amplitudes proportional to those which they have in the transmitter, and with constant delay times.

The writer's method of testing these points is to place in front of the scanner (assuming this to scan vertically) a paper the size of the maximum transmissible subject, with a photographic density constant in the horizontal direction but varying along an ordinate with a sinusoidal variation $\delta = \delta_0 \sin 2\pi\lambda \frac{d}{D}$, where D is the total vertical dimension, d the distance from the top, and λ a whole number constant. The photoelectric cell will then receive a sinusoidal flux of frequency $F = \lambda n N$, where N is the number of scanning sweeps and n the number of rotations per sec. of the rotating system (generally 12). A special arrangement, not described, at the receiving end is used to measure the amplitude E, that is, the difference of illumination between the brightest and darkest horizontal strips. The first paper is then replaced in succession by others for which $\lambda = \lambda_1, \lambda_2, \ldots \lambda_n$, all with densities of the same amplitude; the corresponding amplitudes $E_1, E_2, \ldots E_n$ are thus measured, and from these it is possible to trace the curve of amplitudes E as a function of λ (*i.e.*, as a function of the frequencies F) showing the overall functioning of the transmission. The frequencies which are partially arrested or exaggerated can be detected at once, and correcting devices applied and adjusted. The writer has in this way been able to carry out satisfactory television over a 10 km ordinary telephone line.

New Television System.—Von Ardenne. (*Wireless World*, 25th May, 1932, Vol. 30, p. 539.)

Brief details are given of experimental work carried out by von Ardenne during the past year on lines parallel to Thun's suggestions for scanning at a speed inversely proportional to the brightness of the part scanned (January Abstracts, p. 44). "Von Ardenne has overcome the various difficulties so successfully that he can already transmit and receive 10 000 element pictures by this system. The need for very rapid and accurate variations in the vast speeds of travel involved in television calls for the use of a cathode ray at the transmitter as well as at the receiver."

The Frequencies in Television Signals [The Failure of the "Dot" Theory, etc.].—E. G. Bowen. (*Television*, May, 1932, Vol. 5, No. 51, pp. 104–106.)

The Depth of Origin of Photoelectrons.—H. E. Ives and H. B. Briggs. (*Phys. Review*, 1st April, 1932, Series 2, Vol. 40, No. 1, p. 121.)

Abstract only of a continuation of work (Feb. Abstracts, p. 102) on the photoelectrons from a silver plate covered with an equilibrium film of alkali metal. The majority of photoelectrons are found to originate under all conditions in the alkali metal films.

A More Rigid Proof of the Photoelectric Law.—N. R. Campbell. (Summary in *Sci. Abstracts, Sec. A*, April, 1932, Vol. 34, No. 412, p. 352.)

MEASUREMENTS AND STANDARDS.

Die Temperaturabhängigkeit von Messgeräten mit Trockengleichrichtern und ihre Kompensation (The Variation with Temperature of Meters with Dry-Plate Rectifiers, and Its Compensation).—H. Kaden. (*Hochf:tech. u. Elek:akus.*, April, 1932, Vol. 39, pp. 115–122.)

For a previous paper on these meters and their use in audio-frequency work, *see* Jan. Abstracts, p. 41. From the author's summary:—"The analytical representation of the temperature-dependent static characteristic of the rectifier is derived from experimental measurements, and it is seen from this that the dry-plate rectifier can be adequately specified by three constants, namely, the a.c. resistance, the 'rectifying constant' [*richtkonstante*, involving the factor of merit which is the ratio of the pass- to the stop-currents, for equal potentials in the two directions] and the resistance temperature coefficient.

"With the help of the 'controlled substitution potential source' [described] it is easy to derive, from the characteristic, the temperature variation of the rectified current with change of a.c. voltage or current. By the correct dimensioning of a series resistance [for voltage-measuring instruments] or a parallel resistance [for current-measuring instruments], these instruments can be rendered practically independent of temperature within a range of ±10°C." The calculation of the compensating resistance is simple, for of the three rectifier constants only the a.c. resistance is involved. Instruments which have to work with an input stage of amplification, and which therefore require checking before each measurement, demand a special treatment which is described in the final section.

Application of the Electrometer Triode to the Measurement of High Resistance.—J. A. C. Teegan and N. Hayes. (*Nature*, 2nd April, 1932, Vol. 129, p. 508.)

Some Observations on Vibrating Tubes [and Their Use in Detecting and Measuring High Audio-Frequencies].—Kröncke. (*See* under "Acoustics and Audio-Frequencies.")

The Forced Vibrations of a Circular Plate.—W. Flügge. (*Ibid.*)

Valve Ammeter for Small Alternating Currents from 25 to 6 × 10⁶ Cycles/Second.—Messrs. Tinsley: Barlow. (*Engineering*, 22nd Jan., 1932, Vol. 133, p. 101.)

In which the current to be measured passes through the already partly heated filament of a diode.

SUBSIDIARY APPARATUS AND MATERIALS.

Sur un Chronographe Électrique à Lecture directe permettant la Mesure précise d'Intervalles de Temps très courts (A Direct-Reading Electric Chronograph for the Exact Measurement of Very Short Intervals of Time [Condenser-Charging Principle using an "Electrometer" Valve and a Neon Lamp as Relay: Application to Echo Sounding for Aircraft and Ships]).—R. Dubois and L. Laboureur. (*Comptes Rendus*, 9th May, 1932, Vol. 194, pp. 1639–1641.)

A Simple Harmonic Analyser.—M. G. Nicholson and W. M. Perkins. (*Proc. Inst. Rad. Eng.*, April, 1932, Vol. 20, pp. 734–739.)

A central-zero dynamometer type meter has the leads from its moving and stationary coils brought out separately and connected so that the current to be analysed flows through the stationary coil. The moving coil goes to a variable-frequency audio-oscillator. When this oscillator is adjusted to within one-tenth c/s of the frequency of the component being measured, the pointer of the meter will oscillate at a frequency equal to the difference of the two frequencies. Readings of the swing to left and right are averaged to give the value of the current. The paper enumerates the disadvantages of other methods and the advantages of this device, particularly in analysing valve hum voltages and in measuring the harmonic content of the output of amplifiers and valves.

ZUSAMMENARBEIT VON ELEKTRONEN- UND MAGNETISCHEN RELAIS (The Combined Working of Valve- and Magnetic Relays).—H. Strohmeyer. (*Hochf:tech. u. Elek:akus.*, April, 1932, Vol. 39, pp. 122–127.)

The combined working of thermionic and magnetic relays is examined theoretically and experimentally. It is shown that by the use of a valve stage with the magnetic relay in its anode circuit it is possible to control both the make- and break-times so that both are either greater or less than they would be in the equivalent, valve-less, resistance circuit (by "equivalent" is meant that in both cases, for the same voltage, the final currents and consequently the sureness of contact are the same). To obtain the smallest possible delay times, the valve should have a high internal resistance; also a small penetration coefficient ($1/\mu$), in order that the necessary grid voltages—positive for "make" and negative for "break"—may be kept small.

GASFILLED RELAYS. PART I.—THEORY AND DESIGN.—S. K. Lewer and C. R. Dunham. (*G.E.C. Journal*, May, 1932, Vol. 3, No. 2, pp. 67–75.)

INVESTIGATIONS ON GOLD ALLOYS FOR CONTACTS.—Benedicks and Härdén. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 13, 1932, pp. 111–117.)

