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Editorial

A Further Note on High Resistances at High Frequencies

THE study of the behaviour of high resistances at very high frequencies in our June editorial led to results which were represented graphically on page 295. The curve there reproduced gave the ratio R'/R of the effective high frequency resistance to the direct current resistance plotted against the product $flCR$, where l was the length of the equivalent line, *i.e.*, half the length of the rod, C the capacitance of the rod per cm., and R the total d.c. resistance. Although this method of plotting is interesting in showing the way the effective resistance falls when the frequency exceeds a certain critical value, it is not very convenient for general use because of the logarithmic scale. It is found that a much better curve for general use and a surprisingly instructive result is obtained by plotting the reciprocal ratio R/R', which is, of course, never less than unity, against $\sqrt{flCR}$. It will be more convenient to put L for the length of the resistance rod, so that $L = 2l$ and plot R/R' against $\sqrt{fLCR}$.

For large values of $\theta = \sqrt{\omega lCR}\,\underline{|45^\circ}$ tanh θ approximates to unity, the error not exceeding 1 per cent. if θ is greater than 3, and we can therefore put

$$\frac{\tanh\theta}{\theta} = \frac{1}{\theta} = \frac{1}{\sqrt{\omega lCR}}\overline{|45^\circ}$$

For the effective impedance we then have (see pp. 293, 294)

$$Z = \frac{R}{\sqrt{\omega lCR}}\overline{|45^\circ}$$

And for the effective resistance

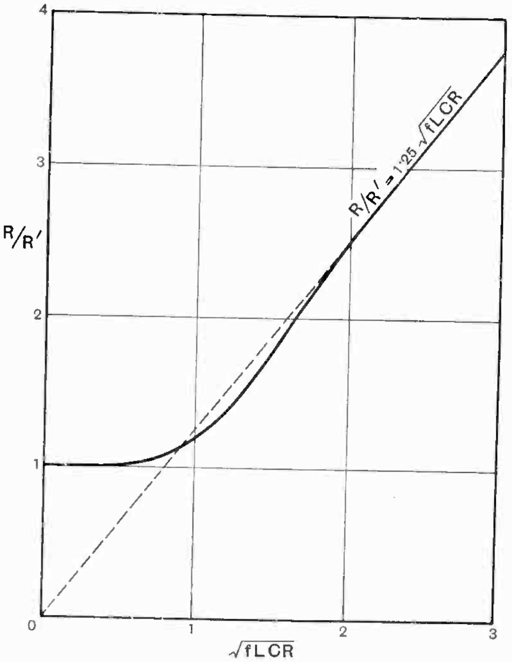
$$R' = \frac{Z}{\cos\phi} = \frac{R}{\sqrt{\omega lCR}}\sqrt{2}$$

and

$$R/R' = \sqrt{\frac{\omega lCR}{2}} = 1.77\sqrt{flCR} = 1.25\sqrt{fLCR}$$

Hence, for large values of $\sqrt{fLCR}$ that is, for very high frequencies, the ratio R/R' is proportional to $\sqrt{fLCR}$. This is represented by the straight line through the origin in the figure.

For low values of the frequency R/R' is unity. In Fig. 8 on p. 295 it will be seen that this holds up to $flCR = 0.1$ and therefore $\sqrt{fLCR} = 0.45$ approximately. Up to this point R/R' is represented by a horizontal line. For values of $\sqrt{fLCR}$ between 0.5 and 2.0 the ratio R/R' has been calculated and is plotted in the figure.



$\frac{R}{R'} = \frac{d.c.\ resistance}{h.f.\ resistance}$

L = *length of rod in cm.*

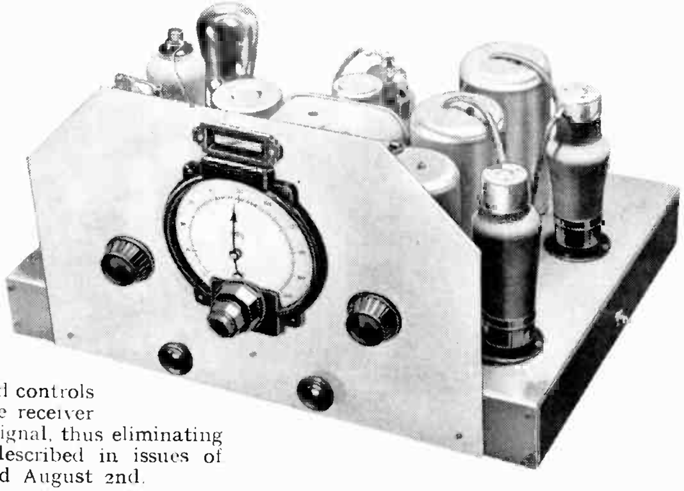
C = *about* $0.2/10^{12}$

As a rough approximation one may say that up to $\sqrt{fLCR} = 0.8$, $R/R' = 1$, and beyond this it is equal to $1.25\sqrt{fLCR}$. This will involve no appreciable error except between 0.5 and 2.0 and even here the error never reaches 10 per cent.

An attempt has been made to compare the calculated values with the experimental results obtained by Boella, Puckle, Sowerby and Marshall, but with little success. Some agree remarkably well, whilst others are widely divergent. The experiments are very difficult to carry out with certainty and some of the results are obviously unreliable. In one case a 2 megohm resistance tested by two different experiments at the same frequency gave effective resistances of 1.3 and 1.7 megohms respectively. Although the calculated results plotted in the figure are based on an approximation any error thereby introduced is likely to be small compared with the probable errors of such difficult measurements. It must be remembered, however, that the calculations are based on a uniform rod, and it is possible that the actual resistance rods are far from uniform, especially in the very high resistances. When a resistance of 10 megohms is made by a deposit on a glass rod 1.2 cm. long and 3 mm. diam., it is possible that the actual conducting path may consist of a few very fine filaments. We mention this because these very high resistances appear to behave at high frequencies as if their diameter were much smaller than that of the rod, but the measurements of such resistances at such frequencies are exceedingly difficult and require careful confirmation before devising explanations of discrepancies between calculated and measured values.

G. W. O. H.

Variable Selectivity



THE 1936 Monodial AC Super is designed to provide the highest standard of quality with a minimum of interference, and with this end in view variable selectivity has been included. The intermediate frequency is 465 kc/s and two stages of amplification with six tuned circuits arranged in three coupled-pairs are used. The frequency changer is a triode-hexode and is preceded by a signal-frequency amplifier with two tuned circuits for the elimination of second channel interference. The AVC system is of the delayed diode type and controls also a muting valve which renders the receiver inoperative when it is not tuned to a signal, thus eliminating inter-station noise. The design is described in issues of *The Wireless World* for July 26th and August 2nd.

Effect of the Detector Load on Transformer Design*

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

1. Subject

THE subject of this article is the stage of a radio-receiver which is illustrated in its most general form in Fig. 1, *i.e.*, a tuned radio-frequency amplifier which is supplying power to a detector (*e.g.*, a diode). It includes, as special cases, the tuned anode circuit, and also the connection of the detector to a tapping on a tuned anode circuit (or on either winding of a tuned transformer). The theory of this system is studied with particular reference to the distribution of the available input electrical power between the three principal elements, *i.e.*, amplifying valve, tuned circuit, and detector.

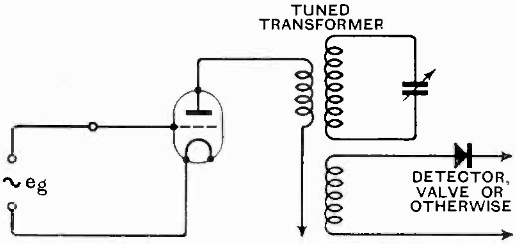


Fig. 1.

2. Particular Questions to be Answered

It is known that the most efficient coupling of a tuned circuit to an amplifying valve is that in which the effective resistance introduced into the anode circuit is equal to the a.c. resistance of the valve, there being in consequence an equipartition of energy between the valve and the tuned circuit. A similar generalisation applies to the coupling of a tuned circuit to a load such as that imposed by a grid-circuit or diode rectifier.

In the case under consideration, the tuned circuit is coupled to an amplifying valve and also to a detector. The following questions arise :

(*A*) Is there any realisable combination of optimum couplings or transformer-ratios in this case, *i.e.*, one which will give a maximum of power in the detector ?

(*B*) If so, how does the corresponding transformer-ratio compare with that appropriate to radio-frequency amplification alone?

(*C*) If there is any optimum combination of couplings, what is its dynamic significance ? That is to say, does it correspond to any simple distribution of available power between the valve, tuned circuit, and detector ?

3. The System of Circuits

The circuits considered are shown in Fig. 2. No. 1 represents the anode circuit of the amplifying valve, R_1 the a.c. resistance of the valve, together with the relatively small r.f. resistance of the primary winding of inductance L_1. The effective e.m.f. is represented by the single symbol $e(= \hat{e} \sin \omega t)$, but is actually $\mu \times$ input grid voltage. No. 2 represents the tunable secondary circuit. In circuit No. 3 the effective fundamental-frequency resistance of the detector is represented as a pure resistance R_3

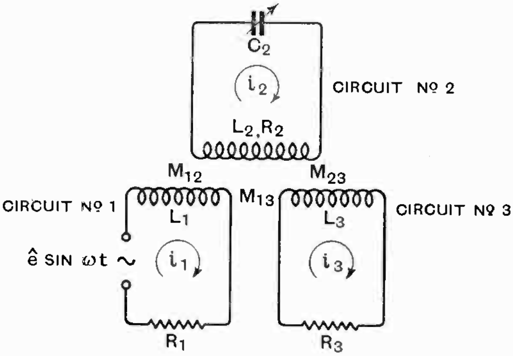


Fig. 2.

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* MS. accepted by the Editor, November, 1934.

which, for convenience, is also taken to include the relatively small r.f. resistance of the winding of inductance L_3. In actual practice L_3 may be a part, or even the whole, of L_2, or even of L_1. This will not materially affect the analysis, and the system as shown is more suitable for analytical purposes.

4. The Equations of the System

There being 10 independent parameters, the analysis is apt to be laborious and complicated, but it has been found possible to keep it in a fairly compact form. For economy of space, however, only the principal steps will be given.

Making use of the impedance-operator symbols

$$\dot{Z}_1 = R_1 + j\omega L_1 \quad \dots \quad \dots \tag{1}$$

$$\dot{Z}_2 = R_2 + j\omega L_2 + \frac{1}{j\omega C_2} \quad \dots \tag{2}$$

$$\dot{Z}_3 = R_3 + j\omega L_3 \quad \dots \quad \dots \tag{3}$$

the circuit-equations are given by the scheme

$$\begin{array}{cccl} \underline{i_1} & \underline{i_2} & \underline{i_3} & \\ \dot{Z}_1 & j\omega M_{12} & j\omega M_{31} & = e \quad \dots \quad (4) \\ j\omega M_{12} & \dot{Z}_2 & j\omega M_{23} & = 0 \quad \dots \quad (5) \\ j\omega M_{31} & j\omega M_{23} & \dot{Z}_3 & = 0 \quad \dots \quad (6) \end{array}$$

with determinant solutions

$$i_1,\, i_2,\, i_3 = \frac{\triangle_1,\, \triangle_2,\, \triangle_3}{\triangle}\, e \quad \dots \quad \dots \tag{7}$$

where $\triangle_1 = \dot{Z}_2\dot{Z}_3 + \omega^2 M_{23}^2 \quad \dots \quad \dots \quad (8)$

$$-\triangle_2 = \omega^2 M_{23} M_{31} + j\omega M_{12}\dot{Z}_3 \quad \dots \tag{9}$$

$$-\triangle_3 = \omega^2 M_{12} M_{23} + j\omega M_{31}\dot{Z}_2 \quad \dots \tag{10}$$

and

$$\begin{aligned}\triangle = {} & \dot{Z}_1\dot{Z}_2\dot{Z}_3 + \omega^2 M_{12}^2 \dot{Z}_3 \\ & + \omega^2 M_{23}^2 \dot{Z}_1 + \omega^2 M_{31}^2 \dot{Z}_2 \\ & - 2j\omega^3 M_{12} M_{23} M_{31} \quad \dots \end{aligned} \tag{11}$$

5. Tuned Transformer Alone

In order to bring out certain fundamental dynamic relations, the case of the tuned transformer without a detector load will be very briefly outlined.

Putting $M_{23} = M_{31} = 0$ gives

$$-i_2 = \frac{j\omega M_{12}}{\dot{Z}_1\dot{Z}_2 + \omega^2 M_{12}^2}\, e = \frac{j\omega M_{12}/\dot{Z}_1}{\dot{Z}_2 + (\omega^2 M_{12}^2/\dot{Z}_1)}\, e \quad \dots \quad \dots \tag{12}$$

The resonance of i_2 with respect to the tuning capacitance C_2 is given by the vanishing of the reactance component of the denominator, *i.e.*,

$$\omega L_2 - \frac{1}{\omega C_2} = \frac{\omega^2 M_{12}^2 X_1}{Z_1^2} \quad \dots \quad \dots \tag{13}$$

Z_1 being the magnitude of $\dot{Z}_1$. Thus

$$i_2\,(\text{res.}) = \frac{j\omega M_{12}}{R_2 + (\omega^2 M_{12}^2 R_1/Z_1^2)}\, e \quad \dots \tag{14}$$

$$\text{or } I_2^2(\text{res.}) \quad \frac{\omega^2 M_{12}^2}{(R_2 + \omega^2 M_{12}^2 R_1/Z_1^2)^2}\, E^2 \quad \dots \tag{15}$$

(R.M.S. values).

Since the maximum or resonance value of the secondary current corresponds to a maximum of power-dissipation in the secondary circuit, we are concerned with what is essentially a power-transference from the primary to the secondary circuit. The secondary power $W_2 = I_2^2 R_2$ can conveniently be expressed as a fraction of $W = E^2/R_1$, the "short-circuit" or zero-external-load power-dissipation in the valve. Further, it will be convenient to express this power-ratio in terms of the power-factor

$$a_2 = R_2/\omega L_2 \quad \dots \quad \dots \quad \dots \tag{16}$$

of the secondary circuit, which is a small quantity having a much smaller range of variation than R_2 and L_2. The quantity

$$a_1 = \omega L_1/R_1 \quad \dots \quad \dots \quad \dots \tag{17}$$

is also, in all practical cases, a small quantity of the same order of magnitude as a_2. It should be particularly noted that in physical constitution a_1 is reciprocal in form to a_2. It is, nevertheless, convenient to use the same symbol in each case, because the quantities are of the same order of magnitude and enter symmetrically into most of the equations and formulae. Finally, the coupling coefficient $k_{12} = M_{12}^2/L_1 L_2 \quad \dots \quad \dots \quad (18)$ is a convenient quantity to make use of, since it is always equal to or less than unity.

These substitutions in (15) lead to the simple expression for the power-transference at resonance

$$\frac{W_2}{W} = \frac{a_2 \dfrac{k_{12}^2 a_1}{1 + a_1^2}}{\left\{a_2 + \left(\dfrac{k_{12}^2 a_1}{1 + a_1^2}\right)\right\}^2} \quad \dots \tag{19}$$

and, neglecting the second order small quantity a_1^2 compared with unity, to the even simpler expression

$$\frac{W_2}{W} = \frac{a_2 \,.\, k_{12}^2 a_1}{(a_2 + k_{12}^2 a_1)^2} \quad \dots \quad \dots \quad (20)$$

It will generally be desired to make this quantity a maximum by suitable adjustment of the number of primary turns (*i.e.*, by variation of $k_{12}^2 a_1$).

The analytical form of eqn. (20) is

$$y = \frac{ax}{(a + x)^2} \quad \dots \quad \dots \quad (21)$$

It reaches a maximum value of $\frac{1}{4}$ when $x = a$.

$$\text{Thus} \quad \frac{W_2}{W} \text{max.} = \tfrac{1}{4} \quad \dots \quad \dots \quad (22)$$

$$\text{when} \quad a_2 = k_{12}^2 a_1 \quad \dots \quad (23)$$

For unity coupling, this has the simple form

$$a_2 = a_1 \quad \dots \quad \dots \quad \dots \quad (24)$$

$$\textit{i.e.,} \quad \frac{R_2}{\omega L_2} = \frac{\omega L_1}{R_1} \quad \dots \quad \dots \quad (25)$$

$$\text{or} \quad \frac{L_2}{L_1} = \frac{\omega^2 L_2^2/R_2}{R_1} \quad \dots \quad \dots \quad (26)$$

which embodies the familiar approximate rule for the design of a radio-frequency transformer stage. The more exact formula is clearly

$$\frac{L_2}{L_1} = \frac{\omega^2 L_2^2/R_2}{R_1} \quad \frac{k_{12}^2}{1 + \omega^2 L_1^2/R_1^2} \quad \dots \quad (27)$$

With this optimum transformer ratio, the secondary power is a quarter of the "short-circuit" power of the valve. It can be shown however, that it is a half of the total power actually supplied by the e.m.f. under the working conditions.

The primary current i_1 is given by

$$i_1 = \frac{\dot{Z}_2}{\dot{Z}_1 \dot{Z}_2 + \omega^2 M_{12}^2} e = \frac{1}{\dot{Z}_1 + \dfrac{\omega^2 M_{12}^2}{\dot{Z}_2}} e \quad \dots \quad (28)$$

and, for secondary current resonance, this becomes

$$i_1 \,(\text{res.}) = \frac{e}{R_1 \left\{ (1 + j a_1) + \dfrac{k_{12}^2 a_1}{a_2 + j \dfrac{k_{12}^2 a_1^2}{1 + a_1^2}} \right\}} \quad \dots \quad (29)$$

For the optimum coupling condition, given exactly by

$$a_2 = \frac{k_{12}^2 a_1}{1 + a_1^2} \quad \dots \quad \dots \quad (30)$$

this becomes

$$i_1 = \frac{e}{2R_1} \quad \dots \quad \dots \quad \dots \quad (31)$$

Thus, for secondary resonance *under optimum coupling conditions*, the primary current is exactly in phase with the e.m.f. The effective external load is then equal to the internal resistance, and the total power supplied by the primary e.m.f. is equally divided between the primary and secondary circuits. A similar dynamical balance is found for the coupling of a detector load to a tuned circuit excited by a sustained e.m.f. From these facts, it might be anticipated that in the three-circuit system of Fig. 2 the optimum condition, if it exists, would correspond to an equipartition of energy in the three circuits. In the next section it is shown that this is not the case.

6. General Case

The expression for i_3, derived from equations (7), (10) and (11) can be put in the form

$$-i_3 = \frac{\dfrac{j\omega M_{31}}{\dot{Z}_1 \dot{Z}_3 + \omega^2 M_{31}^2} \left(\dot{Z}_2 - \dfrac{j\omega M_{12} M_{23}}{M_{31}} \right)}{\dot{Z}_2 + \dfrac{\omega^2 M_{12}^2 \dot{Z}_3 + \omega^2 M_{23}^2 \dot{Z}_1 - 2j\omega^3 M_{12} M_{23} M_{31}}{\dot{Z}_1 \dot{Z}_3 + \omega^2 M_{31}^2}} e \quad \dots \quad \dots \quad (32)$$

$$\text{or} \quad -i_3 = K \,.\, \frac{\dot{Z}_2 - A}{\dot{Z}_2 + B} e \quad \dots \quad \dots \quad (33)$$

It should be noted that A and B vanish when $M_{12} = M_{23} = 0$. Thus K represents the direct transfer of power from the valve to detector independently of the tuned circuit.

The resonance of the other factor would appear to be "diluted," as it were, by the presence of $\dot{Z}_2$ in both numerator and denominator, but with reasonably close couplings between all the windings, A, *i.e.*, $j\omega M_{12} M_{23}/M_{31}$, is very nearly $j\omega L_2$—is exactly $j\omega L_2$, in fact, for unity coupling coefficients—and the resonance is therefore determined almost entirely by the vanishing of the reactance component of $\dot{Z}_2 + B$.

The full development of equation (32) would occupy a great deal of space and will not therefore be given in detail. It follows closely the lines of the simpler case given in Section 5, and only the final steps will be given here. The following abbreviations are used :

$$p = k_{12}{}^2\alpha_1 + k_{23}{}^2\alpha_3 \quad \ldots \quad (34)$$

$$q = \alpha_1\alpha_3(k_{12}{}^2 + k_{23}{}^2 - 2k_{12}k_{23}k_{31}) \quad \ldots \quad (35)$$

$$a = 1 - (1 - k_{31}{}^2)\alpha_1\alpha_3 \quad \ldots \quad (36)$$

$$b = (\alpha_2 + \alpha_3) \quad \ldots \quad (37)$$

where, as in Section 5

$$\alpha_1 = \omega L_1/R_1$$
$$\alpha_3 = \omega L_3/R_3$$
$$\alpha_2 = R_2/\omega L_2$$

all of which are 1st order small quantities.

Also $k_{23} = M_{23}/\sqrt{L_2L_3}$

and similarly for k_{12} and k_{31}. Thus the k's are quantities equal to or less than 1.

Resonance of i_3 with respect to the tuning condenser C_2 is determined by

$$\omega L_2 - \frac{1}{\omega C_2} = -\omega L_2 \frac{qa + pb}{a^2 + b^2} \quad \ldots \quad (38)$$

and at resonance, the ratio of the detector power $W_3 = I_3{}^2R_3$ to the " short-circuit " valve power $W = E^2/R_1$ is given exactly by

$$\frac{W_3}{W} = \frac{\dfrac{k_{31}{}^2\alpha_1\alpha_3}{a^2+b^2}\left\{\alpha_2{}^2 + \left(\dfrac{k_{12}k_{23}}{k_{31}} + \dfrac{qa+pb}{a^2+b^2}\right)^2\right\}}{\left(\alpha_2 + \dfrac{pa-qb}{a^2+b^2}\right)^2} \quad (39)$$

This rather cumbersome expression can be very much simplified without appreciable loss of accuracy, for a differs from unity by a second order small quantity and b^2 is therefore negligible compared with a^2 ; also q is a second order quantity, tending to zero as the coupling coefficients increase to unity. The full expression will therefore differ by no more than a second order small quantity from

$$\frac{W_3}{W} = \frac{k_{12}{}^2\alpha_1 \,.\, k_{23}{}^2\alpha_3}{(\alpha_2 + k_{12}{}^2\alpha_1 + k_{23}{}^2\alpha_3)^2} \quad \ldots \quad (40)$$

which, for unity coupling coefficients, reduces still further to

$$\frac{W_3}{W} = \frac{\alpha_1\alpha_3}{(\alpha_2 + \alpha_1 + \alpha_3)} \quad \ldots \quad \ldots \quad (41)$$

In either case, the whole range of values of the power-ratio, for a coil of given power-factor, is depicted by the surface

$$z = \frac{xy}{(a + x + y)^2} \quad \ldots \quad \ldots \quad (42)$$

The characteristics of this surface are briefly :

(*a*) For a given value of x, the maximum value of z is $\frac{1}{4}\dfrac{x}{(a + x)^2}$, when $y = a + x$.

(*b*) For a given value of y, the maximum value of z is $\frac{1}{4}\dfrac{y}{(a + y)^2}$, when $x = a + y$.

(*c*) There is no max.-max. value of z with respect to x and y, since each of the above optimum values increases uniformly with its argument.

(*d*) z tends to a limiting value $\frac{1}{4}$ when $x = y \rightarrow \infty$.

These features are illustrated in Fig. 3.

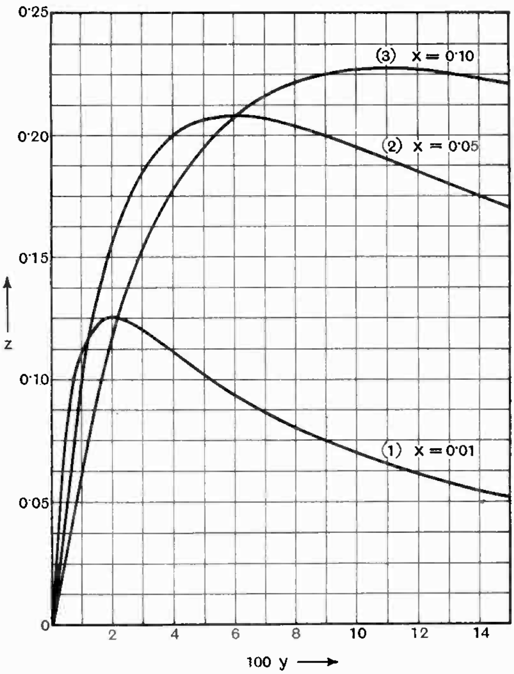


Fig. 3.—*Curves showing the nature of the variation with* y *of* $z = \dfrac{xy}{(a + x + y)^2}$ *for* $a = 0.01$.

The relation of the above to the system of electrical circuits is as follows : *For any given primary and secondary windings* (*i.e., for a given* α_1 *and* k_{12}) *there will be a detector-winding or detector-tapping which gives a maximum detector-power and therefore a maximum audio-frequency output. This optimum detector-power will tend to increase asymptotically to a quarter of the " short-circuit " valve power as the primary coupling is increased within practical limits and the* *detector coupling increased in conformity.* This is the general answer to question A.

There are, of course, a number of other practical considerations involved, particularly selectivity (which will be considered later), but it is immediately obvious that *to design the transformer as for radio-frequency voltage amplification alone (i.e., $a_2 = k_{12}{}^2a_1$) and then to adjust the detector winding or tapping by trial to a suitable value is not the way to realise the most favourable output ratio.* This will, in fact, limit the output-power to one-half of that theoretically attainable, for we have

$$k_{12}{}^2a_1 = a_2 \quad \ldots \quad \ldots \quad \ldots \quad (43)$$

and $$k_{23}{}^2a_3 = a_2 + k_{12}{}^2a_1 = 2a_2 \quad \ldots \quad (44)$$

and $$\frac{W_3}{W} = \frac{2a_2{}^2}{(4a_2)^2} = \frac{1}{8} \quad \ldots \quad \ldots \quad (45)$$

(This is the case illustrated by curve (1) of Fig. 3.)

The general condition for the realisation of maximum detector-power, *i.e.*, maximum audio-frequency output, is clearly

$$k_{12}{}^2a_1 = k_{23}{}^2a_3 >> a_2 \quad \ldots \quad \ldots \quad (46)$$

which, for unity coupling coefficients, becomes $a_1 = a_3 >> a_2$. $\quad \ldots \quad \ldots \quad (47)$

$$i.e., \quad \frac{L_3}{L_1} = \frac{R_3}{R_1} \text{ and } \frac{\omega L_1}{R_1} >> \frac{R_2}{\omega L_2} \quad \ldots \quad (48)$$

The significant resistances under these conditions are the valve a.c. resistance and the effective resistance of the detector. The tuned circuit merely functions as an agent—and charges a small commission.

It is, however, a necessary agent, for power could not otherwise be transfered from the valve to the detector with any practicable untuned windings. As already pointed out earlier in this section [*see* eqn. (33)] the detector-current corresponding to an untuned transformer with windings L_1 and L_3 and mutual inductance M_{31} is given by

$$-i_3 = \frac{j\omega M_{31}}{\dot{Z}_1\dot{Z}_3 + \omega^2 M_{31}} e \;. \quad \ldots \quad (49)$$

and the corresponding power-ratio W_3/W in terms of the symbols already defined is easily shown to be

$$\frac{W_3}{W} = \frac{k_{31}{}^2a_1a_3}{\{1 - (1 - k_{31}{}^2)a_1a_3\}^2 + (a_1 + a_3)^2} \quad \ldots \quad (50)$$

For unity coupling coefficients, this becomes

$$\frac{W_3}{W} = \frac{a_1a_3}{1 + (a_1 + a_3)^2} \quad \ldots \quad (51)$$

This expression approaches $\frac{1}{4}$ for large values of a_1 and a_3, but such large values cannot in fact be realised in the system considered, for with usual values of R_1 and R_3, ωL_1 and ωL_3 cannot be made even to approach R_1 and R_3 in magnitude.

In more general physical terms, the transfer of power is by way of a potential difference (a changing flux-linkage) which is common to both circuits. With untuned windings this common potential difference cannot be made large enough, compared with the other potential differences, to be effective. Apart from the necessary element of selectivity, the tuned circuit permits of the production of a potential difference common to the circuits which is sufficiently large for the transfer to the detector of an appreciable part of the electrical power which is available in the valve.

The actual distributions of electrical power between the three circuits are calculated in Section 7.

7. The Dynamical Aspect of the Optimum Conditions

The perfectly general case leads to somewhat cumbersome expressions for the distribution of power in the three circuits, but these are much simplified in form by assuming unity coupling coefficients, an assumption which is not likely to influence at all significantly the power distributions for the two critical cases. By inserting in the current equations, (7)-(11), the conditions for resonance of the current in the detector circuit, and putting

W_0 = Total input-power supplied by the e.m.f.

$W_1 = I_1{}^2R_1$; $W_2 = I_2{}^2R_2$; $W_3 = I_3{}^2R_3$

$W = E^2/R_1$ = valve "short-circuit" power

it can be shown that for any values of a_1 a_2 and a_3 (*i.e.*, $\omega L_1/R_1$, $R_2/\omega L_2$, $\omega L_3/R_3$)

$$\frac{W_0}{W} = \frac{a_2 + a_3}{a_1 + a_2 + a_3} \quad \ldots \quad \ldots \quad (52)$$

$$\frac{W_1}{W} = \left(\frac{a_2 + a_3}{a_1 + a_2 + a_3}\right)^2 = \left(\frac{W_0}{W}\right)^2 \quad \ldots \quad (53)$$

$$\frac{W_2}{W} = \frac{a_1a_2}{(a_1 + a_2 + a_3)^2} \quad \ldots \quad \ldots \quad (54)$$

$$\frac{W_3}{W} = \frac{a_1a_3}{(a_1 + a_2 + a_3)^2} \quad \ldots \quad \ldots \quad (55)$$

The self-consistency of these relations is illustrated in the fact that

$$W_0 = W_1 + W_2 + W_3 \quad \ldots \quad (56)$$

The first optimum condition

$$\alpha_1 = \alpha_2 + \alpha_3 \quad \ldots \quad \ldots \quad (57)$$

leads to $W_1 = W_2 + W_3$ .. .. (58)

i.e., equipartition of power between the valve circuit on the one hand and the tuned circuit and detector-circuit taken together, on the other hand.

The alternative optimum condition

$$\alpha_3 = \alpha_2 + \alpha_1$$

might be expected, by analogy to correspond to a power-balance

$$W_3 = W_2 + W_1$$

but, in fact, *it does not seem to correspond to any simple dynamical relationship at all.*

This gives the answers to question C of Section 2.

8. Certain Practical Considerations

(*a*) *Screen-grid valve case.*—Where the radio-frequency amplification is by means of a screen-grid valve, R_1, the a.c. resistance of the anode circuit, will in many cases be so large that, even with the tuned circuit directly connected (*i.e.*, $L_1 = L_2$, $k_{12} = 1$) α_1 is smaller than α_2, precluding the optimum condition

$$\alpha_1 = \alpha_2 + \alpha_3$$

This leaves available the alternative optimum condition $\alpha_3 = \alpha_1 + \alpha_3$ which can conveniently be realised in most cases by "tapping down" the detector on the coil of the tuned anode circuit.

(*b*) *Triode valve case.*—The fact that the problem is a transference of power to the detector might lead one to expect that a "power" valve would be a suitable medium; but the maximum detector power obtainable is proportional to E^2/R_1, or, in more familiar symbols, (μ^2/Ra) times the square of the input grid-voltage. In "power" valves, μ^2/Ra tends to be relatively low.

(*c*) *Selectivity.*—For the tuned circuit alone, the selectivity or sharpness of tuning can be taken as proportional to $\omega L_2/R_2$, *i.e.*, to $1/\alpha_2$. It can be shown from equation (32) that when the tuned circuit is coupled to the valve and to the detector, the selectivity is very approximately proportional to

$$\frac{1}{\alpha_2 + k_{12}^2\alpha_1 + k_{23}^2\alpha_3} \quad \ldots \quad (59)$$

or, for unity coupling coefficients, to

$$\frac{1}{\alpha_1 + \alpha_2 + \alpha_3} \quad \ldots \quad \ldots \quad (60)$$

The selectivity will therefore decrease as α_1 and α_3 are increased, *i.e.*, as the couplings to valve and detector are "tightened." Thus, in the absence of any retro-active effect, the optimum-efficiency conditions entail a certain decrease of selectivity. In practice it may be desirable to compromise between the two desiderata of output-power and selectivity. As in all such cases, a condition of more-than-optimum tightness of coupling is doubly damned, being defective both in efficiency and selectivity.

It is interesting to note that if the product of selectivity and efficiency be accepted as the criterion, the significant quantity is (for unity coupling coefficients)

$$\frac{W_3}{W} \cdot \frac{1}{\alpha_1 + \alpha_2 + \alpha_3} = \frac{\alpha_1\alpha_3}{(\alpha_1 + \alpha_2 + \alpha_3)^3} \quad \ldots \quad (61)$$

This has actually a maximum-maximum value which is realised when

$$\alpha_1 = \alpha_2 = \alpha_3 \quad \ldots \quad \ldots \quad (62)$$

and corresponds to a value 1/9 for W_3/W, compared with the upper limiting value of 1/4 for the optimum coupling in respect of efficiency alone.

