THE
WIRELESS ENGINEER

Vol. XVIII. AUGUST, 1941 No. 215

Testing Small Samples of Transformer Iron

In the December number of the Proceedings of the Institute of Radio Engineers, H. W. Lamson describes an apparatus for measuring the magnetic properties of small samples of transformer laminations. The apparatus includes several novel features, especially as regards the use made of copper oxide rectifiers. Instead of over two pounds of iron cut in strips 28 × 3 cm., as required for the standardised American method, the new apparatus requires only a single strip 3in. long and ⅜in. wide. The return path is provided by a number of square plates of mu-metal 3in. square with a central hole 1¾in. diameter, as shown in Fig. 1. Four of these plates are used on each side of the test-strip; they are hydrogen-annealed to give them a high initial permeability. Tests indicate that the reluctance of the return path is negligible compared with that of the test-strip, and that the effective length of the strip is 1.90in. It is only necessary to clamp the plates together finger-tight. A coil of 400 turns surrounds the strip, being distributed approximately over the whole exposed length of 1¾in. The inductance and effective resistance of this coil are measured by means of a Maxwell bridge and used to determine the effective or dynamic permeability and the iron losses. If incremental permeability is required, a steady current is maintained through the coil by the battery shown on the right in Fig. 2; in this case various blocking condensers shown dotted must be employed. In all such magnetic measurements one can employ either a sinusoidal current, in which case the magnetic flux and voltage will be non-sinusoidal, or a sinusoidal voltage, in which case the current will be non-sinusoidal. In the present case the author ensures a sinusoidal current by using such a large series resistance R_4 that the non-linear impedance of the test-coil is negligible in comparison. The voltage across the test-coil will be non-sinusoidal, but by using a selective detector the bridge can be balanced for the fundamental, and it is the permeability so calculated that is called the effective or dynamic permeability.

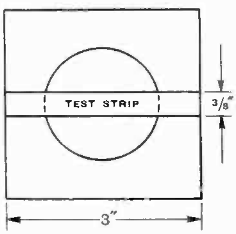


Fig. 1.

Instead of referring to H as the magnetising or magnetic force the author calls it the gradient of magnetomotive force; this is wrong, for the m.m.f. ($0.4\pi\ IT$) is something that acts around the whole magnetic circuit and has not a definite value at this point or that point, as potential or height have, and therefore cannot have a gradient. Another point on which we disagree with the author

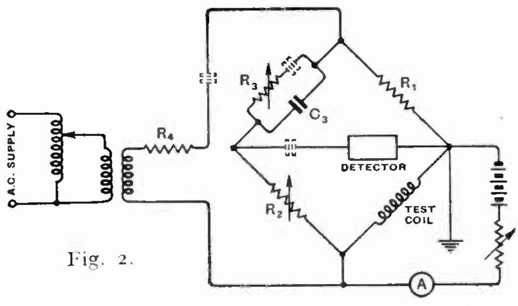


Fig. 2.

is his statement with reference to incremental permeability that "as the dynamic excursion is reduced to zero, the incremental permeability approaches the slope of the static B-versus-H curve at the static H value." This seems highly improbable.

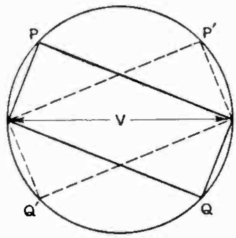


Fig. 3.

The main interest in the article, however, is in the null-balance detector. This has to be very sensitive in order to test such a small sample of iron at very low magnetic inductions; it must also be selective in order to respond only to the fundamental of the complex voltage wave. The detector described has several further advantages; first, the direction of the movement of the galvanometer pointer indicates whether the particular control should be increased or decreased, instead of the usual method of trial and error; secondly, a phase-shifting device makes the indicator sensitive to either the resistance balance or the inductance balance, thus avoiding the usual successive approximations to a perfect balance; and thirdly a limiter network gives maximum sensitiveness at balance, but automatically reduces the sensitiveness when out of balance, thus making it unnecessary to shunt the galvanometer.

From the detector terminals of the Maxwell bridge (Fig. 3) the wires pass to a frequency-selective degenerative amplifier, that is, one in which the negative feed-back passes through a filter or bridge which cuts out the negative feed-back at one definite frequency, but allows it to operate at all other frequencies. This amplifier is only really necessary for measurements near initial permeability. If the amplifier is not used, however, a filter must be inserted to eliminate the third and higher harmonics. The wires then pass to a limiting network, each shunt arm of which contains two copper-oxide rectifiers in parallel but in reverse directions, so that there is no rectification, but a rapid fall of resistance if the voltage exceeds a certain value. This is followed by a so-called modulation bridge, each arm of which contains a copper-oxide rectifier. The galvanometer G is a moving coil instrument with centre-zero, but it will be seen that the rectifiers are so arranged that, in the absence of a polarising current, there is no rectification of the current from the Maxwell bridge, and no current through the galvanometer. When in use, the modulation bridge is polarised by current from a phase-shifting network; this network is supplied from the same source as the Maxwell bridge. The supply voltage V is divided into two components at right angles by the resistance and condenser in series, the exact point on the semicircle in Fig. 4 depending on the relative magnitudes of R and $\frac{1}{\omega C}$. The magnitudes

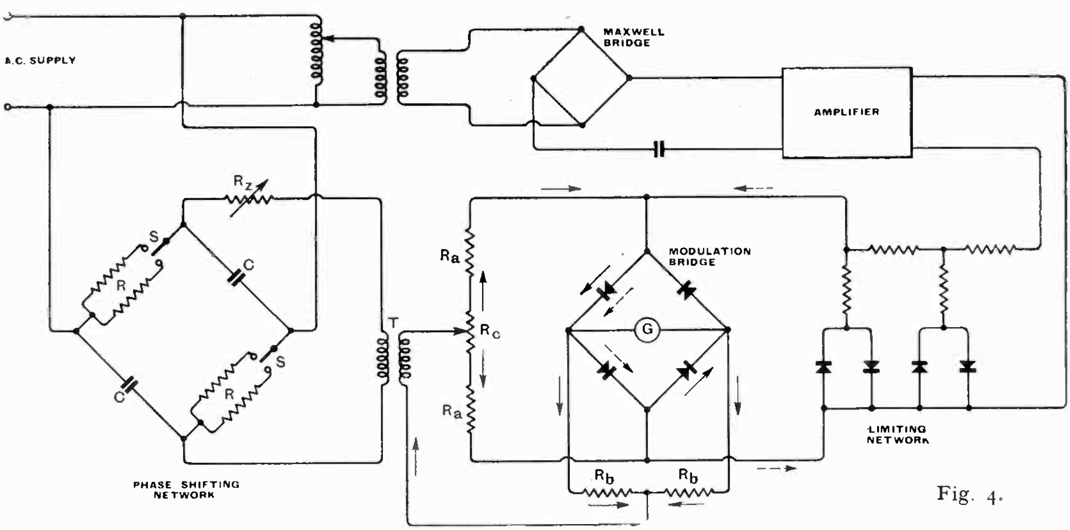


Fig. 4.

are so adjusted that by throwing over the switches SS the points are changed from *PQ* to *P'Q'* where *PQ* and *P'Q'* are at right-angles, that is, the phase of the output is changed 90 degrees. This voltage is supplied to the modulation bridge through a relatively large resistance R_z, the transformer *T*, and the resistances R_a R_b R_c. Here again, when properly adjusted, the currents flow through the opposite arms of the modulation bridge without causing a deflection on the galvanometer. The full-line arrows show the polarising current from the phase-shifting network at a given moment and the dotted arrows the out-of-balance current from the Maxwell bridge. Neither alone would affect the galvanometer, but, due to the non-linear characteristic of the rectifiers, the superposition of the two currents causes a deflection. In the absence of the full-line polarising current, the dotted current would flow through two arms of equal high resistance, but due to the presence of the polarising current, the resistance of the upper arm is reduced, thus upsetting the balance. If the dotted arrows were reversed, the balance would be upset in the opposite direction. Hence the direction of the deflection of the galvanometer indicates whether the particular control of the Maxwell bridge which corresponds to the present position of the phase-shift network should be moved in the one direction or the other. In either case it can be seen that, during the succeeding half-wave when all the arrows are reversed, the direction of the current through the galvanometer is unchanged. Although, as the author says, none of the elements shown in Fig. 3 is individually novel, several of them are not widely known and their combination is very ingenious, and will undoubtedly prove of great interest to all those who are concerned with the routine use of alternating current bridges. G. W. O. H.

Secondary Emission*

Some Effects on Deflector Plate Characteristics of Cathode-Ray Tubes

By Hilary Moss, Ph.D., B.Sc.(Eng.)

SUMMARY.—The paper is limited to effects in high-vacuum, sealed, low-voltage, cathode-ray tubes. A brief discussion is given of the loading of the deflector plates of a C.R. tube due to returning secondary electrons from the screen. Deflector plate characteristics for high-negative plate potentials are given and discussed. The effect of secondary emission from the splitter plate of a double-beam tube is described, together with a form of interaction between the X and the Y plates due to returning secondary electrons from the screen.

The following conventions are used:—

The beam current is defined as that current passing through the final anode hole.

The *X* plates are those remote from the gun.

All plate potentials are referred to the final anode.

A positive electron current implies that electrons are flowing through the vacuum *into* the electrode concerned.

It is now recognised that by far the greater part of the beam current of a C.R. tube returns to the final anode by secondary emission from the screen. These returning secondaries form a fairly diffuse beam, and some are necessarily intercepted on the deflector plates. The proportion thus intercepted can be made small by various forms of plate shield, wall coatings, etc. Fig. 1 shows voltage/current characteristics for a hard tube having a wall coating. In all cases the three plates, apart from the one for which the characteristic was being plotted, were joined back to the final anode. The sharp rise in plate current in the region of the origin indicates that the difference in potential between the screen and the final anode is small compared with the volt velocity of the primary electron beam.

Where the plate spacings are large compared with the beam diameter, as was the case for the *X* plates, Fig. 1, the plate ceases to collect electrons when it becomes a few volts negative. For close plate spacings, however, as for the *Y* plates, the current usually reverses in sign as shown. This can be attributed to high velocity primary

* MS. accepted by the Editor, April, 1941.

electrons grazing the plates and knocking out secondaries, which then flow to the more positive neighbouring electrodes.

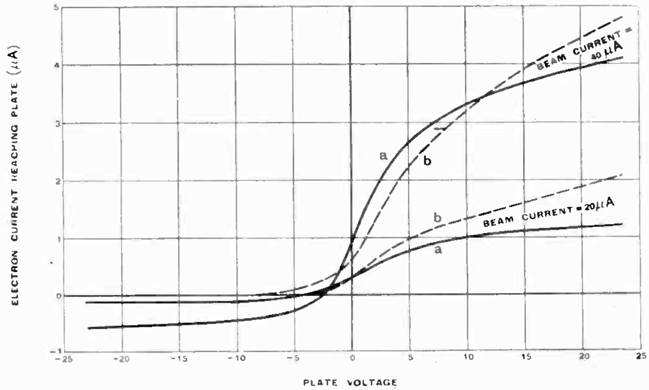


Fig. 1.—*Voltage-current characteristics for a hard C.R. tube. Curves (a) Y plates, (b) X plates.*

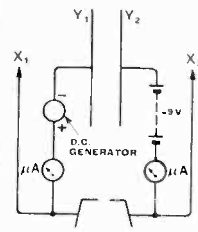


Fig. 2.

Where the plates are being driven from high impedance sources, the non-linear voltage/current characteristic can introduce serious wave form distortion. This distortion can be avoided by pre-biasing the plates so as to operate them always negatively with respect to the final anode. If for the purpose of centring the image both plates are so biased, some astigmatism will be introduced owing to the cylindrical lens between the final anode and the plates. This is not usually very troublesome unless the deflection voltages are large.

An interesting effect occurs when one plate is made increasingly negative, its opposite partner being joined to the final anode. Fig. 2 shows the circuit connections, Y_2 being biased 9 volts negative to stop secondaries reaching it from the screen. Curve (a) of Fig. 3 shows the currents in both plates plotted against the increasing negative potential on Y_1.

It is seen that at a critical negative voltage on Y_1, current commences to flow in both plates. The onset of current flow in Y_2 indicates impact by the primary beam. Owing to the high negative potential on Y_1, the Y_2 plate does not lose secondaries appreciably, and the net current direction means that electrons are flowing into this plate. Some of the primaries hitting Y_2 are reflected with high energies and travel back through the retarding field on to Y_1, which then loses electrons by secondary emission. This effect increases up to the point T, as more and more of the primaries hit Y_2. Beyond this point however, the increasing retarding field surrounding Y_1 acts as an increasing barrier, and the current leaving it gradually falls, reaching zero when $V_{y1} = -V_a$.

Curve (b) of Fig. 3 shows a similar characteristic for a pair of carbonised plates, in which the secondary emission is much reduced.

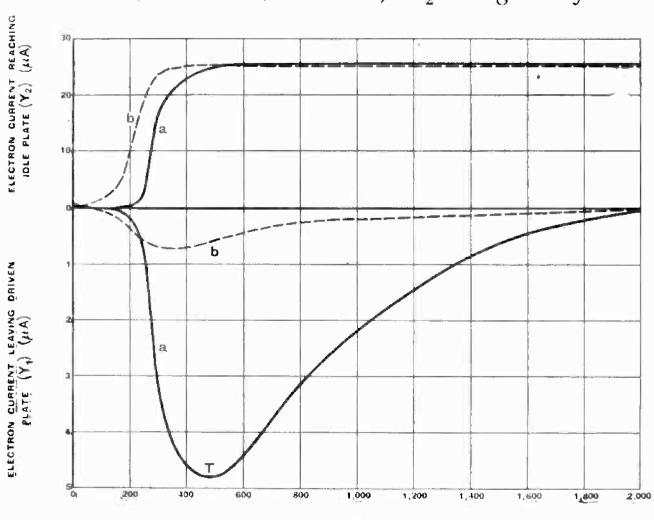


Fig. 3.—*Anode voltage 2,000. Beam current plus final anode current 80 μA. Curves (a) Y plates, (b) X plates.*

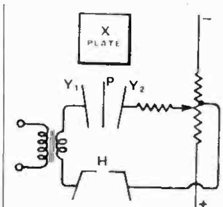
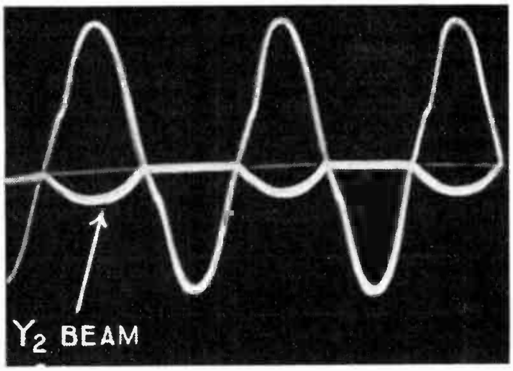
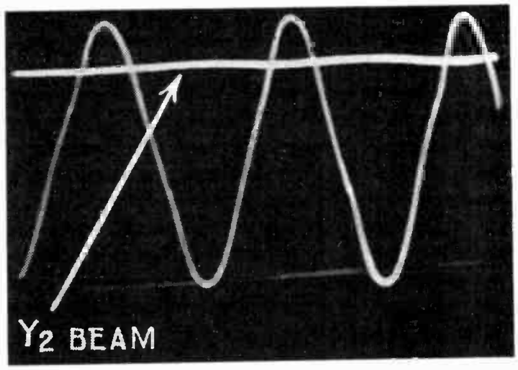


Fig. 4.

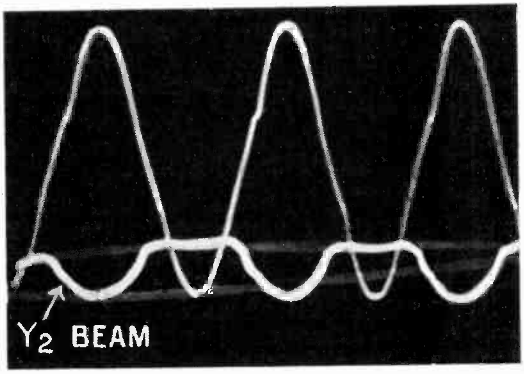


(a)



(b)

Fig. 5—*Photographs showing intermodulation on an early double-beam tube. The Y_2 potential is at zero in (a), $-12V$. in (b) and $+12V$. in (c).*



(c)

Effects in Double-Beam Tubes

Fig. 4 shows a diagrammatic sketch of an early form of Cossor double-beam tube. After emerging from the final anode hole *H*, the beam is divided on the " splitter plate " *P*. The two halves of the beam are then deflected separately by the Y_1 and Y_2 plates. The *X* deflection is common to both beams.

If either *Y* plate is joined back to the final anode via a low impedance, then the beam controlled by this plate is substantially unaffected by variations in the potential of the other plate, i.e., the interpenetration of the electrostatic fields of the two plates is small. If, however, the Y_2 plate, say, is joined back to the final anode through a shift potentiometer chain of a few megohms value, as in Fig. 4, and is not biased negatively, then the Y_2 plate potential is greatly dependent on the Y_1 plate potential. Fig. 5 shows a set of photographs demonstrating this effect. In these the Y_1 plate is being swung approximately sinusoidally with respect to the final anode. It will be seen that the " intermodulation " substantially disappears when Y_2 is made a few volts negative.

Fig. 6 shows the characteristics obtained by plotting the electron current reaching the Y_2 plate, against Y_1 plate voltage for various steady Y_2 potentials. The current reaching Y_2 develops voltages across its return impedance, thus modulating the idle beam.

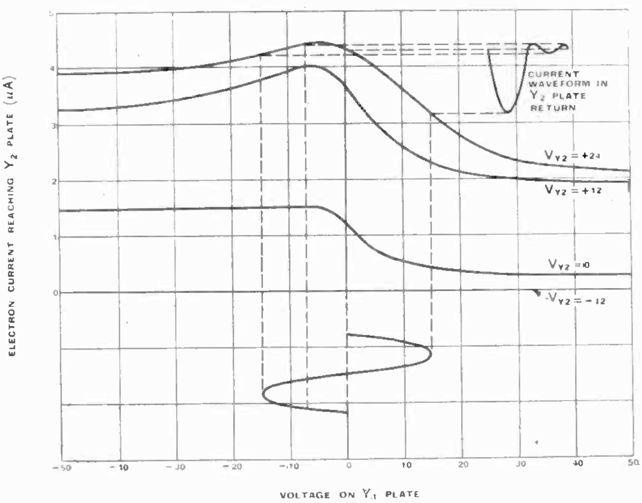


Fig. 6.

The general shape of the characteristics can be explained as follows. When Y_1 is at zero potential some of the secondary electrons ejected from the splitter plate by the grazing primary beam flow into the positive Y_2 plate. As Y_1 is made increasingly positive it robs Y_2 of some of the secondaries from the entry edge of the splitter plate, and the Y_2 current falls. As Y_1 is made negative, the initial rise in Y_2 current is probably due to secondary electrons being diverted from Y_1 to Y_2. As Y_1 becomes still more negative, however, the whole beam is pushed towards Y_2. This shields the side of the splitter plate opposite Y_2 from impact by the primary beam, and the number of secondaries generated therefore falls. When Y_2 is a few volts negative it does not receive any secondaries, and no intermodulation can therefore occur.

The "Pimple" Effect

An interesting form of interaction between the X and the Y plates can be caused in certain conditions by the returning secondaries from the screen.

Fig. 7 shows the observed effect as seen on a double-beam tube. Both Y plates have high impedance plate returns. The Y_1 plate is biased some 10 volts positive—the Y_2 plate has approximately the same negative bias. The "pimple" is caused by the momentary fall in Y_1 plate voltage while the beam is passing centrally through the X

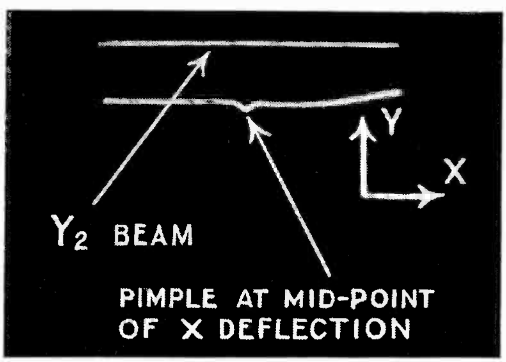


Fig. 7—*The "pimple" effect as observed on a double-beam tube.*

plates. This fall is due to interception by the Y_1 plate of returning screen secondaries which pass through the X plates only at the instant when they are substantially at equal positive potentials to the final anode.

Fig. 8 shows the current picked up on the two Y plates (joined together) as the X_2 plate voltage is varied. The current is at maximum when $V_{x1} = V_{x2}$. The hypothesis that returning secondaries from the screen are responsible is strongly supported

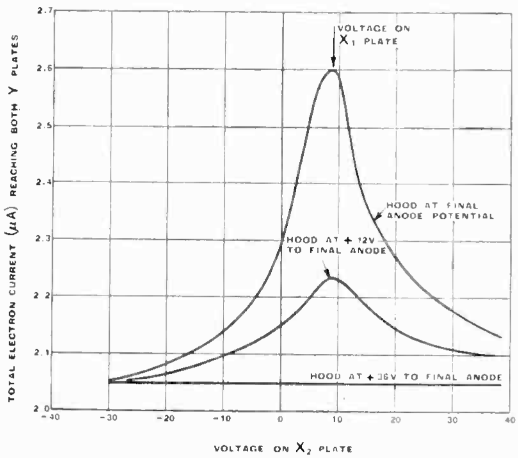


Fig. 8—*Final anode voltage* 1,300. *Beam current plus final anode current* 20 μA.

by the fact that when a hood surrounding the plates is made increasingly positive, the effect disappears. In this case, the secondaries are unable to penetrate the negative barrier, and cannot, therefore, modulate the Y plates.

The pimple effect can, of course, occur equally on single-beam tubes, provided that the Y plates are not symmetrical as regards both voltage and return impedance to the final anode and are not negative.

It is a pleasure to place on record my appreciation of the many helpful discussions I have had with Mr. Shelton on these and many other aspects of cathode-ray tubes. I am also indebted to A. C. Cossor, Ltd., in whose laboratories the work was done which led to this brief account.

"Inductance Linearized Time Base"

In Fig. 9 of the above article, which was published in the July 1941 issue, the numbers 0.005 and 0.05 on the f ordinate have become misplaced: they, like the numbers 0.0005 and 0.5, refer to the abscissæ upon which the $C\beta$ loci terminate.

Stray Capacitances*

Their Influence on the Effective Inductance of a Coil in a Metal Container

By L. I. Farren, Wh.Sch., A.C.G.I., D.I.C., and R. S. Rivlin, M.A.

(Communication from the Research Laboratories of The General Electric Company, Limited, England)

SUMMARY.—If the stray capacitances of a coil in a metal container are replaced by effective lumped capacitances across the coil and from each end of the coil to the container, formulae can be obtained for the effective inductance of the coil in terms of the absolute inductance and these lumped capacitances.

Such formulae are obtained for the cases in which the inductance of the coil is measured by the resonance method, by the unbalanced transformer bridge method and by the balanced transformer bridge method, for the various possible connections of the metal container.

Further, the effects of the stray capacitances of the coils in a "constant-K" band-pass filter and in a band-pass crystal lattice filter are discussed, and methods of overcoming these effects are given.

1. Introduction

A COMPLETE consideration of the reactance of a coil in a metal container must take into account, in addition to the absolute inductance—which is independent of frequency, provided the frequency is so low that the "skin" and "proximity" effects are negligible and the permeability may be considered constant—the distributed self-capacitance of the coil and its distributed capacitance to the container. We shall neglect in this discussion any effects that may result from the induction of E.M.F. in the container. We shall further assume that the distributed self-capacitance may be replaced by an equivalent lumped capacitance C_S between the two ends of the coil and that the distributed capacitance of the coil to the container may be replaced by two equivalent lumped capacitances C_A, C_B between the ends A, B respectively of the coil and the container.

Thus, the coil in its container will be assumed to be equivalent to the circuit of Fig. 1.

We shall see that the effective inductance between the terminals A and B is dependent on the particular way in which the coil is used in circuit, as well as on the location of the container.

At frequencies which are very low compared with the natural frequency of the coil, the impedances of the small stray capacitances are so large compared with that of the inductance that they may be neglected, and most methods of measurement of inductance at such frequencies give the absolute inductance of the coil. At higher frequencies this is no longer true, and the effective inductance may differ from the absolute inductance by a few per cent.

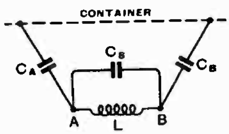


Fig. 1.—*Equivalent circuit of a coil.*

At these frequencies there are three well-known methods in use for measuring inductance. These are the resonant circuit method, the unbalanced transformer bridge method and the balanced transformer bridge method.

We shall here determine theoretically the value of the effective (i.e. measured) inductance in terms of the absolute inductance and stray capacitances for these three methods of measurement.

The effect of the stray capacitances C_A, C_B and C_S on the measured inductance of the coil will depend on the way in which the metal container is connected relatively to the coil terminals. For each of the methods of measurement given above we shall consider four different connections of the container—viz., container connected to A, container connected to B, container earthed, and container free but having a capacitance C_E to earth.

* MS. accepted by the Editor, January, 1941.

In passive networks which have to operate at the frequencies considered, it is often required to use coils whose inductances are equal to design values of inductance with some precision. It could be assured that the absolute values of the inductances of the coils used are equal to the design values by measuring the inductances of the coils at a low frequency, where their stray capacitances have a negligible effect. In general, however, in introducing the coils into their circuit the stray capacitances, which will inevitably be introduced, will have some effect on the performance of the circuit. We shall investigate this effect in the unbalanced constant-K band-pass filter and in the crystal lattice band-pass filter, and we shall see to what extent it can be overcome and the circuit elements given their design values.

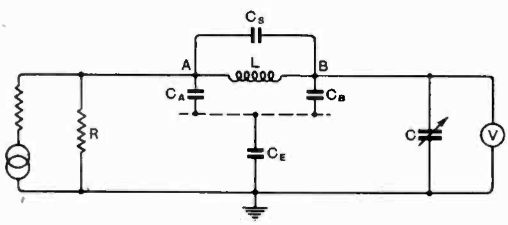


Fig. 2.—*Inductance measurement by resonance method.*

It will be seen that at these frequencies, where the stray capacitances of the coils do not have a negligible effect, every circuit involving coils must be considered separately and a method of coil measurement and adjustment of circuit elements worked out, if it is wished to ensure that the circuit elements actually have their design values, at any rate as far as their inductance and capacitance are concerned.

2. Resonant Circuit Method

In this method, illustrated in Fig. 2, the coil is tuned with a variable air condenser. Resonance is obtained for some setting of this condenser C (which includes stray capacitances across the condenser); this setting gives maximum voltage reading on the valve voltmeter V. The circuit is fed from an oscillator of angular frequency ω, the injected voltage being developed across the low resistance R.

(*a*) *Coil container free but having capacitance C_E to earth*

We can make a star-delta transformation of the capacitances C_A, C_B, C_E of Fig. 2, which gives the equivalent circuit of Fig. 3.

