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# Editorial.

## Gas-filled Rectifying Valves.

TO prevent any misunderstanding we may say at once that the valves to which we wish to refer are not intended for the detection of radio signals but for the rectification of large alternating currents. It is well known that the presence of gas in a valve enables the applied voltage to send a larger current through it than is possible if the gas is not present, but it has been thought impossible to make use of this fact because of the rapid disintegration of the cathode due to its bombardment by the gaseous ions. Research carried out by A. W. Hull and other members of the laboratory staff of the General Electric Company of Schenectady has shown, however, that under certain conditions this disintegration does not take place. "Cathodes have been made which furnish 1,500 amperes emission under conditions which promise long life, and cathodes with a normal emission of 10,000 amperes appear practical." In order that disintegration should not take place, the velocity with which the gaseous ions strike the cathode must not exceed a certain value corresponding for the inert gases to a voltage drop of from 20 to 25 volts. Since lower voltages than this are capable of ionising the gas, it is possible to pass large currents without disintegration of the cathode by ensuring that the cathode drop lies between the disintegration and the ionisation voltage. This can be ensured by suitably adjusting the resistance of the circuit. The maximum current is limited only by the size of the cathode, and the maximum voltage which can be rectified is limited by the arcing back which will occur in any gaseous space if the voltage exceeds a certain value, but the rectifiers described by A. W. Hull operate satisfactorily at 10,000 volts D.C. output.

If a thorium-coated cathode is used in a two-electrode valve containing argon at a pressure of 0.1 mm. and the anode voltage is gradually increased, the current reaches a maximum at about 25 volts and falls rapidly as the voltage is still further increased. It is surprising that at 50 volts the current passing is less than a tenth of what it was for 25 volts. This has been explained by Langmuir by assuming that the emission of electrons is due to a thin layer of thorium atoms on the surface of the cathode and that these atoms are actually removed by the bombardment of gaseous ions if these latter strike them with sufficient velocity. Hence the secret of making such a rectifier with good emission and long life would appear to lie in keeping the voltage drop below about 25 volts.

The efficiency of the cathode as an emitter of electrons has been greatly increased by the introduction of the heat-insulated cathode. In the ordinary separately-heated cathode the emission takes place from the outside of the internally-heated cylinder. This is thermally inefficient because the emissive coating radiates heat about five times as fast as a similar surface of polished nickel. In the heat-insulated cathode the cylinder is open at the end and coated with barium oxide or other emissive coating on the inside, the heating filament being enclosed in a smaller central tube. Not only is the outside of the nickel cylinder polished, but it is surrounded by two further nickel cylinders with small annular gaps, thus greatly reducing the loss of heat. Even the open end of the cylinder is occupied by a number of radial vanes coated with active material. Such a heat-conserving cavity would be useless as a cathode in a high-vacuum valve because it would become choked with an electron space charge, but in the gas-filled valve the space charge is neutralised by the gaseous ions which enter the cylinder. By these ingenious devices the efficiency has been increased to 24 times that of the ordinary cylindrical cathode, so that at a temperature of 1,000 deg. K. the emission per watt of heating has been increased from 24 to 600 milliamperes. It is estimated that such a cathode should have a life of over seven years; some have been in continuous operation for six months without any noticeable change.

As an example of the importance of the vapour pressure in a low-voltage mercury vapour rectifier with a barium-coated nickel-cylinder cathode, it is stated that with a vapour pressure of 1 to 3 mm., the rectifier operated at 5 amperes for 4,000 hours, whereas with a pressure of 0.01 mm. the life was less than 20 hours. This is due to the protective action of the gas in preventing evaporation of the active material. This type of rectifier can only be used for low voltages; for voltages above 1,000 the gas pressure must be so low in order to prevent arcing back that its protective action is negligible.

Very high voltages require careful spacing and design of electrodes with respect to the glass bulb. As Hull points out, the electric field within the bulb is modified by the presence of the gaseous ions and may be very different from that which would exist in a vacuum. The ions tend to modify the field in such a way that the sparking potential is reduced; if the gas pressure is high they tend to shorten the effective length of the path between the electrodes, whereas if the gas pressure is so low that the length of gap which would give the minimum sparking voltage is longer than the actual distance between the electrodes, then the ions actually modify the field so as to lengthen the effective sparking path. A limit may be set to this by the dimensions of the glass bulb.

In the paper describing these researches, which was read by A. W. Hull in New York in May last, a description is also given of a rectifier with an auxiliary electrode or grid which can be used to start the rectifier This has been given the name of "thyratron" (Greek θυρα—a door), but we do not propose to discuss this device here. It would appear that the day of the soft valve is not past and that there still remains much to be discovered in the fruitful field of thermionics.

G. W. O. H.

# Radio Frequency Transformers as Applied to Screen-grid Valves.

*By S. Butterworth, M.Sc.*

IN the orthodox theory of radio frequency transformers* it is usually assumed that the primary of the transformer is working in a circuit of high resistance. A small E.M.F. of radio frequency is impressed on this circuit and the secondary of the transformer is tuned by means of a condenser. It is then shown that if the transformer coupling is such that the load due to the primary circuit doubles the apparent resistance of the secondary circuit a maximum E.M.F. will be obtained across the tuning condenser, and, further, that this maximum E.M.F. will increase as the square root of the magnification of the secondary coil.

In practice, the primary of the transformer is in the anode circuit of a valve and it is found that the theory can only be applied successfully if the input circuit of the valve is aperiodic. If the input circuit is another tuned circuit then any attempt to use an efficient secondary circuit only results in a persistent howl from the whole system.

This state of oscillation is, of course, due to reaction of the secondary on the primary *via* the grid-plate capacity of the valve, and may be countered by the use of a neutrodyning arrangement. Now neutrodyning is a somewhat delicate operation, and when the screen-grid valve was introduced it was hoped that the inter-electrode capacity would be reduced to such a value that efficient secondary circuits could be employed to give stable systems having high magnifications. By using screen-grid valves of special construction, Hull and Williams (*Phys. Rev.*, p. 432, Vol. 27, 1926) were able to reduce the inter-electrode capacity to as low a value as 0.006$\mu\mu$F. as compared with 2$\mu\mu$F. or more for the ordinary triode. With commercial valves of the screen-grid type, however, it is more usual to have values of 0.05 to 0.1$\mu\mu$F. for the grid-plate capacity. It is important, therefore, to find how to make the best use of radio frequency transformers while accepting capacities of the order of 0.1$\mu\mu$F. and without having to make use of neutrodyning arrangements. Also if the receiving set is to be used over the range 300 to 600 metres the stability must be assured for a shorter wavelength than 300 metres and the magnification must be reasonable in the most unfavourable case, that is, at the longest wavelength, 600 metres. We shall, therefore, study the case in which the tuning condensers can be varied in the ratio 10 to 1, the circuit constants being such that the system is just stable at the smallest condenser settings while the magnification at the highest condenser settings will be taken as a measure of the performance of the system. It will be shown that stability may be brought about in a variety of ways, but that the most efficient way is by reducing the primary turns of the transformer while still employing lightly damped tuned circuits. Since the tuned anode is, in effect, a transformer of one to one ratio we can settle the question of the relative efficiencies of tuned anodes and radio frequency transformers and find that the latter system is the one that should be employed.

* See, for example, Dr. McLachlan's article under the above title in *E.W. & W.E.*, p. 597, Vol. IV, 1927.

### Simplifying Assumptions.

In any theory involving grid-plate capacities of valves so many factors have to be taken into account that the principles are apt to become hidden in a mass of mathematical formulæ. The stability or otherwise of the system depends not only on the constants of the anode circuit, but also on those of the input circuit. The circuit to be considered is that shown in Fig. 1. The tuned input and output circuits are assumed in the first place to be electrically similar, having equal inductances $L$, equal capacities $C$ and equal losses represented by the parallel conductances $\sigma$. The working pulsatance (frequency multiplied by $2\pi$) is $\omega$ and the two condensers $C$ are tuned simultaneously, so that the common natural pulsatance of the two circuits is $\omega_0 = 1/\sqrt{LC}$ and in the equations is always supposed to be in the neighbourhood of $\omega$. We therefore write $p = \omega - \omega_0$ and assume $p/\omega_0$ to be small.

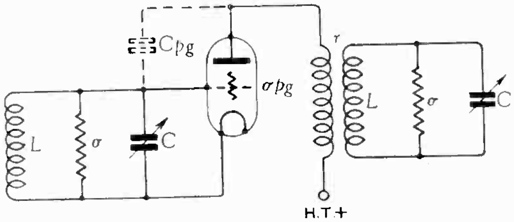



Fig. 1.

The vector admittance of both input and output circuits may then be written

$$\beta = \omega_0 C(\psi + jx) \qquad .. \quad (1)$$

in which $j$ is the operator rotating through a right angle and is treated algebraically as the imaginary $\sqrt{-1}$, $\psi \doteq \sigma/\omega_0 C$ and is the circuit power factor while $x = 2p/\omega_0$ and may be called the tuning factor.

For simplicity the transformer will be assumed to have perfect coupling and the ratio of secondary to primary turns will be denoted by $r$. The output circuit of Fig. 1 may then be replaced by its equivalent anode circuit which has admittance $r^2\beta$, while the actual output voltage is $r$ times that deduced for the equivalent anode circuit. The modifications to theory owing to imperfect coupling are discussed in the Appendix.

As regards the valve, we will suppose it to have infinite anode impedance, grid-plate conductance $\sigma_{pg}$, grid-plate capacity $C_{pg}$ and we will denote the vector admittance linking grid and plate by $\alpha$ so that

$$\alpha = j\omega_0 C_{pg} \qquad .. \quad (2)$$

The assumption of infinite anode impedance means that not only are the variations of anode current independent of anode voltage, but also that the plate filament capacity of the valve can be neglected. In practice the valve impedance acts as a shunt across the admittance $r^2\beta$ so that it is justifiable to neglect it if $r$ is sufficiently large. It will be seen that with existing screened grid valves the value of $r$ necessary to secure stability when using lightly damped circuits is so large that the assumption is justified, but this assumption would break down in the case of valves of negligible grid-plate capacity, that is, anode impedance is of importance in the theory as developed by Dr. McLachlan. Even in this case it would appear that the effect of plate-filament capacity is of more importance than that of plate-filament resistance and this is a factor usually neglected in presenting the orthodox theory. Its effect is chiefly on the optimum coupling condition, but there is also a tendency for a rejector effect to appear when the primary of the transformer gets into resonance with the plate-filament capacity.

### Input Admittance of Valve and Voltage Ratio.

Let a high frequency voltage $v_g$ be applied to the grid of the valve and let the resulting plate voltage be $v_p$. Then from Fig. 2, the current passing direct from grid to plate is $\alpha(v_g - v_p)$ of which $\sigma_{pg}v_g$ flows through the valve from plate to filament, while $r^2\beta v_p$ flows through the anode circuit. Hence

$$\alpha(v_g - v_p) = \sigma_{pg}v_g + r^2\beta v_p$$

giving for the voltage ratio

$$v_p/v_g = -(\sigma_{pg} - \alpha)/(r^2\beta + \alpha) \qquad .. \quad (3)$$

while the input admittance is

$$\beta_g = \alpha(1 - v_p/v_g) = \alpha + \alpha(\sigma_{pg} - \alpha)/(r^2\beta + \alpha) \qquad .. \quad (4)$$

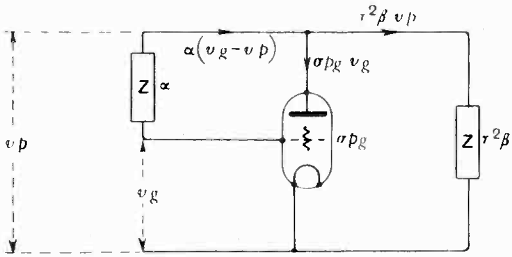



Fig. 2.

Now $\alpha/\sigma_{pg}$ and $\alpha/r^2\beta$ are both small, so that approximately

$$v_p/v_g = -\sigma_{pg}/r^2\beta \qquad .. \qquad .. \quad (5)$$
$$\beta_g = \alpha\sigma_{pg}/r^2\beta \qquad .. \qquad .. \quad (6)$$

The above input admittance is, of course, that due to the grid-plate capacity. There may be a further input admittance due to grid current and grid filament capacity.

These are both supposedly included in the input circuit constants.

### Overall Voltage Magnification.

In its simplest case imagine the input circuit coil to be a frame aerial coil. Then the input voltage $v_1$ is that induced in the frame by the incoming signal and is of the form

$$v_1 = K\sqrt{L} = K/\omega_0\sqrt{C} \quad .. \quad (7)$$

in the neighbourhood of resonance where $K$ depends on the strength of the signal, on the size and shape of the frame, but not on the number of turns.

It is then readily shown that the impressed grid voltage is given by

$$v_g = v_1/j\omega_0 L(\beta + \beta_g) \quad .. \quad (8)$$

Hence, using (5) and (6) and multiplying by the transformation ratio we obtain for the output voltage,

$$v_0 = -r\sigma_{pg}v_1/j\omega_0 L(r^2\beta^2 + a\sigma_{pg}) \quad .. \quad (9)$$

Then by (1), (2) and $\omega_0{}^2LC = 1$,

$$v_0/v_1 = -r\sigma_{pg}/j\omega_0 C\{r^2(\psi + jx)^2 + jC_{pg}\sigma_{pg}/\omega_0 C^2\} \quad (10)$$

The form of the equation is further simplified by writing

$$y = x/\psi = 2p/\omega_0\psi \quad .. \quad .. \quad (11)$$
$$G = C_{pg}\sigma_{pg}/2r^2\omega_0 C^2\psi^2 \quad .. \quad (12)$$

and then (10) becomes

$$v_0/v_1 = \sigma_{pg}/jr\omega_0 C\psi^2\{1 - y^2 + 2j(G + y)\} \quad (13)$$

This is the fundamental equation for determining the performance of the system in the neighbourhood of resonance.

### Stability.

The first essential of any receiving circuit is that it shall be stable throughout the total swing of its tuning condensers. The conditions of critical stability are readily obtained from (13) by equating the real and imaginary parts of the denominator to zero simultaneously. This gives $y = -1$ to determine the frequency of oscillation and $G = 1$ to determine the condition of oscillation. As a system with no grid-plate capacity ($G = 0$) is essentially stable, the condition for stability must therefore be that $G$ is less than unity throughout the whole of the condenser range. Remembering that $\omega_0 = 1/\sqrt{LC}$, (12) shows that $G$ increases as $C$ diminishes, so that at a certain value of $C$, which we will call $C_0$, $G$ will reach unity. For any other value of $C$ the value of $G$ will be given by

$$G = (C_0/C)^{\frac{3}{2}} \quad .. \quad (14)$$

showing that the system will be stable so long as $C$ is greater than $C_0$. Our method of securing stability is therefore to assign a value to $C_0$ at or below the bottom of the condenser scale and so choose our circuit constants that

$$\sigma_{pg}C_{pg}L^{\frac{1}{2}}/r^2C_0{}^{\frac{3}{2}}\psi^2 = 2 \quad .. \quad (15)$$

Thus to take a practical case, suppose we require to work over the 200 to 600 metre band using a condenser varying between 30 and 300$\mu\mu$F. while the valve constants are $\sigma_{pg} = 0.001$ mho, $C_{pg} = 0.1\mu\mu$F. The required value of $L$ is approximately 330$\mu$H. which gives resonance at 30$\mu\mu$F. when $\omega = 10^7$ or $\lambda = 188$ metres. Using these in (15) we find the stability condition gives a simple relation between the ratio of the transformer and the power factor of the circuit, namely,

$$r\psi = 0.0745 \quad .. \quad (16)$$

or since the reciprocal of the power factor is the circuit magnification ($m$),

$$r = 0.0745\ m. \quad .. \quad (17)$$

The practical meaning of (16) or (17) is obvious. We can use highly efficient tuned circuits or highly damped ones. In the former case, the transformer must have few turns in order to secure the necessary value for $r$, the secondary turns being fixed by the inductance. Thus if $m = 200$ the primary turns must be 1/15th of the secondary, and since a coil 3in. in diameter and ¾in. in winding length requires about 55 turns to secure the above inductance, the number of primary turns that can be used is only about four if stability is to be obtained at the bottom of the condenser scale.

It is to be noted that this result is entirely opposed to the conclusion obtained from the orthodox theory where an optimum is sought without regard to stability. In fact for a screened grid valve of high impedance the number of turns demanded for the primary may well be greater than those on the secondary in order to secure the optimum coupling. If we wish to get this so-called optimum and yet retain stability we must necessarily work with circuits of high damping, and this may more than wipe out any advantage obtained from the optimum coupling. As to which system is the correct one will appear when we have studied the nature of the overall magnification.

### Optimum Conditions.

It is clear that if the system is arranged to have critical stability with the condensers set at 30$\mu\mu$F. the magnifications will be very large at settings just above this point and that the magnification will drop as the capacities are increased. It is therefore advisable to study the magnification where it is least, namely, with the condensers at their highest values of 300$\mu\mu$F. From (14) the value of $G$ is then 0.0316 and from (13) the amplitude of the denominator is proportional to

$$F = \{(1 - y^2)^2 + 4(G + y)^2\}^{\frac{1}{2}} \quad .. \quad (18)$$

This is a minimum for variation of the tuning factor ($y$) when $y = -y_0$, where $y_0$ is given by

$$y_0(1 + y_0^2) = 2G \quad .. \quad (19)$$

and the minimum value is

$$F_0 = (1 - y_0^2)\,(1 + y_0^2)^{\frac{1}{2}} \quad .. \quad (20)$$

Using $G = 0.0316$ we obtain $y_0 = 0.0630$ and $F_0$ is practically unity. Using this result in (13) and also putting $\sigma_{pg} = 0.001$, $r\psi = 0.0745$, $\omega_0 = 3.16 \times 10^6$ (the resonant pulsatance at 300$\mu\mu$F.), $C = 3 \times 10^{10}$ we obtain for the resonant magnification at the upper condenser settings

$$v_0/v_1 = 14.2/\psi = 14.2m \quad .. \quad (21)$$

Since the factor $m$ may be regarded as the magnification due to the input circuit alone we conclude that the magnification due to the screened grid valve plus the high frequency transformer is 14.2 whatever the value of $m$. This does not mean, however, that there is no need to pay attention to the power factor of the output circuit because the result only holds when the power factors of the two circuits are equal. The more general case is treated in a later section.

It has been shown (McLachlan, *loc. cit.*) that with ordinary neutrodyned valves, magnifications greater than the above are possible, the figures quoted being 15 to 52 according to the type of valve used. It must be remembered, however, that the above figure is the minimum over the whole scale and that the value is possible without recourse to the complications of neutrodyning. Also the value used for the grid-plate capacity may be pessimistic. If this capacity is less, more primary transformer turns may be used and the magnification will then increase as the inverse square root of the value of the grid-plate capacity. With Hull's valve, the magnification should be of the order of 56, and although this figure may not be attainable with commercial valves, yet it should be quite possible to obtain magnifications of the same order as those theoretically possible with neutrodyned triodes.

### Comparison with Tuned Anode.

We are now in a position to supply a partial answer to the question as to the relative merits of H.F. transformers and tuned anodes. In the latter case we must make $r = 1$ and then (16) tells us that in order to secure stability $\psi$ must be as large as 0.0745. This is an extraordinarily poor factor assuming the worst input circuit, so that, although we still get a nominal valve magnification of 14.2, we have had to secure stability by the very inefficient method of reducing a magnification which already existed before applying the valve. The answer is, however, only partial, as it is not necessary in practice to keep to equal power factors for both input and output circuits.

In Dr. Beatty's article on screen-grid valves with tuned anodes (*E.W. & W.E* p. 619, Vol. IV., 1927), the results quoted appear to be rather more favourable than would appear from the present reasoning, but it may be shown that in Dr. Beatty's worst cases the value of $G$ is 0.312, and this value is too near to instability to allow of the wide range of condenser swing which is necessary when the receiver is intended to be used over a wide band of frequencies. If it is considered profitable to work nearer instability the H.F. transformer may be readily adapted for this purpose by adopting variable coupling. In this case our simple theory which assumes perfect coupling is not applicable, but the theory in the appendix shows that the method is quite feasible. In the case of tuned anodes the same effect can be attained by a variable inductance in series with the primary, but this, as well as the case of tapped anodes, is really converting the tuned anode to a H.F. transformer.

### Unequal Power Factors.

The theory assuming unequal power factors may be developed on lines similar to those given above. The results only will be stated. Let $\psi_1$ and $\psi_2$ be the power factors of the two circuits and let

$$\psi_e^2 = \tfrac{1}{2}\sqrt{\psi_1 \psi_2}\,(\psi_1 + \psi_2) \quad \ldots \quad \ldots (22)$$

TABLE I.

MAGNIFICATIONS WITH TUNED ANODE CIRCUITS.

| $m_1$. | $m_2$. | Overall Magnification. |
|---|---|---|
| 13.4 | 13.4 | 190 |
| 20.0 | 9.63 | 204 |
| 50.0 | 5.76 | 305 |
| 100.0 | 4.46 | 473 |
| 200.0 | 3.48 | 734 |
| 400.0 | 2.74 | 1,160 |

Then to determine the stability condition we simply replace $\psi$ in equations (15) and (16) by $\psi_e$.

The resonance magnification at the upper readings of the condensers is given by

$$v_0/v_1 = 14.2\, \psi_e/\psi_1 \psi_2 \quad \ldots \quad \ldots (23)$$

the equation corresponding to (21) in the above theory.

In the case of anode tuning, where $r = 1$, we have $\psi_e = 0.0745$, so that for a given $\psi_1$ (22) determines $\psi_2$ and then (23) gives the magnification. This leads to Table I, where $m_1$ and $m_2$ are the circuit magnifications (reciprocals of power factors).

Table I clearly shows that the method of bringing about stability in tuned anode circuits by reducing both circuit magnifications simultaneously is the worst possible one and leads (in the present example) to a magnification of only 190, a value which could easily be attained by a very moderately efficient circuit. (See the author's examples of efficient coils, *Wireless World*, December 8th, 1926, where magnifications greater than 500 are quoted.)

To get the best out of a tuned anode circuit, one of the circuits should be chosen so as to have as high a circuit magnification as possible, and the necessary stability should be secured by applying damping in the other circuit.

It is also seen that it is impossible to assign a definite magnification to the combination valve plus tuned anode without specification of the nature of the input circuit. If the input circuit is sufficiently highly damped we can quote a very impressive figure for the valve magnification, but when this circuit is lightly damped, the possible valve magnification is very moderate because of the necessity for securing stability.

TABLE II.

MAGNIFICATIONS AND STABILITY RATIOS OF H.F. TRANSFORMERS.

| $m_1$. | $m_2$ = | 50 | 100 | 200 | 400 | Tuned Anode. |
|---|---|---|---|---|---|---|
| 50 | Ratio ............ | 3.7 | 5.1 | 6.7 | 8.3 | 1 |
| | Magnification ..... | 710 | 1,030 | 1,590 | 2,530 | 305 |
| 100 | Ratio ............ | 5.1 | 7.4 | 10.2 | 13.3 | 1 |
| | Magnification ..... | 1,030 | 1,420 | 1,850 | 3,170 | 473 |
| 200 | Ratio ............ | 6.7 | 10.2 | 15.9 | 20.4 | 1 |
| | Magnification ..... | 1,590 | 1,850 | 2,840 | 4,150 | 734 |
| 400 | Ratio ............ | 8.3 | 13.3 | 20.4 | 31.8 | 1 |
| | Magnification ..... | 2,530 | 3,170 | 4,150 | 5,680 | 1,160 |

It is clear from the symmetry of these equations that it is unnecessary to specify to which circuit $\psi_1$ and $\psi_2$ belong, so we will take $\psi_1$ as the smaller power factor.

Turning now to the H.F. transformer, we can choose $\psi_1$ and $\psi_2$ without regard to stability. This choice determines the effective power factor $\psi_e$ and then the correct transformer ratio follows from $r\psi_e = 0.0745$, while (23) determines the overall magnification. This leads to Table II in which the upper figure in each entry gives the correct transformer ratio and the lower figure the overall magnification.

The last column gives the overall magnification with the tuned anode when the input power factor is that of the first column and is inserted for ready comparison of the two methods. It is seen that in all cases the H.F. transformer shows considerable superiority.

### Stabilisation by Capacity.

Another method of bringing about stabilisation is to work with condensers of larger capacity. Still, assuming equal condensers, we arrive at the formula $C_0\psi = 2.24$ for the stabilising capacity in $\mu\mu$F., and the magnification is $14.2/\psi$, exactly as when stabilisation is brought about by alteration of transformer ratio. There are, however, disadvantages associated with too large a capacity in the input circuit in that the pick-up E.M.F. is apt to be reduced when large capacities and small inductances are used. This is clear from equation (7) in the case where the input circuit is a frame aerial. We could also adopt different capacities in the two-tuned circuits. The theory then shows that some gain in magnification would result in the tuned anode circuits, but the input capacity would have to be considerable before the magnification reached that of the H.F. transformer, and as this would mean lack of standardisation in the condenser system, the adoption of different capacities is hardly to be recommended. On the whole it would appear that condensers having a range of 30–300 $\mu\mu$F., are about the best to use, as these condensers would override the effects of stray capacity and at the same time be sufficiently small to enable many turns to be used in the coils of the input circuit so as to secure a reasonable pick up E.M.F.

### General Conclusions.

It has been shown that when a screen-grid valve is used between two tuned circuits, the residual capacity between grid and plate is the governing factor in the design of these circuits and that, apart from neutrodyning, the best way of securing stability without undue loss of efficiency is by using a radio-frequency transformer in which the primary turns are reduced until the requisite stability attained. The examples chosen to illustrate is the sort of efficiency to be expected are all based on a grid-plate capacity of 0.1 $\mu\mu$F., but it is quite possible that a good commercial screened grid valve will give magnifications twice those quoted in the examples. If this is so then a screen-grid valve should give results comparable with those from a neutrodyned triode without having recourse to the complications of neutrodyned circuits.

Although we have treated only the band 200 to 600 metres, the same principles apply to other bands and the theory shows that the transformer ratio required will vary inversely as the square root of the frequency of instability, while the expected magnification will vary in like manner.

Multi-stage amplification need not be treated in detail as the procedure indicated for one stage should also be applicable for many stages, stability being attained by reducing the primary turns of the intervalve transformers.

It would seem to the writer, however, that it would be preferable in multi-stage systems to interleave transformer coupling with resistance capacity coupling so as to reduce the possibility of instability owing to capacity coupling between tuned circuits.

### Appendix.

Case of imperfect coupling.

If an inductance $l$ is placed in series with the primary of the transformer, then the effective anode admittance is $r^2\beta$ in series with the admittance $1/j\omega_0 l$. Calling this $\beta a$ we have

$$\beta a = r^2\beta/(1 + j\omega_0 l r^2\beta)$$

and the plate voltage becomes

$$v_p = -\frac{\sigma_{pg} v_1 (1 + j\omega_0 l r^2\beta)/j\omega_0 L}{\{r^2\beta^2 + a\sigma_{pg}(1 + j\omega_0 l r^2\beta)\}}$$

The voltage across the secondary of the transformer is

$$v_0 = r v_p/(1 + j\omega_0 l r^2\beta)$$

so that the overall voltage magnification is

$$v_0/v_1 = -\frac{r\sigma_{pg}/j\omega_0 L}{\{r^2\beta^2 + a\sigma_{pg}(1 + j\omega_0 l r^2\beta)\}} \quad .. \quad (1)$$

or using the $G$, $y$ notation and putting $\mu = \omega_0^2 l C r^2 \psi$

$$v_0/v_1 = -\sigma_{pg}/j\omega_0 C r\psi^2$$
$$[(1 + jy)^2 + 2jG\{1 + j\mu(1 + jy)\}] \quad . \quad (2)$$

This equation replaces equation (13) of the text.

Critical stability occurs when the real and imaginary parts of the denominator of (2) vanish simultaneously and thus we find on elimination of $y$

$$G^2 = (1 - 2G\mu)(1 - G\mu)^2 \quad .. \quad (3)$$

as the condition of critical stability.

If $\mu$ is small this may be expressed as a eries giving $G$ in terms of $\mu$—viz. :

$$G = 1 - 2\mu + \tfrac{9}{2}\mu^2 - 11\mu^3 + \frac{227}{8}\mu^4 \quad .. \quad (4)$$

This gives a good approximation up to $\mu = 0.1$, in which case $G = 0.837$. If we use (4) in association with equation (12) of the text to determine the correct transformer ratio, we are led to smaller values of $r$ for stable working, but so long as $\mu$ does not exceed 0.1 the diminution is not serious.

If we have two imperfectly coupled coils having mutual inductance $M$ and coefficient of coupling $k$, the above theory applies if we replace $r$ by $L/M$ and $l$ by $L(1 - k^2)/k^2r^2$, so that, since $\omega_0^2 LC = 1$, $\mu = \psi(1 - k^2)/k^2$. It is seen that with efficient coils, $k$ may be made quite small before $\mu$ becomes as high as 0.1.

We conclude that the theory is reasonably applicable even when the transformer coupling is not perfect.

# Measurements of the Grid-Anode Capacity of Screen-grid Valves.

*By N. R. Bligh, B.Sc. (Eng.).*

**SUMMARY.**—Measurements have been made of the grid-anode capacities of the screen-grid valves of the S625 and the S215 type. The average figure obtained for the S625 was 0.022 micromicrofarads and for the S215 0.014 micromicrofarads.

### Method of Measurement.

THE measurements were made with the valve filaments cold, though when the electron current is flowing the capacities may be slightly different.

A high oscillatory potential was applied across the valve grid-anode capacity $C_0$ and a standard capacity $C_s$.

If $V_t$ is the total applied volts and $V_s$ is the voltage across $C_s$

$$\frac{V_s}{V_t} = \frac{C_0}{C_0 + C_s}$$

and
$$C_0 \doteqdot C_s \frac{V_s}{V_t}$$

since $C_s$ is about $10^4$ times $C_0$.

### Apparatus.

It was considered that the valves would safely withstand a voltage of 600 volts, and using an anode voltage of 420 volts on a D.E.T.1 valve, and a low decrement circuit, a voltage of 700 volts at about 1 mega-cycle was easily obtained. The high potential was read on an electrostatic voltmeter and the low potential on a thermionic voltmeter calibrated at low frequencies.

This voltmeter consisted of a bombarded D.E.V. valve and the circuit used was as shown. The negative bias of 1.5 volts was found advisable, though the voltage to be measured was only 0.1 volt, since, for voltage lower than this, short-circuiting the grid resistance $R$ indicated the presence of grid current by a deflection of the galvanometer $G$.

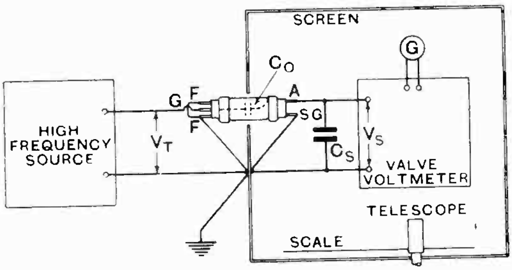
For these small voltages a reflecting galvanometer had to be used and this was used within the screening box.

The scale used was a transparent one reversed, since when viewed as a reflection in the galvanometer mirror, by means of a telescope, it becomes direct reading. The eyepiece of the telescope just projects through a close-fitting hole in the screening box. The galvanometer was brought to zero by varying the resistance $R$ after the preliminary adjustments had been made, as the filament battery was the battery most likely to vary. To do this a close-fitting joint in the lid was made, as all the batteries and resistances are also in the box.

The S625 type of the Marconi Osram Valve Co. was measured first. It was placed in a long close-fitting brass tube in the side of the box.

The filament was earthed externally and the screen-grid internally. The high potential is applied between the control grid and the earthed screening box, the anode being in series with the standard capacity to the inside of the box.

It was decided to calibrate the thermionic




*Arrangement of apparatus.*

voltmeter before and after each test without opening the box. To do this a short piece of stiff wire was attached to the anode pin of the screened valve and hence electrically to the grid of the voltmeter valve. When the screen valve rotates in its tube the wire dips into a mercury pool, in a block of wax, and is connected by a lead to a terminal on the side of the box. During the high-frequency measurements this lead is earthed and the terminal covered by a metal cap.