9. Conclusions

The principal conclusions are:

(*a*) The best design of a radio-frequency amplifier transformer, or tuned circuit with tappings, which supplies power to a detector, is materially different from that of a transformer intended for voltage amplification only, and depends on the relative importance of sensitivity and selectivity. Quantitative details are given in Sections 6 and 8.

(*b*) There is no single optimum combination of valve-tuned circuit and tuned circuit-detector couplings giving maximum output-power but, within limits, there is an optimum of either for any given value of the other. Of these, one set of optimum conditions represents a simple equipartition of power, but the other set does not appear to correspond to any such simple distribution of power.

Oscillographic Response-Curve Examination

An Equipment for the Visual Delineation of the Response Curves of R.F. Filters

By R. F. Proctor, B.Sc., A.M.I.E.E., and M. O'C. Horgan, M.Sc.

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

(*Concluded from page 371, July issue*)

PART I of the paper described necessary precautions in designing apparatus for accurately projecting response curves.

Part II now discusses the effects of certain time-constants and concludes with a description of complete laboratory apparatus.

6. Time Constants and Speed of Variation of Frequency

One of the worst causes of distortion, in that it is one that is easily overlooked, is the question of the time constants of various capacity-resistance combinations in the circuits. It is proposed to deal with the matter rather fully in this paragraph.

When the apparatus was first assembled, a motor speed of 750 r.p.m. on the variometer shaft was chosen quite empirically, as an average and at the same time convenient speed, and a synchronous motor of this speed was employed.

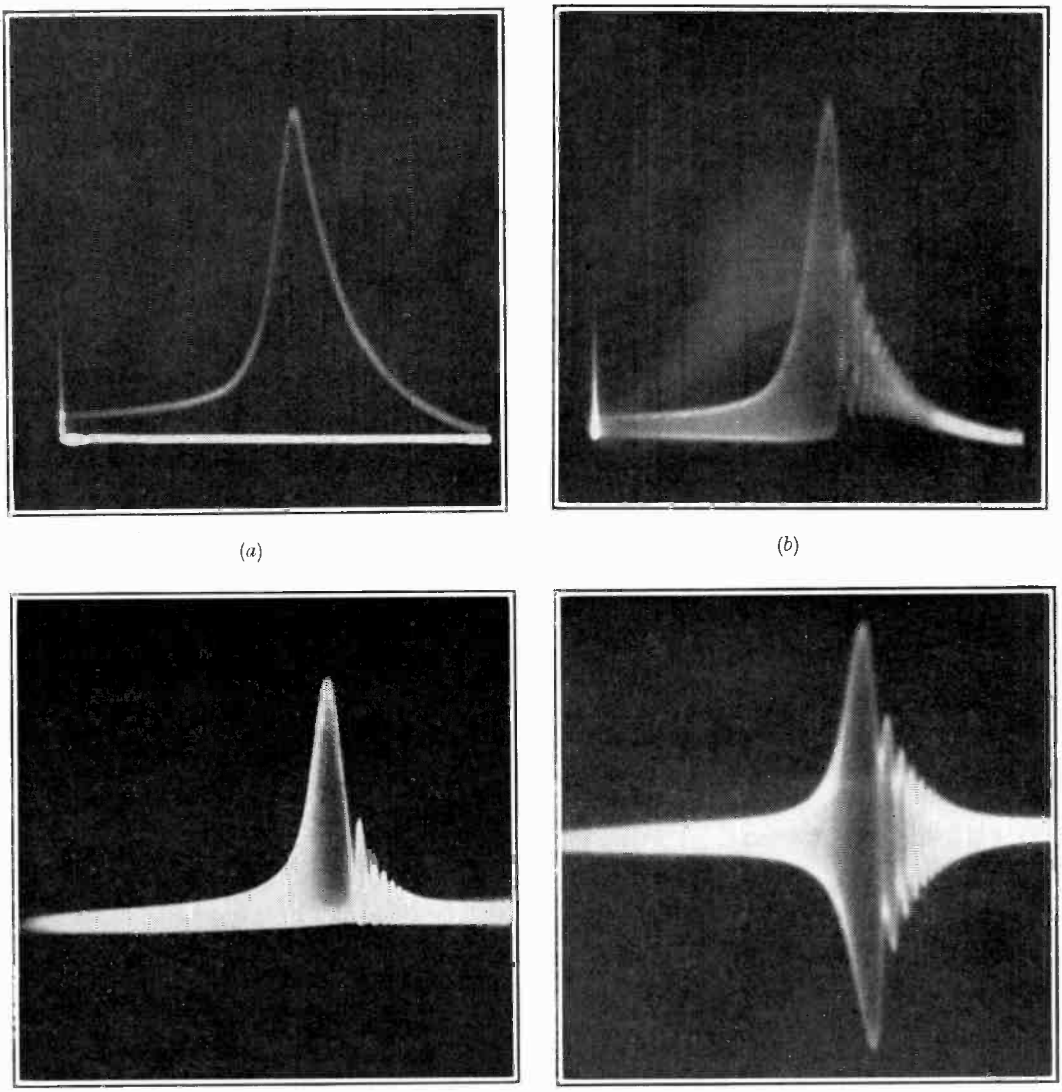
At this stage too, no amplifier was used after the test filter, the output from which was taken straight to the diode, and in order to keep the damping on the tuned circuit reasonably low, a diode load resistance of 5 megohms with a 0.0001 μF coupling condenser was used. The radio frequency filter after the diode was a 2 megohm resistance and another 0.0001 μF condenser, thus giving a reasonably low damping for most practical purposes of just under 2 megohms.

If the time constants of these two combinations are calculated they are found to be 0.0005 second and 0.0002 second, and at 750 r.p.m. these times represent 3 mm. and 1½ mm. travel along the X axis of the picture respectively.

While examining the resonance curve obtained from a single tuned circuit, resistance capacity coupled to the previous stage (i.e., the input amplifier), it was found that the curve was very unsymmetrical, the falling (or higher frequency) side of the resonance curve being less steep than the rising (or lower frequency) side. An oscillograph photograph of an actual curve, taken with a variometer rotor speed of about 1,400 revolutions per minute, is shown in Fig. 9 (*a*). The tuned circuit had a dynamic resistance of about 2 megohms and was composed of a 17.5 millihenry iron-cored coil tuned by means of a small preset condenser.

With the object of analysing the causes of this lack of symmetry, the rectified output from the diode was examined unfiltered. This state of affairs gives an envelope of the type shown by the photograph in Fig. 9 (*b*), whose chief characteristics are the raising of the right hand (or higher frequency) end above the zero, and the pronounced ripple on this part of the envelope.

It was found that the first effect, in which the envelope is raised from the zero line, is due to the time constant for the diode being too high, and it can be almost entirely eliminated by reducing the diode load resistance to 2 megohms. This results in rather too great a damping on the tuned circuit, and has to be overcome by the inclusion of a two-stage amplifier between the filter under test and the diode. It should be explained once again that a two-stage amplifier is needed in order to obtain the



(a) (b)

(c) (d)

Fig. 9.—*The response curves taken at 1,400 r.p.m. on a single tuned circuit of low decrement. Photos (a) and (b) are the filtered and unfiltered curves when the time constant of the diode rectifier following the tuned circuit is appreciable. Photos (c) and (d) are the rectified and unrectified curves for the same tuned circuit when the diode time-constant is negligible.*

necessary voltage output into the diode load, without overloading the low gain first stage valve. When this amplifier is included the circuit is improved in two ways.

First the input damping is raised from 2 megohms to the negligible value of 8 megohms at the highest frequency used (1.2 megacycles), and secondly the diode load resistance can be reduced to $\frac{1}{4}$ megohm giving, with a 0.00005 μF condenser, a time constant of 0.000012 second.

This cures the raising of the right hand end above the zero, but the ripple is still present. The oscillograph envelope at this stage is shown in Fig. 9 (*c*).

Now when this response is examined unrectified, it appears as shown in Fig. 9 (*d*), in which the two halves about the line of symmetry are replicas of the rectified envelope of Fig. 9 (*c*). This eliminates the diode as the cause of the trouble.

Further it was found that the shape of this envelope was not affected if the oscillator were connected direct to the coupling condenser, thus cutting out the injector-amplifier stage; or if the output from the filter were taken direct to the cathode ray tube Y-plates, thus cutting out the complete post-filter amplifier.

The only necessary condition was that the decrement of the test circuit was low. The irregular falling off of the resonance curve is, in fact, caused by the interaction of the decaying oscillatory e.m.f. in the tuned circuit with the variable frequency input e.m.f. from the oscillator.

The extent of the distortion of the response curve picture is a function of two things, the scanning speed and the decrement of the test circuit, and for a given filter the only way to reduce the distortion to a negligible quantity is to scan at such a reduced speed that the decrement time of the tuned circuit represents only a very small distance of traverse on the viewing screen, and a relatively small change of frequency applied. The lower the decrement the lower the speed of scanning.

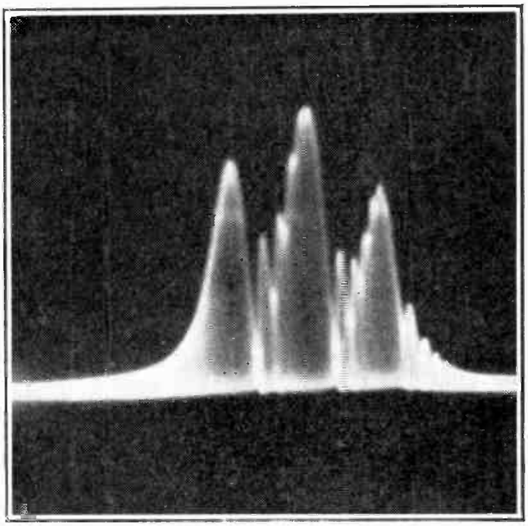
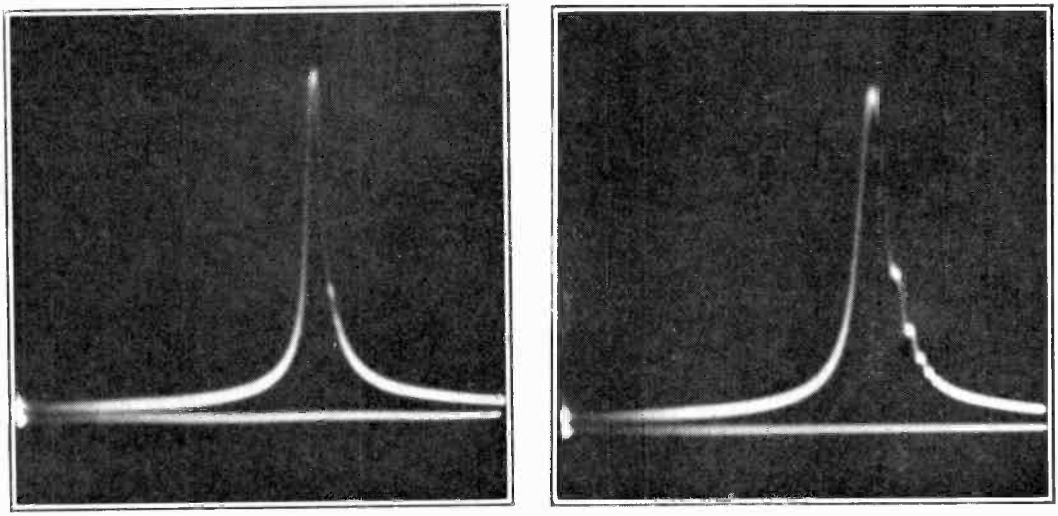


Fig. 11.—*The rectified unfiltered envelope of a good three-circuit unterminated filter with low decrement. The scanning speed was* 1,400 *r.p.m.*

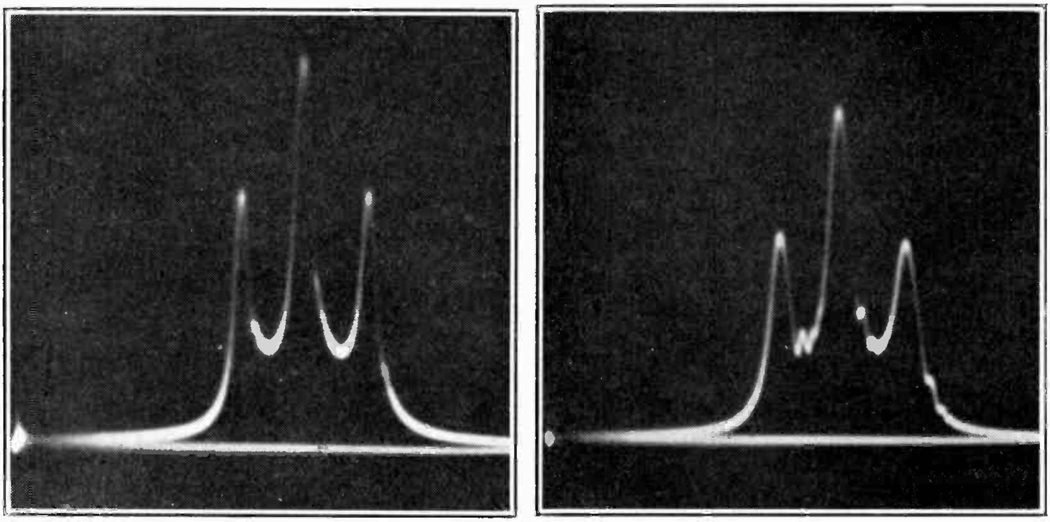
Figs. 10 (*a*) and 10 (*b*) show the effect of scanning speed on the response curves of the above-mentioned tuned circuit for speeds of about 200 and 1,400 revolutions per minute respectively.



(*a*) (*b*)

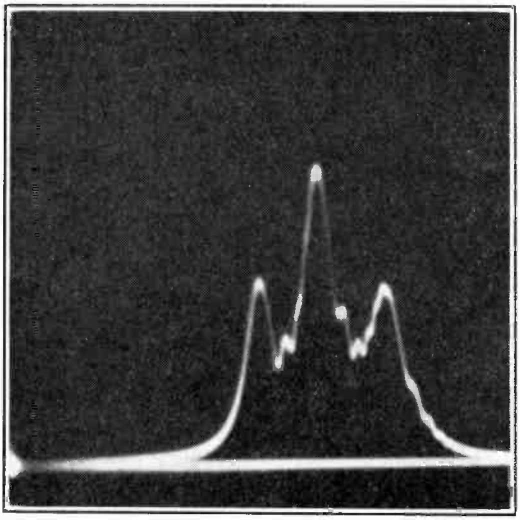
Fig. 10.—*This shows the effect of scanning speed on the picture obtained for a single tuned circuit, after the time-constants of the apparatus have been made negligible.* (*a*) *is taken at* 200 *r.p.m. and* (*b*) *at* 1,400 *r.p.m.*

A reduced scanning speed has the disadvantage that the visual picture becomes less steady and more subject to flicker.



(*a*) 200 r.p.m.

(*b*) 750 r.p.m.



(*c*) 1,400 r.p.m.

Fig. 12.—*The effect of scanning speed on the response pictures, when the apparatus time-constants are negligible. The filter consisted of three low decrement coupled circuits as in Fig.* 11. *The disappearance of the ripples and the raising of the peaks at low speeds should be noted.*

This makes rapid observation of changes rather difficult, but is a necessary evil. It can be reduced to a minimum in two ways, both of which are incorporated in the final design, which will be described in section 7. First, two scans per revolution, taken 180° apart, can be made, making use of the symmetry of both variometer and variable condenser (which may have to be adjusted so that this symmetry is exact, or a displacement will occur between the two pictures). This doubles the number of scans and halves the flicker.

The other remedy is a variable scanning frequency so that the speed may be raised as much as possible without distortion, being reduced to the minimum only for the examination of circuits of very low decrement. This is most easily carried out by the use of a D.C. motor, although, as mentioned before, slight interference may be experienced with " pick up " from the commutator. In the apparatus constructed, it was important that the whole set should run off A.C. supply alone, so that a constant speed motor was used and any alteration carried out by a variable reduction drive.

In practice it is unnecessary to go to any complicated continuously variable gear for this reduction, a pair of cone pulleys giving speeds of about 700, 400, 200 and 100 r.p.m. being quite sufficient.

Where the circuit under test has more than one resonant frequency (as in the case of an unterminated multi-section band pass filter) the observed response curve may be considerably distorted at the higher scanning speeds owing to the ripples caused by the interaction of the variable frequency e.m.f. applied to the filter with the various decaying oscillatory e.m.f.'s of the system. This will be more clearly understood by taking the case of an unterminated filter consisting of (say) three tuned circuits coupled in cascade. Such a filter would give a response curve having three peaks corresponding to three distinct modes of resonance. The difference in frequency between the resonance peaks will be determined by the degree of coupling between the respective circuits.

If this filter is examined on the cathode ray equipment, using a high scanning speed, the decaying oscillatory e.m.f.'s corresponding to each of the separate modes of resonance will be superimposed on the variable frequency e.m.f. applied to the filter. The observed response curve will thus be the result of the interaction of the variable frequency e.m.f. applied to the filter with the decaying oscillatory e.m.f.'s corresponding to the modes of resonance which have just previously been passed through in the scanning cycle.

Fig. 11 shows the rectified unfiltered envelope of a good unterminated filter for a frequency of 125 kilocycles per second, incorporating three tuned circuits of low decrement and taken with a scanning speed of 1,400 r.p.m.

The effect of scanning speed on the response curves (i.e. rectified and filtered) of the same filter, is shown in Figs. 12 (*a*) to 12 (*c*). Besides the distortion due to the time taken for the oscillatory currents to die down, it is also seen that the resonance peaks do not rise to their full extent at the high speeds. This failure of the resonance peaks to reach their full height is caused by the appreciable time constants of the resistance-capacity filter and the test circuit components. The presence of this latter factor is readily seen by comparing the two curves Figs. 13 (*a*) and 13 (*b*), unrectified envelopes taken at scanning speeds of 1,400 and 200 r.p.m. respectively with the same input. It will be noticed that the peaks of the curve taken at 200 r.p.m. are higher than those taken at 1,400 r.p.m., even though the diode and H.F. filter are now removed from the circuit.

In connection with the height of the peaks it is of interest to mention an effect which

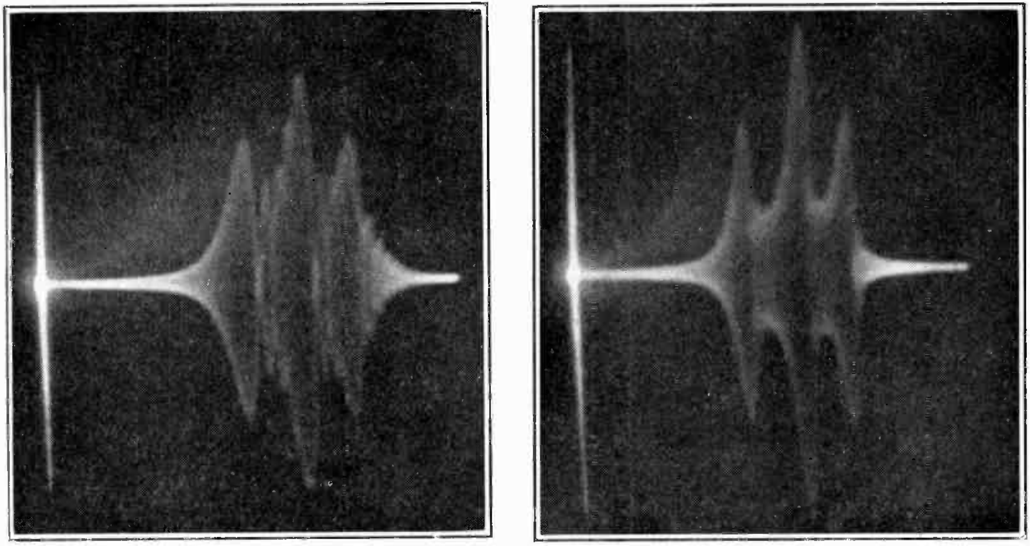

(*a*) 1,400 r.p.m. (*b*) 200 r.p.m.

Fig. 13.—*The response pictures of the circuits of Figs.* 11 *and* 12 *before rectification. The ripples produced at higher speeds are caused by the tuned-circuits having low decrements.*

was obtained on the original experimental apparatus and eluded explanation for some time.

Besides the peaks failing to reach their full height at the high speeds, the left-hand peak, i.e., the lower frequency peak, was reduced to a less degree than the right-hand peak, resulting in an unsymmetrical response curve. It was later found that the degree of distortion thus introduced increased as the whole response curve was moved towards the left-hand end of the picture. This shifting of the curve was possible owing to the inclusion of a variable condenser in the oscillator tuned circuit. The effect was finally traced to the superposition on the subsequent response curve of the slowly-dying response of the test filter to the previous reverse frequency sweep, which occurs when the time base contacts are closed (see bands AB of Fig. 3). Such an effect is only noticeable at high speeds. This source of error occurred more readily in the original apparatus where a scanning angle of 60° was used on the commutator, in place of the 41° employed in the present design.

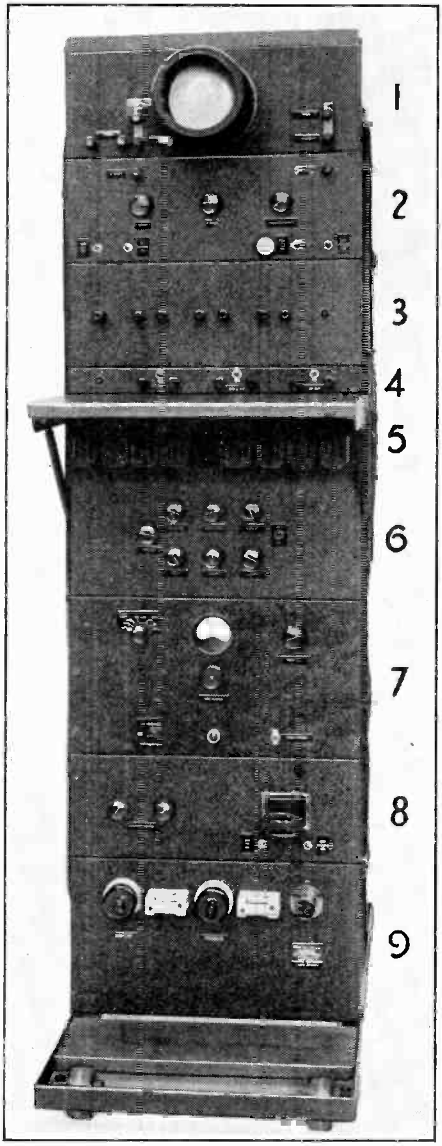


Fig. 14.—*The complete equipment is mounted on a* 19 *in. rack and stands about* 6*ft. high. The separate units will be readily recognised from the text.*

A further peculiar phenomena which had been noticed on the original apparatus was also investigated. During some experiments on the causes of the ripples occurring in low decrement coupled circuits (see Fig. 11), it was noticed that as the response-curve picture was shifted across the screen, the ripples moved in relation to the main peak shifting firstly to the right and then back again to the left.

The cause of this effect was traced to the slightly non-linear frequency characteristic of the variometer controlled oscillator with time. As a result of this non-linearity of the frequency sweep, the actual time between successive resonance peaks of the response curves of the filter varied according to the position of the picture on the screen. Thus since the ripples on any one peak are primarily due to the decaying oscillations corresponding to the preceding peak, their relative positions on the peak will vary as the time displacement between the peaks alters.

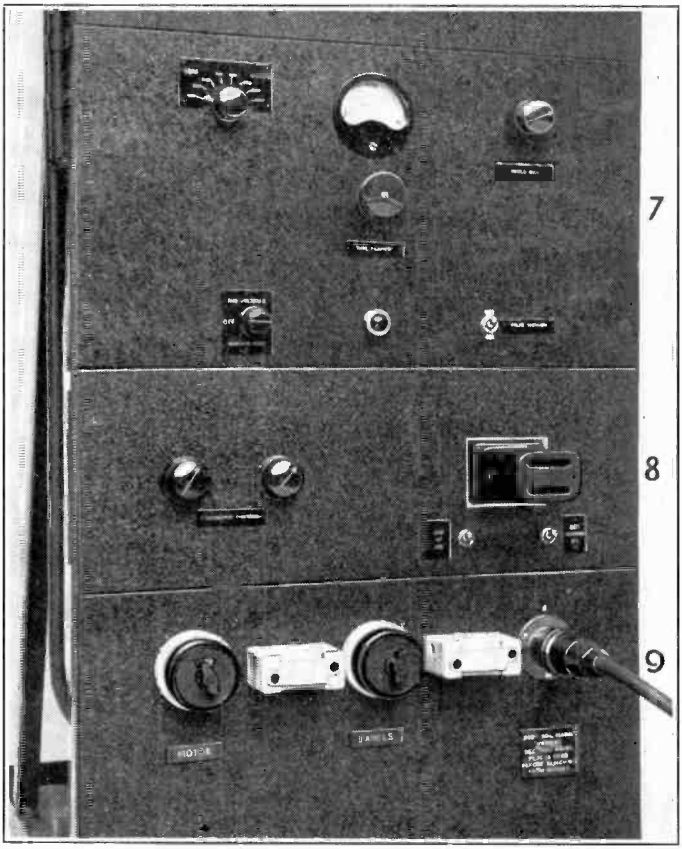
The foregoing considerations have been chiefly concerned with the response curves of low decrement coupled circuits unterminated by their image impedances. When, however, suitable terminating impedances are added, the distortion caused by high scanning speeds is much reduced, owing to the greatly increased damping of the filter circuits. In consequence of this increased decrement of the filter circuits, the highest speed at which response curves are accurately reproduced is raised.

In all tests on coupled circuits, the scanning speed employed should be as high as possible for the particular circuit in order to reduce flicker and consequent eye-strain, and should be determined by trial in any one case.

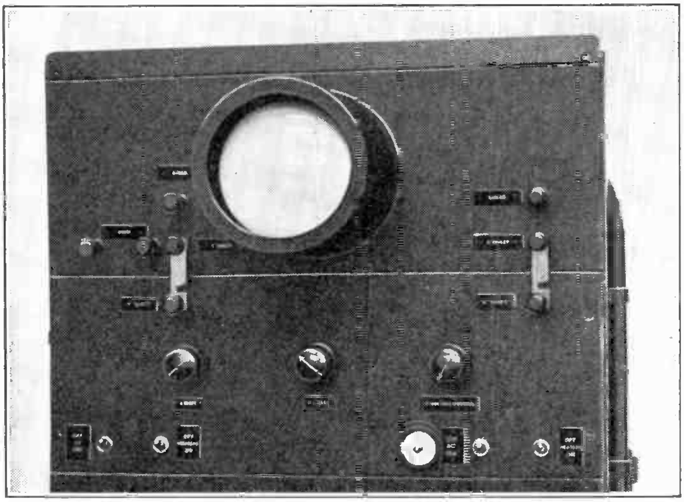
7. The Laboratory Model Equipment

From the foregoing chapters it will be realised that there are a large number of precautions to be taken in the construction of a complete equipment to give accurate visual resonance curves of tuned circuits, and it is the primary object of this paper to set out the details of these sources of error and to indicate how they are to be overcome.

In the light of the experience gained by experiment on a bench apparatus with separate units, a complete rack-mounted equipment has been constructed for laboratory use, having a wide range of application and embodying all the constructional details referred to in the previous paragraphs.



(Above) Fig. 16.—*The photograph shows panel 7, carrying the supply units for the tube and all valves, panel 8, the variable frequency oscillator with a plug-in unit in position, and panel 9, the main switch panel, behind which are the frequency varying devices.*



(Left) Fig. 15.—*The top panel carries the tube and the link system. On the left of the second panel is the response-curve time base with its controls, whilst on the right is the post-filter amplifier and diode. The low damping quartz insulator for the input lead is clearly seen.*

It is thought that the points of construction involved warrant a description of the set for the assistance of other experimenters, so that we shall deal briefly with it in this paragraph.

The laboratory equipment shown in Fig. 14 is rack-mounted on a standard 19 inch rack, the units being on separate aluminium panels for easy removal, and separately screened.

The cathode ray tube is arranged to work either as an indicator of the resonance curves of filters or for the tracing of normal phenomena employing a linear time base.

For this latter purpose a linear time base unit with the usual "shifts" and triggering devices, is included on the panel, and can be seen in the photograph as unit No. 6.

In order to facilitate a rapid change-over from one usage to another, a link system has been devised, and this together with the terminals for application of normal phenomena, can be seen in the photograph, Fig. 15. The two links are one in a *Px*-plate lead and the other in a *Py*-plate lead, the other plates being the "earthy" ones. In the "up" position the tube is joined to the ordinary time base, and this is synchronised with the phenomena. The synchronising is removed by leaving the left-hand link unconnected.

When the links are "down" the *X*-plate is joined to the pentode time base (see section 3), the second *X*-plate being automatically raised to the necessary D.C. voltage above earth by the relay in the base unit, while the *Y*-plate is joined to the output of the diode and amplifier following the test filter, thus putting everything in readiness for the observation of resonance curves.

The photograph (Fig. 15) shows also the iron cylinder screening the tube, the quartz insulator input terminal to the post filter amplifier, and the potentiometers controlling the gain of the amplifier and the pentode time base.

The oscillator for supplying the varying radio frequency voltage to the test filter, is arranged to work around several mean frequencies lying in the medium, long and I.F. wavebands. Its panel is shown in Fig. 16. The various frequencies are selected by means of plug-in units each of which is inscribed with the mean frequency and the frequency band that is swept out around this mean.

The plug-in units contain all the necessary tuning coils, padding condensers, shunting inductances, damping resistances and reaction condensers as are required for each individual frequency, thus allowing a change of frequency to be obtained, merely by plugging in the appropriate unit, without further adjustment.

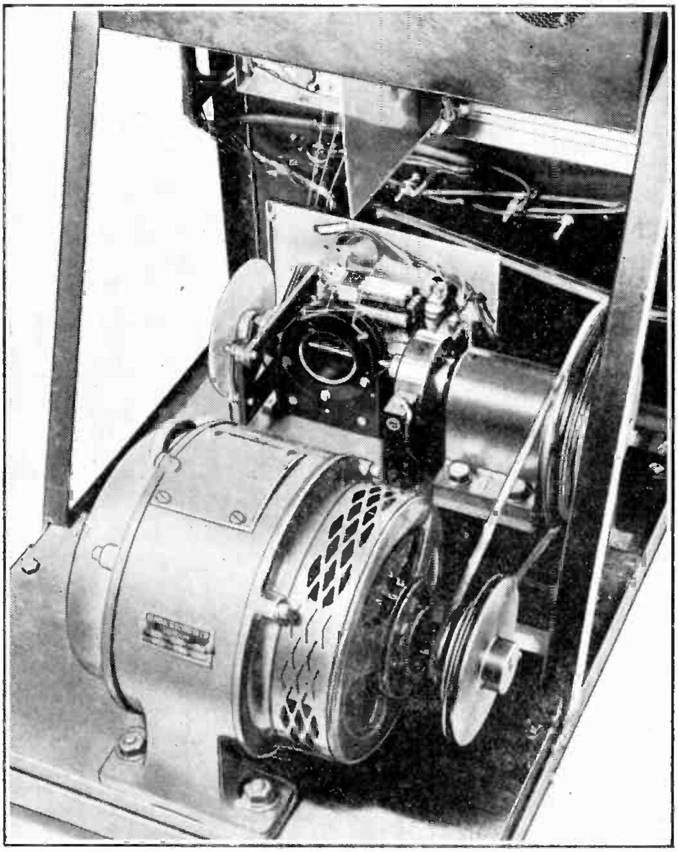


Fig. 17.—*The frequency varying devices. On the driven shaft can be seen the protractor scale, variable condenser, variometer and commutator, with the change-over relay on the sub-panel immediately behind them.*

A list of the frequencies used is shown, together with the details of coils, etc., in

Fig. 5. Since the frequencies extend from 110 kc/s to 1,400 kc/s both variometer and variable condenser methods are used for frequency variations, the former at the lower frequencies and the latter at the higher ones. The various plug-in units are fitted with auxiliary plugs, which automatically select the variometer or variable condenser as required, and short circuit the one not required by means of a relay operating off the H.T. busbars through a resistance.

The variable condenser and variometer are mounted on a common shaft with the commutator required for the synchronised time base, and are driven by a 750 r.p.m. induction motor through a belt drive. A selection of speeds of revolution, adjustable to suit the type of coil being tested, is arranged by a series of four pulley ratios giving axle speeds of 750, 375, 250 and 120 r.p.m., and as a plain "double break" commutator is used this gives 1,500, 750, 500 and 240 scans per minute. Fig. 17 shows a photograph of the layout of the motor and the driven shaft.