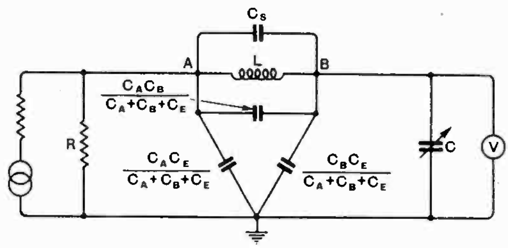


Fig. 3.—*Circuit equivalent to Fig. 2.*

We see from Fig. 3 that there is a capacitance $\left(C_S + \frac{C_A C_B}{C_A+C_B+C_E}\right)$ directly across the coil, and a capacitance $\left(\frac{C_B C_E}{C_A+C_B+C_E}\right)$ across the condenser C.

Whence the effective inductance, L_{eff}, is given by

$$L_{eff} = \frac{L}{1 - \omega^2 L\left(C_S + \frac{C_A C_B + C_B C_E}{C_A + C_B + C_E}\right)}$$

The capacitance $\frac{C_A C_E}{C_A + C_B + C_E}$ across the injector resistance R has no effect on the result.

(*b*) *Coil container earthed*

In this case we see that C_B is across the condenser C.

Hence,

$$L_{eff} = \frac{L}{1 - \omega^2 L(C_S + C_B)}$$

(*c*) *Coil container connected to A*

C_B is now across the coil, and C_E, being the capacitance from A to earth, does not affect the result.

We thus have the same result as in the previous case where the coil container was earthed,

$$L_{eff} = \frac{L}{1 - \omega^2 L(C_S + C_B)}$$

(*d*) *Coil container connected to B*

C_A is across the coil and C_E across the condenser C.

Thus, $$L_{eff} = \frac{L}{1 - \omega^2 L(C_S + C_A + C_E)}$$

3. Unbalanced Transformer Bridge Method

The coil is tuned in the circuit of Fig. 4. The stray capacitances inherent in the circuit (apart from the coil) are balanced out before the coil is inserted. We have therefore not shown them in the figure.

As in the case of the resonant circuit method, a star-delta transformation can be made on C_A, C_B, C_E. This gives three capacitances, viz.:

$$\frac{C_B C_E}{C_A + C_B + C_E}$$

across the tuning condenser,

$$\frac{C_A C_B}{C_A + C_B + C_E}$$

across the coil and

$$\frac{C_A C_E}{C_A + C_B + C_E}$$

across the whole left-hand arm of the bridge (i.e. across coil and tuning condenser in series).

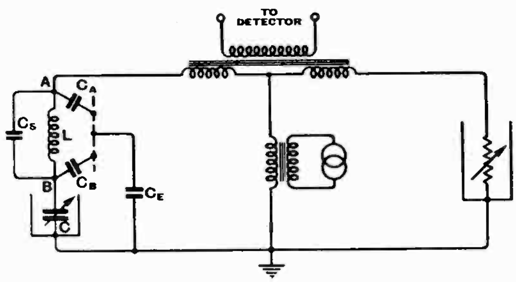


Fig. 4.—*Inductance measurement by unbalanced transformer bridge.*

It can easily be shown that this last capacitance has a negligibly small effect on the tuning capacitance required to balance the bridge.

The conditions obtaining are then substantially the same as those for the resonant circuit method, and the effective inductance for each of the four methods of connecting the container is the same as that given in Section 2.

4. Balanced Transformer Bridge Method

The circuit of Fig. 5 is used. The stray capacitances on both sides of the bridge are balanced out before the coil is inserted.

There are capacitances C_X, C_Y from X and Y respectively to earth, which may be large compared with C_A, C_B, C_S and C_E. These are, in fact, balanced out before the coil is

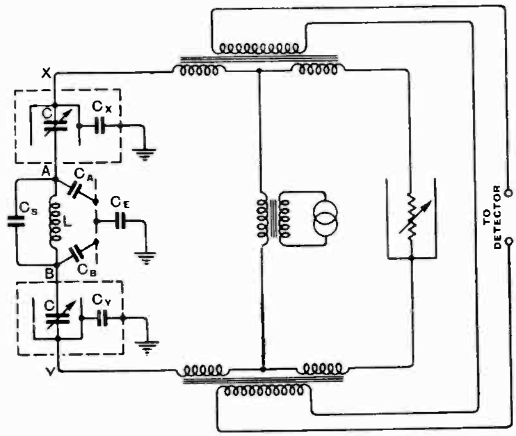


Fig. 5.—*Inductance measurement by balanced transformer bridge.*

inserted, but may nevertheless affect the apparent inductance of the coil.

(a) *Coil container free but having capacitance C_E to earth*

The left-hand arm of the bridge from X and Y is shown in Fig. 6. By applying a star-delta transformation to C_A, C_B, C_E, we obtain the equivalent circuit of Fig. 7.

Now, by applying the transformations given in equations (16) of Appendix II to the network formed by C, C, C_X, C_Y, C_1 and C_2

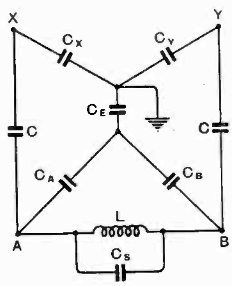


Fig. 6.

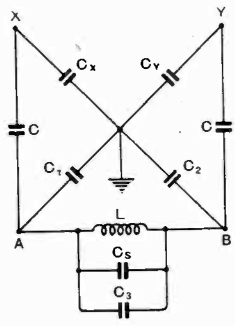


Fig. 7.

$$C_1 = \frac{C_A C_E}{C_A + C_B + C_E}; \quad C_2 = \frac{C_B C_E}{C_A + C_B + C_E};$$

$$C_3 = \frac{C_A C_B}{C_A + C_B + C_E}$$

in Fig. 7, XY being treated as the input terminals and AB as the output terminals of the two-terminal pair so formed, we can see that the network of Fig. 7 is equivalent to that of Fig. 8. where

$$\frac{1}{C_P} + \frac{1}{C_Q} = \frac{2C(C_X + C_Y + C_1 + C_2) + (C_X + C_Y)(C_1 + C_2)}{C^2(C_X + C_Y + C_1 + C_2) + C(C_XC_1 + C_YC_2)} \quad \ldots \quad (1)$$

$$C_R = \frac{C_1C_2(C_X + C_Y)^2 + C(C_X + C_Y + C_1 + C_2)(C_1C_Y + C_2C_X)}{(C_X + C_Y + C_1 + C_2)[2C(C_X + C_Y + C_1 + C_2) + (C_X + C_Y)(C_1 + C_2)]} \quad \ldots \quad (2)$$

and

$$C_T = \frac{C_XC_Y(C_1 + C_2)^2 + C(C_X + C_Y + C_1 + C_2)(C_1C_Y + C_2C_X)}{(C_X + C_Y + C_1 + C_2)[2C(C_X + C_Y + C_1 + C_2) + (C_X + C_Y)(C_1 + C_2)]} \quad \ldots \quad (3)$$

The circuit formed by the arms X_A, A_B, B_Y in series resonates at an angular frequency ω, where

$$L\left(C_s + C_3 + C_R + \frac{C_PC_Q}{C_P + C_Q}\right) = \frac{1}{\omega^2}$$

Now, substituting in this equation the values given for C_R and $\left(\frac{1}{C_P} + \frac{1}{C_Q}\right)$ in equations (1) and (2), we have

$$L\left[C_s + C_3 + \frac{\{C(C_X + C_Y + C_1 + C_2) + C_1(C_X + C_Y)\}\{C(C_X + C_Y + C_1 + C_2) + C_2(C_X + C_Y)\}}{\{2C(C_X + C_Y + C_1 + C_2) + (C_X + C_Y)(C_1 + C_2)\}\{C_X + C_Y + C_1 + C_2\}}\right] = \frac{1}{\omega^2} \quad \ldots \quad (4)$$

Further, the effective inductance L_{eff} is given by

$$\frac{C}{2} \cdot L_{eff} = \frac{1}{\omega^2} \quad \ldots \quad (5)$$

We can see from these two expressions, (4) and (5), that the effective inductance, L_{eff}, cannot be obtained explicitly in terms of the absolute inductance and stray capacitances. However, if we make the assumption that C is large compared with C_1 and C_2 we can do this. The equation (4) may be rewritten as

$$L\left[C_s + C_3 + \frac{C}{2} + \frac{1}{4} \cdot \frac{(C_X + C_Y)(C_1 + C_2)}{C_X + C_Y + C_1 + C_2} - \frac{1}{4} \cdot \frac{(C_X + C_Y)^2(C_1 - C_2)^2}{(C_X + C_Y + C_1 + C_2)\{2C(C_X + C_Y + C_1 + C_2) + (C_X + C_Y)(C_1 + C_2)\}}\right] = \frac{1}{\omega^2} \quad \ldots \quad (6)$$

It can be seen that the last term on the left-hand side of equation (6) is very small compared with the stray capacitances, if C is large compared with these.

It is zero if $C_1 = C_2$, which occurs when $C_A = C_B$. Then,

$$L\left[C_s + C_3 + \frac{C}{2} + \frac{1}{4} \cdot \frac{(C_X + C_Y)(C_1 + C_2)}{C_X + C_Y + C_1 + C_2}\right] \doteqdot \frac{1}{\omega^2}.$$

Combining this equation with equation (5) we have L_{eff}

$$\doteqdot \frac{L}{1 - \omega^2 L\left[C_s + C_3 + \frac{1}{4} \cdot \frac{(C_X + C_Y)(C_1 + C_2)}{C_X + C_Y + C_1 + C_2}\right]}.$$

(*b*) *Coil container earthed.*

In this case we replace C_1, C_2, C_3 of Section 4 (a) by C_A, C_B, 0 respectively.

Then, making the approximation that C is large compared with C_A, C_B as before, we have

$$L_{eff} = \frac{L}{1 - \omega^2 L\left[C_s + \frac{1}{4} \cdot \frac{(C_X + C_Y)(C_A + C_B)}{C_X + C_Y + C_A + C_B}\right]}.$$

(*c*) *Coil container connected to A.*

In this case the arm XY has the configuration shown in Fig. 9. This is equivalent to the configuration of Fig. 7 in which C_1, C_2 and C_3 are replaced by C_E, 0 and C_B respectively.

This gives with the approximation made in Section 4 (a)

$$L_{eff} = \frac{L}{1 - \omega^2 L\left[C_S + C_B + \frac{1}{4} \cdot \frac{(C_X + C_Y)C_E}{C_X + C_Y + C_E} \right]}.$$

By similar considerations we can find

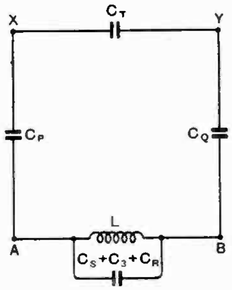


Fig. 8.

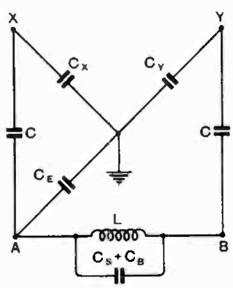


Fig. 9.

the effective inductance of the coil measured in the balanced transformer bridge with its container connected to B.

5.—The Band-Pass Constant-K Filter

The configuration of the ideal constant-K filter is shown in Fig. 10. L_1 resonates with C_1 at an angular frequency ω_m, which is the geometric mean angular frequency of the pass-band of the filter. L_2 resonates with C_2 at the same angular frequency.

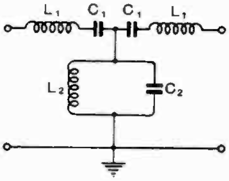


Fig. 10.

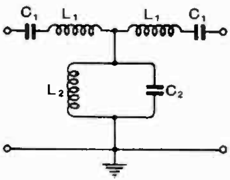


Fig. 11.

Now, it is quite clear that if all the elements are ideal, the position of the inductances L_1 and the capacitances C_1 can be interchanged, giving rise to the alternative configuration of Fig. 11, without affecting the performance of the filter in any way. However, if the inductance has appreciable self-capacitance and stray capacitances to container, these will have a considerable effect on the performance of the filter, unless they are allowed for in the filter design, and this effect will depend on the position of the coils L_1 in the filter (i.e. on whether they are arranged as shown in Fig. 10 or as shown in Fig. 11), and on the potential at which the container is maintained.

Let us assume that the inductances L_1 have self-capacitances C_{S1}, and capacitances C_{A1}, C_{B1} to their containers, and that the containers have capacitances C_{E1} to earth. Again, let us assume that the inductance L_2 has a self-capacitance C_{S2} and capacitances C_{A2}, C_{B2} to the container, which in turn has capacitance C_{E2} to earth.

Then, the configuration corresponding to the arrangement of the coils of Fig. 10 is

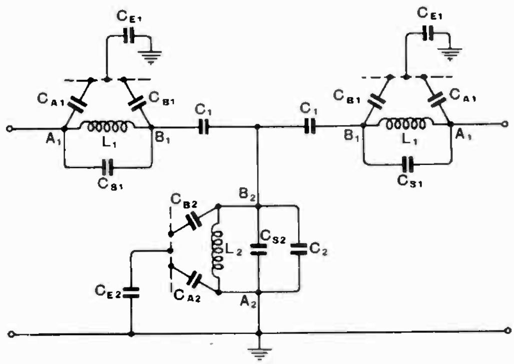


Fig. 12.

shown in Fig. 12 and the configuration corresponding to the arrangement of Fig. 11 is shown in Fig. 13.

The effect of its capacitances on the inductance L_2 and hence on the performance of the filter may easily be seen. If the coil container is earthed (this is equivalent to connecting the container to one side of the

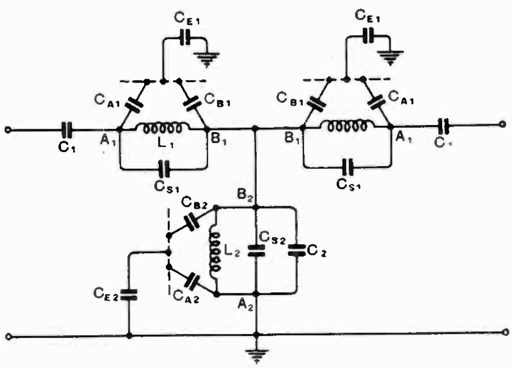


Fig. 13.

coil—the earthy one, and is always the case in practice), C_{B2} is across the coil, in parallel with C_{S2}.

In practice this capacitance can be allowed for by making the absolute inductance of the coil (i.e. the low-frequency inductance) to its correct design value and tuning the shunt circuit to parallel resonance at the prescribed angular frequency ω_m.

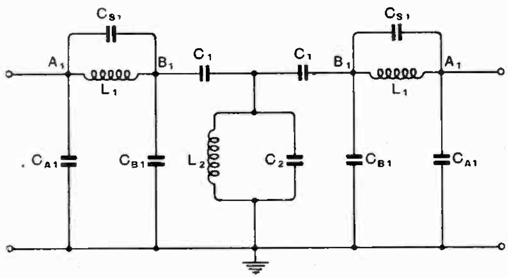


Fig. 14.

We shall now consider the effect of the stray capacitances on the behaviour of the inductance L_1, treating the inductance L_2 as ideal. In the configuration of Fig. 12, if we earth the containers of the inductances L_1, we obtain the configuration of Fig. 14.

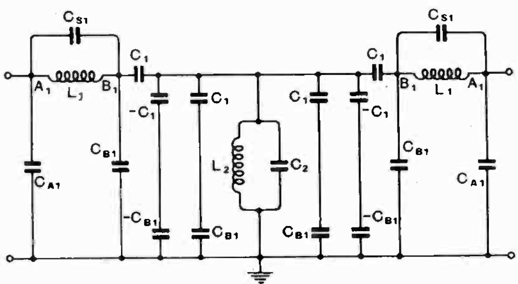


Fig. 15.

The capacitances C_{A1} have a negligible effect since they appear directly across the terminating impedances and have high impedances compared with these.

Now, the circuit of Fig. 14 is equivalent to that of Fig. 15, which, using Norton's transformation[1], can be shown to be equivalent to that of Fig. 16, where

$$\phi = \frac{C_{B1} + C_1}{C_1};$$

if we make the approximation that C_1 is large compared with C_{B1}, the capacitances C_1 and C_{B1} in series are approximately equal to C_{B1}. The circuit of Fig. 16 is equivalent to that of Fig. 17.

On comparing Figs. 10 and 17 we see that in Fig. 17 the inductance L_1 is now shunted by C_{B1}, and C_1 has now changed to (C_1+C_{B1}). However, if C_1 is given the value of the tuning capacitance used in measuring the coil by the resonance method of Section 2 or the unbalanced transformer bridge method of Section 3 in the case when the metal container is earthed, and the low-frequency inductance L_1 is made equal to the value of the series inductance calculated in designing the filter, the impedances of the series arms

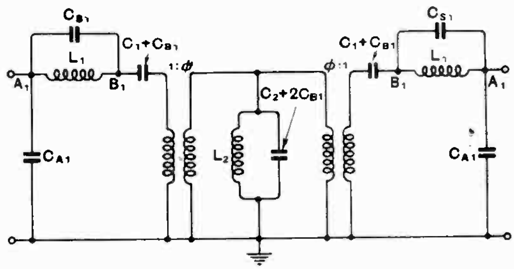


Fig. 16.

will be nearly identical with those of Fig. 10 in the neighbourhood of the resonant frequency of the arms.

We see, however, that the stray capacitances C_{B1} of the coils L_1 have the further effect of modifying both the inductance and capacitance of the shunt arm. An approximation to the ideal of Fig. 10 may be obtained by tuning the shunt arm *in situ*, to parallel resonance at the design frequency. This ensures that the geometric mean frequency of the pass-band is correct, but the cut-off frequencies will be slightly different

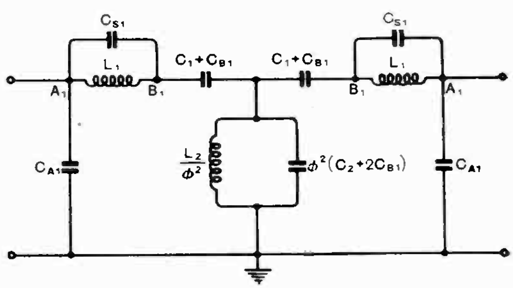


Fig. 17.

from their design values. This discrepancy could be overcome by adjustment of the absolute (low-frequency) inductance of L_2 although this would, in general, be impracticable in manufacture.

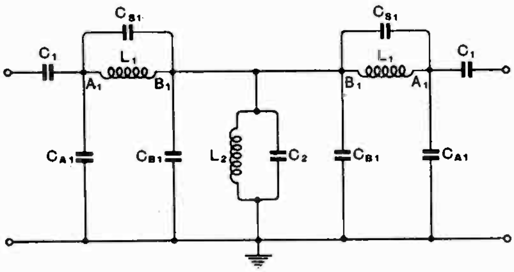


Fig. 18.

If the positions of the series coils are changed as shown in Fig. 11, then the circuit arrangement, taking into account the stray capacitances, is shown in Fig. 13.

We have already discussed the effect on the inductance L_2 of its stray capacitances.

If the container of L_1 is earthed, the circuit becomes that shown in Fig. 18. By transformations rather similar to those already used in the configurations (14) to (17), we obtain the equivalent arrangements shown in Figs. 19 and 20.

Referring to Fig. 20, C_{A1} and C_1 in series appear across the terminations and have no appreciable effect on the filter. Again, the

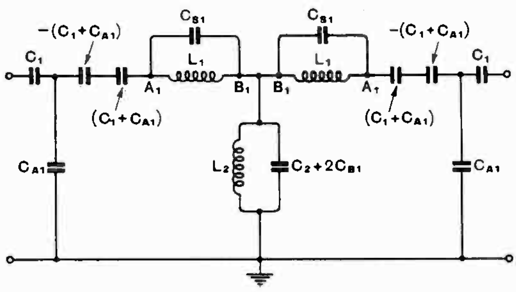


Fig. 19.

ideal transformer, whose transformation ratio is very nearly unity, causes a mis-match between the filter impedance and the input termination which is, in practice, quite negligible in its effects on the filter performance. We see that the series arms are identical with those of Fig. 17 except that the capacitances C_{B1} in the series arms of Fig. 17 are in Fig. 20 replaced by C_{A1}. Thus, a procedure exactly parallel with that discussed for Fig. 17 can be adopted in this case for adjusting the series elements to their correct values.

The shunt inductance is unchanged by the transformations, but a capacitance $2C_{B1}$ is thrown in parallel with C_2. This can be easily taken up in C_2 when the shunt arm is tuned, *in situ*, to parallel resonance at its design frequency.

It would seem advantageous, therefore, to connect the coil shown as shown in Fig. 11 rather than as shown in Fig. 10.

We shall now consider the effect of the stray capacitances of the series arm inductances when the containers are connected to one end of their coils. If the containers are connected to the ends B_1 in the con-

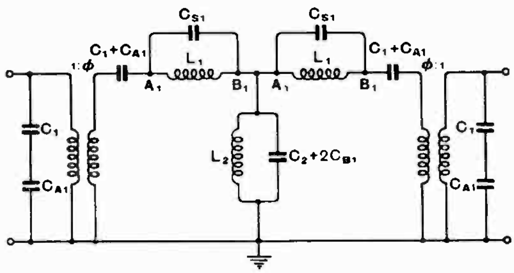


Fig. 20.

figuration of Fig. 12, or to either A_1 or B_1 in the configuration of Fig. 13, no advantage is gained over the methods of connection considered in the previous paragraph to compensate for the undesirable condition that the container is not at earth potential.

However, if in the configuration of Fig. 12 the containers are connected to the ends A_1, we see that the circuit becomes that of Fig. 21. The capacitances C_{E1} which appear

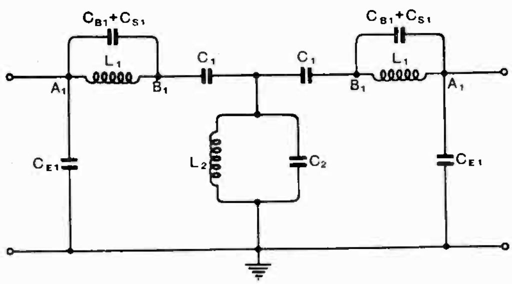


Fig. 21.

across the terminations have a negligible effect on the operation of the filter. The treatment of the series arm is nearly identical with that pertaining to the configuration of Fig. 16. The shunt arm is unaffected by the stray capacitances of L_1. This method of connection has, however, the disadvantage that the container is not earthed and therefore the coils L_1 are electrostatically unscreened. This can be remedied by the use of double screens of which the outer is earthed, as described by Lane[2].

6.—The Band-Pass Crystal Lattice Filter

We have seen that the effective inductance of a coil is dependent on its actual location in circuit. We shall now consider the effect of the stray capacitances C_S, C_A and C_B in the crystal filter of Fig. 22, which is of the type described by Mason[3]. By means of the well-known "star-mesh" transformation[4, 5], C_A and C_B (at both ends of the filter) may be replaced by

$$\frac{C_A C_B}{2(C_A+C_B)}$$

across AB, $A'B'$, AB' and $A'B$, together with

$$\frac{C_A^2}{2(C_A+C_B)}$$

and

$$\frac{C_B^2}{2(C_A+C_B)}$$

between AA' and BB'.

We thus see that the circuit of Fig. 22 is equivalent to that of Fig. 23. Again, the circuit of Fig.

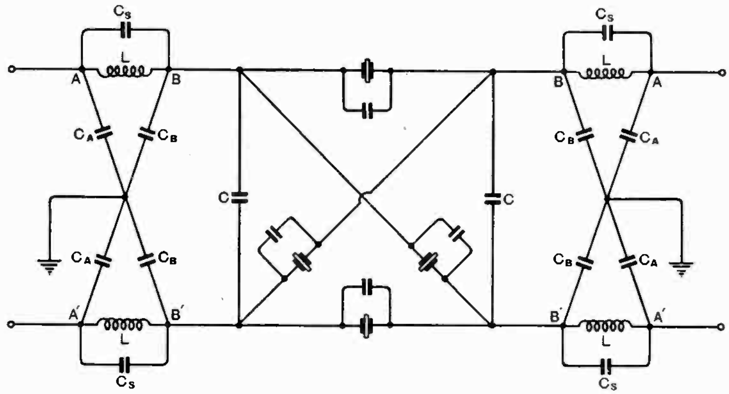


Fig. 22.

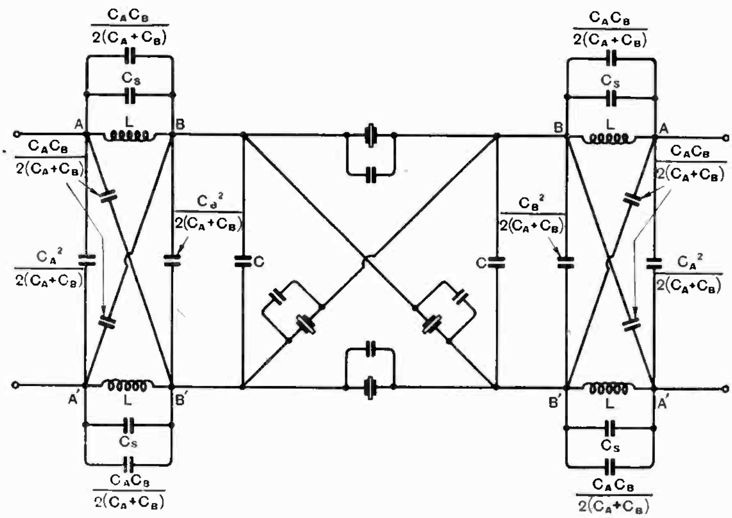


Fig. 23.

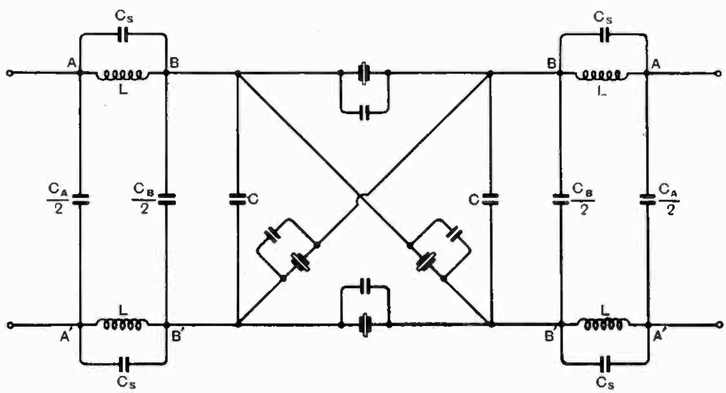


Fig. 24.

23 is equivalent to that of Fig. 24, as shown by Bode[6].

We thus see that apart from capacitances which effectively appear across the input to the filter and whose effect to a first approximation can be neglected, and capa-

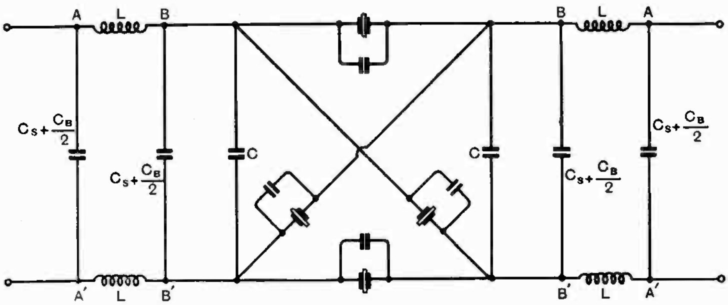


Fig. 25.

citances which are effectively in parallel with C and can therefore be allowed for in C, the inductances consist of the absolute inductances L, in parallel with their self-capacitances C_s.