Using these precautions and making the box of 25 S.W.G. tinned iron, no deflection of the galvanometer took place when the grid of the screened anode valve was earthed, though the electrostatic voltmeter reading 700 volts was directly beside the box. With the lid slightly raised there was no appreciable high-frequency pick-up, but stray low-frequency fields caused a slight deflection, since at low frequencies the grid circuit impedance is high.

Owing to a slight drift in the anode current, readings were taken at equal time intervals, but the deflections were very consistent and could be taken rapidly, agreeing to about 2 per cent.

For each valve four high-frequency measurements were taken. A series of low-frequency measurements were made for each reading, and the voltage to give the high-frequency deflection was obtained graphically. The value of the "standard" capacity includes the effective capacity of the thermionic voltmeter and of the leads to the anode of the screened valve and of this anode to earth, and since the screen-grid is earthed the capacity is quite appreciable. This total capacity was measured, therefore, with the valve in position and was of the order of 100 micromicrofarads. The shunting effect of the grid leak was therefore negligible. For the single-ended valves of the S215 type, of the M.O.V. Co., the screen-grid was earthed externally.

**Measurements.**

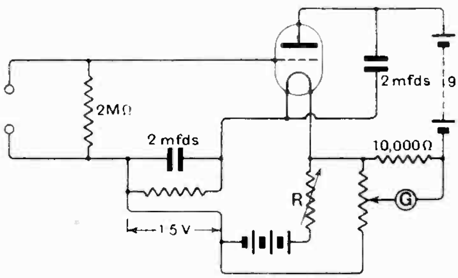
The values obtained were as follows :—

S625. $C_0$ — 0.021, 0.023, 0.021 and 0.022 micromicrofarads.

S215. $C_0$ — 0.016, 0.012, 0.015 and 0.014 micromicrofarads.

The mean valve for each set of four values was therefore, for the S625, 0.022 micromicrofarads and for the S215, 0.014 micromicrofarads, and the latter is slightly more variable.

Normally the screen-grid was at the centre of the tube, but measurements made with it just inside the end of the tube showed no change in capacity, and packing the tube tightly with lead foil also had no effect.




*Valve Voltmeter circuit.*

The values derived are of interest since they are of some assistance in circuit design, but care must be taken to reproduce the shielding conditions.

The author's thanks are due to Mr. A. C. Bartlett, of the Research Laboratories of the G.E.C., Wembley, for the suggestion of the method and advice in carrying it out, and to the above Company for permission to carry out the work in their laboratories.

# On the Writing of Scientific Papers.

*By F. M. Colebrook, B.Sc., D.I.C., A.C.G.I.*

I HAVE lately had occasion to prepare a *résumé* of the literature of a particular branch of the theory and technique of wireless communication. This involved the reading of a very large number of scientific papers and set me wondering why some of them should be so satisfying and easy to read and others of them so very much the reverse. It seemed a good opportunity to try to learn what things to aim at and what to avoid in the exposition of scientific and technical matters. Such observations as I was able to make on this subject I have ventured to set down here, not as a presumptuous offering of advice, but rather as an invitation to comment and suggestion. In doing so I shall at least have reinforced my own good intentions in this respect and may even succeed in interesting some of my fellow workers.

The general conclusion to which I was led is that the preparation and the writing of a paper on even the most severely scientific or technical of subjects is a work of art and should be conceived and executed in that spirit; that it should be judged by the same high standards as a work of art, and demands at least as high an endeavour. This will probably seem an extravagant idea to many, but there is indeed nothing extravagant about it. There is a closer kinship between science and art than is generally realised, though it has been clearly appreciated and as clearly expressed by men distinguished in either field, from Leonardo da Vinci, the great artist-scientist, onwards to, say, Henri Poincaré the mathematician, who has explicitly formulated the æsthetic basis of science in the following words. "The scientist does not study nature because it is useful to do so. He studies it because he takes pleasure in it, and he takes pleasure in it because it is beautiful. . . . I am not speaking of that beauty which strikes the senses, of the beauty of qualities and appearances. I am far from despising this, but it has nothing to do with science. What I mean is that more ordered beauty which comes from the harmonious order of parts, and which a pure intelligence can grasp." And again, suggesting a fundamentally æsthetic basis even for that which is usually considered the most purely rational of sciences, "Briefly stated, the sentiment of mathematical elegance is nothing but the satisfaction due to some conformity between the solution we wish to discover and the necessities of our minds, and it is on account of this very conformity that the solution can be an instrument for us."

This æsthetic element is not confined to the intellectual apparatus of science. It can, and should, find expression in all forms of scientific activity—in the devising of experiments, and the designing of apparatus with which to carry them out; in the analysis of data so obtained, and finally in the exposition of the matter for the benefit of others through the medium of the printed word. In all of these there is scope for that perfect adaptation of means to an end, that ordered harmony of parts and economy of effort that finds an immediate response in the æsthetic part of consciousness. I mean the kind of thing that will on occasion provoke the pleased exclamation "That's very neat," even from one who has no interest at all in the immediate object of the work.

This æsthetic element in science is a tempting field for speculation, and there is a great deal more I would like to say about it; but that would take me rather far from the immediate subject of this essay, which is the technique of the art of applied science, more especially in relation to the writing of scientific papers.

That technique arises naturally from the character of the scientific method. One of the principal characteristics of the scientific method, as also indeed of all forms of art, is economy. To quote once more from Poincaré: " . . . economy of thought, that economy of effort which, according to Mach, is the constant tendency of science, is a source of beauty as well as a practical advantage."

The pursuit of economy will impose certain definite rules. One of the most important can be worded thus. In the analysis or the experimental investigation of any given problem, endeavour to isolate the essential variables.

Two simple examples will perhaps help to make this clear. The anode current in a triode valve is a function of the anode and grid voltages. Representing it by

$$i_a = f(v_a, v_g)$$

it appears that a whole family of curves will be required for a satisfactory delineation of the characteristics of the valve for the range of practical values of $v_a$ and $v_g$; but a theoretical analysis will show that within certain limits of approximation the anode current is the same for any combination of anode and grid voltages which gives the same value to $(v_a + \mu v_g)$ where $\mu$ is a constant number. Here then, is an immediate economy. Putting

$$v_a + \mu v_g = V$$

then $$i_a = f(V).$$

Instead of two variables, the single variable $V$ need only be considered, and, with sufficient accuracy for most practical purposes, the characteristics of the valve can be delineated by means of a single curve.

As another simple example, consider the voltage amplification given by an inductance $L$ of resistance $R$ in the anode circuit of a valve having the characteristics $\mu$ and $R_a$. It is easily shown that at an audible frequency $\omega/2\pi$ the voltage amplification is practically unaffected by the inter-electrode capacities and is given in vector form by

$$\frac{R + j\omega L}{R + j\omega L + R_a}\mu$$

This appears to be a function of five variables. The group $\omega L$ can, however, be treated as a single variable $X$, and any assigned value for this variable will then be applicable to any pair of values of $\omega$ and $L$ having $X$ as product. Thus a first simple economy gives the expression the form

$$\frac{R + jX}{R + jX + R_a}\mu$$

with four variables instead of five. A further inspection now shows that the essential variables of this problem are not $R$, $X$ and $R_a$, but the ratio of $R_a$ to $R + jX$. Putting $a + jb$ for this ratio, the expression becomes

$$\frac{\mu}{1 + a + jb}$$

The magnitude of which is

$$\frac{\mu}{\sqrt{(1 + a)^2 + b^2}}$$

The problem is now reduced to one of three variables only.

This economy of variables is obviously desirable for its own sake, but that is not the whole story. Observe that the elimination of each variable is accompanied by a gain in generalisation. For any assigned values of $a$ and $b$, the above expression is applicable to *any* combination of anode circuit load and internal resistance which satisfies the equation

$$\frac{R_a}{R + jX} = a + jb.$$

Thus the idea of "essential variable" is closely connected with and leads naturally to the idea of generalisation, and generalisation is the very soul of science. It is in respect of this vitally important feature of generalisation that most of the papers I have read in preparing the *résumé* mentioned above are open to criticism. Paper after paper was found to contain nothing more than a record of particular measurements of particular cases, with little or no attempt to disengage the soul of the problem from its matrix of accidental circumstance. In many cases the paper demonstrated nothing more than the author's ability to work out a particular sum in arithmetic and get the correct answer. This achievement is no doubt a source of gratification to the individual concerned, but it is inadequate as a reward to the reader for devoting his attention to the performance.

In some cases the work has been so designed that it does not even contain the possibility of generalisation, suggesting too little thought at the commencement. In others one feels that the author has stopped thinking too soon at the end, for a potential generalisation is arrived at but remains unrevealed.

For a very good illustration of the latter kind I will refer to a paper on aerial couplings which was published some years ago in *E.W. & W.E.*, and lest it be thought that I am unfairly particularising an individual writer for my own base purposes, I would like to state that the paper in question is in my opinion, a very good one indeed. My only criticism is that one step more would have made it even better. The paper is concerned with, amongst other matters, the receiving arrangement shown in Fig. 1a, represented for analysis by the equivalent circuit of Fig. 1b, where $C_1$ represents the effective aerial capacity, including the series condenser, $R_1$ the effective aerial resistance, and $R_s$ the effective input shunt resistance of the receiver. It is shown that under suitable conditions $V/E$ (R.M.S. values) reaches an optimum value given by

$$\frac{V}{E} = \frac{1}{2}\sqrt{\frac{R_s}{R_1 + R}}$$

and there the matter is left. This is certainly a useful and simple result, but it

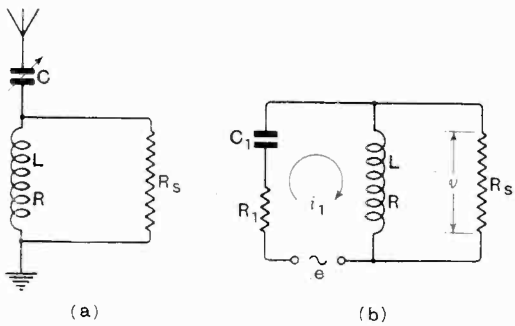


Fig. 1.

stops just short of an even more useful and interesting generalisation. Notice in the first place that a square root of the ratio of two resistances has no immediately obvious physical significance. This aspect of the matter is important and will be further considered. For the present it is enough to point out that this fact should in itself prompt further enquiry, and the squaring of both sides suggests itself as the next step, i.e.,

$$\frac{V^2}{E^2} = \frac{R_s}{4(R_1 + R)}$$

This can now be rearranged thus

$$\frac{V^2}{R_s} = \frac{E^2}{4(R_1 + R)}$$

Already, the significance of the result is becoming clearer, for the left-hand side is the power consumption in the receiver. This fact gives a clue to the significance of the right-hand side, which is discovered to be the power consumed in the aerial and tuning circuit when $i_1$ is in phase with $e$ and the effective resistance is doubled by the load effect of the receiver. A generalisation is now clearly outlined. It is that with *any* single-circuit aerial tuning arrangement in which power is absorbed by the receiver an optimum condition can be established in which there is a balance of power between the receiving system and the remainder of the circuit.

This will of course need further analytical confirmation and experimental test. I had, as a matter of fact, already arrived at such a generalisation by a different route before reading the paper referred to, and a paper on the subject has been prepared for publication. I freely admit that but for this I might not have perceived the generalisation implicit in the above quoted formula, but I also submit that I would have been open to criticism in failing to do so.

It is obvious that generalisation is a very desirable feature in the theoretical or experimental investigation of a problem, and one might be tempted to pursue in all cases the highest attainable degree of generalisation, but some word of qualification is here necessary. Be it admitted that generalisation is the very soul of pure science, it must be remembered, nevertheless, that applied science has, so to speak, a body as well, and a treatment which is all generalisation may not be any more useful than a bricklayer who is all soul. There is, for example, a well-known book on vector analysis, one section of which ends with the words, " Thus . . . the whole of dynamics is included in the remarkable formula $\nabla (L) = 0$." Here is, indeed, the very ecstasy of generalisation, but, to put it colloquially though quite accurately, it is, from a practical point of view, altogether too much of a good thing. The matter is not one in which it is easy to lay down a hard and fast rule, but I suggest the following. A generalised treatment of a practical problem is economic up to the point at which the labour required to isolate a particular case becomes equal to that required for the investigation of the particular case *ab initio*.

In the above example of the generalisation of a particular result, mention was made of the physical interpretation of a certain mathematical formula, and it was shown that the mere rearrangement of the formula in such a way as to bring out its physical significance was sufficient to reveal the latent generalisation. The example leads naturally, therefore, to a further consideration of this matter of mathematical

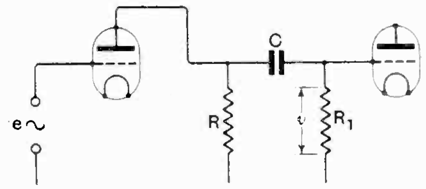



Fig. 2.

formulation, an element of great importance in the technique of the art of scientific exposition.

It has been said, somewhat cynically, that speech was given us to conceal our thoughts. Some writers on scientific subjects seem to think that mathematics was given them to conceal their physics. I would suggest that there is quite definitely a good and a bad mathematical style in the theoretical analysis of physical problems, and that a good style is one in which the mathematical formulation reveals, so to speak, the "physical anatomy" of the problem. An example will perhaps help to make this clear.

In *E.W. & W.E.* for April of 1927 there was published an article on resistance-capacity-coupled low-frequency amplifiers. It happens to be one that I wrote myself and I feel some diffidence in quoting from it on that account However, in spite of certain defects of which I am now uncomfortably conscious, I feel that I can at least claim that I endeavoured to keep the mathematical formulation of the matter clear in the above sense, and the paper contains a particularly good example of the advantages to be gained by so doing. The problem is that illustrated in Fig. 2, and it is a question of finding the ratio of $V$ to $E$, assuming the valve to have the characteristics $\mu$ and $R_a$, at a low audible frequency $n/2\pi$, such that the inter-electrode capacities can be neglected. The circuit can be represented for analytical purposes as shown in Fig. 3. Treating the matter as an exercise in pure algebra, without reference to the physics of the problem, one would arrive at the following vector formula

$$\frac{V}{E}=\frac{jnCR_1(R+R_a)}{(R+R_a)^2+jnc\{R_1(R+R_a)^2+RR_a\}}\,\mu$$

which appears to be an arbitrary conglomeration of symbols quite devoid of physical significance. If, however, in carrying out the analysis, the symbols are organised as far as possible in natural physical groups, the result can be obtained in the form

$$\frac{V}{E}=\left(\frac{R_1}{R_1+\dot{Z}}\right)\left(\frac{R}{R+R_a}\right)\mu$$

where $$\dot{Z}=\frac{RR_a}{R+R_a}+\frac{1}{jnc}.$$

Here $\dot{Z}$ is obviously the impedance of the capacity $C$ in series with the resistances $R$ and $R_a$ in parallel. The second and third factors in the expression for $V/E$ represent the voltage amplification given by the valve in the absence of the coupling capacity and grid leak. The first factor, therefore, represents the effect of the coupling units on the resultant amplification. This is what I mean by a mathematical formulation which reveals the physical anatomy of the problem.

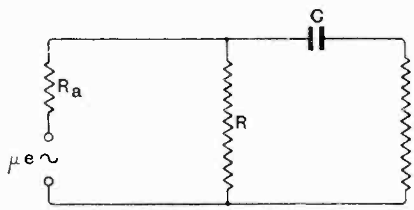



Fig. 3.

A further very important advantage of what I have called a good applied mathematical style is that it is far less liable to error than the pure algebraic style. Suppose, for example, that by some mistake in analysis the first factor had appeared in the form $\dot{Z}/(R_1+\dot{Z})$. A very little thought as to the physical significance of this would show that there was something wrong somewhere, whereas in the other formulation such a mistake might easily pass unnoticed.

The above reference to the physical anatomy of a problem introduces another important feature of technique, one which is, however, concerned with the design of experiment rather than with the exposition of results. Æsop has neatly embodied the idea in his fable about breaking the bundle of sticks. In its present application the idea is that a problem should be resolved into its simplest factors. Suppose, for example, that it is desired to investigate frequency distortion in the reception of wireless telephony by means of a retroactive grid-circuit rectifying detector with one stage of transformer-coupled low-frequency amplification supplying a loud speaker. One might of course, induce a known modulated electromotive force into the tuned circuit and measure the sound intensity as a function of the modulation frequency, but the data so obtained would be practically useless for analytical or design purposes, for it would present the inextricably combined effects of no less than ten separate and distinct factors. These are :—

(*a*) the side-band cut-off effect of the input tuned circuit ;

(*b*) the inherent frequency-efficiency variation of the grid-circuit rectification process ;

(*c*) the effect of the load in the anode circuit of the detector valve on the input impedance of the latter, which input impedance will possibly modify (*b*) ;

(*d*) the frequency characteristics of the low-frequency transformer ;

(*e*) the effect of the detector valve on (*d*) ;

(*f*) the effect of the input impedance of the output valve on (*d*) ;

(*g*) the effect of the loud-speaker load on the input-impedance of the output valve, and thus on (*d*) ;

(*h*) the frequency variation of the impedance of the loud-speaker load ;

(*i*) the frequency variation of the electrical efficiency of the power-valve/loud-speaker combination ;

(*j*) the frequency variation of the acoustic efficiency of the loud speaker ;

A systematic analytical or experimental investigation of the problem requires the isolation and the separate investigation of each of these factors. This may appear laborious, but is in fact an economy of effort, for observe that, each factor being known, *any* combination of them is also known, whereas in default of such systematic investigation each particular combination would require investigation *de novo*, and the data obtained would not permit of further generalisation.

It might by some be thought unnecessary at this stage in our scientific development to preach so obvious a platitude, but in fact contemporary scientific literature contains a surprising amount of justification for so doing.

Finally, assuming that the work to be described has been well conceived and well executed, there remains the actual describing of it to be considered. Here the kinship with art, in this case the art of writing, is obvious ; but, of course, there are differences. The word "style" is applicable in both cases, but the criterion of criticism in scientific writing will be in some degree peculiar to itself. It is not a matter that lends itself to precise formulation, but there are certain general principles that will probably find acceptance, at least as counsels of perfection.

In the first place, it will probably be agreed that the feature which has importance above all these is clarity, and this should be sought not only in the choice of the individual word, but also, and more particularly, in the arrangement of the paper as a whole.

Some while ago, I happened to see a maker of clay statues at work. I noticed that he began by roughly fashioning a wire framework or skeleton which followed the main lines of the figure or group that was intended to be made. This was then clothed, still roughly, with clay, and finally, the actual modelling was done and superfluous material thumbed away. I felt that he was giving me a useful lesson in the art of writing scientific papers. Begin with the wire framework ; then, however complicated the theme, some degree of organic unity is assured. Bergson's essay on laughter, treated from a scientific point of view, is a beautiful example of the value of thus framing up the subject before clothing it in words. It is only fair to say that lack of preliminary design was not conspicuous as a defect in the papers I have had to read. In some even the authors had made things easy for the reader by a preliminary statement of exactly what questions they had set themselves and a final statement of exactly what answers they had obtained. Such papers were rare, but very refreshing. On the other hand, there were papers of which the various parts seemed to have no more organic coherence than the apparently accidental circumstance of spatial proximity. These, fortunately, were also rare.

On the matter of actual wording and phrasing. I have no doubt that much could be said by a qualified person, which I do not claim to be. Here again, however, economy would seem to be a good guiding principle, leading to precision and aptness rather than abundance. As between hitting the bull's eye with a single well-aimed shot and blowing the target to pieces with a machine gun, there can be no doubt as to which is the more admirable performance.

Though I am here suggesting that clearness and economy are the principal desiderata of scientific literary style, I would not have it thought that the more purely literary graces are necessarily out of place in a scientific paper. Let those who have it in them to do so endow their scientific writings with all the beauty of English prose, so long as they preserve the precision and clearness which are the first essentials of scientific writing. After all there is no reason why a scientific paper should not be pleasant to read, in the ordinary æsthetic, as well as the intellectually æsthetic, sense. Up to the present, however, my experience is that such papers are non-existent in German, rare in English, and slightly less rare in French, but that of course may be an accidental consequence of my limited range of reading. Amongst those in English I might mention for instance those by Dr. W. F. C. Swann, in the Journal of the Franklin Institute. Here is one writer at least who can expound the weightiest of matters in a style that runs easily on light feet.

In conclusion, although I am not clear as to how far an essay on the writing of scientific papers is to be considered as a scientific paper, I feel I had better put myself on the safe side of my own criticisms by recapitulating the ideas which I hope to have demonstrated. I have sought to show that the application of the scientific method and the writing of scientific papers should be considered as a work of art, and that in the technique of that art the following are important elements:—

(1) The isolation of the essential variables of a problem both in analysis and in the design of experiments.

(2) The attainment of the highest economic degree of generalisation.

(3) The preservation of the "physical anatomy" of a problem in its mathematical formulation.

(4) The reduction of a problem to its simplest constituent elements for purposes of investigation.

(5) The arrangement of the written exposition in a manner appropriate to the organic unity of the problem considered.

(6) Precision and economy in the phrasing of the written exposition.

# Push-Pull Amplification.

## The Use of Resistance Capacity Coupling.

*By F. Aughtie, M.Sc.*

**SUMMARY.**—To obviate the need for a transformer, use is made of the phase reversal which takes place in a single resistance capacity coupled stage, to provide a grid feed for the second valve of the output pair.

A potentiometer adjustment enables the grid swings of the two output valves to be adjusted to give optimum output power, the correct setting being obtained very easily using only a milliammeter and a pair of phones.

THE arrangement of a pair of valves, (or banks of valves), working in opposite phase, commonly called "Push-pull," has not hitherto been extensively used for amplifiers designed for the highest quality, probably because the usual circuit requires the use of a transformer having a centre tap on the secondary. It is possible, however, to utilise the phase reversal given by a single resistance coupled stage to replace the transformer, enabling resistance coupling to be used throughout.

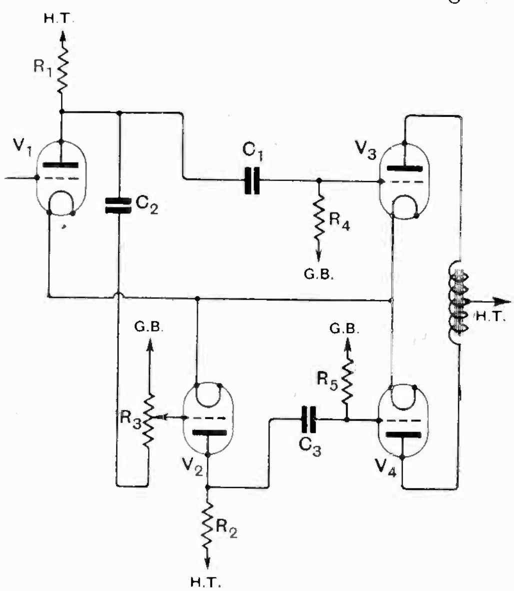



FIG. 1.—*The grid swing of the valve $V_3$ is reversed in phase by the valve $V_2$ and applied to the grid of $V_4$. The tapping on $R_3$ is adjusted so that the anode current variations of $V_3$ and $V_4$ are the same.*

In a single stage, comprising a valve and anode resistance, when the grid is made more positive, the feed current increases: this causes a larger drop of voltage in the coupling resistance, and hence the anode becomes less positive. The grid of the succeeding valve thus becomes more negative. If then the stage gain is made unity by any convenient means, we have a device which gives a phase reversal and which can be used to provide the grid swing for the second valve of the output pair. The stage gain is most conveniently reduced by feeding the input through a potentiometer, rather than by reducing the output, since the valve has then to deal with a smaller voltage swing.

Referring to Fig. 1, $V_1$ is the normal penultimate valve of the amplifier, its grid being fed in the usual way: it feeds one valve $V_3$ of the output pair through the condenser $C_1$, and also the grid of the phase reverser valve $V_2$ through the condenser $C_2$, and potentiometer $R_3$ which serves also as a grid leak. The grid of the second output valve $V_4$ is coupled to the anode of $V_2$ with the condenser $C_3$.

Alternatively, the feed for $V_2$ can be tapped off from the resistance $R_1$ as shown in Fig. 2: there is little to choose in practice between these two arrangements, as once the correct tapping has been found it remains fixed until one of the two output valves is changed.

Clearly the potentiometer ratio should be independent of frequency, and hence if the tapped grid leak arrangement is used, the leak should be of fairly low resistance so that the input capacity of $V_2$ causes no sensible alteration in the ratio over such frequency ranges as are used in practice. This effect is further minimised by using a valve having a low amplification factor for the phase reverser, not only because this reduces the step down ratio required in the potentiometer, but also because the input capacity of such a valve will be lower than that of an otherwise similar valve having a higher amplification factor. In general, $V_2$ is most conveniently made of the same type as $V_1$, and since the output voltages are approximately the same, the coupling resistances can have the same value.

Due to the input capacity of the valve $V_4$, the reversal of phase given by $V_2$ will not be complete for the higher frequencies, but for such deviations as are likely to occur in practice, this results in a negligible loss, as may be seen by drawing the vector diagram. Fortunately, both this effect and the variation of stage gain with frequency are minimised by using a valve having a low amplification factor for $V_2$*.

So far, it has been assumed that the input swings to the two output valves are the same, and that a common value of grid bias is used. It has been shown by Denman (*E.W. & W.E.*, Vol. IV, page 669, and Vol. V, page 42) that when two slightly dissimilar valves are operated in parallel, a considerable increase of maximum (distortionless) output power can be obtained by supplying the valves with separate grid bias and input swings.

Unless separate output transformers are used (and the slight additional gain resulting from their use is insufficient to warrant this) the optimum adjustment is such as results in equal H.T. feed currents to the two valves, and equal changes of anode current when operating into their normal load.

The first condition, that of equal feed currents, is readily obtained with a milliammeter, since it is obvious that separate grid bias can be applied to the two output valves through the two grid leaks $R_4$ and $R_5$. This adjustment has the further advantage of completely removing any polarisation from the core of the output choke (or transformer).

The second condition, that of equal alternating output currents from the two valves, is even more readily obtained. Obviously, the H.T. feed is the sum of the two anode currents and (since the two valves are operating in opposite phase) when the grid swings are such as give rise to equal current changes, there will be no component of the signal frequency in the H.T. feed. Thus, if instead of adjusting the potentiometer to give equal grid swings, it is adjusted so that when the valves are operating into their normal load the H.T. feed is free from any signal component, the output valves will then be working to their best advantage.

* See Hartshorn, "Inter-electrode Capacities and Resistance Amplification," *E.W.*, Vol. V, p. 419.

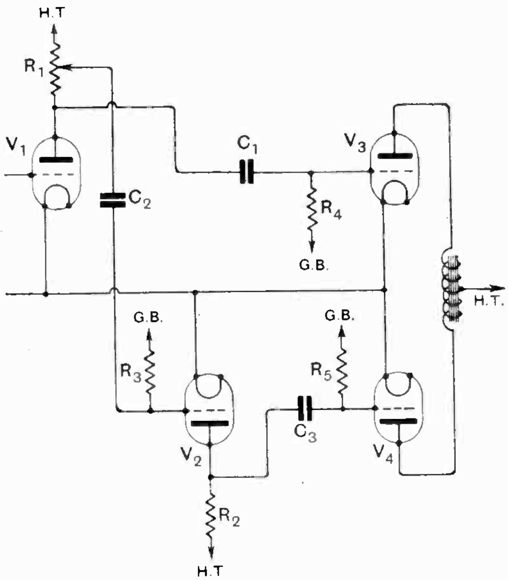



FIG. 2.—*To obviate the use of a large condenser for $C_2$ caused by the need for a low value of $R_3$ when the circuit of Fig. 1 is used, the grid swing for $V_2$ may be tapped off from the coupling resistance $R_1$. It is not necessary to alter the position of the tapping after initial adjustment.*

In practice, the setting of the potentiometer is altered until there is no sound, or a minimum sound, in a pair of phones connected in the H.T. lead to the last stage when there is a signal input to the grid of valve $V_1$. Naturally the feed current should be kept out of the phones by the use of a suitable choke and condenser filter.

This setting also results in there being a minimum of back coupling to earlier stages due to battery resistance.

The adjustment is most conveniently done with a single frequency input, since if the output valves are dissimilar, the setting will depend upon the output load, and this will, in general, vary with frequency. Thus it is not possible to obtain complete silence in the phones if the input to the valve $V_1$ is not of a single frequency.

A second factor which prevents a complete extinction is the departure from complete phase reversal at high frequencies due to the input capacities to which reference has already been made, thus the adjustment is most conveniently made at a medium frequency where this effect is small.

As compared with normal parallel operation of two valves, the arrangement described has the following advantages:—

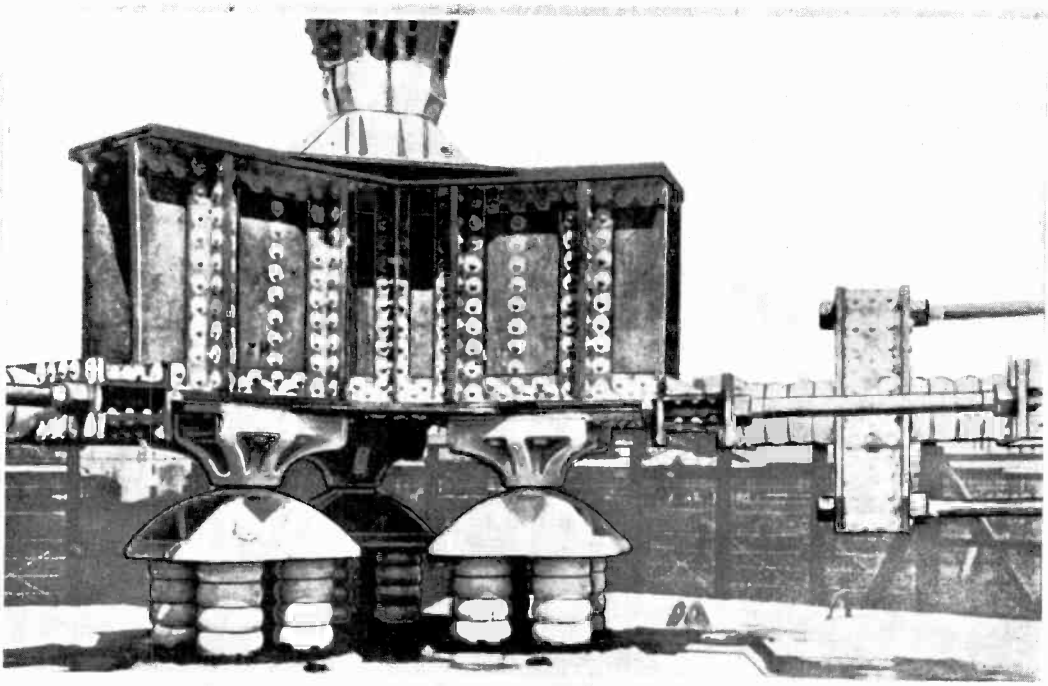
(1) There is no polarisation of the output choke, hence it can be made smaller.

(2) If the output valves are slightly dissimilar the output power may be increased by as much as 200 per cent.,* while at the same time the back coupling due to battery resistance is greatly reduced.

It may be noted as a matter of interest, that by inserting a choke in the H.T. feed to the valves the input swings can be adjusted so that both valves are working over the whole of the straight portion of their characteristics (the grid remaining always negative), and hence the output power will be the sum of the two operating singly. This would, however, give a gain altogether incommensurate with the additional complication.

* See Denman, *loc. cit.*

# Nagoya Wireless Station.



*The photograph reproduced here shows interesting details in the construction of the base of one of the masts of the Nagoya wireless station, which was built by the Telefunken Company for the Japanese Wireless Telegraph Company in Tokyo.*

*The special construction of the mast bases is made necessary in order to suit the peculiar conditions in Japan, where there is the ever-present danger of earthquakes, making it essential that, whilst maintaining proper insulation, the mast should have a certain freedom of movement within limits in the event of earthquake shocks. The station has eight masts, each 250 metres high, and is operated by a high-frequency alternator of 650 kW. From the point of view of power it is claimed that this station is now one of the largest in the world.*

# The Problem of "Turn-over."

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

IT is found that under certain conditions the value of the current obtained in the plate circuit of a rectifying tube, for a given A.C. input, is not the same if the connections to the input of the rectifier are reversed. The ratio of the two values of the plate current is known as the "turn-over," and this article considers the conditions under which it is obtained.

The results obtained are applied to the case of the ordinary valve-voltmeter and to the valve-voltmeter which uses the "slide-back" principle.