Continuation of the paper referred to in May Abstracts, p. 295.

PRECISION METHODS USED IN CONSTRUCTING ELECTRIC WAVE FILTERS FOR CARRIER SYSTEMS.—G. R. Harris. (*Bell S. Tech. Journ.*, April, 1932, Vol. 11, No. 2, pp. 264–282.)

This paper describes the requirements which were met in the design of wave filters for a carrier telephone system and a new manufacturing adjustment (consisting essentially of an inductance continuously variable over a small range above and below its nominal value) designed for these requirements.

KATHODENOSZILLOGRAPH UND LEUCHTMASSE (The Cathode-Ray Oscillograph and Fluorescent Materials).—A. Schloemer. (*Zeitschr. f. tech. Phys.*, No. 5, 1932, Vol. 13, pp. 243–244.)

The opinion already expressed (Rogowski and Rühlemann, 1931 Abstracts, p. 336), that the best commercially procurable fluorescent materials can hardly be improved upon, is now supported by the results of a systematic investigation. The tests were successful in so far that they led to the development of a material which gave a somewhat improved result for voltages between 300 and 1 000 v; at high voltages, however, it had only the advantage of a shorter after-glow than that shown by the Buchler Company's zinc sulphide material with which it was compared.

When it is remembered that a good incandescent lamp gives only 20 lumens per watt, and that outputs of 35 lumens per watt have already been obtained from this Buchler screen, it seems improbable that the zinc sulphide materials will be greatly improved on, though theoretically their efficiency might perhaps be doubled. But if silicate or oxide substances could be made equally efficient (references are given to papers on this) they would be preferable on account of being less affected by heat. Analysis of a "burnt" ZnS–Cu screen shows that some of the zinc sulphide molecules had been destroyed and that the molecular ratio Zn : S had been reduced from 1 : 1 to 1 : 0.96. The writer recommends water-glass as the adhesive—possibly, for better leakage of the electrons, with an addition of conducting dust (zinc or graphite). The grain size has no effect on the brightness, but the after-glow lasts longer with the larger grains, so that for rapid photographic recording the smaller grain size is recommended.

A simple photographic method of comparing the brightness of several materials is described, and a specimen record shows a comparison (left to right) between zinc sulphide (Buchler), calcium tungstate (writer's make), magnesium tungstate (ditto), zinc sulphide (Merz and Benteli) and zinc sulphide (writer's make), the potential being 60 kv.

EINE NEUE ART ZEITPROPORTIONALER KATHODENSTRAHLABLENKUNG (A New Type of Time Base for the Cathode-Ray Oscillograph [for Frequencies up to 10^7 Cycles/Sec. and Over]).—G. Ulbricht. (*Hochf:tech. u. Elek:akus.*, April, 1932, Vol. 39, pp. 130–133.)

The V_g/I_a characteristic of a two-grid valve in screen-grid connection shows a point of discontinuity where the anode potential, owing to the voltage drop i_aR_a, becomes less than the screen-grid potential, with the result that secondary emission occurs. If, after the sudden increase in anode current, the grid voltage is decreased, the curve follows a normal course for a short length and then shows a second vertical "jump," this time downwards to the original curve. The circuit, in fact, acts like a dynatron circuit except that in place of the grid potential of that circuit must be taken the value $V_g + D_{sg}V_{sg}$, where D_{sg} is the penetration coefficient ("durchgriff") of the screen grid with regard to the control grid.

The second "jump" can be almost suppressed by connecting the control grid not to the cathode, as before, but to a tapping point on the anode circuit resistance. Then, after the first "jump," a decrease in grid voltage produces a steady decrease of anode current, *the curve running a sloping straight-line course almost down to the original curve*. In a specimen case the period of the whole "trip" process was of the order of 10^{-7} sec. only, so that the circuit could be used to provide a linear time base for frequencies of 10^7 c/s. The valve in this case had a screen-grid/anode capacity (including leads) of 15 cms. If this could be reduced to 1.5 cms, a frequency of 10^8 c/s could be dealt with.

The circuit may be compared with that given by Hollmann and Schultes (Feb. Abstracts, p. 99) in which, however, the second grid was used in a space-charge connection.

BEITRAG ZUR GEOMETRISCHEN ELEKTRONENOPTIK: I AND II (Contribution to the Geometrical Optics of Electron Beams: I and II).—M. Knoll and E. Ruska. (*Ann. der Physik*, 1932, Series 5, Vol. 12, Nos. 5 and 6, pp. 607–640 and 641–661.)

A paper discussing the effect of a stop, of a magnetic focusing coil, of an electric field, and of combinations of these, in producing a clear-cut image on a screen of the source from which an electron beam is emitted. The analogies between the effect of these magnetic and electric "lenses" on an electron beam and the laws of geometrical optics are demonstrated experimentally.

EIN ABGESCHMOLZENER KATHODENOSZILLOGRAPH HOHER LEISTUNG (A Sealed-Off Cathode-Ray Oscillograph of High Efficiency).—K. Szeghö. (*Archiv f. Elektrot.*, 21st April, 1932, Vol. 26, pp. 291–300.)

Further details of the oscillograph dealt with in 1931 Abstracts, p. 511. Specimen external records are given, including one of oscillations of large amplitude at 10 megacycles/sec. The life has already exceeded 1 000 hours (intermittent use).

CATHODE-RAY OSCILLOGRAPHS.—W. Rogowski. (Summary in *Sci. Abstracts, Sec. B*, Feb., 1932, Vol. 35, No. 410, p. 64.)

"Refinements in cathode ray oscillograph technique are described by which traces of transients, oscillations up to 10^8 hertz, are clearly recorded. Records are reproduced in which the speed of tracing rises to 63 000 km/sec."

DER PIEZOELEKTRISCHE OSZILLOGRAPH (The Piezoelectric Oscillograph [Sensitivity of 200 v/mm and Frequency Range up to 7 500 Cycles/Sec.]).—W. von Philippoff. (*E.T.Z.*, 28th April, 1932, Vol. 53, pp. 405–408.)

THE RAPID RECORD OSCILLOGRAPH IN SOUND PICTURE STUDIES.—A. M. Curtis, T. E. Shea and C. H. Rumpel. (*Journ. Soc. Motion Picture Engineers*, Jan., 1932, Vol. 18, pp. 39–53: *Bell Tel. System Tech. Pub.*, B-644, 15 pp.)

Cf. 1931 Abstracts, p. 625. Authors' summary:—This paper describes a special oscillograph which was designed for making rapid records in sound picture studies. The oscillograph is briefly described and illustrations are presented of records obtained in making the following studies: microphonic action of vacuum tubes; noise levels in amplifiers; investigations on rectifiers; studies on light-valve clash; action of the biasing current of light valves as used in noiseless recording by the variable density method; acoustical studies showing the rise and decay of transients; loud speaker selection with regard to load carrying capacity, and mechanical flutter investigations of reproducer sets.

SCREENS FOR RAISING THE BREAK-DOWN VOLTAGE IN AIR.—H. Roser. (*E.T.Z.*, 28th April, 1932, Vol. 53, pp. 411–412.)

A VACUUM MAKE-AND-BREAK DEVICE FOR POTENTIALS UP TO 65 KV.—G. Vaudet. (*Comptes Rendus*, 9th May, 1932, Vol. 194, pp. 1637–1639.)