The whole equipment is arranged to operate off a single supply of 50 cycle A.C. at 240 volts, no batteries being required. The bottom panel carries the input fuses and main switches, while Panel No. 7 (in Fig. 14) carries two eliminator units, one for the various amplifiers and the oscillator, and the other for the cathode-ray tube. The latter unit is interesting in that the gun voltage is variable up to 2,000 volts and is obtained from a "voltage-doubler" rectifier circuit employing ordinary mains driven triodes with grid tied to cathode, as rectifiers.

Other panels on the rack provide (*a*) a storage rack for the oscillator plug-in units not in use, (*b*) a screened box with concentric sockets and several terminals for screening test filters as necessary, and (*c*) a supply panel for running any additional units or amplifiers in the screened box or on the small table provided.

The connecting leads for supplies to the panels and between the various panels are all carried in screening tubes and permanently connected, thus making a neat and permanent job of the assembly without in any way limiting its range of usefulness.

The Industry

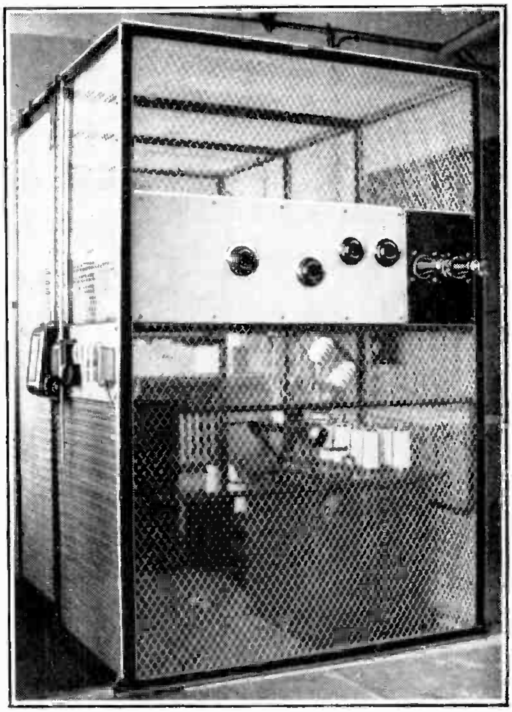
ALTHOUGH the name Ferranti has virtually passed into the language of all who are even remotely connected with radio or electrical engineering, it is only recently that the word has been registered as a Trade Mark.

The Baldwin Instrument Company have notified us of a change of address to Brooklands, Dartford, Kent. Telephone number: Dartford 989.

As many readers are aware, the firm of F. E. Godfrey (Radio), Ltd., of 63/67, Chenies Mews, Tottenham Court Road, London, W.C.1., are specialists in the construction of apparatus to customers' specifications. One of their recent productions, an ultra-sonic oscillator with 200 kc/s quartz crystal, is illustrated on this page.

The development and working into practical form of inventions and ideas is also undertaken.

The opinion has been freely expressed that insufficient attention is paid by the Wireless Industry generally to providing proper facilities for demonstrating receivers. It is therefore interesting to learn that in planning the construction of the new H.M.V. showrooms in London, architects and engineers have collaborated in devising a series of sound-proof demonstration rooms connected to an independent aerial system.



An Ultra-Sonic Oscillator recently made by F. E. Godfrey (Radio), Ltd.

Resonant Functions*

Notes on Their Use in Electric Circuit Calculations

By W. Baggally

THE following proposition is of considerable practical utility in simplifying the analysis of electric circuits involving several resonant dipoles all having the same resonant angular frequency p_0.

If y is any quantity whatever associated with a circuit consisting of resistances, inductances and capacities, and if furthermore

$$y = F(p) \quad \dots \quad \dots \quad \dots \quad (1)$$

is the equation connecting y with the applied angular frequency p, then if we alter the circuit by connecting a condenser in series with each inductance and an inductance in shunt with each of the original condensers, choosing the values of the added elements so that all the resonant circuits so formed have the resonant angular frequency p_0, then the equation corresponding to (1) for the altered circuit is

$$y = F(p_0P) \quad \dots \quad \dots \quad \dots \quad (2)$$

in which $P = \dfrac{p}{p_0} - \dfrac{p_0}{p} \quad \dots \quad \dots \quad \dots \quad (3)$

To prove the proposition consider first the case of a series resonant circuit. We have

$$Z = j\left(pL - \frac{1}{pC}\right) \quad \dots \quad \dots \quad (4)$$

but $\dfrac{1}{p_0C} = p_0L \quad \dots \quad \dots \quad \dots \quad (5)$

therefore $Z = jp_0PL \quad \dots \quad \dots \quad \dots \quad (6)$

In the case of a parallel resonant circuit we have $Z = \dfrac{1}{j\left(pC - \dfrac{1}{pL}\right)} \quad \dots \quad \dots \quad (7)$

which when combined with (5) gives

$$Z = \frac{1}{jp_0PC} \quad \dots \quad \dots \quad \dots \quad (8)$$

Since the expressions (6) and (8) are of the same form as the impedance operators for an inductance and condenser respectively it follows that the original and altered circuits conform to the same mathematical laws, but in the case of the altered circuit the independent variable is p_0P instead of p, which establishes the proposition.

The principle contained in the above proposition may be applied to entire networks or to parts thereof with much saving in both algebra and arithmetic.

In the accompanying graphs (Fig. 1), P and P^2 are shown for different ranges of the argument $x = \dfrac{p}{p_0}$, and should cover most cases likely to arise in practice.

A difficulty arises in the case of the shunt circuit when it is desired to take the coil resistance into account. In the case of the series circuit there is no such difficulty, because the resistance of the inductance coil may be represented by a series resistance which does not form an integral part of the tuned circuit, which may be considered as free from resistance.

The only point at which the effects of coil resistances are likely to be profound is at resonance, and the difficulties in this region may be obviated by using the following approximate circuit equivalence theorem.

Consider the dipole shown in Fig. 2(*a*). Calling its impedance a we readily find

$$a = \frac{\dfrac{R}{p^2LC} - j\left(\dfrac{R^2}{pL} + pL - \dfrac{1}{pC}\right)}{\dfrac{C}{L}\left(R^2 + \left(pL - \dfrac{1}{pC}\right)^2\right)} \quad \dots \quad (9)$$

with practical inductance coils we shall always have $R^2 << p^2L^2 \quad \dots \quad \dots \quad (10)$ except at the very lowest frequencies.

Using this approximation together with the results established above we can write

$$a \doteqdot \frac{p_0{}^2C^2R\dfrac{p_0{}^2}{p^2} - jp_0PC}{(p_0{}^2C^2R)^2 + (p_0PC)^2} \quad \dots \quad (11)$$

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* MS. accepted by the Editor, October, 1934.

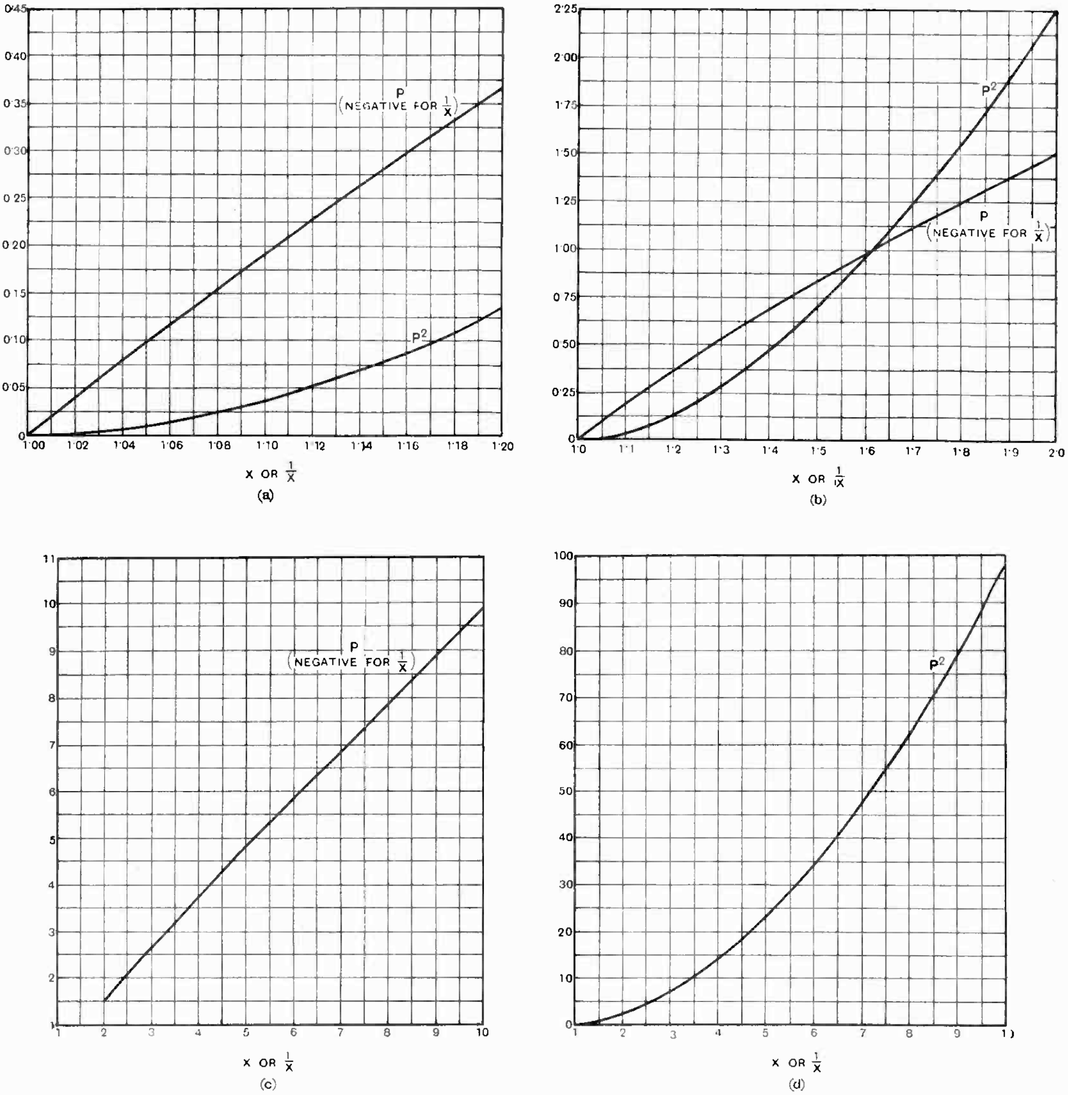


Fig. 1.

For the dipole of Fig. 2(*b*) we have at once by applying our original proposition

$$b = \frac{\frac{1}{S} - jp_0PC}{\frac{1}{S^2} + (p_0PC)^2} \quad \ldots \quad \ldots \quad (12)$$

where *b* is the impedance.

Putting $S = \frac{1}{p_0{}^2C^2R}$ in equation (11) we have

$$a \doteq \frac{\frac{1}{S} \cdot \frac{p_0{}^2}{p^2} - jp_0PC}{\frac{1}{S^2} + (p_0PC)^2} \quad \ldots \quad (13)$$

which is of the same form as (12), except for the term $\frac{p_0{}^2}{p^2}$.

It is now necessary to examine the conditions under which equations (12) and (13) may be substituted for each other without appreciable error, and we note first that at resonance ($P = O$ and $p = p_0$) the two equations give identical results, whilst at high frequencies the term containing $\frac{1}{S}$ can be altogether ignored.

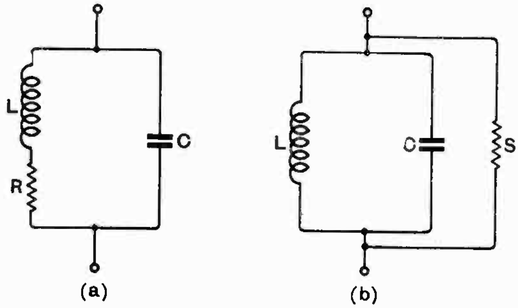


Fig. 2.

To find the lower frequency limit to the validity of this approximate equivalence we note that at low frequencies the following conditions must be fulfilled

$$\frac{1}{S} \cdot \frac{p_0^2}{p^2} << p_0 PC \qquad .. \qquad .. \quad (14)$$

and (10).

It is found that both (10) and (14) are satisfied when $p >> p_0^2 CR$ .. .. (15) so that if this latter condition be fulfilled we can substitute circuit (*b*) for (*a*) without much error.

Some examples will now be given illustrating methods of calculation based on the above results.

We will first calculate the characteristics of a confluent band-pass filter.

Fig. 3 (*a*) shows an ordinary constant K low pass filter section. Its mid-series image impedance is well known to be

$$Z = \sqrt{\frac{L}{C}} \cdot \sqrt{1 - \tfrac{1}{4} p^2 LC}$$

(*i.e.*, Z is the impedance looking into one pair of terminals when the other pair is bridged by the same impedance, Z), but the cut-off frequency is the point at which the image impedance becomes imaginary; giving the well-known formula $F_c = \frac{1}{\pi\sqrt{LC}}$

By adding condensers and an inductance as shown above we obtain Fig. 3 (*b*), which is a confluent band pass filter.

The added condensers and inductance are so chosen that the resonant angular frequency of the dipoles formed by them together with the original circuit elements is p_0.

We can immediately write down the expression for the mid-series image impedance by using our theorem. It is

$$Z = \sqrt{\frac{L}{C}} \sqrt{1 - \tfrac{1}{4} p^2{}_0 P^2 LC}$$

For the cut off frequency we have, at the point where Z becomes imaginary

$$P^2 = \frac{4}{p_0^2 LC}$$

giving $\qquad p = \sqrt{p_0^2 + p_1^2} \pm p_1$

wherein $p_1^2 LC = 1$

This gives the two cut off frequencies of the filter and if we multiply them together we find the answer to be p_0^2 as is well known.

All the other properties of the confluent band pass filter may be derived in a similar manner by considering the simple low pass structure.

An important class of problems in which the present methods are of utility is that in which we have to calculate the numerical value of the attenuation produced by a circuit at several different frequencies.

We will take as example the calculation of the response curve of an equalising network used for correcting the side-band cutting in a broadcast receiver.

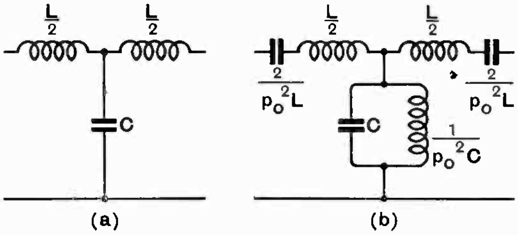


Fig. 3.

The circuit is shown in Fig. 4 (*a*). The scalar ratio of output voltage to input voltage in the case of Fig. 4 (*b*) is found by simple inspection to be

$$\left|\frac{E}{e}\right| = \sqrt{\frac{1 + p^2C^2R^2}{1 + p^2C^2S^2}}$$

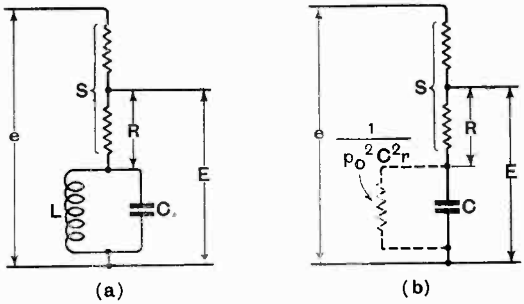
so that the corresponding expression for Fig. 4*a* is $\left|\frac{E}{e}\right| = \sqrt{\frac{1 + p_0^2P^2C^2R^2}{1 + p_0^2P^2C^2S^2}}$ wherein p_0 is the resonant angular frequency of the tuned circuit.

By aid of the graphs for P^2 we may evaluate this expression at a number of different frequencies without undue labour, whereas if we express the same thing directly in terms of frequency we have the equation

$$\left|\frac{E}{e}\right| = \sqrt{\frac{\frac{L}{C}\left(\frac{L}{C} - 2R^2\right) + R^2\left(p^2L^2 + \frac{1}{p^2C^2}\right)}{\frac{L}{C}\left(\frac{L}{C} - 2S^2\right) + S^2\left(p^2L^2 + \frac{1}{p^2C^2}\right)}}$$

which is by no means so pleasant to deal with.

If it is desired to take account of the resistance of the coil L in Fig. 4 (*a*) it can be simulated approximately as shown above by the resistance shown dotted in Fig. 4*b* (r is the resistance of the coil).



(a) (b)

Fig. 4.

From Fig. 4 (*b*) we obtain without difficulty

$$\left|\frac{E}{e}\right| = \sqrt{\frac{(1 + p_0^2C^2rR)^2 + p_0^2P^2C^2R^2}{(1 + p_0^2C^2rS)^2 + p_0^2P^2C^2S^2}}$$

an expression only slightly more complicated than that obtained by neglecting the coil resistance, and offering no greater difficulty in numerical computation than the latter; the corresponding expression involving p is too cumbersome to be worth writing down.

The applications of this method of circuit analysis are many and varied and no attempt has been made to cover all the possibilities. Enough has been said, however, to illustrate the method of procedure.

Having, as we hope, established the utility of our procedure to the satisfaction of the practical man, we come to matters of greater theoretical interest.

It will now be shown that P used above is the first member of a class of functions which will be called resonant functions. Consider the dipoles shown in Fig. 5 (*a*), (*b*), (*c*), (*d*),

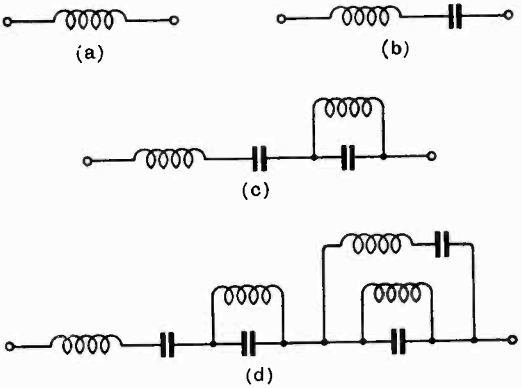


Fig 5.

each one being formed from the preceding one in the manner stated in our original proposition.

Clearly we have a connected series of dipoles of progressively increasing complexity. By a slight modification of notation it is possible to express the impedance operators of these structures in a simple manner.

We define the resonant function of the *n*th order as follows:

$$Pn(x) = x - \frac{1}{x} - \frac{1}{x - \frac{1}{x}} - \frac{1}{x - \frac{1}{x} - \frac{1}{x - \frac{1}{x}}} - \frac{1}{x - \frac{1}{x} - \frac{1}{x - \frac{1}{x}} - \frac{1}{x - \frac{1}{x} - \frac{1}{x - \frac{1}{x}}}} - \text{etc.} \ldots \quad (16)$$

there being n fractions in all. Thus we have

$$P_0(x) = x$$

$$P_1(x) = x - \frac{1}{x}$$

$$P_2(x) = x - \frac{1}{x} - \frac{1}{x - \frac{1}{x}}.$$

Calling the impedances of the dipoles of

Fig. 5 (*a*), (*b*), (*c*), (*d*), respectively, we have by successive applications of the proposition

if $x = \dfrac{p}{p_0}$

$$a = jLp_0 \cdot \frac{p}{p_0} = pLp_0P_0(x)$$

$$b = jLp_0\left(\frac{p}{p_0} - \frac{p_0}{p}\right) = jLp_0P_1(x)$$

$$c = jLp_0\left(\frac{p_0P_1(x)}{p_0} - \frac{p_0}{p_0P_1(x)}\right) = jLp_0P_2(x)$$

$$d = jLp_0\left(\frac{p_0P_2(x)}{p_0} - \frac{p_0}{p_0P_2(x)}\right) = jLp_0P_3(x)$$

and, in fact, we have in general the impedance of the *n*th member of this class of circuits given by $n = jLp_0P_n\left(\dfrac{p}{p_0}\right)$ .. .. (17)

The class of networks which are inverse to those of Fig. 5 is obtained in a similar manner by starting with a capacity instead of with an inductance. The first four members of the class are shown in Fig. 6, the impedance of the *n*th member being

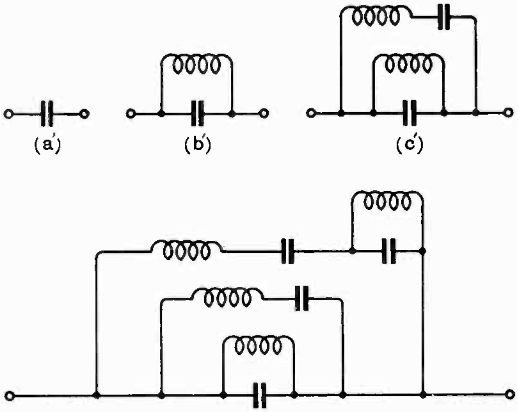


Fig. 6.

$$n' = \frac{1}{jCp_0P_n\left(\dfrac{p}{p_0}\right)} \quad .. \quad .. \quad (18)$$

Each member of the first class is seen to be inverse to the corresponding member of the second class since we have the relationship

$$n\,n' = \frac{L}{C} \quad .. \quad .. \quad .. \quad (19)$$

It should be borne in mind that all the inductances in these structures have the same value and similarly all the condensers have the same value as each other.

It is now necessary to investigate some of the properties of the resonant functions in greater detail.

It will be convenient to speak of resonant circuits of the *n*th order. We shall also speak of those circuits which are derived by commencing with an inductance, as Type 1 circuits, whilst those whose derivation is from a condenser will be termed circuits of Type 2, thus a capacity in shunt with an inductance will under this notation be a Type 2 circuit of the first order.

First we notice that by putting $\frac{1}{x}$ in place of x in equation (16) we have

$$P_n\left(\frac{1}{x}\right) = -P_n(x) \; (n \neq 0) \quad .. \quad (20)$$

and in a similar manner we find

$$P_n(-x) = -P_n(x) \quad .. \quad (21)$$

Putting $x = 1$ in (20) we note that

$$P_n(1) = 0 \text{ or } \infty \; (n \neq 0) \quad .. \quad (22)$$

(plus and minus infinity are equivalent).

The values of x satisfying

$$P_n(x) = 0 \quad .. \quad .. \quad .. \quad (23)$$

will be called resonant points, and those satisfying $P_n(x) = \pm\infty$ .. .. (24) anti-resonant points. It follows that all the resonant functions have anti-resonant points at $x = 0$ and $x = \pm\infty$

Calling the resonant points X we have to solve $P_n(X) = 0$ .. .. .. (25) whilst from the definition of the resonant functions we have, since the denominator of the *n*th fraction equals the sum of all the preceding terms,

$$P_n(X) = P_{n-1}(X) - \frac{1}{P_{n-1}(X)} \quad .. \quad (26)$$

Solving this equation we find

$$P_{n-1}(X) = \frac{P_n(X)}{2} \pm \sqrt{\left\{\frac{P_n(X)}{2}\right\}^2 + 1} \quad (27)$$

and by successively applying this recurrence relation, starting with equation (25), we find

$$P_n(X) = 0 \quad .. \quad .. \quad .. \quad (28.0)$$

$$P_{n-1}X) = \pm 1 \qquad \ldots \quad \ldots \quad \ldots \quad (28.1)$$

$$P_{n-2}(X) = \begin{cases} .5(1+\sqrt{5}) \\ .5(1-\sqrt{5}) \\ .5(-1+\sqrt{5}) \\ .5(-1-\sqrt{5}) \end{cases} \quad \ldots \quad (28.2)$$

$$P_{n-3}(X) = \begin{cases} .25\left(1+\sqrt{5}+\sqrt{22+2\sqrt{5}}\right) \\ .25\left(1+\sqrt{5}-\sqrt{22+2\sqrt{5}}\right) \\ .25\left(1-\sqrt{5}+\sqrt{22-2\sqrt{5}}\right) \\ .25\left(1-\sqrt{5}-\sqrt{22-2\sqrt{5}}\right) \\ .25\left(-1+\sqrt{5}+\sqrt{22-2\sqrt{5}}\right) \\ .25\left(-1+\sqrt{5}-\sqrt{22-2\sqrt{5}}\right) \\ .25\left(-1-\sqrt{5}+\sqrt{22+2\sqrt{5}}\right) \\ .25\left(-1-\sqrt{5}-\sqrt{22+2\sqrt{5}}\right) \end{cases}$$

$$\ldots \quad \ldots \quad (28.3)$$

etc.

Furthermore, since

$$P_{n-n}(X) = X \qquad \ldots \quad \ldots \quad (29)$$

we have, on putting $n = 1, 2, 3$, etc., in the above equations, the result that the resonant points of $P_1(x)$ are given by the right-hand side of equation (28.1); those of $P_2(x)$, by (28.2); and so on.

It will be observed from equations (28) that in general $P_n(x)$ has 2^n resonant points, but that only one-half of these are positive. This follows from the fact that (27) gives two values of $P_{n-1}(x)$, one positive and the other negative, then two values of $P_{n-2}(x)$ for each value of $P_{n-1}(x)$, and so on. In electrical investigations we do not usually encounter negative frequencies, so that we are only concerned with 2^{n-1} resonant frequencies in a circuit of order n.

We have already observed that the resonant functions have anti-resonant points at zero and infinity.

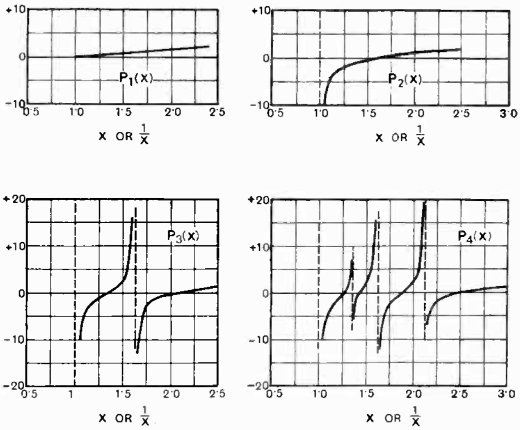
To find the other anti-resonant points we observe that when

$$P_n(x) = \pm\infty, \; P_{n-1}(x) = 0 \text{ or } \pm\infty,$$

from which it follows immediately that the anti-resonant points of the nth function coincide with the resonant and anti-resonant points of the $(n-1)th$ function.

We can compute the values of successive functions quite readily by making use of the fact that $P_{n+1}(x) = P_1(P_n(x))$. We look up the values of $P_1(x)$ from the graph and then, using these as the argument, we look up $P_1(P_1(x)) = P_2(x)$, and so on. The first few functions are shown plotted in Fig. 7.

We may now restate our original proposition in a more generalised form, as follows.



$P_n(\frac{1}{x}) = - P_n(x)$

Fig. 7.

If y is any quantity whatever associated with a circuit consisting of resistances, inductances and capacities, and if furthermore

$$y = F(p) \quad \ldots \quad \ldots \quad \ldots \quad (30)$$

is the equation connecting y with the applied angular frequency p, then if we alter the circuit by connecting a condenser in series with each inductance and an inductance in shunt with each of the original condensers, choosing the values of the added elements so that all the resonant circuits so formed have the resonant angular frequency p_0; and if, furthermore, we perform this operation on the circuit n times, then the equation corresponding to (30) for the altered circuit is

$$y = F\left(p_0 P_n\left(\frac{p}{p_0}\right)\right) \quad \ldots \quad \ldots \quad (31)$$

The proof of the proposition in this more general form is, of course, contained in the foregoing analysis.

It is clearly possible to generalise still further the foregoing analysis, which has so far been limited to the case in which all the inductances have the same value, and similarly for the condensers.

We will define the generalised resonant function of order n as

$$P_{a,\,b,\,\ldots\,n}(x)=x-\frac{a^2}{x}-\cfrac{b^2}{x-\cfrac{a^2}{x}}-\cfrac{c^2}{x-\cfrac{a^2}{x}-\cfrac{b^2}{x-\cfrac{a^2}{x}}}\quad\text{etc.}\quad\ldots\quad(32)$$

there being n fractions.

The corresponding proposition may be stated as follows.

If y is any quantity whatever associated with a circuit consisting of resistances, inductances and capacities, and if furthermore

$$y = F(p) \quad \ldots \quad \ldots \quad \ldots \quad (33)$$

is the equation connecting y with the applied angular frequency p, then if we alter the circuit by connecting a condenser in series with each inductance and an inductance in shunt with each of the original condensers, choosing the values of the added elements so that all the resonant circuits so formed have the resonant angular frequency a; and if, furthermore, we again perform this operation, choosing the values of the added elements so that all the resonant circuits so formed have the resonant angular frequency b; and again for c, d, e, etc., up to and including n; then the equation corresponding to (33) for the altered circuit is

$$y = F(P_{a,\,b,\,\ldots\,n}(p)) \quad \ldots \quad \ldots \quad (34)$$

It is somewhat doubtful whether the proposition in this general form offers any advantage as far as computational simplification is concerned, over the more usual methods, since the generalised resonant function, containing as it does, n parameters, does not lend itself to tabulation or graphical delineation; it is introduced here more for the sake of logical completeness than practical utility, but it may nevertheless be found a convenient artifice for classifying certain types of networks and expressing their impedance operators in a compact form; it is also a convenient method of finding the resonant and anti-resonant frequencies of these networks.

To find the resonant points of the generalised function we may use the same method as was used above for the more restricted function. The positive resonant points of the first three generalised functions will be found to be

$$X_a = a \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (35\cdot1)$$

$$X_{a,\,b,} = \begin{cases} \sqrt{(b/2)^2 + a^2} + b/2 \\ \sqrt{(b/2)^2 + a^2} - b/2 \end{cases} \quad \ldots \quad (35\cdot2)$$

$$X_{a,\,b,\,c,} = \begin{cases} .25\Big(\sqrt{(\sqrt{c^2 + 4b^2} + c)^2 + 16a^2} \\ \qquad + (\sqrt{c^2 + 4b^2} + c)\Big) \\ .25\Big(\sqrt{(\sqrt{c^2 + 4b^2} + c)^2 + 16a^2} \\ \qquad - (\sqrt{c^2 + 4b^2} + c)\Big) \\ .25\Big(\sqrt{(\sqrt{c^2 + 4b^2} - c^2) + 16a^2} \\ \qquad + (\sqrt{c^2 + 4b^2} - c)\Big) \\ .25\Big(\sqrt{(\sqrt{c^2 + 4b^2} - c)^2 + 16a^2} \\ \qquad - (\sqrt{c^2 + 4b^2} - c)\Big) \end{cases} \quad \ldots \quad \ldots \quad (35\cdot3)$$

N.P.L. Annual Invitation Visit

THERE were fewer matters of wireless interest than usual at the annual visit to the National Physical Laboratory on June 25th, while the fact that part of the Radio Department of the Laboratory is at the Radio Research Station at Slough makes it difficult for working observational apparatus from that place to be included in the exhibits of the day. In the Radio Department the main interest was in ultra-short-wave generators, these comprising a four-segment magnetron and also purely electronic generators. Frequency-stability of valve-maintained oscillator circuits was represented by two exhibits, one a short-wave inductance, and the other a variable condenser, both of very high stability as regards temperature variations and variations with time.

Work of the Radio Station at Slough was represented by static exhibits of records. One of these showed the results obtained within the last year in the exploration of the ionosphere, giving the most recent measurements as regards ionisation at different levels and its variations both diurnal and seasonal. An allied exhibit was "The Radio Weather House," a futuristic skyscraper structure annotated with the different levels of various phenomena, and showing their height in relation to such terrestrial heights as Ben Nevis and Mt. Everest. Another "records" exhibit showed the most recent information available on the nature of atmospherics, and illustrated the differences that occur at different distances from the origin. Cathode-ray exhibits were devoted to the use of tubes with special "collector" electrodes, one of these using magnetic retroaction back on to the beam to give an extremely sensitive relay effect.

In the Standards and Measurements Division of the Electricity Department a new exhibit of allied interest was a controlled oscillator for the production of standard *audio* frequencies, with an accuracy of 1 in 10.

Detection at Large Inputs*

By W. F. Cope, B.A.

Summary.—The advantages which accrue from operating the detector with a large input are described. The design of suitable circuit arrangements to provide this large input is discussed and solutions given. Throughout special emphasis is laid on the case of a detector feeding a push-pull output stage directly.

THE idea of exciting the output stage of a quality receiver directly from the detector is attractive for several reasons. There is no audio frequency amplifier to introduce hum and other forms of distortion. The detector works at large amplitude under the best possible conditions, both for the " demodulation " of interference and linearity of response ; furthermore, the load it imposes on the preceding tuned circuit is easily calculable.[1] The radio-frequency amplifier will probably have to comprise more than one stage and for a given selectivity a multi-circuit amplifier causes less attenuation of the higher modulation frequencies.

The difficulties centre round the ultimate R.F. stage and the choice of the detector itself. A set of the kind that is being considered will almost certainly have for its output stage two triodes of either the 12 or the 25 watt class in push pull. In both cases the bias of the individual valves will be about 35 volts. The audio output from the detector then may be as high as 50 volts R.M.S. Assuming that the detector efficiency is 80 per cent. and that the output stage is to be overloaded if the modulation depth exceeds the same figure, the input to the detector may be as high as 110 volts R.M.S. There is no need to cater for 100 per cent. modulation since it is a rare and transient occurrence and a push-pull stage can be somewhat overloaded without ill effect. The ultimate R.F. stage, then, must amplify linearly up to output voltages of at least 110, and the detector must be capable of accepting this input. Moreover, if the load on the detector is a resistance of 100 $k\Omega$, as it very well may be, the instantaneous current through this resistance will exceed 1 mA. These requirements are very severe : it will be convenient to consider them under two heads, the R.F. stage itself and the detector with its output circuit.