Thus, the effective inductance, L_{eff}, of the coil is given by

$$L_{eff} = \frac{L}{1 - \omega^2 L C_s}$$

This cannot be measured directly by any of the three standard methods previously described, but may be conveniently measured using either the resonance method or the unbalanced transformer bridge method with only a slight complication of the method of measurement.

It should be noted that C_B as it appears when the coil is connected in the filter includes also the stray capacitances from the crystals to earth.

We can, however, avoid the necessity for measuring $L_{eff}\left(=\frac{L}{1-\omega^2 L C_s}\right)$ by introducing capacitances equal to C_s between AB' and $A'B$ in Fig. 24. These make the circuit of Fig. 24 equivalent to that of Fig. 25. The effective capacitance C_s which appears between A and A' has a negligible effect on the performance of the filter, and that appearing between B and B' can be made part of the capacitance C. We see that here only the absolute inductance of the coil is involved and this can be taken as the low-frequency inductance.

APPENDIX I

Let E_1, I_1 denote the input potential and current respectively to the two-terminal pair of Fig. 26, and let E_2, I_2 denote the output potential and current respectively.

Then, E_1, I_1 and E_2, I_2 are related by a pair of equations of the form

$$E_1 = AE_2 + BI_2$$
$$I_1 = CE_2 + DI_2,$$

where $AD - BC = 1$.

A, B, C and D are functions of the impedances of the electrical elements constituting the network.

This pair of equations may be re-written as a single matrix equation thus :—

$$\begin{pmatrix} E_1 \\ I_1 \end{pmatrix} = \begin{pmatrix} A, & B \\ C, & D \end{pmatrix} \begin{pmatrix} E_2 \\ I_2 \end{pmatrix} \quad \ldots \quad (7)$$

Following the method used by Feldtkeller and Strecker[7] and others, if we know the values of A, B, C, D (which will in general be functions of frequency) for a number of two-terminal pairs, we can obtain a relation of the form given in equation (7) for the network consisting of these two-terminal pairs connected in tandem, considered as a single two-terminal pair. Thus, if the values of the matrix $\begin{pmatrix} A, & B \\ C, & D \end{pmatrix}$ for the three two-terminal pairs 1, 2, 3 of Fig. 27 are $\begin{pmatrix} A_i, & B_i \\ C_i, & D_i \end{pmatrix}$, where $i = 1, 2, 3$ respectively, then the input potential and current E_1 and I_1 respectively of the network of Fig. 27 consisting of the two-terminal pairs 1, 2 and 3 in tandem, are connected with the output potential and current, E_2 and I_2 respectively, by the relation

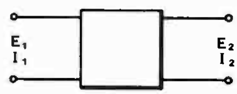


Fig. 26.

$$\begin{pmatrix} E_1 \\ I_1 \end{pmatrix} = \begin{pmatrix} A_1, & B_1 \\ C_1, & D_1 \end{pmatrix} \begin{pmatrix} A_2, & B_2 \\ C_2, & D_2 \end{pmatrix} \begin{pmatrix} A_3, & B_3 \\ C_3, & D_3 \end{pmatrix} \begin{pmatrix} E_2 \\ I_2 \end{pmatrix}$$

Now, suppose the two-terminal pairs 1 and 3 consist of shunt elements Z and Z' respectively, making the network of Fig. 27 that of Fig. 28.

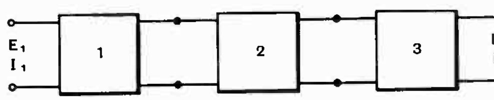


Fig. 27.

Then $\begin{pmatrix} A_1, & B_1 \\ C_1, & D_1 \end{pmatrix} = \begin{pmatrix} 1 & , 0 \\ 1/Z, & 1 \end{pmatrix}$

and $\begin{pmatrix} A_3, & B_3 \\ C_3, & D_3 \end{pmatrix} = \begin{pmatrix} 1 & , 0 \\ 1/Z', & 1 \end{pmatrix}$.

So that $$\begin{pmatrix} E_1 \\ I_1 \end{pmatrix} = \begin{pmatrix} 1 & , 0 \\ 1/Z, & 1 \end{pmatrix} \begin{pmatrix} A_2, & B_2 \\ C_2, & D_2 \end{pmatrix} \begin{pmatrix} 1 & , 0 \\ 1/Z', & 1 \end{pmatrix} \begin{pmatrix} E_2 \\ I_2 \end{pmatrix}$$

$$= \begin{pmatrix} A_2 + \frac{B_2}{Z'} & , B_2 \\ \frac{1}{Z}\left(A_2 + \frac{B_2}{Z'}\right) + C_2 + \frac{D_2}{Z'}, & \frac{B_2}{Z} + D_2 \end{pmatrix}$$

This circuit, considered purely as a two-terminal pair, is equivalent to the circuit of Fig. 26 if

$$\left.\begin{aligned} A &= A_2 + \frac{B_2}{Z'}, \\ B &= B_2, \\ C &= \frac{1}{Z}\left(A_2 + \frac{B_2}{Z'}\right) + C_2 + \frac{D_2}{Z'}, \\ D &= \frac{B_2}{Z} + D_2. \end{aligned}\right\} \quad \ldots \quad (8)$$

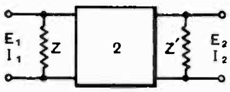


Fig. 28.

Now, suppose the network of Fig. 26 is a lattice network whose arms have impedances Z_1, Z_2, Z_3 and Z_4 as shown in Fig. 29. Then,

$$\left.\begin{aligned} A &= -\frac{(Z_1 + Z_4)(Z_2 + Z_3)}{Z_1Z_2 - Z_3Z_4} \\ B &= -\frac{Z_2Z_4(Z_1 + Z_3) + Z_1Z_3(Z_2 + Z_4)}{Z_1Z_2 - Z_3Z_4} \\ C &= -\frac{Z_1 + Z_2 + Z_3 + Z_4}{Z_1Z_2 - Z_3Z_4} \\ D &= -\frac{(Z_1 + Z_3)(Z_2 + Z_4)}{Z_1Z_2 - Z_3Z_4} \end{aligned}\right\} \quad (9)$$

We can replace the network of Fig. 26, as far as its operation as a two-terminal pair is concerned, by a network of the form shown in Fig. 30, which is identical with the network of Fig. 28, in which the two-terminal pair 2 comprises the impedances Z_1' and Z_2'. Thus, A_2, B_2, C_2, D_2 are now given by

$$\left.\begin{aligned} A_2 &= 1, \\ B_2 &= Z_1' + Z_2', \\ C_2 &= 0, \\ D_2 &= 1. \end{aligned}\right\} \quad \ldots \quad \ldots \quad (10)$$

The matrix elements A, B, C, D for the network of Fig. 30 may be found from equations (7) and (9).

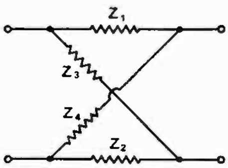


Fig. 29.

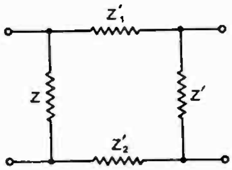


Fig. 30.

Thus,

$$\left.\begin{aligned} A &= 1 + \frac{Z_1' + Z_2'}{Z'}, \\ B &= Z_1' + Z_2', \\ C &= \frac{1}{Z}\left(1 + \frac{Z_1' + Z_2'}{Z'}\right) + \frac{1}{Z'}, \\ D &= \frac{Z_1' + Z_2'}{Z} + 1. \end{aligned}\right\}$$

Whence,

$$\left.\begin{aligned} Z_1' + Z_2' &= B, \\ Z' &= \frac{B}{A - 1}, \\ \text{and} \quad Z &= \frac{B}{D - 1}, \end{aligned}\right\} \quad \ldots \quad (11)$$

The networks of Figs. 29 and 30 will be identical if A, B, C and D in equations (11) have the values given in equations (9).

Then,

$$\left.\begin{aligned} Z_1' + Z_2' &= -\frac{Z_2Z_4(Z_1 + Z_3) + Z_1Z_3(Z_2 + Z_4)}{Z_1Z_2 - Z_3Z_4}, \\ Z' &= \frac{Z_2Z_4(Z_1 + Z_3) + Z_1Z_3(Z_2 + Z_4)}{(Z_1 + Z_4)(Z_2 + Z_3) + (Z_1Z_2 - Z_3Z_4)}, \\ Z &= \frac{Z_2Z_4(Z_1 + Z_3) + Z_1Z_3(Z_2 + Z_4)}{(Z_1 + Z_3)(Z_2 + Z_4) + (Z_1Z_2 - Z_3Z_4)}. \end{aligned}\right\} \quad \ldots \quad \ldots \quad (12)$$

In the special case when the arms of the lattice consist purely of capacitances C_1, C_2, C_3 and C_4,

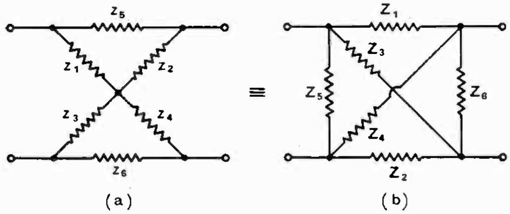


Fig. 31.

the transformed network consists of capacitance C_1', C_2', C and C', where

$$\left.\begin{aligned} \frac{1}{C_1'} + \frac{1}{C_2'} &= -\frac{C_1 + C_2 + C_3 + C_4}{C_3C_4 - C_1C_2}, \\ \frac{1}{C'} &= \frac{C_1 + C_2 + C_3 + C_4}{(C_1 + C_4)(C_2 + C_3) + (C_3C_4 - C_1C_2)}, \\ \frac{1}{C} &= \frac{C_1 + C_2 + C_3 + C_4}{(C_1 + C_3)(C_2 + C_4) + (C_3C_4 - C_1C_2)}. \end{aligned}\right\} \quad \ldots \quad \ldots \quad (13)$$

APPENDIX II

It has been shown by Rosen[4] and Russell[5] that the network of Fig. 31 (a) can be transformed into that of Fig. 31 (b) where the impedances are related in the following way :—

$$\left.\begin{aligned} Z_1 &= \frac{\pi_3 \cdot z_5}{\pi_3 + z_3z_4z_5}, \\ Z_2 &= \frac{\pi_3 \cdot z_6}{\pi_3 + z_1z_2z_6}, \\ Z_3 &= \frac{\pi_3}{z_2z_3}, \\ Z_4 &= \frac{\pi_3}{z_1z_4}, \\ Z_5 &= \frac{\pi_3}{z_2z_4}, \\ Z_6 &= \frac{\pi_3}{z_1z_3}, \end{aligned}\right\} \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

where

$$\pi_3 = z_2z_3z_4 + z_3z_4z_1 + z_4z_1z_2 + z_1z_2z_3.$$

In Appendix I we have derived the transformations of equations (12) by which the network of Fig. 29 can be replaced by an equivalent network

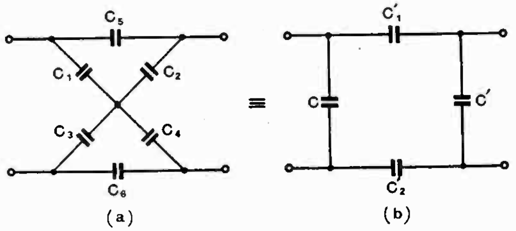


Fig. 32.

of the form shown in Fig. 30. Using these transformations together with the transformations of equations (14) we can replace Fig. 31 (a) by Fig. 30 where,

$$\left.\begin{aligned} Z_1' + Z_2' &= \frac{\pi_3(z_5 + z_6) + z_5z_6(z_1 + z_3)(z_2 + z_4)}{\pi_3 + z_3z_4z_5 + z_1z_2z_6}, \\ Z' &= \pi_3 \cdot \frac{(z_5 + z_6)\pi_3 + z_5z_6(z_1 + z_3)(z_2 + z_4)}{z_2z_4z_5z_6(z_1 + z_3)^2 + \pi_3(z_1z_4z_5 + z_2z_3z_6)}, \\ Z &= \pi_3 \cdot \frac{(z_5 + z_6)\pi_3 + z_5z_6(z_1 + z_3)(z_2 + z_4)}{z_1z_3z_5z_6(z_2 + z_4)^2 + \pi_3(z_2z_3z_5 + z_1z_4z_6)}, \end{aligned}\right\} \quad \ldots \quad \ldots \quad (15)$$

In the special case where the configuration of Fig. 31 (a) consists entirely of capacitances as shown in 32 (a), we have the equivalence of Fig. 32 (b), in which

$$\left.\begin{aligned} \frac{1}{C_1'} + \frac{1}{C_2'} &= \frac{(C_1 + C_2 + C_3 + C_4)(C_5 + C_6) + (C_1 + C_3)(C_2 + C_4)}{(C_1 + C_2 + C_3 + C_4)C_5C_6 + C_1C_2C_6 + C_3C_4C_5}, \\ C' &= \frac{C_2C_4(C_1 + C_3)^2 + (C_1 + C_2 + C_3 + C_4)(C_2C_3C_6 + C_1C_4C_5)}{(C_1 + C_2 + C_3 + C_4)[(C_5 + C_6)(C_1 + C_2 + C_3 + C_4) + (C_1 + C_3)(C_2 + C_4)]}, \\ C &= \frac{C_1C_3(C_2 + C_4)^2 + (C_1 + C_2 + C_3 + C_4)(C_2C_3C_5 + C_1C_4C_6)}{(C_1 + C_2 + C_3 + C_4)[(C_5 + C_6)(C_1 + C_2 + C_3 + C_4) + (C_1 + C_3)(C_2 + C_4)]}. \end{aligned}\right\} \quad \ldots \quad (16)$$

REFERENCES

(1) E. L. Norton. U.S. Patent Specification No. 1,681,554; also Shea "Transmission Networks and Wave Filters."
(2) C. E. Lane. U.S. Patent Specification No. 1,985.042.
(3) W. P. Mason. "Electrical Wave Filters employing Quartz Crystals as Elements." *Bell S. Tech. Journ.*, July 1934.
(4) A. Rosen. "A New Network Theorem." *Journ. I.E.E.*, Vol. 62, pp. 916–918 (1924).
(5) A. Russell. "Star and Pair Connections in Networks." *Faraday House Journ.*, Vol. 20, pp. 86–90 (1927).
(6) H. W. Bode. U.S. Patent Specification No. 2,029,698.
(7) K. Feldtkeller and F. Strecker. "Grundlagen der Theorie des allgemeinen Vierpols." *E.N.T.*, Vol. 6, No. 3, 1929.

Correspondence

"Measurement of Shot and Thermal Noise"

To the Editor, "The Wireless Engineer"

SIR,—I wish to thank Messrs. Aldous and James for pointing out that in my paper, published in the March issue of *The Wireless Engineer*, an incorrect value of constant was inadvertently inserted in the formula for converting anode current fluctuations to equivalent grid noise resistance. So far as I am aware, the well-known formula, which they have set out in detail, is the only method applicable to this transformation, but in practice it is not free from approximation, owing to the uncertainty of the relevant temperature; the temperature of 293° K. actually makes the constant 19.8 instead of 20. In other spheres there is a remarkable diversity in the choice of standard temperatures; e.g., the prototype International metre is supposed to be compared with similar standards at 0° C., but the comparison with red light (Cadmium) was made with the light in air at 15° C., a temperature which is also used frequently by chemists in specifying standard solutions. "Room temperature" in this country is usually between 15° and 17° C., rarely by choice as high as 20°; but circuit temperature in an enclosed amplifier may be nearer 30° C., and the equivalent grid noise resistance formula is frequently used to perform a direct comparison of circuit noise and valve noise. In practice, therefore, the relevant temperature can vary at least between 288° and 303° K., leaving out of account the desirability of adopting the more standard temperature of 0° C., for definitions.

With regard to the EF50, it was pointed out in the original paper that the mutual conductance had not been measured, and the grid resistance figure was only a conditional one based on the assumed conductance. The most probable reason for an incorrect value of grid resistance is simply that the assumed value of mutual conductance was wrong, the actual amount of secondary emission amplification at the time of measurement being much less than that corresponding to a slope of 14 mA/V. I think it improbable that there will be a serious difference in the ratios of peak to r.m.s. values for the noise from a diode or other normal valve and the noise from a valve employing secondary-emission amplification when both are observed at the output of an amplifier employing a number of tuned stages; as I have not at present an amplifier suitable for operating a square-law meter, I hope Messrs. Aldous and James will be sufficiently interested in the question to substitute a linear rectifier for the square-law meter on their equipment, and so obtain a direct check on this point.

London, N.21. D. A. BELL.

Wireless Patents

A Summary of Recently Accepted Specifications

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

533 605.—Back coupling with phase-adjusting means for an electric oscillation-generator controlled by a tuning fork.

"Fides" Ges. m.b.h. Convention date (Germany) 26th October, 1938.

533 682.—Loudspeaker coupling to a low-frequency amplifier with a negative feed-back factor which is dependent on frequency.

Philips Lamps. Convention date (Germany) 15th November, 1938.

533 736.—Back-coupling arrangement designed to facilitate the application of a desired phase-shift in an amplifier or oscillation-generator, utilising negative reaction.

Standard Telephones and Cables (assignees of H. S. Black). Convention date (U.S.A.) 20th December, 1938.

533 913.—Arrangement of coaxially-mounted twin diaphragms in a loudspeaker designed to prevent cabinet resonance.

Goodmans Industries; G. A. Barden; and E. S. Newland. Application date 18th August, 1939.

AERIALS AND AERIAL SYSTEMS

532 164.—A periodic coupling circuit between a pair of crossed frame aerials used for feeding a broadcast receiving set.

K. H. Meier. Convention date (Switzerland) 26th June, 1939.

533 717.—Dipole aerial for receiving television combined with an aerial for medium- or long-wave broadcast "static free" reception.

Standard Telephones and Cables; W. A. Beatty; and P. K. Chatterjea. Application date 18th August, 1939.

534 066.—Horn-shaped collectors or radiators for ultra-short waves, associated with a two-wire, coaxial, or similar transmission line.

Standard Telephones and Cables (assignees of W. L. Barrow). Convention date (U.S.A.) 9th January, 1939.

534 067.—Horn-shaped radiator or collector, used as a substitute for an aerial in ultra-short-wave transmission and reception.

Standard Telephones and Cables (assignees of W. L. Barrow). Convention date (U.S.A.) 3rd January, 1939.

534 909.—Omni-directional aerial system, particularly for receiving horizontally-polarised short waves over a wide band of frequencies.

Marconi's W.T. Co. (assignees of De W. R. Goddard). Convention date (U.S.A.) 26th November, 1938.

DIRECTIONAL WIRELESS

532 955.—Directional aerial of the kind in which loops or extensions are branched as "mirror images" on both sides of a transmission line.

E. C. Cork and J. L. Pawsey. Application date 3rd August, 1939.

533 185.—Navigational beacon transmitter of the overlapping-beam type in which the axis of overlap is also oscillated over a small angle.

Marconi's W.T. Co. and S. B. Smith. Application date 14th October, 1939.

533 538.—Indicating the contour or terrain clearance of the ground below an aeroplane in flight by utilising the reflected waves from a radio transmitter on the aeroplane.

Electrical Research Products Inc. Convention date (U.S.A.) 16th November, 1938.

533 705.—Radio-navigational system for the blind-landing of an aeroplane with means for combining the indications given both in elevation and azimuth.

International Service Corporation. Convention date (U.S.A.) 26th October, 1938.

533 782.—Direction finder of the type in which a pair of spaced vertical aerials are coupled to a common transmission line the mid-point of which is tapped to the receiver.

Marconi's W.T. Co. (assignees of W. L. Carlson). Convention date (U.S.A.) 23rd September, 1938.

534 036.—Direction finding system in which the phase-reversal which occurs at the critical minimum point is utilised to indicate visually both the sense and magnitude of small errors in adjustment.

G. Guanella. Convention date (Switzerland) 23rd August, 1938.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television)

533 254.—Wireless receiver with negative resistance arranged so as not to decrease sensitivity for weak signals, but to come into operation on strong signals and to improve their quality.

Philips Lamps. Convention date (Netherlands) 26th October, 1938.

533 275.—Arrangement of two rectifiers connected in opposition for deriving an A.V.C. voltage which depends only upon the mean voltage of a modulated carrier-wave.

C. J. W. Hill and J. W. Smith. Application date 26th October, 1939.

533 315.—Multiple-band tuning indicator with one or more auxiliary pointers in which means are provided to screen the pointers not required.

Philips Lamps. Convention date (Netherlands) 3rd September, 1938.

533 453.—Tuning circuit in which phase and amplitude matching adjustments can be made in order to balance out an interfering signal whilst allowing the passage of a desired signal.

G. Hodges. Application date 28th August, 1939.

533 558.—Means for eliminating the damping effect of that part of the cathode lead which is included in the input circuit of a valve amplifier, particularly when handling short waves.

The General Electric Co. and W. H. Aldous. Application dates 7th November, 1939 *and 19th August*, 1940.

533 626.—Means for varying the output of a balanced or push-pull circuit by altering the amount of negative feed-back.

Standard Telephones and Cables (assignees of S. T. Brewer). Convention date (U.S.A.) 27th January, 1939.

533 812.—Interference eliminator embodying a narrow band-pass filter having a time constant such as to reject unwanted signals.

Marconi's W.T. Co. (assignees of H. O. Peterson and R. L. Hollingsworth). Convention date (U.S.A.) 29th November, 1938.

533 894.—Receiving signals transmitted on a single side-band, and compensating inherent distortion, particularly for television.

Hazeltine Corpn. (assignees of H. M. Lewis). Convention date (U.S.A.) 10th January, 1939.

533 905.—Method of spacing the windings of a screened coil, more particularly a frame aerial.

Philips Lamps. Convention date (Netherlands) 17th December, 1938.

533 989.—Remote control system for a wireless receiver incorporating a simplified method for switching the set on and off.

Hazeltine Corpn. (assignees of L. F. Curtis). Convention date (U.S.A.) 31st December, 1938.

534 153.—Ultra-short-wave tuning circuits of the concentric resonant-line, or non-radiating, type.

Marconi's W.T. Co. (assignees of N. E. Linden Blad). Convention date (U.S.A.) 25th August, 1938.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

533 650.—Supervisory means for regulating the running of high-powered cathode-ray tubes, as used for television projection, so as to ensure a longer filament life.

Baird Television and C. S. Szegho. Application date 17th August, 1939.

533 993.—Multiple-line scanning arrangement for the transmission and reception of television in natural colours.

B. T. Hewson and A. Locan. Application date 15th June, 1939.

534 466.—Optical compensating system for use when scanning a cinema film through two rotating reflector drums for television.

Cinema Electric Commodities and P. Eisler. Application date 2nd August, 1939.

534 483.—Construction of a diffusing or "prismatic" viewing screen, suitable for television.

J. L. Stableford. Application date 31st August, 1939.

534 548.—Frequency-selective arrangement particularly for separating the picture signals from the synchronising impulses in television.

The Loewe Radio Co. (communicated by K. Schlesinger). Application date 6th March, 1940.

534 650.—Means for preventing distortion in a television transmitter due to the capacity of the photo-cell and to "afterglow" on the screen.

Ges. &c. Technischen Hochschule. Convention date (Switzerland) 21st July, 1938.

534 705.—Means for increasing the linearity of the magnetic deflecting system of a television cathode-ray receiver.

A. A. Thornton (communicated by Philco Radio and Television Corpn.). Application date 18th September, 1939.

534 718.—Control system for stabilising the signal level corresponding to a given shade-value in a television receiver.

Hazeltine Corpn. (assignees of H. A. Wheeler). Convention date (U.S.A.) 6th December, 1938.

534 749.—Frequency-control system for synchronising the impulse generators in a television system operated from power-supply mains of given frequency.

Marconi's W.T. Co. (assignees of A. V. Bedford). Convention date (U.S.A.) 26th October, 1938.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

534 144.—Means for stabilising the frequency of an ultra-short-wave generator of the kind in which the electrons in an electron stream are "bunched" together at spaced intervals.

The Board of Trustees of the Leland Stanford Junior University. Convention date (U.S.A.) 2nd September, 1938.

534 176.—Balancing and frequency-selective arrangements for transmission lines carrying very high frequencies.

Standard Telephones and Cables (assignees of S. Frankel). Convention date (U.S.A.) 10th February, 1939.

534 213.—Multiplex signalling systems, for speech or television, depending primarily on a time-division or phase-relation method of separating the signals.

Electrical Research Products Inc. Convention date (U.S.A.) 26th July, 1938.

534 757.—Phase- or frequency-modulating system utilising the electron stream of a cathode-ray tube and a pair of associated photo-electric cells which are fed by phase-displaced curves produced on the fluorescent screen of the tube.

The British Thomson-Houston Co. Convention date (U.S.A.) 12th November, 1938.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

532 996.—Cathode-ray tube with means to offset the effect of the transit time of the electrons forming the beam when subjected to deflecting voltages of very high frequency.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 30th September, 1938.

533 409.—Cathode-ray tube provided with an independent glass carrier, fused to the tube wall, for taking the fluorescent screen.

The Mullard Radio Valve Co. Convention date (Germany) 7th November, 1938.

533 636.—Method of gettering valves and electron-discharge tubes in the process of manufacture.

J. Fodor. Application date 17th July, 1939.

533 732.—Means for increasing the efficiency of secondary emission in an electron multiplier.

Standard Telephones and Cables (communicated by Le Matériel Téléphonique Soc. Anon.). Application date 17th November, 1939.

533 807.—Means for increasing the effective output, and particularly the secondary emission, from an electron multiplier.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 29th November, 1938.

534 154.—Cathode comprising a pure nickel core with an alkaline-earth coating designed to minimise " noise " for high-mu amplifiers.

Marconi's W.T. Co. (assignees of E. G. Widell). Convention date (U.S.A.) 27th August, 1938.

534 215.—Means for compensating for shifts in the cross-over point along the length of the electron beam in a cathode-ray tube.

O. Klemperer. Application date 28th July, 1939.

534 294.—Signal-recording valve with means for stabilising the negative feed-back over a wide range of frequencies.

Electrical Research Products Inc. Convention date (U.S.A.) 22nd November, 1938.

534 318.—Means for preventing undesired secondary emission in an electron-optical image-translating tube of the Iconoscope type.

Electrical Research Products Inc. Convention date (U.S.A.) 21st February, 1939.

SUBSIDIARY APPARATUS AND MATERIALS

533 010.—Light-beam signalling system in which a photo-electric cell and screen convert the signals into audible or visible form at the receiving end.

Igranic Electric Co. and C. E. Randall. Application date 30th June, 1939.

533 026.—Photo-electric apparatus for reading perforated-strip records as used for compiling accounts and statistics.

Deutsche Hollerith Maschinen Ges. m.b.h. Convention date (Germany) 3rd August, 1938.

533 092.—Discriminator circuit designed to give a direct indication of small differences between a datum frequency and another frequency to be measured.

Marconi's W.T. Co.; F. M. Wright; and H. J. Forster. Application date 5th October, 1939.