DIE ÖLDIFFUSIONSLUFTPUMPE (The Diffusion Air Pump using Oil [with Low Vapour Pressure: a New Design giving Fractional Distillation during the Working of the Pump Itself, by Adjustment of the Three Water Jackets]).—W. Gaede. (*Zeitschr. f. tech. Phys.*, No. 5, 1932, Vol. 13, pp. 210–212.)

A VALVE FOR THE INTRODUCTION OF SMALL QUANTITIES OF GAS [CAPILLARY TUBE CLOSED BY RUBBER PAD ON BIMETALLIC STRIP, ELECTRICALLY HEATED].—K. Becker and M. Pirani. (*Zeitschr. f. tech. Phys.*, No. 5, 1932, Vol. 13, pp. 216–218.)

THE PROBLEM OF MOTION PICTURE PROJECTION FROM CONTINUOUSLY MOVING FILM.—F. Tuttle and C. D. Reid. (*Journ. Opt. Soc. Am.*, Feb., 1932, Vol. 22, pp. 39–64.)

DIE SCHWÄRZUNG PHOTOGRAPHISCHER SCHICHTEN BEIM KATHODENOSZILLOGRAPHEN (The Blackening of Photographic Films in the Cathode Ray Oscillograph—Remark on the Paper by W. Rogowski, E. Flegler and P. Rosenlöcher).—M. Knoll: W. Rogowski. (*Archiv f. Elektrot.*, 23rd Feb. and 22nd March, 1932, Vol. 26, Nos. 2 & 3, pp. 132, 133–134, and 214.)

On the paper dealt with in 1930 Abstracts, p. 113.

PHOTOGRAPHIC PLATES FOR USE IN SPECTROSCOPY AND ASTRONOMY.—C. E. K. Mees. (*Journ. Opt. Soc. Am.*, April, 1932, Vol. 22, pp. 204–206.)

Continuation of the work referred to in April Abstracts, p. 238.

KATHODENOSZILLOGRAPHISCHE METHODEN ZUR MESSUNG VON WIDERSTANDSÄNDERUNGEN BEI KURZEN SPANNUNGSSTÖSSEN. UNTERSUCHUNG FESTER HALBLEITER (Cathode Ray Oscillograph Methods for Measuring Resistance Changes during Short Voltage Impulses. Investigation of Solid Semi-Conductors).—W. Fucks. (*Archiv f. Elektrot.*, 22nd March, 1932, Vol. 26, No. 3, pp. 183–192.)

Further development of the work dealt with in May Abstracts, p. 295.

DÄMPFUNG EINER STOSSWELLE AUF EINEM KABEL (Attenuation of a Surge along a Cable).—W. Fucks. (*Archiv f. Elektrot.*, 23rd Feb., 1932, Vol. 26, No. 2, pp. 118–120.)

A METHOD OF INTERPRETING STATIC FREQUENCY-OR DISTRIBUTION-CURVES.—H. C. Plaut. (*E.T.Z.*, 4th Feb., 1932, Vol. 53, p. 111.)

Summary of the paper referred to in 1929 Abstracts, p. 398. The interpretation of such curves, as regards discrepancies which might be due to real causes or to insufficiency in the number of samples, is helped by the Bernouillian theorem which, put roughly, says that if there are z samples in the width of one graduation, discrepancies of an average value of $\pm \sqrt{z}$ are to be expected.

THE ADVANTAGES AND DISADVANTAGES OF THE VARIOUS METHODS OF CONNECTING-UP A NUMBER OF RECTIFIERS: AND A SUGGESTED NOMENCLATURE.—J. G. W. Mulder. (*Tijdschr. Nederland. Radiogenoot.*, March, 1932, Vol. 5, No. 4, pp. 99–123.)

THE ECONOMICAL DESIGN OF SMOOTHING FILTERS.—F. S. Dellenbaugh, Jr., and R. S. Quimby. (*QST*, April, 1932, Vol. 16, pp. 33–40 and 88, 90.)

Continuation of the work dealt with in June Abstracts, p. 358.

A METHOD OF ELIMINATING PULSATIONS IN THE TERMINAL VOLTAGE OF MERCURY ARC RECTIFIERS [USE OF A SPECIAL SINGLE-PHASE THREE-WINDING COMPENSATING TRANSFORMER].—K. Ohsumi. (Long English summary in *Journ. I.E.E. Japan*, No. 7, Vol. 51, pp. 61–63.)

THE USE OF THE NEW HIGH-VOLTAGE RECTIFIER VALVES ON 220 VOLT MAINS.—(*Rad., B., F. f. Alle*, May, 1932, pp. 210–212.)

NEW INVESTIGATIONS OF THE ELECTROLYTIC VALVE ACTION. III. THE DIELECTRIC CONSTANT OF THE Al_2O_3 ATTENUATING LAYER. IV. THE CURRENT MECHANISM IN THE ATTENUATING LAYERS OF THE VALVE METALS. *Also* COLD TEMPERATURE PHOSPHORESCENCE [OF ELECTROLYTIC VALVES DURING THEIR FORMATION].—A. Güntherschulze and H. Betz. (*Zeitschr. f. Phys.*, No. 9/10, Vol. 74, 1932, pp. 580–585, 586–601 and 681–691.)

THE DIELECTRIC CONSTANTS OF A NUMBER OF OXIDES (in particular Al_2O_3).—Güntherschulze and Keller. (*Ibid.*, No. 1/2, Vol. 75, 1932, pp. 78–83.)

ON THE CHEMICAL NATURE OF THE OXIDE LAYERS WHICH FORM ON THE METALS AL, ZR, TI AND TA WITH ANODIC POLARISATION.—W. G. Burgers, A. Claassen and J. Zernike. (*Zeitschr. f. Phys.*, 1932, Vol. 74, No. 9/10, pp. 593–603.)

DER SELENGLEICHRICHTER (The Selenium Rectifier [A Survey]).—E. Presser. (*E.T.Z.*, 7th April, 1932, Vol. 53, pp. 339–341.)

ON THE COMPOSITION OF THE OXIDE IN COPPER OXIDE RECTIFIERS AND PHOTOELECTRIC CELLS.—L. Dubar. (*Comptes Rendus*, 18th April, 1932, Vol. 194, pp. 1332–1334.)

Continuation of the work dealt with in 1931 Abstracts, p. 280. Here it was shown that the moderately conducting cuprous oxide could acquire a considerable resistivity after prolonged heating in a closed vessel. Intermediate resistivities could be obtained. The writer gives to the two extremes the names "conducting" and "semi-insulating" oxides. The former, in which the internal photoelectric effect is masked by the high permanent conductivity, constitutes the outer layer of rectifiers. The latter, which shows a large relative conductivity variation on illumination, probably forms the hypothetical thin film (the "stop layer") situated immediately next to the copper in rectifiers and cells.

The present Note gives the results of numerous tests to determine the constitution of these oxides and to establish the causes of their different properties. These tests include chemical, microscopic and X-ray analysis, electrolytic deposition, and the measuring of the resistance of individual crystals and of compressed powders. Three of these methods suggest that the Cu_2O may be completely insulating and that the hypothetical substance which causes the conductivity is disseminated in very small quantities. There is no information as to the nature of this substance, which seems likely to consists of excess oxygen, perhaps in the form of CuO. The electrolytic deposition test suggests that the conductive material forms a network in the gaps between the crystals, but the last two methods enumerated throw doubt on this by indicating that the high conductivity exists in grains of "conducting" oxide a few microns in size. Microscopic analysis shows that the opaque crystals observed in the "conducting" oxide but absent in the "semi-insulating" oxide are of such dimensions and spacing as to prevent them from being the cause of increased conductivity. The hypothetical material can only be present in the form of a solid, or possibly colloidal, solution.