Consider an ordinary rectifier and assume that the bias applied to its grid has a value $a$.

Since the output from an oscillator (or any similar system) is generally applied to a rectifier through a transformer, therefore the mean value of the oscillator voltage wave must be zero. It can therefore be represented by:

$$V_0 = V_1 \sin \omega t + V_2 \sin (2\omega t + \theta_2) + \dots V_n \sin (n\omega t + \theta_n) = \phi(t).$$

The voltage applied to the grid of the rectifier is therefore given by:

$$v_g = a + \phi(t).$$

The equation of the rectifier characteristic can be represented by:

$$i_a = f(v_g).$$

Hence the plate current at any instant is given by:

$$i_t = f[a + \phi(t)].$$

This expression can be expanded by Taylor's Theorem and we have:

$$i_t = f(a) + \phi(t) \cdot f'(a) + \frac{[\phi(t)]^2}{\lfloor 2} f''(a) + \dots \frac{[\phi(t)]^n}{\lfloor n} f^n(a) \quad \dots (1)$$

where $f^n(a)$ denotes the $n$th derivative of $f(a)$.

The mean rectified plate current is given by:

$$I_+ = \frac{\omega}{2\pi} \int_0^{2\pi/\omega} i_t dt.$$

$$= f(a) + a_1 f'(a) + \frac{a_2}{\lfloor 2} f''(a) + \dots \frac{a_n}{\lfloor n} f^n(a) \quad \dots (2)$$

where

$$a_n = \frac{\omega}{2\pi} \int_0^{2\pi/\omega} [V_1 \sin \omega t + V_2 \sin (2\omega t + \theta_2) + \dots V_n \sin (n\omega t + \theta_n)]^n dt \quad \dots (3)$$

If the connections from the oscillator to the rectifier are now reversed, the voltage applied to the grid will be given by:

$$v'_g = a - \phi(t)$$

Hence the mean rectified plate current will now be given by:

$$I_- = f(a) - a_1 f'(a) + \frac{a_2}{\lfloor 2} f''(a) + \dots (-)^n \frac{a_n}{\lfloor n} f^n(a) \quad \dots (4)$$

The difference between the mean rectified current is therefore given by:

$$I_0 = I_+ - I_-$$

$$= 2\left[a_1 f'(a) + \frac{a_3}{\lfloor 3} f'''(a) + \frac{a_5}{\lfloor 5} f^v(a) + \dots \frac{a_{2r+1}}{\lfloor 2r+1} f^r(a) + \dots\right] \quad \dots (5)$$

We shall now evaluate $a_1$, $a_2$, and $a_3$. These can be obtained from equation (3) by putting $n = 1$, 2, and 3, respectively.

$$a_1 = \frac{\omega}{2\pi} \int_0^{2\pi/\omega} [V_1 \sin \omega t + V_2 \sin(2\omega t + \theta_2) + \dots V_n \sin (n\omega t + \theta_n)] dt$$

$$= \frac{\omega}{2\pi} \int_0^{2\pi/\omega} V_1 \sin \omega t + \frac{\omega}{2\pi} \int_0^{2\pi/\omega} V_2 \sin (2\omega t + \theta_2) + \dots$$

$$= 0 \quad \dots (6)$$

$$a_2 = \frac{\omega}{2\pi}\int_0^{2\pi/\omega} V_1 [\sin \omega t + V_2 \sin(2\omega t + \theta_2) + \ldots V_n \sin (n\omega t + \theta_n)]^2 dt$$

$$= \frac{\omega}{2\pi}\left[\int_0^{2\pi/\omega} V_1{}^2 \sin^2 \omega t \,.\, dt + \int_0^{2\pi} V_2{}^2 \sin^2 (2\omega t + \theta_2)\, dt + \ldots\right]$$

$$+ 2 \,.\, \frac{\omega}{2\pi}\left[\int_0^{2\pi/\omega} V_1 V_2 \sin \omega t \,.\, \sin (2\omega t + \theta_2)\, dt + \ldots\right]$$

$$= \tfrac{1}{2}[V_1{}^2 + V_2{}^2 + \ldots V_n{}^2] \quad \ldots \quad \ldots (7)$$

$$a_3 = \frac{\omega}{2\pi}\int_0^{2\pi/\omega}\left[V_1 \sin \omega t + V_2 \sin (2\omega t + \theta_2) + \ldots V_n \sin (n\omega t + \theta_n)\right]^3 dt$$

$$= \frac{\omega}{2\pi}\left[\int_0^{2\pi/\omega} V_1{}^3 \sin^3 \omega t\, dt + \int_0^{2\pi/\omega} V_2{}^3 \sin^3 (2\omega t + \theta_2)\, dt + \ldots\right]$$

$$+ \frac{3\omega}{2\pi}\left[\int_0^{2\pi/\omega} V_1{}^2 V_2 \sin \omega t \,.\, \sin (2\omega t + \theta_2)\, dt + \ldots\right]$$

$$+ \frac{3\omega}{2\pi}\left[\int_0^{2\pi/\omega} V_2{}^2 V_1 \sin^2 (2\omega t + \theta_2) \sin \omega t \,.\, dt + \ldots\right]$$

$$+ \ldots\ldots\ldots\ldots$$

$$+ \frac{6\omega}{2\pi}\left[\int_0^{2\pi/\omega} V_1 V_2 V_3 \sin \omega t \,.\, \sin (2\omega t + \theta_2) \sin (3\omega t + \theta_3)\, dt + \ldots\right]$$

$$= \tfrac{3}{4}[- V_1{}^2 V_2 \sin \theta_2 + V_2{}^2 V_4 \sin (2\theta_2 - \theta_4) + V_3{}^2 V_6 \sin (2\theta_3 - \theta_6) + \ldots]$$

$$= \tfrac{3}{4}\sum_{r=1}^{r=n/2} V_r{}^2 V_{2r} \sin (2\theta_r - \theta_{2r}) \quad \ldots (8)$$

In practice the derivates such as $f'''(a)$, etc., would be calculated from the equation of that portion of the rectifier characteristic which was being operated on. It can generally be assumed that this equation will not contain terms with powers higher than the third, and hence all derivates higher than the third will be zero. It will be shown later that the assumption that the equation for the characteristic does not contain appreciable terms with powers higher than the third is justified.

Hence making use of equations (6) and (8) and assuming that the equation for the rectifier characteristic does not contain powers higher than the third, equation (5) reduces to:

$$I_0 = \frac{2a_3}{\lfloor 3} f'''(a)$$

$$= \frac{f'''(a)}{4} \,.\, \sum_{r=1}^{r=n/2} V_r{}^2 V_{2r} \sin (2\theta_r - \theta_{2r}) \quad (9)$$

As an illustrative example consider a voltage wave of the form:

$$V = V_1 \sin \omega t + V_2 \sin (2\omega t + \phi_2) + V_3 \sin (3\omega t + \phi_3) + \ldots\ldots V_6 \sin(6\,\omega t + \phi_6)$$

applied to a rectifier whose equation is:

$$i = A + Bv_g + Cv_g{}^2 + Dv_g{}^3 + Ev_g{}^4$$

$$\therefore \quad \frac{d^3 i}{dv_g{}^3} = 6D + 24Ev_g$$

$$\therefore \quad f'''(a) = 6D + 24Ea.$$

Since there are only six harmonics, therefore $n = 6$ in equation (9).

Hence:

$$I_0 = \frac{f'''(a)}{4}\left[V_1{}^2 V_2 \sin (2\theta_1 - \theta_2) + V_2{}^2 V_4 \sin (2\theta_2 - \theta_4) + V_3{}^2 V_6 \sin (2\theta_3 - \theta_6)\right]$$

Therefore

$$I_0 = \tfrac{3}{2}(D + 4Ea)[- V_1{}^2 V_2 \sin \phi_2 + V_2{}^2 V_4 \sin (2\phi_2 - \phi_4) + V_3{}^2 V_6 \sin (2\phi_3 - \phi_6)]$$

Consideration of equation (9) will give the different factors which influence the value of $I_0$. They may be summarised as follows:

(1) The value of $I_0$ will be zero if the equation of the rectifier characteristic does not contain powers higher than the second. In this case the value of $f'''(a)$ will be zero.

(2) If over a certain range, the equation of the rectifier characteristic can be expressed by a cubic, then, if the input is kept constant and the valve is operating within this range, the value of $I_0$ will be independent of the value of $a$ (*i.e.*, the grid bias). This is due to the fact that for a cubic the value of $f'''(a)$ will be a constant and independent of $a$, and hence from equation (9) the value of $I_0$ will remain constant.

(3) For a given value of $f'''(a)$ and for a given wave form, the value of $I_0$ will increase with increase of input. It can be seen, for example, that if there is only a second harmonic present, the value of $I_0$ will be

proportional to the cube of the input voltage.

(4) The value of $I_0$ will be zero if the voltage wave does not contain the appropriate harmonics. It is seen that the value of $I_0$ is dependent on the product of a given harmonic with a harmonic of twice its frequency. Hence, unless the voltage wave contains a harmonic of double the frequency of any given harmonic, that harmonic will not influence the value of $I_0$. For example, the fundamental $V_1$ requires a second harmonic to give the necessary product, and hence so long as the voltage wave contains a second harmonic there will be a value of $I_0$, providing the other conditions are satisfied. Similarly a third harmonic requires a sixth harmonic to give the necessary product, and so on. Thus it can be seen that the value of $I_0$ will be zero if there are only odd harmonics present in the voltage wave. Even harmonics, higher than the second, will only influence the value of $I_0$ if the appropriate harmonics of half or double frequency are also present.

(5) The value of $I_0$ will be zero if some of the harmonics are not out of phase with the fundamental. In this case $\theta_2$, $\theta_3$, etc., will be zero, and hence $\sin(2\theta_r - \theta_{2r})$ will be zero, thus giving a zero value for $I_0$. Also, the value of the phase angle of any given harmonic must not be equal to half the value of the phase angle of the appropriate double frequency harmonic. If the phase angles are so related then $2\theta_r - \theta_{2r} = 0$, and the two harmonics under consideration will not affect the value of $I_0$.

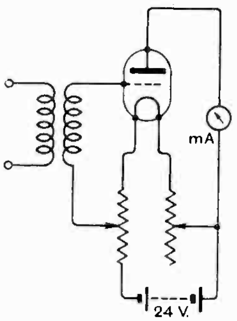


Fig. 1.—*Rectifier circuit.*

The above points can be summarised as follows: The difference between the two values of rectified plate current is due to the fact that the applied voltage contains certain out-of-phase harmonics, and that it is applied to a rectifier whose characteristic can be expressed by an equation which is at least a cubic over the working portion.

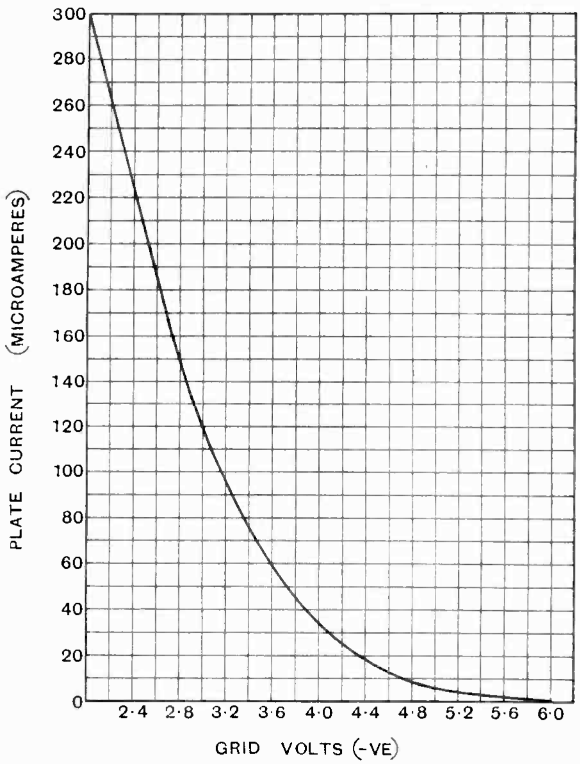


Fig. 2.—*Rectifier valve characteristic.*

Now "turn-over" has been defined as $I_-/I_+$ and it is therefore given by:

$$\text{T.O.} = I_-/I_+ = 1 - \frac{I_- - I_+}{I_+}$$
$$= 1 - I_0/I_+ \quad .. \quad (10)$$

Since the error introduced in a given measurement will depend not so much on the value of $I_0$ as on the relative values of $I_0$ and the nominal value of the plate current $I_+$, therefore the value of the "turn-over," and not the value of $I_0$ only, should be used as the basis of measurement. It follows that the error in a given measurement will be proportional to the amount by which the value of the "turn-over" differs from unity. With reference to the above, it should be pointed out that when making an experimental test, the key which reverses the output from the oscillator is labelled so that one position of the key is associated with $I_+$ and the other with $I_-$. The choice of these positions is quite arbitrary but it must be adhered to throughout the test. Therefore in equation (10) it does not matter which we call $I_+$ or $I_-$ so long as it is understood that one position of the reversing key will always give $I_+$ and the other $I_-$.

The above theory will now be applied to the case of the valve-voltmeter of the ordinary and of the "slide-back" type.

A rectifier of the form shown in Fig. 1 was fitted up and its characteristic obtained.

The non-linear part of the curve obtained is shown in Fig. 2, and by calculation its equation from $V_g = 2.8$ to $v_g = 5$ was found to be given very closely by:

$$I_a = 146 - 150\, v_g + 56.5\, v_g^2 - 7.9\, v_g^3$$

From $v_g = 5$ to $v_g = 6$, its equation was found to be:

$$I_a = 6 - 10\, v_g + 10\, v_g^2 - 9.3\, v_g^3 + 1.8\, v_g^4 + 2.2\, v_g^5$$

The curve between $v_g = 0$ and $v_g = 2.8$ is approximately a straight line.

For convenience the grid voltages have been plotted and inserted in the equations as if they were positive although actually negative bias was used.

From the equations it can be seen that when the valve is used as a rectifier, the major part of the operating portion of the characteristic can be represented by a cubic. Hence over this portion the value of $I_0$, for a given input, will be independent of the value of the grid bias.

Consider first the ordinary valve-voltmeter. In the case of this instrument the rectifier is calibrated with some fixed value of the grid bias; the unknown voltage is then applied and from the calibration curve the value of the applied voltage is obtained for the corresponding plate current. We are therefore interested in how the value of the "turn-over" varies for a given input with the value of the initial grid bias. The following test was therefore carried out. The input* to the rectifier was maintained constant, and for different values of the grid bias the values of the plate current with the connections to the rectifier normal and with these connections reversed were obtained. The measurements are given in Table I, and Fig. 3 shows a curve between "turn-over" and grid bias. From this curve it is seen that the amount by which the value of the "turn-over" differs from unity increases as the negative bias is increased. The reason for this is as follows:

TABLE 1.

| Initial Plate Current. | Grid Bias Volts. | $I_-$ $\mu a$. | $I_+$ $\mu a$. | $I_0 = I_+ - I_-$ $\mu a$. | T.O. $= I_-/I_+$ |
|---|---|---|---|---|---|
| 5 | −5.04 | 47 | 40 | −7 | 1.175 |
| 10 | −4.70 | 66.5 | 59 | −7.5 | 1.125 |
| 15 | −4.50 | 79.5 | 72 | −7.5 | 1.102 |
| 20 | −4.32 | 93 | 85.5 | −7.5 | 1.086 |
| 30 | −4.08 | 113.5 | 106 | −7.5 | 1.070 |
| 40 | −3.88 | 132 | 125 | −7.0 | 1.055 |
| 50 | −3.72 | 148.5 | 141.5 | −7.0 | 1.050 |
| 60 | −3.58 | 163 | 156 | −7.0 | 1.045 |
| 70 | −3.46 | 178 | 171 | −7.0 | 1.040 |
| 80 | −3.36 | 190 | 184 | −6.0 | 1.032 |

A.C. input kept constant.

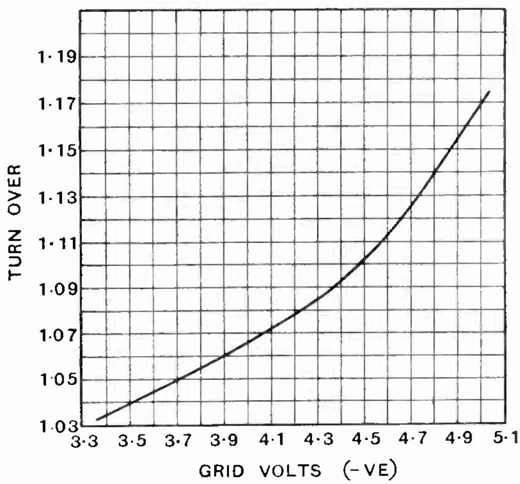



Fig. 3.—*Turn-over-grid bias curve with constant input.*

Since most of the measurements were made on, or very near to, the portion of the characteristic whose equation is a cubic, therefore the value of $I_0$ will not change very much with the value of the grid bias. The value of the nominal plate current (*i.e.*, $I_+$) will, however, decrease as the negative grid bias is increased, and hence the ratio $I_0/I_+$ will increase. Therefore the difference between the value of the "turn-over" and unity will decrease as the negative grid bias is reduced.

* The oscillator which gave this input was adjusted to give a bad wave-form.

The fact that $I_0$ remains practically constant is borne out by column 5 of Table I.

In the case of the ordinary valve-voltmeter, therefore, the error due to "turn-over" will become less as the initial negative bias on the grid of the rectifier is reduced.

Consider now the case of the "slide-back" valve-voltmeter. In this case the plate current is set at some fixed value by means of the grid bias. The voltage to be measured is then applied and the grid bias is adjusted to give the same plate current.

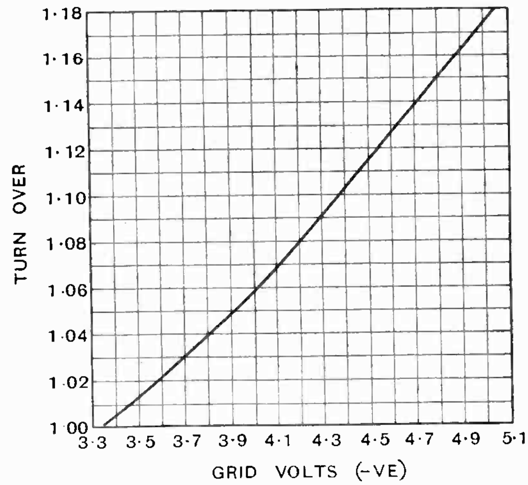



Fig. 4.—*Turn-over-grid bias curve with constant plate current.*

The difference between the two values of grid bias gives a measure of the applied voltage. In this case we are therefore interested in the change in "turn-over" with grid bias for a constant value of the plate current. The following test was therefore carried out. For different values of the grid bias the input was adjusted to give the same value of plate current with the connections from the oscillator to the rectifier normal. In each case the reading of the plate current with the connections reversed was recorded and the "turn-over" calculated. Fig. 4 shows the curve obtained between "turn-over" and grid bias. The "turn-over" is also a measure of $I_0$, since the nominal value of the plate current was made 100 micro-amps. It is seen that the curve of Fig. 4 is similar in shape to the curve of Fig. 3 in that the amount by which the value of the "turn-over" differs from unity decreases with decrease of negative grid bias. The shape of the curve of Fig. 4 can be accounted for as follows: Since the value of $I_+$ is kept constant, therefore we have from equation (10) that the value of the "turn-over" will be directly proportional to the value of $I_0$. Now as the negative bias is reduced, the initial plate current will increase and hence the value of the input will have to be reduced to obtain the same value for $I_+$. Also the rectifier is operating mainly over that portion of the characteristic which may be represented by a cubic, therefore the value of $f'''(\alpha)$ will remain practically constant during the test. Hence it follows from equation (9) that the value of $I_0$ will decrease as the input to the rectifier is decreased, that is, as the negative bias applied to the grid is reduced. Therefore the amount by which the value of the "turn-over" differs from unity will become smaller as the negative bias applied to the grid is decreased. This type of valve-voltmeter is therefore similar to the ordinary valve-voltmeter in that the error due to "turn-over" becomes less as the negative bias on the grid is reduced.

A final test was carried out on the rectifier of Fig. 1. The grid bias was kept fixed at $-4.32$ volts and readings of "turn-over" for different values of the input were recorded. The measurements are given in

TABLE 2.

| $I_-$ Micro-amps. | $I_+$ Micro-amps. | $I_0 = I_+ - I_-$. | T.O. $= I_-/I_+$. |
|---|---|---|---|
| 42 | 40 | −2 | 1.05 |
| 53 | 50 | −3 | 1.06 |
| 64.5 | 60 | −4.5 | 1.07 |
| 87 | 80 | −7.0 | 1.0875 |
| 109.5 | 100 | −9.5 | 1.095 |
| 132 | 120 | −12.0 | 1.10 |
| 154 | 140 | −14.0 | 1.10 |
| 177 | 160 | −17.0 | 1.106 |

Grid bias kept constant at −4.32 volts.

Table II, and from these it is seen that the difference between the value of "turn-over" and unity increases slowly with increase of input. The reason for this is as follows:

Since the grid bias is kept constant therefore the value of $f'''(\alpha)$ will remain constant, and hence from equation (9) the value of $I_0$ will increase as the input is increased. The value of $I_+$, however, will also increase with input, and hence the ratio $I_0/I_+$ will only increase with input so long as the rate of increase of $I_0$ is greater than that of $I_+$.

The results of this test indicate how the valve will behave, with reference to "turn-over," when it is used as an ordinary rectifier.

Table 2 shows that for the inputs used during the test, the rate of increase of $I_0$ was greater than that of $I_+$, although the rate of increase of the latter seemed to increase more rapidly than that of the former as the input was increased.

## Conclusions.

1. In both types of valve-voltmeters there will be an error due to "turn-over" if the applied voltage wave contains suitable harmonics and if the equation of the rectifier characteristic is at least a cubic.

2. The error due to "turn-over" will become less as the value of the negative grid bias on the rectifier is decreased.

3. To avoid error due to "turn-over" it would be necessary:

(*a*) To make the input free from harmonics, or

(*b*) To employ two valves to form a balanced rectifier. In this way full-wave rectification will be obtained and the value of the mean plate current will be independent of the connections from the oscillator to the rectifier.

4. The error due to "turn-over" can also be avoided:

(*a*) By employing a rectifier whose characteristic can be expressed by a quadratic over the operating portion, or

(*b*) By determining the value of the grid bias so that the operating point is in a region where the rectifier characteristic can be expressed by a quadratic, and arranging that the input to the rectifier is such that the grid swing does not go beyond this region. The valve-voltmeter can then be used in the manner indicated in Fig. 5.

The meter is calibrated by determining the attenuation required to give a fixed rectified plate current for known inputs to the terminals *AB*. The value of this rectified current is determined by taking into account the fact that the input to the rectifier must be such that the working portion of the characteristic can be expressed by a quadratic. The value of an unknown voltage can then be determined from the calibration curve from a knowledge of the attenuation required to give the fixed plate current with that voltage. In this method the input to the rectifier will be the same for all voltages applied to terminals *AB* and hence the same

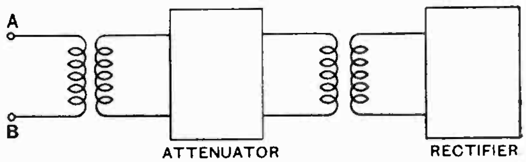



Fig. 5.—*Method of employing the valve voltmeter.*

portion of the rectifier characteristic will be used in all cases. This method has the additional advantage in that the value of the rectified current will be independent of the shape of the input wave and it will be directly proportional to square of the R.M.S. value of the input voltage. The calibration curve will therefore hold for all inputs. The reason for this can be seen from the following considerations. Since the working portion of the rectifier characteristic can be expressed by a quadratic, therefore we have from equations (2) and (4) that:

$$I_p = I_+ = I_- = f(a) + a_1 f'(a) + \frac{a_2}{|2} f''(a)$$

Hence from equations (6) and (7) we have:

$$I_p = f(a) + \frac{f''(a)}{2} \cdot \frac{V_1^2 + V_2^2 + \ldots V_n^2}{2}$$

Now $f(a)$ is the value of the plate current due to the initial grid bias, and $f''(a)$ will be a constant for a quadratic, hence the plate current due to the input voltage is given by:

$$I_p = \text{constant} \times \frac{V_1^2 + V_2^2 + \ldots V_n^2}{2}$$

$$= \text{constant} \times V^2$$

where $V$ is the R.M.S. value of the voltage applied to the rectifier. Therefore the rectified plate current is directly proportional to square of the R.M.S. value of the voltage applied to the terminals *AB*.

It is obvious from equation (3) that this would not be the case if the rectifier characteristic had an equation which contained powers higher than the second.

# A Portable Radio Intensity-Measuring Apparatus for High Frequencies.

(Paper by Dr. J. Hollingworth, M.A., M.I.E.E., and Mr. R. Naismith, A.M.I.E.E., read before the Wireless Section, I.E.E., on 1st May, 1929).

ABSTRACT.

THE recent increase in the use and importance of high-frequency transmissions renders urgent the need of apparatus capable of measuring field strength in absolute units. The requirements of such apparatus are :—

(1) It must be easily portable.

(2) It should be capable of use both with telephones and galvanometers.

(3) Abnormal polarisation should not affect the accuracy with which readings can be obtained.

(4) Accuracy of observation should be high, even at the expense of sensitivity.

(5) The time taken to make an observation should be as short as possible.

(6) The effect on the electromagnetic field of the apparatus and of the antenna should be known and should preferably be negligible.

## General Principles.

There are two fundamental problems: (*a*) The use of an aerial system of known constants. (*b*) The production of a very small E.M.F. of known value and its introduction into the receiving set.

*Aerial.*—In the author's apparatus the aerial is untuned, and its maximum height kept well below $\frac{1}{4}\lambda$. The use of an aerial permits a greater equivalent height to be used at these high frequencies than is possible with a coil, and its disconnection during calibration simplifies the problem of screening.

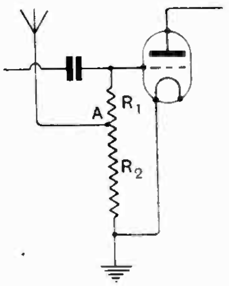



Fig. 1.—$R_1$ = 10,000 ohms, $R_2$ = 5 megohms.

The arrangement is shown in Fig. 1*, the aerial being separated from the grid by the high resistance $R_1$, which is thus in series with any parallel paths from the grid to earth. Special precautions are taken to keep the self-capacity of $R_1$ as low as possible so that the shunting effect produced by these paths on $R_2$ is kept small.

The aerial is led in through a $\frac{1}{4}$in. hole in the screen, thereby reducing the capacity to earth to a fraction of 1 $\mu\mu$F.

*Receiver.*—The first experiments were made with a commercial form of supersonic heterodyne receiver, but this was abandoned in favour of the circuit shown in Fig. 2. Wiring is kept as short and closely spaced as possible and a symmetrical layout is adopted. Toroidal inductances are used throughout, allowing the use of much smaller screening boxes, since the coil can be mounted quite close to the side of the box. The valve shown to the left-hand side effects retroactive tuning control. The aerial, as already shown in Fig. 1, is joined to an intermediate point in the grid leak of the detector valve, which works into a pentode. For aural working telephones are connected in this stage, but for observations these are replaced by a detector unit which rectifies the audiofrequency. The rectified current operates a microammeter of 24$\mu$A. full scale with a set of shunts. The heterodyne is coupled to the oscillatory circuit of the receiver by an untuned single-turn coil. By varying the position of this coil a great control of sensitivity can be obtained without any change in the tuning of any of the circuits. The effects of hand and body capacities are negligible.

*Attenuator.*—The two problems in any attenuator are (*a*) to produce a current of sufficient amplitude to be easily measurable ; and (*b*) to cut this down by some known factor to give a value of E.M.F. of the order desired.

The first experiments were made with a condenser potential divider, but the results were unsatisfactory. The authors' arrangement is shown in Fig. 3, being in the form of a resistance potential divider.

The wavelength range of the complete apparatus is from 25 to 66 m., and the

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

measurable intensity range is 10 to 10,000 $\mu$V. per metre.

*Operation.*—With the aerial-calibrate switch in the " aerial " position, the set is adjusted aurally. If the signal is of sufficient strength (*i.e.*, above 10 $\mu$V./m.) to deflect the output microammeter the detector unit is plugged in and the signal adjusted for reasonable output. The switch is then moved to " calibrate," the injection oscillator tuned to the signal frequency and attenuation applied to obtain the same deflection as from the signal.

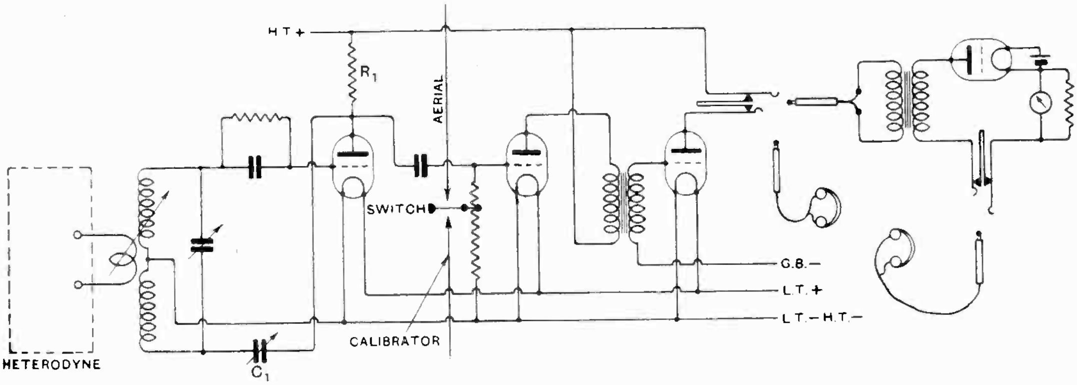



Fig. 2.—*Receiver for short-wave absolute intensity measurements.*

## Tests.

Various tests to verify the self-consistency of the apparatus are described and experimental results shown.

*Relative Intensity Test.*—A test for relative intensity was effected by a small 2-turn coil transmitter 200 m. from the receiver. This was orientated at different angles and the measured intensities give good agreement with the theoretical *sine* curve.

*Test for Stray E.M.F.s.*—A signal from the calibrator was steadily reduced by means of the attenuator. If stray E.M.F.s were present the output curve, if produced back, would cut the intensity axis at a positive point when the attenuation was infinity. The results show that the reverse is the case, due probably to non-linearity of the detector at low intensities.

*Test of Aerial.*—To verify aperiodicity the few lowest feet of the aerial were replaced by a piece of resistance wire of 500 ohms, the intensity was only reduced 30 per cent., showing that no resonance peak was involved.

*Effective Height.*—Measurements of effective height were made with an arrangement of 6 masts, each 5 m. high, round a circle of 8 m. diameter, with pulleys to allow the height and size of the top to be varied. Starting with the full height of 16 ft., the top was lowered in 2 ft. steps, while corresponding measurements of field strength were made 300 m. away. The results show that heights from about 4 ft. to 12 ft. are suitable for a standard transmission. Below

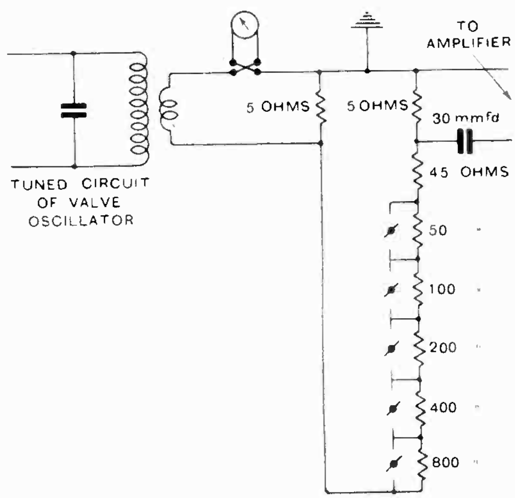



Fig. 3.—*Attenuator.*

4 ft. the small transmitter and containing hut probably exercise an effect; above 12 ft. it appears to be approaching the natural frequency of the aerial.

A further experiment tested the size of top required to give an effective height equal to actual height. Starting with a plain vertical aerial 1.8 m. high, intensity measurements were made at 300 m. distance. Lengths of 2 ft. were added to the top in six radial directions and intensities measured, etc. The results show that effective height is equal to mechanical height when 8 to 10 ft. of radial top is in use. To check current distribution a second milliammeter was introduced at the centre of the vertical portion, and it was noted that its reading was the same as that at the base of the antenna when the radial wires were 8 to 10 ft. long.