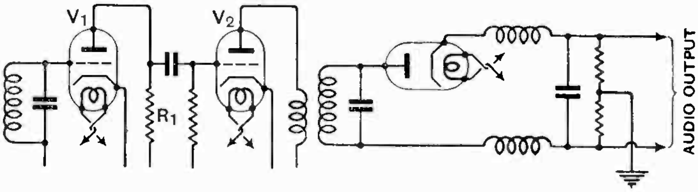


Fig. 1.—*Two-triode amplifier.*

An output linear up to 110 volts is well outside the powers of a tetrode,[2] may be just possible with a pentode,[3 & 4] and is easily obtainable with a two-triode amplifier. This arrangement is illustrated in Fig. 1. It has been investigated both analytically and experimentally by Colebrook,[2 & 7] and is sufficiently described for the present purpose by saying that V_2 acts as an R.F. amplifier in the usual manner, the transformer in its anode circuit being preferably of low-loss construction, and that V_1 acts as a buffer valve between the input and output tuned circuits. In setting up an amplifier of this type the important things to consider are : the grid-anode capacitance of the valves C_{ga}, the quantity μ^2/R_a and the anode load of the buffer valve (R_1). Of these C_{ga} is the most important ; it should be as low as possible principally to reduce the inevitable damping of the input circuit. μ^2/R_a is a measure of the performance of the valve as an R.F. amplifier : it should be as high as possible. R_1 should be kept low[2 & 7] about 1–2 $k\Omega$, if no reaction is used, also to reduce damping ; it may, however, sometimes be advantageous to increase it to about 10 $k\Omega$ and apply reaction to the input circuit. In an average triode C_{ga} is about 7 $\mu\mu$F, but there are a few types now available commercially in which this figure has been reduced to 3 $\mu\mu$F. On the other hand, these valves are of the high-μ type, which is not

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* MS. accepted by the Editor, February, 1935.

necessarily an advantage; small power valves usually perform best in this kind of amplifier. The author has tried both small power valves and the special type, and finds the overall amplification obtained under practical conditions is about twice as great if the latter be used. This is due to the combined effects of a low C_{ga} and a high μ^2/R_a and agrees with the results of calculation.

Various ways of dividing the detector output load to feed a push-pull audio stage have been described.[5] It does not, however, appear to have been explicitly pointed out that there is necessarily an element of asymmetry present in them all. The cathode-heater capacitance of the detector is in parallel with one half of the output load only. In itself this capacitance is not large, it has been found to be about $4\mu\mu$F. in those cases the author has considered, but it could be increased to a very undesirable extent by using a solid valve holder, mounting it on a metal chassis and running the cathode leads close to earth points. The difficulty cannot be evaded by using a metal oxide or other form of cold rectifier small enough to be slung from the wiring, since no suitable types appear to be commercially available. It was pointed out earlier that the detector must be capable of accepting inputs of 110 volts R.M.S. and have a total emission of over 1 mA. In addition, if of the valve type, it must stand the application of up to 70 volts between cathode and heater.

A value of 100 kΩ total (*i.e.*, 50 + 50) for the detector load appears to give satisfactory results. This value allows the grid leaks of the output valves to be kept low without seriously shunting the detector load, and at the same time is high enough to permit a satisfactory step up from the ultimate R.F. stage. The usual R.F. filter is necessary and can, if thought desirable, be utilised for purposes of tone control.[6]

The arrangement of Fig. 2, which is new so far as the author is aware, appears to merit a trial. It is essentially the well-known push-pull or full wave detector with the load divided to give a push-pull audio output. It damps the preceding tuned circuit very little, so a high step up can be used, and it is balanced as regards R.F. for both input and output. On the other hand, the cathode-heater asymmetry, to which reference has already been made, is doubled and the various points mentioned in that connection demand careful attention.

The arrangement of Fig. 1 with the low capacitance triodes has been in use for some months as a local station receiver with a good outdoor aerial some 20 miles S.S.W. of Brookmans Park. The results are very satisfactory. The sensitivity is more than sufficient to excite fully a push-pull stage of the kind previously mentioned from the Regional transmissions, it is more than enough for a single valve, and not quite enough for a pair from the National transmissions. The decrease is due partly to increased damping on the input circuit from V_1, and partly to the weaker signal. The application of a little reaction to the input circuit from the anode of V_1 gives the requisite increase in output (about $1\frac{1}{2}$ times voltage amplification, say 4 db.) without audible damage to the frequency response.

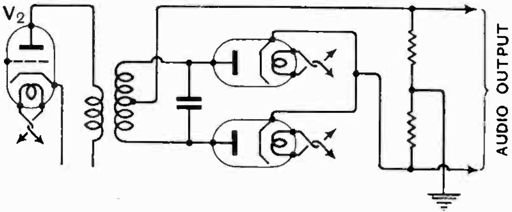

Fig. 2.—*Circuit suggested by the author.*

Another possibility, and one for which there is much to be said, is to apply this technique to a superheterodyne of the Single-Span type. Only one other R.F. valve would be necessary, and it could be preceded and followed by filters adjusted once and for all to give the desired response. The amplifier tuning being fixed, it is advantageous[2] to increase the value of R_1 to 10 or 15 kΩ and to connect in parallel with it a small R.F. choke of fairly high resistance. By properly adjusting the inductance of the choke this combination can be made to give the same amplification as a pure resistance load without damping the input circuit to any appreciable extent.

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2540. A NEW TEST OF THE MAGNETO-IONIC THEORY [at Wavelengths longer than 214 m: Experiments on E Region at Midnight in Midwinter, with Circularly Polarised Aerial, gave Easier Penetration of Extraordinary Wave, agreeing with Theory].—F. T. Farmer and J. A. Ratcliffe. (*Nature*, 18th May, 1935, Vol. 135, pp. 831–832.)

2541. VELOCITY OF PROPAGATION OF ELECTROMAGNETIC ENERGY [Theoretical Note].—J. van Mieghem. (*Comptes Rendus*, 20th May, 1935, Vol. 200, No. 21, pp. 1735–1737.)

Maxwell's equations with Poynting's theorem give a formula for the mean value of velocity of propagation of energy in an ionised medium which, for high frequencies, becomes identical with that found by L. Brillouin ("Theory of Quanta and Bohr's Atom," 1927), and reduces to the group velocity in the absence of friction and conductivity.

2542. EQUATION OF A WAVE IN A MEDIUM WITH VELOCITY A FUNCTION OF TIME.—P. I. Wold. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, pp. 735–738.) *See* also 1752 of June.

2543. OBSERVATIONS OF FIELD-STRENGTH FADING IN THE BROADCASTING BAND IN DAYLIGHT ["Day Fading" Records on Zugspitze: Effect of Thundery Tendency: Slow and Rapid Types: etc.].—A. Agricola. (*T.F.T.*, April, 1935, Vol. 24, No. 4, pp. 92–93.) Following on the paper dealt with in 1314 of May.

2544. AIR-MASS CONDITIONS AND THE BENDING OF ULTRA-HIGH-FREQUENCY WAVES: NEW LIGHT ON HOW 5-METRE SIGNALS ARE TRANSMITTED OVER LONG INDIRECT PATHS.—R. A. Hull. (*QST*, June, 1935, Vol. 19, No. 6, pp. 13–18 and 74, 76.)

See also Brooks, 2154 of July. "This preliminary qualitative survey, over these particular indirect paths, shows that stratification of the lower atmosphere is very frequently responsible for an order of bending of u-h-f waves considerably greater than that accounted for in analytical studies of atmospheric refraction. The assumption, in such studies, that the atmosphere is normally homogeneous, with a uniform water-vapour gradient and a steady temperature lapse rate, has possibly given a misleading result." While diffraction and reflection play a part, "it is extremely probable that the dominant phenomenon involved is that of refraction." Beliefs concerning the freedom from fading of such waves, and their limitation of range to paths only slightly greater than the optical range, must be revised: and so striking is the relationship between signal level and the prevailing lapse rate that these waves may well form a valuable added tool for the meteorologist.

2545. "ÜBER EINFLÜSSE DER HEAVISIDE-SCHICHT AUF DIE AUSBREITUNG ULTRAKURZER [Ultra-Short] WELLEN."—Chen Yü-Shon. (At Patent Office Library, London: 24 pp.: Catalogue number 74964.)

2546. ASTRONOMICAL SEEING [and the Part Played by Air Movements, etc.].—J. A. Anderson. (*Journ. Opt. Soc. Am.*, May, 1935, Vol. 25, No. 5, pp. 152–155.)

2547. ATTENUATION OF LIGHT IN THE LOWER ATMOSPHERE [Survey].—E. O. Hulburt. (*Journ. Opt. Soc. Am.*, May, 1935, Vol. 25, No. 5, pp. 125–130.)

2548. ON THE INTERACTION OF TWO ELECTRIC WAVES IN THE HEAVISIDE LAYER.—K. Försterling. (*Hochf:tech. u. Elek:akus.*, May, 1935, Vol. 45, No. 5, pp. 145–148.)

In section 1 the field strength of a long wave, reflected at the lower part of the Heaviside layer without getting near to the region of maximum ionisation, is discussed with the help of Gans' analysis of the case of a linear decrease of ϵ with altitude (*Ann. der Phys.*, 1915), which can be assumed to hold good here. Equation 5b shows that the superposition of the incident and reflected rays produces a field strength at the point of reflection which may be very considerably greater than that calculated from the simple inverse distance formula. Section 2 brings in the work of Lassen (*E.N.T.*, 1926) to estimate the ratio of the additional electron speed, produced by the wave of frequency ω_1, to the mean thermal speed, taking into account the earth's magnetic field. The wave produces the greatest speed increase, at the point of total reflection, if the oscillation here is parallel to the magnetic field, so that if the lower Heaviside layer is horizontally stratified ("which, from latest observations, is uncertain") the most "favourable" position (for the occurrence of Luxembourg effect) for the reflecting points of the interfered-with wave should lie about east and west of the interfering station (whose wave is referred to throughout the paper as the "modulated" wave, that of the interfered-with station being called the "originally unmodulated wave"). Making certain assumptions regarding the radiation characteristics of Luxembourg and Droitwich, etc., and bringing in equation 5b referred to above, it is found that the electron velocity due to the 150 kw transmission may be about 9×10^6 cm/sec. at the point of total reflection (equation 6). The mean thermal speed $\bar{w}$ at a temperature of $-53°$ is also 9×10^6 cm/sec., so that under the conditions assumed the speed at this point of total reflection may be doubled by the action of the "modulated" wave. At a point lower by the amount Δ the increase of mean speed produced by the wave is given by

$$\bar{u} = \bar{w}(1 - 0.5 \, . \, \Delta/\lambda_1) \quad . \quad . \quad . \quad . \quad (8).$$

Section 3 considers the effect on the absorption index and the index of refraction, for the incident "unmodulated" wave of frequency ω_2, of the number of electron collisions per second. This collision frequency S is given by the ratio of the mean speed to the mean free path-length l, so that under the action of ω_1, $S = \bar{w}/l + \bar{u}/l$, or, from equation 8, $= \bar{w}/l + \bar{w}(1 - 0.5 \, . \, \Delta/\lambda_1)/l$. The second term determines the influence of the wave ω_1 on the absorption coefficient of the wave ω_2, which is proportional to S. Section 4 works out the effect of this change of absorption coefficient on the absorption of the ω_2 wave with angles of incidence ψ_0 outside the layer and ψ in the neighbourhood of the reflection point of the ω_1 wave. The simplified equation for the increased absorption A, given six lines below equation 11, shows that A decreases rapidly as ν_2 (the frequency of the "unmodulated" wave) increases; but even taking ν_2 at the "unfavourably" high value of 1000 kc/s the value for A comes out at about 0.6, assuming a free path of 20 cm at a height of 90 km. Thus the "modulated" wave of around 200 kc/s frequency and 150 kw power would produce an additional absorption, varying with the modulation frequency, which would act on the "unmodulated" wave and modulate it, to an extent comparable with the depth of modulation actually observed in the Luxembourg effect (up to 10%). All this is assuming that it is electrons which are responsible for the ray refraction in the lower Heaviside layer: if ions were involved, a factor m/M would have to be introduced into equation 6. The absorption of the "modulated" wave has been neglected: this absorption would, of course, tend to diminish the modulating effect on the second wave.

2549. INTERACTION OF RADIO WAVES [U.R.S.I., 1934].—B. van der Pol and J. van der Mark. (*Tijdschr. Nederlandsch Radiogen.*, March, 1935, Vol. 7, No. 1, pp. 12–17: in English.) *See* also 10 of January.

2550. THE SEASONAL VARIATION OF IONISATION IN REGION F_2 OF THE IONOSPHERE [Maximum Noon Ionisation: Remarks on Interpretation of Results].—E. V. Appleton: Hulburt. (*Phys. Review*, 1st May, 1935, Series 2, Vol. 47, No. 9, p. 704.) *See* 1733 of June.

2551. RECENT STUDIES OF THE IONOSPHERE.—S. S. Kirby and E. B. Judson. (*Journ. of Res. of Nat. Bur. of Stds.*, April, 1935, Vol. 14, No. 4, pp. 469–486.)

A summary of a part of this paper was dealt with in 1934 Abstracts, p. 364. "The variation of the normal E-layer critical frequency during the daytime was found to be approximately in accordance with the equation $f_E \approx (\cos \psi)^{1/4}$ [where ψ is the angle which the sun's rays make with the zenith]. Magneto-ionic splitting was not observed in this layer. These results indicated a rapid recombination and a layer of heavy ions. The diurnal variation of F_2-layer critical frequency did not follow the above equation but in general lagged behind the variations of the ionising force of the sun. Magnetic double refraction usually occurred. These results indicated a slower rate of recombination and a layer effectively of electrons." Most of the night-time E layer observed was of the "sporadic E layer" type—reflecting, frequently semi-transparent, and showing no critical frequencies.

2552. SOME RECENT STUDIES OF THE IONISATION OF THE IONOSPHERE [Pacific Science Congress, 1933].—Schafer and Goodall. (*Bell Tel. S. Tech. Pub.*, Monograph B-834, pp. 1–9.)

For other papers of about the same date *see* Abstracts, 1933, p. 558, and 1934, p. 85. "The presence of erratic variations in the ionisation maximum of the F layer suggests that there is an erratic source of ionisation, solar or cosmic, which is superposed on the regular diurnal variation of the ionisation due to the light from the sun. Another explanation might be that different parts of the F region are not equally ionised, and that motion of some sort causes the observed variations. The writers favour the first explanation, but believe it should be submitted to some crucial test. An interesting experiment would be to take similar data simultaneously at two widely separated points on the earth."

2553. RECORDING OF IONOSPHERE ECHOES AT NON-VERTICAL INCIDENCE [Synchronism attained by Portable Crystal-Controlled Thyratron Inverter].—P. B. King, Jr., and H. R. Mimno. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, pp. 786–787: abstract only.)

2554. A Mobile Radio Research Laboratory [for Propagation Investigations: Receivers and Transmitters mounted on Relay Racks].—H. Selvidge and H. R. Mimno. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 786: abstract only.)

2555. Measurements of the Heights of the Kennelly-Heaviside Layer in Japan.—III. From September 1933 to April 1934.—T. Minohara and Y. Ito. (*Rep. of Rad. Res. in Japan*, March, 1935, Vol. 5, No. 1, pp. L–1 to L–15: in English.) For previous parts *see* 945 of April.

2556. Measurements of Heights of the Ionosphere and Experiments on the Scattering of the Electromagnetic Wave.—K. Maeda. (*Rep. of Rad. Res. in Japan*, March, 1935, Vol. 5, No. 1, Abstracts pp. 2–3.)

"The scattered waves owe their energy to a part of one which is radiated at higher angles and which, after penetrating the E and F layers, returns to earth from a height of 400–700 km. It is doubtful if the scattering of waves causes a great loss of wave energy at a distant receiving station. The author concludes by estimating the distortion of the wave form of various modulation systems caused by the received echoes."

2557. Scattering, Polarisation Errors and the Accuracy of Short-Wave Direction Finding.—Eckersley. (*See* 2660.)

2558. The Attenuation Characteristics of Short Waves in the K-H Layer.—Nakagami. (*Rep. of Rad. Res. in Japan*, March, 1935, Vol. 5, No. 1, Abstracts p. 2.)

The writer has calculated the short-wave attenuation characteristics of the 1st and 2nd kind (*see* Namba, 1933 Abstracts, p. 149, 2nd abstract) and arrives at conclusions as to the effects, on the two kinds, of (i) approach to critical frequency, (ii) sun's altitude, and (iii) change in frequency and projection angle of the waves. Attenuation of the 1st kind is not subject to the inverse square law of frequency, but gives a greater value.

2559. Tests of Low-Angle Short-Wave Transmission between Japan and Europe.—Ohno. (*See* 2639.)

2560. Report for the Propagation of Waves Committee, Fifth U.R.S.I. Assembly, *and* Report of Radio Wave Observations at Angmagssalik by the Dutch Expedition during the International Polar Year 1932–1933.—G. J. Elias: J. A. de Bruïne. (*Tijdschr. Nederlandsch Radiogen.*, May, 1935, Vol. 7, No. 2, pp. 33–37, in French: pp. 38–44, in English.) For the full paper (in Dutch) on which the second report is based see *ibid.*, pp. 45–75.

2561. Summary of Some Theoretical Contributions by Dr. Balth. van der Pol and Dr. K. F. Niessen to the Problem of Propagation of Radio Waves over the Earth [U.R.S.I., 1934].—B. van der Pol. (*Tijdschr. Nederlandsch Radiogen.*, March, 1935, Vol. 7, No. 1, pp. 1–11: in English.)

2562. The Measurement of the Dielectric Constant and Specific Conductivity of the Soil.—I. E. Baligin and V. I.Vorobiev. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 4, 1934, pp. 1836–1843.)

An account of measurement of ϵ and σ of soil (large grain sand) made over a period of more than a month in order to investigate, among other things, the effect of weather changes on these factors. The method used was based on that originally proposed by Abraham (*Physik. Zeitschr.*, 1919, April, pp. 145 and 147), *i.e.*, the attenuation of h.f. electromagnetic waves in a Lecher system buried in the soil was measured, and from these measurements ϵ and σ calculated. An outline of the theory of the method is given, followed by a detailed account of the experiments. The Lecher system employed consisted of two parallel conductors 140 m long, spaced 2 cm apart, and buried to a depth of 50 cm. At distances of 2.5, 5, 10, 20 and 50 m from the beginning of the line, branches were led out to the surface to enable the amplitudes of the electromagnetic waves to be measured at these points by means of a valve voltmeter. The h.f. energy was fed into the line from an oscillator. The wavelengths used were within the range of 110 to 175 m. The results obtained are shown in a number of curves, and a table is added giving the values of ϵ and σ for different days and various wavelengths. It can be seen from this table that ϵ varies from 9.2 to 19.0 electrostatic units, and $\sigma \times 10^{-5}$ from 1.34 to 1.97 Siemens/cm.

The main conclusions reached are as follows:—(a) while ϵ is independent of the wavelength (within the above wavelength range), σ decreases when the wavelength increases; (b) an increase in humidity of the soil greatly increases ϵ; σ is also apparently affected by complex ionic processes in the soil due to changes in weather conditions. In conclusion it is mentioned that the velocity of propagation of electromagnetic waves in the Lecher system, as computed from the values of ϵ and σ, was found to be $0.22c$ after a prolonged period of rain, and $0.27c$ after a few dry days.

2563. A New Nitrogen Afterglow Spectrum [with Very Small Current: Resemblance to Night Sky Radiation].—K. Kaplan. (*Nature*, 22nd June, 1935, Vol. 135, pp. 1034–1035.)

2564. The Vegard-Kaplan Bands in the Spectrum of the Night Sky [Presence of Metastable Nitrogen Molecules].—J. Cabannes and J. Dufay. (*Comptes Rendus*, 29th April, 1935, Vol. 200, No. 18, pp. 1504–1506.) *See* 24 of January and 1740 of June.

2565. Red Oxygen Radiation in the Spectrum of the Night Sky.—J. Cabannes. (*Comptes Rendus*, 3rd June, 1935, Vol. 200, No. 23, pp. 1905–1908.)

2566. Quantitative Analysis of Atmospheric Ozone by Fluorescin [Autodestruction of Ozone: Negligible Effect of Other Gases].—W. Heller. (*Comptes Rendus*, 3rd June, 1935, Vol. 200, No. 23, pp. 1936–1938.)

2567. THE ABSORPTION SPECTRUM OF OZONE IN THE PHOTOGRAPHIC INFRA-RED REGION [6500 Å to 10 000 Å: Positions of Absorption Maxima].—Lucie Lefebvre. (*Comptes Rendus*, 20th May, 1935, Vol. 200, No. 21, pp. 1743–1744.)

2568. RESEARCHES ON OZONE AND ITS MAGNETIC PROPERTIES.—P. Lainé. (*Ann. de Physique*, May/June, 1935, Series 11, Vol. 3, pp. 461–554.)

2569. ON THE THEORY OF OPTICAL ACTIVITY. I—GENERAL THEORY OF A SYSTEM OF COUPLED ISOTROPIC OSCILLATORS. II—MOLECULES WITH A BINARY AXIS OF SYMMETRY.—M. Born. (*Proc. Roy. Soc.*, Series A, 1st May, 1935, Vol. 150, No. 869, pp. 84–105.)

2570. REMARKS ON THE DERIVATION OF SNELL'S LAW OF REFRACTION [Treatment of Boundary Conditions at Infinity for Wave Equation: Their Influence on Conditions at Finite Distances and Derivation of False Refraction Laws].—A. Erdélyi. (*Zeitschr. f. Physik*, No. 1/2, Vol. 95, 1935, pp. 115–132.)

2571. NOTE ON THE REPRESENTATION OF PERIODIC PROCESSES ON LINES.—J. Fischer. (*Hochf: tech. u. Elek:akus.*, May, 1935, Vol. 45, No. 5, pp. 167–169.)

In his previous paper (1934 Abstracts, p. 315) the writer made the simplifying assumption that the four line constants L, R, C and G did not vary with the frequency. He now considers how the results are modified by the variations with frequency of these constants, and in so doing gives a number of literature references relating to these variations. His treatment of their effect on his previous results is based on the work of H. Pleijel in Sweden (pub. 1923).

2572. TRANSIENTS IN THE FINITE ARTIFICIAL LINE.—E. Weber and M. J. Di Toro. (*Elec. Engineering*, June, 1935, Vol. 54, No. 6, pp. 661–663.)

2573. THE POLARISATION OF SEISMIC WAVES IN THE PRIMARY PHASE OF EARTH TREMORS [Local Geological Conditions at Receiver are Chief Cause of Polarisation in E/W Vertical Plane].—A. Dinca-Samuracas. (*Comptes Rendus*, 20th May, 1935, Vol. 200, No. 21, pp. 1772–1773.)

2574. THE PROPAGATION OF RAYLEIGH WAVES IN HETEROGENEOUS MEDIA [Mathematical Discussion.].—C. L. Pekeris. (*Physics*, April, 1935, Vol. 6, No. 4, pp. 133–138: addition, May, 1935, Vol. 6, No. 5, p. 178.)

A method is given for obtaining a power series expansion for the Rayleigh wave velocity in a half-space whose parameters vary with depth. The problem is discussed specifically for one type of variation, for which curves of wave velocities and surface amplitude ratios are shown. The addition gives the curves replotted in a way more useful in seismology.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2575. ON THE NECESSITY FOR A PERMANENT POLAR STATION FOR RADIO-METEOROLOGICAL OBSERVATIONS FOR THE WEATHER-FORECASTING SERVICES: WITH AN APPENDIX DESCRIBING THE ATMORADIOGRAPHS AND RADIOGONIOGRAPHS.—J. Lugeon. (*Rzeczopospolita Polska Państwowy Inst. Meteorolog.*, Warsaw, 1935, 96 pp: in French.) For *Comptes Rendus* Notes on some of the material *see* 35 of January, and 1934 Abstracts, p. 375. The most suitable site for the permanent station would seem to be Isfjord, near the Swalbard Radio Station. Tromsö would be excellent in every way if only its latitude were higher (70° compared with Swalbard 78° 13′). Perhaps luckily for the prospective personnel, Bear Island also (at 74°) is outside the polar night at the ionosphere level.

2576. THE ELECTRICITY OF RAIN AND THUNDERSTORMS [Raindrops and Surrounding Ionised Water Vapour constitute Concentration Cell: Separation of Charge in Thunderstorms].—R. Gunn. (*Phys. Review*, 1st May, 1935, Series 2, Vol. 47, No. 10, p. 786: abstract only.)

2577. THE MECHANISM OF THE HIGH VELOCITY OF PROPAGATION OF LIGHTNING DISCHARGES [Ionisation by Collision ahead of the Tip].—A. M. Cravath and L. B. Loeb. (*Physics*, April, 1935, Vol. 6, No. 4, pp. 125–127.)

Calculations show that "ionisation by collision by the electrons present in the gas before the stroke would be great enough to advance the tip" at the rate observed by Schonland and Collens (1934 Abstracts, p. 262).

2578. BREAKDOWN OF AN IRRADIATED SPARK GAP [Theoretical Considerations including Space-Charge show that Dischargebecomes Self-Supporting at a Definite Value of Current Density].—W. Rogowski and W. Fucks. (*Arch. f. Elektrot.*, 18th May, 1935, Vol. 29, No. 5, pp. 363–370.)

2579. MODERN CONCEPTIONS OF LIGHTNING DISCHARGE PHENOMENA [including Predilection of Localities: Experiments to show that Increased Ionisation does Not affect Course of Impulse Discharges].—Stekolnikov and Javorski. (*Elektrichestvo*, No. 8, 1935, pp. 29–36: in Russian.)

2580. GAS DISCHARGES IN THE CLOUD CHAMBER [Photographs of Negative and Positive Points].—H. Raether. (*Zeitschr. f. Physik*, No. 9/10, Vol. 94, 1935, pp. 567–573.)

2581. A HIGH-PRESSURE WILSON CLOUD CHAMBER [up to 100 Atmospheres].—P. Kipfer. (*Nature*, 16th March, 1935, Vol. 135, pp. 431–432.)

2582. A CIRCUIT FOR THE ANALYSIS OF GEIGER-COUNTER PULSES.—W. E. Ramsey and M. R. Lipman. (*Review Scient. Instr.*, April, 1935, Vol. 6, No. 4, pp. 121–125: *Journ. Franklin Inst.*, May, 1935, Vol. 219, No. 5, pp. 632–636.)

2583. Sudden Changes in Velocity and Direction shown by the Trajectories of High Energy Electrons [Cloud Chamber Studies illustrating Possible Behaviour of Cosmic Rays: High Angle Scattering].—L. Leprince-Ringuet. (*Comptes Rendus*, 29th April, 1935, Vol. 200, No. 18, pp. 1524–1526.)

2584. International Physics Congress, London: Papers on Cosmic Rays.—(*Rev. Gén. de l'Élec.*, 4th May, 1935, Vol. 37, No. 18, pp. 566–571.)

PROPERTIES OF CIRCUITS

2585. Power Matching in High-Frequency Circuits [" Resonance " Matching in place of Transformer Matching: Resonant Lines for Ultra-High Frequencies].—K. Küpfmuller. (*E.N.T.*, April, 1935, Vol. 12, No. 4, pp. 107–113.)

Matching for maximum power transfer to the consuming circuit in audio-frequency work, and to some extent also with radio-frequencies, is usually accomplished by a transformer so wound that $\omega_1/\omega_2 = \sqrt{R_1/R_2}$. But with radio-frequencies another method is also used, in which the potential transformations occurring in oscillatory circuits are involved in the matching process. An example is the matching of an aerial to a receiver (Kautter, 1931 Abstracts, p. 495). Since magnetically coupled circuits are usually employed in this method also, it is often not clearly recognised that a fundamentally different principle of power matching is concerned. The writer therefore shows how this " resonance " matching between two resistances R_1 and R_2 can be represented in its simplest forms (Fig. 2), where a capacity is connected in parallel with one resistance and an inductance in series with the other, or *vice versa*. These auxiliary elements can always be so chosen that the resulting energy components are equal to each other and the wattless components neutralise each other, so that each resistance absorbs all the possible energy from the other. Owing to the ohmic resistance R of the coil and the leakage of the condenser, there is a transmission loss which, as is shown in § 3, can be found by a simple approximate formula involving the " figures of merit " g_1 and g_2 of the coil and condenser. Of these, $g_1 = \omega L/R$ and $g_2 = \omega C/G$, and the transmission attenuation is approximately given by $b = \log_e \{1 + (\sqrt{\delta} - 1)/2g\}$ Nepers, where $g = g_1 g_2/(g_1 + g_2)$ and δ is the ratio of R_1 to R_2 or R_2 to R_1, whichever is greater than unity. This formula holds for all four cases of Fig. 2 provided g is large compared with unity. Fig. 4 shows four attenuation curves, for $g = 20$, 50, 100 and 200 respectively, with δ varying. Curve b_0 represents a direct coupling between generator and load, giving $b_0 = \log_e(1 + \delta)/2\sqrt{\delta}$ Nepers; even for a figure of merit as low as $g = 20$ the " resonance " matching gives an improvement, and for $g = 100$ (as can easily occur even at very high frequencies) the matching is almost loss-free up to resistance ratios of $\delta = 1000$.

§ 4 deals with selectivity. Full matching, strictly speaking, only occurs at the frequency for which the inductance and capacity values were calculated according to equations 2. Below and above this frequency the energy transferred to the consuming circuit falls as in a resonance curve, so that in practice there is a definite narrow frequency band in which the approximately full output is passed on. The width of this transmission band depends on (a) the nature of the generator and load resistances; (b) the resistance ratio δ: the greater this is, the sharper is the resonance yielding the matched condition, and therefore the smaller is the transmission band: and (c) the arrangement of the elements: the circuits of Fig. 2 are only the simplest possible forms, and can be extended by the addition of various coils and condensers. As regards matching, such complex extensions can be reduced to the equivalent forms in Fig. 2, but as regards selectivity they may behave differently, so that without upsetting the matching the selectivity can be varied within wide limits. The section ends with a discussion of special forms of " resonance " matching using T or H combinations of three reactances, one of which can be of selected value, while the other two are determined by the matching condition. An " interesting case " is that of Fig. 5, where symmetrical quadripoles are combined to give " resonance " matching.

Finally, §5 deals with the use of resonant lines, particularly for ultra-high frequencies. " For concentric lines the practically obtainable values of characteristic impedance lie in the neighbourhood of 50 ohms; for parallel wires, around 300 ohms. The consequent limitation of use is removed if one of the two resistances, R_1 or R_2, is provided with a reactive component, *e.g.* by a parallel condenser as in Fig. 8." The input resistance of a loss-free line of length l and characteristic impedance Z, closed by a resistance R_2, is given by equation 11, and by introducing the matching condition into this, equations 13–15 are obtained for calculating the necessary capacity value C and line length l. If $\delta > 1$ and $\zeta < 1$ (where $\zeta = Z^2/R_1R_2$) the minus sign of 14 applies, the line length is between $\lambda/4$ and $\lambda/2$, and the condenser must be connected across the *smaller* of the two resistances. If $\zeta > 1$, δ must < 1, the line length is between 0 and $\lambda/4$, and the other conditions are reversed. As an example of the matching calculation the case of a concentric cable for connecting a valve with an aerial is worked out, and the substitution of a series condenser, or an inductance, for the parallel condenser is discussed. The effect of line loss can be dealt with on line theory: a general idea is obtained from the locus curve of the line input resistance, where the circle of Fig. 9 is changed by the presence of loss into the spiral of Fig. 12. Fig. 16 gives an approximate formula involving the line figure of merit calculated as before. The above results hold good the more accurately, the smaller the value of r/R_2 thus found. Apart from extreme ratios of R_1/R_2, the ratio r/R_2 is as a rule very small even at the highest frequencies, since lines can easily be constructed with figures of merit of the order of 100–500.

2586. The Telegraphist's Equations at Ultra-High Frequencies.—R. King. (*Physics*, April, 1935, Vol. 6, No. 4, pp. 121–125.)

A generalised form of the telegraphist's equations is derived from Maxwell's equations, in which retardation and the time rate of change of current are taken into account. A new circuit parameter is thus obtained, which integrates into the radiation resistance of the parallel wires. The approximations used are discussed and a numerical example is given.

2587. [Mathematical] RELATIONS BETWEEN THE REAL AND IMAGINARY PARTS OF IMPEDANCES AND DETERMINATION OF THE IMPEDANCES AS FUNCTIONS OF ONE OF THE PARTS.—M. Bayard. (*Rev. Gén. de l'Élec.*, 25th May, 1935, Vol. 37, No. 21, pp. 659–664.)