533 147.—Relaying or repeating system for telegraphic television, or facsimile signals transmitted by frequency modulation.

Marconi's W.T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.) 1st July, 1938.

533 204.—Composite piezo-electric crystal oscillator provided with loading means to give it substantially constant frequency-stability over a range of temperature variation.

Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.) 3rd November, 1938.

533 241.—Thermionic valve circuit arranged to exhibit negative transconductance, i.e. so that a rising potential on the control grid causes a decrease in the output current.

Marconi's W.T. Co. (assignees of E. W. Herold). Convention date (U.S.A.) 22nd October, 1938.

533 282.—Means including a harmonic-generator for measuring the phase shift or delay between two currents of the same frequency.

Standard Telephones and Cables (assignees of G. B. Engelhardt). Convention date (U.S.A.) 15th November, 1938.

533 286.—Method of producing a material having a high coefficient of secondary emission by heating magnesium, calcium, strontium or barium with oxygen, nitrogen or one of the halogens.

H. Rupp. Application date 7th June, 1939.

533 342.—Short-wave magnetron oscillator in which the cathode and anode are located in axial apertures in the control pole-piece.

British Thomson-Houston Co. Convention date (U.S.A.) 1st November, 1938.

533 635.—Time-delay circuit of the resistance-capacity type for controlling the operation of thermionic-valve relays and gas-filled discharge tubes.

Marconi's W.T. Co. and R. H. Burdick. Application date 12th July, 1939.

533 731.—Mounting a piezo-electric crystal so as to ensure a constant clamping pressure, even under conditions of shock.

Standard Telephones and Cables (assignees of W. L. Bond). Convention date (U.S.A.) 30th December, 1938.

533 784.—Valve cathode-coupling circuits giving phase and frequency control for tone-correction, or for use as a whistle filter, or other form of interference preventer.

Marconi's W.T. Co. and O. E. Keall. Application date 18th August, 1939.

533 925.—Mounting or terminal apparatus for a piezo-electric crystal relay.

Standard Telephones and Cables (assignees of T. G. Kinsley). Convention date (U.S.A.) 9th September, 1938.

533 939.—Impedance-matching arrangements for a transmission line between a generator of ultra-short waves and a modulator or amplifier.

The British Thomson-Houston Co. Convention date (U.S.A.) 1st November, 1938.

534 104.—Means for counteracting the effect of the input conductance of a valve amplifier on its transmission or translating characteristic when handling ultra-short waves.

Hazeltine Corpn. (assignees of R. L. Freeman). Convention date (U.S.A.) 12th January, 1939.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

PROPAGATION OF WAVES

2042. ON THE LIFE OF FREE ELECTRONS IN AFTER-GLOWING MERCURY VAPOUR [examined by Absorption Measurements on Centimetric Waves].—R. Grübling. (*Ann. der Physik*, 1st May 1940, Vol. 37, No. 5/6, pp. 453–469.)

Author's summary :—" The excitation of a Hertz oscillator by direct current is described [Fig. 1 : supply voltage was 16 kv. A vacuum bolometer was used for reception]. The decay of the absorption of 3 cm Hertzian waves in mercury plasma was measured after the disconnection of the exciting potential. The dependence on the pressure and on the current strength of the discharge was investigated. As a maximum, a 10% absorption was found 0.06 sec. after the switching-off of the discharge. By means of a rotating mirror the after-glow of the mercury vapour was photographed and a duration of 1/50th to 1/30th sec. was found. The influence of some added gases (argon, air) was examined. An attempt was made to deduce from the absorption measurements the decay of the electron density in the plasma, taking into account the diffusion and recombination losses."

2043. ABSORPTION MEASUREMENTS IN COLLOIDAL SOLUTIONS AND ELECTROLYTES IN THE WAVE-RANGE 10.5 TO 20 METRES.—J. Heffels. (*Ann. der Physik*, 10th June 1940, Vol. 37, No. 7, pp. 477–494.)

2044. THE CHEMICAL EXPLORATION OF THE STRATOSPHERE [by Sounding Balloons, up to over 30 km : Increase of He Content & Decrease of O_2 Content above 20 km, suggesting Absence of Wind].—F. A. Paneth. (*Chemistry & Industry*, 4th Jan. 1941, Vol. 60, No. 1, pp. 8–9.)

2045. DAYTIME PHOTOELECTRIC MEASUREMENT OF CLOUD HEIGHTS [including Detection of Dark Overcast Clouds at 9000 Feet].—M. K. Laufer & L. W. Foskett. (*Journ. of Res. of Nat. Bur. of Stds.*, April 1941, Vol. 26, No. 4, pp. 331–340.) *Cf.* 1560 of May.

2046. THE STATISTICAL METHOD IN PROPAGATION RESEARCH.—J. Grosskopf & K. Vogt. (*E.N.T.*, Jan./Feb. 1941, Vol. 18, No. 1/2, pp. 8–11.)

Authors' summary :—" The introduction of the statistical method is of great importance to wireless engineering. In the determination of the probability of success of a wireless link, in the investigation of the service area of a broadcasting station, in the testing-out of aerial installations (anti-fading systems), and in many other problems, the use of this method seems indispensable. Instead of long and at first sight unintelligible lengths of record strips, the [recurrence-] frequency counter here described yields, in a single curve or just a few, a clear picture of the propagation processes at the moment." As an example of the inconvenience of previous methods it is mentioned that Brown & Leitch's investigations of the fading characteristics of end-loaded aerials [2964 of 1937] involved the interpretation of about 350 metres of record strips.

The receiver is connected (Fig. 2) to a Neumann recorder (the reference here given is to a paper by von Braunmühl & Weber, 3944 of 1935) leading to a counting device. Fig. 3 shows how, in the Neumann recorder, the record tape is replaced by a " scanning plate," consisting of ten mutually insulated plates and corresponding in its total width to the " stroke " of the recording stylus. The ten contact plates can be switched to either of two groups *A* and *B*, each of ten " conversation meters " (counters used in the telephone service) : the closing of the current circuit from the batteries supplying these occurs on the one hand through a rotating interrupter and on the other through the recorder stylus. The counter mechanism thus measures the time that the stylus remains on a contact plate: the interrupter frequency is so chosen that even for the most rapid fading these times are correctly reproduced (an interrupter frequency of 7 c/s was found suitable for particular fading observations). The use of the two counter groups A and B makes it possible to obtain a series of measurements without any break. It is pointed out that since the counter shows the time during which the field strength remains between two given levels, the curve obtained from the series of figures from a counter group is the differential curve of the (recurrence-) frequency curve obtained by the usual methods: the latter can be obtained by a summation process. There would, naturally, be no difficulty in obtaining the (recurrence-) frequency curve directly.

Figs. 4, 5, and 8 show the frequency curves obtained for the field strengths from Breslau received on a frame aerial in Berlin during one day. Each curve represents an observation period of length from ½ to 1 hour. The method seems specially indispensable for investigations such as those carried out by the writers on polarisation and angle of arrival (1087 of April and 2047, below) and on direction-finding fluctuations, where it is in general necessary to record two or more magnitudes, such as amplitude and phase, simultaneously. In many cases a statistical method would offer the only hope of establishing relations between the various quantities. A multiple counter equipment for such purposes is being developed: it uses an optical commutator in the place of the mechanical arrangement, and has other novelties, including the addition of a counter which deals with field strengths attaining a determined value, and which thus provides the additional information of the recurrence-frequency of the fading. An example of the need for such a multiple equipment is shown in Fig. 8, which gives the frequency curves taken with the receiving frame successively oriented in the "maximum" and "minimum" positions. Such records, if taken simultaneously, would allow conclusions to be drawn as to the angles of arrival.

2047. Polarisation Measurements in the Short-Wave Range [Preliminary Communication].—J. Grosskopf & K. Vogt. (*T.F.T.*, Dec. 1940, Vol. 29, No. 12, pp. 360–363.)

In the course of the short-wave field-strength recordings reported in an earlier paper (Grosskopf, *ibid.*, Vol. 29, 1940, p. 127) certain fading phenomena were observed, at moments of layer break-up, which were closely connected with echo observations at zenithal reflection and which gave an unusually clear picture of the reflection processes. It was found that as the edge of the "dead zone" (skip region) passed over the receiving position an interruption of reception occurred in steps. The ordinary component first disappeared, the remaining extraordinary wave producing, in a vertical aerial, an e.m.f. of unusual constancy: then, a few minutes later, a beat-type "roughening" of the signals set in and became stronger and stronger until, after a last steep rise, reception disappeared except for that due to scattered radiation. The explanation of this phenomenon was given in the paper: the beat-type effect was attributed to interference between the distant and near radiations of the extra-ordinary component. "It is an obvious step to make use of these particularly simple propagation conditions, occurring during the fall of a layer, for measurements on polarisation and angle of arrival." Such measurements, on the polarisation, are reported in the present paper.

The method described dispenses with pulse transmitters and uses the short-wave signals from distant stations (Daventry, Moscow, and Rome) received on a horizontal crossed-dipole aerial. The phase difference of the voltages excited in the two dipoles is measured with the phase-metering apparatus dealt with in 2048, below. The amplitudes and the phase are continually recorded with the triple ink-writer described in a previous paper (1087 of April). Table 1 shows the observed polarisation phases r' and amplitude-ratios E_1/E_2 for the three stations. "The polarisation was in all cases right-handed and showed a very marked dependence on direction. The polarisation phase was greatest for Daventry, least for Moscow, and intermediate for Rome. The table shows the effect of the height of the crossed-dipoles above ground on the r' value, for a change from 3 m to 10 m. This change reduced the r' value by about 15–20°, which agrees well with results calculated for the ground conditions obtaining." The correction for the influence of the ground, calculated for a height of 10 m, is -11, -13.5, and -15 degrees for 20, 25, and 30 m waves respectively. This correction has been applied in the table to the readings at 10 m height, giving the values for r (corrected polarisation phase) shown in the column "$r°$". These values "show a strong dependence on the direction of propagation [Moscow, $r = 10–28°$; Daventry, 92–102°, and 87° on a longer wave; Rome, 55°, and 47° on a longer wave]. This result cannot be explained on existing theory. According to that, in the northern hemisphere the polarisation should be right-handed ($r = 90°$) for practically all directions of propagation, the largest angle being at any rate that in the south/north direction. An explanation of this point requires further investigation. A frequency-dependence of the polarisation-phase seems to be indicated (over the range 9.7–15.3 Mc/s) by the admittedly scanty measurements shown in table 1. The estimated ratio E_1/E_2 yields an angle of arrival about what would be expected. A later paper will deal with the measurement of these angles, for the same stations, from which it will be seen that the layer-drop phenomena under investigation occur at the F layer. A comparison between Figs. 5, a Moscow record showing the onset of the phenomena, and Fig. 6, the amplitude and phase curves calculated for the interference of two waves, "shows that it is obviously a matter of the interference of two elliptically polarised components with opposite directions of rotation": such discrepancies as there are between the two figures are due to the fact that the phase-metering apparatus does not function correctly below a certain threshold value.

2048. A Recording Phase-Meter for Reception Observations in the Short, Medium, and Long Wave Ranges.—J. Grosskopf. (*T.F.T.*, Nov. 1940, Vol. 29, No. 11, pp. 334–339.)

Description of the apparatus used in the researches dealt with in 1087 of April and 2047, above. Both the first and second types of phase-meter (Figs. 7 and 9) mentioned in the former abstract are here included. A long section deals with the heterodyne generator (common to the two separate receivers) which produces an i.f. of 1000 c/s and which must have its own frequency very accurately stabilised over the whole long range of received wavelengths, where quartz stabilisation cannot be used. The method adopted is that employed in automatic tuning correction in modern receivers.

2049. A NOTE ON IONISATION BY METEORS [South African Data: Coincidences between Observed Meteors & Appearance of Ionised Regions (Heights 100–340 km): Technique useful in studying Diffusion & Recombination, and in counting Meteors].—J. A. Pierce. (*Phys. Review*, 15th April 1941, Vol. 59, No. 8, pp. 625–626.)

"The density of ionisation decreases because of diffusion and recombination. In the case of a large meteor the density might, after a time, become nearly uniform over an area many wavelengths in diameter. In this event the rate of change of the max. density of ionisation would not be greatly affected by diffusion, so that it might be used as a measure of the recombination coefficient". On the other hand, the numerical results from a meteor which left only a short record at 6.4 Mc/s lead to the conclusion that in its case diffusion was an important factor.

2050. ON THE DAILY COURSE OF THE MAXIMUM ELECTRON CONCENTRATION IN THE F_2 LAYER OF THE IONOSPHERE.—R. Hechtel. (*Hochf:tech. u. Elek:akus.*, April 1941, Vol. 57, No. 4, pp. 108–111.)

Whereas the E_1 and F_1 layers follow fairly exactly, in the daily and yearly courses of their electron concentration, the situation of the sun as demanded by Chapman's theory (1931 Abstracts, p. 202), the F_2 layer shows a very different behaviour. In the daily characteristic, instead of a single maximum, at mid-day, there appear two, the second of which in certain circumstances may distinctly surpass the first in amplitude and may occur in the evening hours. "This behaviour is generally explained as the result of an expansion of the atmosphere due to heating by the sun's radiation, followed by a contraction on cooling (Appleton & Naismith, 3304 of 1935). The action of the expansion is a double one: first, the number of electrons already present in a unit of volume is reduced, and secondly, the electron production per unit volume is diminished owing to the decreased density of the atmosphere. In the following work it is examined whether it is possible to explain quantitatively the daily course of max. electron concentration by a suitably selected temperature characteristic. For this purpose we calculate the particular variation of temperature with the time of day which would be necessary to produce, for a certain electron-production characteristic, the variation actually observed in the electron concentration".

The following assumptions are made: (1) Ions and neutral atoms and molecules possess the same temperature T and are subject to the same temperature variations. The temperature in the particular height-region where the max. electron concentration is moving is independent of height. (2) The temperature T_e of the electrons need not, owing to the small number of collisions occurring in the F_2 layer, coincide with T. Two cases are therefore distinguished: (a) T_e = const. (valid for a very small number of collisions) and (b) $T_e = T$ (valid for a larger number of collisions). (3) The electron gas follows the volume changes of the ion and atom or molecule gas *independently* of its temperature, owing to the electrical forces which would occur at a separation of electrons and ions. The electron gas consequently undergoes in certain conditions (when the number of collisions is very small) a change in its partial pressure, which however owing to its smallness is without effect on the total pressure. The electron concentration n is thus, other conditions remaining constant, proportional to the density of the gas and consequently inversely proportional to the volume.

The following conclusions are reached:—"A temperature maximum occurs in the early hours of afternoon, and a minimum at sunrise. The ratio of the maximum temperature to the minimum is dependent on the value of the recombination coefficient, and in summer amounts to at least 4.5 : 1. It is shown that the recombination coefficient and the ion production cannot be determined definitely from the daily course of the electron concentration: only a *lower limit* for each can thus be derived. The value of the recombination coefficient α [Milne, *Phil. Mag.*, Vol. 47, 1924], if the electron temperature is taken as constant, is at least 0.8×10^{-10}; if the electron temperature is taken as equal to that of the gas, α lies between 0.4×10^{-10} and 0.9×10^{-10} ["values of 1.5×10^{-10} or over are extremely improbable on account of the great temperature change ($T_{max.}/T_{min.} \geq 27$ —*see* Fig. 2) which they would imply"]. In both cases the mid-day ion production amounts to at least 60 ions (or electrons) per cm³ and sec." These results are based on the Herzogstand observations (July 1939) shown in the curves of Fig. 2, for all of which the abscissae are the hours of the day and night: the top curve shows the course of the critical frequency for the ordinary component, the second shows the electron concentration calculated from this, the next represents the function $\cos \chi$ (χ being the sun's zenith distance), while the next three curves represent the ratio T/T_0 for three different fixed values of α, and the bottom curve the same for an α varying with $\sqrt{T_0/T}$.

2051. MAGNETIC DISTURBANCES AND REGION F_2 OF THE IONOSPHERE.—J. Bannon, A. J. Higgs, & G. H. Munro. (*Terr. Mag. & Atmos. Elec.*, March 1941, Vol. 46, No. 1, pp. 61–69.)

Further development of the work dealt with in 2142 of 1940. It is concluded that: (1) when a magnetic disturbance occurs during *frontal* conditions the incoming radiation (particle or otherwise) tends to increase any difference in ionisation already existing in region F_2 above Liverpool and Mount Strombo: (2) the **D** current-system is located for the most part in region F_2 of the ionosphere: (3) when a magnetic disturbance occurs with *frontal* conditions prevailing, the **D** current-system, owing to the variations in the gases in region F_2, is subjected to many changes, and as a consequence the disturbance tends to become intensified.

2052. FLOW OF ELECTRIC CURRENTS IN THE ATMOSPHERE [Present Indications that Max. Current Flow is at 70–80 km: Increase of about 300% in Electrified-Particle Density in F_2, of 50% in E & F_1, between Min. & Max. Sunspot Periods].—Carnegie Institution. (*Science*, 28th March 1941, Vol. 93, Supp. p. 8.) For other recent work of the Institution *see* 1599 of June.

2053. THE GEOMAGNETIC RING-CURRENT: I—ITS RADIAL STABILITY [and the Period of Radial Oscillations: Possible Cause of World-Wide Magnetic-Field Fluctuations during Magnetic Storms: etc.].—S. Chapman & V. C. A. Ferraro. (*Terr. Mag. & Atmos. Elec.*, March 1941, Vol. 46, No. 1, pp. 1–6.)

2054. ELECTRICAL WORKS BY HELIOS, OR THE SUN AND THE IONOSPHERE [Kelvin Lecture].—S. Chapman. (*Electrician*, 16th May 1941, Vol. 126, pp. 285–286: summary only.)

2055. PROBLEMS OF THE MOTIONS OF SOLAR PROMINENCES [Short Survey].—M. A. Ellison. (*Nature*, 31st May 1941, Vol. 147, pp. 662–664.)

2056. A PREFACE TO SOLAR RESEARCH [Outstanding Problems: the New Data needed, & How these may be Obtained].—D. H. Menzel. (*Scient. Monthly*, April 1941, Vol. 52, No. 4, pp. 320–336.)

2057. A PERSISTENT SOLAR-ROTATION PERIOD OF 27.26 DAYS [in Spite of Gaseous Outer Parts rotating at Different Speeds in Different Latitudes: Probability of Period of Free Swing in Solar Atmosphere: etc.].—H. H. Clayton. (*Terr. Mag. & Atmos. Elec.*, March 1941, Vol. 46, No. 1, pp. 71–77.)

"The large amplitudes shown by the 27.26-day period at the time of sunspot-maximum in the 11-year period might be explained by the greater solar activity at that time, or on the other hand the larger oscillation of the 27.26 days might be the cause of the greater solar activity. If this latter conclusion is a fact it has a profound meaning, is deserving of thorough investigation, and should facilitate the forecasting of solar activity."

2058. SUMMARY OF THE YEAR'S WORK, DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON.—J. A. Fleming. (*Terr. Mag. & Atmos. Elec.*, March 1941, Vol. 46, No. 1, pp. 43–50.)

2059. ON THE ANALYSIS OF SURFACE MAGNETIC FIELDS BY INTEGRALS: PART I [applicable to Complicated Fields of Magnetic Storms & Magnetic Geophysical Prospecting].—E. H. Vestine. (*Terr. Mag. & Atmos. Elec.*, March 1941, Vol. 46, No. 1, pp. 27–41.)

2060. THE SEVERE MAGNETIC STORM OF MARCH 1ST, 1941 [Alibag Observations], *and* THE MAGNETIC ACTIVITY OF THE YEARS 1939 AND 1940.—M. R. Rangaswami. (*Current Science*, Bangalore, March 1941, Vol. 10, No. 3, pp. 132–133: pp. 153–155.)

2061. COSMIC RADIATION AND MAGNETIC STORMS [1936/39: Average Course of Cosmic-Ray Disturbance bears Broad Resemblance to Course of Magnetic Storm: Disturbance usually apparent a Few Hours after Onset of Storm: etc.].—A. R. Hogg. (*Terr. Mag. & Atmos. Elec.*, March 1941, Vol. 46, No. 1, pp. 51–58.)

2062. GEOMAGNETIC CHARACTER AND COSMIC-RAY INTENSITY PULSES, *and* COSMIC-RAY INTENSITIES AND TYPHOONS.—J. W. Broxon: Nishina & others. (*Phys. Review*, 15th April 1941, Vol. 59, No. 8, pp. 678–679: p. 679.)

2063. EFFECT OF AN ECLIPSE ON COSMIC RAYS [hitherto sought without Success: observed at Sao Paulo].—A. H. Compton. (*Phys. Review*, 1st Nov. 1940, Vol. 58, No. 9, p. 841.) A note reporting news cabled by Wataghin.

2064. THE SUN'S MAGNETIC FIELD AND THE DIURNAL AND SEASONAL VARIATIONS IN COSMIC-RAY INTENSITY.—L. Jánossy & P. Lockett. (*Proc. Roy. Soc.*, Ser. A, 9th May 1941, Vol. 178, No. 972, pp. 52–60.)

2065. A HYPOTHESIS AS TO THE ORIGIN OF COSMIC RAYS AND THE EXPERIMENTAL TESTING OF IT IN INDIA AND ELSEWHERE.—R. A. Millikan, H. V. Neher, & W. H. Pickering. (*Science*, 9th May 1941, Vol. 93, pp. 433–434.) Summary of Nat. Ac. of Sci. lecture.

2066. NUCLEUS DESTRUCTION AND HEAVY PARTICLES IN THE COSMIC RADIATION.—E. Bagge. (*Naturwiss.*, 23rd May 1941, Vol. 29, No. 21, p. 318.)

2067. PROTONS AS PRIMARY COSMIC RAYS.—A. H. Compton & M. Schein. (*Science*, 9th May 1941, Vol. 93, p. 436.) Summary of Nat. Ac. of Sci. paper.

2068. THE ENERGY DISTRIBUTION AND COMPOSITION OF THE PRIMARY COSMIC-RAY PARTICLES.—N. Hilberry. (*Phys. Review*, 1st May 1941, Vol. 59, No. 9, pp. 763–764.)

"The fact that an energy distribution determined in this energy range [above 5×10^{13} ev] is capable of giving quantitative agreement with observations depending on primaries with energies of 10^{10} ev indicates that there is but one kind of primary cosmic-ray particle in any significant number. The experiments of Schein, Jesse, & Wollan just reported agree with this conclusion and show that this source is most probably the proton." *See* also Swann, *ibid.*, pp. 770–771.

2069. ON THE PRODUCTION OF SECONDARY IONISING PARTICLES BY NON-IONISING AGENTS IN COSMIC RADIATION, *and* PRODUCTION OF MESOTRONS BY PENETRATING NON-IONISING RAYS.—Rossi & others. (*Phys. Review*, 1st Nov. 1940, Vol. 58, No. 9, pp. 761–766: pp. 837–838.)

2070. NEUTRAL MESOTRONS IN THE COSMIC RADIATION?—Y. Nishina & K. Birus. (*Naturwiss.*, 13th Dec. 1940, Vol. 28, No. 50, pp. 779–780.)

2071. THE MEAN LIFETIME OF THE MESOTRON FROM ELECTROSCOPE DATA, *and* NOTE ON THE NEHER-STEVER EXPERIMENT.—Neher & Stever: Nelson. (*Phys. Review*, 1st Nov. 1940, Vol. 58, No. 9, pp. 766–770: pp. 771–773.)

2072. COSMIC RAYS: RECENT DEVELOPMENTS [Guthrie Lecture].—P. M. S. Blackett. (*Proc. Phys. Soc.*, 1st May 1941, Vol. 53, Part 3, pp. 203–213.)

2073. "TRANSACTIONS OF WASHINGTON MEETING, SEPTEMBER 4–15, 1939: BULLETIN NO. 11" [Book Review].—Int. Union of Geodesy & Geophysics. (*Terr. Mag. & Atmos. Elec.*, March 1941, Vol. 46, No. 1, pp. 127–128.) A number of papers from this volume were dealt with in the June "Abstracts & References."

2074. ON THE SCATTERING OF RADIATION AT THE EARTH'S SURFACE IN THE NEIGHBOURHOOD OF BROADCASTING TRANSMITTERS [Comparison with the Phenomena in a H.F. Cable with Irregularities: Effects of Hills, Woods, etc.].—W. Gerber & A. Werthmüller. (*Hochf:tech. u. Elek:akus.*, March 1941, Vol. 57, No. 3, pp. 93–94: summary of Swiss P.O. Report).

The interference between the direct ground wave and scattered rays in mountainous country like Switzerland is shown by the difference in the behaviour of a straight-wire receiving aerial and a loop antenna. Thus in Fig. 1 (reception of the 443 m Sottens wave in the Lauterbrunnen valley) the aerial curve (E_L) and the loop curve (E_R) for distances between 0 and 1000 m from the station are superposed: "the appearance of maxima and minima of the electric and magnetic field strengths and the different situations of these is clearly seen and shows the presence of interference and the formation of standing waves. But inhomogeneities in the vegetation also produce scattered radiation: approximate formulae are calculated for an idealised wood of length l and width b. The writers have measured the currents induced by the primary wave $\mathfrak{E}_P$ in tree trunks, and find from statistical measurements in woods near Bern in winter, for medium waves, the empirical formula $I_B \approx \mathfrak{E}_P/3000$; or, for a wood area of F square metres of trees with an average height of 15 m and a distribution density of n = 0.05 to 0.06 per sq. m, electric-field strengths of "Rückfluss" (backward component of scattering) of about $b\mathfrak{E}_P/60D \cdot \sin 2\pi l/\lambda$ and of "Mitfluss" (forward component) of about $F\mathfrak{E}_P/10\lambda D$, where D is the distance measured from the middle of the wood.

A field-strength profile in a vertical plane, obtained by aeroplane measurements, is seen in Fig. 3 for the Beromünster station (540 m): the maxima visible at I, II, & III are the effects of scattered radiation from a long mountain ridge (*see* Fig. 4). The final equation represents the vertical radiation characteristic resulting from a strip of forest.

2075. EQUATIONS OF THE INCIDENT AND REFLECTED WAVES IN NON-UNIFORM LINES IN THE STATIONARY RÉGIME.—G. Zin. (*Alta Frequenza*, March 1941, Vol. 10, No. 3, pp. 149–178.)

Author's summary:—"The theory of reflection is extended to the most general type of inhomogeneous line in the stationary régime, two fundamental systems of differential equations being determined for the voltage and current waves, incident and reflected. From these it is possible to obtain a whole series of equations which allows an easy study of special types of line. As an example of application, the behaviour of a quasi-uniform line in the stationary state is investigated. The system of differential equations with which the treatment started allows a simple method of successive approximation to be applied. From the interpretation of the results it is seen that the different orders of the successive approximations correspond to the different orders of multiple reflections. The method is valid [not only for a quasi-uniform line but] also for any non-uniform line, and is applied, as an example, to an exponential line. Finally, the conditions are pointed out which are necessary for the validity of the formulae used by other writers in the study of the effect of line irregularities.

"The work may be considered to be the approximate integration of the telegraphist's equations for non-uniform lines in the stationary régime, effected by means of the translation of the concept of reflection into mathematical equations."