Lastly, to test screened boxes, etc., the apparatus was set up in the open on a table 3 ft. above the ground, receiving from a small transmitter 200 m. away. A large screened box close to the receiver but resting on the ground gave considerable effect, and even when placed 1 m. away its effect was still noticeable. Ultimately, the receiver was placed in a pit so that no part of the apparatus was actually in the field to be measured. An aerial of just under 2 m. effective height was used, with the following results :—

| Frequency, in Megacycles per sec. | Intensity. | |
|---|---|---|
| | Measured. | Calculated. |
| | $\mu V./m.$ | $\mu V./m.$ |
| 10 | 650 | 675 |
| 7.5 | 520 | 510 |
| 6 | 340 | 335 |

No special significance is attached to the larger discrepancy for 10 megacycles, as this is within the accuracy claimed for this particular experiment.

After the reading of the paper the apparatus described was demonstrated in operation on signals and on local injection. A chart of the apparatus on a 24-hour record of signal was also displayed.

## DISCUSSION.

Mr. E. B. Moullin, who opened the discussion referred first to the great difficulty of dealing with measurements at these frequencies. He was pleased to see the straightforward use of an aerial, and had always thought that an aerial was preferable to a coil for field-strength measurements. The solution shown was very interesting and useful. He also upheld the use of a resistance form of potential divider. Had the authors considered the use of a high-resistance wire in a concentric cable, of known or calculable capacity? As regards the input/output curves shown by the authors, he suggested that the linearity of the detector at low intensities should be separately checked.

Mr. A. J. Gill referred first to the authors' requirement that the accuracy of the apparatus should be high. There was need for a tool for engineers' use where sensitivity was more important than extreme accuracy. Rapid variation of the signal itself made accuracy less important in commercial work, but ability to measure $\frac{1}{10}\mu V./m.$ was important. He considered the use of reaction very dangerous, and there was liability of it changing during measurements.

A field-strength-measuring set had been developed for the American Telegraph and Telephone Coy. in the Bell Laboratories and had been described by Friis and Bruce, in the proceedings of the Institute of Radio Engineers. The Post Office had constructed and used such sets in England. He showed a slide illustrating the principles of the apparatus and gave a brief outline of its operation. Slides were also shown of measurements made on a transmission from Dollis Hill at various points in and around London, the slides being in the form of intensity curves, and summarised in the form of a contour map.

Mr. J. F. Herd spoke of the need for information on the instrumental side of short-wave working. As regards the attenuator he suggested that information on the details of construction of the resistances for such high frequencies would be useful to other workers. He was surprised to learn that the authors had been criticised for their aerial arrangement. An aperiodic aerial with a resistance between it and the input grid had been in regular use for atmospheric observations for a long time. He did not agree with the authors in regarding the left-hand valve of Fig. 2 as the first valve of the system. The aerial terminal was the input and the valve shown in the left was an auxiliary. No doubt equal results could have been obtained with a conventional cascade, about the first valve of which there could be no doubt.

Dr. R. L. Smith-Rose suggested that, in the table at the end of the paper, the discrepancy shown for 10 megacycles was not greater than the probable error of calculating the attenuation between the local transmitter and receiver. He also criticised Fig. 2, and redrew the circuit showing the effective impedances from aerial input to earth. With the arrangement shown the experiment of replacing a portion of the aerial by a 500 ohms wire would not matter much.

Dr. Hollingworth briefly replied to several of the points raised in the discussion, and on the motion of the Chairman (Commander J. A. Slee, C.B.E.) the authors were cordially thanked for their paper.

This being the concluding meeting of the present session, the Chairman announced that Capt. C. E. Kennedy-Purvis, R.N., had been nominated as Chairman of the Wireless Section for the next session.

# Correspondence.

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

### The Transmitting Station actually sends out Waves of one Definite Frequency but of Varying Amplitude.

*To the Editor, E.W. & W.E.*

SIR,—In the discussion arising from the above subject, Mr. Aughtie brought up the apparent fallacy of envelope frequency alteration with carrier frequency harmonics if looked at from the spectrum basis, and Mr. Howe in the February issue has given a concise mathematical reply as to why

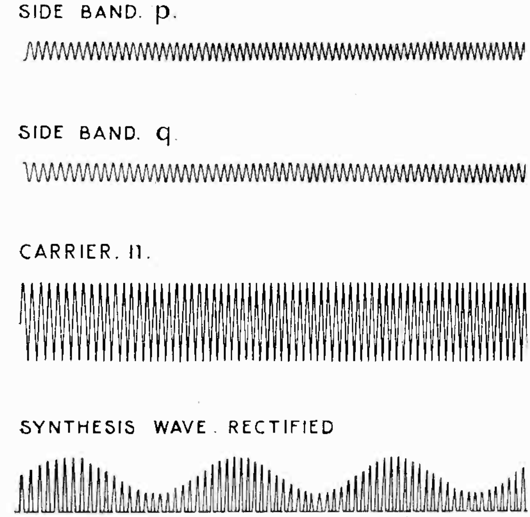



Fig. 1.

the envelope is not increased in pitch, and further that one can deal with it either from the spectrum basis or the single modulated carrier.

Mr. Howe says in his letter that it is difficult to form a clear mental picture as to why the envelope is not pitched higher when listening to the harmonic, and in this connection perhaps the attached curves with explanatory notes may be of interest, although I leave the exact interpretation of these curves to the reader.

Virtually the point in question is the following: If one rectifies a group of waves separately and then beats the result, is this the same thing as beating the waves first and rectifying the resultant wave? Mr. Aughtie says not, and suggests the case of a sine modulated wave, passed through a rectifier. Such a wave can be analysed into a carrier and two side bands, say, $n$, $p$, $q$, and if separate rectification of each is considered, the output will contain component frequencies of $n$, $p$, $q$, $2n$, $2p$, $2q$, etc. Mr. Aughtie then assumes that if one listens to the second harmonic of such a station we should hear the envelope pitched up an octave because one is dealing with the terms $2n$, $2p$ and $2q$.

No one denies the introduction of the multiple frequency terms due to rectifier distortion, but the fallacy of the argument at root is that one cannot assume the terms $2n$, $2p$ and $2q$ conveniently isolate themselves from all others to form the second harmonic modulated wave. Instead one must consider them in conjunction with other terms.

The writer came across this fallacy some time ago, and to see if additional light could be thrown upon the subject studied the effect with the aid of a mechanical synthesis machine on which a modulated wave can be built up automatically from a carrier and side bands.

The usual pictorial result obtained by the addition of carrier and side bands does not give us any information on the harmonic question, the curves of Fig. 1 being for a wave 50 per cent. modulated; the resultant being rectified.

But if the carrier and side band waves are each separately rectified, and then added, the resultant wave obtained is as shown in Fig. 2. Examination of this wave is of interest as the double frequency carrier can easily be picked out, and it will be seen that the envelope of this double frequency carrier is of the same, and not double, the frequency of the fundamental envelope.

The record also brings out a second point, observed by Mr. Howe, that the percentage modulation of the harmonic carrier is double that of the fundamental carrier. The latter in the example is

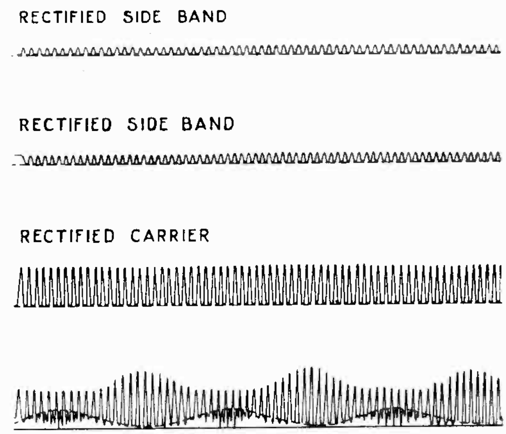



Fig. 2.

50 per cent., giving a 100 per cent. modulation of the second harmonic.

Fig. 3 shows the case of a wave modulated 100 per cent. obtained in the same manner, and here it is observed that the envelope of the second harmonic carrier is completely rectified.

Neither method of graphical representation of a modulated wave gives an accurate representation of the effect of rectification, but it would appear from the attached records that the second method of

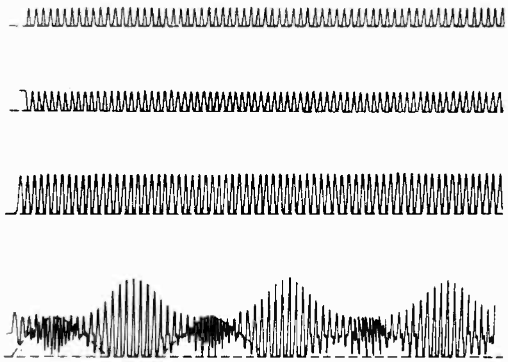


Fig. 3.

producing the result supplies information as to the behaviour of the modulation on the second harmonic.

A. W. LADNER.

**Television.**

*To the Editor, E.W. & W.E.*

SIR,—I note in the daily press and in several of your contemporaries that Denes von Mihaly is again coming into prominence in connection with far-reaching claims for his television apparatus.

In the issue of *E.W. & W.E.* for April, 1927, Mihaly attacked Mr. Baird with considerable assurance, pointing out that the disc method was hopelessly impracticable, and finishing up by asserting in the most insolent fashion that Mr Baird's statement that he used low frequency amplifiers to amplify the television signals at the Receiving Station was absurd, and that had Mr. Baird the knowledge that even an amateur possesses he would realise how ridiculous his statement was, thus insinuating that either Mr. Baird did not know what he was talking about, or that he was a pure mountebank. Following upon what appears to be Mr. Baird's usual practice, no reply whatsoever was given to this criticism, but time has shown how far Baird's statements were correct, and how absurd the criticism of Mihaly.

In his original apparatus Mihaly used a vibrating mirror of very small dimensions controlled by a stringed galvanometer. This device, as pointed out by Miss Everitt in the columns of *E.W. & W.E.*, was optically unsound, and there is no evidence that Mihaly was ever able to give anything in the nature of a public demonstration with it, although this did not prevent him from making claims of an extravagant nature.

At the German Radio Exhibition, however, Mihaly did demonstrate television of shadows, supplying, by the apparatus he used, the most convincing contraversion of his criticism of Baird, for he had discarded his mirror system, and was using an almost exact copy of the disc mechanism used by Baird.

The absurdity of his statement with regard to the impossibility of using a low frequency amplifier for television is made manifest by the fact that low frequency amplifiers are now universally used in all successful television demonstrations.

It is a well-known British trait to vaunt the foreigner and to accept any claims coming from abroad at the expense of the home worker, and I therefore feel the true facts of the case should be laid before you.

FULLARTON ROBERTSON.

# Book Reviews.

THE PHYSICAL PRINCIPLES OF WIRELESS. By J. A. Ratcliffe, M.A. Pp. 104 + viii. 37 Figs. Pubd. by Methuen & Co. 2s. 6d.

This is one of Methuen's series of Monographs on Physical Subjects under the general Editorship of B. L. Worsnop, B.Sc., Ph.D., of King's College, Strand. The author, J. A. Ratcliffe, M.A., is a Fellow and Lecturer of Sidney Sussex College, Cambridge; he is known as a research worker on the characteristics of the waves employed in radio telegraphy and their reflection, refraction, and polarisation, and the little book is obviously written by a physicist with first-hand acquaintance with many of the problems of wireless. It is addressed both to physicists seeking information on the application of physical principles to wireless and to the practical man wishing to know more of the physical principles underlying the subject. Everything is necessarily treated very briefly, but the statement of the essential principles is very concise and clear. Except for a small printer's error on page 55, the only point we would criticise is the description on page 88 of the production of the oscillations of the Barkhauser and Kurz type; the explanation that they are caused by " the circulation of the electrons round the grid wires " might have been expressed a little more clearly. Such brief monographs written by those who not only have the scientific knowledge, but also possess the gift of imparting it, are very useful in these days of specialisation. We are pleased to note that Professor Appleton is writing one of the series on the Thermionic Valve.

STREIFZÜGE DURCH DIE EMPFANGSTECHNIK (selected chapters in the reception of broadcast signals). By Manfred von Ardenne. 99 pp., 106 Figs. Pub. by Rothgiesser & Diesing, Berlin, N.24. Bound in linen, M.3.50.

This book contains ten chapters, each devoted to the consideration of some subject of importance in the design and operation of wireless receiving equipment. Among the subjects dealt with are " The Frame as an Aerial," " Back Coupling," " Push-pull Experiments " and " Anode Bend or Grid Rectification ? ' These are all dealt with in a scientific but non-mathematical manner, with many practical hints and experimental results, obviously the result of much personal testing of the various circuits and devices. The book can be recommended to those with sufficient knowledge of the language. G. W. O. H.

# Abstracts and References.

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## PROPAGATION OF WAVES.

L'ABSORPTION DES ONDES ÉLECTROMAGNÉTIQUES AU-DESSUS DES FORÊTS (The Absorption of Electromagnetic Waves by Forests).—A. Nodon. (*L'Onde Élec.*, February, 1929, V. 8, pp. 85–86.)

After quoting Barfield's observations (Abstracts, 1928, V. 5: Rolf, p. 341; Barfield, p. 462) on the increased absorption of waves over wooded country as compared with other regions, and the increase of this absorption in summer over that obtaining in winter (30 per cent. increase), the writer mentions—as examples of the same effect—two French stations whose performance is handicapped by the presence of forests, and the well-known difficulties encountered in the forest-covered regions of Africa. He then suggests as an explanation the ionising effects of foliage: it is known that foliage produces an ionising radio-activity of the order of one-tenth that of uranium. Only a small part of this activity seems to be due to the potassium content; the total amount is appreciably increased at blossoming-time, and moreover increases with sunshine and diminishes at night. Thus the conductivity due to ionisation would explain the effects noted: it would be greater—in our parts of the world—in summer than in winter, since the leaves play an important part, while it would be more constant and more marked in the tropics, where the leaves rarely fall and where the sun's power is greater. The remedy appears to be to raise the stations to a height above the ionised layer of atmosphere above the forests.

THE EQUIVALENT HEIGHTS OF THE ATMOSPHERIC IONISED REGIONS IN ENGLAND AND AMERICA.—E. V. Appleton. (*Nature*, 23rd March, 1929, V. 123, p. 445.)

Previous explorations with waves of medium length at night obtained evidence of the existence of at least two ionised regions in the upper atmosphere (Appleton, Abstracts, 1927, V. 4, p. 635). Now, the use of short waves has confirmed this for the daylight hours also: the lower region being penetrable by these (99.8 m.) waves on some days even at mid-day. On other days they are reflected at one moment and pass through at the next, owing to the inhomogeneity of the lower region. The mean equivalent heights of the two regions, from these latest tests, are 98 and 226 km. [For the medium waves, the heights indicated in the 1927 work were 90–130 and 250–350 km.]

The writer refers to the results of Breit, Tuve and Dahl in America (Abstracts, 1928, V. 5, p. 683) and points out that what they considered to be a doubly reflected ray from a layer at 105 km. is often (from their photographs) seen to be of greater intensity than the singly reflected ray, and that no triply reflected ray was found between the doubly and quadruply reflected ones. He suggests that these two difficulties would disappear if we adopt the double-layer hypothesis for the American as well as for the English observations: according to this, singly reflected rays were obtained at Washington from regions at heights of 105 km. and 225 km., and a doubly reflected ray was also obtained from the upper region.

AN INVESTIGATION OF SHORT WAVES.—T. L. Eckersley. (*Electrician*, 19th April, 1929, V. 102, p. 468.)

Summary of the paper recently read before the I.E.E. Short Wave Scattering: Mutilation of Signals due to (*a*) "long" echo, (*b*) "quick" echo, (*c*) dispersion by passage through Heaviside layer—probably negligible on the short-wave band, (*d*) blurring, from multiple scattering, and (*e*) double or multiple signals (time interval of the order of 0.01 sec.), objectionable for picture transmission: Results of D.F. Interception of Short-wave Commercial Stations: Connection between Fading and Magnetic Storms: The Nature of Skip Effects—the Heaviside layer as a complex structure of scattering clouds: Revision of Author's Estimate of Effective (Daylight) Height from long-wave measurements—new estimate is about 80 km. for summer and 97–100 km. for winter: Lower Wavelength Limit for Night Transmission depends on season and time of night, late-night regions behaving very differently from early-night regions, thus confirming Appleton's results showing a progressive change in the layer during the hours of darkness; short-wave daylight limit appears to be close to 10 m., but sporadic long-distance transmissions have been observed on waves shorter than this.

ÜBER DIE AUSBREITUNG DER KURZEN WELLEN BEI KLEINER LEISTUNG IM 1,000 KILOMETER-BEREICH (Short-wave Low-power Communication for 1,000 Kilometer Range).—K. Krüger and H. Plendl. (*Zeitschr. f. Hochf. Tech.*, March, 1929, V. 33, pp. 85–92.)

Further developments in the work on short-wave aircraft communication referred to in Abstracts, 1928, V. 5, pp. 163 and 589. The immediate object of the present tests was to determine whether reliable communication could be counted on with low powers (2 watts in the aerial) for ranges of 600 or even 1,000 kilometres. The tests were divided into two parts: between two ground stations 500 km. apart, to find how signals varied according to time of day, etc.; and from aeroplane to ground station, to determine how signals varied with distance.

It was found that 2 watts from a quartz-controlled C.W. telegraph transmitter gave continuous communication over 600 km. by day; the best wave was 50 m., and with this there were no zones of weakness. The height of the aeroplane had apparently no effect: signals were the same even if the machine had landed. Reception was even possible, at 500 km., when the aeroplane was housed in an iron-covered shed.

The average course of a test was as follows:—as the aeroplane, with its transmitter, started off from the receiving station, the strength of signals (as measured on a milliammeter) fell during the first 20 km. from 15 to 5 mA. and then remained constant over a long distance until a certain critical point was reached which varied according to the wavelength used. Beyond this critical distance, signal strength fell off rapidly, though communication still remained possible. For a 37.2 m. wave, this distance was about 800 m. (in March; in summer this wavelength gave a very inferior performance, zones of weak signals appearing at quite short distances); for 53 and 55 m. it was 400 m., while for the 50 m. wave it was 600 km.

Fading only became noticeable at ranges beyond the critical distance. Below about 38 m., zones of weakness frequently appeared: between 38 and 48 they only appeared occasionally, more markedly in summer than in winter. It is suggested (as a result of later tests) that if a vertical aerial or some aerial combination had been used at the receiver, these zones of weakness would have been less prominent: in the actual tests, di-pole aerials were used at transmitter and receiver. Communication on waves below 50 m. was subject to a sudden and marked interruption at night, presumably due to the migration of a zone of weakness, through changing height of the Heaviside layer.

The paper also describes tests where the reception was done in the aeroplane from the ground station. The previous results were duplicated so long as the aeroplane was on land, but when in the air the usual aeroplane interference made the 2-watt power insufficient on most occasions, though on one occasion this power gave satisfactory C.W. telegraphic communication up to 450 km. In other cases, 60 w. was used and was satisfactory up to 600 km.

Some Experiments in Short Distance Short-Wave Radio Transmission.—J. K. Clapp. (*Proc. Inst. Rad. Eng.*, March, 1929, V. 17, pp. 479–493.)

Author's summary:—"Some experiments in short-wave radio transmission over a distance of 55 miles are described, the results of which are interpreted to indicate the presence of strong 'sky' waves, with 'ground' waves of negligible amplitude in comparison with the 'sky' waves as received. Upon decreasing the transmitter wavelength, at a given time of day, a minimum wavelength was reached below which no communication could be obtained; this wavelength is termed the 'cut-off' wavelength. The average value of the cut-off wavelength, for various times of day, is given for several different months. The minimum observed wavelength upon which communication was possible was 28 meters.

"A series of experiments in which an orientable half-wavelength antenna was employed served to indicate definitely an optimum position of the antenna for transmission over the 55 mile distance. The indicated transmission path left the transmitter at an angle of approximately 65 degrees to the horizontal. In long distance communication the position of the antenna was found to have no appreciable effect."

The range of wavelengths used was 25–80 m. The orientable aerial referred to consisted of 50 feet of copper tubing mounted on a lattice frame, carrying the transmitter at the mid-point. The centre of the frame was supported on a universal joint at the top of a 50 ft. pole set in a sandy beach. Incidentally, this beach was composed of fine sand, highly piezoelectric, showing strong resonance frequencies from 15,000 kc. to 3,000 kc. This would have to be taken into account in attempting to calculate the radiation characteristics.

The long distance tests, where apparently the random polarisation of the waves at the receiver, due to the characteristics of the medium of propagation, completely wiped out all effects due to the angle of the aerial itself, were mainly with England and Belgium.

In the short distance tests, twin transmitters and twin receivers were used, each receiver going to one telephone of a split head-set. Two wavelengths were thus tested simultaneously, both transmitters being keyed together. Adjusted to equality, the two lots of signals gave a resultant resembling that obtained with an ordinary single receiver, except that the signal appeared to change from one ear to the other, as the fading periods on the two wavelengths were not the same. No definite relationship between the fading periods on any two wavelengths was observed, even when the difference in wavelength was small.

Doppel- und Mehrfachzeichen bei Kurzwellen (Echoes, Single and Multiple, on Short Waves).—E. Quäck and H. Mögel. (*E.N.T.*, February, 1929, V. 6, pp. 45–74, with Supplement, pp. 74–79.)

A long paper, copiously illustrated by oscillograms, etc., based on recent observations at the Geltow receiving station on signals from Rio de Janeiro, Buenos Aires, New York, Mukden, Manila, Bandoeng, Siam, Cape Town and Nauen. Among the results may be mentioned the following:—(1) Echoes have been found for all waves from 12 to 45 m.; (2) the intervals measured between true signal and echo, or between successive echoes, are always longer than those calculated on the basis of the velocity of light in space and of the actual direct path-length round the earth, the observed intervals consistently suggesting a great circle distance of about 41,400 km.; (3) as opposed to the results of Taylor and Young, the intervals do not vary; (4) magnetic disturbances diminish the echoes, this effect being greater the stronger the disturbance and the nearer the angle between earth's field and direction of propagation approaches a right angle. The supplement deals with the short-time echoes ("nah-echos") observed by Taylor and Young and Hoag and Andrew (January Abstracts, p. 38) examples of which have recently occurred at Geltow in recording (for check purposes) the signals from Nauen. Among others, an oscillogram is given showing how the record of the true signal (a letter "v") is blotted out by the short-time echo, while the round-the-world signal is perfect. Systematic tests were then carried out: dots, at half-second intervals, being transmitted. The records show that the short-time echoes vary greatly in form and in their intervals; generally, however, the average (group) interval is a whole multiple of the interval between true signal and first short-time echo. Thus one set of tests (using directional receiving aerials) shows a series of no less than 7 short-time echoes, corresponding to reflections at the following distances: 3150, 6300, 9300. . . . 23100 km. It may be concluded that they are due to multiple reflections between the earth and a layer about 1,500 km. above it (*cf.* Wagner, March Abstracts, p. 144.)

VARIATIONS IN SIGNAL STRENGTH FROM AUSTRALIA.—R. G. de Wardt. (*P.O. Elec. Eng. Journ.*, April, 1929, V. 22, pp. 52–58.)

A record from June, 1927, to November, 1928, of variations at Skegness of the Beam signals from Australia. Sunrise and sunset do not show any effect on the average strength when the service is worked on the "long" route (westward from England)—any possible effect being masked by the fact that the sun has risen in Australia before it has set in England on this route. On the "short" route, the Australian sunrise has a very marked effect on signal strength at certain periods of the year: the effect being noticeable half an hour to two hours before the sun actually rises, according to the month (maximum advance in winter). This effect (also apparent on the Indian service) appears to be due to the altitude of the sun and the formation of day conditions in the Heaviside layer before actual sunrise—this producing a diminution of signal strength, as the wave used is primarily a night wave.

Figures showing the attenuation produced under the differing daylight and seasonal conditions are given showing that, under similar seasonal conditions, daylight at the Australian end has a worse effect on signal strength than daylight at the English end. Unfortunately, similar figures for reception in Australia are not available; it is not, therefore, possible to say whether daylight at the transmitting end has a greater attenuating effect than at the receiving end, or whether the deciding factor is the difference in latitude.

ON THE DIFFERENCE OF EAST TO WEST AND WEST TO EAST RADIO TRANSMISSION PHENOMENA AT SUNRISE AND SUNSET.—T. Nakai. (*Res. Electrot. Lab.*, Tokyo, November, 1928, No. 241, 18 pp.)

In Japanese. Author's abstract:—The 24-hour change in the ionisation of the upper atmosphere by the ultra-violet ray emitted from the sun has been closely studied, and a conclusion arrived at that the Heaviside layer goes down far more rapidly after sunrise than it goes up after sunset.

Taking into consideration Kennelly's or Nagaoka's theory on sunrise and sunset effects, it may thus be said that no great difference between sunrise and sunset effects is to be found in the radio transmission from East to West, while sunrise effect is to be much larger than sunset effect in the transmission from West to East. This reasoning has been illustrated by the actual data of transmissions from Bolinas (22.9 kc., near San Francisco) to Isohama (near Tokyo) and from Haranomachi (19.8 kc., 150 km. North from Tokyo) to Marshall (near Bolinas).

ÜBER DIE ANWENDUNG DES EBERTSCHEN IONENZÄHLERS ZUR BESTIMMUNG DER ZAHL UND DER BEWEGLICHKEIT DER KLEINEN IONEN IN DER ATMOSPHÄRE (The Use of the Ebert Ion-counter for the Measurement of the Number and Mobility of the Small Ions in the Atmosphere).—W. J. Baranow and E. S. Stschepotjewa. (*Physik. Zeitschr.*, No. 21, 1928, V. 29, pp. 741–750.)

A method designed to avoid the usual errors. Mobility of the light ions is probably not less than 1.2 and 1.6 cm./sec.: volt/cm. for positive and negative ions respectively. There are great divergences, so that the mean mobility in no way expresses the mobility of certain groups. To obtain useful results the ions must be divided into several groups, and the average mobility determined for each group separately.

SUR L'IONISATION ATMOSPHÉRIQUE (Atmospheric Ionisation).—Ch. Maurain and E. Salles. (*Comptes Rendus*, 4th March, 1929, V. 188, pp. 723–725.)

A summary of measurements of large and small ions at Val-Joyeux and Paris, and a discussion on their meaning.

L'ÉCLIPSE DU SOLEIL DU 9 MAI 1929 (The Solar Eclipse of 9th May, 1929). (*L'Onde Élec.*, February, 1929, V. 8, pp. 80–84.)

The programme of the Baïkam (Indo-China) Expedition.

THE ANGULAR DISTRIBUTION OF INTENSITY OF RESONANCE RADIATION.—R. W. Gurney. (*Nature*, 23rd March, 1929, V. 123, p. 479.)

Summary of a Washington (Nat. Ac. Sci.) paper. The assumption of random distribution is suggested to be unwarranted. If the plane of polarisation of plane polarised light is rotated rapidly, consideration of the movement of the atomic oscillators shows that, though the intensity along the beam is unaltered, in other directions it is modified.

A GRAPHICAL THEORY OF TRAVELLING ELECTRIC WAVES BETWEEN PARALLEL CONDUCTORS.—N. Karapetoff. (*Journ. Am.I.E.E.*, February, 1929, V. 48, pp. 113–117.)

VARIATION OF CONDUCTIVITY OF THE UPPER ATMOSPHERE.—J. Egedal. (*Nature*, 27th April, 1929, V. 123, pp. 642–643.)

"Summarising, it may be said that the heights of the base of the aurora are able to give information on the tide of the upper atmosphere and thereby on the variation of the electric conductivity in the regions considered; further, that certain observed magnetic variations seem to confirm the result found. The existence of a resulting enormous variation [in latitude 45 deg. a variation of 25 per cent. from the mean height may be expected] of the height of the conducting layer may be tested by means of radio waves."

Über die experimentelle Erforschbarkeit der höheren Schichten der Atmosphäre (On the Explorability of the Higher Layers of the Atmosphere).—H. Benndorf. (*Physik. Zeitschr.*, 1st March, 1929, pp. 97–115.)

A general survey. This, the first part, deals with the exploration by means of sound waves.

Die Schallausbreitung in der Atmosphäre bei künstlichen Sprengungen (Sound Propagation in the Atmosphere from Artificial Explosions).—O. Meisser. (*Physik. Zeitschr.*, 15th March, 1929, pp. 170–175.)

The Total Reflexion of Electric Waves at the Interface between Two Media.—H. M. Macdonald. (*Proc. Roy. Soc.*, 6th April, 1929, V. 123 A, pp. 391–400.)

A mathematical investigation of the transmission and reflexion of electric waves, when the surface separating the media is a sphere, and the source of the waves is a simple oscillator inside the sphere, whose axis passes through the centre of the sphere.

Signal Strength Measurements at Bangalore.—K. Sreenivasan. (*Electrotechnics*, Bangalore, March, 1929, pp. 199–200.)

The strength of 3 minute dashes from Rugby was measured at Bangalore at the same hours each day over two months. The effect of earthing the insulated masts at Rugby was noted; signal strength rose from less than 0.28 microvolt/metre per aerial ampere (all masts but one insulated) to 0.31 (two masts earthed), to 0.335 (three earthed) and to 0.386 (six earthed). Another result to which attention is directed, though the short duration of the test is recognised, was that transmission with the waves travelling all the way in darkness gave a signal about 35 per cent. stronger than the daylight transmission. The mean morning and evening strengths are respectively 270 and 200 microvolts per metre, with 800 amperes aerial current.

The Measurements of the Field Intensities of some High-Power Long-Distance Radio Stations. Part II.—Malabar, Palao and Rugby; Part III.—Kahuku, Pearl Harbour and Saigon. E. Yokoyama and T. Nakai. (*Res. Electrot. Lab.*, Tokyo, July and September, 1928, Nos. 233 and 238.)

A continuation of the work referred to in Abstracts, 1928, V. 5, p. 683.

## ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

Wireless Telegraphy and Magnetic Storms.—H. B. Maris and E. O. Hulburt. (*Proc. Inst. Rad. Eng.*, March, 1929, V. 17, pp. 494–500.)

Authors' Summary :—A recent theory of auroras and magnetic storms (Abstracts, 1929, V. 6, pp. 101, 147 and 265) attributes these phenomena to the action of a flash of ultraviolet light from the sun. The flash causes an unusual ionisation in the Kennelly-Heaviside layer. Therefore, it is only daylight wireless circuits which are, or may be, disturbed at the commencement of the magnetic storm, the night circuits remaining normal until dawn, when they may be disturbed; the disturbance in the daytime circuits may persist after night-fall. This very simple theory is found to be borne out in a detailed discussion of the data of the short-wave (15 to 40 meters) circuits of the United States Navy during the magnetic storms of 28th May, 7th July, 18th October, and 24th October, 1928.

Weather and Wireless.—R. A. Watson Watt. (*Nature*, 30th March, 1929, V. 123, pp. 500–501.)

Summary of the Symons Memorial Lecture of the Royal Meteorological Society. Among the points made, the following, relating to atmospherics, may be mentioned :—The average atmospheric is a hundred thousand times as strong as a readable signal; they have been known to disturb broadcast reception up to 4,000 miles from their place of origin. They originate in thunderstorms, and the predominant source of the world's supply of atmospherics at any moment usually lies in a land where it is summer afternoon. The average atmospheric received in England is of such strength as would be expected from a thunderstorm 2,000 miles away.

The lecture was illustrated by the reception, on the Fultograph system, of current weather maps and written forecasts, and by demonstrations of the author's cathode ray direction finder. It was mentioned that an experimental transmission from Daventry of daily weather charts is to begin shortly.

A fuller summary, with reproductions of the synoptic chart and forecast mentioned above, is given in the next issue (6th April), pp. 545–546; another (also illustrated) in the *Wireless World*, 10th April, pp. 389–390. In this latter summary it is mentioned that Lindenberg observations have shown that surfaces of air discontinuity between sender and receiver diminish the received energy, while over the sender they increase the received energy. It is also mentioned, regarding the Stôrmer-Hals echoes, that Appleton has recently observed them again just at the time which Stôrmer predicted for their re-appearance (see March Abstracts, p. 144).