ÜBER DIE NATUR DER SPERRSCHICHT BEI KUPFEROXYDULGLEICHRICHTERN (On the Nature of the Attenuating Layer in Copper Oxide Rectifiers).—F. Waibel and W. Schottky. (*Naturwiss.*, 22nd April, 1932, Vol. 20, No. 17, pp. 297–298.)

Seeking the explanation of the attenuating and rectifying layers in copper oxide rectifiers in the particular chemical nature of the copper oxide layer next to the metal, the writers have obtained direct experimental evidence of a material layer of very high resistance in bombarded "Vorderwandzellen" (anterior wall cells—1930 Abstracts, p. 636); its thickness and the variation of its properties with penetration depth have been determined.

RECTIFIER EFFECT AND HETEROGENEOUS CATALYSIS IN COPPER-CUPROUS OXIDE SYSTEMS.—Wo. Ostwald and H. Erbring. (Summary in *Sci. Abstracts, Sec. A*, April, 1932, Vol. 35, No. 412, p. 370.)

"The earlier qualitative experiments [1930 Abstracts, p. 638] between the catalytic and rectifier effects of the Cu_2O-Cu system (on the oxidation of *p*-phenylenediamine) are now quantitatively substantiated. Good rectifier plates give, in general, larger amounts of aniline black and quinhydrone than bad plates. The rectifier and catalytic effects of the Cu_2O-Cu plate disappear by oxidation and reduction. The so-called stop-layer-free plates give positive catalytic effects and possess a positive rectifier effect when in conjunction with a pressed steel electrode. The recent experiments of Schottky, Störmer and Waibel are discussed with respect to the rôle of the external oxide layer, which appears to be the origin of the rectifier and catalytic effects."

ZUR THEORIE DER DETEKTORWIRKUNG (On the Theory of Detector Action).—L. Nordheim. (*Zeitschr. f. Phys.*, 1932, Vol. 75, No. 7/8, pp. 434–441.)

Author's abstract :—The picture of a semi-conductor given by quantum mechanics, together with simple assumptions as to the nature of the transition layer, gives a mechanism explaining the rectifying effect of the contact between a metal and a semi-conductor. The mechanism gives the correct order of magnitude and temperature variation of the effect, and plausible inferences as to the boundary layer are deduced.

DIFFRACTION OF ELECTRONS BY THIN FILMS OF NICKEL AND COPPER OXIDES.—Darbyshire. (*See* under " General Physical Articles.")

A NEW IODINE ACCUMULATOR.—F. Boissier. (*Comptes Rendus*, 21st March, 1932, Vol. 194, pp. 1069–1072.)

An accumulator resembling in appearance a cylindrical dry cell : a central rod of carbon acts as positive electrode, surrounded by an agglomerate of powdered carbon (or a special very porous material) contained in a cellulose envelope which acts as a porous diaphragm. The whole is surrounded by a zinc container forming the negative electrode. The neutral electrolyte (iodide of zinc) is entirely immobilised in the agglomerate and the envelope. The reaction $ZnI_2 \rightarrow Zn + 2I$ is completely reversible, and is not limited in time by any secondary reactions. There is no disengagement of gas. On charge, the voltage rises almost at once to 1.2 v and remains there during the whole charging. On discharge, the voltage falls very gradually from between 1.1 and 1.2 v to 1 v at almost complete discharge. Efficiency is between 70 and 80 %. " On open circuit there is a very slow formation of iodide of zinc, leading to a loss in capacity ; but this loss is negligible in most applications."

DEVELOPMENT OF B-BATTERY DEVICES FOR AUTO-RADIO.—(*Electronics*, March, 1932, pp. 80–81.)

THE " ISOVOLT " VOLTAGE REGULATOR.—H. André. (*Rev. Gén. de l'Élec.*, 2nd April, 1932, Vol. 31, pp. 466–467.)

A regulating transformer in conjunction with a condenser in series with the primary winding, with an efficiency of 85% for 1 kw and of 75% for 40 w. The small units, designed chiefly for mains receivers, have the added advantage of arresting high-frequency disturbances carried along the mains. The capacity between windings and magnetic circuit is reduced to a minimum by suitable spacing.

A THYRATRON VOLTAGE REGULATOR.—C. E. Weinland. (*Electronics*, April, 1932, pp. 132–133 and 150.)

As applied to a 12.5 kVA 60-cycle 220-volt generator.

MICA CONDENSERS IN HIGH-FREQUENCY CIRCUITS.—I. G. Maloff. (*Proc. Inst. Rad. Eng.*, April, 1932, Vol. 20, pp. 647–656.)

Author's summary :—Mica condensers have a variety of uses in high-frequency circuits. They are called upon to store electrical energy, block direct current, by-pass high-frequency current, etc. Each of these functions is discussed in detail. Conventional construction of mica condensers is described. A method of arriving at satisfactory ratings is shown. The following examples are worked out : 1. Calculation of requirements for tank condenser bank. 2. Calculation of rating of a given condenser. 3. Calculation and choice of a proper bank of condensers for a tank circuit with 100 per cent modulation.

TESTS ON JAPANESE STANDARD MICA CONDENSERS.—K. Yamaguchi and S. Inoue. (*Electrot. Lab. Tokyo*, Circular No. 81, 1931, 16 pp.)

METHODS OF TESTING CHARACTERISTICS OF ELECTROLYTIC CONDENSERS.—W. W. Garstang. (*Rad. Engineering*, March, 1932, Vol. 12, pp. 24–25.)

ELECTROLYTIC VARIABLE CONDENSERS.—W. W. Garstang. (*Radio Craft*, March, 1932, Vol. 3, p. 531.)

EQUIVALENT CIRCUITS OF IMPERFECT CONDENSERS.—C. L. Dawes and W. M Goodhue. (Summary in *Physik. Ber.*, 15th April, 1932, Vol. 13, p. 799.)

A PRECISION POTENTIOMETER OF IMPROVED DESIGN [LOW-RESISTANCE TYPE WITHOUT SLIDE-WIRE, EFFECT OF CONTACT RESISTANCE NEGLIGIBLE].—F. C. Bobier and L. O'Bryan. (*Gen. Elec. Review*, March, 1932, Vol. 35, pp. 185–187.)

THE DESIGN OF LIQUID RESISTANCES, TAKING INTO ACCOUNT THE WEHNELT EFFECT.—G. Becker. (*Elektrot. u. Masch:bau*, 3rd April, 1932, Vol. 50, pp. 213–217.)

ELECTRIC COIL TURN-COUNTER.—B. M. Smith, (*Gen. Elec. Review*, April, 1932, Vol. 35. pp. 236–237.)

Based on the d.c. reversal-null deflection method.

INTERMEDIATE FREQUENCY TRANSFORMERS—COST *versus* QUALITY.—C. C. Henry and R. E. Stemm. (*Electronics*, March, 1932, p. 97.)

APPARATUS FOR AUTOMATICALLY RECORDING THE RATE OF VARIATION OF A SLOWLY VARYING PHYSICAL QUANTITY.—G. Aprile. (*L'Elettrotec.*, 25th April, 1932, Vol. 19, pp. 322–323.)