The general mathematical properties of the impedance of a two-terminal resistance are discussed. The real and imaginary parts are not independent but, if one is given, the other is determined except for an additive constant, which may be a pure resistance or a pure reactance. Formulae for calculating the real or imaginary part when the other is given are deduced. Analogous questions are considered for the absolute value and phase of the impedance.

2588. GENERATION OF HIGH-FREQUENCY OSCILLATIONS IN RESISTANCE-COUPLED AMPLIFIERS.—P. A. Borissovsky and A. B. Sapojnikov. (*Izvestia Elektroprom. Slab. Toka*, No. 1, 1935, pp. 28–34.)

For a paper on l.f. relaxation oscillations *see* 983 of April. In the present paper the writers discuss the phenomenon of h.f. oscillations and find an expression for the possibility of the self-excitation of such oscillations where there is inductance in the plate-battery circuit: it is shown that the effect is due to the natural capacity of the inductance. Experimental results agree very closely with the theoretical conclusions.

2589. SUBHARMONICS IN FORCED OSCILLATIONS IN DISSIPATIVE SYSTEMS.—Pedersen. (*See* 2665.)

2590. CROSS-TALK FREQUENCIES [with Table giving All Components of Output Current].—K. Wilhelm. (*Electronics*, April, 1935, p. 130: summary only.)

2591. ON THE MATHEMATICAL THEORY OF AUTO-OSCILLATORY SYSTEMS WITH TWO DEGREES OF FREEDOM.—A. Andronow and A. Witt. (*Tech. Phys. of U.S.S.R.*, No. 3, Vol. 1, 1934, pp. 249–271: in French.)

For previous work see 1930 Abstracts, p. 209. "The preceding results [of the mathematical section of the paper, consisting of the finding of the periodic solutions of systems of differential equations and the study of the stability of these solutions on the lines indicated by Liapounov] can be applied directly to a whole series of problems relating to electrical and mechanical oscillatory systems with two degrees of freedom, whatever may be the modes of coupling and of excitation, if the systems are sufficiently close to conservative linear systems and if, in consequence, their oscillations are sufficiently near to sinusoidal. As examples may be quoted the oscillations of two coupled damped transmitters; the oscillations of a single transmitter, taking the grid circuit into account; and the oscillations of two coupled circuits one of which is excited." This last case is considered in detail, particularly the application of the formulae obtained in the first section to the "ziehen" effect ("traînage") and the jump from one frequency to the other.

2592. ON RESONANCE IN LINEAR SYSTEMS WITH PERIODICALLY VARIED PARAMETERS.—G. Gorelick. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 4, 1934, pp. 1783–1817.)

Until recent years the theory of resonance was mainly concerned with oscillating systems whose parameters remain constant and which select harmonic (sinusoidal) oscillations from the applied external force. Recently, however, great importance, especially in radio technique, has been attached to oscillating systems with periodically varied parameters, such as for instance the oscillating circuit of a super-regenerative receiver, the effective resistance of which is a function of time. In this paper a detailed mathematical investigation of such systems is presented and the usual harmonic resonator is treated as a particular instance of the more general case. Conditions of equilibrium are established and equations derived for free oscillations in the system, as well as for forced oscillations produced by an external force. The resonance condition is investigated and it is shown that when an external force is applied to a system with varied parameters the phenomena taking place in it are comparable to those which occur under similar conditions in a harmonic resonator. It is pointed out, however, that there is an important difference between the two cases, *viz.*, that oscillations in a system with varied parameters do not conform to the sinusoidal law but are expressed by the so-called Hill's functions (*see* Strutt, 1933 Abstracts, p. 461). This makes the system unselective with regard to sinusoidal oscillations, so that a receiver using such a circuit would receive all stations operating on sinusoidal waves within a certain frequency range.

Also, while in the case of harmonic forces and resonators the resonance condition is obtained only in those resonators which are tuned to a particular frequency, in the case of systems with varied parameters a force conforming to a Hill's function will produce resonance in a number of systems, the free oscillations of which are expressed by the same type of function. This necessitates a modification of our conception of resonance and resonance curves, and these points are discussed at great length.

2593. ON SOME NON-STATIONARY OSCILLATION PROCESSES [and the "Autoparametric" Principle of Elimination of Interference].—L. Mandelstam and N. Papalexi. (*Tech. Phys. of U.S.S.R.*, No. 4, Vol. 1, 1935, pp. 415–428: in German.)

Van der Pol's method of finding approximate solutions of equations of the type of $\ddot{x} + x = \mu f(x, \dot{x})$ has been very useful in dealing with modern oscillation problems. The present paper gives a stricter treatment of this method, using the method of successive approximation; the "shortened" equations are then applied to the treatment of non-stationary processes in those "resonance phenomena of the second type" which the writers have already dealt with, as regards stationary processes, in previous papers (1932 Abstracts, pp. 279–280): where a sinusoidal e.m.f. $- e_0 \sin 2\omega t$ acts on an oscillatory circuit which has its damping reduced by retroaction but not to the point of self-excitation, and is tuned approximately to ω; producing strong undamped, almost sinusoidal oscillations exactly ω in frequency. These "second type" resonance phenomena (*see* also Tetelbaum, 2233 of July and back reference) are of great importance in connection with the separation of comparatively long-lasting actions (telegraphy signals) from short impulses (atmospherics); the possibility of using the special "autoparametric" methods of transmission and reception (*cf.* the "autoparametric" filters dealt with by Melikjan, 2594, below) depends chiefly on these phenomena.

2594. ON THE GROWTH OF AMPLITUDE IN RESONANCE PHENOMENA OF THE SECOND TYPE [as in "Autoparametric" Filters].—A. Melikjan. (*Tech. Phys. of U.S.S.R.*, No. 4, Vol. 1, 1935, pp. 429–448: in German.)

See end of 2593. Author's summary:—"This paper gives an approximate theory of the growth of amplitude in an autoparametric system under the action of a harmonic force. An experimental investigation [with undamped oscillations] . . . was carried out, with results agreeing with the theory. Qualitatively, the action of damped oscillations, both alone and together with undamped oscillations, was investigated experimentally. In this way the effect of extinction [or reduction] of oscillation—'Zerhackung' [chopping]—was confirmed, and a new effect demonstrated, namely the speeding-up of the establishment of the frequency-divided oscillations." Regarding these last points, the behaviour of the autoparametric system to the simultaneous presence of a damped and an undamped oscillation is of two alternative kinds:—(a) If the damped oscillation acts on the system at the moment when, under the influence of the undamped external force, oscillations of the halved frequency are already established with an amplitude near or equal to the stationary amplitude, then the "chopping" effect may appear (oscillogram Fig. 22): the depth of the "chop" depends on the ratio of the maximum amplitude of the damped to the amplitude of the undamped oscillation, the effect being negligible in practice unless the ratio exceeds about 10. (b) If the damped impulse acts on the system at a moment when the half-frequency oscillation is practically absent, then an acceleration of the building-up process is seen (Fig. 24—with damped impulse, compared with Fig. 23—without); this occurs even when the maximum impulse amplitude is only of the same order as the undamped amplitude, and has the effect of shortening the building-up period and lengthening the almost stationary condition, as is seen from the oscillograms.

2595. ON PARAMETRIC REGENERATION.—L. I. Mandelstam and N. D. Papalexi. (*Izvestia Elektroprom. Slab. Toka*, No. 3, 1935, pp. 1–7.)

In an ordinary regenerating circuit, *i.e.*, in a valve with the anode and grid circuits back-coupled, the losses are partly compensated by the local source of power (anode battery). A similar effect can be obtained in a circuit, one of the parameters of which (inductance or capacity) is varied with a frequency which is a multiple or sub-multiple of that of the applied e.m.f. This effect is most pronounced when the frequency of the variation is half that of the applied frequency. In this paper, which is the first of a series on the subject to be published (*see* also 2596), a theoretical examination is given of a circuit which consists of a capacity C, resistance R, and inductance

$$L = L_0(1 + m \sin 2\omega t).$$

The applied e.m.f. $E = E_0 \sin(\omega t + \psi)$.

A differential equation for the system is given (3) and a formula is derived (5) representing the amplitude A of the oscillations in the circuit as a function of the detuning ξ of the circuit, damping δ, depth of modulation of the varied parameter m, and phase angle ψ between the variation of the parameter and the external e.m.f. The dependence of A on ψ is a characteristic feature of the parametric regenerator. Inasmuch as (5) shows the relationship between A and ξ it also represents the resonance curve. Depending on the value of ψ the following two typical conditions can be obtained:—(a) $\sin 2\psi = 0$; $\cos 2\psi = 1$. The variation of the parameter produces an effect equivalent to a reduction of δ and the system in this respect is similar to an ordinary regenerative circuit. The resonance curves are similar to normal curves except that they are somewhat wider and flatter.

(b) $\sin 2\psi = 0$; $\cos 2\psi = -1$. The variation of the parameter in this case is equivalent to an increase in δ, as in an ordinary regenerating circuit with back-coupling of opposite sign. The resonance curve has a deep trough at the point of resonance. The balance of energy in the system is also given for each case. Finally a brief examination of the system is given when it is in the condition of self-excitation, and a formula is derived (22), similar to (5), for the amplitude of the resultant oscillations.

2596. ON THE BEHAVIOUR OF AN OSCILLATORY CIRCUIT WITH A PERIODICALLY VARYING INDUCTANCE UNDER THE ACTION OF AN EXTERNAL E.M.F.—E. M. Rubchinski. (*Izvestia Elektroprom. Slab. Toka*, No. 3, 1935, pp. 7–17.)

Author's summary:—"It is shown that in an oscillatory circuit with a periodically varying inductance, under the action of an external e.m.f. whose period is double the period of the parameter (inductance) variation, the latter may cause an effect analogous to the decrease or increase of the circuit damping, according to the phase relation of the external e.m.f. and the current modulating the parameter. The frequency characteristics (resonance curves) of such a system show different shapes depending mainly on the phase relation of the forces acting on the circuit. By varying this phase relation we can obtain a continuous variation of the shape of the curve, passing from that which characterises so-called 'strong' resonance to the shape distinguishing 'weak' resonance." *See* also 2595, and for other work on similar systems *see* Watanabe and others, 1933 Abstracts, p. 500 and back references.

TRANSMISSION

2597. MAGNETRON OSCILLATION [Agreement on Recent Discussion].—I. K. Posthumus and E. C. S. Megaw. (*Nature*, 1st June, 1935, Vol. 135, p. 914.) *See* 1370 of May.

2598. Theory of the Magnetron Valve Transmitter with Split Anode, *and* On the Theory of the Electron Oscillations appearing in Magnetron Valve Transmitters.—F. Müller. (*Tech. Phys. of U.S.S.R.*, Nos. 5/6, Vol. 1, 1935, pp. 509–528: pp. 529–538: both in German.)

The first paper is also given in *E.N.T.*, May, 1935, Vol. 12, No. 5, pp. 131–142. It develops, on certain simplifying assumptions, an electron mechanism to correspond satisfactorily with the observed facts, and then applies the theory to the oscillations of the "first type," otherwise known as "circuit oscillations," for which the magnetic field is always coaxial with the cylinder axis. The calculation of the power of these oscillations is dealt with in the final section. The second paper extends the previous results to the "second type" or "electron" oscillations, of wavelengths considerably shorter than the "first type" and conforming approximately to Okabe's formula $\lambda = 13\,200/H$. For these, the magnetic field must have an inclination of several degrees, and the filament heating conditions must be suitable. The second paper also contains an experimental confirmation of the theory. The two types of oscillation are found to differ in their heating effects: thus (1) the "circuit" oscillations always produce a marked heating of the slit edges, which may go so far as to cause a partial destruction of these, while the rest of the anode surface is not seriously heated. (2) With "electron" oscillations, on the other hand, it is chiefly the ends of the anode that become strongly heated; the position of the hottest points varies according to whether the field angle lies in the plane of the slit or perpendicular to it. "Both effects are in complete qualitative agreement with the theory—see also Appendix [p. 537]. Their significance is hardly mentioned in the literature, and is here applied for the first time to a physical explanation of the phenomena." Among other experimental results, the increase in the "electron" oscillation wavelength (*e.g.* from 25 to 40 cm), as a valve becomes more and more used, is discussed: the original conditions can be restored by re-evacuation. This increase in wavelength with increasing gas content confirms the idea of a coupling wave, which would increase in length as the heightened gas content increased the coupling with the oscillating space charge.

2599. On the Ultra-Short Waves obtained with a Magnetron [Sudden Doubling of Anode Current near Critical Field, traced in part at least to 6–12 cm Waves *along Filament*, Normal Wavelength being over 30 cm].—E. Pierret and C. Biguenet. (*Journ. de Phys. et le Radium*, April, 1935, Series 7, Vol. 6, No. 4, pp. 67–68 s.) Similar propagation along the grid, in the case of triodes, prompted these researches.

2600. On the Generation of the Ultra-Short-Wave Oscillation by means of a New Tube called the Double-Anode Magnetron.—K. Okabe and M. Hishida. (*Journ. I.E.E. Japan*, March, 1935, Vol. 55 [No. 3], No. 560, p. 241: Japanese only.)

2601. On Electronic [Ultra-Short-Wave] Oscillation Circuit.—S. Ohtaka. (*Journ. I.E.E. Japan*, March, 1935, Vol. 55 [No. 3], No. 560, p. 243: Japanese only.)

2602. A New Type of Electron Oscillation outside the Oscillation Electrode [of an "Inner-Grid" Dynatron].—T. Hayasi. (*Journ. I.E.E. Japan*, April, 1935, Vol. 55 [No. 4], No. 561, pp. 268–273: English summary p. 38–39.)

"This new system of simultaneous generation of the dynatron oscillation and the electron oscillation can be applied to single-valve ultra-short-wave telegraphy, the single-valve super-regenerative u.s.w. receiver, and to the secret telephone system by means of double modulation."

2603. A New Type Radio Transmitter for Short Waves [Multi-Oscillator and Directional Antenna System: Field approximating to Magnetic Dipole].—R. King. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 787: abstract only.)

2604. The Construction of Small, Self-Exciting Experimental Transmitters [Three-Point Connection and Huth-Kühn Circuit].—W. Möller. (*Radio, B., F. für Alle*, June, 1935, pp. 87–93.)

2605. A Complete 20-Watt 'Phone operating on 110-Volt D.C. Mains: illustrating the Wide Adaptability of the New Gas Triodes in A.F. and R.F. Circuits.—P. L. Spencer and R. M. Purinton. (*QST*, June, 1935, Vol. 19, No. 6, pp. 9–12 and 68, 70, 72.) For this RK-100 gas triode *see* 2649.

2606. New Method of Starting Oscillations in a Self-Excited Valve Generator [with Leak Resistance in Grid Circuit and High Resistance in Plate Circuit, for Constancy of Frequency].—A. I. Iakovlev. (*Izvestia Elektroprom. Slab. Toka*, No. 1, 1935, pp. 35–40.)

At the beginning of the operation the grid is made positive by connecting the grid-circuit coil to the positive end of the filament. Oscillations are thus prevented from starting, but on short-circuiting the plate-circuit resistance by a hand-key they will set in, and will not die away when the key is opened since the grid is forced to a negative potential and the working point transferred to the middle of the curve. A formula is derived for calculating the maximum resistance in the plate circuit for the maintenance of a constant frequency.

2607. The Stabilisation of a Beat Frequency by Compensation of the Temperature Coefficients [Master-Oscillator controlled by Beat Frequency of Two Suitably Selected Quartz Oscillators].—A. de Gramont and D. Beretzki. (*Comptes Rendus*, 6th May, 1935, Vol. 200, No. 19, pp. 1558–1559.)

The beat frequency $f - f'$ will be unaffected by temperature changes if it is arranged that $f_0K = f'_0K'$; even if this equality is not fulfilled exactly, so that f' has an error of $\Delta f'$, the temperature variation of the beat frequency will be only $\Delta(f - f') = \Delta f'Kt$, where K is at most 1/50000.

By this plan it has been possible to obtain beat frequencies constant within 1×10^{-5} or even 1×10^{-6} of their value through a temperature range of 50°. For such a stability an ordinary single quartz would have to have its temperature kept constant within 1/10th of a degree. A further advantage is the avoidance of disturbance due to the retroaction of the transmitted energy on the master oscillator, for f and f' can be chosen so as to bear no simple relation to the beat frequency.

2608. THEORY OF ANODE VOLTAGE MODULATION. PART 2.—R. Hofer. (*Telefunken-Zeit.*, April, 1935, Vol. 16, No. 70, pp. 22–30.)

For Part 1 *see* 1386 of May. After a discussion of linear distortion in the h.f. stage, non-linear distortion is treated by the method of successive approximation and Fig. 8 shows the approximate graphical determination of the distortion arising in oscillator and modulator circuits. The resistance of the h.f. valve at audio-frequencies is expressed exactly by eqn. 9 and approximately by eqn. 9a; Fig. 18 shows the voltage in the conducting half-period of the h.f. oscillation. Fig. 19 gives equivalent l.f. circuits for the modulator and oscillator circuits, for the discussion of linear and non-linear distortion; it is found that increase of the internal resistance R_{in} of the modulator valve always produces decrease of the non-linear distortion due to the oscillator valve: an optimum value of R_{in} can be determined.

2609. POWER REQUIREMENTS OF THE FINAL STAGE OF A TRANSMITTER WITH PUSH-PULL B MODULATION.—R. Hofer. (*Telefunken-Zeit.*, April, 1935, Vol. 16, No. 70, pp. 30–35.)

§ A: *Modulation with a Constant Carrier.* The circuit discussed is shown in Fig. 20; the optimum grid bias for the modulator valves is determined as shown in Fig. 21, and eqns. 1 and 3, 3a give the total efficiency of the final stage in the unmodulated and modulated state respectively. The valves required are discussed, with practical examples. § B: *Combination of this Method of Modulation with Carrier Control.* An estimate is made of the current which may be saved by adjustment of carrier strength to the degree of modulation. The method (used with anode modulation) is only economical when, instead of the grid voltage, the anode voltage of the final stage varies with the depth of modulation. Fig. 23 shows the percentage of power used as a function of the depth of modulation.

2610. I—THE MEANING OF "MODULATION" IN H.F. TECHNIQUE, AND THE MEASUREMENT OF THE DEGREE OF MODULATION: II—THE MODULATION SYSTEMS OF RADIO ENGINEERING: *and* III—MODULATION SYSTEMS AND THE WORKING COSTS OF BROADCASTING AND TELEPHONY TRANSMITTERS.—H. Brückmann. (*T.F.T.*, Vol. 24, 1935, January, No. 1, pp. 17–20: February, No. 2, pp. 29–36: April, No. 4, pp. 83–91.)

2611. CONTRIBUTION TO THE THEORY AND CALCULATION OF PLATE MODULATION WITH SEPARATELY EXCITED VALVE OSCILLATOR.—A. I. Berg. (*Izvestia Elektroprom. Slab. Toka*, No. 1, 1935, pp. 1–7.)

Author's summary:—A complete analysis is given of the operation of a separately excited type G-47 valve oscillator as the resistance in the load circuit, and the plate voltage, are varied, the grid excitation remaining constant. It is shown that under certain conditions, for all modes of operation and all possible forms of plate impulses, the variation in the plate voltage during modulation may remain directly proportional to the variation of the amplitude of the fundamental harmonic of the plate current. A new theory of plate modulation is developed, based upon the following formula which is derived: $I_{a1} = \{E_a - E_{a0} + \mu(U_g - E_g)\}/(R_e + R_{ia})$, where $R_{ia} = R_i . (1 - \cos\psi_2)/\alpha'_1 (\cos\psi_1 - \cos\psi_2)$. This resistance, whose physical meaning is explained, forms the main variable dependent on plate voltage, form of plate impulse, its magnitude, etc. The whole process of modulation results in varying this value, and this results in turn, according to the above formula, in varying the amplitude of the fundamental harmonic. The derived formula is a universal expression interconnecting all the main electrical values when plate or other type of modulation takes place. It holds true for any form of plate impulse. It is stated that undistorted modulation may be obtained under any conditions if the modulating factor involved (plate voltage) is the reciprocal of the equivalent valve resistance.

2612. MULTIPLE SIGNALLING BY PHASE VARIATION.—A. A. Pistolkors. (*Izvestia Elektroprom. Slab. Toka*, No. 3, 1935, pp. 51–58.)

Author's summary:—An analysis is given of telegraph transmission by varying the phase of oscillations, their amplitude remaining constant. The advantages of phase- over amplitude-manipulation are enumerated, and the possibility is shown of double transmission without widening the frequency band in comparison with usual transmission. In conclusion the problems are pointed out arising with phase signalling by wire and wireless. For reception of phase-modulated waves *see* 2624.

2613. A [Cathode-Ray Oscillograph] METHOD OF MODULATION PERCENTAGE MEASUREMENT OF RADIO TRANSMITTER.—N. Mori. (*Journ. I.E.E. Japan*, April, 1935, Vol. 55 [No. 4], No. 561, p. 322: Japanese only.)

2614. OVERMODULATION AND MODULATION METERING: THE USE OF THE TWO-TONE "SPEECH EQUIVALENT" FOR LABORATORY MEASUREMENTS.—(*QST*, June, 1935, Vol. 19, No. 6, pp. 21–22 and 64.)

2615. MEASURING THE MODULATION FACTOR AT DECIMETRE WAVELENGTHS [Split-Anode Magnetron Equipment showing Modulation Curve on Cathode-Ray Oscillograph Screen].—B. P. Asseyev. (*Izvestia Elektroprom. Slab. Toka*, No. 1, 1935, pp. 48–51.)

2616. SOME NOTES ON THE STABILISING OF H.F. POWER AMPLIFIERS.—J. Greig. (*Journ. I.E.E.*, June, 1935, Vol. 76, No. 462, pp. 702–706.)

"The output units of practically all, except the smallest, wireless transmitters employ 3-electrode valves in Class B stages. The methods employed for the stabilisation of such stages now follow a fairly well-established practice. In describing the principles of these methods certain elementary considerations in connection with neutrodyne circuits are not infrequently overlooked, and it is the purpose of this paper to consider some of these points."

2617. TYPE 59 TUBE AS INVERTED AMPLIFIER [requiring No Neutralisation].—R. P. Austin: Romander. (*QST*, June, 1935, Vol. 19, No. 6, p. 42.) *See* 1934 Abstracts, p. 34.

2618. [Tentative] HIGH-FIDELITY TRANSMISSION STANDARDS OF THE F.C.C.—(*Electronics*, April, 1935, p. 127.)

RECEPTION

2619. MEASUREMENTS OF THE HIGH-FREQUENCY IMPEDANCE OF POWER MAINS [in connection with Interference with Broadcast Reception].—H. Reppisch and F. Schulz. (*E.N.T.*, April, 1935, Vol. 12, No. 4, pp. 124–130.)

Interference from electrical apparatus is chiefly carried by the supply network itself, and the magnitude of the interference voltage E_s appearing at the mains terminals of apparatus unprovided with interference-suppressors depends very closely on the h.f. impedance Z_N of the network. Since the interference voltage E_e at the broadcast receiver is proportional to this terminal voltage E_s (Eppen and Müller, Abstracts, 1934, p. 560), it is clear that Z_N must play an outstanding part in the transmission of interference. But it also has an important rôle as regards the effectiveness of interference-quenching devices, such as those whose equivalent circuits are shown in Fig. 2. Methods for determining the values for the equivalent "generator" are known (Wild, 1933, p. 272); the values of Z_Q and Z_L (parallel and series elements) of the interference suppressing device can be calculated or measured, so that only the value of Z_N remains to be found.

Portable apparatus for such measurements on various types of mains has been developed by Siemens & Halske, and the writers, after a short description of this, discuss the results of tests on numerous cable and overhead-line systems, in which both "symmetrical" and "asymmetrical" impedances were measured (*see* Eppen and Müller, *loc. cit.*) at three frequencies, 160, 680 and 1 100 kc/s. Figs. 7–9 show these results, the abscissae representing the impedances and the ordinates the frequency of occurrence. Figs. 7 (cable) and 8 (overhead line) show mixed curves for the three test frequencies and for symmetrical and asymmetrical types, whereas in Fig. 9 only two curves are shown, representing all the symmetrical and all the asymmetrical measurements respectively. Another set of results is illustrated in Figs. 10–14; here the frequency was varied in small steps between 100 and 2 000 kc/s. Figs. 15–17 give the locus curves of symmetrical and asymmetrical impedances, 15 representing measurements in a large block of dwellings, 16 those from the mains of a large detached house, and 17 those taken at a socket of a largish installation including an electric range.

All the results combine to show that the h.f. impedance of supply systems varies within wide ranges: in cable systems, however, it generally keeps well under 400 ohms, while in overhead-line systems it is usually of the same order but occasionally rises to higher values. For the problem of interference-quenching of electrical apparatus connected to either type of system, using the simplest possible devices (*i.e.* condensers), it is chiefly the values in the region round or below 200 ohms which are of importance. "If the impedance is between about 100–200 ohms, for many types of interfering apparatus there is already a favourable potential distribution of the interfering electromotive force, of which (since, for example, the internal resistance of a motor is considerably greater) only a small proportion will reach the terminals. With high values of impedance, it is true, a larger proportion of the interfering electromotive force would reach the terminals, but in this case the introduction of a quenching device such as a condenser might be expected to produce a marked effect on the potential distribution and a corresponding reduction of the interfering potential at the terminals."

2620. THE ELIMINATION OF BROADCAST INTERFERENCE DUE TO PRIVATE AUTOMATIC TELEPHONE SYSTEMS.—W. Eibel. (*Elektrot. u. Masch:bau*, 26th May, 1935, Vol. 53, No. 21, p. 251: summary only.)

2621. THE BROADCAST-INTERFERENCE SUPPRESSION SERVICE OF THE GERMAN POST OFFICE: ITS WORK AND LATEST EQUIPMENT.—H. Reppisch. (*T.F.T.*, April, 1935, Vol. 24, No. 4, pp. 95–98.)

2622. VOLTAGE VARIATION AT CONSUMERS' TERMINALS.—Wedmore and Flight. (*Journ. I.E.E.*, June, 1935, Vol. 76, No. 462, pp. 685–701.)

2623. THE LIMITS OF DISTANT RECEPTION BY DAY [for Medium-Wave German Broadcasting Stations].—O. Nairz. (*Funktech. Monatshefte*, February, 1935, No. 2, pp. 67–68.)

2624. ON THE RECEPTION OF A PHASE-MODULATED WAVE BY A TUNING CIRCUIT.—T. Sakamoto and M. Kamazawa. (*Rep. of Rad. Res. in Japan*, March, 1935, Vol. 5, No. 1, Abstracts pp. 1–2.)

"The authors discuss this problem both theoretically and experimentally and arrive at the following conclusions:—(a) When a pure phase-modulated wave is detected after passing through a tuning circuit, the a.f. output, which becomes almost zero at the tuned point for the carrier frequency, increases very rapidly as it leaves the tuned condition, and reaches its maximum . . . at the tuned points for the upper and lower sideband frequencies. (b) Consequently, the points where the audible output reaches the maximum vary with the modulation frequency, so that the lower the modulation frequency the nearer comes the point of the maximum audio output to the tuned point for the carrier frequency." For multiple signalling by phase-manipulation *see* 2612.

2625. SECONDARY MODULATION IN REGENERATIVE RECEIVERS.—E. G. Momot. (*Izvestia Elektroprom. Slab. Toka*, No. 3, 1935, pp. 58–65.)

Author's summary:—In regenerative receivers now in use a single valve acts both as first detector and as oscillator, and since (in order to obtain linear rectification) high grid swings are generally permitted, such a combination of functions leads to distortions of a special kind. The secondary modulation here arising causes a considerable decrease in the modulation ratio in the regenerative circuit, and consequently a decrease in the sensitivity of the receiver; it limits the output and (what is most important) gives rise to strong non-linear distortions. The writer comes to the conclusion that in regenerative receivers with valves of the usual type high grid swings should not be permitted.

2626. SUPER-REGENERATION USING THE PENTAGRID CONVERTER [a Highly Efficient Non-Radiating Circuit with Low Hiss].—R. O. Williams. (*Electronics*, April, 1935, p. 126.)

2627. FIVE-METRE RECEIVER [Super-Regenerative Battery - Driven]. — "G2AW." (*Wireless World*, 17th May, 1935, Vol. 36, pp. 490–491.)

2628. ULTRA-SHORT-WAVE RECEPTION [Design Data and Comparison of Super-Regenerative and Superheterodyne Types].—H. B. Dent. (*Wireless World*, 7th June, 1935, Vol. 36, pp. 556–558.)

2629. SINGLE-SPAN TUNING AND THE QUARTZ CRYSTAL.—W. T. Cocking. (*Wireless World*, 24th May, 1935, Vol. 36, pp. 511–513.)

The Single-Span type of superheterodyne is normally less selective than the more conventional type and, to avoid a multiplicity of tuned circuits, reaction is usually employed to increase selectivity. The writer describes experiments which he has conducted in order to obtain selectivity by means of a quartz crystal. His conclusions are that, while offering a fascinating field for the experimenter, it is not, at present, a method suitable for general use.

2630. HIGH-FREQUENCY TUNING BY IRON VARIOMETER (PERMEABILITY TUNING).—W. J. Polydoroff and H. C. Riepka. (*Funktech. Monatshefte*, May, 1935, No. 5, pp. 173–177.) Survey, with illustrations of components on the "Draloperm-M" system.

2631. THE PERMEABILITY BATTERY FOUR.—(*Wireless World*, 24th and 31st May, 1935, Vol. 36, pp. 508–510 and 532–534.)

Permeability tuning is the leading feature. Theoretically this should provide constant sensitivity and selectivity over the whole waveband covered; in actual practice, however, these advantages are by no means fully achieved, although selectivity is considerably more constant than in the conventional condenser-tuned type of receiver.

2632. AUTOMATIC RECEIVER FOR DISTRESS SIGNALS [the A.A.2.B. Auto-Alarm].—O. Bracke and P. Giroud. (*Elec. Communication*, April, 1935, Vol. 13, No. 4, pp. 301–310.)

2633. THE TONE CONTROL TRANSFORMER.—L. E. C. Hughes. (*Wireless World*, 3rd May, 1935, Vol. 36, pp. 436–437.)

2634. PRACTICAL VOLUME EXPANSION [Design of A.F. Amplifier for Restoring Original Balance].—L. E. T. Branch. (*Wireless World*, 10th May, 1935, Vol. 36, pp. 461–462.) *See* also 1934 Abstracts, p. 620 (Nestel: Sowerby).

2635. THE INCORPORATION OF A VOLUME-EXPANDING DEVICE: A SUGGESTION FOR AMATEUR CONSTRUCTORS [Simple Circuit with Variable-Mu Pentode and Copper-Oxide Rectifier].—R. Oechslin. (*Radio, B., F. für Alle*, June, 1935, pp. 96–97.)

2636. DEVELOPMENT OF BROADCAST RECEIVERS IN RELATION TO THE WHOLE DEVELOPMENT OF INFORMATION TECHNIQUE.—F. Troeltsch and A. Schöne. (*E.T.Z.*, 6th June, 1935, Vol. 56, No. 23, pp. 644–645.)

2637. THE NEW REGULATIONS ON THE ABATEMENT OF AND EXEMPTION FROM BROADCAST LICENCE FEES [in Germany].—(*Radio, B., F. für Alle*, June, 1935, pp. 95–96.)

2638. CANADIAN RADIO [Production Figures for 1934].—(*Electrician*, 7th June, 1935, Vol. 114, p. 771.)

AERIALS AND AERIAL SYSTEMS

2639. JAPAN/EUROPE WIRELESS COMMUNICATION TESTS WITH A SHORT-WAVE TRANSMITTING AERIAL [of Specially Low Projection Angle] HUNG BETWEEN TWO IRON TOWERS, EACH 250 METRES HIGH.—K. Ohno. (*Rep. of Rad. Res. in Japan*, March, 1935, Vol. 5, No. 1, pp. 13–23: in English.)

In October, March, and half of November and February, direct short-wave contact between Yosami and Beelitz is difficult during the interval 0100–0500 G.M.T.; the ionisation of the K-H layer near Beelitz may be very weak, so that the frequency used must be lower than 8 000 kc/s, while, near Japan, the sun is fairly high and a frequency such as JNH 7 820 kc/s is strongly attenuated owing to the heavy ionisation. "We hung a new antenna of JNG 7 820 kc/s at as low an angle of projection as 4.5° to see whether or not the waves . . . would overcome the large E-layer attenuation, and also to see if some means could not be found for maintaining direct contacts of 24 hours between Japan and Europe with short waves only." The tests "clearly showed the new antenna to be superior to the old," which was sharper in horizontal directivity but had a projection angle of about 14.5°.

2640. DESIGN OF BROADCASTING ANTENNAS: ON ITS NATURAL WAVELENGTH AND EFFICIENCY [Vertical Aerial with Horizontal Top].—Y. Itow and T. Yokoyama. (*Journ. I.E.E. Japan*, March, 1935, Vol. 55 [No. 3], No. 560, pp. 164–172: long English summary pp. 26–28.)