Recherches sur les Perturbations électromagnétiques, sismiques et solaires (Researches on Electromagnetic, Seismic and Solar Disturbances).—A. Nodon. (*Comptes Rendus*, 4th March, 1929, V. 188, pp. 725–726.)

Results at the Santiago observatory (Chili) confirm the close relationship between these disturbances, and also show the value of the Nodon magnetograph for obtaining warning of earthquakes.

EARTH CURRENT REGISTRATION.—S. K. Banerji. (*Nature*, 30th March, 1929, V. 123, p. 506.)

The writer has succeeded in registering earth currents with lines only 250 yards long, overcoming polarisation difficulties (which ordinarily make lines of some miles' length necessary) by making the electrodes neutral with respect to the soil.

SUR L'ÉLECTRISATION DE VENTS CHARGÉS DE NEIGE.—A. Vincent. (*Comptes Rendus*, 25th March, 1929, V. 188, p. 928.)

In Canada, snow lifted from the ground by the wind is so electrified (presumably by friction) that half-centimetre sparks can be drawn from a small aerial against which it is driven. *Cf.* dust winds in China, May Abstracts.

THEORETICAL AND FIELD INVESTIGATIONS OF LIGHTNING.—C. L. Fortescue, A. L. Atherton, and J. H. Cox. *And* LIGHTNING: PROGRESS IN LIGHTNING RESEARCH IN THE FIELD AND IN THE LABORATORY.—F. W. Peek. (*Journ. Am.I.E.E.*, April, 1929, V. 48, pp. 277–280 and 303–307.)

## PROPERTIES OF CIRCUITS.

NOTE SUR LE CALCUL DES ÉTAGES MULTIPLICATEURS DE FRÉQUENCE À TRIODES (Note on the Calculation of Triode Frequency-multiplying Stages).—J. Marique. (*L'Onde Élec.*, January, 1929, V. 8, pp. 1–19.)

The author writes:—"In spite of numerous articles on quartz-regulated transmitters—in which triode frequency multiplication is involved—little information exists on this subject. We have thought that, making the hypotheses generally allowed for valves functioning as amplifiers (*i.e.*, sinusoidal nature of grid and plate voltages) and using the static characteristics, it ought to be possible to calculate at least the order of magnitude of the phenomena involved in frequency multiplication; particularly the power that one could hope to draw from a valve so used. We put forward a theory which we consider enables one by quick calculations to choose the most suitable design of valve and to determine the values of inductance, capacity, polarising voltages, in fact all the elements of a multiplying stage, with an accuracy perhaps better than that obtained in the calculation of ordinary transmitters."

Tests on valve type E.303.B Radiotechnique, used as a frequency doubler, with anode voltage 1,800 and various grid voltages, gave efficiencies ranging from about 20 per cent. to 40 per cent. (with increasing grid voltage), whereas the calculated values ranged from about 13 per cent. to 40 per cent. A method of improving the efficiency is mentioned, by superposing on the fundamental E.M.F. a small E.M.F. of the required harmonic frequency: this supplementary component is always present in triode generators, and its amplitude and sign can be adjusted by inserting, in the anode circuit of the preceding stage, a circuit tuned to the harmonic and coupled to the grid circuit of the multiplying stage.

NOTES ON GRID-CIRCUIT DETECTION.—J. R. Nelson. (*Proc. Inst. Rad. Eng.*, March, 1929, V. 17, pp. 551–561.)

Author's summary:—A dynamic method of finding $\delta^2 i_g/\delta e_g^2$ or $\delta k_g/\delta e_g$, the main term in grid-circuit rectification, is given. This method is based upon formulas given by Chaffee and Browning and consists in calculating $\delta k_g/\delta e_g$ from the change of D.C. when a known A.C. input voltage is applied to the grid. The values of $\delta k_g/\delta e_g$ found by the dynamic method are compared with the values found by the usual method. The effect of frequency, internal grid resistance, and external resistance on the detection voltage introduced in the plate circuit are also considered. An experimentally determined curve is given showing the detector frequency distortion of a commercial set for a 2-megohm grid leak and for a ½-megohm grid leak.

LE MÉCANISME DE LA STABILISATION DES OSCILLATIONS DANS UN OSCILLATEUR À LAMPES (The Mechanism of the Stabilisation of Oscillations in a Valve Oscillator).—J. Mercier. (*L'Onde Élec.*, January and February, 1929, V. 8, pp. 29–36 and 60–67.)

An investigation of the building-up process leading to a steady state. It first assumes that the plate current-grid voltage characteristic is a straight line, and neglects the effect of grid current; later, the modifications which must be made to adapt the conclusions reached, in order to fit in with actual conditions, are considered.

ZUR FRAGE ÜBER DIE ANLAUFVORGÄNGE IM RÖHRENGENERATOR (The Starting-up Processes in the Valve Generator).—G. Ostroumoff. (*Zeitschr. f. Fernmeldetech.*, No. 10, 1928, V. 9, pp. 145–147.)

The building up of oscillation, at switching on, is investigated by glow lamp oscillograph. The three-electrode valve in the ordinary reaction arrangement is to be regarded as a negative resistance in shunt connection.

THE RESPONSE OF H.F. CIRCUITS TO STEADY AND TRANSIENT MODULATION.—W. B. Medlam. (*Journ. Inst. Wireless Tech.*, September, 1928, V. 2, pp. 35–72.)

Author's summary:—A theoretical investigation of the behaviour of H.F. resonant circuits when supplied with a complex modulation. Formulæ are developed for the effective modulation present in the voltage across the condenser of a resonant circuit, with various valve couplings, and this is compared with the modulation present in the input to the circuit, both in amplitude and phase. Numerical results are calculated, and curves are given showing quantitatively how the results depend on the values of the circuit constants, and on the carrier frequency and character of the modulation. The conditions for the faithful reproduction of a transient modulation envelope are determined, and the results are applied to numerical cases.

Le Transformateur à Basse Fréquence "Philips" (The "Philips" L.F. Transformer).—A. van Sluiters. (*Rev. Gén. de l'Élec.*, 30th March, 1929, V. 25, pp. 485–491.)

The paper begins with the theory of the L.F. intervalve transformer and the determination of the values of the amplification per stage for low, medium and high frequencies. The theoretical results are applied to the actual case of the Philips transformer.

Untersuchungen an Drosseln mit geschlossenem Hypernik-Kern (Investigations on Chokes with Closed Hypernik Cores).—P. Hermanspann. (*Zeitschr. f. Hochf. Tech.*, March, 1929, V. 33, pp. 81–84.)

A study of the behaviour of such choke coils in resonant circuits fed with sinusoidal A.C. of various frequencies (50–1,000 cycles per sec.). The advantages of this iron-nickel alloy over ordinary dynamo show up properly only for very weak fields, the *B/H* curve here rising very sharply. A special property is that the inductance of such a coil can be increased by a small super-imposed D.C. magnetising current. This effect decreases as the frequency is lowered, but can be shown to exist even at 50 cycles.

Vector Presentation of Broad-Band Wave Filters.—R. F. Mallina and O. Knackmuss. (*Journ. Am. I.E.E.*, April, 1929, V. 48, pp. 265–269.)

The function of such a filter, of the iterative ladder type, is expressed in terms of two characteristic vectors. The diagram of these shows clearly that the angle between them is the phase shift of the filter, that the natural logarithm of the ratio of their magnitudes is the attenuation, and the relationship between a mid-series and a mid-shunt structure. The equations for such filters can be derived in a very simple manner from the geometry of one vector triangle.

Les Caractéristiques des Circuits contenant une Bobine d'inductance à Noyau de Fer et des Condensateurs (Characteristics of Circuits containing Iron-cored Inductances and Condensers).—P. Kalantaroff. (*Rev. Gén. de l'Élec.*, 2nd March, 1929, V. 25, pp. 315–322.)

An application of graphic methods to the predetermination of the current/voltage and current/frequency characteristics in various complex circuits.

A Complex Pendulum driven by Two Pendulums having Commensurate Periods.—H. M. Browning. (*Phil. Mag.*, April, 1929, V. 7, No. 44, pp. 721–729.)

## TRANSMISSION.

Ultra-short Waves (15–20 cms.).—G. Beauvais. (*Rev. Gén. de l'Élec.*, 16th March, 1929, V. 25, pp. 393–394.)

A paper read before the Soc. franç. des Élec., containing much the same matter as the same writer's *Comptes Rendus* paper (March Abstracts, p. 149). He puts 1.5 m. as the lowest limit for ordinary methods of production, owing to the electron time of passage being comparable with the oscillating period (*cf.* Hollmann, April Abstracts, p. 208). By the use of his super-regenerative receiver he obtained ranges of the order of 600 metres with 15–20 cms. waves. By using parabolic mirrors at each end, he obtained "satisfactory reception" with "only one L.F. valve" at a distance of 10 km.; the tolerance of the angle of the mirror at the receiving end was 4 deg. on either side of the mean position. He considers that by improving the concentration of the beam, ranges of 30 to 40 km. should be obtained.

Die Erzeugung kürzester elektrischer Wellen mit Elektronenröhren (The Production of the Shortest Electric Waves by Valves).—H. E. Hollmann. (*Zeitschr. f. Hochf. Tech.*, March, 1929, V. 33, pp. 101–107.)

Final part of the long survey referred to in April and May Abstracts. It deals first with the theoretical explanations of the electron oscillations: the multitudinous results described in the previous parts show that the simple B-K theory requires a good deal of expansion. Up to the present no complete theory has been found to cover all the known facts, but various workers have brought forward partial theories which the writer summarises, one after the other. A later section deals with the energy of electron-oscillations. The writer has obtained up to 0.5 ampere for a 66 cm. wave and 0.12 A. for a 38 cm. wave, a single valve being used in each case. Scheibe has used valves in parallel, and finds that the energy from two valves is more than twice (it may be as much as seven times) the energy from one.

Electron oscillations in a magnetic field are then dealt with—Žaček and Yagi and Okabe (split magnetron). The final section is concerned with the filtering-out of harmonics, and the paper ends by announcing the production of the shortest wave yet attained—3.5 cm., by Potapenko, using a modified Barkhausen "brake-field circuit" and grid voltages 100–150. The complete paper includes a bibliography of 72 items, of which a third are in this final part.

Die Erzeugung von kurzwelligen ungedämpften Schwingungen bei Anwendung des Magnetfeldes (The Production of Short Wave Undamped Oscillations by the Use of a Magnetic Field).—A. A. Slutzkin and D. S. Steinberg. (*Ann. der Physik*, 12th March, 1929, Series 5, V. 1, No. 5, pp. 658–670.)

"Intensive" oscillations corresponding to wavelengths down to 7 cm. are produced by a special diode (similar results, but much weaker, were obtained with commercial triodes). Relations between wavelength, electron path times, magnet field, etc., etc., were investigated. For the shortest (7 cm.) wave the anode voltage was 780 V., the field 1,617 Gauss, the emission current 4.7 mA. It was possible to calculate the wavelengths with very good accuracy from the electron path time.

Study and Measurement of Ultra Short Waves.—B. Mazumdar. (*Indian Journ. Phys.*, 30th September, 1928, V. 3, pp. 77–93.)

Wavelengths round 5 m. were obtained with one, or two, three-electrode valves, in circuits such as van der Pol and Englund used, where reaction was due to the grid-plate capacity. A theory has been worked out for the modified van der Pol method, giving good agreement between calculated and observed wavelengths.

Über ungedämpfte elektrische Ultrakurzwellen mit Demonstrationen (On Ultra-short Undamped Electric Waves, with Demonstrations).—K. Kohl. (*Zeitschr. f. tech. Phys.*, March, 1929, p. 107.)

Short description of a lecture. 14 cm. waves were generated in a small valve "whose most important element was a small spiral" set into undamped oscillation by electron movements. Reflection, polarisation, diffraction, etc., were demonstrated. The use of reflectors at transmitter and receiver showed the possibility of covering "large distances with small expenditure of energy." Distilled water was shown to be almost opaque to these waves, paraffin oil to be very transparent.

Valves for Generating Ultra-short (30 cm.) Waves.—W. Wagner. (See under "Stations Design and Operation.")

A Piezo-controlled Valve Generator. (Amer. Patent 1,683,130, Gebhard, pub. 4th Sept., 1928.)

In order to obtain the greatest amount of power with as few stages as possible, a condenser is connected between grid and anode.

By adjusting this condenser, the oscillation process can be so regulated as to give maximum output.

A Short-wave Piezo-controlled Transmitter. (German Patent 468629, Lorenz, pub. 19th November, 1928.)

Anode and grid circuits are both aperiodic, and are coupled together for reaction. A special crystal is provided for each wavelength, each crystal being furnished with a non-interchangeable mounting so that its introduction automatically changes the switching to suit itself.

Directional Antennæ. (French Patent 643559, S. F. R., pub. 19th Sept., 1923.)

A continuous aerial conductor is zig-zagged along a cylindrical surface. When the axis of the cylinder is vertical, radiation is vertically polarised and radiates horizontally.

Fading Elimination. (German Patent 467595, Telefunken, pub. 2nd November, 1928.)

The transmission of the same signal on more than one wavelength simultaneously is a known method of fading elimination. The invention refers to the choice of two wavelengths differing in frequency by a number which is double the frequency of a convenient audible note; so that by the same heterodyne, the two waves will produce this same note.

Prevention of Disturbing Effects in H.F. Generators. (French Patent 643013, Lorenz, pub. 8th September, 1928.)

The use of mercury for balancing, to avoid the production of "trill" (*cf.* Hahnemann, February Abstracts, p. 102.)

Frequency Multiplication by Iron-cored Chokes. (German Patent 468672, Dornig, pub. 19th November, 1928.)

An Examination of A.C. Plate Supply: Considerations Governing the Use of Self-rectification.—R. A. Hull. (*QST*, February, 1929, pp. 23–27 and 88.)

The simplicity of self-rectification can be made use of without loss of constancy of frequency if the set is designed and adjusted according to the lines here given. But the author hopes that the new mercury vapour rectifiers (see Pike and Maser, under "Subsidiary Apparatus") will be a still better and simpler solution.

## RECEPTION.

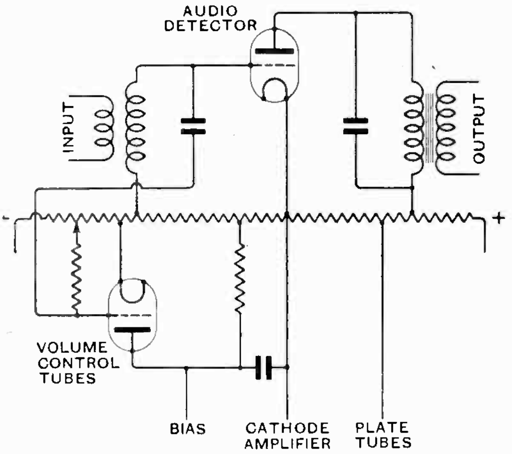
Recent Developments in Superheterodyne Receivers.—G. L. Beers and W. L. Carlson. (*Proc. Inst. Rad. Eng.*, March, 1929, V. 17, pp. 501–515.)

Authors' summary:—"Major electrical elements of a modern superheterodyne receiver—tuned radio-frequency amplifier, intermediate frequency amplifier detector and audio-frequency amplifier—are briefly discussed in light of recent developments. A practical automatic volume control is described. Curves illustrating the major performance characteristics of the receiver are shown."

Among various points in the paper the following may be quoted:—In past superheterodyne receivers the intermediate frequency has usually been in the neighbourhood of 40 or 50 kc. This choice resulted from the ease of obtaining a stable amplifier for a frequency in this region, having the necessary amplification and the desired selectivity. Now, however, it is realised that (as shown by a curve of selectivity of two tuned circuits) the higher the intermediate frequency, the less the possibility of encountering interference from stations separated by twice the intermediate frequency. From the curve it is seen that this interference for a 40 kc. amplifier would be 350 times that for a 400 kc., and 60 times that for a 200 kc., amplifier. 180 kc. is suggested as the best compromise between amplification, stability, selectivity, and undesired responses.

Discussing the radio-frequency circuits, a transformer is described giving improved fidelity, its primary having a large number of turns making it resonant to a frequency below the low-frequency end of the range. With a primary thus tuned to a lower frequency than the secondary, the plate circuit has a capacitive reactance and the voltage fed back through the valve capacity is therefore of such a phase as to oppose the applied grid voltage, and will reduce this to a fraction of its normal value. Methods are shown for overcoming this difficulty.

In the audio-frequency system, distortion, hum, etc., are reduced by using a plate circuit detector and only one audio-frequency stage. Regarding automatic volume control, the writers say that the chief objections to past systems have been the number of adjustments required and the use of separate voltage supplies for certain




parts of the circuit. The arrangement shown in the schematic diagram overcomes these objections.

Aerial Coupling for Short-Wave Reception.—T. S. Rangachari. (*Electrotechnics*, Bangalore, March, 1929, pp. 175–177.)

An investigation of coupling in the reception of wavelengths of the order of 30 m. by a detector with reaction (followed by L.F. amplification) with a view to determining the conditions for maximum energy transfer. It is shown that the coupling required may be extremely small even when the aerial is far from resonance: which explains the experience that even though the aerial is apparently not coupled to the receiver but allowed to remain close by, quite satisfactory reception is sometimes obtained. Another point considered is the ratio between the energy transferred for optimum conditions for an untuned aerial and that which would be transferred if the aerial were also tuned: this ratio depends upon the nearness of the natural wavelength of the aerial to the received wavelength. Moreover, if the aerial wavelength exceeds about twice the received wavelength a variation in the size of the aerial does not appreciably affect signal strength.

La Qualité de la Réception Radiophonique (Quality of Radiotelephonic Reception).—P. David. (*L'Onde Élec.*, February, 1929, V. 8, pp. 41–59.)

First instalment. The causes of distortion are divided into three classes: incorrect reproduction of frequencies: incorrect reproduction of amplitudes: superposition of parasitic vibrations. These types of distortion are examined for their origins: they are not looked for in the transmitter, partly because this has been dealt with by Deloraine (*ibid.*, January-February, 1928), but chiefly because the writer considers that the modern transmitter gives practically perfect results: they are sought in the actual transmission through space, in the receiving aerial, in selectivity against atmospherics and interference, in H.F. amplification, reaction, and detection. Here the first instalment ends. A few dicta may be quoted:—Reaction, voluntary or otherwise, should be very weak for short waves, inappreciable for long waves and utterly banned from the "intermediate frequency amplifier" of superheterodyne reception: in the latter, deliberate damping in the coupling circuits may be advisable. With regard to frequency fidelity, "between 80 and 5,000 p.p.s. the ratio of the amplitudes of the least favoured and the most favoured frequencies should be between ½ and 1." Regarding the cutting out of interference, Borias' proposal (March Abstracts, p. 152) to detune the circuits from the carrier wave in such a way as to receive unsymmetrically the two side-bands, and to compensate for the weakening of the one by the strengthening of the other, is favourably mentioned: but fear is expressed that the adjustment—to obtain the desired result—would be beyond the average operator.

La Qualité des Réceptions Radiophoniques (Quality in Radiotelephonic Reception).—B. Decaux. (*T.S.F. Moderne*, October, 1928, V. 9, pp. 604–616.)

In dealing with the three main classes of distortion-producing factors (those in the R.F., rectifying, and L.F. circuits) the writer maintains that the first, which are often ignored, are often the most important: reaction, sharpening the resonance curves, is allowed to suppress the higher frequencies. Proper use of band-pass filters is not yet being made in amateur reception. Among the steps to be taken to avoid L.F. distortion, the choice of a loud speaker by trial with the set itself is mentioned.

Récepteur pour Sous-Marins (Receiver for Submarines).—(*Bull. de la S.F.R.*, January, 1929, pp. 15–19.)

A special 8-valve receiver for a wave-range of 250–6,000 m., the long waves being indispensable for communication when the submarine is submerged.

How Much Selectivity?—J. E. Smith. (*Rad. Engineering*, February, 1929, V. 8, pp. 44–45.)

An article dealing with the relation between selectivity and circuit resistance, and the rôle regeneration plays in modern receivers. Quality is also considered: "the amount of side-band cutting that occurs in even rather broad receivers is surprising. And when we obtain such a great amount of selectivity as is required [for modern conditions of congestion], can you imagine how much more of the side-bands is lost to us? . . . And in spite of it all, designers still go on trying to bring out stronger and stronger the low notes. Is it any wonder that so much of the music coming from loud speakers is drummy?" The suggestion is approved that it would be well to make one part of the receiver compensate for the losses in another part: for instance, in order to compensate for the side-band cutting, in the R.F. amplifier, of the higher frequencies, the L.F. amplifier might be designed to amplify these frequencies more strongly.

More Amplification from Screen-Grid Valves: Doubling the Stage Gain and Maintaining Stability.—A. L. M. Sowerby. (*Wireless World*, 24th April and 1st May, 1929, V. 24, pp. 424–426 and 456–458.)

In spite of the hopes aroused by the screen-grid valve, the greatest amplification by the ordinary method of using it is not much more than 40 per stage—which is not as much as can be obtained with a good 3-electrode stage. This comparative failure is due to the fact that the inter-electrode capacity has only been partially removed by the screen-grid. By the system of neutralising described, the writer obtains amplifications from 100 upwards.

Improving Short-Wave Phone Reception.—R. A. Hull. (*QST*, March, 1929, V. 13, pp. 9–20.)

"A modern super-heterodyne for short-wave phone, code, and general broadcasting."

## AERIALS AND AERIAL SYSTEMS.

The Radiation Resistance of Beam Antennæ.—A. A. Pistolkors. (*Proc. Inst. Rad. Eng.*, March, 1927, V. 17, pp. 562–579.)

By the Poynting vector method of calculating the power radiated from an aerial it is impossible to obtain the contributions, to the radiated power, of different parts of the aerial system, as is sometimes desirable to do when dealing with practical cases. This disadvantage is not present in the "induced E.M.F. method" proposed by Brillouin in 1922, based on the electromagnetic field equations in the form employing the retarded potentials of Lorentz. This method was applied by Kliatzkin in the analysis of the radiation from a vertical earthed wire, and the present paper applies it to several types of beam aerials. New formulæ are deduced and some interesting results obtained showing the distribution of the radiated power among the different wires of beam aerials, and giving the numerical values of the radiation resistance in various cases (synphase, antiphase, and Marconi three-stage aerials). The radiation resistance in the presence of a perfect conducting plane is also considered. A table of values of the components of radiation resistance is added for practical use.

Strahlung von Antennen unter dem Einfluss der Erdbodeneigenschaften. (A) Elektrische Antennen; (B) Magnetische Antennen (Radiation from Antennæ under the Influence of the Properties of the Ground. (A) Electric Antennæ; (B) Magnetic Antennæ).—M. J. O. Strutt. (*Ann. der Physik*, 6th April, 1929, Series 5, V. 1, No. 6, pp. 721–772.)

The first question, "What effect has the earth's finite conductivity on the radiation of horizontal and vertical aerials at finite radiation-angles with the earth?" is answered by direct integration of the differential equation, leading to formulæ for the radiation of horizontal and vertical dipoles and for aerials at any angle. For vertical dipoles these are identical with Weyl's and T. L. Eckersley's results. The second question, "What fraction of the total radiation is lost in the earth?" is answered in certain special cases from which other cases may be inferred approximately. The third question, "How does the useful radiation (and the useful radiation-resistance) alter with increasing height of aerial above the earth?" and the fourth, "Is a horizontal or a vertical aerial, at a given height above the earth, the more favourable as regards useful radiation?" are dealt with together, the results contradicting Sommerfeld's opinion that the horizontal aerial is always worse than the vertical: either may be better than the other, according to the height and the condition of the ground.

The paper is illustrated by tables and curves.

Transmitting Aerials for Broadcasting Stations.—P. P. Eckersley, T. L. Eckersley and H. L. Kirke. (*Journ. I.E.E.*, April, 1929, V. 67, pp. 507–526.)

The complete paper, with discussion, a summary of which was dealt with in April Abstracts, p. 211.

The Resonance Effect of Receiving Antennæ.—C. Coston. (*QST*, April, 1929, V. 13, pp. 51, 55.)

Methods of mitigating this effect (which prevents the oscillation of a regenerative receiver on certain frequencies, and the most efficient operation at all frequencies) without the use of a "coupling valve" (an untuned R.F. stage).

Isolateurs suspendus: Étude de l'Influence de la Longeur des Attaches (Suspended Insulators: the Influence of the Length of the Connecting Links).—G. Viel. (*Rev. Gén. de l'Élec.*, 22nd December, 1928, V. 24, pp. 945–948.)

The distance between individual insulators in a chain is of importance owing to their effect on one another, resulting in a decrease of effective insulation. This result is quantitatively examined in this paper.

Experiments with Multi-feed Aerials.—W. H. B. de M. Leathes. (*Journ. Inst. Wireless Tech.*, September, 1928, V. 2, pp. 5–18.)

Effect of feeders on (*a*) natural wavelength, (*b*) resistance, (*c*) radiation. General remarks on the comparison between Inverted *L* and Radial aerials as to radiation: Spurious oscillations in a multi-fed aerial: Losses. In the discussion, G. L. Morrow questions whether the use of an earth screen does not make the whole system radically different from the case where the aerial is earthed. Stations working on wavelengths round 30 m. are incapable of being D.F.'d at short or medium ranges, especially in marine work: but a multi-feed system with a screen whose electrical and physical constants are as near as possible to those of the aerial can be D.F.'d on these wavelengths at quite small ranges—suggesting that such a combination approximates to a loop. He corroborates the author's statement that directive radiation decreases the radiation resistance.

## VALVES AND THERMIONICS.

THE OPERATION OF RADIO RECEIVING TUBE FILAMENTS ON ALTERNATING CURRENT. Part II.—K. H. Kingdon and H. M. Mott-Smith, Jr. (*Gen. Elec. Review*, April, 1929, V. 32, pp. 228–232.)

Sequel to a previous article (*ibid.*, March, 1929, pp. 139–148) dealing with the reduction of disturbances when using A.C. heated valves as amplifiers, this part discusses the subject of such valves used as grid-leak detectors.

Authors' summary:—"When the grid is made positive enough to take electron current, disturbances occur in the grid current which are similar to those in the anode current, which were described in Part I [primary potential, magnetic, and temperature ripples]. If the grid current flows through a grid-leak resistance, the fluctuations in grid current cause fluctuations in grid potential, which in turn give rise to 'secondary' ripples in the anode current. Usually the secondary potential ripple is of by far the greatest importance. This is a double-frequency ripple, ordinarily of opposite phase to the primary potential ripple. It is discussed quantitatively in Section VII. This ripple is so large as to give rise to serious disturbances in a tube used as a grid-leak detector, if the filament drop is greater than about 0.1 volt." A summary of Part I is also given. It includes mention of the method of opposing voltage ripple to magnetic ripple so as to neutralise these two components by a suitable choice of voltage and filament resistance.

CONTROL OF AN ARC DISCHARGE BY MEANS OF A GRID.—A. W. Hull and I. Langmuir. (*Proc. Nat. Acad. Sci.*, March, 1929, V. 15, pp. 218–225.)

By an exposition of the condition of affairs in a mercury vapour three-electrode valve, the writers show that grid control of the arc current (once this has started) can only be obtained by using closely spaced grid wires and not too great currents, so that the positive-ion sheaths of adjacent wires touch or overlap. They mention that this kind of control, though restricted, has many interesting features which they propose to report on later.

The present paper deals with grid control in such a valve *before* the arc has started. No ions are present to form the sheaths, and the electrostatic fields are the same as in a vacuum valve; if the valve has $\mu = 10$, then 10 volts negative grid potential will prevent any current from flowing for an anode voltage of 100. But if this bias is decreased a little, the small electron current now allowed to flow produces ions which promptly form sheaths round the grid wires, and the current instantly rises to a value limited only by the filament emission or the circuit resistance.

(By this extremely sensitive relay action, the voltage of transients of only a fraction of a volt and less than a microsecond in duration can be measured.)

The control just described is a particularly effective way of turning the current *on* (thousands of amperes may be turned on by a fraction of a volt applied to the grid) but it cannot turn it *off*. The current however can turn itself off if alternating anode voltage is used: it will cease at the end of the positive half-cycle. At the next positive half-cycle, it will start or not start according to the grid voltage: thus grid control of the average current is obtained. Another and better method of control is obtained by using alternating grid voltage and controlling its phase with respect to the anode alternating voltage: as for example by determining the phase by the rate of charging of the grid condenser by photoelectric current—in which case the average current through the valve varies continuously and uniformly as the illumination is varied.

In the case of direct current anode supply it is necessary to produce a momentary drop of anode voltage to such a value that ionisation stops, and to maintain this drop long enough for the ions to diffuse to the electrodes.* This can be done in various ways, the most useful perhaps being by means of a second valve. Such a pair of valves gives an arrangement in which the current can be shifted at will from one valve to the other: it can be used to convert direct into alternating current.

HOT-CATHODE THYRATRONS.—A. W. Hull. (*Gen. Elec. Review*, April, 1929, V. 32, pp. 213–223.)

Part I of a paper on the practical aspects of the gas- or vapour-filled triode rectifier referred to above.

CALCULATIONS ON VACUUM TUBES AND THE DESIGN OF TRIODES.—Y. Kusunose. (*Res. Electrot. Lab. Tokyo*, September, 1928, No. 237, 163 pp.)

Dealing first with diodes, the writer shows how the Langmuir equation is applied to the design of these: minor effects (initial velocity of electrons, superposition of anode current on filament current, etc.) are neglected for practical purposes. He shows how, for example, the quantity $A$ (effective anode area) is best reckoned, confirming by examples in which the calculated and observed curves agree very well. He mentions that when the filament is supported by a complex structure (as in many high-power rectifiers) the latter must be considered as the grid of a triode and the characteristic computed by the triode equation assuming zero grid voltage. Numerous examples, on various types of valve, are given.

Passing on to triodes, he makes use of Eccles' statement that the current through a (cylindrical) triode is the same as that through a diode of the same length and of radius equal to that of the surface on which the grid is wound, provided that the voltage applied to the diode is $\frac{e_a + \mu e_g}{1 + \mu}$ where

*Time for de-ionisation is considered in the paper, and a semi-empirical formula given.

$\mu$ is the amplification constant. Here, again, the writer shows how, according to his experimental results, the effective grid area should be measured. Numerous static characteristics, calculated and observed, are shown; agreement being excellent. For roughly calculating grid current (for low positive grid voltages, where it is small compared with anode current) he uses formulæ given in Lange's paper (Abstracts, 1928, V. 5, p. 520, etc.). He shows how to calculate the amplification constant, mutual conductance, anode impedance, and saturation current.

The next part of the paper deals with the determination of the behaviour of a triode, from its static characteristics, in any given circuit arrangement. For this purpose the writer obtains curves giving the values of the D.C. and A.C. components of the anode current under any conditions: from these he derives the "dynamic characteristic diagram," the use of which allows the behaviour of the triode to be calculated. Among numerous examples worked out, the following is one chosen as an illustration: a triode, type VM-100, has a rating as shown in a table: its optimum operating conditions used as a power amplifier for distortionless reproduction are required. The last chapter deals with the design of triodes for particular requirements.

Electronic Emission in a Vacuum Tube.—L. Tieri and V. Ricca. (Summary in *Science Abstracts*, Sec. A., 25th March, 1929, p. 257.)

An experimental investigation of the relation between the variations of filament current and the variations of electronic current, when the plate/filament voltage is varied. The effect on the filament current is connected with the work of separation of the electrons, and can therefore be used for determining the intrinsic potentials of some metals.

Phases of the Thermionic Saturation Current: Thermionic Valve Circuit with Condenser in a Derived Circuit.—C. Dei. (Summaries in *Science Abstracts*, Sec. A., 25th March, 1929, p. 257.)

Two papers from the Acad. Lincei, Rome. They both deal with a mathematical investigation of the phases and intensity of current in circuits which include a diode valve at saturation. The current intensity does not reach a value rigorously constant, because with increase of anode/filament voltage it increases approximately linearly.

Émission thermo-ionique de Tubes de Cuivre remplis de Sels (Thermionic Emission from Copper Tubes filled with Salts).—T. Pecsalski and J. Chichocki. (*Comptes Rendus*, 4th March, 1929, V. 188, pp. 699–701.)

A tube of copper was filled with a salt and then drawn out till its diameter was almost quartered, so that the salt completely filled the tube. The tube was arranged along the axis of a much larger tube, these two tubes being in a container exhausted to $10^{-6}$ mm. A current was passed through the salt-filled tube, and a P.D. (80 v.) applied across the two tubes. A thermionic current, rising to $2 \times 10^{-7}$A. in about 40 minutes, was obtained for positive emission, a smaller value, appearing more slowly, for negative; this was with $NiCl_2$ in the tube. With an empty tube no thermionic current could be obtained. Further details are given.