SAVING INSTRUMENT LOSSES BY PROPER FUSE PROTECTION [OSCILLOGRAPHIC INVESTIGATION; QUICK-ACTING "LITTELFUSES"].—E. V. Sundt: Kollath. (*Rad. Engineering*, April, 1932, Vol. 12, pp. 20 and 37.)

STATIONS, DESIGN AND OPERATION.

THE NEW HIGH POWER BROADCAST STATION AT BEROMUNSTER, CANTON LUCERNE.—H. A. Ewen. (*Marconi Review*, March-April, 1932, No. 35, pp. 1–14.)

Capable of putting unmodulated energy of 60 kw into the aerial system and of transmitting on any wave between 300 and 600 metres, with deep modulation (up to 75%) free from distortion between 30 and 10 000 c/s. The carrier frequency is kept constant by a Marconi valve master oscillator with its massive tuning coils and condensers in a heat-insulated chamber thermostatically controlled: the oscillator works at half the carrier frequency and is supplied from storage batteries. The valve water-cooling equipment uses a closed circulating system, which enables pure water of high electrical resistance to be employed: air-pressure water-feed tanks obviate the need for overhead tanks and enable the whole cooling plant to be placed in the basement—simplifying the problem of preventing freezing during the winter. Brown-Boveri rectifiers are used for the power supply, the total power required being about 260 kw.

A NEW BROADCASTING STATION IN SWITZERLAND.—(*Engineer*, 22nd April, 1932, Vol. 153, p. 439.)

Paragraph giving details of a Marconi 15-kw transmitter to be erected at Monte Ceneri as the "regional" station for Italian-speaking Switzerland.

NEW BROADCASTING STATION ("PARISIAN STATION") OF THE COMPAGNIE GÉNÉRALE D'ÉNERGIE RADIOÉLECTRIQUE.—(*Bull. de la S.F.R.*, April, 1932, Vol. 6, No. 3, pp. 50–60.)

MULTIPLEX TRANSMISSION AND SECRET RADIOTELEPHONY.—Chireix: Villem. (*See* under "Transmission.")

EMPIRICAL STANDARDS [OF RECEPTION, INTERFERENCE AND SERVICE AREA] FOR BROADCAST ALLOCATION.—A. D. Ring. (*Proc. Inst. Rad. Eng.*, April, 1932, Vol. 20, pp. 611–625.)

Author's summary:—The method used by the Engineering Division of the Federal Radio Commission in determining empirical standards of reception, interference, and service area is explained, for consideration in connection with the engineering aspects of the allocation of radio broadcast facilities. The average good service areas of 100-watt local channel stations, 250- to 1 000-watt regional channel stations, 5 000- to 10 000-watt high power regional channel stations, and 5 000- to 50 000-watt clear channel stations are defined with reference to the voltage intensity ratio of the desired signal to the undesired signal incidental to specified mileage and kilocycle separations between stations. It is pointed out that the empirical standards will be changed when justified by additional data and further development of the art along the lines of suppression of sky-wave radiation, synchronisation, improvements in reception conditions, etc. Various tables and graphs are included.

DISTANCE RANGES OF RADIO WAVES.—Dellinger. (*See* under "Propagation of Waves.")

BROADCASTING DISTRIBUTION AND THE ELECTRIC LIGHT NETWORK.—Philips Company. (*Rad., B., F. f. Alle*, April, 1932, pp. 147–148.)

More editorial comments on the subject referred to in June Abstracts, p. 360. Results appear to have been successful.

GENERAL PHYSICAL ARTICLES.

DIFFRACTION OF ELECTRONS BY THIN FILMS OF NICKEL AND COPPER OXIDES.—J. A. Darbyshire. (Summary in *Sci. Abstracts, Sec. A*, April, 1932, Vol. 35, No. 412, p. 348.)

Showing, *inter alia*, that the oxide film formed by heating copper in a flame is the cubic cu_2o.

THE EXTENSION OF PASCHEN'S LAW TO INCLUDE THE ELECTRODELESS GLOW DISCHARGE.—O. Stuhlmann, Jr. (*Journ. Franklin Inst.*, March, 1932, Vol. 213, No. 3, pp. 273–282.)

DIE ELEKTRODENLOSE ENTLADUNG NACH MESSUNG MIT DEM KATHODENOSZILLOGRAPHEN (The Electrodeless Discharge as Measured by the Cathode-Ray Oscillograph [Number of Initiating Electrons, etc.]).—K. Buss. (*Archiv f. Elektrot.*, 21st April, 1932, Vol. 26, pp. 261–265.)

PAPERS ON THE ELECTRODELESS DISCHARGE.—Tykociner: Kunz. (*See* abstracts under "Propagation of Waves.")

DER STUFENDURCHSCHLAG (The Step-by-Step Discharge [and Krug's Denial]).—K. Buss: Rogowski. (*Archiv f. Elektrot.*, 21st April, 1932, Vol. 26, pp. 266–272.)

See also June Abstracts, p. 361.

MISCELLANEOUS.

GENERAL FERRIÉ.—P. Brenot. (*Bull. S.F.R.* Feb.–March, 1932, Vol. 6, pp. 20–82.)

The oration broadcast from Radio Paris on 16th February, the day of General Ferrié's death.

OBITUARY: DR. D. W. DYE, F.R.S.: GENERAL GUSTAVE FERRIÉ.—G. W. O. Howe. (*Wireless Engineer*, April, 1932, Vol. 9, p. 207.)

GERMAN TECHNICAL LITERATURE ON BROADCASTING DURING 1931. (*E.T.Z.*, 10th March, 1932, Vol. 53, p. 249.)

THE STANDARDISATION OF BOOKS AND PERIODICALS IN GERMANY.—A. F. C. Pollard. (*Journ. Scient. Instr.*, April, 1932, Vol. 9, pp. 113–116.)

REPORT ON THE WORK AND STUDIES OF THE FRENCH NATIONAL LABORATORY OF RADIO-ELECTRICITY : WITH LIST OF PUBLICATIONS.—C. Gutton. (*Ann. des P.T.T.*, Jan., 1932, Vol. 21, pp. 70–80.)

THE SEVENTH MEETING OF THE GERMAN PHYSICISTS AND MATHEMATICIANS IN BAD ELSTER, NOVEMBER, 1931.—E. Lübcke. (*E.T.Z.*, 11th Feb., 1932, Vol. 53, pp. 129–132.)

PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION :—RADIO AND ALLIED INSTRUMENTS AND APPARATUS : LABORATORY ELECTRICAL INSTRUMENTS.—R. L. Smith-Rose : C. V. Drysdale. (*Journ. Scient. Instr.*, March, 1932, Vol. 9, pp. 81–85, 86–90.)

THE LEIPZIG SPRING FAIR.—(*Rad., B., F. f. Alle*, May, 1932, pp. 205–209.)

THE PERIODIC FLUCTUATION OF THE ELECTRIC FIELD OF THE HUMAN BODY.—W. E. Boyd, (*Br. Journ. Radiol.*, April, 1932, Vol. 5, New Series, 10 pp.)

Further development of the work dealt with in 1930 Abstracts, p. 413. Among the conclusions arrived at are that certain of the potentials on the skin of the human body show periodic change of the same periodicity as the electrocardiograph current change : the periodic static potential change is due to direct internal communication from the region of the heart or from the heart itself : and the field of electric force surrounding the body will show changes corresponding to the alterations in the skin potentials.