2076. THE TRANSIENT ELECTROMAGNETIC PROCESSES IN A LINE DURING DUPLEX TRANSMISSION OF SIGNALS, *and* DURING THE TRANSMISSION OF INTERRUPTED CURRENTS.—V. I. Kovalenkov. (*Automatics & Telemechanics* [in Russia], No. 3, 1940, pp. 7–18: No. 4, 1940, pp. 23–40.)

(1) Using formulae derived in a previous paper (1836 of July) tables are compiled and graphs drawn showing the distribution of voltages and currents during duplex telegraph transmission along a single iron-wire line 300 km long and 5 mm in diameter. The batteries at the ends of the wire are assumed to be switched on simultaneously and the cases when the two batteries are (a) opposing and (b) aiding each other (Figs. 3 and 7 respectively) are considered separately. A general discussion of the case when the two batteries are not switched on simultaneously is also given. (2) The transmission of single (Fig. 13) and double (Fig. 14) current impulses is considered separately, and the current and voltage distribution on the line is investigated both by determining the integration constants and by the superposition of curves.

2077. REMARK ON THE THEORY OF THE PASSAGE OF LIGHT THROUGH INHOMOGENEOUS TRANSPARENT LAYERS [Bauer's Approximate Formula for Reflecting Power obtained by Simple Treatment: etc.].—H. Schröder. (*Ann. der Physik*, 13th Jan. 1941, Vol. 39, No. 1, pp. 55–58.)

"A similar result can be derived from a paper by Thomas & Colwell [1305 of 1940] for the special case where the refraction index of the transition layer is only slightly greater than unity, as in the reflection of radio waves at various air masses in the troposphere".

2078. OPTICAL INVESTIGATIONS IN A SPECIAL INHOMOGENEOUS MEDIUM [Propagation of Light in a Medium whose Refractive Index is Constant in Parallel Planes and follows a Linear Law of Variation].—E. von Heydebrand und der Lasa. (*Ann. der Physik*, 5th July 1940, Vol. 37, No. 8, pp. 589–627.)

2079. ON THE DIFFRACTION OF ELECTROMAGNETIC WAVES AT A HALF PLANE.—W. Magnus. (*Zeitschr. f. Phys.*, 20th Jan. 1941, Vol. 117, No. 3/4, pp. 168–179.)

In 1891 Poincaré suggested the treatment of the diffraction of electromagnetic waves at completely conducting surfaces by the calculation of the currents flowing on the surfaces. This means that the diffracting surface would be replaced by a surface covered with Hertz dipoles with their axes tangential to the surface. This proposal seems however to have been carried no further: at any rate the strict solutions of the diffraction problem hitherto known have been by other methods. The Poincaré method has certain disadvantages, but it has also the advantages that the radiation condition presents no difficulty and that the case where the diffracting surface possesses edges or is an "open fragment" of surface can readily be included.

"The present paper deals with the integral equation to which the Poincaré treatment leads (if the problem is limited to the two-dimensional case) for the diffraction of a plane wave at a half plane. The resulting example of a non-trivial but explicitly solvable system of infinitely many equations with an infinite number of unknowns (formulae 14 & 16) may claim some interest. The visible lighting of the diffracting edge is directly understandable from the calculated distribution of the currents on the half plane. A simple expression for the current distribution is given in formula 23". The transformation to the Sommerfeld formulae is dealt with in a final section.

2080. THE THEORY OF ANOMALOUS DIFFRACTION GRATINGS AND OF QUASI-STATIONARY WAVES ON METALLIC SURFACES (SOMMERFELD'S WAVES) [Physical Meaning of Wood's Anomalous Diffraction Gratings: Connection with Wireless Ground Waves: etc.].—U. Fano. (*Journ. Opt. Soc. Am.*, March 1941, Vol. 31, No. 3, pp. 213–222.)

2081. FINAL MEASUREMENTS OF THE VELOCITY OF LIGHT [including Correction Factor for Group Velocity: Electron Transit Time as Limiting Factor of Method].—W. C. Anderson. (*Journ. Opt. Soc. Am.*, March 1941, Vol. 31, No. 3, pp. 187–197.)

2082. A PLUTONIC PHASE IN SEISMIC PROSPECTING [Phase *pP* observed].—L. D. Leet. (*Nature*, 24th May 1941, Vol. 147, pp. 645–646: summary only.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2083. MEASURED LIGHTNING CURRENTS THROUGH DISTRIBUTION ARRESTERS ON 4800-VOLT RURAL CIRCUITS.—W. R. Wilbur & W. A. McMorris. (*Gen. Elec. Review*, March 1941, Vol. 44, No. 3, pp. 159–165.)

2084. SURGE CHARACTERISTICS OF A BURIED BARE WIRE.—E. D. Sunde. (*Bell Tel. System Tech. Pub.*, Monograph B-1279, 10 pp.) A summary was referred to in 309 of February.

2085. AVALANCHE PRODUCTS, THE LOWERING OF THE BREAKDOWN POTENTIAL, AND THE FALLING CHARACTERISTIC [Survey of Latest Researches on the Mechanism of Irradiated Discharges], *and* ON THE BUILDING-UP OF GASEOUS DISCHARGES.—Rogowski: Raether. (*Zeitschr. f. Phys.*, 20th Jan. 1941, Vol. 117, No. 3/4, pp. 265–284: 26th March & 30th April 1941, Vol. 117, Nos. 5/6 & 7/8, pp. 375–398 & 524–542.)

2086. ON THE BASIC PROBLEM OF ATMOSPHERIC ELECTRICITY [and Aurora].—G. Michel. (*Zeitschr. f. Phys.*, 20th Jan. 1941, Vol. 117, No. 3/4, pp. 205–212.)

"The earth forms a Faraday unipolar d.c. generator. This generator supplies a spherical condenser, whose electrodes are formed by the conducting earth and the stratosphere, and whose imperfect dielectric is the troposphere. The conductive-loss current of this condenser is the atmospheric electric current. Auroras are equilibrating phenomena at the positive poles of this generator. A qualitative interpretation is given for the vector diagram of the horizontal variations of the earth current as measured on the Berlin/Dresden and Berlin/Thorn telegraph cables." The above mechanism for the aurora has the advantage, over Störmer's theory, that it does not require electrons having a velocity approximating to that of light. "Since electrons of such a high velocity are extremely improbable, this point forms a great difficulty in the ruling theory of aurora."

2087. DEPOSITION OF ATMOSPHERIC RADIOACTIVITY ON OBJECTS EXPOSED TO AIR STREAMS.—Freed & Schultz. (*Journ. Franklin Inst.*, April 1941, Vol. 231, No. 4, pp. 345–355.)

2088. SUMMARY OF THE YEAR'S WORK, DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON.—J. A. Fleming. (*Terr. Mag. & Atmos. Elec.*, March 1941, Vol. 46, No. 1, pp. 43–50.)

2089. IMPROVED TYPE OF RADIOSONDE [used by Italian Meteorological Service: reporting Temperature, Pressure, & Moisture: Range up to 125 miles].—(*Inter Avia*, 19th Sept. 1940, No. 728, p. 4.)

2090. A REGULATED BATTERY-OPERATED HIGH-VOLTAGE SUPPLY [with Constancy sufficient for Accurate Geiger-Counter Measurements: primarily for Radiosondes], *and* A LIGHT-WEIGHT, HIGH-VOLTAGE SUPPLY FOR GEIGER COUNTERS.—Barry: Neher & Pickering. (*Review Scient. Instr.*, March 1941, Vol. 12, No. 3, pp. 136–139: pp. 140–142.) The first device is developed from Huntoon's circuit (3772 of 1939), the second employs a buzzer.

PROPERTIES OF CIRCUITS

2091. COUPLED NETWORKS [Open-Wire Lines] IN RADIO-FREQUENCY CIRCUITS.—Alford. (*See* 2118.)

2092. DISTRIBUTED CAPACITANCE AND RADIATING PROPERTIES OF COILS.—Sacco. (*See* 2119.)

2093. Theory of the General Alternating Current Network [of Linear Conductors possessing Resistance, Capacitance, & Self-Inductance, with Mutual Inductance between Conductors]: Part I—Solution of the General Alternating Current Network.—S. Noda. (*Memoirs of Ryojun Coll. of Eng.*, No. 6, Vol. 13, 1940, pp. 289–305: in English.)

2094. A New Classification of Chain Filter Circuits.—V. N. Listov. (*Automatics & Telemechanics* [in Russian], No. 3, 1940, pp. 19–26.)

The reduction of chain filters to equivalent bridge filters is discussed, and on the basis of the classification of the latter type proposed in a previous paper (1848 of July) tables I, II, and III are prepared in which band-pass, l.f. and h.f. chain filters are classified in accordance with the type of impedance presented and the variation of attenuation with frequency. From these tables the most suitable circuit can be selected to meet any specific requirements.

2095. Two Methods for designing Electrical Filters.—V. N. Listov. (*Automatics & Telemechanics* [in Russian], No. 3, 1940, pp. 27–32.)

A comparison is made between the methods proposed by Cauer (filter is split into two symmetrical parts; Fig. 1) and Zobel (filter is split into a number of separate elements; Figs. 3 and 4), and types of filter are indicated for which one or the other of the two methods should preferably be used.

2096. The Shea-Norton Transformations and their Significance in Filter Design.—V. N. Listov. (*Automatics & Telemechanics* [in Russian], No. 6, 1940, pp. 25–35.)

The following two transformations proposed by Shea and Norton are considered:—(1) an ideal transformer (*i.e.* a transformer without losses) with an impedance connected across one of the windings can be replaced by a "T" section (Fig. 1), and (2) an ideal transformer with an impedance in series with one of the windings can be replaced by a "pi" section (Fig. 2). A proof of these two transformations is given and their application is discussed for the following purposes: (1) operation of a filter between two unequal loads without the use of a matching transformer; (2) design of a filter with predetermined equal inductances and capacities; (3) elimination of undesirable components from the circuit; (4) design of complicated circuits, and (5) derivation of equivalent chain and bridge filters. The references given are E. L. Norton, Patent 1 681 554 of 21st Aug. 1928 (Transformer Band Filters), and T. E. Shea, "Transmission Networks and Wave Filters" (presumably a book).

2097. The Optimum Damping of Coils with Compressed-Powder Cores.—J. Labus. (*Hochf:tech. u. Elek:akus.*, April 1941, Vol. 57, No. 4, pp. 112–114.)

In the expression for the quality factor of such coils, $Q = \omega L/R_{eff}$, the effective series resistance R_{eff} is made up of the d.c. resistance of the winding, the additional resistances due to skin effect and the self-capacity of the coil, and finally the loss-resistance of the core itself. Kersten has already given extensive literature references to investigations into the nature and frequency-dependence of these components of the effective resistance, in his own paper on the subject (496 of 1938).

If the quality factor of a given coil is plotted against frequency, an optimum value for Q appears at a certain frequency. "It will be shown that on certain assumptions this max. value can be calculated beforehand in a simple manner. The relation found is notable in that it contains only the core data and the frequency. The coils considered are compressed-powder-core coils in which the effect of the winding capacity is negligibly small, so that the coils are worked below their resonance frequency. Further, conditions are assumed such that the core hysteresis losses are negligible compared with the eddy-current losses. This condition is generally fulfilled in the field of application now considered" [a.f. technique and carrier-current telephony].

Use is made of some of the results obtained by Kersten (*loc. cit.*) and the final formula arrived at, eqn. 8c, is $Q_{opt} = 1000\pi / \{\omega f \cdot 10^{-3} + n + 2\pi\delta(f/f_o)^2\}$, where w is the eddy-current coefficient (eddy-current loss resistance $R_w = w.L.(f/1000)^2 = 4\pi\mu k\omega^2 L$—*see* footnote 4, where the μ from eqn. 7 seems to have been omitted—so that $w = 16\pi^3\mu k \cdot 10^6$), f is the working frequency, n is a constant representing magnetic viscosity (after-effect), δ is the loss angle of the insulation of the winding (about the inclusion of these resistance components *see* r-h col. of p. 113), and f_o is the natural frequency of the winding. For $n = \delta = 0$, the above expression for Q_{opt} becomes that of eqn. 8b, namely $Q_{opt}.f = \pi.10^6/w$. The full expression differs from that of eqn. 8b also by including a certain influence on the part of the shape of the winding, since this affects the natural frequency f_o of the coil. As already mentioned, when low-loss dielectrics are employed the effect of the dielectric losses is negligible, and Q_{opt} can again be calculated from the data of the core material, namely the eddy-current coefficient k and the magnetic viscosity coefficient n: the formula then becomes $Q_{opt} = 1000\pi/(wf.10^{-3} + n)$, by omitting, in the full equation, the denominator term involving δ.

2098. On a Bridge-Type Direct-Current Amplifier.—L. Sponzilli. (*Alta Frequenza*, July 1940, Vol. 9, No. 7, pp. 423–425.)

Extension of the work dealt with in 1792 of 1940 to cover the use of a tetrode in place of the triode. Some advantage in sensitivity is thus obtained, but only if the resistance of the indicating instrument is very low compared with the other bridge resistances.

2099. The Cathode Follower [Formula for Its Impedance].—Good: Turney. (*Wireless World*, June 1941, Vol. 47, No. 6, pp. 166–167.) Disagreement with formula given by Turney (1729 of June).

TRANSMISSION

2100. Special Phenomena in Certain Triode Oscillators [with Grid insulated and coupled to Plate by Air Condenser: Super-Regenerative Action & Shock Excitation of

Very High Frequencies leading to a Combined Transmitter-Receiver for 2.5 m Waves, used for Remote Control over 17 km].—H. Copin. (*Ann. Guébhard-Séverine*, Neuchâtel, 1938/39, 14th/15th Years, pub. 1940, pp. 233–235.)

It is stated that with this circuit a triode type E4, designed for waves above 10 m, will give "frequencies around 300 Mc/s with an anode power reaching a hundred watts." For other work, on the action of a magnetic field on u.s.w. oscillators, *see* 1373 of 1940.

2101. Push-Pull Arrangement for the Amplification and/or Frequency Multiplication of Ultra-Short Waves [Stable Circuit with Axes of Electrode Systems parallel, and Anodes connected by One U-Shaped Tube (Output Circuit), Control Grids by Another (Input Circuit), Screen Grids & Cathodes by Parallel Bands forming Bridging Condenser].—K. Fritz. (*Hochf: tech. u. Elek:akus.*, March 1941, Vol. 57, No. 3, p. 94.) Telefunken Pat. DRP 679 574.

2102. Modulated Functions.—G. Cocci & R. Sartori. (*Alta Frequenza*, Feb. 1941, Vol. 10, No. 2, pp. 67–98.)

Authors' summary:—"A function of time $f(t)$ can be represented in an infinite number of modes in the form $f(t) = A(t) . \cos[\phi(t)]$. By applying the rotating-vector method of representation, generalised by the use of the Fourier integral, to the function $f(t)$, this form can be rendered unequivocal, so as to bring into evidence special well-defined properties of the function in question. The fundamental properties of the representation thus established are studied.

"When the Fourier spectrum of the function $f(t)$ is limited to the neighbourhood of a given angular frequency Ω_0, the function can be written $f(t) = A(t).\cos[\Omega_0 t + \phi_1(t)]$, and $A(t)$ and $\phi_1(t)$ can be interpreted directly as the amplitude and phase modulations of a sinusoidal function. In this way the general definition of modulated sinusoidal functions is related to the limitation of their frequency spectrum. On the basis of this criterion some special cases are studied, such as the suppression of a sideband, the suppression of the carrier, and the like [mixing and frequency conversion].

"In the case of non-sinusoidal modulated functions, their frequency spectrum has appreciable values only in the neighbourhood of the fundamental and of its harmonics, so that the above criterion can be applied more generally to this case. As applications, a theory is outlined of detectors and frequency changers for signals with amplitude and phase modulation."

2103. Oscillations in a Coupled Two-Oscillator Circuit System, especially for the Push-Pull Oscillator [Two Possible Modes, only the One which builds up More Rapidly appearing as Stable Oscillation: Frequency & Phase Relations controlled by Mutual Coupling Coefficient: Push-Pull & Parallel Oscillations both Possible: etc.].—I. Takao. (*Memoirs of Ryojun Coll. of Eng.*, No. 5, Vol. 13, 1940, p. 5: summary only.)

2104. Phase-Shift Oscillators [Resistance-Capacity-Tuned, with Single Valve (in Simplest Form), for Audio Frequencies].—Ginzton & Hollingsworth. (*See* 2161.)

RECEPTION

2105. Reducing Loading on Short [and Ultra-Short] Waves: Offsetting the Effect of Cathode-Lead Inductance.—R.C.A. Laboratories. (*Wireless World*, June 1941, Vol. 47, No. 6, pp. 159–160.)

2106. Circuit Differences between Amplitude- and Frequency-Modulation Receivers [including Pre-Emphasis & Its Compensation, "Side-Circuit" Types of Detectors, & Automatic Volume Control suitable for Frequency Modulation].—M. Hobbs. (*Proc. I.R.E.*, Feb. 1941, Vol. 29, No. 2, p. 84: summary only.) For a previous paper *see* 4252 of 1940.

2107. Noise in Frequency-Modulation Receivers: Further Light on the Behaviour of Discriminator and Limiter Circuits.—V. D. Landon. (*Wireless World*, June 1941, Vol. 47, No. 6, pp. 156–158.) From the paper dealt with in 1878 of July.

2108. Paper on Noise Crest Factors, including Effect of Amplifier Band Width [*e.g.* in Frequency-Modulation Receivers].—Landon: Plump. (*See* 2129, below.) The apparent variation in crest factor shown by Plump (491 of 1939), in his paper on interference reduction by frequency modulation, may perhaps be accounted for on these lines.

2109. Noise in Receiving Aerial Systems [and the Question of the Validity of Nyquist's Theorem for Radiation Resistance].—Burgess. (*See* 2122.)

2110. The Spraying of High-Tension Insulators in Service.—Estorff. (*Zeitschr. V.D.I.*, 26th April 1941, Vol. 85, No. 17, pp. 401–402.) For previous work *see* 370 of February.

2111. Vibrator Power Packs: a New Development in Smoothing for Use with Sensitive Receivers.—Masteradio, Ltd. (*Wireless World*, June 1941, Vol. 47, No. 6, p. 167.)

2112. An Oscillographic Equipment for observing Frequency-Response Curves of Radio Receivers [of Special Type for Reception of Very Short R.F. Pulses, and having Uniform Response to Modulation Frequencies 0–200 kc/s].—L. U. Hibbard. (*Journ. Inst. Eng. Australia*, March 1941, Vol. 13, No. 3, p. 80: summary only.)

2113. Making the Most of Short Waves: Improving the All-Wave Receiver.—L. A. Moxon. (*Wireless World*, June & July 1941, Vol. 47, Nos. 6 & 7, pp. 148–151 & 180–182.) From the Murphy laboratories.

2114. Calculation of Cathode Bias Resistors [when Anode & Screen Currents vary with Signal Amplitude: Example of 6V6-G Valve].—(*Sci. Abstracts*, Sec. B, May 1941, Vol. 44, No. 521, p. 92.) Abstract of a *Radiotronics* article.

2115. High-Impedance Input Circuits for A.F. Service [RC-Coupled Stage with Unbypassed Cathode-Resistor Section: Input Impedance varies with Relative Value of This Section: Equations: Noise Voltages in Cathode Resistor: Neutralising Hum Pick-Up].—C. A. Parry. (*Sci. Abstracts*, Sec. B, May 1941, Vol. 44, No. 521, p. 92.)

2116. Makeshifts: War-Time Measures to Meet a Shortage of Servicing Components.—W. H. Cazaly. (*Wireless World*, June 1941, Vol. 47, No. 6, pp. 152–155.) *See* also 1884 of July.

AERIALS AND AERIAL SYSTEMS

2117. The Input Impedance of a Symmetrical Antenna [Centre-Driven, Cylindrical: derived from Hallén's Rigorous Expression (2763 of 1939): Conditions for Resonance & for Max. Input Resistance: etc.].—R. King. (*Phys. Review*, 15th April 1941, Vol. 59, No. 8, p. 684: summary only.)

"The new curves are a good approximation for all lengths and a wide range of radii, whereas all those based on a sine distribution of current [*e.g.* Labus, 1933 Abstracts, p. 214] are entirely incorrect over ranges of lengths near those for which they become infinite, and considerably in error for all but vanishingly small radii. The radii of many self-supporting u.h.f. antennas are sufficiently large to contribute appreciably to the input impedance."

2118. Coupled Networks in Radio-Frequency Circuits [Theory & Physical Picture of Electromagnetic Coupling between Open-Wire Transmission Lines, and Induced Currents in Wires of Non-Resonant Lengths placed in Electromagnetic Field].—A. Alford. (*Proc. I.R.E.*, Feb. 1941, Vol. 29, No. 2, pp. 55–70.)

"If the problem is approached from this point of view [in terms of inductive and capacitive coupling], we are left completely unsuspecting of the possibility that beautifully simple laws govern such phenomena and that these laws can be so easily and completely visualised that in many cases the result of interaction can be predicted in a qualitative way from a mere inspection of the geometrical configuration of conductors, and that relatively very accurate quantitative results can be obtained after only a few minutes of calculation... Once we dispense with the idea of magnetic coupling, only the electric field has to be known, for when once this field is known at every point in space, we can calculate the currents which it produces." "It is this second type of radiation interaction [not given by the Pistolkors classical theory] outlined above which is responsible for the fact that a wire $2\frac{1}{2}$ wavelengths long will act as a reflector as well as a wire $2\frac{3}{4}$ wavelengths long without any regard for its so-called self-impedance." The end of the paper deals with the use of coupled line-sections as network filters and impedance transformers for the 5–140 Mc/s band (*e.g.* for feeding one aerial simultaneously from three 50 kw transmitters).

2119. Distributed Capacitance and Radiating Properties of Coils.—L. Sacco. (*Alta Frequenza*, June & July 1940, Vol. 9, Nos. 6 & 7, pp. 339–370 & 406–422.)

Author's summary:—"A special distribution of capacitance in single-layer coils fed at high frequency is studied, and this leads to the establishment of a general theory on the distribution of the current and voltages in the individual turns of the winding. Some consequences are deduced, which are confirmed experimentally:—the estimation of the residual capacitance of the coils used in oscillating circuits; the approximate determination of the natural frequencies of such coils; the estimation of the influence, on the 'antenna effect,' of earthing the middle point of the coil, as a function of the number of turns. The concepts of electric and magnetic potentials, and of electric and magnetic heights of the coils, are introduced: these contribute respectively to the antenna effect (non-directional) and frame effect (directional), values which are important for coils used in wireless reception or transmission.

"In the first part a study is made of the distribution of the currents and voltages in the various turns under the action of an e.m.f. operating in the exciting circuit of the frame. The second part examines the radiating properties of a frame of any shape, and the 'cymomotive force' in transmission [1354 & 1704 of 1936] and the receiving current are deduced. The magnetic and electric heights are calculated for the more usual types of frame, and by employing the results of the first part the antenna effect and frame effect, due to the feeding circuit, are studied. Finally a note is given on the [generally distinct] quality factors of a frame excited by a concentrated and by a distributed e.m.f., respectively.

2120. Harmonic Impedance as Quasi-Stationary Antenna Model.—H. Wigge. (*Hochf:tech. u. Elek:akus.*, April 1941, Vol. 57, No. 4, pp. 101–108.)

Author's summary:—"(1) A harmonic reactance is one whose null points and poles lie at frequencies which are whole multiples of a given fundamental frequency. (2) Harmonic reactances which have null points for uneven multiples of the fundamental, and poles for the even multiples, are suitable for use as artificial aerials. (3) The arrangement of circuit components corresponds to a low-pass filter with inductances and capacitances differing from section to section and increasing, at first slowly and then more quickly, towards the end of the chain. The ratios of the inductances and capacitances in any section to their values in the first section can be calculated by formulae 12 and 13. The ohmic resistances are distributed according to the same law as the inductances. For very large numbers of sections the chain behaves more and more like an ordinary two-wire circuit. (4) An artificial aerial with n sections has n impedance minima and $n - 1$ maxima. The number of sections is determined by the number of extreme values occurring in the range of practical application of the aerial. The impedance of the chain coincides with that of the aerial up to the frequency $\omega = \omega_0 (2n - 1)$: above this frequency the chain departs in its behaviour from that of the aerial and acts more and more as an inductance. (5) The components L, C, and R of the artificial aerial can be calculated if the static capacity of the aerial and its natural wavelength are known, together with the impedance minimum at its foot when oscillating to a quarter-wavelength (eqns. 60, 62, & 64). (6) An aerial should, therefore, be regarded not as the limiting case of a filter chain with equal inductances and capacitances for an infinite number of sections, but as a harmonic impedance in the limiting case of an infinite number of sections and consequently of a continuous distribution of capacitance and inductance."

2121. On the Theory of the Straight [Dipole] Receiving Aerial.—W. Magnus & F. Oberhettinger. (*Hochf:tech. u. Elek:akus.*, April 1941, Vol. 57, No. 4, pp. 97–101.)

From the Telefunken laboratories. Most previous treatments (Colebrook, *E.W. & W. Engineer*, 1927, Vol. 4, p. 657; 1932 Abstracts, pp. 526–527; 1933, p. 327: Grosskopf, 3576 of 1938: Niessen & de Vriess, 3567 of 1939) are based on line theory, and "the results are applicable to practical purposes only with limitations. On the other hand Hallén, on very general assumptions, has developed a theory of transmitting and receiving aerials on the basis of Maxwell's theory in two long papers (1931 Abstracts, p. 269, and 2763 of 1939): since these are difficult to get hold of and also, owing to their wide scope, are burdened with elaborate mathematical developments, they have attracted no attention up to the present. In the following pages some of Hallén's results will be made available for practical application; a short extract from his theory, containing only the simplified formulae necessary for the task in hand, is given in section I. It is seen that the strict theory yields simpler results than the line theory. The most important result can be formulated thus: the receiving aerial may be regarded as a generator whose e.m.f. $\mathfrak{B}$ can be calculated in a simple manner from the incident field, and whose internal resistance $\mathfrak{R}_i$ is independent of the incident field and of the terminating resistance. Thus $\mathfrak{R}_i$ is also the value of the input resistance of a transmitting aerial geometrically identical with the receiving aerial (*cf.* Franz, 761 of March): in his second paper Hallén has calculated the input resistance for the transmitting aerial, and in fact arrives at the value for $\mathfrak{R}_i$ explained in the present text; this value is therefore also of importance for the transmitting aerial."

Hallén's treatment consists in determining $\phi(x)$ from eqn. 2 (x being the distance of a point on the cylinder axis from the middle of the dipole), introducing the function thus found (still containing integration constants) into eqn. 5, and then deriving for $I(x)$ in the usual way, by iteration, a series development in powers of $1/\Omega$, and finally determining the integration constants by satisfying the limiting conditions for I and ϕ. In the present paper this is carried out for the receiving aerial. The current I_0 at the receiver input of a cylindrical aerial broken at the middle by the receiving circuit is thus found to be of the form $I_0 = \mathfrak{B}\mathfrak{W}/(\mathfrak{R}_a + \mathfrak{R}_i)$, where $\mathfrak{B}$ is a voltage depending only on the external field and the aerial length, and $\mathfrak{R}_a$ is the resistance of the receiver, while the "internal resistance" $\mathfrak{R}_i$ and the "transformation factor" $\mathfrak{W}$ (*see* r-h col. of p. 100) depend only on the length and cross-section of the aerial. The necessary data for calculating $\mathfrak{R}_i$ and $|\mathfrak{W}|$ are given in the curves of Figs. 4–7.