Un Abaque de Classification pour les Triodes de Réception (An Abac of Receiving Valve Classification).—B. Decaux. (*L'Onde Élec.*, January, 1929, V. 8, pp. 37–40.)

The principal types of receiving valves sold in France are included in this chart, which shows their amplification coefficients, internal resistances and spheres of usefulness.

The UV-861.—H. P. Westman. (*QST*, February, 1929, pp. 41–43 and 88.)

Full description and details of a 500-watt screen-grid transmitting valve, normal anode voltage 3,000, suitable for short wavelengths. Its use is described in a following article (pp. 44–48) by C. C. Rodimon.

Mica Screen for Locating the Deposition of Magnesium in Valves.—(*French Patent*, 646,813, Loewe, pub. 16th November 1928.)

A specially arranged mica screen prevents the magnesium from depositing itself near the stem of the bulb or on the electrodes. It is found that a better vacuum is thus maintained, chiefly because any magnesium deposited on the anode is liable to give up its gas when the valve is in use owing to the heat produced.

Burn-out of Incandescent Lamps.—(*Gen. Elec. Review*, April, 1929, V. 32, pp. 206–212.)

Gas-filled lamps burn out at a much smaller loss in weight than vacuum lamps. Various factors are found to contribute to this result: change in crystalline structure is the "most spectacular"; leakage currents and the chemical effects of the gas are also important.

## DIRECTIONAL WIRELESS.

Prevention of Locating by Direction-finding.—(*German Patent* 467,693, Telefunken, pub. 9th November, 1928.)

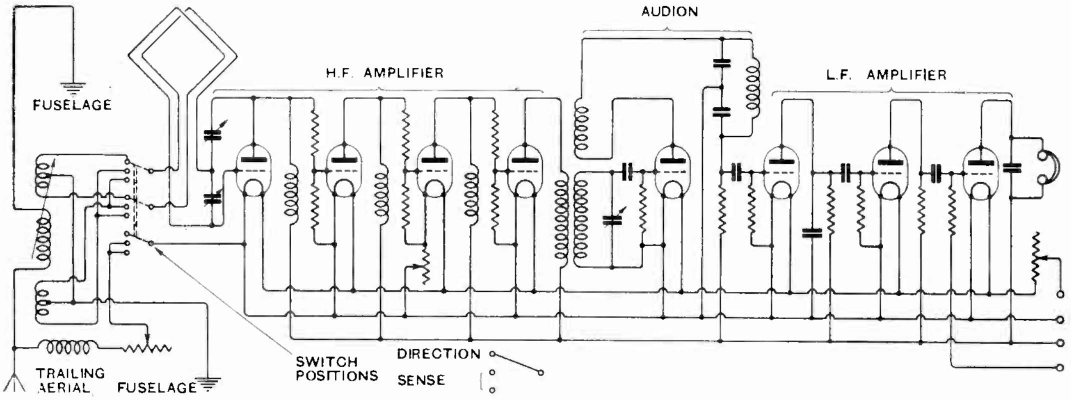
The direction of a transmitting station is concealed by making its directively radiating aerial rotate, or by using a number of directive aerials and connecting them in succession to the transmitter. Directive aerials usually send out a small component which is not directed: this must be compensated for by an auxiliary aerial.

Le Chemin du Rayon Électromagnétique (The Path of the Electromagnetic Ray).—de la Forge. (*QST Franç.*, December, 1928, pp. 6–11.)

Conclusion of the long analysis of the Radio Research Board report on Direction Finding (Abstracts, 1928, V. 5, p. 642).

DER BORDPEILEMPFANGER IM FLUGZEUG (The Direction-finding Receiver for Use on Board Aircraft).—M. H. Gloeckner. (*Zeitschr. f. Hochf. Tech.*, March, 1929, V. 33, pp. 92–101.)

A paper on the new Telefunken D.F. outfit and the series of tests leading up to its design. The writer admits that both the two main systems of D.F. have their advantages, but points out that for long distance work the D.F. on the aircraft itself is always preferable because of the greater power of the ground station. After enumerating the various requirements which this new outfit had to fulfil, he goes on to describe the methods adopted for neutralising the antenna effect of the frame (by means of an auxiliary aerial, generally trailing, though a photograph of a Junkers F.13 shows a fixed auxiliary aerial) and for determining sense. The diagram reproduced shows these arrangements.




The rest of the paper deals with the installation of the apparatus and its correction for effects due to metal parts, etc. Fischer's work (see Abstracts, 1928, V. 5, p. 522) is made use of. Calibration is carried out on the ground, the aeroplane being rotated on a turn-table while receiving from a fixed station 20 km. away.

REPÉRAGE DES DIRECTIONS FIXES AU MOYEN D'ONDES HERTZIENNES—RADIO - ALIGNEMENTS (Course-Setting by Hertz Waves—Radio Alignments).— — Aicardi. (*L'Onde Élec.* January, 1929, V. 8, pp. 20–28).

In trials of this method, using a D.C. input of 200 w. at the transmitting ground station, an aeroplane has been guided with an accuracy of the order of 1 degree up to a distance of about 60 km. 60 m. waves were employed, transmitted simultaneously from two vertical aerials spaced about 45 m. apart (consisting of copper tubes 6–8 metres high, with radial counterpoise). One aerial sends out continuous waves, the other modulated waves of the same length but of much smaller amplitude. Along the nodal lines (of which there may be one, two or more, depending on the ratio of aerial spacing to wavelength*), these two sets of waves give a resultant field of high and *constant* strength.

In order to make it easier for the aeroplane to keep to its course, and to find it again when it has been lost, the nodal lines are periodically swept through an angle of 5 to 10 degrees by the use of a rotating condenser in parallel with the aerial capacity. The combined results are as follows: signal strength, which has been practically constant outside the swept zone, suffers a periodic and increasing weakening as this zone is approached. As the zone is penetrated, the minima become of zero strength and double in number, becoming equally spaced when the axis of the zone (the true course) is reached. It is said that this equidistant spacing is very easily observed.

A further refinement allows the observer to see on which side of the course he is at any moment: this consists in changing the modulation frequency, for a very short period, once in every complete "sweep." On one side of the axis this frequency-change follows the minimum (or group of two minima if the zone is already penetrated); on the other side, it precedes it.

RADIO DIRECTION-FINDING BY TRANSMISSION AND RECEPTION (With Particular Reference to its Application to Marine Navigation).—R. L. Smith-Rose. (*Proc. Inst. Rad. Eng.*, March, 1929, V. 17, pp. 425–478.)

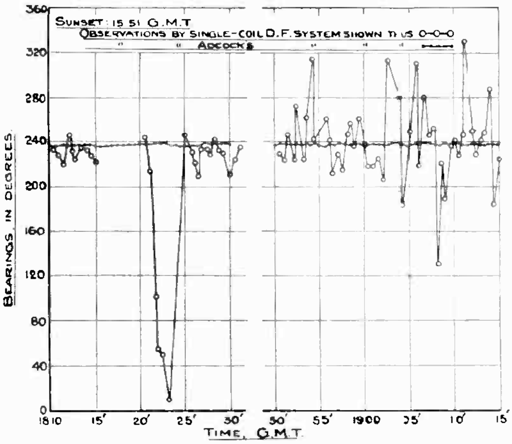
An abridgment of this paper was read at the 1928 U.R.S.I. meeting in Brussels. Author's summary :—"This paper presents a critical *résumé* of the performance of apparatus employed for radio direction determination either by transmission or by reception. After an historical summary of results obtained in various parts of the world, a brief description is given of the fundamental principles underlying radio direction-finding. In this section attention is drawn to the application of the principle of reversibility to this art, by the aid of which the behaviour of directive radio transmitters can be largely

* If the spacing is slightly less than half the wavelength, only one nodal line is obtained: "sufficient" accuracy was found in this case, but the accuracy is greater with larger values of the ratio.

predicted from the more numerous results and greater experience already obtained with directional receivers.

"The next two sections of the paper give a review of the results obtained in Great Britain during the course of extensive investigations into this subject during the past seven years. Observations obtained from thirteen direction-finding receiving stations, specially erected for the purpose, have been carefully analysed and the performance of the apparatus studied under a variety of conditions, including operation in daylight and darkness, and both oversea and overland. In addition, some two years have been spent in studying the performance of a rotating-loop beacon transmitter, by means of which accurate radio bearing can be obtained with any type of receiving apparatus.

"The later portions of the paper deal with the application of direction-finding to marine navigation, and with the possible effect of coastal and night errors in connection therewith. The production of night errors on closed loop receivers by the horizontal component of the electric force in downcoming waves is explained, and a demonstration is given of the manner in which the Adcock aerial system gives freedom from such errors. The paper concludes with a discussion of the relative advantages of direction-finding by transmission and reception for navigation purposes. A bibliography of the subject is appended."




*Observations of Bearings on Bournemouth, Dec.* 10, 1925 ($\lambda = 386$ *m.*).

The figure reproduced shows the type of result obtained with the Adcock direction-finder (in which the errors due to down-coming waves polarised with the electric force horizontal are avoided) as compared with simultaneous observations on the ordinary closed-coil direction-finder.

## ACOUSTICS AND AUDIO-FREQUENCIES.

APPARENT EQUALITY OF LOUD-SPEAKER OUTPUT AT VARIOUS FREQUENCIES.—L. G. Hector and H. N. Kozanowski. (*Proc. Inst. Rad. Eng.*, March, 1929, V. 17, pp. 521–535.)

Authors' summary:—A type of alternation phonometer has been developed which permits rapid switching of power at two frequencies to the same loud speaker without the distracting effect of the transients that would result from ordinary types of commutation. This result is obtained by the use of rotating condensers to provide variable capacitative reactance in the input circuit of the power amplifier that operates the speaker. The power consumed by the loud speaker is measured with a specially constructed wattmeter of the electrodynamometer type and the output of the loud speaker is measured by means of the torques produced on a Rayleigh disc. With the aid of the alternation phonometer and an additional capacitative reactance, the observer is able to adjust the power input to the loud speaker until two tones of different frequencies appear to have the same intensity. The purpose of the research was to develop a method for the comparison of loud-speaker efficiency at various frequencies that could be used in ordinary laboratories with limited equipment.

MINIMUM VALUE OF AMPLITUDE OF SECOND HARMONIC WHICH MUST BE SUPERPOSED ON FIRST HARMONIC SO THAT IT BECOMES NOTICEABLE IN AN "ORDINARY" LOUD SPEAKER.—(*Nature*, 23rd March, 1929, V. 123, p. 466.)

A paragraph on recent B.B.C. tests. With a fundamental of 900, the amplitude of the second harmonic has to be at least 3 per cent. of that of the fundamental: at higher frequencies a much greater percentage is necessary (*e.g.*, 49 per cent. for a 5,000 fundamental). "The introduction of cone loud speakers and the annulment of resonance effects by frequency filters were notable steps in advance. The efficiency of transformation of all ordinary loud speakers is very low. Some of the loud speakers, however, used in the commercial operation of 'Movietone' and 'Vitaphone' talking-film systems have efficiencies of 30 per cent. A new Western Electric loud speaker is claimed to have a 50 per cent. efficiency."

INSENSITIVE LOUD SPEAKERS AND FALSE ECONOMY.—A.L.M.S. (*Wireless World*, 20th March, 1929, V. 24, p. 301.)

Poor loud speakers often require heavy anode current, and what is saved in the price of the loud speaker may be lost many times over.

TRANSIENTS *alias* "ATTACK": NATURAL OSCILLATIONS OF LOUD-SPEAKER DIAPHRAGMS.—N. W. McLachlan. (*Wireless World*, 3rd and 10th April, 1929, V. 24, pp. 346–348 and 385–388.)

The first part describes the nature of a "transient" (a sudden change in current) and shows how it may be expected to produce the same kind of effect as is obtained by tapping the apex of a loud-speaker cone; i.e., an effect involving the natural oscillations of the diaphragm. It then outlines a series of experiments on the behaviour of various types of loud speaker under the influence of such sudden changes which occur to a greater or less extent in the reproduction of all speech, music, etc. The second part gives the result of these experiments, in the form of oscillograms with analytical comments on each.

VORÜBERTRAGER VERZERRUNGSFREIER VERSTÄRKER (Input Transformers of Distortionless Amplifiers).—R. Feldtkeller and H. Bartels. (*E.N.T.*, February, 1929, V. 6, pp. 87–90.)

Authors' summary:—The desired width of the frequency band to be transmitted, and the data of the amplifier valves employed, definitely determine a maximum allowable transformation ratio and leakage coefficient. A simple relation is established between the top frequency and the highest amplification attainable without distortion by one valve; this amplification is independent of the width of the frequency band.

CHOOSING A POWER VALVE FOR THE REED-DRIVEN LOUD SPEAKER: AN ANALYSIS OF IMPEDANCE RELATIONSHIP.—N. W. McLachlan. (*Wireless World*, 20th March, 1929, V. 24, pp. 298–301.)

FREQUENCY GRAMOPHONE RECORDS.—(*Electrician*, 5th April, 1929, V. 102, p. 428.)

A paragraph on the set of 15 double-sided records recently brought out by the Gramophone Company, giving a series of pure tones ranging over about $8\frac{1}{2}$ octaves up to 8,400 p.p.s. "Provided the turntable runs exactly 78 r.p.m., the frequencies are correct to within 1 per cent." The exact amount of energy has been calibrated and is given on the labels in the form of T.U.'s above or below the energy of the 993 cycle note.

NEUE HILFSMITTEL FÜR AKUSTISCHE MESSUNGEN (New Aids to Acoustic Measurement).—(*E.N.T.*, March, 1929, V. 6, p. 112.)

A paragraph on a new series of gramophone records providing standard frequencies. One side of the first record begins with 6,000 cycles and changes continuously down to 100. The amplitude of the needle movement is inversely proportional to the frequency. The reverse side has the same range but each note varies some ten times per second by ± 50 cycles, producing a "sliding howl." Other records give steady howls, each side covering only two frequencies.

ENERGIEBILANZ IM RUNDFUNK (The Balance of Energy in Broadcasting).—E. Wolf. (*Elektrot. u. Masch:bau.*, 10th March, 1929, pp. 197–200.)

A paper on fidelity of transmission and reception.

THE STUDY OF NOISES IN ELECTRICAL APPARATUS.—T. Spooner and J. P. Foltz. (*Journ. Am. I.E.E.*, March, 1929, V. 48, pp. 199–202.)

PROGRESS IN TECHNICAL ACOUSTICS IN GERMANY IN 1928.—W. Wagner. (*E.N.T.*, March, 1929, V. 6, pp. 119–120.)

## PHOTOTELEGRAPHY AND TELEVISION.

PICTURE TELEGRAPHY.—(German Patent 467977, Lorenz, published 3rd November, 1928.)

Coloured paper covered with a thin layer (0.001–0.003 mm.) of wax is used for recording; a very small movement of armature or diaphragm can cause the cutting away of the wax to reveal the coloured background.

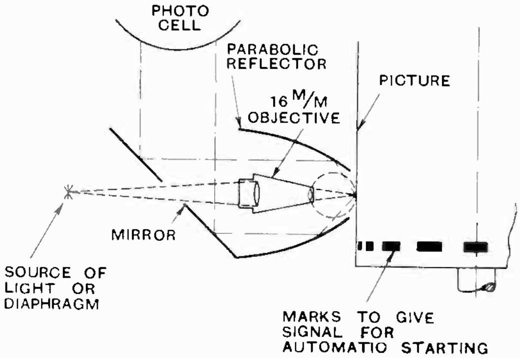
FACSIMILE PICTURE TRANSMISSION.—V. Zworykin. (*Proc. Inst. Rad. Eng.*, March, 1929, V. 17, pp. 536–550.)

Author's summary:—"A facsimile picture-transmitting system is described. The chief object of the design of this system was to produce a simple, rugged apparatus for practical usage, which would not require the attention of a skilled operator. The system does not require a special preparation of the original, and the receiver records the copy directly on the photographic paper.

"The usually delicate problem of photo-cell current amplification has been simplified to such an extent that only three stages of resistance-coupled amplification suffice between the photo-cell and modulator of the broadcasting station. This was made possible through the design of a very efficient optical system, which supplies to the photo-cell quite enough light reflected from the picture even though only a small incandescent lamp for illumination is used.

"The synchronising and framing have also been simplified to such a degree that they do not require any special channels or special amplifiers.

"Automatic starting devices obviate the use of any complicated scheme of signal dispatch for starting the apparatus. In spite of the simplicity of operation, it is capable of transmitting a 5 in. by 8 in. picture either in black and white or in half-tone in 48 seconds, or a message at the rate of 630 words per minute over short distances.




"The resulting picture prints are of a quality quite satisfactory for newspaper reproduction and clear facsimile of messages may be made from type-written originals."

The transmitting optical system referred to is shown in the diagram.

Recording is done by a Knowles grid-glow (helium) tube, a discharge of about 15 mA. at 400 v. being sufficient, at the speeds named, to give very satisfactory blackening on the bromide paper used.

Synchronisation is by periodic correction of 70-cycle tuning fork control. A very satisfactory example of the work done by this system is given (transmitted over a short telephone line and a few miles of wireless).

THE COLVERGRAPH: TECHNICAL DETAILS OF A NEW PICTURE RECEIVER.—F. H. Haynes. (*Wireless World*, 27th March, 1929, V. 24, pp. 331–334.)

Special points are:—The mechanism by which the standardised "stop-start" synchronising is performed; this mechanism gives an "accelerated start" which relieves the motor of the starting load, and also provides that the driving and driven pinions are running at the same speed when they mesh; trigger-release relays are done away with, the release-magnet winding being permanently traversed by an insufficient current which the starting signal increases—this is said to give constancy of time of release for varying strength of starting signal due to fading, etc.; the stylus does not travel, and any side-play is in the direction of rotation of the cylinder and not transverse to the image-forming line; a spare cylinder, ready loaded, can be dropped into position over the central drum when one picture is finished.

DER GEGENWÄRTIGE STAND DER BILDTELEGRAPHIE: 3.—DER ELEKTROLYTISCHE QUERSCHREIBER VON TELEFUNKEN. 4.—DIE BILDRUNDFUNKENEMPFÄNGER (The Present Position of Picture Telegraphy: 3.—The Telefunken Electrolytic Transcriber, and 4.—The Picture Broadcast Receiver).—F. Noack. (*Rad. f. Alle*, March and April, 1929, pp. 139–143 and 166–171.)

UN NOUVEAU SYSTÈME DE TÉLÉVISION ET DE TÉLÉCINÉMATOGRAPHIE (A New System of Television and Telecinematography).—L. Thurm. (*QST* Franç., January 1929, pp. 58–59.)

Continuation of article referred to in March Abstracts, p. 157.

SYNCHRONISATION.—(German Patent 469012, Dieckmann and Hell, published 29th November, 1928.)

In the system depending on a periodic correcting-signal, the dislocation liable to be caused by a false signal is avoided by making the correcting-signal a definite series of signals, the correcting mechanism at the receiver functioning only on the arrival of the correct series.

THALLIUM PHOTOELECTRIC CELLS.—L. Rolla. (*Nature*, 9th March, 1929, V. 123, p. 396.)

Rolla states that the procedure described by Majorana and Todesco (March Abstracts, p. 158) was published by him in 1927, has been patented, and has been used successfully by the Italian military authorities.

PHOTOELECTRIC CELLS, AMPLIFICATION, ETC.—See under "Miscellaneous," A Recording Photoelectric Colour Analyser.

CÆSIUM-MAGNESIUM PHOTOELECTRIC CELL.—V. Zworykin and E. D. Wilson. (*Sci. News-letter*, 2nd March, 1929, V. 15, pp. 133–134.)

A paragraph on this new cell, in which the difficulty in working with cæsium is overcome by the use of magnesium, which binds the cæsium to the walls of the glass bulb. Its sensitivity is higher than that of other cells; its greatest response is to bluish-green light, and its use in television would give an image with colour values closely approaching those of the eye.

## MEASUREMENTS AND STANDARDS.

NOTE ON AN APPLICATION OF THE WHIDDINGTON ULTRA-MICROMETER.—H. Lloyd. (*Journ. Scient. Instr.*, March, 1929, V. 6, pp. 81–84.)

The dimensional change which it is required to measure alters the capacity of a condenser, and by a heterodyne method indicates its magnitude. This paper describes certain difficulties encountered when using the arrangement for magnetostriction measurements, and the ways in which these were overcome. The wavelength worked on was about 20 m., and the note was matched with that of a 256 p.p.s. tuning fork. Frequency changes due to the movements of the operator wearing the head telephones were completely obviated by using a loud-speaker movement connected by a glass tube 3 ft. long, at the other end of which was a sensitive telephone ear-piece which acted as an electro-dynamic microphone completely insulated (electrically) from the heterodyne circuits.

A further improvement was made by adjusting the length of this tube to suit the fork frequency, thus making it work as an acoustic filter. The tendency of the two H.F. circuits to pull into synchronism was cured by halving the frequency of the second oscillator, using its second harmonic to beat with the first oscillator. Successful visual indication of tuning was obtained (in the form of Lissajous' figures) by the use of an oscillograph device adapted from a reed type Brown relay, a Pointolite lamp, and a mirror on the tuning fork.

Handley (pp. 84–88) describes methods of mounting the variable condenser to eliminate vibration, and other precautions (in connection with the magnetostriction process) to eliminate temperature variations, etc.

NOTE ON MAGNETOSTRICTION AND ALLIED PHENOMENA.—J. H. Vincent. (*Journ. Scient. Instr.*, March, 1929, V. 6, pp. 89–90.)

The writer points out that Whiddington's ultra-micrometer, as adapted by Lloyd and Handley (see above), should be an ideal tool for future investigations on magnetostriction in diamagnetic substances, Barrett effect (change in volume due to magnetic field) in liquids, Joule effect in glass, etc.

LES VIBRATIONS DU QUARTZ PIÉZOÉLECTRIQUE RENDUES VISIBLES EN LUMIÈRE POLARISÉE (The Vibrations of Piezoelectric Quartz rendered Visible by Polarised Light).—E. P. Tawil. (Summary in *Rev. Gén. de l'Élec.*, 12th January, 1929, V. 25, p. 58.)

The piezoelectric vibrations of a quartz crystal involve compressions and dilatations which modify the optical properties of the crystal: it changes from a uni-axial to bi-axial condition and *vice versa*. The paper describes a method of rendering visible, by this effect on polarised light, the nodes and antinodes of vibration, however complex in form they may be. Once recorded, these figures enable one to know at once at what frequency the crystal is vibrating. Moreover, the point of greatest clearness of the image indicates the resonance point with great accuracy. Finally, the writer mentions that the phenomenon, which has nothing in common with the Kerr effect, gives a method of modulating a light ray at very high frequencies.

Die Wellenkontrolle der Internationalen Rundspruchunion (The Wave Control of the International Radiotelephony Union).—G. A. Schwaiger. (*Elektrot. u. Masch:bau*, 20th January, 1929, pp. 45–49.)

A description of the methods of the Brussels Control Office.

Standardisation of Frequency.—S. Jimbo. (*Res. Electrot. Lab.*, Tokyo, No. 236, September, 1928, 53 pp.)

In English: a long and detailed account of the setting up of a frequency standard. In the part dealing with the measurement of frequency, the stroboscope, phonic motor and harmonic comparator are discussed, together with various improvements. In another part, tuning fork and quartz-oscillator controlled standards, etc., are dealt with, while a final part considers resonators, with their characteristics and response curves. An extensive bibliography is included.

Some Properties of a Fused Silica Tuning-fork.—E. A. Harrington. (*Journ. Opt. Soc. Am.*, February, 1929, V. 18, pp. 89–95.)

"The logarithmic decrement, the coefficient of damping, and the coefficient of stiffness of a fused silica tuning fork were determined from data obtained from photographic records of the vibrations of the tuning-fork after it had been struck with a pianoforte hammer." The results show that fused silica is a highly suitable material, chiefly owing to its high elasticity, small temperature-effect and invariance with time, its very low coefficient of expansion and the almost negligible effect of damping on its vibration period (less than two parts in a thousand million). The chief objections are: (1) its fragility, whence only a small intensity of sound can be produced by hammering—thus preventing its use as a practical standard of pitch; and (2) the vibrations cannot be maintained electrically without loading the prongs with iron.

The Measurement of the Anode Circuit Impedances and Mutual Conductances of Thermionic Valves.—L. Hartshorn. (*Proc. Phys. Soc.*, 15th February, 1929, V. 41, pp. 114–125.)

Author's Abstract:—"The paper describes the application of the Wheatstone Bridge to the measurement of the anode circuit admittance or impedance, and the mutual conductance of a valve under actual operating conditions. Current of telephonic frequency is used. The measurements can be made for grid bias of any desired value, and both methods can be made direct-reading. The results of measurements made on a few typical valves are given, and it is shown that although both anode circuit resistance and mutual conductance vary very considerably with the grid bias, the product of the two, which gives the voltage factor of the valve, is approximately constant. The anode circuit admittance consists of a conductance associated with a comparatively small capacity, but this capacity is larger than the inter-electrode capacities of the valve when the filament is cold. The increase in the effective values of the inter-electrode capacities is explained by the presence of the space charge, which also has the effects of making these capacities vary with the frequency and of giving them a comparatively high power factor, especially at low frequencies."

Later, the author remarks that circuits for comparatively rough measurements of anode circuit resistance have been described by Barkhausen and Bagally, but for precision work, and especially if the actual impedance or admittance is required, and not merely the resistance, a number of refinements are necessary: these include a Wagner earthing device. In the subsequent discussion, he mentions that what he considers one of the most important conclusions to be drawn from his investigation is that the effective inter-electrode capacities of valves are not simply the same as the corresponding "static" capacities, but that they vary with the position on the characteristic curve of the operating point ($V$, $v$), and therefore the resistance of the valve, and also with the frequency. His results show the kind of variation and also its order of magnitude. The method could be applied to high frequencies, provided that suitable bridge components were used and that everything were properly screened: the practical difficulties would be considerable, but not insuperable.

An Extension of the Method of Measuring Inductances and Capacities.—S. Harris. (*Proc. Inst. Rad. Eng.*, March, 1929, V. 17, pp. 516–520.)

The substitution method commonly employed for measuring small capacities is shown to be a special case of a more general principle. As other special cases of this principle, methods are presented for simultaneously measuring inductance and capacity when joined in series and when joined in parallel. The cases discussed indicate the method of application of the general principle to any type of measuring or measured circuit.

In a subsequent discussion, R. R. Batcher points out several precautions necessary in applying the methods outlined in the paper.

The Measurement of the Inductances and Effective Resistances of Iron-Cored Coils carrying both Direct and Alternating Current.—L. Hartshorn. (*Journ. Scient. Instr.*, April, 1929, V. 6, pp. 113–115.)

"A method is described for the measurement of the effective inductance and resistance of coils of large self-inductance, which are required to carry a comparatively large direct current, with a superposed alternating current ripple. Hay's inductance bridge is used, with special arrangements for the independent control and measurement of the A.C. and D.C. components, the avoidance of earth-capacity effects without earth-connecting the D.C. supply, and the elimination of the direct current from the vibration galvanometer used as detector, without losing sensitivity. Typical results are given."

A METHOD FOR THE DETERMINATION OF THE EQUIVALENT RESISTANCE OF AIR-CONDENSERS AT HIGH FREQUENCIES.—G. W. Sutton. (*Proc. Phys. Soc.*, 15th February, 1929, V. 41, pp. 126–134.)

Author's Abstract :—"The losses in air-condensers are divided into two portions, (1) those due to leakage through the solid dielectric, and (2) those due to terminal and plate resistance. A method is developed for measuring each, under conditions such that the other is negligibly small. The limits of the errors to which the methods are liable are discussed and some results of practical measurements are quoted."

The method is based on the similarity between the distribution of the lines of current-flow between two electrodes immersed in a conducting solution and that of the lines of electric force between two insulated and charged surfaces of the same area, shape and relative position (a principle used in the investigation of the electromagnetic field of machines, etc.—*cf*. Hague, May Abstracts, p. 280). In the discussion the author defends his method against various criticisms based on the possible effects of submerging the condenser in an electrolyte. Referring to Dye's results and to Wilmotte's (Abstracts, 1928, p. 644, and 1929, p. 162), he mentions points of difference from his own: he finds the solid insulation losses to have an equivalent resistance very closely proportional to $1/f$, and the remaining losses to be represented by a series resistance rapidly increasing with the frequency (as would be expected if they are ascribable to skin effect).

A LOSS-FREE AIR CONDENSER FOR A.C. BRIDGE WORK.—K. Ogawa. (*Journ. I.E.E., Japan*. December, 1928, pp. 1278–1298.)

The use of earthed screening round the insulators supporting the two series of electrodes has already been described by others, but here the use of such a condenser is particularly recommended for use with an A.C. bridge. Also, being independent of frequency, it can serve as a standard of capacity.

RESONANCE RADIOMETRY.—A. H. Pfund. (*Science*, 18th January, 1929, V. 69, pp. 71–72.)

The limiting sensitivity of any radiometric system is reached when spurious deflections become comparable with real deflections. Beyond this point optical magnification, increased period, etc., are of no avail. An attempt is here most successfully made to reduce the relative effect of spurious disturbances by causing the radiations to be intermittent with a definite period, and to "tune" the entire system to that period. A thermopile was exposed to radiation at intervals of 0.75 sec. by means of a pendulum with a 1.5 sec. period, and was connected to a D'Arsonval galvanometer tuned to 1.5 sec.

A concave mirror on this projected the image of a coarse grid on to a second, similar grid, this latter being "split" centrally so that the image of the first grid—when in motion—increased the amount of light transmitted on one side and decreased that on the other. By means of a split lens, the light passing the second grid was brought to two foci on the junctions of a compensating thermopile (later, sensitivity was increased 1,000 times by replacing this by a photoelectric cell and amplifier). This controlled a second galvanometer also tuned to 1.5 sec. High sensitivity, combined with a high degree of immunity from disturbances, was obtained.

SUR UNE MÉTHODE DE MESURE DE TRÈS FAIBLES COURANTS ÉLECTRIQUES, MÉTHODE DITE D'ÉLECTROMÉTRIE TACHYMÉTRIQUE (The "Tachometric" Method of Measuring Very Small Electric Currents).—C. Guilbert. (*Comptes Rendus*, 18th March, 1929, V. 188, pp. 861–863.)

The writer calculates that by this method currents of the order of $10^{-13}$ ampere can be measured. It depends on noting the r.p.m. of a motor which in its rotation successively charges a very small condenser to a fixed voltage and discharges it into an electrometer; the motor speed being adjusted so that the charges thus given compensate for the charge which is being lost from the electrometer by reason of the current to be measured; so that the electrometer is kept at a constant deflection.

DEUX EXEMPLES DE MONTAGES QUI FONT INTERVENIR LA VARIATION DES CARACTÉRISTIQUES D'UN APPARAIL RÉCEPTEUR OU DE MESURE (Two Examples of Methods of Connection which introduce Variation of the Characteristics of a Receiving or Measuring Instrument).—L. Cagniard. (*L'Onde Élec.*, February, 1929, V. 8, pp. 68–76.)

Second part of the paper referred to in Abstracts, 1928, V. 5, p. 523. It shows how a quadrant electrometer can be used as the indicating instrument in a Wheatstone bridge supplied with H.F. current, and how its use results in an arrangement of extraordinary sensitivity and accuracy for the measurement of capacities, inductances, etc. A change in capacity of the order of 1 in a million or even more can be measured.

MEASUREMENT OF ULTRA-RADIO FREQUENCIES BY STANDING WAVES ON WIRES AND ITS COMPARISON WITH THAT BY MULTIVIBRATOR SYSTEM.—S. Ishikawa. (*Res. Electrot. Lab., Tokyo*, November, 1928, No. 242, 34 pp.)

In Japanese. To test whether Lecher wire measurements could be relied on (after applying Hund's correction factor) a comparison with Multivibrator results was made. It was found that while the latter system had an accuracy of about 0.003 per cent., the parallel wire method had an accuracy about a tenth of this; direct comparison showed that the latter system always gave higher values than the former, by about 0.1 per cent. The tests were on a narrow band round 25 m.