THE EXTENSION OF ELECTRICAL ENGINEERING ANALYSIS THROUGH THE REDUCTION OF COMPUTATIONAL LIMITATIONS BY MECHANICAL METHODS.—H. L. Hazen. (Summary in *Massachusetts Inst. Technol., Abstracts*, Jan., 1932, No. 9, pp. 58–59.)

PRECISION MEASUREMENTS OF MECHANICAL DIMENSIONS BY ELECTRICAL MEASURING DEVICES.—A. V. Mershon. (*Gen. Elec. Review*, March, 1932, Vol. 35, pp. 139–144.)

PAPERS ON A PHOTOELECTRIC APPARATUS FOR THE QUANTITATIVE INVESTIGATION OF PARTICLE SIZE.—N. N. Andrejew. (*Kolloid-Zeitschr.*, No. 1, Vol. 57, pp. 39–42 and 42–47.)

A PHOTOELECTRIC RECORDER [FOR MEASURING SMOKE, HEAT, LIGHT, PRESSURE, NOISE, AND THICKNESSES OF THIN MATERIALS].—C. W. La Pierre. (*Science*, 29th Jan., 1932, Vol. 75, Supp. p. 8.)

Combination of "an optical system, using a galvanometer mirror" and a photoelectric circuit. "Errors of a millionth of an inch are detected when this new engineering tool is used to measure dimensions." *See* also *Elec. Engineering*, February, 1932, Vol. 51, pp. 114–116.

THE "PHOTOELECTROGRAPH" FOR THE BLIND.—Brachet : Thomas. (*Electronics*, April, 1932, p. 142.)

Short description of the reading device referred to in April Abstracts, p. 242. For ordinary print, 42 photocells are used ; for flat Braille, only 6.

A MAGNETO-OPTIC METHOD OF CHEMICAL ANALYSIS [RESULTING IN THE DISCOVERY OF THE ELEMENTS "VA" (87) AND "AM" (85)].—F. Allison. (*Sci. News Letter*, 6th Feb., 1932, Vol. 21, pp. 83–84.)

Capable of detecting concentrations of a substance as low as one part in a trillion. Allison found that in rotating the plane of polarisation of a ray by a liquid in a magnetic field, about one billionth of a second elapses between the switching on of the magnetising current and the occurrence of rotation : this lag is different for various substances. *See* also *Science*, 8th April, 1932, Vol. 75, Supp. p. 8.

NEW METHODS OF MEASUREMENT FOR WORKSHOP MACHINES [DRESDEN DEVELOPMENTS IN MECHANICAL, MECHANICAL-OPTICAL, ELECTRICAL AND OPTICAL-ELECTRICAL METHODS].—E. Sachsenberg and W. Osenberg. (*Zeitschr. V.D.I.*, 12th March, 1932, Vol. 76, No. 11, pp. 262–268.)

MÉTHODE DE MESURE DE HAUTE PRÉCISION DES LONGEURS ET DES ÉPAISSEURS (High Precision Method of Measuring Lengths and Thicknesses [Ultra-Micrometer on Pneumatic Principle]).—M. Mennesson. (*Comptes Rendus*, 25th April, 1932, Vol. 194, pp. 1459–1461.)

MONOCHROMATIC SOURCES OF RED AND YELLOW LIGHT USING THE ELECTRODELESS DISCHARGE.—F. Esclangon. (*Comptes Rendus*, 18th Jan., 1932, Vol. 194, pp. 266–268.)

THE APPLICATION OF FLUORESCENCE TO ULTRA-VIOLET PHOTOMETRY.—A. Chevallier and P. Dubouloz. (*Comptes Rendus*, 11th Jan., 1932, Vol. 194, pp. 174–176.)

An application of the Thoverts' suggestion of the use of a fluorescent layer as a frequency changer in the detection of short wavelengths by a photoelectric cell (1931 Abstracts, p. 104).

SUR L'ÉVAPORATION CATHODIQUE DANS UN CHAMP MAGNÉTIQUE (Cathodic Evaporation in a Magnetic Field).—E. Henriot and O. Goche. (*Comptes Rendus*, 11th Jan., 1932, Vol. 194, pp. 169–170.)

Extension of the experiments on the catching-up of atoms in a cathode ray (1931 Abstracts, p. 341) to the case of a cold cathode. The deposit on the anode consists of two components : one, due to "confused" evaporation from the cathode, dissolves completely in a solvent of the metal of the cathode : the other, due to "directed" evaporation, always leaves a residue which has the same appearance whatever the cathode material may be. This residue is found to be carbon, present as an impurity in the metal or in the gas. The method gives a qualitative means of detecting the presence of carbon.

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.

NEGATIVE RESISTANCES.

Convention date (Germany), 16th August, 1929. No. 367790.

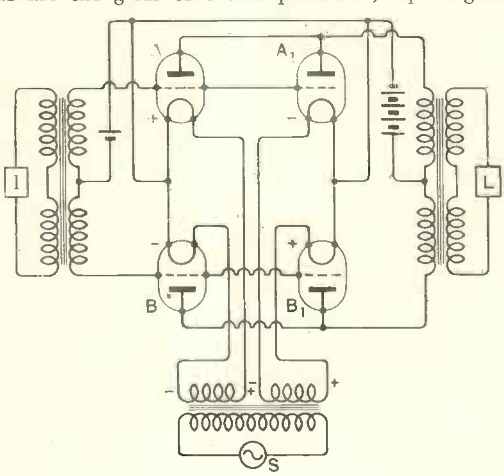
A negative resistance, suitable for use in generating or amplifying high-frequency oscillations, or as a telephony repeater, is prepared by powdering a crystalline substance, such as galena, until the individual granules are of less size than one-tenth of a millimetre, and then mixing with a neutral powder, such as antimony trisulphide, and finally mounting the mixture under pressure between electrodes, with or without intermediate cooling-fins.

Patent issued to E. Habann.

A.C. VALVE AMPLIFIERS.

Convention date (U.S.A.) 31st December, 1929. No. 367022.

The effect of the fluctuating mains voltage is eliminated in directly-heated A.C. valve amplifiers, without using the ordinary mid-point tapping. As shown in the figure, two pairs of push-pull valves A, B and A_1, B_1 are energised from a common source S of filament supply, the arrangement being such that when the filament of A is positive relatively to that of B, the filament of B_1 is positive relatively to that of A_1. The grids of the amplifiers A, A_1 are fed in parallel from the signal input I, as are the grids of the amplifiers B, B_1. Signal



No. 367022.

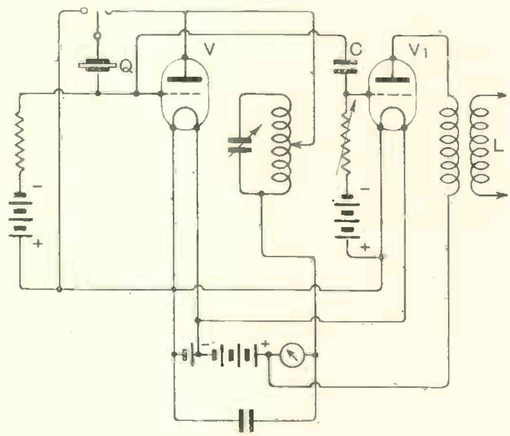
currents are transferred cumulatively to the output or loudspeaker L, whilst fluctuating components due to the periodicity of the mains mutually balance out.

Patent issued to Electrical Research Products Inc.

STABILISING FREQUENCY.

Application date, 6th November, 1930. No. 366572.