2641. DISTRIBUTION OF RETARDED POTENTIAL NEAR A TUNED STRAIGHT RADIATOR.—H. Iwakata and S. Tanaka. (*Rep. of Rad. Res. in Japan*, March, 1935, Vol. 5, No. 1, Abstracts p. 3). *See* 1060 of April; and for Iwakata's "isovalent" and "isoclinic" line method *see* 1934 Abstracts, p. 323.

2642. A TREATISE ON THE CHARACTERISTIC FORMS OF ELECTRIC WAVE LENSES BY PICARD'S THEORY OF GEOMETRICAL FIGURES.—H. Kikuchi. (*Journ. I.E.E. Japan*, March, 1935, Vol. 55 [No. 3], No. 560, pp. 190–193: English summary pp. 31–32.) Part VI of the writer's "Multi-Hertzian Oscillators" (*see* 936 and 937 of April, and 1934 Abstracts, p. 383).

2643. ON THE COAXIAL TRANSMISSION CIRCUIT [Analysis by Circuit Theory: Circuit Constants from Actual Measurements].—S. Bekku and B. Inoue. (*Journ. I.E.E. Japan*, March, 1935, Vol. 55 [No. 3], No. 560, pp. 181–186: English summary pp. 28–29.)

VALVES AND THERMIONICS

2644. THE AMOUNTS OF POWER AND DISTORTION GIVEN BY END-STAGE AMPLIFIERS [General Summary and Calculations based on the Graphical Use of Non-Linear Characteristics].—H. Bartels. (*Telefunken-Zeit.*, April, 1935, Vol. 16, No. 70, pp. 5–22.)

The constants characterising a power valve are first tabulated and explained (§ 1); it is assumed throughout that the load resistance R_a has its optimum value. The maximum a.c. power N_m is considered in § 2, on the basis of an idealised valve with characteristics linear up to a boundary beyond which distortion occurs. N_m is given by eqn. 1 (*see* Fig. 1) and it is explained how it may be determined graphically. Three special cases are discussed: (1) a triode with negative grid voltage, giving a relatively small amount of power, (2) a triode with both negative and positive grid voltage, giving much more power, and (3) a pentode, which gives more power and has the advantage of power-free grid control but a high internal resistance.

The loss of power through the anode is considered in § 3, in relation to the two types of amplifier, A and B, with constant and variable grid bias; the results are displayed graphically in Figs. 6–8. Special properties of various types of circuit are discussed in § 4 and suggestions are made for decreasing the distortion: § 4_1 considers the effect of grid current, § 4_2 the effect of non-linearity of the anode current characteristics. § 4_3 mentions some differences between A- and B-amplifiers: Fig. 15 shows the curves of "klirr" factor as a function of output. Amplifiers with automatic adjustment of grid bias are finally discussed (§ 4_4).

2645. ON A NEW 120-KW VACUUM TUBE [Type TW-502-A].—M. Kobayashi. (*Journ. I.E.E. Japan*, March, 1935, Vol. 55 [No. 3], No. 560: long English summary pp. 23–25.)

2646. A NEW 100-WATT TYPE ZERO-BIAS TRANSMITTING TUBE: THE 838 CLASS-B MODULATOR AND R.F. POWER AMPLIFIER.—(*QST*, June, 1935, Vol. 19, No. 6, pp. 27 and 74, 90.) May be used at full ratings down to 10 metres, or below this at reduced plate voltage (about 600 v at around 3 metres) in carefully designed circuits.

2647. THE DEVELOPMENT OF SOME SPECIAL VACUUM TUBES [Special Transmitting Pentodes: Metal Envelope Valves with Reduced Interelectrode Capacity: Miniature Triodes for Micro-Waves, etc.].—S. Hamada, M.So and T. Shimizu. (*Rep. of Rad. Res. in Japan*, March, 1935, Vol. 5, No. 1, pp. 25–33: in English.)

The special pentodes (Fig. 1, 0.5 to 20 w) gave suppressor-grid modulation, linear up to 100%, without attendant frequency variation. Another design (Fig. 4), of 20 and 50 w output, had the plate seal at one end and the remaining seals at the other, while the suppressor grid was so designed as to shield the plate completely, giving very low capacitances. Such a valve could be used with a tuned-plate circuit in crystal control, or as an electron-coupled oscillator and r.f. power amplifier. Of the metal envelope valves, the larger were provided with cooling fins and could easily dissipate 150 w: the receiving triodes used a new sealing process resulting in reduced interelectrode capacitances and very small dimensions. The microwave valves (in glass envelopes) had a maximum overall length below 3 cm and parallel-plate construction: a stable regenerative oscillator at 60 cm could be worked with a plate voltage as low as 80 v. Other miniature glass-envelope valves (space-charge tetrodes with cylindrical electrodes) worked on 22.5 v with a filament supply of 60 mA at 1.1 v, for very small portable receivers for broadcasting, etc.

2648. MODERN VALVES FOR MODERN RECEIVERS [the X41 Triode-Hexode, going down to 7 Metres: the WD40 Double-Diode Screened-Pentode: and the TP22 Triode-Pentode].—K. Jowers. (*Television*, June, 1935, Vol. 8, No. 88, pp. 317–319.) *See* also p. 361, for the X31, which is the same as the X41 except that it is for a.c./d.c. instead of battery operation.

2649. A NEW HOT-CATHODE GASEOUS DISCHARGE AMPLIFIER AND OSCILLATOR: THE MERCURY-VAPOUR RK-100 TRIODE FOR AUDIO- AND RADIO-FREQUENCY SERVICE AT LOW PLATE VOLTAGE [with "Cathanode" Fourth Electrode between Control Grid and Cathode].—J. R. Nelson and J. D. Le Van. (*QST*, June, 1935, Vol. 19, No. 6, pp. 23–25 and 82.) *See* also 2605.

2650. "ALL-METAL" TUBES FOR RADIO RECEIVING AND INDUSTRIAL POWER PURPOSES.—Nolte, Beggs and Elder. (*Gen. Elec. Review*, May, 1935, Vol. 38, No. 5, pp. 212–218.)

2651. "INDUSTRIAL ELECTRONIC TUBES."—Westinghouse Company. (At Patent Office Library, London: Catalogue number 74951.)

2652. COLD-CATHODE AMPLIFYING TUBES [Survey: Difficulties in Way of Development].—F. Schröter. (*Electronics*, April, 1935, p. 131; summary only.)

2653. The Exact Measurement of Electron Tube Coefficients [Effect of Grid Current and Tube and Battery Capacitances: Addition of Auxiliary Capacitance Bridge to Usual Circuits].—R. W. Hickman and F. V. Hunt. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 787: abstract only.)

2654. "Potential Reliefs" for Electron Valves [the Representation of Valve Processes by Plastic Models].—H. Gottmann. (*Funktech. Monatshefte*, February, 1935, No. 2, pp. 69–76.)

2655. The Diffusion of Gases through Metals [Tests of Richardson's Equation].—C. J. Smithells and C. E. Ransley. (*Proc. Roy. Soc.*, Series A, 1st May, 1935, Vol. 150, No. 869, pp. 172–197.)

2656. Thermionic Electron Emission and Adsorption. Part I. Thermionic Emission.—J. A. Becker. (*Reviews of Modern Physics*, April, 1935, Vol. 7, No. 2, pp. 95–128.)

2657. Essential Structural Discontinuities in Certain Adsorbed Films [Oxygen on Tungsten: Proportion of Uncovered Surface Atoms].—J. K. Roberts. (*Nature*, 22nd June, 1935, Vol. 135, p. 1037.)

2658. Thermionic Emission from Tungsten with Weak Accelerating Fields [as Function of Temperature: Values of Thermionic Constants compared with those obtained by Extrapolation: Local Contact Potential Fields between Crystal Facets may explain].—W. B. Nottingham. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 806: abstract only.)

2659. Dependence on Applied Field of Thermionic Constants for Thoriated Tungsten [Square Array Patch Theory].—A. Rose. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 806: abstract only.)

DIRECTIONAL WIRELESS

2660. Scattering, Polarisation Errors and the Accuracy of Short-Wave Direction-Finding [Ongar/Chelmsford 10 Mc/s Pulse Tests].—T. L. Eckersley. (*Marconi Review*, March/April, 1935, No. 53, pp. 1–8.)

"The evidence in support of this picture [representing the region within the skip distance as illuminated by a fog of scattered radiation] is mainly based on directional measurements which are themselves in doubt. Again, the ordinary pulse technique, in which short pulses are projected up to the ionosphere and reflected back, has failed to indicate scattered signals, and I suppose a sceptical attitude towards the existence of such scattering is natural. The existence of scattered radiation is put beyond doubt, and the part it plays in short-wave direction finding is disclosed, in the experiments described here, which were undertaken with these objects in view, and also with the object of determining the limiting accuracy obtainable in short-wave direction finding. . . . It has been suggested that the path of 'S' reflections [scattering echoes, showing no signs of direction on an Adcock aerial, and no signs of circular polarisation] is vertical, and that they are reflected from ionic clouds at a height of some 900–2 000 km above the earth's surface. There is very definite evidence against this view and in support of the supposition that the path or paths are nearly horizontal." The writer stresses that it is possible to conceive of receiving arrangements to eliminate the polarisation error, but not to eliminate the scattering error: "the limiting accuracy of short-wave d.f. is therefore defined by this degree of scattering." The last part of the paper (which is to be continued) gives a description of spaced-aerial tests on the elimination of polarisation error: to avoid transfer coupling between the outer sheath of the feeders and the aerials, the latter were frame aerials arranged to lie in a plane perpendicular to the line of the feeders and symmetrically with respect to the vertical plane through these. This arrangement is free from polarisation errors, even those due to the horizontal component of the wave. For a paper by Maeda *see* 2556.

2661. Marconi Crystal-Controlled Automatic Wireless Beacon.—(*Marconi Review*, March/April, 1935, No. 53, pp. 29–30.)

2662. The Telefunken Apparatus for Directional Flying.—O. Nairz. (*Telefunken-Zeit.*, April, 1935, Vol. 16, No. 70, pp. 43–51.)

§ 1: Aeroplane reception of signals from all directions with 7-valve receiver (Fig. 33) and fixed aerials (Figs. 30–32). § 2: Determination of position of aeroplane by using frame antenna (two steel rings in series, Fig. 35) to obtain minimum signals from two stations; sharp minima are obtained by coupling the fixed aerial to the input circuit through a differential condenser and transformer (Fig. 37). § 3: Flight in a definite direction. The frames and auxiliary fixed aerial are again used, with periodical changes in the sign of the coupling of the fixed aerial; Fig. 38 shows how their magnetic fields combine. Fig. 39 shows the circuit for use with headphones and Fig. 41 that used with an optical indicator. Fig. 43 shows how position is indicated on a map with strings marking the observed directions from the two stations, Fig. 44 a triangle of transparent material graduated for correcting observations of aeroplane position, and Fig. 45 a circular scale for rapid evaluation of observations.

ACOUSTICS AND AUDIO-FREQUENCIES

2663. "Mitnahme" [Pull-In] Phenomena in Acoustics.—H. Seiberth. (*Hochf:tech. u. Elek:akus.*, May, 1935, Vol. 45, No. 5, pp. 148–158.)

An oscillographic investigation using (a) an adjustable-frequency sound source (loudspeaker) acting on a fixed-frequency source (organ pipe, trumpet, etc.), and (b) two similar sound sources, such as two organ pipes. The first oscillogram, illustrating the pull-in of two valve oscillators, clearly shows the asymmetry of the beats before and after their disappearance in the pull-in zone: this asymmetry is the same in both cases—a steep rise and a gentle descent. In the acoustic pull-in oscillograms, asymmetry is also shown, but according to the conditions of coupling this may take the form of a slow rise and steep descent before and after the pull-in zone, a slow rise and steep descent before this zone and a steep rise and slow descent after, and so on. Another point brought out is that a strongly blown organ pipe can be pulled-in by a loudspeaker of far less power; also, that the frequency difference at which pull-in starts is not the same as that at which it stops—so that there is evidently a kind of "ziehen" (hysteresis loop or "back-lash") effect. Pull-in occurs not only when the "external" frequency comes close to the fixed frequency but also when its ratio to the latter approaches a small whole number. It is also shown that *outside* the pull-in zone, in the beat zone, the pitch of the "fixed" sound source is altered by the action of the "external" source (Fig. 9: this is of importance in connection with pitch-determination by beat counting). Other results are obtained, some of which are of special interest from the musical point of view.

2664. The Amplification of Transients [Refutal of "Greater Amplification than for Steady Tones"].—G. Builder: C. H. Smith. (*Wireless Engineer,* May, 1935, Vol. 12, No. 140, pp. 246–250.) Criticism of Smith's method and results (1933 Abstracts, pp. 509–510).

2665. Subharmonics in Forced Oscillations in Dissipative Systems. Part I.—P. O. Pedersen. (*Journ. Acoust. Soc. Am.*, April, 1935, Vol. 6, No. 4, pp. 227–238: to be concluded.) *See* 1934 Abstracts, p. 156, and back references.

2666. The Perceptibility of Building-Up Times [Measurements of the Smallest Detectable Time Difference between the Appearance of Two Tones: Application to Lines for Broadcast Programmes].—F. Strecker. (*T.F.T.*, January, 1935, Vol. 24, No. 1, pp. 1–5.)

2667. Demodulation of a Low-Frequency Carrier Current [applied to Telephone Circuit: Theoretical Basis].—M. Marro. (*Rev. Gén. de l'Élec.*, 15th June, 1935, Vol. 37, No. 24, pp. 767–769.)

2668. The Transmission Equivalent of Pupinised Lines.—W. Weinitschke. (*T.F.T.*, May, 1935, Vol. 24, No. 5, pp. 113–118.)

2669. Electrical Properties of Wires of High Permeability [Mumetal Group: A.F. Skin Effect, etc.].—Harrison, Turney and Rowe. (*See* 2783.)

2670. An Application of Number Theory to the Splicing of Telephone Cables [Scheme for Minimising Recurrence of Same-Layer Adjacencies: Table of Solutions for Numbers not greater than 139].—H. P. Lawther, Jr. (*Bell S. Tech. Journ.*, April, 1935, Vol. 14, No. 2, pp. 273–284: *Amer. Math. Monthly,* February, 1935.)

2671. The Tolerable Non-Linear Distortion in Reproduction.—Beljers. (*Tijdschr. Nederland. Radiogen.*, December, 1934, Vol. 6, No. 6, pp. 113–126: in Dutch, with English summary.)

2672. Acoustics in Architecture: a Practical Guide to the Solution of Acoustical Problems in Halls, based largely on the Work of Hugh Tallant.—D. A. Kirchner. (*Ann. des P.T.T.*, May, 1935, Vol. 24, No. 5, pp. 455–473: French version from the Dutch: to be continued.)

2673. What is Measured in Sound Absorption Measurements?—P. E. Sabine. (*Journ. Acoust. Soc. Am.*, April, 1935, Vol. 6, No. 4, pp. 239–245.)

2674. Absorption of Sound in Gases.—V. O. Knudsen. (*Journ. Acoust. Soc. Am.*, April, 1935, Vol. 6, No. 4, pp. 199–204.)

2675. Preliminary Report on the Experimental Method of Detecting Anomalous Dispersion of Sound in Air in the Audible Range as a Function of Frequency and Humidity.—L. P. Delsasso and J. H. Munier. (*Phys. Review,* 1st Feb. 1935, Series 2, Vol. 47, No. 3, p. 259: abstract only.)

2676. Propagation of Explosion Condensation through Air.—L. Thompson. (*Phys. Review,* 15th May, 1935, Series 2, Vol. 47, No. 10, p. 811: abstract only.)

2677. Finite Strains in Elastic Problems.—B. R. Seth. (*Philos. Trans. Roy. Soc. London,* Series A, No. 738, Vol. 234, 1935, pp. 231–264.)

2678. Transverse Vibrations of Long Rods [Fundamental Frequencies].—I. A. Balinkin. (*Phys. Review,* 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 340: abstract only.)

2679. Contribution to the Theory of the Free Elastic Oscillations of Cylinders and Tubes.—L. Posener. (*Ann. der Physik,* Series 5, No. 2, Vol. 22, 1935, pp. 101–128.)

2680. On the Calculation of the Acoustic Part of the Telephone Receiver [Analysis yielding Formulae for Natural Frequency from Geometrical and Material Data].—Andrejew and Rjabinina. (*Tech. Phys. of U.S.S.R.*, No. 2, Vol. 1, 1934, pp. 151–168: in German.) *See* 1930 Abstracts, p. 340.

2681. Performance of Telephone Receivers as Affected by the Ear.—H. F. Olson and F. Massa. (*Journ. Acoust. Soc. Am.*, April, 1935, Vol. 6, No. 4, pp. 250–254.)

2682. Sound Waves of Finite Amplitude in an Exponential Horn [Rocard's Value of Second Harmonic Power Four Times too Large: Influence of Flaring: etc.].—S. Goldstein and N. W. McLachlan. (*Journ. Acoust. Soc. Am.*, April, 1935, Vol. 6, No. 4, pp. 275–278.) For Rocard's paper *see* 1933 Abstracts, p. 216: also p. 627, l-h column.

2683. "Elements of Loud Speaker Practice" [Book Review].—N. W. McLachlan. (*Wireless World,* 10th May, 1935, Vol. 36, p. 460.)

2684. Papers on Rochelle Salt.—Körner: Goedecke. (*See* 2763 and 2764.)

2685. A New Type Crystal Microphone [Shure Microphone with "Matched Impedance" Mechanical Link, on Cantilever Principle, between Diaphragm and Bimorph Crystal Unit].—(*QST*, June, 1935, Vol. 19, No. 6, pp. 96 and 98.)

2686. Electrical Organ Tones [New Method].—(*Wireless World*, 24th May, 1935, Vol. 36, pp. 514–515.)

The Compton "Electrone" has no separate valve oscillators, photoelectric cells, etc., for the development of tones. Sine waves of various pitches are obtained by means of an exploring electrode mounted on a revolving disc and travelling close to a fixed disc of insulating material having concentric conducting paths engraved on it. The output is connected to the first valve of a conventional valve amplifier of the public address type.

2687. The WCAU Photona [New Electrical Organ with Rotating Discs and Photocells].—Eremeeff. (*World-Radio*, 26th April, 1935, p. 8: *Electronics*, April, 1935, p. 123.)

2688. The Physics of the Concert Grand Piano.—I. The Grand Piano as Mechanical/Acoustical Energy Transformer [Experimental Investigation].—W. Lange. (*Hochf:tech. u. Elek:akus.*, April, 1935, Vol. 45, No. 4, pp. 118–128.)

The movements of hammers, etc., were recorded oscillographically by means of a special variable-capacity device (Fig. 2) whose insensitivity to transverse motion of the mobile electrode (even under the most violent shock) was due to the plan of using two dielectrics (air and mica) of very different dielectric constant: a transverse motion would only alter the air gap, whereas the capacity would depend predominantly on the mica dielectric and would therefore only vary with the axial movement of the mobile electrode.

2689. A Mirror for the Voice [Portable, with Endless-Band Steel Tape for 5-Seconds Test].—R. F. Mallina. (*Bell Lab. Record*, March, 1935, Vol. 13, No. 7, pp. 200–202.)

2690. The Making Visible of Speech and Music by an Electro-Acoustic Apparatus [Short Survey: Description of a Simple Oscilloscope].—G. Panconcelli-Calzia. (*Radio, B., F. für Alle*, June, 1935, pp. 85–86.) For the writer's "voice colour profiles" *see* 793 of March.

2691. An Acoustic Spectroscope.—Meyer and Thienhaus. (*Wireless World*, 10th May, 1935, Vol. 36, pp. 467–468.) Describing a method of rapidly analysing the energy distribution of complex sound waves of short duration and changing intensity. *See* 453 of February.

2692. New Electrical Processes of Harmonic Analysis [replacing Electro-Dynamometers by Permanent-Magnet D.C. Instruments of Greater Sensitivity].—K. Noguchi. (*Journ. I.E.E. Japan*, April, 1935, Vol. 55 [No. 4], No. 561, pp. 273–281: English summary pp. 39–40.)

2693. A General-Purpose Frequency Analyser [Portable, for Noise Investigations].—T. G. Castner. (*Bell Lab. Record*, May, 1935, Vol. 13, No. 9, pp. 267–272.)

2694. A Loudness Scale for Industrial Noise Measurements.—B. G. Churcher. (*Journ. Acoust. Soc. Am.*, April, 1935, Vol. 6, No. 4, pp. 216–226.)

2695. Noise Investigations on Electrical Machines.—H. Moser. (*Bull. Assoc. suisse des Élec.*, No. 12, Vol. 26, 1935, pp. 305–322: in German.) To be continued.

2696. The Movement for Noise Abatement, *and* Noise Measurement Methods [Survey].—(*Electronics*, April, 1935, pp. 108–109: 110–113.)

2697. War against Noise [Present Position and Achievements of Electrotechnics: Further Requirements].—E. Lübcke. (*E.T.Z.*, 9th May, 1935, Vol. 56, No. 19, pp. 529–530.)

2698. On the Design of an Attenuator for a Noisemeter.—I. M. Bronstein and L. S. Freimann. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 4, 1934, pp. 1829–1835.)

Methods are indicated for the design of an attenuator consisting of two potentiometers in cascade, the second one being connected to the wiper arm of the first. The attenuator covers a range of 100 db and enables the intensity of sound from the local source to be varied in steps of 1 db.

2699. Low Distortion 400-Cycle Oscillator [with Total Harmonic Distortion of Less than 0.3%].—D. E. Noble. (*Electronics*, April, 1935, p. 131.)

2700. New A.C. Mains Operated Speech Input Equipment at Lausanne.—E. Metzler and R. W. Hardisty. (*Elec. Communication*, April, 1935, Vol. 13, No. 4, pp. 279–289.)

2701. A Triple-Quartz-Plate Supersonic Generating and Receiving System [Precision Apparatus for Research on Gases].—H. L. Yeagley. (*Review Scient. Instr.*, May, 1935, Vol. 6, No. 5, pp. 148–153.)

2702. The Diffraction of Light by Supersonic Waves [Survey].—Sansoni. (*Nuovo Cimento*, January, 1935, Vol. 12, No. 1, pp. 36–48.)

2703. On the Practical Use of Light Diffraction in a Medium Oscillating at Supersonic Frequency.—Sokolov. (*See* 2759.)

2704. Some Experiments on the Refraction of Supersonic Waves [Standing Waves in Liquid form Optical Grating].—W. Bez-Bardili. (*Physik. Zeitschr.*, 2nd Jan. 1935, Vol. 36, No. 1, pp. 20–24.) For the method used *see* Bär and Meyer, 1933 Abstracts, p. 453.

2705. A New Process for the Production of Photographic Halogen-Silver-Gelatin Emulsions [with Help of Supersonic Waves].—Claus. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 16, 1935, pp. 109–115.) Following on the work referred to in 1934 Abstracts, p. 273.

2706. Measurement of the Velocity of Sound in Low Temperature Liquids at Ultrasonic Frequencies.—A. Pitt and W. J. Jackson. (*Canadian Journ. of Res.*, May, 1935, Vol. 12, No. 5, pp. 686–689.)

2707. A Sonic Interferometer for the Study of Absorption in Liquids.—A. L. Quirk and G. D. Rock. (*Review Scient. Instr.*, January, 1935, Vol. 6, No. 1, pp. 6–7.)

2708. On the Behaviour of Suspended Particles in Air, and the Velocity of Sound at Supersonic Frequencies [Existence of Dispersion].—E. B. Pearson. (*Proc. Phys. Soc.*, 1st Jan. 1935, Vol. 47, Part 1, No. 258, pp. 136–145: Discussion pp. 145–148.)

2709. The Velocity of Sound in Sheet Materials [Measured by Chladni's Figures].—A. B. Wood and F. D. Smith. (*Proc. Phys. Soc.*, 1st Jan. 1935, Vol. 47, Part 1, No. 258, pp. 149–151: Discussion pp. 151–152, Demonstration pp. 185–186.)

2710. "Ultraakustik" [Supersonics: Book Review].—E. Grossmann. (*Alta Frequenza*, April, 1935, Vol. 4, No. 2, pp. 211–212.)

2711. Discussion on "On a Project for a Vocabulary of Acoustics."—Bouthillon. (*Bull. de la Soc. franç. des Élec.*, March, 1935, Series 5, Vol. 5, No. 51, pp. 246–274.) *See* 1934 Abstracts, p. 623.

PHOTOTELEGRAPHY AND TELEVISION

2712. Television Reception on a Large Screen [and the Effect of After-Glow in Cathode-Ray Reception: Artificial Extinction of After-Glow by Infra-Red Light].—V. A. Gourov. (*Izvestia Elektroprom. Slab. Toka*, No. 3, 1935, pp. 21–28.)

Author's summary:—" Conditions are discussed under which a television image on a large screen may be obtained, and the difficulty is shown of solving this problem by mechanical scanning methods. The employment of an arrangement which is able to maintain a light signal on a multicellular screen during the transmission of a frame (*e.g.* by means of condensers) appears to be most useful. The writer derives a formula for the brightness of the image on a cathode-ray tube, and shows that the after-glow of a fluorescent screen is a natural accumulator of light energy during the image transmission, with the result that the image brightness does not depend on the number of elements n but is expressed by the formula

$$B_{\text{image}} = B_{\text{source}}\,[1/(n+1) + N/a \,.\, (1 - e^{-a/N})],$$

where N is the number of frames per sec. and a the extinction factor of the screen, which for Willemite is equal to 80/sec. Thus for $N = 20$ and $n > 1000$, $B_{\text{image}} = 0.25\,B_{\text{source}}$ approximately. A description is also given of a new method of obtaining a bright image on a cathode-ray tube with artificial extinction of the after-glow by infra-red rays." For a paper on this extinguishing action *see* Tumerman, 1934 Abstracts, p. 627, r-h column.

2713. Silver Mosaics.—V. N. Lepeshinskaia. (*Izvestia Elektroprom. Slab. Toka*, No. 3, 1935, pp. 28–37.)

Author's summary:—The present paper is devoted to the technique of obtaining silver mosaics which have some practical applications. All the factors influencing the process of forming mosaics are determined—*i.e.*, the method of depositing a thin film; its thickness; temperature and duration of tempering—and characteristics are given of different types of mosaic obtained with different régimes of preparation. By a microscopic investigation the following quantitative data were obtained characterising the mosaic surface:—mean dimensions of globules; density of distribution; quantity of globules per surface unit; regularity of shape of separate globules and uniformity of size and distribution. The plate of microphotographs given illustrates different types of mosaic and the process of their gradual formation. The investigations provide the explanation of the process of separating a thin film into globules isolated one from another by the action of the forces of metallic recrystallisation.

2714. Synchronising Cathode Rays from A.C. Mains.—R. L. Ashmore. (*Television*, June, 1935, Vol. 8, No. 88, pp. 313–315.) To avoid the distortions sometimes produced by the picture signal upsetting the ordinary synchronisation.

2715. The Cossor High-Vacuum Cathode-Ray Tube.—Cossor Company. (*Television*, June, 1935, Vol. 8, No. 88, pp. 343 and 344.)

2716. Recent Television Progress—the Barthélémy System and the Paris–P.T.T. Transmissions.—M. Adam. (*Génie Civil*, 8th June, 1935, Vol. 106, No. 23, pp. 549–553.)

Details of the first official experimental television service in France are given. Using the Barthélémy system with its special synchronising method (*see* 2717), the transmissions are on a 175 m wavelength, with 60 lines and 25 frames/sec. The number of lines will be increased to 180 in 3 months' time (with a new transmitter working on 7 m); it is hoped eventually to reach a definition of 240 lines.

2717. Automatic Synchronisation in Cathode-Ray Television.—R. Barthélémy. (*Génie Civil*, 8th June, 1935, Vol. 106, No. 23, pp. 553–554.) As used in the new French television service (*see* 2716). For a *Comptes Rendus* Note *see* 2327 of July.

2718. The Witzleben Ultra-Short-Wave Transmitter and the German Television Schemes [Speeches at the Opening Ceremony: the Berlin Cable and Its Use].—(*Radio, B., F. für Alle*, May, 1935, Vol. 14, No. 5, pp. 77–79.) *See* also pp. 83–84.

2719. On the Quality of Images in Television [Physiological and Psychological Analysis of Necessary Number of Elements, etc.].—J. A. Riftin. (*Tech. Phys. of U.S.S.R.*, No. 4, Vol. 1, 1935, pp. 449–468: in English.)

The paper ends with: "It follows from the above table that, in spite of the enormous variation in the number of elements, the discrepancy between the definition of the image calculated according to Wiedemann's formulae and according to 10′ [the writer's formula for the maximum number of elements, based on the resolving power of the eye] amounts to only 15% on the average, which agrees completely with the conclusions previously drawn by us, and confirms the correctness of the experimental results of Wiedemann [1931 Abstracts, p. 331] and of our theoretical deductions. This fact confirms once more that there is no need to aspire to the theoretical 100% definition of the image at the price of enormous effort and expense, since a clearness of 85% is in practice quite sufficient for television." For a previous paper *see* 1524 of May.

2720. The Effect of Movement on Definition.—E. L. Gardiner. (*Television*, June, 1935, Vol. 8, No. 88, pp. 357–358.)

2721. Recent Development of Television Technique in Europe and America.—K. Takayanagi. (*Journ. I.E.E. Japan*, March, 1935, Vol. 55 [No. 3], No. 560, pp. 172–180: Japanese only.)

2722. The Position of Television.—F. Schröter. (*Radio, B., F. für Alle*, May, 1935, Vol. 14, No. 5, pp. 65–75.) *See* 204 of January.

2723. Television in the Netherlands?—(*Radio Centrum*, 10th May, 1935, Vol. 1, No. 10, pp. 167–168.)

2724. The Telefunken Home Television Receiver [Cathode-Ray Sound-Sight Receiver].—Telefunken Company. (*Radio, B., F. für Alle*, May, 1935, Vol. 14, No. 5, pp. 75–77.)

2725. No "People's Television Receiver" in Sight.—(*Radio, B., F. für Alle*, May, 1935, Vol. 14, No. 5, p. 84.)

2726. "Black" Modulation with L.F. Amplifiers [" Schwartzsteuerung," by an Amplitude-Limiting Device regulating the Bias of the Output Valve, as a Cure for the Grey Reproduction of Black due to Suppression of Lower Frequencies by Resistance-Capacity Amplifiers].—R. Möller. (*Funktech. Monatshefte*, February, 1935, No. 2, Supp. pp. 7–9.)

2727. L.F. Amplification in Television Receivers [Theoretical Principles governing Amplifier Design].—W. T. Cocking. (*Wireless World*, 26th April and 3rd May, 1935, Vol. 36, pp. 417–419 and 444–446.)

2728. The Amplification of Transients.—Builder: Smith. (*See* 2664.)

2729. The Problem of Long-Distance Television.—G. Valensi. (*Ann. des P.T.T.*, May, 1935, Vol. 24, No. 5, pp. 401–454.)

Continuation of the paper dealt with in 2335 of July. The present instalment discusses tests on different types of line in various countries:—Germany (Kirschstein and Laub, Abstracts, 1934, pp. 159–160 and 275; Höpfner, *Europaïscher Fernsprechdienst*, July, 1932, pp. 219 and 220—*see* also Abstracts, 1933, p. 229); America (Espenschied and Strieby, Schelkunoff, 810 and 811 of March); France (Jannès and Marzin, 1934, p. 623, and the Paris/Palaiseau—or Villebon—cable resulting from these tests; tests by the S.F.R. on concentric feeders with steatite insulation; tests on the sample cable made by "Soc. Lignes Télég. et Téléph."); and England (feeder tests, Walmsley, 1934, p. 441). The writer then deals with submarine cables, particularly the Key-West/Havana and Teneriffe/Grand-Canary results (Affel and others, *Bell S. Tech. Journ.*, April, 1932: E. W. Smith, *Journ. I.E.E.*, Sept. 1933) and concludes this instalment by a long discussion, based on the above measurements, of the attenuation of interurban television lines of different types.

2730. On the Coaxial Transmission Circuit [Analysis by Circuit Theory: Circuit Constants from Actual Measurements].—S. Bekku and B. Inoue. (*Journ. I.E.E. Japan*, March, 1935, Vol. 55 [No. 3], No. 560, pp. 181–186: English summary pp. 28–29.)

2731. High Fidelity Transmission over Lines.—Espenschied and Strieby. (*Wireless World*, 31st May, 1935, Vol. 36, p. 542.)

2732. Possibilities of Further Development in Picture Telegraphy [Mechanical Arrangements for Multiple Canal Transmission: Ink Recorder: Use of Cathode-Ray Tube: Production of Picture by Mechanical Printing].—F. Schröter. (*Telefunken-Zeit.*, April, 1935, Vol. 16, No. 70, pp. 35–43.)