USE OF THE MODIFIED BELFILS BRIDGE FOR THE MEASUREMENT OF THE IRREGULARITY OF A VOLTAGE NOT STRICTLY CONTINUOUS.—C. Chiodi. (*L'Elettrotec.*, 5th October, 1928, V. 15, pp. 757–764.)

The author has applied this bridge very successfully to such investigations as that of the current through a mercury vapour rectifier, and finds it the easiest of all methods so far known.

THERMIONIC VALVE POTENTIOMETER FOR E.M.F. MEASUREMENTS.—H. M. Partridge. (Summary in *Nature*, 20th April, 1929, V. 123, pp. 620–621; from *J. Am. Chem. Soc.*, January.)

An arrangement of a tetrode and a triode is described (the latter acting as an amplifier giving greater sensitivity) which is said to be independent of constancy of the valve characteristics and of the filament and plate potentials. Its action is essentially electrostatic; no calibration of the valves is necessary, the E.M.F. being read directly from a voltmeter in the grid circuit of the first valve.

EINE EINFACHE KOMPENSATIONSSCHALTUNG ZUR MESSUNG DER KAPAZITÄT UND DES DIELEKTRISCHEN VERLUSTWINKELS VON KONDENSATOREN UND KABELN (A Simple Compensation Circuit for the Measurement of Capacity and Dielectric Loss Angle of Condensers and Cables).—W. Geyger. (*Arch. f. Elektrot.*, 8th April, 1929, V. 21, pp. 529–534.)

CONTACTS IN APPARATUS FOR MEASURING ELECTRICAL RESISTIVITY.—J. L. Haughton. (*Journ. Scient. Instr.*, April, 1929, V. 6, pp. 120–124.)

"In the measurement of electrical resistances by means of potential drop methods, four contacts are required. Methods for making these contacts with the resistance to be measured, both in the cold and at high temperatures, are discussed, and types of contacts suitable for different requirements are specified."

A DIRECT-READING INSTRUMENT FOR MEASURING LOW RESISTANCES.—L. H. Bainbridge-Bell. (*Journ. Scient. Instr.*, April, 1929, V. 6, pp. 139–140.)

This instrument was developed in the course of experiments on mercury contacts. The requirements were that no damage to the indicating instrument should result if the resistance under test suddenly became infinite, and that the current flowing in the device under test should be limited to 1 ampere.

A NEW A.C. MICROAMMETER.—(*Journ. Scient. Instr.*, April, 1929, V. 6, pp. 137–138.)

A Ferranti moving-coil, copper-oxide rectifier instrument: with useful frequency-range 20-6,000 cycles, reading to 750 microamperes with a scale nearly linear from about 100 microamperes upwards.

A VALVE POTENTIOMETER FOR HIGH AND LOW FREQUENCY MEASUREMENTS. — (*Journ. Scient. Instr.*, April, 1929, V. 6, pp. 135–137.)

A Tinsley instrument "designed to provide a means of measuring small high-frequency voltages with the same facility that direct current measurements can be made with the potentiometer."

ON THE MEASUREMENT OF THE DIELECTRIC CONSTANTS OF LIQUIDS, WITH A DETERMINATION OF THE DIELECTRIC CONSTANT OF BENZENE.—L. Hartshorn and D. A. Oliver. (*Proc. Roy. Soc.*, 6th April, 1929, V. 123 A, pp. 664–685.)

MUTUAL INDUCTANCE AND TORQUE BETWEEN TWO CONCENTRIC SOLENOIDS.—C. Snow. (*Bur. of Stds. J. of Res.*, November, 1928, V. 1, No. 5, pp. 685–699.)

Formulæ are derived for the mutual inductance and torque, for any angle between axes, presuming strip windings, so that the solenoids constitute current sheets; correction terms are obtained to allow for finite cross section and discrete nature in the two windings.

SIMPLE INDUCTANCE FORMULAS FOR RADIO COILS.—(*Proc. Inst. Rad. Eng.*, March, 1929, V. 17, pp. 580–582.)

A discussion on Wheeler's paper dealt with in January Abstracts, p. 49.

EINE VERALLGEMEINERTE METHODE ZUR BERECHNUNG DER INDUKTIVITÄTEN EBENER FIGUREN BELIEBIGER FORM (A General Method for the Calculation of the Inductance of Plane Figures of any Shape).—V. J. Bashenoff. (*E.N.T.*, January, 1929, V. 6, pp. 22–40.)

HIGH VOLTAGE MEASUREMENT.—J. S. Carroll and B. Cozzens. (*Journ. Am. I.E.E.*, December, 1928, V. 47, pp. 892–896.)

A new method is described of measuring high voltages, in which the current through a water resistance is recorded on an oscillograph. Over a million volts to earth have been measured with an accuracy believed to be better than 2 per cent. The calibration of a metre-sphere gap was determined for voltages up to 1,100 kv.; also the arc-over voltages for point gaps, for distances up to 30 ft.

A SIMPLE EARTHING SWITCH FOR SMALL ELECTROMETERS.—G. B. Moss. (*Journ. Scient. Instr.*, April, 1929, V. 6, pp. 124–126.)

A suitably shielded switch, adding little to the capacity of the instrument, and worked by a bulb and tube such as are used for photographic shutters.

ÜBER DIE MAGNETOSTRIKTION DER EISENEINKRISTALLE (The Magnetostriction of a Single Crystal of Iron).—N. Akulov. (*Zeitschr. f. Phys.*, 4th December, 1928, V. 52, No. 5/6, pp. 389–405.)

The general formulæ here arrived at agree well with the experimental results of Honda and Mashiyama.

UNTERSUCHUNGEN ÜBER DIE ANFANGSSTROME IM QUARTZ (Investigation of the Initial Current in Quartz).—A. D. Goldhammer. (*Zeitschr. f. Phys.*, 31st December, 1928, V. 52, No. 9/10, pp. 708–725.)

NEUE AUSFÜHRUNGEN VON FERNMESSANLAGEN (New Developments in the Distant Reading of Meters, etc.).—W. Stern. (*E.T.Z.*, 7th March, 1929, pp. 351–353.)

A description of the latest developments of the Telewatt system.

DECIBEL—THE NAME FOR THE TRANSMISSION-UNIT.—W. H. Martin. (*Bell Tech. Journ.*, January, 1929, V. 8, pp. 1–2.)

The European International Advisory Committee has recommended to the various European telephone administrations that they adopt either the decimal or the napierian unit and designate them the "bel" and "neper" respectively. The Bell System has adopted the name "decibel" for the old T.U. (*see* Herd, February Abstracts, p. 111). It will be represented by the abbreviation "db."

UNITS OF ELECTRICAL TRANSMISSION.—J. W. Horton. (*Rad. Engineering*, February, 1929. V. 9, p. 31.)

An article starting with the old "800 cycle mile" and ending with the new "decibel" (here spelt "decibell," thus preserving more clearly the derivation from Graham Bell). It is mentioned that "in high quality broadcast transmission, a power level of 0.006 watt has been arbitrarily chosen as zero level. Thus when we say that an amplifier is capable of delivering a 'plus 10 db level' we mean that it is capable of delivering 0.06 watt."

A SONIC INTERFEROMETER FOR MEASURING COMPRESSIONAL VELOCITIES IN LIQUIDS: A PRECISION METHOD.—A. L. Loomis and J. C. Hubbard. (*Journ. Opt. Soc. Am.*, October, 1928, Part I, V. 17, pp. 295–307.)

The quartz plate is driven at 500,000 cycles/sec. At such a frequency the wavelength in the liquid is small compared with the diameter of the vibrating plate, and it is found that under this condition the measured velocity is independent—to a very high degree of precision—of the dimensions and material of the containing vessel (other methods, using audible frequencies, were vitiated by elastic reaction of the walls, etc.). Very consistent curves are given showing the velocity in water, salt solutions, and mercury, as a function of temperature: and another showing the velocity in salt solution as a function of the percentage of salt.

A MEASUREMENT OF RADIATION AT ABOUT $5\mu$.—K. E. Gould. (*Journ. Opt. Soc. Am.*, September, 1928, V. 17, pp. 198–206.)

A description of the methods and apparatus employed in certain measurements of infra-red radiations by means of a linear thermopile. The latter was constructed by a somewhat new process; the temperature-control methods, though not new, are specially adapted to the particular purpose.

## SUBSIDIARY APPARATUS AND MATERIALS.

ARRANGEMENT FOR OBTAINING AN ALTERNATING CURRENT OF CONSTANT VOLTAGE FROM AN A.C. SUPPLY OF VARIABLE VOLTAGE.—(*French Patent*, 646,957, Brown Boveri et Cie, pub. 19th November, 1928.)

The primaries of two transformers are connected in series across the mains. One transformer has a saturated, the other an unsaturated core. Their secondaries are in series but in opposition, and if these windings are properly chosen the voltage across them remains constant for considerable variations in the voltage across the mains (test has shown that it is also very little affected by variations of frequency). The constancy can be increased still further by the insertion of an ohmic resistance in the primary circuit, and is so good that the device is specially suitable for use with those vacuum-measuring instruments which are heated by A.C.

TEMPERATURE CONTROL APPARATUS.—L. A. Richards. (*Journ. Opt. Soc. Am.*, February, 1929, V. 18, pp. 131–137.)

A detailed description of easily-constructed apparatus for use in an air or water bath. A thermoregulator, utilising the thermal expansion of methyl alcohol or preferably ether, controls the current through the nichrome resistance wire stretched in the air chamber. A pencil-type electric heater consisting of nichrome wire wound on porcelain, encased in a 14-inch brass jacket, is used in the case of a water bath. (*Cf.* Jarvis and Black, Abstracts, 1929, p. 163.)

A PRECISION REGULATOR FOR ALTERNATING VOLTAGE.—H. M. Stoller and J. R. Power. (*Jour. Am. I.E.E.*, February, 1929, V. 48, pp. 110–113.)

A small transformer in one line adds or substracts the voltage required to compensate for fluctuations, its saturation being controlled by a valve-circuit acting through an inductance bridge. Output voltage can be kept constant to within 0.03 per cent. for an input voltage range of 10 per cent. and a load range of from zero to full load. The control valve is a diode, in which a 0.1 per cent. change in filament current will produce a 2 per cent. change in anode current.

CONVERTISSEUR DE COURANT ÉLECTRIQUE DE GRANDE PUISSANCE À ÉTINCELLE PILOTE (High Power Current Converter with Pilot Spark).—P. Toulon. (*Rev. Gén. de l'Elec.*, 30th March and 6th April, 1929, V. 25, pp. 477–482 and 518–526.)

An authoritative paper on the Toulon "converter," which can be used "not only to rectify an alternating current but also to regulate voltage, current and frequency: all these results being obtained with entirely stationary apparatus." It depends on the rectifying properties of a circuit connected to one pole of an arc and to a conductor placed in the arc itself. The second part of the paper includes oscillograms of the work of such a converter, and a description and illustrations of a six-phase model, for 100 kw. at 600 v. The paper ends with an enumeration of the advantages of these converters over large mercury vapour rectifiers: but the last words are a warning that the former will never come into general use until a metal is discovered resistant enough to produce a life equal to that of the latter.

A Thermionic-Valve Type Close Voltage Regulator.—F. C. Turner. (*Engineering*, 21st October, 1927, V. 124, pp. 537–538.)

Voltage from a 15 kw., 200 v., D.C. generator driven off the mains was kept constant within ±0.03 v. by a two-valve circuit, or within 0.3 v. by a single valve circuit. The method depends on the fact that whereas a variation from 199 to 201 v. is small, a change from −1 through 0 to +1 v. is a different matter; this is made use of by means of a balancing battery (practically on open circuit) and a three-electrode valve or valves, whose filament and anode supply is provided by the generator itself.

The Application of the Properties of Thin Metal Films to the Manufacture of Delicate Electric Fuses.—(*Journ. Scient. Instr.*, March, 1929, V. 6, pp. 102–104.)

Fuses which blow at currents between 5 and several hundred milliamperes are now being manufactured. The time of operation of a 80 mA. fuse is less than one thousandth of a second. The paper deals with these fuses and with the superiority of their performance over what might be expected from their dimensions and the thermal properties of the metal—gold—composing them. The final section deals with the preparation of thin metal film, and some performances.

La Théorie Électronique et le Mécanisme de l'Effet de Soupape dans les Cellules Électrolytiques (The Electronic Theory and the Mechanism of the Valve Effect of Electrolytic Cells).—R. Audubert. (*Rev. Gén. de l'Élec.*, 17th November, 1928, V. 24, pp. 737–740.)

The behaviour of these rectifiers is here said to conform with the electrochemical theory of oxidation-reduction and *not* with the electronic theory. The arguments, however, are refuted by Dubar (*ibid.*, 16th March, 1929, p. 399), but Audubert continues the argument on p. 401.

A New Type of Rectifier Tube for Amateur Use.—O. W. Pike and H. T. Maser. (*QST*, February, 1929, V. 13, pp. 20–22.)

The UX-866 is a new hot-cathode mercury vapour rectifier differing from the usual mercury arc tube in (1) its low temperature operation, resulting in high breakdown reverse voltage; and (2) that the rectified current is made up of electrons emitted from a coated ribbon filament. Absence of starting mechanism, low voltage drop (only about 15 v.), and possibility of series connection are some of its advantages. Its rating is stated in terms of its fundamental limits: namely, the maximum peak inverse voltage (5,000 v.), and the peak current through the tube (0.6 amp.).

Alternating Current Rectification as Applied to Radio. Part I.—R. J. Kryter. (*QST*, April, 1929, V. 13, pp. 33–37, 39, 50).

The Prevention of Ionisation in Paper Dielectrics.—S. G. Brown and P. A. Sporing. (*Nature*, 23rd March, 1929, V. 123, p. 472.)

Summary of a lecture before the *I.E.E.* Discussing the breakdown of paper condensers after about a year's service, and the similar behaviour of cables insulated with impregnated paper, it is stated that there is considerable evidence that this is due to the presence of air bubbles in the dielectric. The authors show by theory and experiment the incorrectness of the usual assumption that if the dielectric is worked below the "critical" or "ionisation" voltage (at which the power taken by the cable suddenly begins to increase rapidly) then no ionisation of the air can take place. What is true is that however close together two electrodes are in air at atmospheric pressure, ionisation does not ensue unless the voltage exceeds (approximately) 330 v. The application of this fact to the design of condensers is described: either many thin sections are built up in series so that the voltage across any one section does not exceed that required for ionisation, or isolated conducting layers (interleaves) are placed in the dielectric.

Dielectric Properties of the Sulphur-Rubber Combinations.—S. Kimura, T. Aizawa and T. Takeuchi. (*Journ. I.E.E., Japan*, December, 1928, pp. 1274–1279.)

The conclusions of Curtis and his Bureau of Standards collaborators are condemned on the ground that all their measurements were taken at one temperature; the writers describe their own tests between 0° and 180°C.

Leitsätze fur die Prüfung von Glimmererzeugnissen (Test Specifications for Mica Products).—(*E.T.Z.*, 18th April, 1929, pp. 586–588.)

Proposals of the Insulating Material Committee of the VDE.

The Mechanical Properties of Mica. (*World Power*, January, 1928, V. 11, pp. 32–34.)

Results of the tests carried out for the Electrical Research Association with the object of classifying micas derived from various sources.

Application du Démultiplicateur Statique de Fréquence à l'Oscillographe Cathodique. (Application of the Static Frequency Transformer to the Cathode-ray Oscillograph).—F. Vecchiacchi. (*L'Elettrotec.*, 25th October, 1928, V. 15, pp. 805–814. Summary in *Rev. Gén. de l'Élec.*, January, 1929, V. 25, pp. 19D–20D.)

To produce his time base the writer uses a current of frequency which is an exact sub-multiple of that of the current or potential to be analysed, thus producing a figure which can be conveniently examined or photographed. Mechanical (rotating commutator) methods will work for an analysed frequency up to 1,000 p.s. (assuming a frequency ratio of 20), but valve methods extend the scope to high frequencies. The ordinary valve method of frequency-multiplication is applicable over a wide range of frequencies, but certain advantages (for frequencies over 100,000) are offered by the method of using a triode as a rectifier to charge up a condenser which discharges itself after a certain number of periods. The writer suggests that the method would be of great use in a new study of the functioning of triodes—for very high frequencies a Wood or Dufour type oscillograph taking the place of the Western.

Lenard Ray Tube with Glass Window.—C. M. Slack. (*Journ. Opt. Soc. Am.*, February, 1929, V. 18, pp. 123–126.)

See March Abstracts, p. 163 : Cathode Rays as a Laboratory Tool.

Ein Zeitkipper für den Kathodenoszillographen (A Time-switch for Cathode-ray Oscillographs).—W. Rogowski and O. Wolff. (*Arch. f. Elektrot.*, 8th April, 1929, V. 21, pp. 645–654.)

A starting arrangement for oscillographs used for recording uncontrolled phenomena is described which the writers consider a desirable substitute for Gabor's switching-relay, chiefly on the grounds of simplicity, reliability, and small lag (as low as $10^{-8}$ sec.). A condenser is kept charged to a voltage just insufficient to break down a spark gap. The incoming surge induces just enough extra potential to produce the breakdown ; the condenser discharges and, in so doing, starts the recording. By a suitable arrangement the whole device re-sets itself for the next record.

Aussenaufnahmen von Kathodenstrahloszillogrammen durch Lenardfenster (External Recording of C-R-Oscillograms through a Lenard Window).—M. Knoll and -.Stoerk. (*Zeitschr. f. tech. Phys.*, January, 1929, pp. 28–30).

A photographic recording-speed of 20 m./sec., and a visual recording-speed of 1.4 km./sec., have already been successfully obtained.

Über eine neue erschütterungsfreie Aufstellung für empfindliche Messinstrumente (A New Vibration-free Mounting for Sensitive Measuring Instruments).—R. Müller. (*Ann. der Physik*, 12th March, 1929, Series 5, V. 1, No. 5, pp. 613–656.)

Oscillographs for Recording Transient Phenomena.—W. A. Marrison. (*Journ. Am.I.E.E.*, April, 1929, V. 48, pp. 261–264.)

Two instruments (both of the moving iron balanced-armature type) are described :—the "polar" oscillograph for recording very short transients on a rotating disc of film, and the "continuous-film" oscillograph for making long continuous records. Examples of the work of both types are given. A system of operation is described in which two polar and one c.f. type instruments are used together for studying transients likely to occur at any time during a long period.

The Construction and Calibration of a Sensitive Form of Pirani Gauge for the Measurement of High Vacua.—L. F. Stanley. (*Proc. Phys. Soc.*, 15th April, 1929, V. 41, pp. 194–203.)

The instrument described is capable of measuring pressures within the range $2 \times 10^{-3}$ and $4 \times 10^{-6}$ mm.

The Behaviour of Glass as a Dielectric in Alternating Current Circuits : Part II. The Effect of Frequency and of Temperature upon the Power Loss.—L. S. McDowell and H. L. Begeman. (*Phys. Review*, January, 1929, V. 33, pp. 55–65.)

A Test Condenser for Extra High Tensions.—R. Vieweg and H. Schering. (*Zeitschr. f. tech. Phys.*, November, 1928, pp. 442–445.)

The full paper, a summary of which was referred to in March Abstracts, p. 163.

Über die Phasenlage des Magnetisierungsstromes des Lufttransformatoren (The Phase Conditions of the Magnetising Current of Air Core Transformers).—G. Hauffe. (*Zeitschr. f. tech. Phys.*, February, 1929, pp. 66–67.)

A mathematical treatment, resulting in the proof that for toroidal air-core transformers, where the primary winding is completely inside the secondary, the magnetising current is always in phase with the flux in the inner toroidal coil.

Le Stroborama, nouvel Appareil Stroboscopique à grand Éclairage (The Stroborama, a new Stroboscope with High Illumination).—L. and A. Seguin. (Summary in *Rev. Gén. de l'Élec.*, 23rd February, 1929, V. 25, p. 62D.)

A rotating contact, of variable speed, combined with a condenser and spark gap, acts as a kind of shunting relay and governs the current through a neon tube. Various commercial applications are mentioned.

Eine einfache Anordnung für stroboskopische Untersuchungen (A Simple Arrangement for Stroboscopic Investigations).—H. E. Linckh and R. Vieweg. (*Zeitschr. f. Inst:kde.*, No. 9, 1928, V. 48, pp. 416–421.)

An electrical arrangement is described, on the "flash" method, in which the observation-frequency is automatically controlled by the frequency of the observed process. The flashes of the glow-lamp are produced inductively by an auxiliary voltage, and they are very much brighter than those produced by the sine-wave A.C. so often used.

Spiral Springs of Quartz.—K. Šliūpas. (*Technika, Lithuania*, No. 3, 1927.)

An apparatus is described for the manufacture of these springs by a direct method, which avoids the formation of a compression on the inside and an extension on the outside such as are obtained with the indirect methods.

THE ALUMINIUM ELECTROLYTIC CONDENSER.—H. O. Siegmund. (*Bell Tech. Journ.*, January, 1929, V. 8, pp. 41–63.)

AN AUTOMATIC MERCURY STILL.—F. L. Robeson. (*Journ. Opt. Soc. Am.*, January, 1929, V. 18, pp. 72–74.)

This new form of vacuum mercury still is easily made from standard laboratory glassware, starts and stops automatically, and needs very little attention. The power required is 90 w. for an output of 100 gms. of mercury per hour. Another type of still is described by K. Hickman (pp. 62–68).

DRALOWID-VARIATOR (The "Dralowid" Variable Resistance).—(*E.T.Z.*, 28th February, 1929, p. 329.)

The system here adopted reduces resistance by connecting more resistances in parallel.

ÜBER EINEN NEUEN KOHLEWIDERSTAND (A New Carbon Resistance).—C. A. Hartmann and H. Dossmann. (*Zeitschr. f. tech. Phys.*, November, 1928, pp. 434–438.)

The complete paper, a summary of which was referred to in April Abstracts.

CHOKE-COILS WITH SATURATED IRON CORES.—F. Ollendorff. (*Archiv. f. Elektrot.*, 22nd October, 1928, V. 21, pp. 6–24.)

By replacing the saturation curve by a closely approximate hyperbolic sine function, problems of saturated-core chokes can be dealt with by the use of elliptic and Bessel functions.

ÜBER DEN EINFLUSS DER KORNGRÖSSE AUF DIE MAGNETISCHEN EIGENSCHAFTEN (On the Influence of Grain Size on the Magnetic Properties).—O. v. Auwers. (*Zeitschr. f. tech. Phys.*, December, 1928, pp. 475–478.)

Conflicting results of various workers are reconciled by the writer's theory—based on the tests described—that the effect of grain size is merely a secondary effect due to the amount of deleterious matter—oxide, carbide, etc.—varying with the grain size. If these substances are absent, through purity, or are removed by suitable heat treatment, the effect is no longer present.

LES REDRESSEURS À VALVE THERMO-IONIQUE (Thermionic Rectifiers).—*Génie Civil*, 9th February, 1929, V. 94, p. 155.)

In a summary of an article in *L'Industrie Élec.*, oscillograph tests are mentioned which indicate that the smoothing capacities and inductances usually employed are quite inadequate.

ERFAHRUNGEN MIT DEM TANTALGLEICHRICHTER (Results with the Tantalum Rectifier).—F. Bödigheimer. (*Rad. f. Alle*, January, 1929, pp. 13–16.)

An article in praise of this form of accumulator-charging rectifier, claimed to be the only one free from defects of one kind or another.

LES REDRESSEURS DE COURANTS ALTERNATIFS (A.C. Rectifiers).—*Génie Civil*, 2nd February, 1929, V. 94, pp. 123–124.)

Summary of a paper by Soulier, dealing with (*a*) electrolytic valves; chief difficulties are temperature-rise and the presence of impurities; the use of tantalum and lead as electrodes and the addition of iron sulphate in the electrolyte appears to give a cell which will function continuously for small powers, as also will Audubert's silicium rectifier (Abstracts, 1928, V. 5, p. 404); (*b*) arc rectifiers; notably the mercury vapour rectifiers, but also the Murphy and the recent Toulon rectifier, the latter consisting of two electrodes a few millimetres apart in a gas, connected through a resistance to the source of A.C.; a cathodic spot is formed on one electrode (either by a momentary contact or by a very short over-voltage); for high powers the electrodes are water-cooled; (*c*) rarified gas rectifiers: Villard's aluminium spiral—straight-wire cell, a laboratory instrument for rectifying currents of a few milliamperes at 10,000–60,000 v., requiring regeneration after some hours' working; (*d*) hot-filament rectifiers, *e.g.*, Tungar, up to 1 kw.; (*e*) electronic rectifiers such as the "colloid valve" of André, the "Sulfotron" and the oxide rectifiers; and (*f*) the mechanical arrangements—vibrating blades with water or glycerine damping, and the Soulier type resembling an electricity meter; polarised relay rectifiers, derived from the Baudot relay, of several types; rotary forms, capable of design for large powers; though these do not seem to have made their way in opposition to the mercury vapour rectifiers.

METAL TO GLASS ELECTRODE SEALS.—D. R. Barber. (*Journ. Scient. Instr.*, April 1929, V. 6, pp. 138–139.)

JOINING GLASS TO METAL BY SOLDERING. (*Scient. Amer.*, April, 1929, pp. 352—354.)

Various methods are mentioned of obtaining the thin metal film on the glass, which is the necessary preliminary step.

COMPRESSED POWDERED PERMALLOY: MANUFACTURE AND MAGNETIC PROPERTIES.—W. J. Shackelton and I. G. Barber. (*Journ. Am.I.E.E.*, April, 1928, V. 47, pp. 429–436; also *Bell Tel. Lab. Reprint*, *B.* 328.)

THE INFLUENCE OF GLAZE ON INSULATOR STRENGTH.—D. H. Rowland. (*Gen. Elec. Review*, March, 1929, V. 32, pp. 136–138.)

## STATIONS, DESIGN AND OPERATION.

HORAIRES DES ÉMISSIONS RADIOTÉLÉGRAPHIQUES ET RADIOTÉLÉPHONIQUES DE LA STATION DE LA TOUR EIFFEL (The Daily Programme of Telegraphic and Telephonic Transmissions from the Eiffel Tower Station). (*Rev. Gén. de l'Élec.*, 12th January, 1929, V. 25, pp. 11B–12B.)

This programme, however, would appear to be modified by an announcement (*ibid.*, 19th January, pp. 18B–19B) in which it is stated, in the course of an explanation of the reasons for the change of wavelength from 2,650 m. to 1,485 m., that owing to protests from the Parisians against interference the *broadcasting* from the Eiffel Tower Station will cease at once.

DIE NEUEN WELLENLÄNGEN (The New Wavelengths). (*Rad. f. Alle*, March, 1929, pp. 123–129.)

A table of the new (1929) wavelengths of the European broadcasting stations. Identification notes are added in many cases. In the next (April) issue is given a table of the most important short-wave stations of the world (14.75–90 m.).

ÉMISSION RADIOTÉLÉPHONIQUE DE RENSEIGNEMENTS GÉOPHYSIQUES ET ASTROPHYSIQUES (Radiotelephonic Transmission of Geophysical and Astrophysical Information). (*L'Onde Élec.*, January, 1929, V. 8, p. iii.)

A note on the Eiffel Tower geophysical and astrophysical bulletin, appended since 1st December, 1928, to the usual meteorological report, under the auspices of the U.R.S.I.

WELTRUNDFUNKVEREIN (World Broadcasting Union). (*E.T.Z.*, 18th April, 1929, p. 577.)

A paragraph, with a list of the organisations concerned, on the International Union of Radiotelephony.

THE FUTURE OF WIRELESS BROADCASTING.—J. C. W. Reith. (*Discovery*, February, 1929, V. 10, pp. 37–39.)

An article by the Director-General of the B.B.C. on the solution of present difficulties caused by the fact that there are to-day nearly 300 stations in Europe trying to broadcast on a wave band just sufficient for 100.

SELECTIVITY AND THE REGIONAL SCHEME: DISCUSSION.—G. Leslie and others. (*Journ. Inst. Wireless Tech.*, September, 1928, V. 2, pp. 19–34.)

THE ARMY-AMATEUR RADIO SYSTEM IS REVISED. (*QST*, March, 1929, V. 13, pp. 21–25.)

An article on the recent revision of the Army-Amateur System, the structure of relations between the transmitting amateurs of the American Radio Relay League and the Signal Corps of the U.S. Army.

PROGRESS OF BROADCASTING (SOUND AND PICTURE) IN GERMANY IN 1928.—W. Wagner. (*E.N.T.*, March, 1929, V. 6, pp. 118–119; part of a long paper on Progress in Electrical Communication.)

PROGRESS OF WIRELESS TELEGRAPHY AND TELEPHONY IN GERMANY IN 1928.—W. Wagner. (See above, pp. 117–119.)

Special mention is made of ultra-short wave (e.g., 30 cm.) valves recently developed and soon to be put on the market. One type, designed by Habann, has—under the simultaneous influence of magnetic and electric fields—a falling current-voltage characteristic and thus possesses the property of generating oscillations without the use of reaction.

TRASMETTITORI A ONDA CORTA PER I COLLEGAMENTI TRANSOCEANICI DELLA ITALO RADIO (Short Wave Transmitters, for Transoceanic Communication, of the Italo Radio Company).—V. Gori. (*L'Elettrotec.*, 25th February, 1929, V. 16, pp. 137–142.)

An authoritative technical outline.

WORLD-WIDE TELEPHONY: SUCCESSFUL SHORT-WAVE SERVICE BETWEEN HOLLAND AND JAVA.—A. de Haas. (*Wireless World*, 20th March, 1929, V. 24, pp. 313–316.)

The text of this article deals exclusively with the anti-fading receiving equipment used at the Java end. As many as six receiving sets, each with its directive aerial, are used to provide a combined L.F. output. Automatic volume control is also employed.

MODERN PRACTICE IN HIGH-FREQUENCY RADIOTELEPHONY.—R. A. Hull. (*QST*, April, 1929, V. 13, pp. 8–22.)

"A discussion of improved methods which virtually revolutionise amateur telephone transmission." Very complete details of a set embodying these are given.

## GENERAL PHYSICAL ARTICLES.

THE CHANGE OF ELECTRICAL CONDUCTIVITY IN STRONG MAGNETIC FIELDS (Two Parts).—P. Kapitza. (*Proc. Roy. Soc.*, 6th March, 1929, V. 123 A, pp. 292–372.)

The first part contains a description of improvements on the previous methods (Abstracts, 1928, V. 5, p. 469; bismuth crystals only) and a systematic account of the experiments on a large number of other metals. The second part gives a theoretical generalisation of the results, and a discussion of their bearing on the present theory of metallic conductivity.

SOME CHARACTERISTICS OF THE DISCHARGE BETWEEN COLD ELECTRODES IN VACUUM.—A. W. Hull and E. E. Burger. (*Phys. Review*, June, 1928, V. 31, p. 1121.)

Fixed tungsten electrodes were used at 2 mm. gap in a good vacuum, and heavy discharges from a transformer or charged condenser were passed. Current-time and voltage-time cathode ray oscillograms showed that the discharge began as a purely electron discharge, but in less than $10^{-7}$ sec. passed into a tungsten vapour arc, with an arc voltage of less than 1,000 v. for 20,000 A. discharge current. Other results are mentioned.

A THEORY OF THE ELECTRIC DISCHARGE THROUGH GASES.—P. M. Morse. (*Phys. Review*, June, 1928, V. 31, pp. 1003–1017.)

Three general differential equations are set up which determine the average behaviour of a discharge of electricity through a gas. Approximate solutions giving the electric field and the concentration of electrons and positive ions at any distance from the cathode are found for several ranges of value of field. The various phenomena of the process (*e.g.* the electric arc: striations in the positive column of a glow discharge) are explained in terms of these equations.

Die Rolle des Positiven Ions bei der selbsttätigen Entladung in Luft (The Rôle of the Positive Ion in the Spontaneous Discharge in Air).—W. Muller. (*Zeitschr. f. Phys.* 14th May, 1928, V. 48, pp. 624–646.)

Experiments are described to decide whether the activity of the positive ions is exerted in the form of shock-ionisation in the gas or by setting free electrons at the cathode. The second alternative is deduced to be correct.

The Time Lag of the Spark Gap.—J. W. Beams. (*Journ. Franklin Inst.* December, 1928, V. 206, pp. 809–815.)

A new method of measuring the time lag is described and some of the lags for sparks in air at atmospheric pressure have been recorded. The field strength used ranged from 60,000 to 400,000 v/cm., with as steep wave-fronts as could be obtained. The method (involving a Kerr cell) enables one to measure very short lags occurring with high field strengths, and the measuring device itself does not affect the results.