2122. Noise in Receiving Aerial Systems [and the Question of the Validity of Nyquist's Theorem applied to Radiation Resistance: Incorrectness of Bell's Suggestion of replacing R_r by Reactance of Equal Magnitude: R_r *can* be Source of Thermal Noise, & obeys Nyquist's Theorem when Aerial is in Radiative Equilibrium with Surroundings: the Practical Problem—Thermal Noise, Jansky Noise, etc: Use of T_r to express Actual Received Noise: K, a Criterion of Aerial-System Efficiency: Comparison of Vertical Aerial (coupled to Tuned-Grid Circuit) & Tuned-Loop Aerial: etc.].—R. E. Burgess. (*Proc. Phys. Soc.*, 1st May 1941, Vol. 53, Part 3, pp. 293–304.)

2123. The Antenna with Multiple Downleads [for Very Long Waves: Alexanderson Multiple-Tuned Aerial, adopted at New Brunswick & Warsaw in the 1920's: New Tests on Reduced Model, using Modern Technique, and prompted by Problem of Communication with Submerged Submarines: Calculation & Measurement of Equivalent Height: Optimum Design].—S. Rosani. (*Alta Frequenza*, May 1940, Vol. 9, No. 5, pp. 278–304.)

VALVES AND THERMIONICS

2124. Theoretical and Experimental Investigations of Electron Motions in Alternating Fields with the Aid of Ballistic Models [Dynamic Roll-Paths in Cathode-Ray Tube, by Rubber-Membrane Model, and Energy Exchange, by Beam of Balls and Tilting Plate: Heil Generator, by Rubber Membrane & Balanced Plate: Klystron, with "Buncher" & "Catcher" Plates linked by Rubber Membrane].—H. E. Hollmann. (*Proc. I.R.E.*, Feb. 1941, Vol. 29, No. 2, pp. 70–79.) Based on the work dealt with in 1659 of 1939 and 1376 & 2544 of 1940.

2125. An Amplifier Valve for Decimetric Waves [Type EFF50, Two Pentodes in Push-Pull in One Bulb: Voltage Gains of 16.5 at 1 m and 8 at 60 cm (under Certain Conditions): applicable also to Frequency Conversion].—M. J. O. Strutt & A. van der Ziel. (*Alta Frequenza*, March 1941, Vol. 10, No. 3, pp. 187–188.) Summary of paper in *Rev. tech. Philips* of June 1940.

2126. A Magnetron with Cathode surrounded by Even Number of Concentric Segments (Control Electrodes) and Radial Anode Plates, all encircled by Accelerating Cylinder not reached by the Electrons

OWING TO CURVATURE OF PATHS.—K. Fritz. (*Hochf:tech. u. Elek:akus.*, March 1941, Vol. 57, No. 3, p. 94.) Telefunken Pat. DRP 695 781.

2127. NEW TYPES AND TRENDS IN TRANSMITTING TUBES [particularly for Ultra-High Frequencies: Beam Type Advantages: Inductive-Output Valve Type 825: etc.].—E. E. Spitzer. (*Proc. I.R.E.*, Feb. 1941, Vol. 29, No. 2, p. 84: summary only.)

2128. FLUCTUATIONS INDUCED IN VACUUM-TUBE GRIDS AT HIGH FREQUENCIES [by Random Variations in Space Current: predicted by Ballantine and observed in Study of Noise Sources in Receiving Circuits for 10–20 Mc/s: New Formula corresponding to Nyquist's Passive-Network Formula: Experimental Confirmation at 30 & 100 Mc/s: Estimation of Relative Importance].—D. O. North & W. R. Ferris. (*Proc. I.R.E.*, Feb. 1941, Vol. 29, No. 2, pp. 49–50.)

2129. THE DISTRIBUTION OF AMPLITUDE WITH TIME IN FLUCTUATION NOISE [is a Statistical Distribution following the Normal-Error Law, even after Passage through Frequency-Selective Circuits: Effect on Previous Measurements of Crest Factor (Common Value of 4 perhaps justified for Rough Calculations, but Occasional Peaks go Considerably Higher): Ratio Average-Voltage/Effective-Voltage is 0.798: Types of Noise which do Not follow Normal-Error Law (Ignition Noise: Noise, under Certain Conditions, in Frequency-Modulation Receivers)].—V. D. Landon. (*Proc. I.R.E.*, Feb. 1941, Vol. 29, No. 2, pp. 50–55.)

2130. THE FLUCTUATION OF SPACE-CHARGE-LIMITED CURRENTS IN DIODES [Experimental Investigation of Dependence of Smoothing Factor on Valve Geometry: including an Effect of Unknown Origin].—F. C. Williams. (*Electrician*, 16th May 1941, Vol. 126, p. 290.) Paragraph on an I.E.E. paper.

2131. INITIAL-VELOCITY CURRENTS IN THERMIONIC VALVES [Experimental Investigation: Relationship between I-V.C. & Potential required to reduce Current to Zero: I-V.C. & Softness: Effects of Temperature & Inter-Electrode Spacing: Control of I-V.C. during Processing: Variation during Life: etc.].—J. A. Darbyshire. (*Proc. Phys. Soc.*, 1st May 1941, Vol. 53, Part 3, pp. 219–232.) From the Ferranti laboratories.

2132. ELECTROMETER TUBE FOR LABORATORY AND INDUSTRIAL USE [Triode: for Currents above 10^{-16} Ampere].—L. Sutherlin & R. H. Cherry. (*Sci. Abstracts*, Sec. B, April 1941, Vol. 44, No. 520, p. 55.)

2133. ELECTRON MULTIPLIER AS AN ELECTRON COUNTING DEVICE [for Photons, Alpha, Beta, Gamma, & X Rays: Commercial Types are Unsuitable: Development of Special Multipliers].—Z. Bay. (*Review Scient. Instr.*, March 1941, Vol. 12, No. 3, pp. 127–133.)

The specially important requirements are:—very small dark current, negligible field emission, high insulation of output electrode, and low inter-electrode capacity. Various emitting surfaces were tried: thus a 12-stage amplifier using Ag-Mg alloy electrodes gave a total multiplication of 10^8 for an over-all voltage of 3500 volts; thermal and field emissions were "entirely negligible" and unobservable, respectively; insulation resistance was about 10^{14} ohms (probably owing to the absence of any getter). For previous work *see* 1891 of 1938 and *Nature*, 1938, Vol. 141, p. 1011. An 18-page version is to be found in *Zeitschr. f. Phys.*, 20th Jan. 1941, Vol. 117, No. 3/4: for a correction to a formula in this see *ibid.*, 30th April, No. 7/8, p. 544.

2134. ON THE INFLUENCE OF TEMPERATURE ON THE SECONDARY ELECTRON EMISSION OF METALS: REMARK ON THE PAPER BY W. REICHELT, *and* NOTE ON R. KOLLATH'S REMARK.—R. Kollath: A. Becker: Reichelt. (*Ann. der Physik*, 13th Jan. 1941, Vol. 39, No. 1, pp. 19–22: pp. 23–24.)

See 405 of February. Kollath points out the great importance of Reichelt's main result, if confirmed: namely the distinct increase of the mean energy of the secondary electrons, without increase in their numbers, on heating the emitting layer to 1500° C: but he refers to previous work of his own which throws doubt on this conclusion. Becker replies for Reichelt, who has been called up for military service.

2135. THE ENERGY DISTRIBUTION OF SECONDARY ELECTRONS: I—THE METHOD OF THE LONGITUDINAL MAGNETIC FIELD.—R. Kollath. (*Ann. der Physik*, 13th Jan. 1941, Vol. 39, No. 1, pp. 59–80.)

Author's summary:—"For the investigation of the energy distribution of secondary electrons a method hitherto unused for this purpose was employed, namely that of the longitudinal magnetic field, and the conditions were carefully investigated in which a reliable measurement of the energy distribution can be carried out. As an example of the usefulness of the method, some results on films of tantalum, molybdenum, and beryllium are given; in particular, the effect of annealing on the shape of the distribution curves is discussed. Preliminary energy-distribution measurements on the photo-electrons from a caesium-antimony photocathode show the practicability of the method for photo-electrons also."

2136. A NEW FORM OF FIELD ELECTRON EMISSION, AT VERY LOW PRESSURES, FROM METALLIC SURFACES COVERED BY A DEPOSIT OF INSULATING MATERIAL.—H. Paetow. (*Zeitschr. f. Phys.*, 26th March 1941, Vol. 117, No. 5/6, pp. 399–408.)

From the Siemens laboratories. Author's summary:—"If, at low gaseous pressures, a high voltage [around 1000 v] is applied to a discharge tube on whose cathode there is some powdered insulating material, a discharge process occurs in the course of which the cathode becomes coated with a thin layer of the powder. At the cathode thus formed a new discharge process takes place, at pressures down to 10^{-6} mm Hg, and yields current densities up to 100 mA/cm² for voltages of about 200 V. The two discharge processes are compared with the two emission forms of the Malter stratified cathode [of type $Al\text{-}Al_2O_3\text{-}Cs_2O$: *see* 3418 & 3419 of 1936 and 158 of 1939] : a far-reaching agreement is established."

2137. SECONDARY ELECTRON EMISSION OF Ni AT THE CURIE POINT [No Sudden Alteration].—P. S. Varadachari. (*Sci. Abstracts*, Sec. A, March 1941, Vol. 44, No. 519, p. 72.) Contradicting the results of other workers.

2138. AFTER-EFFECT OF METAL BOMBARDED BY ELECTRONS [Delayed Electron Emission at Surface of Almost All Metals, and the Factors controlling It].—M. Tanaka. (*Sci. Abstracts*, Sec. A, April 1941, Vol. 44, No. 520, p. 106.)

2139. THE ENERGY LOSSES ATTENDING FIELD CURRENT AND THERMIONIC EMISSION OF ELECTRONS FROM METALS [measured in Same Experimental Tube, by Thermal E.M.F. in Junction acting as Cathode : No Measurable Temperature Change for Field Emission up to Thermionic Temperatures : for Thermionic Emission, Temperature Changes leading to Calorimetric Value for Work Function of Tungsten of 4.46 ± 0.09 Volts : Theoretical Expression for Average Net Energy Loss per Electron for Both Types of Emission].—G. M. Fleming & J. E. Henderson. (*Phys. Review*, 15th Nov. 1940, Vol. 58, No. 10, pp. 887–894.)

"The experiment gives strong additional evidence that in field emission the electrons escape by penetrating rather than by surmounting the surface potential barrier as in thermionic emission" [Fowler-Nordheim theory].

2140. REMARKS ON THE TEMPERATURE DEPENDENCE OF THE WORK FUNCTION OF TUNGSTEN [Criticism of Potter's Paper : Reply].—W. B. Nottingham : J. G. Potter. (*Phys. Review*, 15th Nov. 1940, Vol. 58, No. 10, pp. 927–928.) *See* 99 of January.

2141. SOME APPLICATIONS OF THE X-RAY POWDER METHOD IN INDUSTRIAL LABORATORY PROBLEMS [including the Study of Thermionic Cathodes and Nickel-Iron-Alloy Powders].—H. P. Rooksby. (*See* 2303, below, and 2599 of 1940.)

2142. TEMPERATURE DISTRIBUTIONS IN HOLLOW CYLINDRICAL SYSTEMS [Equation giving Distribution of Source Density yielding Uniform Temperature over Finite Length].—M. Avrami. (*Phys. Review*, 15th April 1941, Vol. 59, No. 8, p. 691 : summary only.)

DIRECTIONAL WIRELESS

2143. DOUBLE-LOOP DIRECTION FINDER WITH CATHODE-RAY-TUBE INDICATION, *and* DIRECTION FINDER FREE FROM NIGHT ERROR.—E. Schulz. (*Hochf:tech. u. Elek:akus.*, March 1941, Vol. 57, No. 3, p. 96 : p. 96.) Telefunken Pats. DRP 694 208/9.

2144. RADIO CONTROL EQUIPMENT AT THE NEW WASHINGTON, D.C., AIRPORT.—D. L. Bunday. (*Proc. I.R.E.*, Feb. 1941, Vol. 29, No. 2, p. 84 : summary only.)

Among the refinements mentioned, Lucite panels and rings are used, with the light transmitted through them, to avoid glare.

ACOUSTICS AND AUDIO-FREQUENCIES

2145. ON THE PROPERTIES OF PRESSURE-GRADIENT MICROPHONES.—A. Gigli. (*Alta Frequenza*, Feb. 1941, Vol. 10, No. 2, pp. 99–109.)

"With reference to a previous paper (644 of 1940) in which a classification of microphones was proposed, it is mentioned that the considerations there set out apply, so far as pressure-gradient microphones are concerned, only to the case of the sound field formed by plane waves and the case of the spherical sound field of complete symmetry. It is shown, and confirmed by experimental results, what deviations from the common figure-of-eight directional characteristic are encountered with a pressure-gradient microphone in an asymmetrical sound field : the case is specially considered of a field formed by the superposition of two systems of plane waves crossing at an angle 2θ, and also the case of the spherical field produced by a sound generator of the first order."

2146. A PHILIPS MOVING-COIL MICROPHONE SENSITIVE TO PRESSURE GRADIENT [Good Frequency Characteristic, Not influenced by Resonances : Sensitivity 0.9 mV/(dyne.cm^{-2}): Marked Directivity at 500 c/s, Little at 5000 c/s owing to Screening Effect of Magnetic Circuit].—J. de Boer. (*Alta Frequenza*, Feb. 1941, Vol. 10, No. 2, pp. 118–119.) Summary of paper in *Philips Tech. R.*, May 1940.

2147. THE USE OF EQUIVALENT ELECTRICAL CIRCUITS FOR THE EXPERIMENTAL ANALYSIS OF ELECTROACOUSTICAL SYSTEMS [Method illustrated by Application to High-Sensitivity Electro-Magnetic Microphone].—F. Massa. (*Alta Frequenza*, July 1940, Vol. 9, No. 7, pp. 388–392.) For the semi-automatic recording equipment used for obtaining the response curve of the equivalent circuit, *see* 3806 of 1936.

2148. ON THE PRESSURE-DEPENDENCE OF THE D.C. CORONA [Derivation of a $p^{-3/2}$ Law : Comparison with Experimental Results : Discontinuous Character of Discharge shown by Oscillograms of Noise : Behaviour in a Sound Field is That of a Pressure-Type Receiver : etc.].—H. Hinderer & A. Walter. (*Zeitschr. f. Phys.*, 20th Jan. 1941, Vol. 117, No. 3/4, pp. 213–226.)

2149. MEASURED ADMITTANCES OF A ROCHELLE-SALT RESONATOR.—Van Dyke & Waltz. (*See* 2185.)

2150. PROPERTIES OF ROCHELLE SALT : IV.—Mueller. (*See* 2186.)

2151. ACOUSTIC VELOCITY IN ROCHELLE-SALT SOLUTIONS.—Sibaiya & Narasimhaiya. (*Current Science*, Bangalore, March 1941, Vol. 10, No. 3, pp. 168–169.)

2152. "MYSTERY" RECORD PLAYERS: G.P.O. RULING.—E. F. H. Gould. (*Wireless World*, June 1941, Vol. 47, No. 6, p. 166.) *See* 1687 of June.

2153. THE NEW MIRROPHONE STEEL-TAPE RECORDER [and Its Applications in Singing & Speech Instruction (Advantage of Retaining only Last Minute's Records): etc.].—H. J. Hogan. (*Proc. I.R.E.*, Feb. 1941, Vol. 29, No. 2, p. 85: summary only.)

2154. THE RECORDING OF SPEECH TO SHOW VARIATIONS OF THE ELEMENTARY PHONETIC UNITS.—Gemelli. (*See* 2321.)

2155. TELEPHONOMETRIC [Articulation] TESTS ON PUBLIC-ADDRESS SYSTEMS.—A. Ferrari-Toniolo. (*Alta Frequenza*, July 1940, Vol. 9, No. 7, pp. 393–405.)

Survey, leading to a discussion of the difficulties met with in applying intelligibility tests to public-address systems, and to a description of a new method in which the logatoms are given a definite cadence by means of a special glow-lamp metronome. "The values of the articulation as a function of the new variable depend on the reverberation time, and they provide a means of judging the acoustic properties of the surroundings, separating the effects of these from those due to the quality of the electro-acoustic installation."

2156. ELECTROACOUSTICS APPLIED TO THE STUDY OF VIOLINS.—G. Pasqualini. (*Alta Frequenza*, July 1940, Vol. 9, No. 7, pp. 426–428: summary only.)

2157. THE SOUND LOCATING OF UNSEEN AIRCRAFT FOR A.A. CONTROL.—A. Kuhlenkamp. (*Zeitschr. V.D.I.*, 26th April 1941, Vol. 85, No. 17, pp. 393–400.)

2158. AERIAL AND SUBMARINE PHONOGONIOMETRY [Sound Location: Survey].—F. Botta. (*Alta Frequenza*, Feb. 1941, Vol. 10, No. 2, pp. 111–112.) Summary of an article in *Rivista di Artiglieria e Genio*.

2159. THEORETICAL AND EXPERIMENTAL INVESTIGATION ON THE REFERENCE EQUIVALENT AND ON THE LEVEL OF ACOUSTIC SENSATION [including a Very General Definition of the Reference Equivalent, and Some Methods of Measuring It].—K. Braun. (*T.F.T.*, Feb. 1940, Vol. 29, No. 2, pp. 31–37: long summary in *Alta Frequenza*, July 1940, Vol. 9, No. 7, pp. 429–432.)

2160. WATTMETERS FOR ACOUSTIC FREQUENCIES.—Pinciroli & Francini. (*See* 2195.)

2161. PHASE-SHIFT OSCILLATORS [Resistance-Capacity-Tuned, with Single Valve (in Simplest Form), for Audio Frequencies].—E. L. Ginzton & L. M. Hollingsworth. (*Proc. I.R.E.*, Feb. 1941, Vol. 29, No. 2, pp. 43–49.)

"If one desires a constant a.f. oscillator, it is probably impossible to devise any cheaper or simpler circuits than those shown in Fig. 1. If one desires a high-quality, variable-frequency oscillator, it will be found that an oscillator similar to the one shown in Fig. 7 is as good as any available on the market or described in the literature. In certain applications it may actually prove to be superior, especially in cases where frequency stability (with reference to supply-voltage fluctuation) is an important factor."

2162. HIGH-IMPEDANCE INPUT CIRCUITS FOR A.F. SERVICE.—Parry. (*See* 2115.)

2163. MAGNETIC SCREENING BY SINGLE AND MULTIPLE CYLINDERS OF LIMITED LENGTH, AT NOTE FREQUENCIES.—Moeller. (*See* 2237.)

2164. SUPERSONIC OSCILLATOR [for Uses in Industrial Chemistry].—B. H. Porter. (*Sci. Abstracts*, Sec. A, March 1941, Vol. 44, No. 519, p. 71.)

2165. AN OPTICAL METHOD FOR THE MEASUREMENT OF ULTRASONIC ABSORPTION.—E. C. Gregg, Jr. (*Review Scient. Instr.*, March 1941, Vol. 12, No. 3, pp. 149–151.)

PHOTOTELEGRAPHY AND TELEVISION

2166. COLOUR TELEVISION [using Standard Type Receiver with Addition of Revolving Disc only (and Similar Disc in front of Iconoscope)].—E. F. W. Alexanderson. (*Gen. Elec. Review*, March 1941, Vol. 44, No. 3, p. 185: paragraph only.) *Cf.* Lorenzen 3944 of 1940.

2167. "TELEVISION BROADCASTING" [Programme Production: Organisation: Economics: etc: Book Review].—L. R. Lohr. (*Electrician*, 9th May 1941, Vol. 126, p. 272.) By the President of the N.B.C.

2168. DEFLECTION ERRORS OF ELECTRIC AND MAGNETIC DEFLECTING SYSTEMS: CORRECTIONS.—W. Glaser. (*Zeitschr. f. Phys.*, 26th March 1941, Vol. 117, No. 5/6, p. 412.) *See* 1577 of 1939.

2169. EQUATIONS OF THE INCIDENT AND REFLECTED WAVES IN NON-UNIFORM LINES.—Zin. (*See* 2075.)

2170. THE TRANSMISSION OF PICTURES BY FREQUENCY MODULATION [of a Note Frequency imposed by Amplitude Modulation on the R.F. Carrier].—E. Hudec. (*E.N.T.*, Jan./Feb. 1941, Vol. 18, No. 1/2, pp. 12–27.)

1—The development of picture-telegraphy by frequency modulation, from the fundamental suggestion of Ilberg & Schröter, Telefunken Patent of 5.1.30: all the development work mentioned was put in hand a long time ago, but its completion has been badly held up in recent years by unfavourable circumstances. 2—The transmission of an image-surface of uniform tone by a modulated wave, and its reproduction. 3—The elimination of fading by forced relaxation oscillations. 4—The transmission of the edge between two surfaces of different tones. 5—The transformation of amplitude modulation, from the scanning of the picture, into frequency modulation. 6—The other equipment at the transmitting end. 7—The production of the amplitude modulation necessary for the recording of the picture. 8—The other equipment for reception. 9—Practical results, including reproductions of pictures from New York and Buenos Ayres.

2171. A GAS-FILLED PHOTO-RELAY.—Goncharski. (*See* 2325.)

2172. THE USE OF THE LONGITUDINAL MAGNETIC FIELD METHOD FOR MEASURING THE ENERGY DISTRIBUTION OF PHOTOELECTRONS [*e.g.* from a Caesium-Antimony Photocathode].—Kollath. (*See* 2135.)

2173. PHOTOELECTRIC WORK FUNCTIONS OF (100) AND (111) FACES OF SILVER SINGLE CRYSTALS, AND THEIR CONTACT POTENTIAL DIFFERENCE.—H. E. Farnsworth & R. P. Winch. (*Phys. Review*, 1st Nov. 1940, Vol. 58, No. 9, pp. 812–819.)

MEASUREMENTS AND STANDARDS

2174. FREQUENCY-MODULATED GENERATOR [for Use in Design of F.M. Transmitters, Receivers, & Components].—Boonton Radio. (*Review Scient. Instr.*, March 1941, Vol. 12, No. 3, p. 158.)

2175. A RECORDING PHASE-METER FOR RECEPTION OBSERVATIONS IN THE SHORT, MEDIUM, AND LONG WAVE RANGES.—Grosskopf. (*See* 2048.)

2176. THE MEASUREMENT, BY VOLTMETER AND AMMETER, OF THE POWER DELIVERED BY A TRANSMITTER TO THE RADIATING AERIAL.—L. Palieri. (*Alta Frequenza*, March 1941, Vol. 10, No. 3, pp. 131–148.)

Author's summary :—" It is shown that it is possible to estimate the power furnished by the transmitter to the radiating aerial as the arithmetical product of the effective values of the aerial current (I_A) and of a voltage (V_A) which is easily measured at the transmitter, between ground and aerial terminals, when the aerial is disconnected. The measurement is rigorously correct if the circuits of the transmitter are composed of pure reactances, however these may be disposed and whatever may be the total of unavoidable stray inductive and capacitive couplings. It retains a high accuracy even if the circuit losses cannot be neglected, and the necessary correction is easily determined both in magnitude and sign. The method requires that the tuning of the transmitter should be carried out twice, first by the resonant anode circuit of the output valve, with aerial disconnected ,and then by the aerial circuit. The possible causes of error are examined : the amount of error to be expected is estimated and found in general to be negligible. Finally some results of measurements are given, carried out to check the accuracy of the method by comparison with other methods " [calorimetric method].

2177. BRIDGE-BALANCE METHOD OF ELIMINATING FEEDBACK IN MEASUREMENT OF TRUE VALVE INPUT CONDUCTANCE.—W. R. Ferris. (Mentioned in North & Ferris's paper dealt with in 2128, above.)

2178. DISTRIBUTED CAPACITANCE AND RADIATING PROPERTIES OF COILS.—Sacco. (*See* 2119.)

2179. THE OPTIMUM DAMPING OF COILS WITH COMPRESSED-POWDER CORES.—Labus. (*See* 2097.)

2180. A METHOD OF MEASURING THE MAGNETIC PROPERTIES OF SMALL SAMPLES OF TRANSFORMER LAMINATIONS.—H. W. Lamson. (*Proc. I.R.E.*, Dec. 1940, Vol. 28, No. 12, pp. 541–548.)

Including the use of a polarised modulation bridge, with phase-shifting network, to give a visual null-balance detector sensitive uniquely to either the reactive or the resistive balance control.

2181. EXPANSIONAL VIBRATION OF A FREE CIRCULAR RING [for Investigations on Magnetostriction Vibrators].—T. Hayasaka. (*Nippon Elec. Comm. Eng.*, Jan. 1941, No. 23, pp. 186–189.)

2182. THE MAGNETOSTRICTION OF IRON IN HIGH MAGNETIC FIELDS.—O. Rüdiger & H. Schlechtweg. (*Ann. der Physik*, 13th Jan. 1941, Vol. 39, No. 1, pp. 1–18.)

2183. ELASTIC VIBRATIONS OF AN ANISOTROPIC BODY IN THE FORM OF A RECTANGULAR PARALLELEPIPED [with Special Application to Quartz Plates].—R. Bechmann. (*Zeitschr. f. Phys.*, 20th Jan. 1941, Vol. 117, No. 3/4, pp. 180–197.)

From the Telefunken laboratories. Author's summary :—" A solution is given for the free elastic natural frequencies of an anistropic body of parallelepiped shape with surfaces free from forces. Starting from the elastic motional equations, the six deformations x_x . . . x_y are expressed as independent degrees of freedom which, in the vibrating condition, are coupled together by the elastic reciprocal-action coefficients [eqns. 7 & 8]. The frequency equation is given by a secular equation of the sixth order, whose elements are the elasticity moduli c_{ik} and the elasticity coefficients s_{ik}. The equations for the motions are derived. The general solution [eqn. 21] contains the following limiting cases, which are investigated in detail :—the longitudinal vibrations of a bar, both of infinitely thin and also of finite cross section ; the ' thickness ' vibrations of an infinitely large plate ; the longitudinal vibrations of a very thin plate of finite size ; and finally the natural vibrations of the isotropic body ".

The writer concludes :—" The experimental values for the natural frequencies of the ' thickness ' vibrations of quartz plates whose longitudinal extension is large compared with the thickness are in satisfactory agreement with the values obtained from eqn. 30, as we have shown already [Bechmann, 503 & 504 of 1935]. It is proposed to examine the solution of eqn. 32 for the longitudinal vibrations of thin plates more closely and to compare it with experimental values for quartz plates. This would allow the foregoing treatment of the longitudinal vibrations to be tested as regards not only the frequency but also the distribution of motion, since in addition to the natural frequencies of the plates the position of the nodal lines can easily be determined by experiment. The representation of the natural vibrations has to be extended, as pointed out at the beginning of this paper, to the other groups of natural vibrations, the bending and torsional modes, in order to reach a complete description of the possible motional conditions of the anisotropic body under consideration ".