In order to prevent variations in the load, or any inherent reaction in the oscillatory circuits, from affecting the master control crystal, the latter is separated from the main work circuit by an auxiliary valve arranged in parallel with the oscillator valve.



No. 366572.

As shown, the input circuit of the auxiliary valve V_1 is in parallel with that of the oscillator valve V through a coupling condenser C, whilst its output is coupled to the work circuit L. The frequency-control crystal Q is arranged so that it can be switched across either the input or output circuit of the valve V.

Patent issued to Kolster Brandes, Ltd.

MAGNETIC DIRECTION-FINDER.

Convention date (U.S.A.), 19th November, 1929. No. 367426.

An electron-discharge tube of the magnetron type is suspended in an aeroplane or other moving craft so as to rotate freely about a horizontal axis, and is adjusted by means of a course-setting device associated with a mariner's compass. A polarizing-field is applied to the magnetron from an A.C. source, and the resulting output current is fed to a two-phase motor in such a way that no turning torque is applied so long as the craft maintains the desired course. Any deviation in direction alters the effective component of the earth's magnetic field applied to the magnetron, whereupon the resulting variation in plate current rotates the motor and so gives a visible indication to the aviator that he is off his course.

Patent issued to British Thomson-Houston Co., Ltd.

INTERFERENCE ELIMINATORS.

Convention date (Germany) 4th November, 1930.
No. 366891.

To prevent interference from A.C. mains and other local sources of induction, the aerial is erected at a considerable height and the down-lead is "paralleled" by an additional wire earthed at the lower end and open at the top. Or the two wires may be twisted together. Or the additional wire may be used as a counterpoise earth. The same potentials are induced by the disturbing fields in each of the wires, and, being opposed across the input coil, cancel out. A similar arrangement is used to couple a duplex transmitting and receiving set to an elevated dipole aerial, so that only the signal components can affect the receiver, all in-phase induction being balanced out.

Patent issued to C. Lorenz Aktiengesellschaft.

RELAYING PROGRAMMES.

Convention date (Germany), 26th June, 1930.
No. 366410.

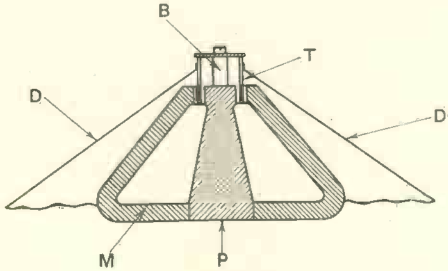
It has already been proposed to relay a series of broadcast programmes from a single short-wave transmitter, but, owing to the non-linear characteristic of the transmitter valve the tendency to cross-modulation sets a limit to the number of programmes that can be handled in this manner. To overcome this difficulty, the linear part of the plate-current grid-volts characteristic of the transmitter is made smaller than the sum of the amplitudes, but the range of frequencies to be transmitted is so arranged that the highest frequency is less than twice the lowest frequency. The inventor points out that in spite of the present limitations on the amplification of wavelengths below 30 metres, the whole of the programmes included within the normal broadcast range of 200–600 metres could be handled by only two short-wave relaying stations.

Patent issued to M. von Ardenne.

LOUD SPEAKERS.

Application date, 24th January, 1931. No. 366706.

The permanent magnet M is made in the form of a conoidal shell so as to fit snugly inside the apex



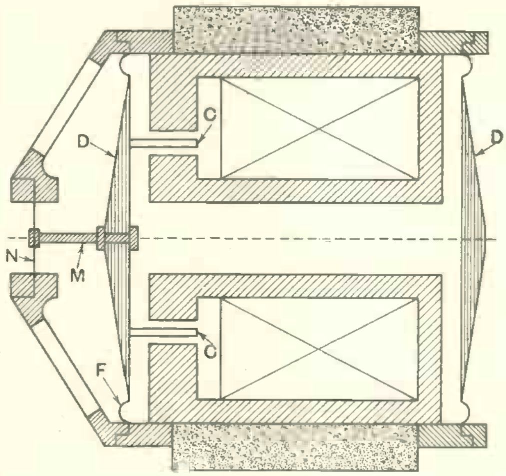
No. 366706.

of a conical diaphragm D, to which the former T for the moving coil is attached. A flexible spider, carried by the pillar B attached to the main pole-piece P, serves to centre the cone.

Patent issued to Graham Amplion, Ltd.; L. F. Laurence; and J. R. Beard.

Convention date (France), 5th February, 1930.
No. 367119.

The diaphragm D of a dynamic speaker, impulsed by the moving-coil C, is supported by a flexible strip F around its periphery, and by a



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flexible disc N and a spindle M at its centre. The disc N is mounted in open arms surrounding the sound exit. The vibrations from the back of the diaphragm D are transmitted through a central passage to a second diaphragm D_1, constructed and mounted so as to have a low natural period of vibration, *i.e.*, below 50 or 60 cycles a second. Under these conditions the diaphragm D_1 is forced into vibration in phase-opposition with the main diaphragm D, and then functions in the same manner as an external baffle-plate by preventing wave-interference on the lower notes.

Patent issued to J. Bethenod.

WIRELESS NAVIGATIONAL SYSTEMS.

Convention date (Germany), 2nd July, 1930.
No. 367286.

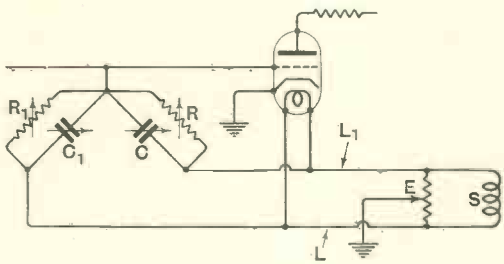
The invention relates to systems wherein a desired course of flight is indicated to the pilot of an aeroplane by means of a short-wave wireless transmitter, which radiates a swinging "beam" distinctively modulated at each side of the central position. The improvement consists in causing the transmitter to execute a complete rotation, instead of the usual swinging movement, relatively to the focus of the "backing" reflector. This allows the time period between successive signal indications to be reduced.

Patent issued to Telefunken Gesellschaft für drahtlose Telegraphie m.b.H.

ELIMINATING MAINS "HUM."

Convention date (Germany), 26th May, 1930. No. 368152.

"Hum" voltages induced through fortuitous couplings are counterbalanced by other couplings deliberately inserted in the grid-filament circuit.



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As shown the secondary *S* of the supply transformer is centre-tapped to earth at *E*, and a connection is taken from each of the supply leads *L*, L_1 through variable resistances *R*, R_1 and condensers *C*, C_1 to the grid, so that any accidental coupling, inductive or capacitive, between either of the supply leads and the grid can be separately neutralised, whilst at the same time the earthing of the heating filament is left under independent control.

Patent issued to Allgemeine Elektricitats-Ges.

CURRENT-LIMITERS.

Application dates, 23rd January and 2nd April, 1931. No. 369321.

A bridge circuit is arranged so that its input is supplied by the output of the amplifier to be limited, the output of the bridge being coupled back to apply negative reaction to the amplifier, whenever the effective signal voltage exceeds a critical value determined by the characteristic of a diode valve inserted in one of the arms of the bridge. The arrangement provides a "limiter," which (*a*) absorbs no power until the output exceeds a predetermined value, and (*b*) can readily be fitted to existing apparatus.

Patent issued to Kolster-Brandes Ltd. and W. S. Percival.

CATHODE-RAY TUBE OSCILLATORS.