The Effect of Superimposed Magnetic Fields on Dielectric Losses and Electric Breakdown Strength.—A. Monkhouse. (*Proc. Physical Soc.*, 15th December, 1928, V. 41, Part I, pp. 83–93.)

Both factors are seriously affected by the superimposed fields. A theoretical explanation by Smouroff is mentioned.

Spectral Excitation by Recombination in the Electric Arc.—J. M. Dewey. (*Phys. Review*, December, 1928, V. 32, No. 6, pp. 918–921.)

Recent measurements of electron velocities in arcs have made it probable that most of the light in the negative glow is a result of recombination of positive ions and electrons. Since the velocities of the positive ions are high, Compton suggested that the lines of the negative glow should show Döppler broadening corresponding to these velocities. Evidence of this broadening is here presented. Results obtained can be explained on the assumption that all the light of the negative glow results from recombination of ions having a temperature about one-tenth that of the electrons.

The Possibility of Detecting Individual Cosmic Rays.—W. F. G. Swann. (*Journ. Franklin Inst.*, December, 1928, V. 206, pp. 771–778.)

The writer's object is to show that in view of the enormous energy available for ionisation in a single cosmic ray, and of the relatively small number of ions produced per second by the rays in a vessel of moderate size, the ionisation produced should occur in spurts which may be observable under suitable conditions. To obtain 1 spurt in 10 seconds the radius of a spherical container would have to be about 9.7 cm., which is practical for pressures of 100 atmospheres.

A New Method for Investigating Gamma Rays.—W. Bothe and W. Kolhörster. (*Naturwissen.*, 7th December, 1928, summarised in *Nature*, 26th January, 1929, V. 123, p. 145.)

Secondary electrons set free by waves of very high frequency move off from their parent atoms approximately in the direction of the radiation; their direction (and therefore that of the radiation) can be found by setting a pair of Geiger electron-counters in various positions until they show a maximum number of coincident discharges, due to the individual electrons affecting each in turn. The method has an obvious application to the problem of the origin of the Cosmic rays, and the writers (in this preliminary account) mention that when relatively soft rays are excluded by a filter of 10 cm. of lead, the number of coincident discharges of the counters which cannot be ascribed to the presence of radioactive substances is increased threefold by rotation of the detecting system from the horizontal to the vertical. (See below.)

The Nature of the Penetrating Radiation.—W. Kolhörster and W. Bothe. (*Nature*, 27th April, 1929, V. 123, p. 638.)

Simultaneous film records of the effect on two "tube-counters" (Geiger and Muller: see April Abstracts, p. 220) indicate the probability that the radiation is of corpuscular nature and *not* of the gamma ray type.

Penetrating Radiations.—E. Rutherford. (*Nature*, 30th March, 1929, V. 123, p. 501.)

Summary of a lecture at the Royal Institution.

Cosmic Rays. (*Nature*, 23rd March, 1929, V. 123, p. 472.)

Corlin finds a consistent variation in the intensity of the softer components during the sidereal day. If the soft rays are screened off, temporal fluctuations are not present; the obvious inference being that the more penetrating rays are produced ndifferently throughout space, but that at least a part of the softer radiation has a more localised origin. In a second communication it is suggested that the softer rays are really initially hard, but that they are produced inside material celestial bodies, and are softened by scattering on the way out. (*Cf.* Abstracts, 1928, V. 5, p. 230.)

The Electronic Charge *e*.—J. H. J. Poole. (*Nature*, 6th April, 1929, V. 123, p. 530.)

Birge has pointed out the improbability that any of the measurements of the three physical quantities in the expression $hc/2\pi e^2$ could be so much in error as to account for the discrepancy between the experimental value of 137.2 and Eddington's recently published theoretical value of 136. The writer suggests, as a way out of the *impasse*, the "rather fantastic idea" that the intense electric field near the electron may have an increasing effect on $\pi$. [But *Sci. News-Letter*, 16th February, 1929, announces that Siegbahn has just found an experimental value very near 136.]

COSMIC RAYS.—J. A. Gray. (*Nature*, 23rd March, 1929, V. 123, p. 447.)

Investigation of the results of Millikan and his colleagues leads the writer to disagree with their conclusions as to the rays falling into four bands, and with their deduction that atom building is taking place in outer space (see recent Abstracts).

DIFFRACTION OF CATHODE RAYS BY CALCITE.—S. Nishikawa and S. Kikuchi. (*Nature*, 10th November, 1928, V. 122, p. 726.)

A monochromatic beam of cathode rays was directed against a cleavage face of calcite at a grazing incidence, and the diffraction pattern was obtained on the photographic plate behind the crystal normal to the incident beam. The patterns consist of a number of bands of different widths and many black and white lines ; sometimes also spots similar to Laue's. One conclusion drawn is that the structure-factor for X-ray reflection has a similar influence on cathode ray reflection.

LA POLARISATION DANS LA THÉORIE DES QUANTA DE LUMIÈRE (Polarisation in the Theory of Light Quanta).—J. Ullmo. (*Comptes Rendus*, 29th October, 1928, V. 187, pp. 758–761.)

The writer shows how the phenomena of polarisation can be explained as statistical effects due to the distribution and arrangement in space of the photons, without any hypotheses as to their internal structure such as are involved by other interpretations.

SUR LE CHAMP INTERNE DE POLARISATION (The Internal Field of Polarisation).—R. de Mallemann. (*Comptes Rendus*, 22nd October, 1928, V. 187, pp. 720–722).

An extension of the writer's paper referred to in Abstracts, 1928, p. 693.

RECENT THEORIES OF THE ATOM.—W. F. G. Swann. (*Journ. Opt. Soc. Am.*, September, 1928, V. 17, pp. 163–197.)

PROPRIÉTÉS DIÉLECTRIQUES ET STRUCTURE DES COLLOIDES HYDROPHILES (Dielectric Properties and Structure of the Hydrophil Colloids).—N. Marinesco. (*Comptes Rendus*, 2nd October, 1928, V. 187, pp. 718–720.)

When a liquid with permanent dipoles solidifies, its dielectric constant falls sharply owing to the forced orientation of the dipoles, which can no longer follow the reversals of the external field. The dissolving of an electrolyte in water produces the same effect ; the ions condense and fix a large number of the dipoles, leading to a fall in the inductive capacity of the liquid. An identical blockage can be produced by absorption, as the writer explains in connection with colloids which swell up and retain a large quantity of water.

WAVE ATOMS.—P. R. Heyl. (*Scientific American*, November, 1928, pp. 406–408.)

A continuation of the article referred to in Abstracts, 1928, p. 470. The "inwardness of the new Schrödinger Atom concept" is explained, in the light of recent results connected with the reflection of rays and particles. Incidentally, the accident is described which led Davisson and Germer to their discovery of the regular reflection of electrons by a nickel crystal : the usual scattering by a nickel surface was being obtained when the glass bulb broke and the hot target was tarnished by the in-rushing air. To clean it, it was heated for some time in hydrogen. Regular reflection was then obtained, owing to the greatly increased size of crystals produced by the heating.

SCATTERING OF QUANTA WITH DIMINUTION OF FREQUENCY.—K. Darrow. (*Science*, 16th November, 1928, V. 68, pp. 488–490.)

The writer says that the correlation of several recent results in the scattering of quanta (Raman, Landsberg and Mandelstam, Compton, etc.), leads to the general principle that a quantum can divide its energy, giving up a part and retaining the remainder ; and this can happen whenever there is an encounter between a quantum and an electron, atom or system of atoms capable of receiving energy in quantities smaller than the quantum originally possesses. He points out that this principle was adumbrated by Smekal in 1923, and that it was not appreciated probably because at that time it was difficult to conceive that a quantum could change its frequency and yet remain the same quantum. But now it is clear that electrons also possess the properties of wave-motion, and when an electron is speeded up or slowed down, its wavelength changes ; "if we conceive that nevertheless it remains the same electron, can we do otherwise than suppose that a quantum retains its identity when its wavelength is altered ?" See also long paper by same author (*Bell Tech. Journ.*, January, 1929, V. 8, pp. 64–93) in his series "Contemporary Advances in Physics."

ÜBER DIE AUSLÖSUNG VON SEKUNDÄRELEKTRONEN DURCH ELEKTRONEN VON 1–30 KILOVOLT (The Setting Free of Secondary Electrons by Electrons of 1–30 kV.).—E. Buchmann. (*Ann. der Physik*, No. 20, V. 87, pp. 509–535.)

An extension of the work of Kossel, Compton and Voorhis at lower voltages.

ZUR POLARISATION DES KANALSTRAHLLICHTES IN SCHWACHEN ELEKTRISCHEN FELDERN (Polarisation of the Canal ray light in weak electric Fields).—E. Rupp. (*Ann. der Physik*, No. 19, V. 87, pp. 285–297.)

THÉORIE DE LA DIFFUSION DE LA LUMIÈRE PAR UN CORPS PLACÉ DANS UN CHAMP ÉLECTRIQUE OU MAGNÉTIQUE (Theory of the Diffusion of Light by a Body in an Electric or Magnetic Field).—Y. Rocard. (*Ann. de Physique*, November-December, 1928, V. 10, pp. 472–488.)

La Conductibilité Électrique (Electrical Conductivity).—W. J. de Haas. (*Journ. de Phys. et le Rad.*, September, 1928, V. 9, pp. 265–277.)

A description of the experiments made by the writer, with Sizoo and Voogd, on the supraconductors.

Neues zum Barkhauseneffect (New Information on the Barkhausen Effect).— –. Pfaffenberger. (Summary in *E.T.Z.*, 13th December, 1928, p. 1816.)

The swinging over of the elementary magnets owing to change of field was investigated after suitable amplification, using a string galvanometer. The quantitative distribution of the effect over the hysteresis curve was plotted ; there is a certain connection with the heat development. The length over which simultaneous induction change takes place has been measured and found to be about 3 m. [3 mm. ?] ; it is therefore independent of crystal length, and the Barkhausen effect cannot correspond to magnetostriction effects.

Thermoelectric Power of Selenium Crystals. —R. M. Holmes and A. B. Rooney. (*Phys. Review*, June, 1928, V. 31, p. 1126.)

Selenium crystals were prepared by slow condensation of the vapour in a tube evacuated to 0.008 mm., one end of the tube being in the open air, the other in an oven with automatic temperature control. The best crystals were formed on a thread of pyrex glass in the middle of the tube. The thermoelectric force (against copper) follows the equation $E = 1.10\ t + 0.00017\ t^2 m\ V.$ between 0 and 180 deg. C., and is the greatest value hitherto measured, being 800 times as large as that for copper-lead. If the one contact is at 0 deg. C., the thermoelectric force is approximately a linear function of *t*, showing that the Peltier effect is responsible for almost the whole of it. In certain crystals there is an E.M.F. from light absorption, which may amount to 10 mv. for a 100 w. lamp at 50 cm. distance.

## MISCELLANEOUS.

Hot Cathode Neon Arcs.—C. G. Found and J. D. Forney. (*Journ. Am.I.E.E.*, December, 1928, V. 47, pp. 855–859.)

"In general, we believe that the hot cathode neon arc is the most efficient high-intensity source of red light." The substitution of a hot cathode reduces the cathode drop to a few volts and all the difficulties caused by the high cathode fall are avoided. At a pressure of 2 mm. practically all of the tube is filled with positive column and a current of about 3.5 amps. is produced when the heater is taking 60 watts. The tubes are started (1) by bringing an H.F. discharge close to the cathode ; (2) by an auxiliary starting anode ; or (3) by an inductance "kick."

Various types are discussed together with their uses and advantages : important features being their long life and their independence of surrounding temperature.

Ultra-violet Light and Tracing Cloth. (*Science*, 15th March, 1929, V. 69, p. xiv.)

Ordinary tracing cloth has been found to pass the ultra-violet part of sunlight very well, though a single thickness cuts off much of the heat and glare.

Some Photoelectric and Glow-Discharge Devices and Their Applications to Industry.—J. V. Breisky and E. O. Erickson. (*Journ. Am.I.E.E.*, February, 1929, V. 48, pp. 118–121.)

Sorting and counting ; matching colours ; smoke recording (for smoke stacks) ; smoke detection (alarms, automatic $CO_2$ equipment, etc.) ; grid-glow tube Oil-Burner control (instantaneous, whereas thermostatic controls are too slow to prevent certain troubles). *Cf. Engineer*, 22nd March, 1929, p. 323, where an article in *Nature* is referred to on the application of photoelectric and selenium cells to operate alarms and automatic controls regulating the level of liquids in tanks and stand pipes : the device being particularly useful when the liquids are under high pressures so that the standard methods of level control cannot be used.

The Excitation of Luminescence by the Agitation of Mercury in Glass and Transparent Fused Silica Tubes and Vessels.—W. L. Lemcke. (*Science*, 18th January, 1929, V. 69, pp. 75–78.)

Use of the Oscillograph for Measuring Non-Electrical Quantities.—D. F. Miner and W. B. Batten. (*Journ. Am.I.E.E.*, February, 1929, V. 48, pp. 126–129.)

Speed recording ; turbine blade vibration, etc.; timing a sequence of operations ; stresses—railroad track and locomotive side rods ; pressure recording.

Radium as a Means of Preventing Sparks from Static Electricity in certain Factories. (*Nature*, 13th April, 1929, V. 123, pp. 578–579.)

In a Russian rubber factory a capsule of radium is used to ionise the air so that the electric charges (produced by friction of rubber-covered fabric with parts of the drying machinery) flow through it harmlessly to earth.

A Recording Photoelectric Colour Analyser. —A. C. Hardy. (*Journ. Opt. Soc. Am.*, February, 1929, V. 18, pp. 96–117.)

A very full treatment of an apparatus similar to or identical with that referred to in May Abstracts. The choice of the type of photoelectric cell for the purpose in question, various ways of connecting the cell to the first stage of amplification, the design of the amplifier, etc., are dealt with.

Selenium Cell Developments. (*Elec. Review*, 23rd November, 1928, V. 103, pp. 910–911.)

The automatic lighting of street lamps, automatic sectional signalling and train control are dealt with.

Sound Beam Sending Horn. (*Scient. Amer.*, January, 1929, p. 89.)

"The practicability of directing a beam of sound to a definite distant point was demonstrated recently when officers of the U.S. Navy Dirigible, flying at 1,500 feet, distinctly heard the voices of officials of the Victor Talking Machine Company, as well as a programme of music and constant tone signals, projected to them by the recently developed super-directional horn mounted on the roof of a ten-story building."

Ein elektromechanischer Schwingungserzeuger (Schwingungsmotor) (An Electromechanical Oscillation Generator—Oscillating Motor).—W. Späth. (*E.T.Z.*, 28th March, 1929, pp. 455–458.)

The chief use of this new motor seems to lie in the testing of materials.

Aircraft Compass Problems.—T. R. Rhea. (*Gen. Elec. Review*, April, 1929, V. 32, pp. 190–193.)

Certain disadvantages of the ordinary earth inductor compass are pointed out; these are absent in the "Magneto Compass" recently developed by Tear, in which the earth's flux is concentrated in a specially shaped bar of high permeability and low coercive force; the bar has a gap at its mid-point in which a very small wound armature spins rapidly on a vertical axis which carries a small commutator.

Electrical Aids to Navigation.—R. H. Marriott. (*Journ. Am.I.E.E.*, March, 1929, V. 48, pp. 195–199.)

Short descriptions of the Earth-Inductor Compass, Radio Compass, Radio Beacon, Submarine Signal (80 miles range has been obtained), Combined Submarine Sound Beacon and Radio Beacon (for obtaining distance: Abstracts, 1928, p. 649; 1929, p. 107; both J. H. Service), Sonic Depth Finding, and Leader Gear (proposed also for aircraft, and installed in France on a pole line). Proposals are mentioned:—for fog penetration, high-power Geissler-type tubes working in conjunction with photoelectric cells which are more sensitive than the eye to this kind of light; aircraft height above ground to be determined by sound reflection, radio reflection (Alexanderson—May Abstracts, p. 286); variation of air dielectric of a condenser to be used as a substitute for a barometer.

Über die biologische Wirkung kurzer elektrischer Wellen (The Biological Effects of Short Electric Waves).—E. Schliephake. (*E.T.Z.*, 18th April, 1929, p. 574.)

A short outline of the results obtained by the writer, by Esau's methods, on waves from 5 m. down. The most obvious results are heating effects, which can be obtained far deeper than by ordinary diathermy. For this work, the field between the plates of a condenser is used; but there are also effects in the ordinary radiation field—a production of nervous irritability, and slight raising of body temperature—the former being probably due to a purely electrical action independent of heating; it was more marked with the 3 m. wave than with the 5 m. The research is continuing.

The Measurement of Emotions.—G. G. Blake. (*Elec. Review*, 23rd November, 1928, V. 103, pp. 882–884.)

The increase in conductance of the human body under the stimulus of emotion is measured by a thermionic valve method and compared with the reaction produced by an electric shock at a known voltage. The increase of conductance appears a second or two after the cause. Thoughts passing through the subject's mind may approximate to a 12-volt shock. An interesting point is that any subject is more sensitive to a self-inflicted shock than to one externally and unexpectedly applied. The application of the method to the investigation of nervous fatigue and the effects of drugs is suggested.

Regelwidrigkeiten in der Wirkungsweise einiger Kontaktdetektoren (Anomalous Behaviour of Certain Contact Detectors).—R. H. Elsner. (*Rad. f. Alle*, March, 1929, pp. 107–109.)

An article on Grosskowski's work on detectors with abnormal dynamic characteristics (Abstracts, 1928, V. 5, p. 225). The writer points out that if such detectors are used as indicators in wavemeters, bridges, etc., they may lead to serious errors. He also suggests that use might be made of the unusual characteristic in atmospheric elimination.

Very High Vacuum Contact-Breaker.—(*French Patent* 621316549, Siemens-Schuckert, published 10th December, 1928.)

The contact-breaker is contained in a glass vessel. Electrodes (tantalum or tungsten) are oil- or water-cooled, and the glass vessel contains (*a*) a filament which can be heated so as to provide an electronic bombardment to out-gas the electrodes; (*b*) a fixed electrode coated with magnesium or other "getter"—this also can be heated by electron bombardment; and (*c*) a three-electrode valve system which "controls" the vacuum.

Sur le Sondage magnétique des Arbres de Machines (Magnetic Sounding of Machine Shafts).—J. Peltier. (*Comptes Rendus*, 4th March, 1929, V. 188, pp. 701–703.)

Flaws, etc., in a rotating axle can be detected by their effect on a polarised electromagnet system such as that of a telephone ear-piece. Vibration (of turbine shafts, for example) could be studied with the help of a similar arrangement.

The "Deion" Circuit Breaker. (*Elec. Review*, 29th March, 1929, V. 104, p. 590.)

A note on Slepian's new circuit breaker, in which the arc is driven by a magnetic field over a circular metallic path at the rate of 2,400 miles per hour; the metal, instead of yielding ions to the arc, removes them from it, so that after 30 or 40 circuits of the path the arc is extinguished.

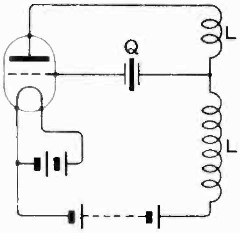
# Some Recent Patents.

*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.*

## PIEZO-CONTROLLED GENERATORS.

(*Convention date* (*Germany*), 26*th October*, 1926. *No.* 279845.)

The figure shows a simplified circuit connection for generating oscillations of stabilised frequency. The plate and cathode of a thermionic valve are directly connected through an inductance coil $L$, $L_1$. The piezo crystal $Q$ is connected directly between the grid and an intermediate tapping on the coil. The tapping point is so chosen that the inductance $L$ has approximately the same natural frequency as that of the crystal, whilst the inductance $L_1$ is comparatively high and acts as a choke.



No. 279845.

Patent issued to Radio Frequenz G.M.B.H. and H. Eberhard.

## THERMIONIC OSCILLATION GENERATORS.

(*Application date*, 20*th October*, 1927. *No.* 304369.)

In order to generate high-frequency oscillations of constant amplitude, free from harmonics, a negative-resistance device such as a screened-grid valve or pentode, operating on the falling portion of its characteristic curve, is associated with a resonant output circuit, and with means for tapping off a constant voltage from that circuit. Preferably the resonant output circuit is shunted by a condenser and resistance in series, the required voltage being tapped off from the series resistance to a subsequent amplifier.

Patent issued to W. S. Smith and N. W. McLachlan.

## MODULATING SYSTEMS.

(*Convention date* (*Germany*), 14*th October*, 1927. *No.* 298647.)

In picture-transmission and high-speed telegraphy it is usual to introduce an intermediate-frequency carrier, which is first modulated by the picture or other signal currents, and is then eliminated prior to the actual modulation of the transmitted wave, so as not to widen unduly the radiated side-bands.

According to this invention the modulated intermediate-frequency carrier is applied directly to the grid of the high-frequency modulator, and the anode of the latter is coupled to the final transmitter valve through a wave-trap circuit designed to absorb the unwanted carrier frequency.

Patent issued to Telefunken, G.M.B.H.

## DETECTOR CIRCUITS.

(*Application date*, 5*th December*, 1927. *No.* 304430.)

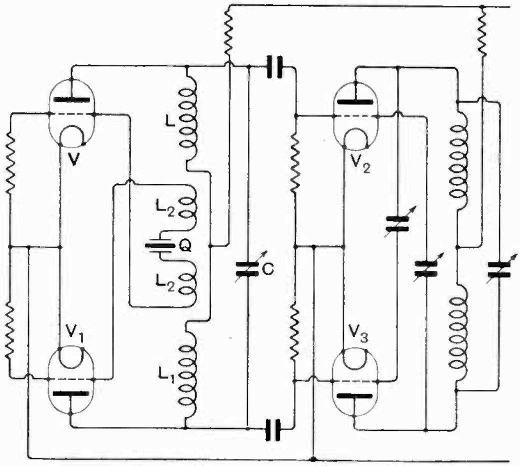
In order to separate the radio-frequency from the audio-frequency currents, either in the output circuit of a crystal or valve detector, or on the input side of a leaky-grid rectifier, a low-pass filter circuit is employed comprising a number of series chokes and shunt condensers. The filter is so designed that regarded from its input side (which receives mixed radio and audio frequencies) it offers a low impedance to radio-frequency currents, while regarded from its output side (which feeds an audio-frequency telephone or loud speaker) it has a high impedance for audio frequency currents. It is also designed to have a high attenuation factor for the lowest radio frequencies and a low attenuation factor for the highest audio frequencies.

Patent issued to Graham Amplion, Ltd., and P. K. Turner.

## STABILISED PUSH-PULL OSCILLATORS.

(*Application date*, 24*th October*, 1927. *No.* 304382.)

Two back-coupled valves, $V$, $V_1$, acting alternately upon the tuned oscillatory circuit, $L$, $L_1$, $C$ are controlled by a single piezo crystal $Q$. The crystal is arranged symmetrically with respect to the two grids of the double-acting oscillator, and is associated with coils $L_2$, also arranged symmetrically and coupled to the main oscillatory circuit. Subsequent stages of push-pull amplification are coupled to the generator, as shown at $V_2$, $V_3$.



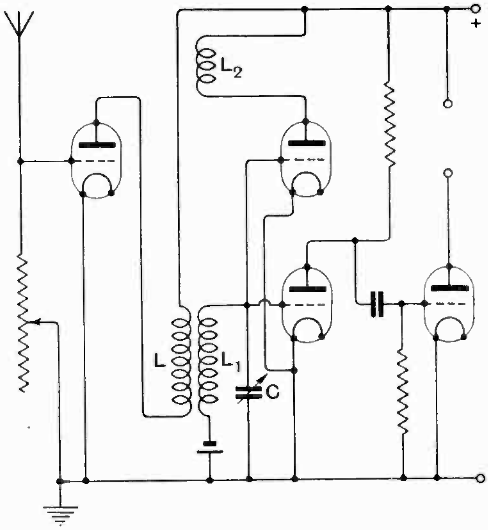
No. 304382.

Patent issued to J. K. im Thurn, G. Shearing, and C. Matthews.

## REDUCING STATIC INTERFERENCE.

(*Application date, 9th November*, 1927. *No.* 303608.)

The input to the H.F. valve is taken from a non-inductive resistance in the aperiodic aerial. The non-selective system is then compensated by feeding the output from the H.F. valve to two valves in parallel, the first acting as a detector, and




No. 303608.

the second as a local generator of oscillations of the desired signal frequency. This frequency is determined by the setting of the condenser $C$ in combination with the inductance $L_1$. The coupling of the coils $L_1$, $L_2$ determines the strength of the local oscillation, and is stated to produce a highly-selective combination largely impervious to static disturbance.

Patent issued to The Edison Swan Electric Co., Ltd., and L. H. Soundy.

## LOUD SPEAKERS.

(*Application date, 31st January*, 1928. *No.* 304487.)

In order to utilise the power of the magnet to the fullest degree, and also to provide a more uniform distribution of sound, several armatures are arranged symmetrically around the air-gap, each co-operating with a separate diaphragm. Preferably three such armatures are arranged near pole-pieces of triangular cross-section, the three respective diaphragms forming, in section, the sides of an equilateral triangle.

Patent issued to C. French.

## SCANNING FOR TELEVISION, ETC.

(*Application date, 5th July*, 1927. *No.* 303771.)

A system for transmitting still-life pictures or moving scenes is characterised by the fact that the bands or zones into which the picture is analysed in transmission, and from which it is synthesised in reception, are made narrower over the central parts of the picture than at the edges. The object is to take advantage of the known characteristic of the human eye, which sees an extended object with acute definition at the centre, and then shades off to areas of more or less indistinct vision.

Patent issued to J. L. Baird and Television, Ltd.

## RECEIVING SETS.

(*Application date, 15th October*, 1927. *No.* 303587.)

The set as a whole is designed so that it can readily be used either with an A.C. mains-eliminator, or with batteries, as desired. The *HT*, *LT*, and grid-biasing contacts are brought out into line at the side of the cabinet, and are connected in groups by three straps where the current supply is taken from batteries. When the supply is to be taken from the mains, the straps are removed, and a rectifier unit provided with a corresponding line of terminal contacts is fitted snugly against the cabinet.

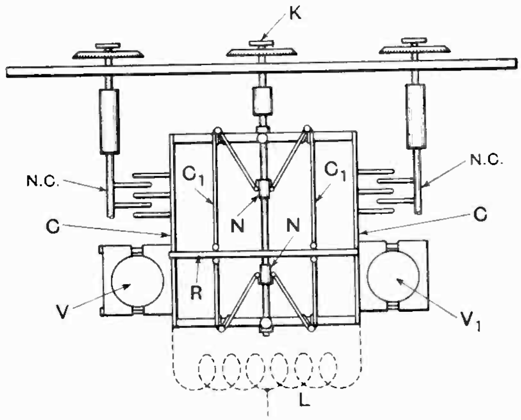
Patent issued to S. G. S. Dicker.

## SHORT-WAVE TRANSMITTERS.

(*Convention date* (*U.S.A.*), 19*th March*, 1927. *No.* 287462.)

In order to minimise the length of leads between the circuit components of a high-powered short-wave transmitter, the tuning-condenser is robustly constructed and serves directly to support the valves and other parts. The condenser consists of two fixed plates $C$ and two movable plates $C_1$. The resultant capacities are in series and their effective value is adjusted by moving the plates $C_1$ to and fro along an insulated guide-rail $R$. For this purpose a hand-control $K$ moves the two nuts $N$ in opposite directions along a screwed spindle.

The fixed outer plates $C$ are made to support the transmitting valves $V$, $V_1$ arranged in push-pull,




No. 287462.

the heavy gauge circuit inductance $L$, and the fixed plates of the neutralising condensers $NC$. The control knobs of the latter are taken through the same panel as the tuning-control $K$.

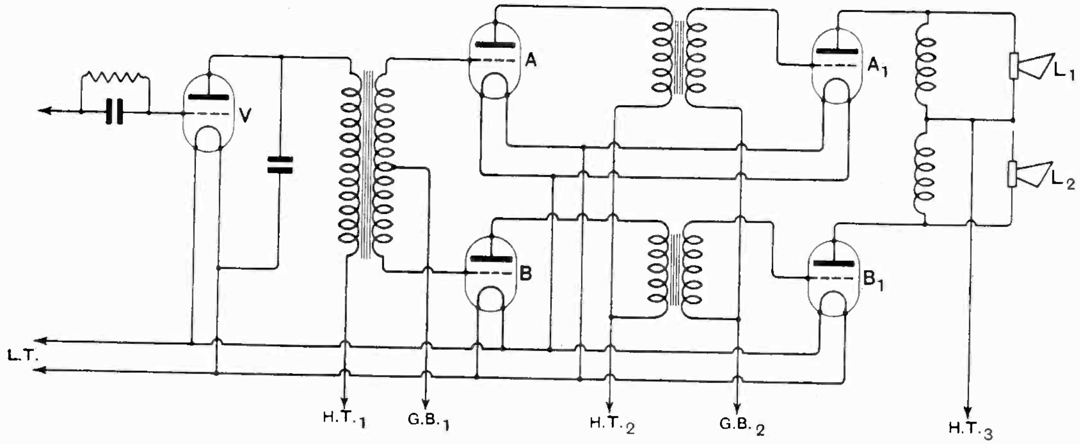
Patent issued to Marconi's Wireless Telegraph Co., Ltd.

## L.F. AMPLIFIERS.

(*Application date, 20th February, 1928. No.* 303681.)

Two loud speakers $L_1$, $L_2$ are fed through separate amplifying-channels from a common input. By suitable design each amplifying channel can be given any desired frequency characteristic, so that, for instance, one speaker favours the higher, and the second the lower notes. The input valve $V$ is fed from an aerial or gramophone pick-up, the output being passed in push-pull relation to the Channels $A$, $A_1$, $L_1$ and $B$, $B_1$, $L_2$ respectively. The arrangement is such that a common source of high and low tension and grid-biasing voltage can be used for all the valves.

Patent issued to L. F. Douglass.




No. 303681.

## LOUD SPEAKER HORNS.

(*Application date, 15th March, 1928. No.* 304511.)

A sound horn of the cabinet type is formed with an inlet passage of gradually-increasing area, passing to a central conduit. The latter is also of gradually-increasing area and leads to two outlets arranged at opposite sides of the cabinet. Each outlet is of large area and has a depth approximately equal to the length of the inlet passage. The dimensions of the horn as a whole follow a logarithmic or exponential law.

Patent issued to Electrical Improvements, Ltd., and L. C. Grant.

## RECTIFIERS.

(*Convention date* (*Germany*), *6th October*, 1926. *No.* 278731.)

Copper pyrites and zincite crystals are arranged in layers between metal discs in such a way that they make good contact with the metal backing and with each other. The combination gives a heavy-current rectifier which can be used for supplying $HT$ and $LT$ to a valve receiver.

Patent issued to M. Singelmann.

## INDIRECTLY HEATED VALVES.

(*Application date, 26th August*, 1927. *No.* 303037.)

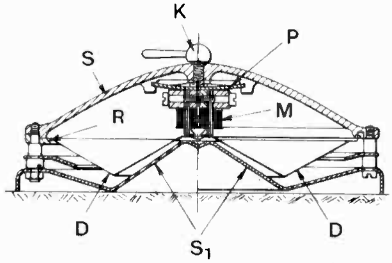
When the filament of an indirectly-heated valve is energised from a source of alternating voltage, electrostatic action between the heater and the filament proper is liable to give rise to undesirable interference. To prevent this a metallic shield or screen, perforated to allow the free passage of heat, is interposed between the heater and the cathode, and is either earthed or connected to a point of fixed potential.

Patent issued to W. S. Smith and N. W. McLachlan.

## LOUD SPEAKERS.

(*Convention date* (*Austria*), *11th January*, 1927. *No.* 283492.)

The diaphragm consists of two conical surfaces $D$ clamped around the edges between the sound box or casing $S$ and an annular ring $R$. At the top of the casing a square plate $P$ is secured between undercut lugs, as shown, and carries the magnets. A control screw $K$ flexes the plate $P$ and so adjusts the gap between the pole-pieces and the diaphragm. The lower parts are closed in by a metal bottom plate $S_1$ which also serves as a stand. The resultant shape of the air-passage is such that the volume of fluid set in motion increases progressively from the centre outwards.




No. 283492.

Patent issued to E. D. Feldman.