2184. A DETERMINATION OF THE ELASTIC MODULUS s_{13} OF BETA-QUARTZ.—A. W. Lawson. (*Phys. Review*, 1st April 1941, Vol. 59, No. 7, pp. 608–612.) "By-product of an attempt . . . to excite longitudinal vibrations in beta-quartz". Osterberg & Cookson's value of c_{44} is discredited.

2185. MEASURED ADMITTANCES OF A ROCHELLE-SALT RESONATOR [Vector Admittance Circles at Different Temperatures yield Values of Dielectric, Piezoelectric, Viscous, & Elastic Constants].—K. S. Van Dyke & M. C. Waltz. (*Phys. Review*, 15th April 1941, Vol. 59, No. 8, p. 686: summary only.)

2186. PROPERTIES OF ROCHELLE SALT: IV [Kerr Effect: Morphic Effects in Crystal Physics: Quadratic Piezoelectric Effect and Anomalous Thermal Expansion: the Transition of Rochelle Salt].—H. Mueller. (*Phys. Review*, 1st Nov. 1940, Vol. 58, No. 9, pp. 805–811.)

"The Kerr effect in Rochelle salt belongs to a new class of effects in crystal physics which, as far as the writer knows, have not been discussed previously and which we propose to call 'morphic' effects. They occur when the symmetry of a crystal is altered by elastic strains..." For previous parts *see* 151 of January.

2187. A NEW METHOD FOR THE DETERMINATION OF THE TIME [Method of Azimuthal Couples or Equal Azimuths: Advantages].—Guyot. (*Ann. Guébhard-Séverine*, Neuchâtel, 1938/39, 14th/15th Years, pub. 1940, pp. 236–240.) Based on observing the instant when 2 stars are in the same vertical plane.

2188. A DIRECT-READING METER FOR SMALL TIME-INTERVALS [*e.g.* for Relay Measurements].—A. Ferrari-Toniolo. (*Alta Frequenza*, March 1941, Vol. 10, No. 3, pp. 179–181.)

2189. AN INSTRUMENT FOR MEASURING SHORT INTERVALS OF TIME [Relay Contacts, etc: Full-Scale Deflections of 0.001, 0.1, & 1.0 Second: Condenser-Charging Principle].—E. A. Walker. (*Journ. Franklin Inst.*, April 1941, Vol. 231, No. 4, pp. 373–379.)

2190. A STROBOSCOPIC METHOD FOR MEASURING THE OPERATING AND RELEASING TIMES OF RELAYS.—Jurgenson. (*Automatics & Telemechanics* [in Russian], No. 3, 1940, pp. 113–114.)

A single-phase synchronous motor 1 (Fig. 1) drives a commutator 4 and two stroboscopic discs 10 and 11. The commutator operates a relay which in turn charges and discharges a condenser *C* through the primary winding of a transformer. The currents so induced in the secondary of the transformer switch-on neon lamps 12 and 13 mounted behind the stroboscopic discs, and by noting the slots on the discs through which these flashes are seen the time delays of the relays can be determined. Time delays from 0 to 500 μsec. can be measured, and it is stated that the accuracy of the method is only limited by the frequency variation of the mains feeding the motor.

2191. THE LIMITING DISTANCE IN MEASUREMENTS BY ORDINARY ELECTRIC MEASURING APPARATUS.—D. L. Orshanski. (*Automatics & Telemechanics* [in Russian], No. 4, 1940, pp. 69–87.)

Every electrical measurement is essentially made from a "remote" position, and in this paper the question of the limiting distance at which these measurements can be carried out is discussed for the case when ordinary (*i.e.* not specially designed for telemetering) apparatus is used. Various errors introduced by the line connecting the apparatus to the circuit are established, and on the basis of the conclusions reached by Pflier (*Arch. f. Tech. Mess.*, 1937, No. 72) equations (14) and (22) are derived for determining the maximum distance, as limited by the temperature variation and leakage-current variation, respectively, of the line. A detailed analysis of these equations is given and the discussion is illustrated by graphs plotted for a particular case.

2192. THE DESIGN OF A DIODE MILLIVOLTMETER [with Full-Scale Deflection for 2 Millivolts: High-Input-Impedance Pre-Amplifier, Diode Rectifier, & D.C. Voltmeter].—C. Brunetti & C. W. Harrison. (*Communications*, Jan. 1941, Vol. 21, No. 1, pp. 14–16 and 22.)

2193. MEASURING FAST PEAK VOLTAGES BY MAGNETIC OSCILLOGRAPH [with Its Range greatly extended by Use of Capacitor & Thermionic Circuit].—Scudder Smith. (*Gen. Elec. Review*, Feb. 1941, Vol. 44, No. 2, pp. 121–123.)

2194. CREST-VOLTAGE MEASUREMENT IN DIELECTRIC TESTING.—H. W. Bousman. (*Gen. Elec. Review*, March 1941, Vol. 44, No. 3, pp. 183–184.)

2195. WATTMETERS FOR ACOUSTIC FREQUENCIES.—A. Pinciroli & G. Francini. (*Alta Frequenza*, June 1940, Vol. 9, No. 6, pp. 324–338.)

Authors' summary:—"The first part examines the mode of action of the various instruments already proposed for the measurement of small powers at acoustic frequencies, arranging them according to their working principles and discussing the similarities and defects of each system. This examination brings out the special merits of thermocouple wattmeters.

"The second part studies the possibility of obtaining, in an instrument of this type, protection of the thermocouple and an indication when the limit of the useful range is reached, by means of a valve amplifier with special characteristics. Some experimental results are given, obtained with a wattmeter on this principle: these show its suitability for measurements between 30 and 40 000 c/s; the [full] scale of max. sensitivity corresponds to 90 μW and the error is limited to a few per cent."

2196. MEASUREMENTS WITH THE STAGE COMPENSATOR ["Stufenkompensator."] — W. Zschaage. (*E.T.Z.*, 26th Dec. 1940, Vol. 61, No. 52, pp. 1185–1187.)

The fundamental relations and formulae are derived for the Schmidt "stage compensator," which in its later developments forms a particularly convenient instrument for works and laboratories for checking meters of various kinds and for measuring resistances between 1 milliohm and 30 000 ohms.

SUBSIDIARY APPARATUS AND MATERIALS

2197. The Time-Linear Resolution of Short Waves [Use of Kallirotron Circuit, with Hard Valves, for obtaining High-Frequency Time Base for recording Ultra-High-Frequency Phenomena].—Lichtenberg. (*Hochf: tech. u. Elek:akus.*, March 1941, Vol. 57, No. 3, pp. 84–90.)

Hitherto, time-base circuits using hard valves have not been so successful as those with gas-filled valves, and "the question arises, up to what frequencies can the high-vacuum valves at present available be employed to provide useful 'kipp' voltages? In the following paper the Kallirotron arrangement (*see*, for example, *Electrician*, Vol. 111, 1933, p. 97 [also *cf.* Hollmann & Schultes, 1932 Abstracts, pp. 99 & 176]) is therefore investigated systematically: the results are then applied to the construction of a time-base oscillator which enables even [ultra-] short waves to be resolved." The basic circuit (Fig. 1) contains the relaxation-oscillation ("kipp") condenser C which is charged at constant current through a charging pentode L and discharged through a discharging valve E, controlled by a control valve S. At the beginning of the charging process the point 1 (between anode of L and the pole of C connected to the cathode of E) takes practically the full potential U above earth (curve 1, Fig. 2), the control valve S passes a large current, since the grid is at cathode potential (curve 3), and the anode voltage of S (curve 4) is very small, so that the grid potential of the discharge valve E (difference between curves 1 and 4) is strongly negative and the valve is blocked. As C becomes more fully charged the negative bias on E diminishes until this valve begins to carry an appreciable current: the resulting negative potential appearing at the near end of its anode-lead resistance R_1 is transferred by the coupling condenser K to the grid of S, and chokes down the anode current of this valve, so that its anode voltage rises. Since S has its anode circuit back-coupled to the grid of E, the bias on this also increases in the positive sense, and the discharge current through E increases. This goes on until, as C becomes more and more discharged, the discharge current begins to decrease: the positive potential pulse appearing at that instant at R_1, and thus at the grid of S, opens the latter valve slightly, and the back-coupling process (onto the grid of E) builds up the action so that the discharge through E is completely cut off.

The approximately constant charging current is provided by using a pentode for L. The resolving power of the time base is the greater, the greater the charging current and the smaller the condenser C. Moreover, the voltages at C must be large so that post-amplification may be omitted, this being very important because of the high harmonic content of saw-tooth voltages. The pentode must therefore be chosen to pass a large current and stand a large load, and at the same time to have a high internal resistance, to ensure linearity of deflection. Finally, since its anode/cathode capacity adds itself to C, this capacity must be as low as possible so as to keep the resolving power high. As regards E, the discharging valve, here again the anode/cathode capacity (and that of the leads) is added to C and must therefore be kept small; also the capacity to earth of the cathode must be low, so that a pentode is unsuitable. An indirectly heated triode of small anode/cathode capacity is therefore the best choice, but the grid/cathode capacity must also be kept small in order to obtain a good linearity of the time axis (*see* top of p. 86) and also to avoid other troubles (*see* Fig. 10 and adjacent text).

Design considerations for other parts of the complete time-base circuit are contained in sections III c & d, and section IV deals with the limits of charging speed and consequently of resolving power: the design of the control amplifier is of decisive importance here, but luckily the upper frequency limit of this can be some 30% higher than that of ordinary wideband amplifiers (which usually amounts to a few Mc/s for an output voltage of 200–300 v) because the control amplifier may be over-controlled. Section V deals with methods of obtaining the synchronisation necessary to obtain stationary images.

Section VI discusses the complete circuit finally evolved (Fig. 11) and the results obtained. With a d.c. voltage of 650 v on the time base the max. charging velocity is 2.3 kv/μsec., so that for a deflection sensitivity of 0.2 mm/v the time-spread on the screen is 500 mm/μsec. and the period of a 30 Mc/s oscillation stretches over a maximum of 16 mm. If the fly-back is darkened, the true "kipp" frequency of 2.5 Mc/s is converted into an apparent frequency of 5 Mc/s, since the fly-back occupies 50% of the total "kipp" period. A "kipp" voltage of 320 v, for the sensitivity assumed above, yields a time axis 67 mm long. The oscillograms of Figs. 12–14 are of waves of 20 and 30 Mc/s. By adjusting the condenser C and the charging current, the time-base frequency can be varied from a minimum of 8 c/s (Fig. 15 shows an oscillogram of a 50 c/s wave taken with this adjustment) to the full 5 Mc/s. "The above figures are about ten times as high as those of time bases previously described."

2198. Decimetric-Wave Oscillography.—Ganswindt & Pieplow. (*Hochf:tech. u. Elek:akus.*, April 1941, Vol. 57, No. 4, pp. 114–116.)

Section I describes the difficulties besetting the distortionless oscillography of such high-frequency processes even when a suitable cathode-ray tube is available: thus the necessity for the shortest possible leads (which must however be tunable) is stressed, in order that the voltage drop may not be too great, especially if a sealed-off tube, with its comparatively low sensitivity, is used. Such leads, to avoid loss by radiation and the penetration of h.f. energy into the lens system (producing a blurred or brightness-modulated spot) should be screened (*e.g.* by use of the coaxial form), and matched as to characteristic impedance both to the deflecting-plate capacity and to the source of the voltage to be recorded. Further, points of "jump" and reflection must be avoided.

Section II considers the choice of oscillographic method: stationary images are no doubt eminently desirable, but although periodic "kipp" oscillations linear in time have recently been developed with frequencies of several Mc/s (*see* Lichtenberg, 2197, above) such methods fail, even if frequencies still higher could be obtained, owing to the fact that phenomena of frequency above 100 Mc/s cannot be synchronised exactly because their sources are themselves too imperfectly constant (Pieplow, *Archiv. f. Elektrot.* paper in the press). Either, therefore, one must work on a single, unrepeated image for qualitative observation or photographic recording, or one must turn to the method of Hollmann's "inversion spectrograph" (3077 of 1939), or his method of "ultradynamic Lissajous' figures" (544 of 1940). Both methods have the disadvantages of representing the process only indirectly (so that a time-wasting graphical construction is necessary for its explicit representation as a function of time) and of failing in practice in the presence of harmonics of very high order: they demand, moreover, a tube construction which is special in some points. Fig. 1 illustrates the ultradynamic Lissajous' figure of a two-wave voltage (frequencies 2 : 7, amplitudes 2 : 1) and shows the lack of straightforwardness which appears in certain conditions.

On the other hand, the obtaining of an oscillogram of a decimetric wave on a single occurrence puts extreme demands on the performance of the tube employed: thus if a 10^9 c/s oscillation is to be traced even with only a 1 cm amplitude, this involves (where the curve passes through the zero points) a tracing speed of over 60 000 km/s, well above the limits of the commercial cold-cathode oscillograph (Buchkremer, 279 of 1939). A very brilliant tube is evidently required, and the high-performance design of Katz & Westendorf (4098 of 1939) will do the work: it is a sealed-off tube with 20 kv anode voltage, giving reliable recording at speeds up to 50 000 km/s (Pieplow, *loc. cit.*). It is true that the sensitivity curve shows a marked decrease around 10^9 c/s (Fig. 2, calculated from the simple formula given by Hollmann—*see* Abstracts, 1932, pp. 652–653, and 1933, pp. 634), so that the curve-images of multi-wave processes at such frequencies will be more or less distorted: "but in most practical cases a view will be obtained of the course of the fundamental oscillation which is at any rate qualitatively correct."

Section III deals with the time base. The combination of two ordinarily simple requirements—the greatest possible linearity as a function of time, and symmetry with respect to earth—presents considerable practical difficulty when it is a matter of generating very rapidly varying deflecting voltages; for linearity is usually obtained with the help of non-linear components such as valves, while symmetry generally requires that the cathode potential of at least one of these valves should not be fixed with respect to earth (the use of a phase-reversing valve, which would get round this difficulty, is ruled out for reasons given in footnote 11). But this is likely to result in large ballast capacities, which would hinder the rapid variation of the deflecting voltage—an example given shows that a variation rate of 100 kv/μsec. may well be required, and since the total circuit capacity can hardly be reduced below 100 picofarads, this involves charging or discharging currents for the time-base condenser of the order of 10 amperes, which must be carried by the charge or discharge valve. From these considerations the circuit of Fig. 3 was designed: the condenser C, charged symmetrically with respect to earth through equal resistances R_1 and R_2, is discharged through a high-powered pentode V_E at the moment of the oscillogram. The pentode current is kept constant, in spite of the fluctuating cathode potential, by deriving the pentode control-grid bias from the discharge potential of a gaseous-discharge tube Th which is decoupled (as regards a.c.) from its d.c. supply by high resistances, and which follows the potential changes of the cathode of V_E. The releasing impulse is taken to the grid of Th. Simultaneously with the time-base deflection the spot of the cathode-ray tube is brightened by control through the Wehnelt cylinder.

Section IV describes some results obtained to illustrate the capabilities of the equipment. Fig. 4a shows the method of coupling the oscillograph plates to a magnetron: the latter works into a Lecher pair short-circuited at its far end, and the coupling-loop connected to the plates is also short-circuited by a wire running parallel to the other short-circuiting wire, thus providing the coupling. Fig. 2b shows the coupling method for a triode: here the Lecher pair from the valve is open-ended and a quarter-wavelength long, while the pair leading to the plates has a shorting bar a quarter-wavelength from its free ends, which slightly overlap the open ends of the other pair. This latter method has proved very successful in symmetrising the potentials to the plates. The various oscillograms shown are reduced, from their size on the screen, in the ratio 1 : 1.25. Fig. 5 shows a two-wave magnetron oscillation with 600 Mc/s as the higher of the two frequencies: since the relations between the two waves were exactly those for the ultradynamic Lissajous' figure of Fig. 1 discussed above, this oscillogram shows the advantages of the present direct technique. Another adjustment of the magnetron yielded the curves of Figs. 6 and 7, where the two frequencies are not merely superposed as in Fig. 5, the shorter wave (around 600 Mc/s) appearing modulated: the Lissajous' figure method would fail here. "A comparison of Figs. 6 and 7 (the latter is only recorded with heightened resolution) yields the interesting fact that the 'modulation frequency' and the harmonic content vary equally with the working conditions of the magnetron." The magnetron can be so regulated as to give practically only a single frequency (Fig. 8). The voltage of a triode oscillator at a frequency of 1000 Mc/s is seen in Fig. 9, which clearly shows the capabilities of the time-base circuit: in its linear part its resolution is actually 1.4×10^{-10} s/mm: regarding the ignition lag of the gaseous-discharge tube Th, the first four waves of Fig. 9, recorded rather more slowly than the later ones, show that the full discharge current of the time-base condenser is reached at least 4×10^{-9} s after the beginning of the oscillogram. Since in this record the repose position of the darkened spot almost coincides with this beginning, the total delay between the striking of Th and the attainment of the full voltage on the control grid of the pentode can be estimated at 6–8×10^{-9} second.

2199. MEASUREMENT OF THE BUILDING-UP TIME OF GAS-FOCUSED CATHODE RAYS.—Stefaniak. (*Ann. der Physik*, 10th June 1940, Vol. 37, No. 7, pp. 541–556.)

The method of observation by means of a rotating mirror driven at 2000–3000 r.p.s. by a high-speed turbine was abandoned on account of mechanical difficulties with the four-surfaced mirror, although it has proved very satisfactory in another application. The method adopted was to allow the ray to pass only for a short time τ, to increase τ gradually, and to take a photographic record of the ray for each τ. So long as τ is small compared with τ_A, the building-up time of the ray (that is, the time necessary for the formation of the requisite space-charge field), the images are different for different values of τ, but as soon as τ exceeds τ_A the image no longer changes.

The description of the apparatus includes the method of producing the rectangular pulses of duration τ, for application to the Wehnelt cylinder, and a circuit (using two space-charge-grid valves) for measuring τ. To make the sharpness of the ray (as judged by the spot) more easily estimated, it was deflected by a 50 c/s rotating field. Tests on a commercial type of gas-focused tube gave a building-up time of 3.3×10^{-6} s. Further projected tests, with filamentary rays in hydrogen, were interrupted by the war after it had been found that different values for the building-up time were obtained according to whether the rectangular pulses were applied to the Wehnelt cylinder, the pre-anode, or the main anode. This difference was shown also in the amplitude of the deflection caused by the magnetic field: it led to the conclusion that the building-up process in the accelerating system plays an important rôle regarding the building-up time of the ray, and that the mean electron velocity at the beginning of the building-up process is smaller than in the complete ray. Another experiment, however, described in the final paragraph, seems rather to contradict this last conclusion.

2200. THE MEASUREMENT OF VELOCITY-DISTRIBUTION FUNCTIONS [by a Special Cathode-Ray-Oscillograph Equipment: with Specimen Records of the Velocity-Distribution Curves of the Electrons in Mercury Vapour].—Vetterlein. (*Ann. der Physik*, 5th July 1940, Vol. 37, No. 8, pp. 583–588.)

2201. AN OSCILLOGRAPHIC EQUIPMENT FOR OBSERVING FREQUENCY-RESPONSE CURVES OF RADIO RECEIVERS.—Hibbard. (*See* 2112.)

2202. THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF ELECTRON MOTIONS IN ALTERNATING FIELDS WITH THE AID OF BALLISTIC MODELS.—Hollmann. (*See* 2124.)

2203. A MAGNETIC-LENS BETA-RAY SPECTROMETER [Successful Use of the Chromatic Aberration of Klemperer's "Short" Magnetic Lens (302 of 1936)].—Deutsch. (*Phys. Review*, 15th April 1941, Vol. 59, No. 8, pp. 684–685: summary only.)

2204. DEFLECTION ERRORS OF ELECTRIC AND MAGNETIC DEFLECTING SYSTEMS: CORRECTIONS.—Glaser. (*Zeitschr. f. Phys.*, 26th March 1941, Vol. 117, No. 5/6, p. 412.) *See* 1577 of 1939.

2205. THE RIGOROUS CALCULATION OF MAGNETIC LENSES WITH THE FIELD-FORM $H = H_0/[1 + (z/a)^2]$, [as used in the High-Resolution Electron Microscope: Derivation of Optimum Conditions as regards Chromatic & Spherical Aberrations: Effect of Field Asymmetry: etc.].—Glaser: Dosse. (*Zeitschr. f. Phys.*, 26th March 1941, Vol. 117, No. 5/6, pp. 285–315: pp. 316–321.)

2206. ON SURVEYING THE FIELD OF A MAGNETIC ELECTRON LENS [Method suitable for the Very Inhomogeneous Fields occurring in Short-Focus Lenses for Electron Microscopes].—Dosse. (*Zeitschr. f. Phys.*, 30th April 1941, Vol. 117, No. 7/8, pp. 437–443.)

From the Siemens & Halske laboratories. Previous methods which have proved quite satisfactory for comparatively large fields or for enlarged models fail for the present purpose. In the method here described an exploring coil (winding space 0.4 mm long, 0.3–0.4 mm external diameter: about 100 turns) is mounted at the end of a small glass tube carried on a rigid rod capable of fine (microscope-observed) adjustment along and normal to the lens axis. The current pulses generated when the field is suddenly changed (switched on, off, or reversed) are measured by a ballistic galvanometer. Other possible methods (bismuth spiral, etc.) are rejected on grounds given in footnote 1.

2207. FRESNEL DIFFRACTION OF ELECTRONS AS A CONTOUR PHENOMENON IN ELECTRON SUPERMICROSCOPE IMAGES.—Hillier. (*Phys. Review*, 1st Nov. 1940, Vol. 58, No. 9, p. 842.) *Cf.* Boersch, 1736 & 1737 of June. For the instrument referred to by Hillier *see* 1173 of April.

2208. AN ELECTRON SUPERMICROSCOPE WITH AN ELECTRON PROBE SWITCHED-ON AT WILL TO GIVE ELECTRON-DIFFRACTION DIAGRAMS OF A DEFINITE SMALL REGION OF THE FIELD OF VIEW.—von Ardenne. (*Zeitschr. f. Phys.*, 30th April 1941, Vol. 117, No. 7/8, pp. 515–523.) Thus helping in the interpretation of the ordinary electron-microscopic image.

2209. HIGH-RESOLUTION MICROSCOPY WITH FAST ELECTRONS.—von Borries & Ruska. (Survey in "*Ergebnisse der exakten Naturwissenschaften*", Vol. 19, reviewed in *Naturwiss.*, 4th April 1941, Vol. 29, No. 14/15, pp. 223–224.)

2210. THE CATHODE FOLLOWER [Formula for Its Impedance].—Good: Turney. (*Wireless World*, June 1941, Vol. 47, No. 6, pp. 166–167.) Disagreement with formula given by Turney (1729 of June).

2211. "MAGIC EYE" IONISATION GAUGE [for Pressures 10^{-3} to 10^{-7} mm Hg].—Ridenour. (*Review Scient. Instr.*, March 1941, Vol. 12, No. 3, pp. 134–136.)

2212. VACUUM PACKING FOR VALVES [Standard Hand-Operated Valve made Vacuum-Tight].—Ridenour & Harnwell. (*Review Scient.*

Instr., March 1941, Vol. 12, No. 3, p. 157.) Using the principle of the sliding seal described by Wilson, 1753 of June.

2213. THE QUANTUM OUTPUT OF THE OPTICAL DISPERSAL OF THE F' BAND IN ALKALI-HALIDE CRYSTALS, *and* ON THE INCLUSION OF CHEMICALLY DEFINED ADDITIONS IN ALKALI-HALIDE CRYSTALS.—Pick: Akpinar. (*Ann. der Physik*, 1st May 1940, Vol. 37, No. 5/6, pp. 421/428: pp. 429–441.)

2214. ON THE POLAR VIBRATIONS OF ALKALI HALIDES.—Lyddane & others. (*Phys. Review*, 15th April 1941, Vol. 59, No. 8, pp. 673–676.)

2215. ELECTRON MULTIPLIER AS AN ELECTRON COUNTING DEVICE.—Bay. (*See* 2133.)

2216. A METHOD OF MEASURING HIGH RADIATION INTENSITIES BY THE COUNTER TUBE.—Trost. (*See* 2301.)

2217. A NEW FORM OF FIELD ELECTRON EMISSION FROM METALLIC SURFACES COVERED BY A DEPOSIT OF INSULATING MATERIAL.—Paetow. (*See* 2136.)

2218. THE PRODUCTION OF PROTON BEAMS [Further Work on Capillary Ion Sources of Diffusion Type: 50% Yield Increase by Coating of Phosphorus Pentoxide: etc.], *and* AN EXPERIMENTAL INVESTIGATION OF ION-BEAM FOCUSING.—Lamar & others. (*Journ. of Applied Phys.*, Feb. 1941, Vol. 12, No. 2, pp. 132–140: pp. 141–148.)

2219. ACCELERATION OF ELECTRONS BY MAGNETIC INDUCTION [Previous Unsuccessful Attempts: Success of Experiment, leading to Development of the "Induction Accelerator"].—Kerst. (*Phys. Review*, 1st Nov. 1940, Vol. 58, No. 9, p. 841.) For this new accelerator *see* also 1485 of May.

2220. THE USE OF A ROTATING DISC FOR CHARGE TRANSPORTATION IN ELECTROSTATIC HIGH-VOLTAGE GENERATORS [of van de Graaff Type: Advantages over the Moving Band]. Fauldrath. (*Zeitschr. f. Phys.*, 5th Dec. 1940, Vol. 116, No. 11/12, pp. 701–703.) For a correction see *ibid.*, 26th March 1941, Vol. 117, No. 5/6, p. 412. For comments by Dahl see *ibid.*, 30th April 1941, No. 7/8, pp. 543–544.

2221. ON THE PRESSURE-DEPENDENCE OF THE D.C. CORONA.—Hinderer & Walter. (*See* 2148.)

2222. AVALANCHE PRODUCTS, THE LOWERING OF THE BREAKDOWN POTENTIAL, AND THE FALLING CHARACTERISTIC, *and* ON THE BUILDING-UP OF GASEOUS DISCHARGES.—Rogowski: Raether. (*See* 2085.)

2223. ON THE LIFE OF FREE ELECTRONS IN AFTER-GLOWING MERCURY VAPOUR.—Grübling. (*See* 2042.)

2224. CORRECTIONS TO MISPRINTS IN "THE DESIGN OF COPPER-OXIDE AND SELENIUM RECTIFIERS."—Vitenberg. (*Automatics & Telemechanics* [in Russian], No. 3, 1940, p. 108.) *See* 540 of February.

2225. A RECTIFIER OF THE SELENIUM GROUP ["Westalite", with Advantages over Copper-Oxide Type for Large Outputs].—Westinghouse. (*Journ. of Scient. Instr.*, June 1941, Vol. 18, No. 6, p. 117.) "Not purely of the selenium type."

2226. A REGULATED BATTERY-OPERATED HIGH-VOLTAGE SUPPLY, *and* A LIGHT-WEIGHT, HIGH-VOLTAGE SUPPLY FOR GEIGER COUNTERS.—Barry: Neher & Pickering. (*See* 2090.)

2227. VIBRATOR POWER PACKS: A NEW DEVELOPMENT IN SMOOTHING FOR USE WITH SENSITIVE RECEIVERS.—Masteradio, Ltd. (*Wireless World*, June 1941, Vol. 47, No. 6, p. 167.)