Convention date (U.S.A.), 3rd January, 1930. No. 367978.

Oscillations are generated by back-coupling the input and output circuits of a cathode-ray tube, and the frequency is stabilised by inserting a transmission line on which standing-waves are set up in the feed-back circuit. A piezo-electric crystal may also be shunted across the line. The requisite phase-relation of voltage to ensure sustained oscillation is obtained by adjusting the electrical length of the transmission to an odd number of half wavelengths by means of a movable bridge-piece.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

FREQUENCY STABILISERS.

Convention date (U.S.A.), 31st May, 1930. No. 369009.

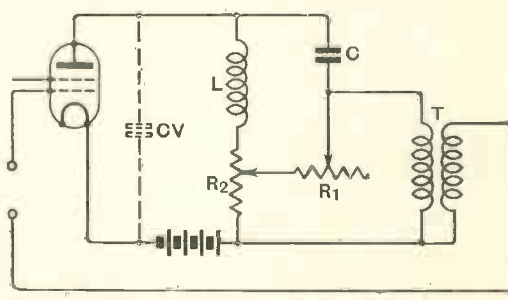
In a short-wave transmitter adapted to work at a number of different frequencies, the feed-back circuit includes an electrically-long line, consisting of a shielded coil, which is tapped at various points along its length to the input circuit through appropriate surge impedances. The arrangement ensures a constant frequency for each adjustment, irrespective of variations in load or tuning, and independently of the biasing potentials applied to the oscillator. The stabilised oscillator will handle high power directly thus eliminating the usual low-power frequency control.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

THERMIONIC AMPLIFIERS.

Convention date (Holland), 26th March, 1930. No. 367511. (Addition to 366683).

The circuit arrangement shown in the Figure is designed to ensure uniform amplification over a wide range of frequencies. The output coupling-element *L* is in series with a resistance R_2, part of which is back-coupled to the input through another variable resistance R_1 and a transformer *T*. A condenser *C* is connected in parallel with the internal capacity *CV* of the valve (indicated in dotted lines). The specification contains a mathematical analysis which shows that for uniform



No. 367511.

amplification at all frequencies R_1 is to R_2 as *CV* is to *C*; also that SR_2 is equal to unity, *S* being the mutual conductance of the valve.

Patent issued to N. V. Philips Gloeilampen Fabrieken.

COMMON-WAVE BROADCASTING.

Convention date (Germany), 13th September, 1930. No. 369145.

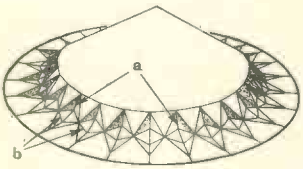
To minimise mutual interference in the "overlap" area between two transmitters working on a common wavelength, the percentage modulation of the carrier-wave at each station is maintained below a predetermined value. In addition the amplitude of the carrier-wave at each station is adjusted so as to throw the zone of greatest interference into a preselected area, preferably one which is thinly populated.

Patent issued to H. Harbich.

LOUDSPEAKER DIAPHRAGMS.

Convention date (U.S.A.), 29th July, 1930. *No.* 369746.

The cone, rim, and an intermediate flexible part are formed from a single piece of flat paper by folding or pleating it in the manner shown in the drawing. A detailed description of the method of folding is given in the specification. In general the corrugations *a* on the conical portion are deeper or wider near the rim portion than towards the apex of the cone; whilst those *b* on the rim portion are deeper or wider near the inner circumference than towards the outer circumference. This allows the effective diameter of the base of the cone, or the rim to be expanded or contracted within limits.



No. 369476.

Patent issued to V. T. Houghton.

LOUD SPEAKERS.

Convention date (Holland), 15th August, 1930. No. 368654.

In order to prevent box or cabinet "resonance," the driving-movement and the diaphragm of the speaker are first mounted centrally inside an open-ended cylinder, and this is then fitted as a separate unit inside the cabinet, preferably so that the rear end of the cylinder projects slightly beyond the wall of the casing. The speaker movement is held inside the cylinder by spokes, and rubber pads or springs are interposed between the outer surface of the cylinder and the cabinet to damp out vibrations.

Patent issued to N. V. Philips Gloeilampenfabrieken.

Application date, 2nd December, 1930. No. 368708.

In a moving-coil speaker a pole-bar forming part of the magnetic circuit is bored to receive a central pole-member and forms an annular field-gap. The pole-member is held concentric with the bore by a ring of non-magnetic material, the assemblage being pulled up solid by a bar magnet drilled for bolts at each end. The construction ensures that the field-gap is located definitely, both externally and internally, in relation to the tympanum and moving coil, independently of the magnet or its means of attachment.

Patent issued to F. W. Lanchester.

NAVIGATION BEACONS.

Convention date (Germany), 15th January, 1930. *No.* 369679.

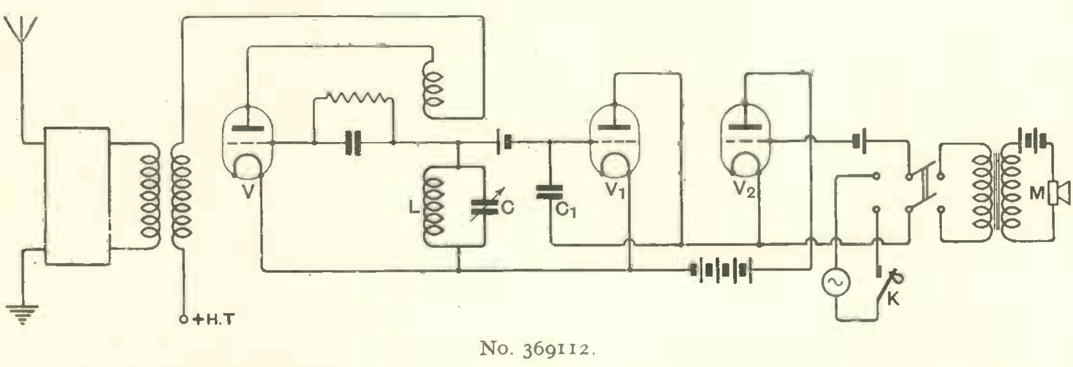
Relates to D. F. navigation systems of the kind in which signals are radiated in two different directions, with an overlapping area, so that a receiver located in the area of overlap receives a characteristic signal. According to the invention the beacon consists of a single highly-directional aerial in combination with a reflecting mirror, which is swung so that it remains pointing for a longer time in one direction than in the other, means being provided to suppress radiation during the change-over period. The use of a single transmitter, instead of two, ensures constant frequency and a desirable equality of the radiation fields.

Patent issued to Telefunken Ges fur Drahtlose Telegraphe m.b.H.

FREQUENCY MODULATION.

Convention date (U.S.A.), 10th July, 1930. *No.* 369112.

The main oscillatory circuit *L*, *C*, of the generating valve *V* is in parallel with a valve V_1 having in its plate circuit a variable resistance comprising a valve V_2, the effective impedance of which is controlled by speech currents applied to a microphone *M*, or by a keying-circuit *K*. The valve V_1 may be considered as a network comprising the inter-electrode capacity (augmented by the condenser C_1) and the external resistance of the plate circuit of that valve. Variation of the resistance component of the network, represented by the microphone or key, alters the effective capacity of the network as a whole. This being in parallel with the main oscillatory circuit *L*, *C* causes the generated frequency to vary in accordance with the applied speech or keying-note.



No. 369112.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

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