2733. Facsimile Messages as Aids to Industry [and the Development of High-Speed Ultra-Short Wave Facsimile Circuits, *e.g.* New York/Philadelphia].—RCA. (*Electronics*, April, 1935, p. 122.)

2734. An Investigation of the Optical Effects in Electrically Stressed Quartz. Part II [including Its Unsuitability as Substitute for Kerr Cell for Television].—L. M. Myers. (*Marconi Review*, March/April, 1935, No. 53, pp. 9–18.)

"In the first part of this article [1576 of May] formulae were developed for the investigation of the linear and circular retardation in stressed quartz. In what follows, the experimental determination of these retardations, of the ellipticity of the vibration within the quartz, and of the piezo-optical constant is described. The behaviour of the stressed quartz is compared with that of nitrobenzene." The experiments lead to the conclusion that the distortion of the isochromatic rings is a secondary effect of the electric field, the primary effect being to produce dilation or contraction along the mechanical axis. Tests with a quartz cell showed many disadvantages compared with the ordinary Kerr cell, and only one advantage—smaller capacity. "If the piezoelectric property of quartz is to be employed for the purpose of controlling light intensity, then other methods than those in which polarised light plays a part might be adopted."

2735. The Kerr Effect in Polar Molecules [Castor Oil].—O. Specchia and N. Dallaporta. (*Nuovo Cimento*, January, 1935, Vol. 12, No. 1, pp. 15–25.)

2736. Optical Inverter (using Prism with Total Reflection and Double Internal Reflection]. —de Gramont. (*Comptes Rendus*, 27th May, 1935, Vol. 200, No. 22, pp. 1806–1808.) *See* 1544 of May.

2737. On the Radiation from a Helium Discharge Tube with an Incandescent Cathode.—E. D. Deviatkova and N. D. Deviatkov. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 4, 1934, pp. 1855–1860.)

A description of a tube of the above type developed in Leningrad, and of tests carried out for determining the efficiency under various conditions, the distribution of radiated energy over the spectrum, etc. The tube is similar to that originally produced in Germany (Pirani, 1930 Abstracts, p. 587).

2738. The Spectral Selective Photoelectric Effect [Fowler's Theory can explain Observed Currents: Predicted Normal Velocity Distribution Function].—K. Mitchell. (*Nature*, 11th May, 1935, Vol. 135, pp. 789–790.) *See* 1551 of May, and Fowler, 1930 Abstracts, p. 578, l-h column.

2739. Photoelectric Fatigue and Oxidation [of Clean Metal Surfaces].—J. S. Hunter. (*Phil. Mag.*, May, 1935, Series 7, Vol. 19, No. 129, pp. 958–964.)

Turned metallic surfaces of cu, Ag, Bi and Ni were covered with a film of oxide by heating in air or oxygen, and examined photoelectrically under the same conditions as unoxidised turned surfaces. Curves of the photoelectric currents obtained (Fig. 1) gave, by extrapolation, the apparent thresholds. These are tabulated (Table II) with the true theoretical thresholds; Table III gives a comparison of the thresholds for the turned surfaces, outgassed surfaces and oxide-film surfaces. It is found that " if a clean metallic surface is exposed to the air, its photoelectric threshold moves towards the longer wavelengths," though the threshold for a clean outgassed surface is intermediate between those of the turned surface and oxide-film surface respectively. " If a clean metal surface is exposed to the air, the potential barrier at the surface is lowered, but oxidation of the clean surfaces raises the potential barrier . . . . no oxide film is formed instantaneously on the clean surface or the turned surface when exposed to air," but there is instantaneous adsorption of gas by the surface.

2740. The Photoelectric Behaviour of Composite Surface Films at Low Temperatures [Fatigue Phenomena].—R. Suhrmann and D. Dempster. (*Zeitschr. f. Phys.*, No. 11/12, Vol. 94, 1935, pp. 742–759.)

The fatigue phenomena already observed by the writers in K/naphthalene or KH/K surfaces (1934 Abstracts, p. 276: *see* also 487 of February) have been further studied. The photocell used is described (§ 2, Fig. 1) (*see* also 490 of February) and curves are given of the change with time of the spectral sensitivity at room temperature (Fig. 2), the sensitivity at 83° abs. (Fig. 3, which shows the decrease in the sensitivity maxima after irradiation), the influence of irradiation with $\lambda = 297\ m\mu$ on the spectral sensitivity (Fig. 4), the decrease of sensitivity at low temperatures in some regions of the spectrum due to irradiation by light of various wavelengths (Fig. 5), and the decrease of sensitivity under various conditions (Figs. 6–8). The fatigue phenomena are produced by irradiation with light of the same wavelength as that of a selective maximum; the sensitivity chiefly decreases on the long wavelength side of the light used for irradiation. The decrease in sensitivity is particularly marked at the maxima. Removal of the fatigue by irradiation with red light is discussed (§ 3c, Figs. 9, 10) and a theoretical explanation is attempted (§ 3d, curves showing measured and calculated values Figs. 11–13). § 3e discusses the influence of temperature on the form of the sensitivity curve (Figs. 14, 15). The two spectral maxima are ascribed to two different kinds of absorbing centres.

2741. The Influence of the External Field on the Photoelectric Effect at Caesium Oxide Cathodes.—R. Fleischer and P. Görlich. (*Zeitschr. f. Physik*, No. 9/10, Vol. 94, 1935, pp. 597–606.)

A discussion is given of previous work on the effects of the internal and external field (*see* Suhrmann, Abstracts, 1932, p. 233; Lawrence & Linford, 1930, p. 638; Nottingham, 1933, p. 47; Marx & Meyer, 1930, p. 460, and 1931, p. 274; Görlich, 1934, p. 41; and Fleischer & Görlich, 1934, p. 331). These effects are tabulated (table 4). Tables (1, 2, 3) and curves (Figs. 6, 7) are given for oxide cathodes containing metallic atoms, showing the movement of the long-wave maximum of spectral sensitivity towards longer wavelengths, as the voltage increases. The effect of the external field is to bring out electrons which otherwise would not be able to leave the cathode. The unevenness of the surface creates sufficiently high potential gradients in its neighbourhood. This displacement of the maximum is not observed with oxide cathodes with an atomic layer of an alkali metal or with hydrated, compact potassium cathodes.

2742. On the Oxidisation of Silver during the Manufacture of Caesium Photocells.—E. V. Gernet and K. K. Diakov. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 4, 1934, pp. 1867–1876.)

An account of experiments carried out in Leningrad to determine the nature of the oxidisation of silver subjected to chemical and thermal treatment when caesium is deposited on it. A description is given of the methods and apparatus used in these experiments, and the results obtained are shown in a number of curves and tables. The main conclusions reached are as follows:—(a) the structure of the oxidised silver produced by a glowing discharge in an atmosphere of oxygen almost exactly corresponds to the formula Ag_2O; (b) this structure is not altered when the amount of oxygen absorbed by silver is varied from 0.8 to 15 μgr/cm^2; and (c) the various colours of the oxidised silver are due to changes not in the chemical structure but in the thickness of the reflecting layer. This stability of Ag_2O indicates that the performance of a cell is much more affected by the physical structure of the surface than by the chemical structure of the underlying silver layer.

2743. Quantum Theory of Metallic Reflection [Electric Intensity not discontinuous but fluctuating within a Few Electron Wavelengths of the Surface: Use for Calculation of Surface Photoelectric Effect].—L. I. Schiff and L. H. Thomas. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 790: abstract only.)

2744. Temperature and Entropy of Light Quanta [Consideration of Photoelectric Effect from Thermodynamic Standpoint].—R. von Hirsch. (*Ann. der Physik*, May, 1935, Series 5, Vol. 22, No. 7, pp. 609–628.)

2745. The Photoelectric Threshold of Uranium, Calcium and Thorium treated with Limited Amounts of Oxygen.—H. C. Rentschler and D. E. Henry. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 807: abstract only.)

2746. Capacitive Photo-Effect in Silicon Photo-Resistive Cells.—O. V. Lossev. (*Izvestia Elektroprom. Slab. Toka*, No. 3, 1935, pp. 38–40.)

For previous work *see* 1933 Abstracts, p. 455, l-h col. The photo-sensitivity of the silicon cells constructed by the writer is found to be due mainly to a change in capacity under illumination. Fig. 6 gives the curve of spectral photo-sensitivity distribution.

2747. On the Nature of the Barrier Plane in the Cuprous-Oxide Photovoltaic Cell [Potential Energy Diagrams for Two Possible Structures: Semi-Transparent Metal probably separated from Oxide by Polarised Layer].—J. W. Ballard and E. D. Wilson. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 794: abstract only.)

2748. Action of Gases (H, N, O) on Colouring-Matter Photocells [and the Appearance of Negative Photo-Potentials].—Cécile Stora. (*Comptes Rendus*, 1st April, 1935, Vol. 200, No. 14, pp. 1191–1194.) For previous work *see* Abstracts, 1934, p. 392, and 1561 of May.

2749. Note on the Names of Photoelectric Devices.—C. H. Sharp. (*Journ. Opt. Soc. Am.*, May, 1935, Vol. 25, No. 5, pp. 165–166.) *See* also 823 of March.

2750. Measurement of Light of Small Intensity by means of Counters [Photoelectric Yield from Counters made of Zn, Cd, Al, Cu, Fe agrees with Yield from Photocells of Same Metals: Yield at 254 mμ increased 100-fold by treating Counter Cathodes with Active Hydrogen: Calibration of Sensitive Cathodes].—K. H. Kreuchen. (*Zeitschr. f. Physik*, No. 9/10, Vol. 94, 1935, pp. 549–566.)

2751. The Third All-Union Conference on Semi-Conductors [May/June, 1934, in Odessa: Some Effects in Photoelectricity, etc.].—I. Kikoin. (*Tech. Phys. of U.S.S.R.*, No. 3, Vol. 1, 1934, pp. 344–349: in English.)

2752. The Mobility of Sodium on Tungsten [Measurement by Photoelectric Properties: Absorption Process].—R. C. L. Bosworth. (*Proc. Roy. Soc.*, Series A, 1st May, 1935, Vol. 150, No. 869, pp. 58–76.)

MEASUREMENTS AND STANDARDS

2753. Wavelength Control in Brussels in the U.I.R. Laboratory.—K. Schmoll. (*Funktech. Monatshefte*, May, 1935, No. 5, pp. 165–172.)

2754. Intercomparison of Frequency Standards by means of Modulation Emission [Modulation of about 1 002 c/s made to beat with Various Standard 1 000 c/s Frequencies].—K. Takatsu, K. Tani and Y. Kusunose. (*Rep. of Rad. Res. in Japan*, March, 1935, Vol. 5, No. 1, pp. 35–37: in English.)

2755. The Stabilisation of a Beat Frequency by Compensation of the Temperature Coefficients.—de Gramont and Beretzki. (*See* 2607.)

2756. Quartz Crystals with Low Temperature Coefficients.—De Cock Buning. (*Radio-Centrum*, 17th Jan. 1935, Vol. 1, No. 2, pp. 25–28: in Dutch.)

From the radio laboratory of the Dutch State Telegraphs. Plates of consistent and very low temperature coefficients, for wavelengths between about 1 200 and 6000 metres, are obtained by the use of the Y-wave in a rectangular X-cut, with the sides—unlike in earlier methods—making a definite angle with the crystallographic axis. A paper dealing with plates for wavelengths 100–1 200 m will follow.

2757. Electrocoupling of Vibrating Quartz Plates.—Osterberg and Cookson. (*See* 2788.)

2758. On a Method for the Determination of Parameters of Piezo-Resonators.—A. B. Melikian and E. K. Pietrova. (*Izvestia Elektroprom. Slab. Toka*, No. 3, 1935, pp. 40–51.)

A method is presented for determining the parameters of an equivalent circuit of a piezo-crystal. The method is similar to that proposed by Dye, and is based on measurements of potentials U_e applied to the crystal at various frequencies, and of the resultant currents I_e flowing through it. Having determined the maximum and minimum values of the ratio U_e/I_e and the frequencies at which these values are obtained, the parameters of the equivalent circuit can be calculated with sufficient accuracy. The main difficulty in the original method was the variation and measurement of the applied frequency. In the proposed method this difficulty is obviated by the use (on the suggestion of Mandelstam and Papalexi), of a combined frequency $\omega \pm \Omega$ of which ω is 1 to 2% higher than the natural frequency of the crystal, and is generated by a crystal-controlled oscillator, while Ω equals 1 to 2% of ω and can be continuously varied. A sufficient frequency range can thus be covered and instead of measuring the variations of high frequency ω, comparatively large variations of low frequency Ω are measured. Furthermore the stability of the combined frequency is considerably greater than of the continuously variable h.f. oscillator which would otherwise be employed. Finally the danger of feed-back from the crystal under investigation to the crystal-controlled oscillator is diminished in view of the differences between the natural frequencies of the two crystals. This permits a crystal oscillator of lower power to be used.

The theory of the method is given and formulae are deduced for calculating the parameters. A description is given of a circuit specially developed for this investigation, and it is shown that this circuit can also be used for determining the frequency variation of the crystal controlled oscillator by noting the variation of U_e. The circuit has been actually employed in an investigation of zero temperature coefficient crystals, and the results obtained are discussed and shown in a number of curves.

2759. ON THE PRACTICAL USE OF LIGHT DIFFRACTION IN A MEDIUM OSCILLATING AT SUPERSONIC FREQUENCY [Velocity of Sound in Quartz: etc.].—S. J. Sokolov. (*Izvestia Elektroprom. Slab. Toka*, No. 3, 1935, pp. 17–21.)

A description of experiments in which the above phenomenon was observed with a view to investigating the structure of samples of metal, and also certain properties of piezoelectric quartz crystals. In the latter series of experiments one of the objects was to determine the highest frequency of oscillation at which it is still possible to obtain a diffraction spectrum. It was found with a number of crystals that sufficiently strong oscillations can be produced on frequencies of the order of 10^8 cycles, and with one particular crystal $10 \times 40 \times 48$ mm in size it was possible to observe the diffraction spectrum on frequencies between 6×10^8 and 1.3×10^8 cycles. On these frequencies a number of measurements were made of the distances between the main spectrum and the green line of the spectrum of the first order. The distances so measured were invariably found to be lower than those obtained by calculation, which seems to indicate that the velocity of propagation of sound in quartz increases with the increase of the frequency. This requires further investigation.

2760. AN INVESTIGATION OF THE OPTICAL EFFECTS IN ELECTRICALLY STRESSED QUARTZ.—Myers. (*See* 2734.)

2761. STUDY OF SOME VIBRATORY RÉGIMES OF OSCILLATING QUARTZ.—L. Bruninghaus. (*Journ. de Phys. et le Radium*, April, 1935, Series 7, Vol. 6, No. 4, pp. 159–167.)

Using the optical method, with rectangular parallelepiped crystals with edges parallel to optical and electrical axes and to a line perpendicular to the plane containing these. "It is shown notably that the figures obtained result in general from the combination of two (or perhaps three) rectangular vibratory motions, which often leads to curious and complicated designs, of a particular intensity when an agreement between the three frequencies is approximately realised."

2762. THE MOTION OF A BAR VIBRATING IN FLEXURE INCLUDING THE EFFECTS OF ROTARY AND LATERAL INERTIA [Theoretical Results agreeing with Quartz Crystal Measurements].—W. P. Mason. (*Journ. Acoust. Soc. Am.*, April, 1935, Vol. 6, No. 4, pp. 246–249.)

2763. PRODUCTION OF ROCHELLE SALT PREPARATIONS GIVING REPRODUCIBLE MEASUREMENTS [including Measurements of Piezoelectric Modulus, Conductivity and Dielectric Constant].—H. Körner. (*Zeitschr. f. Physik*, No. 11/12, Vol. 94, 1935, pp. 801–807.)

2764. THE DIELECTRIC CONSTANT OF ROCHELLE SALT IN AN ELECTRIC FIELD, AS A FUNCTION OF TIME [Three Stages of Charging Condenser Dielectric show Three Types of Charge Carrier].—H. Goedecke. (*Zeitschr. f. Physik*, No. 9/10, Vol. 94, 1935, pp. 574–589.)

2765. SIGNAL GENERATOR FOR H.F. INVESTIGATIONS ON CABLES [Almost Constant 6-Watt Output between 60 and 1 400 kc/s].—F. Gutzmann and H. Bender. (*T.F.T.*, February, 1935, Vol. 24, No. 2, pp. 36–38.)

2766. MODULATED TEST OSCILLATOR [100–1 840 kc/s: Colpitts R.F. Circuit and Hartley A.F. Circuit].—(*Wireless World*, 10th and 17th May, 1935, Vol. 36, pp. 458–460 and 482–485.)

2767. A SHORT-WAVE FIELD-STRENGTH MEASURING EQUIPMENT FOR USE IN OUTDOOR EXPERIMENTS.—H. Iinuma and E. Iso. (*Rep. of Rad. Res. in Japan*, March, 1935, Vol. 5, No. 1, pp. 1–12: in English.)

Frequency range 500–19 000 kc/s. Sensitivity, with a frame aerial mounted on the equipment, 15–125 db above 1 μv/m for the higher frequencies and 9–115 db for the lower: the use of a 10-metre vertical aerial raises these sensitivities to -8 db and -1 db above 1μv/m.

2768. A LOW-RANGE EARTH TESTER.—Baxter and Taylor. (*World Power*, May, 1935, Vol. 23, No. 137, pp. 222–225.)

2769. THE MEASUREMENT OF THE DIELECTRIC CONSTANT AND SPECIFIC CONDUCTIVITY OF THE SOIL.—Baligin and Vorobiev. (*See* 2562.)

2770. THE DIELECTRIC CONSTANTS OF AIR AND HYDROGEN AT HIGH PRESSURES [Measured with Capacity Meter of Heterodyne Type at 2 500 kc/s].—R. McNabney, W. Moulton and W. L. Beuschlein. (*Phys. Review*, 1st May, 1935, Series 2, Vol. 47, No. 9, pp. 695–698.)

2771. ON MEASURING OSCILLATORY CURRENT [at Ultra-High Frequencies].—S. Ohtaka. (*Journ. I.E.E. Japan*, March, 1935, Vol. 55 [No. 3], No. 560, p. 242: Japanese only.)

2772. The Leads and the Formula in Electric Calorimeter Calibration.—W. P. White. (*Review Scient. Instr.*, May, 1935, Vol. 6, No. 5, pp. 142–143.)

2773. The Exact Measurement of Valve Coefficients.—Hickman and Hunt. (*See* 2653.)

2774. Current Measurement with the Cathode-Ray Tube [*e.g.* Current Changes in a Lighting Network, with No Connection between Line and Tube].—W. Holzer. (*Bull. Assoc. suisse des Élec.*, No. 12, Vol. 26, 1935, pp. 322–324: in German.)

2775. Measurements of High Voltage with Electron Beams [including Principles of Application of Electron Optics: General Account].—H. Toeller. (*E.T.Z.*, 13th June, 1935, Vol. 56, No. 24, pp. 678–680.)

2776. Measurements of the H.F. Impedance of Power Mains.—Reppisch and Schulz. (*See* 2619.)

2777. Bathymeter [C.C.I.F. Name for Transmission Loss Meter] for Telephone Circuits.—R. Bigorgne and P. Marzin. (*Ann. des P.T.T.*, May, 1935, Vol. 24, No. 5, pp. 474–483.)

2778. On the Error of Rectifier-Type Instruments due to the Wave-Form Distortion by the Rectifier Itself.—S. Sanefudi and K. Okada. (*Journ. I.E.E. Japan*, April, 1935, Vol. 55 [No. 4], No. 561, p. 317: Japanese only.)

2779. Rectifier and Thermo-Transformer Meters.—P. M. Pflier. (*Elektrot. u. Masch:bau*, 16th June, 1935, Vol. 53, No. 24, p. 285: summary only.)

2780. A Sensitive Peak Voltmeter [using Two Mains-Driven Triodes and Portable Milliammeter].—J. C. B. Missel. (*Tijdschr. Nederlandsch Radiogen.*, May, 1935, Vol. 7, No. 2, pp. 77–81: in Dutch.)

2781. Discussion on "The Development of a Sensitive Precision Wattmeter for the Measurement of Very Small Powers."—N. H. Searby. (*Journ. I.E.E.*, June, 1935, Vol. 76, No. 462, p. 716.) *See* 2010 of June.

2782. The Problem of a Negative Loss Angle when Taking Measurements on the Schering Bridge.—N. Bruex. (*Elektrichestvo*, No. 9, 1935, p. 26: in Russian.)

SUBSIDIARY APPARATUS AND MATERIALS

2783. Electrical Properties of Wires of High Permeability [Mumetal Group: Audio-Frequency Skin Effect: Changes in Resistance and Reactance with Current in Wire].—Harrison, Turney and Rowe. (*Nature*, 8th June, 1935, Vol. 135, p. 961.)

2784. A Rapid Practical Method of Demagnetisation [of Materials with High Coercive Force] involving High Frequency [Damped Oscillating Discharge passed through Solenoid containing Material].—Davis. (*Nature*, 11th May, 1935, Vol. 135, pp. 790–791.)

2785. Present Position of Research and Development of Ferromagnetic Materials [Physical Bases of Variation of Magnetisation Loop: Properties and Applications of Available Magnetic Materials].—Kussmann. (*Arch. f. Elektrot.*, 18th May, 1935, Vol. 29, No. 5, pp. 297–332.)

2786. The Coercive Force of Magnetite Powders [Increase on Grinding: Relation to Specific Surface].—Gottschalk. (*Physics*, April, 1935, Vol. 6, No. 4, pp. 127–132.)

2787. The Calculation of the Torque Acting on Circular Metal Plates in a High-Frequency Magnetic Field.—J. Hak. (*Hochf:tech. u. Elek:akus.*, May, 1935, Vol. 45, No. 5, pp. 170–172.)

"To test the validity of the formula [equation 2] used by Pidduck and by Pierce (which, however, only apply to coils and narrow rings), Taylor has recently carried out new measurements on metal plates [1934 Abstracts, p. 570] without, naturally, finding agreement with the formula. In the following paper we will calculate the torque acting on metal plates in a homogeneous alternating field, taking into account the radial skin effect and employing the 'approximation by subdivision' method already used in another connection [1206 of April]. It will be seen that the results of Taylor's measurements are in good agreement with the theory." The writer obtains first the formulae (4) and (5) for the torque on a thin plate of diameter *D*, on the assumption of uniform current distribution; at higher frequencies, where the radial skin effect must be allowed for, these are replaced by (7) and (8). The full-line curve of Fig. 3 shows the agreement between Taylor's measurements and these last formulae: the dotted curve is calculated from (4) and (5) and shows the error produced by neglecting the skin effect.

2788. Electrocoupling of Vibrating Quartz Plates [Resonant Responses characteristic of Plates as a Whole: Possible Application to Wave Filters].—Osterberg and Cookson. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 781.)

The resonant responses of piezoelectric plates, with similar resonance frequencies and vibrational patterns and driven through common electrode arrangements, are characteristic of the plates as a group and formed by "electrocoupling" of the mechanical modes of the plates. Observations on this phenomenon are presented and the possibility of application to electrical wave filters is indicated.

2789. Values of Q [Reactance/Resistance Ratio] for Various Component Parts.—Franks. (*Electronics*, April, 1935, p. 126.)

2790. H.F. Chokes.—Scroggie. (*Wireless World*, 17th and 24th May, 1935, Vol. 36, pp. 486–488 and 529–530.) The author discusses in detail the various requirements of h.f. chokes for use in particular parts of radio circuits and deals with the details of design necessary to fulfil those requirements.

2791. The Replacement of Tin in Lead Cable Sheaths by Small Quantities of Tellurium.—Kröner. (*E.N.T.*, April, 1935, Vol. 12, No. 4, pp. 113–119.)

2792. The Gordon Magnesium Battery.—Hallows. (*Wireless World*, 17th May, 1935, Vol. 36, pp. 493–494.) A new type of primary battery which, it is claimed, does not become polarised. The electrodes of carbon and magnesium are not covered by the potassium bromide electrolyte but are kept moist by a wick of wood-wool. The e.m.f. on load is slightly over one volt.

2793. A Simple Circuit for Counting Pulses at High Speed [Discharge of Condenser through Gas Triode: Pulses on Grid produce Current].—Turner, Kuper and Risser. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 813: abstract only.)

2794. On Dielectric Losses in Wood.—Brake and Schütze. (*E.N.T.*, April, 1935, Vol. 12, No. 4, pp. 120–124.)

The dielectric losses in wood, on which little work seems to have been done, is of interest not only because wood is used in aerial towers, coil formers, etc., but also because its cell substance enters largely into the composition of paper and other dielectrics whose dielectric properties are of great importance. Moreover, results on such fibrous materials may lead to deductions as to the nature of dielectric loss in substances of such a structure. The writer used a Wagner bridge for his measurements at audio-frequencies, where the total losses were often so small that they could not be measured accurately by the special adiabatic calorimeter which he employed for his high-frequency measurements up to 20 Mc/s. With this calorimeter (*see* Vogler, 1931 Abstracts, p. 451: the approaching publication of a paper by Rieche is also mentioned) losses of about half a watt upwards could be measured to within 2%. The wood discs (of pitch pine, beech, oak, etc.) were so cut that the electric field was perpendicular to the direction of the fibres.

Fig. 1 shows the dielectric constant, and Fig. 2 shows tan δ, for various woods, as functions of the loss of weight by drying (expressed as a percentage of the maximum loss of weight, so that the various samples, with different original moisture contents, can be compared); the measuring frequency was 800 c/s. The interesting fact emerges that all these woods, of very differing structures, give curves of the same shape which nearly coincide when about 70% of the removable moisture has been eliminated: from about this point onwards a further drying has no effect on the value either of ϵ or of tan δ. The above confirms that the practical method of moisture-content determination by dielectric-constant measurements is well suited to wood. The difference between moist and dried wood is very great: for pitch pine tan δ drops to one-fiftieth of its original value.

Fig. 3 shows the variation of tan δ for "air-dried" beech (two samples) and dried-out beech (curve marked by circles), as the frequency is raised. Below 10^6 c/s the large differences indicated by Fig. 2 are seen, but at higher frequencies the loss due to conductivity is negligible compared with the pure dielectric loss, so that the rapidly falling curves for the moist woods, and the almost horizontal curve for the dried-out wood, come together near 4×10^6 c/s, where they all show a slight "hump." This maximum of tan δ at 4×10^6 c/s is shown by all the samples of wood (Fig. 5): it is smaller, the drier the wood and the finer its structure, and it must be attributed to the Wagner (dielectric inhomogeneity) effect.

2795. Relations between the Temperature Variation of Losses and the Rigidity against Breakdown of Paper Condensers [Greater Temperature Variation of Loss corresponds to Greater Decrease in Rigidity with Temperature: Nature of Breakdown: Experimental Curves].—Nauk. (*E.T.Z.*, 9th May, 1935, Vol. 56, No. 19, pp. 539–541.)

2796. Criticisms of Kessler's Paper "Measurements on Solid Commercial Insulating Materials at 3×10^6—7.5×10^7 c/s."—O. Zinke: Rohde & Schwarz: Kessler. (*Hochf:tech. u. Elek:akus.*, May, 1935, Vol. 45, No. 5, pp. 173–174.) The methods and results described in Kessler's paper (2086 of June) are subjected to the severest criticism.

2797. Variable Condensers with Solid Dielectric. — Daletzky and Mandryka. (*Izvestia Elektroprom. Slab. Toka*, No. 4, 1935, pp. 48–52.)

Authors' summary:—This condenser is based on the use of a new insulating material. Oxide-coated aluminium plates, after a preparatory treatment for removing the ionic valve action of the oxide coating, are treated with a solution of polymerised styrol or divinyl acetylene; the insulating coating thus formed adheres very strongly to the metal and sustains over 10 000 revolutions under friction without appreciably reducing its high insulating properties. The small size of these condensers, in comparison with air condensers, renders them useful where economy of space is essential.

2798. New Types of H.F. Condensers [using "Condensa" N and D, and a New Material "Tempa"].—Hescho Company. (*Hochf:tech. u. Elek:akus.*, May, 1935, Vol. 45, No. 5, pp. 176–177.)

Fixed condensers of disc, cup, tube and flat types (Figs 1–4) for broadcast, short- and ultra-short-wave receivers: condensers for transmitters, electro-medical apparatus, high-frequency furnaces, etc., with plates thickened at the edges: small tube condensers of "Tempa," of hitherto unattainable constancy of capacity owing to the exceptionally small temperature-coefficient of the dielectric constant of this new material.

2799. "Tempa," a New H.F. Insulating Material with Very Small Temperature Coefficient. (*See* 2798.)

2800. Hard Insulating Material with High Dielectric Constant [produced by Addition of Rutile, TiO_2].—Bogoroditzki. (*Elektrichestvo*, No. 9, 1935, pp. 24–25: in Russian.)

2801. Dry Electrolytic Condensers [up to 12 V and up to 400 V].—Roenne. (*Elektrichestvo*, No. 7, 1935, pp. 33–37: in Russian.)

2802. Electrical Conductivity and the Breakdown of Aluminium Oxide Films.—Prushinina. (*Elektrichestvo*, No. 9, 1935, pp. 13–18: in Russian.)

2803. Electrical Properties of the Oxide Insulation on Aluminium.—Gutin. (*Tech. Phys. of U.S.S.R.*, No. 2, Vol. 1, 1934, pp. 128–141: in German.)

2804. Electrical Properties of Insulated Light-Current Conductors [Insulation Resistance as Function of Temperature, Voltage and Moisture-Content of Air: etc.].—Renne and Saltykowa. (*Izvestia Elektroprom. Slab. Toka*, No. 1, 1935, pp. 54–59.)

2805. Esterified Fibrous Insulating Materials. Part II.—New. (*Elec. Communication*, April, 1935, Vol. 13, No. 4, pp. 359–379.) For Part I *see* 2092 of June.

2806. Resinite as Insulating Material.—Nikotin. (*Elektrichestvo*, No. 7, 1935, pp. 30–33: in Russian.)

2807. Mycalex [Production, Properties and Applications].—Bogoroditzki and Malishev. (*Elektrichestvo*, No. 9, 1935, pp. 22–24: in Russian.)

2808. Mica Insulation of an Increased Breakdown Strength [Effect of Selection of Thin Mica Layers on Properties of Micanite].—Mantrov. (*Elektrichestvo*, No. 9, 1935, pp. 25–26: in Russian.)

2809. Ionisation by Collision in Solid Dielectrics [Not Responsible for Increased Conductivity just before Breakdown: the Essential Rôle of the Local "Weak Spots"].—Alexandrow and Solotarewa. (*Tech. Phys. of U.S.S.R.*, No. 2, Vol. 1, 1934, pp. 142–150: in German.) For previous work on thin layers of glass and mica *see* 1933 Abstracts, p. 637.

2810. The Method of Testing Insulating Varnishes.—Kalitvianski. (*Elektrichestvo*, No. 9, 1935, pp. 32–37: in Russian.)

2811. On the Peculiarities of Dielectric Constant *versus* Pressure Curves for Vapours [Adsorption on Insulator Surfaces].—Stranathan. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 794: abstract only.)

2812. Conductivity of Oils and Waxes [Negative Temperature Coefficient: Suggested Explanation by Progressive Crystallisation with Decreasing Temperature].—A. Gemant. (*Nature*, 1st June, 1935, Vol. 135, p. 912.)

2813. The Mechanism of Dielectric Loss in Paraffin Wax Solutions at High Radio Frequencies [Variation of Power Loss agrees with Debye Theory].—Jackson. (*Proc. Roy. Soc.*, Series A, 1st May, 1935, Vol. 150, No. 869, pp. 197–220.)

2814. Molecular Structure of Dielectrics.—Bragg. (*Nature*, 18th May, 1935, Vol. 135, p. 838: Note on Kelvin Lecture.)

2815. The Breakdown of Compressed Nitrogen in a Non-Uniform Electric Field.—Goldman and Wul. (*Tech. Phys. of U.S.S.R.*, No. 4, Vol. 1, 1935, pp. 497–505: in English.)

2816. Study on the Electro-Magnetic Oscillograph of Moving-Coil Type [and the Determination of Its Predominating Natural Frequencies].—Numakura. (*Res. of Electrot. Lab.*, Tokyo, No. 376, 1934, 99 pp: in English.)

2817. The Marconi Cathode-Ray Oscillograph [Complete Equipment].—A. J. Young. (*Marconi Review*, March/April, 1935, No. 53, pp. 19–25.)

2818. A Cathode-Ray Oscillograph Equipment embodying a High-Voltage, Gas-Filled, Sealed-Glass Oscillograph Tube.—Parker Smith, Szeghö and Bradshaw. (*Journ. I.E.E.*, June, 1935, Vol. 76, No. 462, pp. 656–665: Discussion pp. 666–676.)

2819. Self-Contained Portable Cathode-Ray Oscillograph Unit [Only Power Source a 2-Volt Accumulator].—(*Elec. Communication*, April, 1935, Vol. 13, No. 4, pp. 380–381.)