2228. THE THEORY OF THE OPERATION OF VIBRATOR VOLTAGE REGULATORS USED IN AIRCRAFT.—Bobov. (*Automatics & Telemechanics* [in Russian], No. 6, 1940, pp. 37–49.)

The output voltage of engine-driven generators is normally maintained constant by a vibrator regulator which periodically short-circuits a resistance in the excitation circuit of the machine (Figs. 1 and 2). The theory of these regulators is discussed, and regulators with and without an accelerating winding, with contacts rigidly fixed, and with contacts mounted on springs, are considered.

2229. THE DESIGN OF THE ANODE CIRCUITS OF THYRATRON REGULATORS FOR ALTERNATING CURRENT.—Ivakhnenko. (*Automatics & Telemechanics* [in Russian], No. 6, 1940, pp. 121–132.)

2230. THE ELECTRICAL CHARACTERISTICS OF DRY CELLS.—Daniele-Bek. (*Elektrosvyaz* [in Russian], No. 10, 1940, pp. 71–79.)

The behaviour of dry cells with manganese (Leclanché type), manganese-air, and air depolarisation was observed under the conditions of an interrupted discharge: data are given for computing the working capacity of these cells for various operating conditions.

2231. THE SURFACE PROTECTION OF METALS [Survey].—Wiederholt. (*Zeitschr. V.D.I.*, 17th May 1941, Vol. 85, No. 20, pp. 451–459.)

2232. PROTECTOR OF METALS ["Tectyl" Compounds].—(*Review Scient. Instr.*, March 1941, Vol. 12, No. 3, pp. 163–164.) In four grades, for uses ranging from the protection of instruments used indoors to the cleaning of salvaged machinery.

2233. "WERKSTOFFSPAREN: HEFT I — WERKSTOFFSPAREN IN KONSTRUCKTION UND FERTIGUNG" [Saving in Materials during War: Book Review].—Wögerbauer. (*E.N.T.*, Jan./Feb. 1941, Vol. 18, No. 1/2, p. 7.)

2234. THE VDI LECTURES ON "SUBSTITUTION OF MATERIALS IN MACHINE AND APPARATUS MANUFACTURE" [to increase Use of Native Materials].—Ehlers. (*Zeitschr. V.D.I.*, 3rd May 1941, Vol. 85, No. 18, pp. 413–416.) *Cf.* 1515 of May.

2235. THEORY OF THE PLASTIC PROPERTIES OF SOLIDS: II [Work Hardening, and the associated Energy Increase: Resoftening: Hardening Influence of Impurities: Precipitation Hardening: Multiple Gliding: Asterism].—Seitz & Read. (*Journ. Applied Phys.*, March 1941, Vol. 12, No. 3, pp. 170–186.)

2236. "THE MODERN THEORY OF SOLIDS" [Book Review].—Seitz. (*Nature*, 24th May 1941, Vol. 147, pp. 623–624.) "The application of atomic theory to solids." *See* also *Proc. Phys. Soc.*, 1st May 1941, Vol. 53, Part 3, pp. 324–325.

2237. MAGNETIC SCREENING BY SINGLE AND MULTIPLE CYLINDERS OF LIMITED LENGTH, AT NOTE FREQUENCIES [Cylinders exposed to an External, Coaxial Field].—F. Moeller. (*E.N.T.*, Jan./Feb. 1941, Vol. 18, No. 1/2, pp. 1–7.)

For previous work *see* 2377 of 1939. Author's summary:—"After a description of the testing equipment and of the cylinder material employed [commercial copper foil and sheet of thickness 10–120 μm], measurements on single cylinders of limited length are first compared with Kaden's calculations for infinitely long cylinders [1932 Abstracts, p. 654]. The damping action of 15 cm long cylinders was found, as expected, to become smaller and smaller as the ratio of the cylinder length to diameter became smaller (Fig. 8). A cylinder of 5 cm radius and 30 cm length can be regarded as practically of infinite length (Fig. 9). The dependence [of the damping] on frequency and wall-thickness is shown in Fig. 10 for 15 cm and 30 cm lengths with and without end covers [the screening effect of a cylinder with covers can, according to these limited tests, be considered as about half way between those of an open-ended and an infinitely long cylinder]. The variation of damping with the product wall-thickness × frequency is established (Fig. 11).

"To obtain information on the influence of cylinder spacing, average diameter, and number, for cylinders of limited length, systems of from 2 to 15 cylinders were investigated. For example, a particular series of 15 cylinders with diameters ranging from 6 to 20 cm was measured at 10 kc/s in all possible arrangements. The most important results are collected at the end of section 4" [thus the damping is found to increase, very roughly, linearly with the number of cylinders].

2238. THE MAGNETOSTRICTION OF IRON IN HIGH MAGNETIC FIELDS.—Rüdiger & Schlechtweg. (*Ann. der Physik*, 13th Jan. 1941, Vol. 39, No. 1, pp. 1–18.)

2239. FERROMAGNETIC ANISOTROPY AND THE ITINERANT ELECTRON MODEL.—Brooks. (*Phys. Review*, 15th Nov. 1940, Vol. 58, No. 10, pp. 909–918.)

2240. THE SPOILING OF TUNGSTEN MAGNET STEELS [X-Ray Examination of Changes during Heat-Treatment].—Wainwright. (*See* 2303.)

2241. CONSTRUCTION OF A LABORATORY ELECTRO-MAGNET WITH WATER-COOLED EXCITING COILS.—Joyet & Perrier. (*Bull. de l'Assoc. suisse des Élec.*, No. 25, Vol. 31, 1940, pp. 577–585: in French.)

2242. THE USE OF GRAPHICAL AND NUMERICAL INTEGRATION OF NON-LINEAR EQUATIONS FOR DETERMINING THE LAWS OF THE DISTRIBUTION OF MAGNETIC FLUX IN THE MAGNETIC CIRCUIT OF A NEUTRAL ELECTRO-MAGNETIC DEVICE.—Livshits. (*Automatics & Telemechanics* [in Russian], No. 2, 1940, pp. 39–62.)

Simplified methods of sufficient accuracy are proposed for integrating the differential equations. Sucking and rotating electro-magnets are considered, with air gaps shaped in accordance with various laws. Special consideration is given to magnetic circuits with varying specific conductivity of leakage fluxes.

2243. A METHOD FOR THE DESIGN OF A.C. MAGNETIC CIRCUITS.—Sotskov. (*Automatics & Telemechanics* [in Russian], No. 2, 1940, pp. 101–112.)

Based on graphical construction and enabling the magnetic reluctance and losses in iron, leakage fluxes, and ohmic resistance of coils to be taken into account. Using this method, the magnetic flux in the circuit can be determined with an accuracy within 8–20%. The force of attraction of an electro-magnet for various air gaps is also determined.

2244. A COMPLEX METHOD FOR DESIGNING MAGNETIC CIRCUITS.—Shumilovski. (*Automatics & Telemechanics* [in Russian], No. 4, 1940, pp. 41–58.)

A new method is proposed based on determining magnetic reluctances of various sections of the circuit. The reluctances are represented by complex quantities, in the imaginary parts of which the losses due to hysteresis, Foucault currents, and secondary currents in short-circuited turns are taken into account. The method is illustrated by a numerical example which has been verified experimentally.

2245. REMARKS ON MY PAPER "CIRCUIT ARRANGEMENTS FOR QUICK-ACTION MAGNETS."—Blankenburg. (*E.T.Z.*, 26th Dec. 1940, Vol. 61, No. 52, p. 1204.) *See* 212 of January.

2246. A GENERAL METHOD FOR THE DESIGN OF THE WINDING OF A D.C. ELECTRO-MAGNETIC RELAY.—Sotskov. (*Automatics & Telemechanics* [in Russian], No. 4, 1940, pp. 59–68.)

A grapho-analytical method is proposed for determining the main parameters (wire, diameter number of turns, resistance of winding) of the winding of an electro-magnetic relay from the volt/ampere characteristics of the winding. It is claimed that this method enables the above parameters to be easily determined even for use in the most complicated circuits.

2247. The Inductance of Telephone Relays, *and* The Determination of the Sensitivity of a Russian-built Telephone Relay.—Vitenberg : Mats. (*Elektrosviaz* [in Russian], No. 10, 1940, pp. 39–53 : pp. 64–70.)

2248. Papers on Apparatus for Measuring the Operating Times of Relays.—Ferrari-Toniolo : Walker : Jurgenson. (*See* 2188/2190.)

2249. Coil Winding Machine [for Small Coils such as those of Loudspeakers, Relays, or Pick-Ups].—(*Journ. of Scient. Instr.*, June 1941, Vol. 18, No. 6, p. 116.)

2250. The Optimum Damping of Coils with Compressed-Powder Cores.—Labus. (*See* 2097.)

2251. The Interaction of Electrons in Metals and Insulators.—Ufford. (*Phys. Review*, 1st April 1941, Vol. 59, No. 7, pp. 598–608.)

2252. The Light emitted by Solid Insulators [and the Band Models of Quantum Theory : Multiple Collision (Interaction of Electrons & Sound Quanta) : Decrease of Transparency with Increased Temperature : etc.].—Möglich. (*Angewandte Chemie*, 31st Aug. 1940, Vol. 53, No. 35/36, pp. 405–409.)

2253. Results and Problems in Chemistry, Physical Chemistry, and the Physics of Macromolecular Materials [Polystyrols, etc : Long Survey].—Husemann & others. (*Naturwiss.*, 23rd May 1941, Vol. 29, No. 21, pp. 305–317 : to be concluded.) Continued from No. 18.

2254. New Plastic Materials : Commercial Development of Ethyl Cellulose and Polystyrene.—(*Electrician*, 16th May 1941, Vol. 126, p. 288.) Including a review of the catalogue produced by the British Plastics Export Group.

2255. Saran—New Vinylidene Chloride Resins. —Goggin. (*Journ. Franklin Inst.*, April 1941, Vol. 231, No. 4, p. 380 : summary only.)

2256. Measurement of the Conductivity and Dielectric Constants of Biological Substances in the Wave-Range 400 to 10 000 Metres.—Stachowiack. (*See* 2317.)

2257. Dielectric Properties of Organic Compounds : Relation to Chemical and Physical Structure [Departures of Dielectric Constants of Polar Liquids from Calculated Values explained by Association or Interaction : Geometry of Molecule the Determining Factor for High Dielectric Constant in Solids : Motion of Polar Groups (instead of Rotation of Molecules) in Plastics : etc.].—Morgan & Yager. (*Bell Tel. System Tech. Pub.*, Monograph B-1265, 25 pp.)

2258. The Electrical Conductivity of Plastic Dielectrics [treated by Ionic Mobility Equations : Comparison of Calculated Results with Experimental].—Gemant. (*Phil. Mag.*, May 1941, Vol. 31, No. 208, pp. 405–412.)

2259. On Some Studies for Steatite as High-Frequency Insulators : Teison No. 1 [Curves of Dielectric Loss *versus* Firing Temperature, for This Steatite without & with Additions : Other Tests].—Kamayachi & Sugiura. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, p. 236.)

2260. Judgment on the Superiority of Mica with the Schlieren Method.—Shimizu & Nishifuji. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, pp. 231–232.)

2261. On the Elasticised Japanese Lacquer Coating and Its Electrical Characteristics [Elasticity, etc., of Urushiol improved by Admixture of Synthetic Rubbers].—Shimizu & Inai. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, p. 233.)

2262. Study on Heat Absorptive Power of Various Electrical Materials [including Glass, Bakelite, etc : with Method of Measurement at about 50° C].—Shimizu & others. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, pp. 222–223.)

2263. The Electric Breakdown of Glass with Impulse Voltage [Experimental Investigations with Varying Steepness of Wave Front].—Inada & Soijima. (*Electrotech. Journ.*, Tokyo, Oct. 1940, Vol. 4, No. 10, p. 231.)

2264. Effect of Heat on the Breaking Strength of Asbestos Tape and Glass-Fibre Tape. —Wolochow. (*Canadian Journ. of Res.*, Feb. 1941, Vol. 19, No. 2, Sec. B, pp. 56–60.) For another comparison of the two types of tape *see* Jamieson, *Sci. Abstracts*, Sec. B, Jan. 1941, Vol. 44, No. 517, pp. 11–12.

2265. Reproducible Flame for testing Electrical Insulating Materials. — Wyman. (*Engineering*, 25th April & 2nd May 1941, Vol. 151, pp. 321–323 & 345.) E.R.A. Report Ref. L.T. 75a.

2266. Absorption Measurements in Colloidal Solutions and Electrolytes in the Wave-Range 10.5 to 20 Metres.—Heffels. (*Ann. der Physik*, 10th June 1940, Vol. 37, No. 7, pp. 477–494.)

2267. Ionic Mobilities in Insulating Liquids [computed from Conductivity/Time Curves after Application of D.C. Potential : Mobilities of Order of 10^{-7} cm/s per volt/cm for Mineral Oils].—Gemant. (*Phys. Review*, 15th Nov. 1940, Vol. 58, No. 10, pp. 904–908.)

2268. Effect of Flow on the Dielectric Constant of Liquids.—Prasad & others. (*Nature*, 7th June 1941, Vol. 147, p. 712.) *See* also 1261 of April.

STATIONS, DESIGN AND OPERATION

2269. Wired Radio Broadcasting.—Shinohara & Hirano. (*Nature*, 14th June 1941, Vol. 147, pp. 753–754.) Summary of the paper dealt with in 1985 of July.

2270. Radio Control Equipment at the New Washington, D.C., Airport. — Bunday. (*See* 2144.)

2271. Recent Tests on the Alexanderson Long-Wave Aerial [in connection with Communication with Submerged Submarines].—Rosani. (*See* 2123.)

2272. The Havana Agreement and Its Effect on Canadian Broadcasting.—Bain. (*Proc. I.R.E.*, Feb. 1941, Vol. 29, No. 2, p. 86: summary only.)

2273. Frequency-Modulation Station Monitor [acts as Centre-Frequency Monitor, Modulation & High-Fidelity Audio Monitor, and Modulation-Limit Flasher-Type Indicator].—(*Gen. Elec. Review*, March 1941, Vol. 44, No. 3, p. 188.)

GENERAL PHYSICAL ARTICLES

2274. On the Diffraction of Electromagnetic Waves at a Half Plane, *and* The Theory of Anomalous Diffraction Gratings and of Quasi-Stationary Waves on Metallic Surfaces (Sommerfeld's Waves). — Magnus: Fano. (*See* 2079 & 2080.)

2275. The Reflection and Refraction of Photons [on the Writer's Vibratory Electron Doublet Theory].—Taylor Jones. (*Phil. Mag.*, May 1941, Vol. 31, No. 208, pp. 394–404.)

2276. Ionisation Maximum for Protons [in Air: probably One Half, rather than One Third, of That for Alpha Particles].—Feather. (*Nature*, 26th April 1941, Vol. 147, pp. 510–511.)

2277. The Excitation of the Hydrogen Molecule by Electron Impact [Calculations covering Excitation of All the More Important States by Fast Electrons, using the Born Approximation]. — Roscoe. (*Phil. Mag.*, May 1941, Vol. 31, No. 208, pp. 349–362.)

2278. The Effect of an Electric Field of Strength $-1/2aF^2$ on the Polarisability Constant of the Normal Hydrogen Atom.—Robinson. (*Indian Journ. of Phys.*, Oct. 1940, Vol. 14, Part 5, pp. 405–408.)

2279. The Ratio of e, c, and h.—Landé. (*Phys. Review*, 1st Nov. 1940, Vol. 58, No. 9, p. 843.)

2280. The Specific Charge of the Positron [Data obtained by Direct Comparison between Electrons & Positrons].—Spees & Zahn. (*Phys. Review*, 15th Nov. 1940, Vol. 58, No. 10, pp. 861–864.)

2281. Larmor's Law in Wave Mechanics.—Knittel. (*Ann. der Physik*, 13th Jan. 1941, Vol. 39, No. 1, pp. 51–54.)

2282. Artificial Boundary Conditions in Wave Mechanics: the Restricted Rotator.—Sommerfeld & Hartmann. (*Ann. der Physik*, 1st May 1940, Vol. 37, No. 5/6, pp. 333–343.)

A later work by Hartmann will deal with the connection with phase transitions in certain solid materials and with Debye's theory of the oscillation of a dipole molecule in an electric field.

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MISCELLANEOUS

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2285. The Design and Interpretation of Experiments based on a Four-Fold Table: the Statistical Assessment of the Effect of Treatment.—Kermack & M'Kendrick. (*Proc. Roy. Soc. Edinburgh*, Part 4, Vol. 60, 1939/40, pp. 362–375.)

2286. A Mechanical Method for Graphical Solution of Polynomials.—Brown & Wheeler. (*Journ. Franklin Inst.*, March 1941, Vol. 231, No. 3, pp. 223–243.)

2287. Discovery and Invention. — Gregory. (*Journ. Roy. Soc. Arts*, 16th May 1941, Vol. 89, pp. 393–408.)

2288. Industrial Research in the United States in 1940.—Hamor. (*Science*, 14th Feb. 1941, Vol. 93, pp. 160–162: long summary only.)

2289. Debt of Modern Physics to Recent Instruments.—Darrow. (*Review Scient. Instr.*, Jan. & Feb. 1941, Vol. 12, Nos. 1 & 2, pp. 1–10 & 53–61.)

2290. "Atoms in Action: the World of Creative Physics" [Book Review].—Harrison. (*Proc. Phys. Soc.*, 1st March 1941, Vol. 53, Part 2, pp. 197–199.) An enthusiastic review.

2291. Science and Secrecy [Leading Article on Address "Science, National & International, and the Basis of Cooperation"].—Hill. (*Engineer*, 21st Feb. 1941, Vol. 171, pp. 130–131.) *See* also pp. 134–135, and *Engineering*, 21st Feb. 1941, pp. 151–152. For the address itself see *Engineering*, 28th Feb. & 7th March, pp. 175–176 & 194–195: a part is given in *Nature*, 1st March, pp. 250–252.

2292. Science and Government [Correspondence].—(*Nature*, 8th March 1941, Vol. 147, pp. 298–299.) *See* also Editorial, pp. 275–276.

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2294. Wireless in the Royal Army Ordnance Corps: Testing and Repairing Equipment: the Training of Personnel.—Cocking. (*Wireless World*, March 1941, Vol. 47, No. 3, pp. 67–70.)

2295. The Future of Amateur Radio [Correspondence].—(*Wireless World*, March 1941, Vol. 47, No. 3, pp. 91–92.) Prompted by a letter in the February issue. *See* also April issue, pp. 101–102 & 107, and Editorial, p. 97: and May issue, pp. 140–141.

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2297. Nomenclature relating to Electrical Communication: in connection with the Proposed Italian Vocabulary of Telecommunications. — Ferrari - Toniolo. (*Alta Frequenza*, July 1940, Vol. 9, No. 7, pp. 436–438: summary only.)

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2299. Analysis of Surface Magnetic Fields by Integrals: Part I [applicable to Magnetic Geophysical Prospecting].—Vestine. (*See* 2059.)

2300. New Clue for Oil Explorers [Gamma Rays, radiated from Rock Formations, will provide Tool for Prospecting].—(*Journ. Franklin Inst.*, April 1941, Vol. 231, No. 4, p. 344: summary only.)

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2303. Symposium on X-Ray Analysis in Industry: Part I—Industrial Applications of X-Ray Analysis: Contents of Part II—Technique of X-Ray Analysis Methods and Some Recent Developments.—(*Journ. of Scient. Instr.*, May 1941, Vol. 18, No. 5, pp. 69–102.)

2304. Beryllium Windows for X-Ray Tubes [Superiority over Aluminium: Grinding Technique].—Klug. (*Review Scient. Instr.*, March 1941, Vol. 12, No. 3, pp. 155–156.)

2305. Images of Minute Particles, especially of Molecules, by means of the Universal Electron Microscope. — von Ardenne. (*Sci. Abstracts*, Sec. A, May 1941, Vol. 44, No. 521, p. 139.)

2306. Application of the Electron Microscope to the Study of Photographic Phenomena.—Hall & Schoen. (*Journ. Opt. Soc. Am.*, April 1941, Vol. 31, No. 4, pp. 281–285.)

2307. The Cathode - Ray Oscillograph in Industry.—Wilson. (*BEAMA Journal*, April & May 1941, Vol. 48, Nos. 46 & 47, pp. 58–61 & 75–77.)

2308. Some Factors influencing the Performance of Diaphragm Indicators of Explosion Pressures.—Caldwell & Fiock. (*Journ. of Res. of Nat. Bur. of Stds.*, March 1941, Vol. 26, No. 3, pp. 175–196.)

2309. An Electro-Optic Pressure Indicator [developed from the Labarthe Diaphragm Indicator]. — Robertson. (*Review Scient. Instr.*, March 1941, Vol. 12, No. 3, pp. 142–148.)

2310. Physics in the Printing and Paper-Making Industries [including Some Pitfalls in the Path of the Physicist].—Harrison. (*Journ. of Scient. Instr.*, June 1941, Vol. 18, No. 6, pp. 103–109.)

2311. Dynamic Investigations on Machine-Tool Frames [using Capacity-Change Pick-Up].—Kettner. (*Zeitschr. V.D.I.*, 12th April 1941, Vol. 85, No. 15, pp. 370–371.)

2312. Surface Hardening by Induction [Frequencies 2–100 kc/s and over].—Osborn. (*Engineer*, 6th June 1941, Vol. 171, pp. 372–373.)

2313. Colour-Music for the Home [and the Development of the Dual Colour-Organ, automatically controlled by Broadcast or Gramophone Music]. — Burchfield. (*Electronics*, Jan. 1941, Vol. 14, No. 1, pp. 44..50.) The "dual" action here described seems a quite new feature, giving a new effect.

2314. Discreteness of Sensations [Phenomenon of Fluctuation of Threshold of Hearing, already observed, occurs also in Fields of Vision & Touch].—Lifshitz. (*Nature*, 29th March 1941, Vol. 147, pp. 390–391.)

2315. Tribo-Electricity in Wool and Hair [Sign of Charges depends on Sense of Rubbing: Results due to Cuticle Cells, but Not the Cortical Cells, being Piezo-electric].—Martin. (*Proc. Phys. Soc.*, 1st March 1941, Vol. 53, Part 2, pp. 186–189.)

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2318. On the Theory of the Biological Action of Radiation : I [Derivation of a Function by which the Number of Hits can be calculated from the Experimental Curve of Injury].—Koyenuma. (*Zeitschr. f. Phys.*, 30th April 1941, Vol. 117, No. 7/8, pp. 510–514.)

2319. Critical Currents in Superconducting Films [Film acts as Energy Amplifier, suggesting that the " Trigger " Effect might be useful for measuring Radiation].—Brucksch & others. (*Phys. Review*, 15th April 1941, Vol. 59, No. 8, p. 688 : summary only.)

2320. Impedance of the Squid Giant Nerve Fibre during Current Flow [at 1–500 kc/s: Membrane is Rectifier with Ratio of about 100, comparable with Commercial Cu/Cu_2O & Se Rectifiers].—Cole & Baker. (*Phys. Review*, 15th April 1941, Vol. 59, No. 8, p. 685 : summary only.)

2321. Symptomatic and Significant Variations and Individual Variations of the Elementary Phonetic Elements of Human Speech : Electroacoustical Methods of Detection, and Physiopsychological Interpretation of the Results.—Gemelli. (*Alta Frequenza*, July 1940, Vol. 9, No. 7, pp. 434–436 : summary only.) *Cf.* Silink, 1730 of June.

2322. Effect of Flow on the Dielectric Constant of Liquids.—Prasad & others. (*Nature*, 7th June 1941, Vol. 147, p. 712.) *See also* 1261 of April.

2323. Infra-Red : Production and Transmission, Reflection and Measurement.—Koller. (*Gen. Elec. Review*, March 1941, Vol. 44, No. 3, pp. 167–173.)

2324. A New Polarising Sheet [Type H : using " Submicroscopic Molecules instead of Crystals " : Polyvinyl - Alcohol Plastic stretched to 3–8 Times Original Length & treated with Iodine].—Land. (*Science*, 18th April 1941, Vol. 93, Supp. pp. 10 and 12.)

2325. A Gas-Filled Photo-Relay.—Goncharski. (*Automatics & Telemechanics* [in Russian], No. 3, 1940, pp. 115–116.)

The relay consists essentially of two concentric semi-cylindrical electrodes with a central incandescent filament. The inner surface of the outer electrode 1 serves as a caesium photocathode, while the intermediate electrode 2 is a wire-mesh anode. The relay is assembled in a glass envelope filled with neon or argon (Figs. 1 and 2).

As a result of the ionisation of gas by photo-electrons emitted from the photocathode, the space charge at the filament is compensated by positive ions and the thermionic current is amplified in proportion to the illumination of the photocathode. A highly sensitive photocell is thus obtained without a serious increase in the applied voltage. Actually in the model experimented with an 80 v dry battery was connected between the photocathode and the anode and a 12 v accumulator, in series with a telephone relay, between the filament and the anode. The amplification factor of the model was estimated to be of the order of 50 000, and owing to the use of an incandescent filament currents up to 60 mA, proportional to the illumination of the photocathode, could be taken off. Tests have proved the stability of the relay and its applicability for use under difficult operating conditions.

2326. Photoelectric Pyrometers and Colour-Temperature Measurements.—Gurevich. (*Automatics & Telemechanics* [in Russian], No. 4, 1940, pp. 133–150.)

A survey of literature (mainly foreign) on photoelectric pyrometers. A description is also given of a colour-temperature pyrometer built in Russia, and similar to that developed at the N.P.L. (*Proc. Phys. Soc.*, No. 263, 1935) but using a caesium-antimony photocell with a sensitivity of 120 μA/lumen at 2850°K. The accuracy obtained with this pyrometer is ± 20°K at 3000° K.

2327. Daytime Photoelectric Measurement of Cloud Heights [including Detection of Dark Overcast Clouds at 9000 Feet].—Laufer & Foskett. (*Journ. of Res. of Nat. Bur. of Stds.*, April 1941, Vol. 26, No. 4, pp. 331–340.)

2328. Portable Meters for the Measurement of Light and Ultra-Violet Energy.—Luckiesh & Taylor. (*Gen. Elec. Review*, April 1941, Vol. 44, No. 4, pp. 217–221.)

2329. Prism and Sector Photoelectric Photometers for Determination of Concentrations in Gaseous or Liquid Systems [using Balanced Photocells with Dark Current reduced from 1.5×10^{-10} A to about 10^{-12} A by " Guard Rings "].—Harris & others. (*Journ. Opt. Soc. Am.*, March 1941, Vol. 31, No. 3, pp. 263–267.)

2330. Electronic Photometer for Vitamin A.—Photovolt Corporation. (*Review Scient. Instr.*, March 1941, Vol. 12, No. 3, p. 160.)

2331. Military Telemechanics and Automatic Devices in Foreign Countries.—Livshits & Govyadkin. (*Automatics & Telemechanics* [in Russian], No. 4, 1940, pp. 161–172.)

A survey of foreign literature and the press on the use of automatic devices and telemechanics by the armies, navies, and air forces of foreign countries, including experiments with " death rays," " blinding rays," explosions at a distance by means of ultra-violet rays, etc.

2332. The Transient Electromagnetic Processes in a Line during Duplex Transmission of Signals, *and* during the Transmission of Interrupted Currents.—Kovalenkov. (*See* 2076.)