2820. Discussions on "The Theoretical and Practical Sensitivities of Gas-Focused Cathode-Ray Oscillographs."—MacGregor Morris and Henley. (*Journ. I.E.E.*, June, 1935, Vol. 76, No. 462, pp. 666–674.) *See* 203 of January.

2821. Distortions of the Cathode-Ray Spot for Large Deflections [Calculations].—Wallraff. (*Arch. f. Elektrot.*, 18th May, 1935, Vol. 29, No. 5, pp. 351–355.)

For reference to experiments on this subject *see* 1523 of May. Calculations are here given which take into account the finite cross-section of the cathode-ray beam. The distortion is found to vary as the square of the deflection. With electrostatic deflection it is chiefly in the direction of deflection; with magnetic deflection it is also perpendicular to the deflection and is smaller than with electrostatic deflection.

2822. Some Phenomena of Cathode Phosphorescence [including Study of Calcium Tungstate].—Servigne. (*Comptes Rendus*, 12th June, 1935, Vol. 200, No. 24, pp. 2015–2017.)

2823. Film Camera and Daylight Developing Equipment for Cathode-Ray Oscillographs.—(*Elec. Communication*, April, 1935, Vol. 13, No. 4, p. 380.)

2824. An Electron Diffraction Camera [with Sharply Defined Beam: Flexible Copper Bellows for Motions inside Evacuated Container: etc.].—Germer. (*Review Scient. Instr.*, May, 1935, Vol. 6, No. 5, pp. 138–142.)

2825. Electron Beams in High Voltage Measurement.—Holzer: Toeller. (*See* 2774 and 2775.)

2826. The Actinic Power of Sources of Artificial Light for Photography.—Reeb. (*E.T.Z.*, 30th May, 1935, Vol. 56, No. 22, pp. 619–620: abstract only.)

2827. Studies of the Process of Photographic Development [with Microphotograms showing Single Grains: Development Velocity with Various Developers and Degrees of Illumination].—Meidinger. (*Physik. Zeitschr.*, 1st May, 1935, Vol. 36, No. 9, pp. 312–320.)

2828. Contribution to the Photographic Technique of the Cathode-Ray Oscillograph in the Investigation of High Voltage Impulse Lay-Outs [without Use of Delay Cable: Oscillograph near Impulse, Delay produced by Spark-Gap Device], *and* Investigation of High Voltage Impulse Lay-Outs with the C.-R. Oscillograph, for the Production of Correct Normal Voltage Impulses.—Lieber. (*E.T.Z.*, 6th June, 1935, Vol. 56, No. 23, pp. 633–636: 654–655.) Abstract only of the second paper.

2829. A Variable-Capacity Device for the Oscillographic Recording of Sudden Violent Movements.—Lange. (*See* 2688.)

2830. Changes in Transients [on Cables] produced by Corona [Oscillographs showing Smoothing Effect].—Förster. (*E.T.Z.*, 9th May, 1935, Vol. 56, No. 19, pp. 530–531.)

2831. Switching-Off Processes in High-Power Switches: Cathode-Ray Oscillograph Investigations.—von Borries and Kaufmann. (*Zeitschr. V.D.I.*, 18th May, 1935, Vol. 79, No. 20, pp. 597–604.)

2832. Tests of a Cut-Off Switch and Current Limiting Device of Specially Rapid Action [for High Voltages: Circuit Diagrams and Oscillograms of Current].—Douhéret. (*Rev. Gén. de l'Élec.*, 25th May, 1935, Vol. 37, No. 21, pp. 667–672.)

2833. Thermionic Delay Relays for Cathode Protection.—Miles and Morack. (*Electronics*, April, 1935, pp. 124–125.)

2834. A High-Speed Oil Diffusion Pump [with Conical or Spiral Baffles, etc.].—Edwards. (*Review Scient. Instr.*, May, 1935, Vol. 6, No. 5, pp. 145–147.)

2835. Production of Light by Phosphorescent Materials [Application to Gas Discharge Tubes].—Larché. (*E.T.Z.*, 6th June, 1935, Vol. 56, No. 23, p. 649: abstract only.)

2836. "Elektrische Gasentladungen" [Book Review].—von Engel and Steenbeck. (*Hochf:tech. u. Elek:akus.*, May, 1935, Vol. 45, No. 5, p. 178.) Second volume (Discharge Properties: Technical Applications) of the book referred to in 1934 Abstracts, p. 337.

2837. The Velocity Distribution of Electrons in Gas Discharge Problems [Homogeneous Electron Beam shot into Field-Free Space: Behaviour in Uniform Electric Field].—P. M. Morse, W. P. Allis and E. S. Lamar. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, pp. 806–807: abstract only.)

2838. The Breakdown Voltage of Mercury Vapour.—K. F. Nesturh. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 4, 1934, pp. 1844–1854.)

A report on preliminary experiments carried out to determine the relationship between the voltage at which a glow discharge begins in mercury vapour, and the product of the number of molecules of gas per unit volume and the distance between the electrodes.

2839. "All Metal" Tubes for Radio Receiving and Industrial Power Purposes.—Nolte, Beggs and Elder. (*Gen. Elec. Review*, May, 1935, Vol. 38, No. 5, pp. 212–218.)

2840. The Thyratron Inverter.—Butler. (*Wireless World*, 31st May, 1935, Vol. 36, pp. 535–537.)

2841. Ionic Devices developed in the C.R.L. [Thyratron High-Speed Stroboscope: Controller for Spot- and Seam-Welding: Marx Arc-in-Air Rectifier with Supplementary H.F. Ignition].—M. A. Speezin. (*Izvestia Elektroprom. Slab. Toka*, No. 3, 1935, pp. 66–76.) Regarding the last item, such rectifiers are found to be "inefficient for the anode supply of radio stations, although they can probably be utilised in other fields."

2842. Static Characteristics of the Anode-Ignition of a Glass Mercury-Arc Rectifier with Controlling Grid—especially the Effects of the Ambient Temperature and the Arrangement of Grid and Anode.—Matuura. (*Journ. I.E.E. Japan*, April, 1935, Vol. 55 [No. 4], No. 561, pp. 254–261: English summary p. 38.)

2843. The Use of Thermionic Vacuum Tubes for Voltage Control [in Ionisation Counters: Study of Fluctuations in Regulators].—Larkin. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, pp. 793–794: abstract only.)

2844. An Electronic Regulator for an Alternator [using Non-Linear Bridge Circuit as Voltage-Sensitive Element: No-Load/Full-Load Regulation of 0.17% on 12 kw Alternator].—Whipple and Jacobsen. (*Elec. Engineering*, June, 1935, Vol. 54, No. 6, pp. 663–667.)

2845. Voltage Variation at Consumers' Terminals.—Wedmore and Flight. (*Journ. I.E.E.*, June, 1935, Vol. 76, No. 462, pp. 685–701.)

2846. The Third All-Union Conference on Semi-Conductors [May/June, 1934, in Odessa: Some Effects in Photoelectricity, etc.].—I. Kikoin. (*Tech. Phys. of U.S.S.R.*, No. 3, Vol. 1, 1934, pp. 344–349: in English.)

2847. Effect of Vapours and Occluded Gases on the Electrical Conductivity of Copper Oxide [Diminution, particularly with Water Vapour].—Dubar. (*Comptes Rendus*, 3rd June, 1935, Vol. 200, No. 23, pp. 1923–1925.)

2848. Vibrating-Reed Rectifiers for Measuring Purposes.—Pfannenmüller. (*Zeitschr. V.D.I.*, 25th May, 1935, Vol. 79, No. 21, pp. 648–649.)

2849. The Force at the Anchored Cathode Spot [along Meniscus Edge at Mo Surface].—Tonks. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 807: abstract only.)

2850. Over-Voltage [and Lightning] Protection Device in Low-Voltage Networks [Ion Discharge Tube].—A.E.G. Communication. [*E.T.Z.*, 30th May, 1935, Vol. 56, No. 22, advt. p. 11.)

2851. Electrical Contacts [Permanent Metallic Contacts with and without Intermediate Film: Wearing and Breakdown of Film: Movement of Material in Lift-Up Contacts: Resistance/Voltage Characteristics].—Holm. (*E.T.Z.*, 9th May, 1935, Vol. 56, No. 19, pp. 537–539.)

2852. An Apparatus for Projecting Harmonic Curves in Space.—Dod. (*Journ. Acoust. Soc. Am.*, April, 1935, Vol. 6, No. 4, pp. 279–281.)

2853. A Linear Scale for the Direct Measurement of Slopes of Curves.—Chilton. (*Journ. Scient. Instr.*, June, 1935, Vol. 12, No. 6, pp. 199–200.)

2854. New Planimeters [as Integrators] for Powers with Fractional Exponents.—Dubois. (*Génie Civil*, 8th June, 1935, Vol. 106, No. 23, pp. 555–558.)

2855. The Use of Electronic Tubes for Plotting the Curves characterising Periodic Phenomena. — Gutenmacher. (*Elektrichestvo*, No. 8, 1935, pp. 43–46: in Russian.)

"The new method may be applied (a) for determining curves from low up to the highest frequencies, (b) for determining simultaneously a large number of curves, and (c) for determining high voltages at a low power consumption. The arrangement, designed as a self-recording unit, may in many practical cases take the place of the loop and cathode-ray oscillographs."

2856. Influence of Low Temperatures on the Behaviour of Lead Accumulators [Increase of Viscosity of Electrolyte, leading to Retarded Diffusion: Diminution of Capacity: Separate Study of Effect on Positive and Negative Plates].—Génin. (*Rev. Gén. de l'Élec.*, 8th June, 1935, Vol. 37, No. 23, pp. 728–737.)

2857. Single-Unit Frequency Converters [including the New Induction Type].—Hildebrand. (*Gen. Elec. Review*, May, 1935, Vol. 38, No. 5, pp. 226–229.)

2858. A Simple Device for Producing Very Small Unidirectional Currents [for Measurement of Ionisation Currents by Null Method: Rotating Condenser with Eccentric Pin.].—Failla. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, pp. 805–806: abstract only.)

2859. A Cheap, Sensitive Compensating Circuit for Comparative Tests of Transformers [Circuit Fig. 1: Theory and Tests].—Berghahn and Janssen. (*Arch. f. Elektrot.*, 18th May, 1935, Vol. 29, No. 5, pp. 356–361.)

2860. A Rotating-Coil Alternating-Current Potentiometer [of High Sensitivity].—Michels and Raines. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 793: abstract only.)

2861. A Completely Supraconducting Galvanometer.—Burton, Smith and Tarr. (*Nature*, 1st June, 1935, Vol. 135, p. 906.)

2862. On the Designation of the New Counters for Elementary Rays and Photoelectrons: the "Spark Counters" [Hydraulic and Hydrostatic Types].—Greinacher. (*Helvet. Phys. Acta*, Fasc. 3, Vol. 8, 1935, pp. 265–266: in German.) *See* 2449 of July and 2863, below.

2863. New Counting Methods for Elementary Rays and Photoelectrons (Spark Counter).—Greinacher. (*Zeitschr. f. tech. Phys.*, No. 6, Vol. 16, 1935, pp. 165–170.)

The particles are counted when they arrive at the position of shortest distance between two electrodes with very high potential difference, when a spark passes. The different forms of this apparatus are here described. § 1 gives the ordinary type, with electrode arrangements as in Fig. 1; in § 2 the hydrostatic and hydraulic types are discussed. Fig. 8 shows a record obtained from a combination of the latter types. *See* also 2862, above.

2864. The Mechanism of Electric Breakdown in Liquid Dielectrics.—Inge and Walther. (*Tech. Phys. of U.S.S.R.*, No. 5/6, Vol. 1, 1935, pp. 539–550: in English.)

2865. New Experiments on the Voltage Dissociation Effect [Changes in Conductivity of Electrolytes at High Voltages].—Michels. (*Ann. der Physik*, Series 5, No. 8, Vol. 22, 1935, pp. 735–747.)

2866. DIELECTRIC BEHAVIOUR OF ALCOHOLS AND ETHER IN VARIOUS SOLVENTS.—Müller and Mortier. (*Physik. Zeitschr.*, 15th May, 1935, Vol. 36, No. 10, pp. 371–377.)

2867. DIELECTRIC SATURATION AND PREVENTION OF FREE ROTATION IN FLUIDS [Theoretical Note]. —Debye. (*Physik. Zeitschr.*, 15th March, 1935, Vol. 36, No. 6, pp. 193–194.)

2868. SPACE CHARGE IN A CONDUCTING ELECTROLYTE [Measurements in $CuSO_4$].—Schriever. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 327 : abstract only.)

2869. THE [Negligible] SATURATION EFFECT OF THE DIELECTRIC CONSTANT OF ELECTROLYTIC SOLUTIONS [LiF and KCl].—Hackel. (*Physik. Zeitschr.*, 1st April, 1935, Vol. 36, No. 7, pp. 220–222.)

STATIONS, DESIGN AND OPERATION

2870. THE BROADCASTING WAVELENGTHS OF EUROPE [and the Suggestion to Transmit only Carrier Wave and One Set of Sidebands, thus minimising Spectrum Overlap].—P. P. Eckersley. (*Nature*, 11th May, 1935, Vol. 135, p. 800 : note on recent I.E.E. paper.)

2871. WORLD BROADCASTING PROGRESS IN 1934 [Data].—Burrows. (*World-Radio*, 31st May, 1935, Vol. 20, No. 524, p. 3.)

2872. WIRED BROADCASTING [" Drahtfunk " : Tests in Berlin : Apparatus].—Gladenbeck. (*T.F.T.*, March, 1935, Vol. 24, No. 3, pp. 55–58.) *See* also 1683 of May.

2873. POWERFUL TELEFUNKEN BROADCAST EMITTER IN THE ARGENTINE [Circuit and Pictures].—W. Meyer. (*Telefunken-Zeit.*, April, 1935, Vol. 16, No. 70, pp. 51–54.)

2874. WIRELESS WORKING WITH SHIPS.—Chetwode Crawley. (*Wireless World*, 7th June, 1935, Vol. 36, pp. 559–561.) A review of the various radio services which are available at sea and of the manner in which they are maintained.

GENERAL PHYSICAL ARTICLES

2875. ON THE QUANTISATION OF THE NEW FIELD THEORY. II.—Born and Infeld. (*Proc. Roy. Soc.*, Series A, 1st May, 1935, Vol. 150, No. 869, pp. 141–166.) For I *see* 1222 of April.

2876. THE SPHERICALLY SYMMETRIC FIELD IN THE BORN-INFELD THEORY.—Hoffmann. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, p. 639 : abstract only.)

2877. GRAVITATIONAL AND ELECTROMAGNETIC MASS IN THE BORN-INFELD ELECTRODYNAMICS.—Hoffmann. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 11, pp. 877–880.)

2878. COMMUTING CO-ORDINATES IN THE NEW FIELD THEORY.—Pryce. (*Proc. Roy. Soc.*, Series A, 1st May, 1935, Vol. 150, No. 869, pp. 166–172.)

2879. CORRELATION BETWEEN ELECTROMAGNETIC THEORY AND WAVE MECHANICS [Effect of Electrodynamics of Bohr Model on Assumptions].—DeVore. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, p. 638 : abstract only.) *See* also 2113 of June.

2880. THE RATIO 136/137 IN ATOMIC PHYSICS [Most Reliable Estimate of Electronic Charge is $(4{\cdot}775{,}9 \pm 0{\cdot}000{,}4_3) \times 10^{-10}$ e.s.u.].—Bond. (*Nature*, 18th May, 1935, Vol. 135, p. 825.)

2881. FUNDAMENTAL DIMENSIONS OF ELECTRIC AND MAGNETIC CONSTANTS μ_0 AND K_0.—Henderson. (*Nature*, 27th April, 1935, Vol. 135, p. 656.) *See* 1694 of May.

2882. GYROMAGNETIC AND ELECTRON-INERTIA EFFECTS.—Barnett. (*Reviews of Modern Physics*, April, 1935, Vol. 7, No. 2, pp. 129–166.)

2883. THE MOMENTUM OF IONS LEAVING A REGION OF IONISATION [How Different from Electrostatic Force on Collector].—Tonks. (*Phys. Review*, 15th April, 1935, Series 2, Vol. 47, No. 8, pp. 621–622.)

2884. ELECTRONIC CHARGE FROM DE BROGLIE WAVELENGTHS OF ELECTRONS.—von Friesen. (*Nature*, 22nd June, 1935, Vol. 135, p. 1035.)

2885. INVESTIGATIONS ON THE PHYSICAL PROCESSES OF ELECTROFILTRATION [of Gases : Discharge Phenomena, Mechanism of Dust Removal].—Mierdel and Seeliger. (*Arch. f. Elektrot.*, 12th March, 1935, Vol. 29, No. 3, pp. 149–172.)

2886. REMARKS ON THE EXPLANATION OF THE TANBERG EFFECT [Pressure on the Cathode of an Arc Discharge : Refutal of Tonks's Theory].—Lüdi. (*Helvet. Phys. Acta*, Fasc. 3, Vol. 8, 1935, pp. 272–278 : in German.)

2887. THE THEORY OF THE " DEPENDENT " DISCHARGE OF ELECTRICITY IN GASES.—Mache. (*Elektrot. u. Masch:bau*, 2nd and 9th June, 1935, Vol. 53, Nos. 22 and 23, pp. 253–258 and 269–273.)

2888. "REIGNITION OF AN ARC AT LOW PRESSURES": CORRESPONDENCE.—Mackeown and others. (*Elec. Engineering*, April, 1935, Vol. 54, No. 4, p. 460.) *See* 1934 Abstracts, p. 573.

2889. EFFECT OF ELECTROSTATIC FIELD UPON RATE OF VAPORISATION [from Solid Metallic Surface : Theory of Lowered Rate].—Hutchisson. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 328 : abstract only.)

2890. THE ELECTROMAGNETIC EQUATIONS OF THE SUPRACONDUCTOR.—F. and H. London. (*Proc. Roy. Soc.*, Series A, 1st March, 1935, Vol. 149, No. 866, pp. 71–88.)

2891. ELECTRON AND LATTICE CONDUCTIVITY IN HEAT FLOW THROUGH METALS [at Low Temperatures].—Grüneisen and Reddemann. (*Ann. der Physik*, Series 5, No. 8, Vol. 20, 1934, pp. 843–877.)

2892. The Establishment and Destruction of Superconductivity at Radio Frequency [Simultaneous Application of Direct and Alternating Current of Suitable Magnitude].—Scott, Silsbee and Brickwedde. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, p. 794: abstract only.)

2893. The Direct Determination of the Free Path of Electrons in Metals.—Eucken and Förster. (*E.T.Z.*, 23rd May, 1935, Vol. 56, No. 21, p. 593: summary only.)

2894. On Recent Experiments on the Variation of Conductivity in Metal Films [due to an Electric Charge].—Pierucci: Deubner. (*Nuovo Cimento*, February, 1935, Vol. 12, No. 2, pp. 73–75.) *See* 911 of March.

2895. The Optical Constants of Thin Metallic Films in the Long-Wave Infra-Red [Theory and Measurements].—Woltersdorff. (*Zeitschr. f. Physik*, No. 3/4, Vol. 91, 1934, pp. 230–252.)

2896. Orientation of Oxide Films on Metal [Parallelism of Crystal Planes].—Mehl, McCandless and Rhines. (*Nature*, 29th Dec. 1934, Vol. 134, p. 1009.)

2897. Demonstration of the Internal Electric Field of Rochelle Salt using X-Rays.—Staub. (*Physik. Zeitschr.*, 15th Sept. 1934, Vol. 35, No. 18, pp. 720–725.)

MISCELLANEOUS

2898. The Symbolic Calculus (with Some Applications to Radiotelegraphy [U.R.S.I., 1934]).—B. van der Pol. (*Tijdschr. Nederlandsch Radiogen.*, March, 1935, Vol. 7, No. 1, pp. 18–32: in English.)

2899. The Application of the Calculus of Probabilities to the Theory of Telephone Traffic [Probability of Traffic received by Any One Line out of a Number].—Vaulot. (*Comptes Rendus*, 27th May, 1935, Vol. 200, No. 22, pp. 1815–1818.)

2900. Periodic Solutions of Non-Linear Partial Differential Equations.—N. Artemjew. (*Tech. Phys. of U.S.S.R.*, No. 2, Vol. 1, 1934, pp. 187–193: in German.)

2901. The Differential Analyser [Machine for solving Differential Equations graphically and numerically].—Hartree. (*Nature*, 8th June, 1935, Vol. 135, pp. 940–943.)

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Some Recent Patents

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

SUPERHETERODYNE RECEIVERS

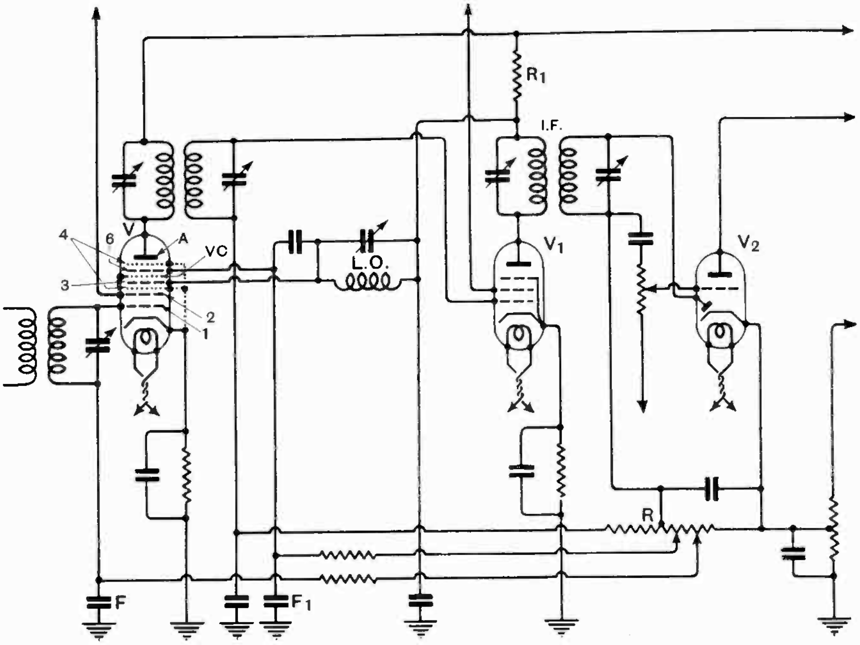
Application date, 23rd May, 1933. *No.* 419885

A multigrid valve *V*, of the kind in which a "virtual cathode" is formed at an intermediate point of the normal electron-stream, functions as a combined amplifier, oscillator, and detector in the first stage of a superhet circuit. The second valve *V*1 is an intermediate-frequency amplifier of the pentode type, whilst *V*2 is a single-diode-triode which supplies automatic volume-control voltages to the first valve, and also acts as a second detector and low-frequency amplifier for the received signals.

The aerial is coupled to the grid 1 which is followed by a screen grid 2 and an intermediate mesh anode 3, these electrodes acting as a high-frequency amplifier. The two electrodes marked 4 are combined to form suppressor grids. Between the intermediate anode 3 and a second control grid 6 a space-charge accumulates to form a virtual cathode *VC*. The emission from this is utilised as the basis of the local-oscillator action of the valve, the frequency being determined by the tuned circuit *L.O.*

Mixing takes place by electron coupling, and the resultant intermediate frequency appears in the circuit *I.F.* The load resistance *R* of the diode-triode *V*2 is tapped to feed A.V.C. voltages to the grid 1 through a filter *F*, and to the grid 6 through a filter *F*1. The resistance *R*1 in the anode circuit of the pentode *V*1 applies a further control voltage to the intermediate anode 3 of the first valve.

Patent issued to E. K. Cole, Ltd., and G. Bradfield.



No. 419885.

CATHODE-RAY TUBES

Convention date (Germany), 23rd May, 1933. *No.* 420049

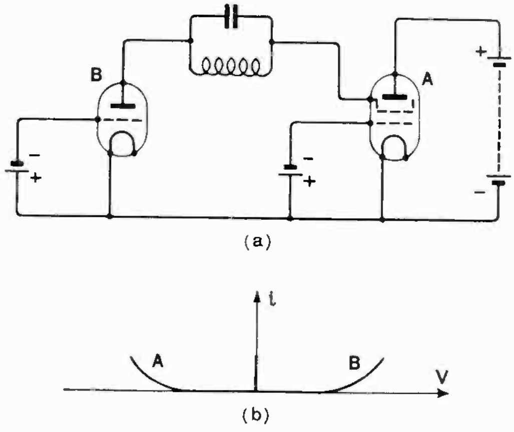
In order to avoid any disturbing effect due to magnetic leakage from the supply transformer, a mains-driven cathode-ray tube is so aligned with respect to the transformer that the bulk of the leakage lies in the same axis as the electron stream when the tube is in operation. The mains transformer is first assembled so as to be freely movable, and the position of the tube is then varied until no fading or distortion is observed on the fluorescent screen. As a further refinement, it is then possible to adjust the distance between the tube and transformer, so that the position of the electron beam in its "resting" position also coincides with certain of the stray lines of force.

Patent issued to Allgemeine Electricitats Ges.

THERMIONIC VALVE CIRCUITS

Convention date (Germany), 22nd July, 1932.
No. 419970

The control grid of a two-grid valve is given such a negative bias that current can only flow to the anode when the voltage applied to the second or screen-grid has a high positive value so that intense secondary emission occurs, *i.e.*, more electrons leave the screen-grid than impinge upon it. Under these conditions the screen-grid will show a "falling" characteristic curve from the inception, i.e., without the preliminary "rising" portion which is characteristic of the ordinary dynatron.



(a)

(b)

No. 419970.

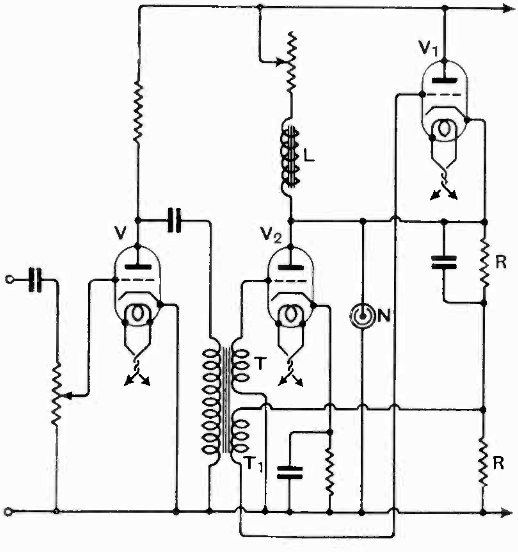
The arrangement is capable of a number of applications. As shown in Fig. (a), a two-grid valve *A*, biased as described, is coupled to a three-electrode valve *B*, and the combination is used to generate oscillations. The characteristic curves of the two valves are shown in Fig. (b). The resultant curve is of steep slope, so that the arrangement is capable of producing oscillations of large amplitude.

Patent issued to Telefunken ges. für drahtlose Telegraphie m.b.h.

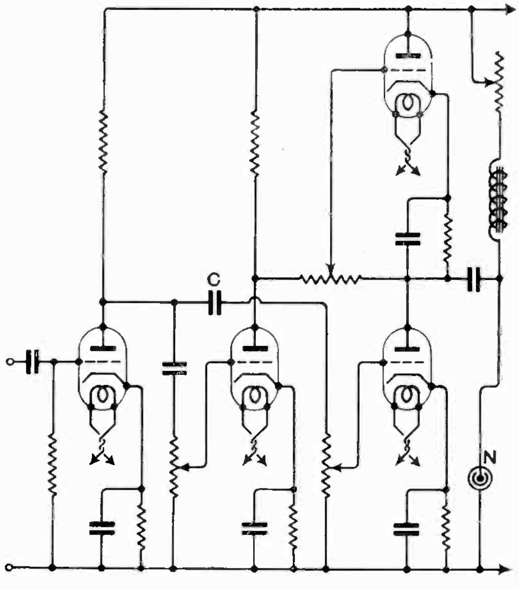
NEON LAMPS FOR TELEVISION

Application date, 24th April, 1933. *No.* 420074

Relates to means for matching the comparatively low impedance of a neon lamp to the last valve of a television receiver, in order to prevent distortion. The lamp *N* is inserted in parallel with the output valve *V2*, and in series with an auxiliary valve *V1* to which the received signals are applied in phase-opposition.



No. 420074 (1).



No. 420074 (2).

The output from the first valve *V* is coupled to the valves *V1*, *V2* through a transformer with two secondary windings *T*, *T1* which feed the signals in opposite phase to the valves *V1*, *V2*. Resistance *R* in shunt with the neon lamp provide grid-biasing voltages. The H.T. supply to the valve *V2* and lamp *N* is fed through a choke combination *L*. Instead of the transformer coupling *T* an additional valve may be used to introduce the necessary phase-reversal of the signals as in the second Fig.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.; H. M. Dowsett; and E. F. Goodenough.

TELEVISION RECEIVERS

Application date, 13*th February,* 1933.
No. 420065

In a cathode-ray receiver, the relation between the applied control-voltage and the resulting light-intensity produced on the fluorescent screen does not usually follow a straight-line law. In general the rate of change of light-intensity is greater for less-negative grid-potentials than it is for more-negative potentials. Also it is usually necessary to "bias" the control grid in such a way that a signal of maximum amplitude in the "black" direction reduces the electron beam substantially to zero; and when this is done, it is found that variations of intensity in the darker portions of the picture are almost completely masked, whilst in the lighter parts of the picture they are unduly accentuated.

In order to overcome these defects the incoming signals, before they reach the cathode-ray tube, are passed through a "compensating" valve or screen-grid rectifier which serves to increase the amplitude of the signals representing "dark" areas as compared with those representing "light" areas, and so balances-out the undesirable effects in question.

Patent issued to Electrical and Musical Industries, Ltd.; F. Blythen and J. Hardwick.

CONSTANT-FREQUENCY CIRCUITS

Convention date (Germany), 19th April, 1933.
No. 420417

In certain receivers of the heterodyne type, it is essential to maintain the frequency of the local-oscillations constant, once the tuning has been set. If the set is subject to rapid temperature variations, for instance, as it may be when installed in an aeroplane, this in itself is sufficient to upset the predetermined tuning.

According to the invention the components of the local-oscillator circuit are designed to be free from expansion or contraction due to heat. The condenser, for instance, consists of a thin metal coating on pot-shaped formers of ceramic material, whilst the inductance consists of a metal strip wound on a cone of similar material, so that the effective impedance of both remains constant over a wide range of temperature.

Patent issued to Telefunken Ges. für drahtlose Telegraphie m.b.h.

HIGH-FREQUENCY SIGNALLING

Application date, 2nd June, 1933. *No.* 420447

"Localised" transmission of signalling frequencies up to 1750 megacycles is effected by feeding the currents into a dielectric guide *G*, Fig. 1, consisting of an insulating compound, such as a phenol-condensation product, which has a fairly high dielectric constant, high resistivity, and low conductance loss. Transmission takes place by waves of dielectric displacement. The end of the guide is fitted with a central disc *D* and an annular ring *R* to which the signal voltages are applied. A central metallic conductor may be embedded in the dielectric.

Fig. 1A shows the input end of the guide-line. It encases a short-wave generating-valve *V*, the grid of which is directly connected to the centre disc *D* whilst the anode is connected to the peripheral ring *R*. In this case the whole of the guide line is covered with a metal sheath. The arrangement is applicable for multiplex signalling and is stated to be able to accommodate 400 separate voice channels each 5,000 cycles wide.

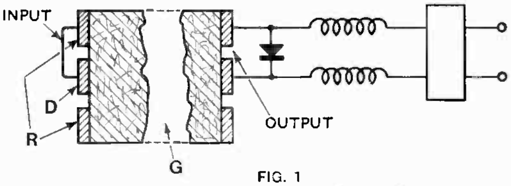


FIG. 1

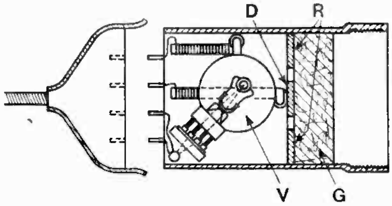


FIG. 1A

No. 420447.

Patent issued to Standard Telephone and Cables, Ltd.

DETECTOR CIRCUITS

Convention date (Holland), 29th April, 1933.
No. 420476

In order to prevent the leak resistance of a detector valve from damping the preceding tuned circuit, the input of the valve is shunted by a series connection of a choke coil and resistance. Whilst this prevents damping, the choke coil is liable to pick up "noise" from the mains. Accordingly it is made in two parts which are closely coupled together and wound in opposite directions, so that disturbing voltages are automatically balanced out. One half of the coil is shunted by a condenser of low impedance to H.F. currents, so that as regards damping, the arrangement works as if only one coil were used. The invention is applied to a diode-triode valve serving as a combined detector and L.F. amplifier.

Patent issued to N.V. Philips Gloeilampenfabrieken.

TELEVISION

Convention date (U.S.A.), 30th March, 1933.
No. 420479

In order to provide an identity mark or "call" sign which shall be constantly visible at the receiver, the sensitised "mosaic" surface of the cathode-ray tube transmitter is masked at one corner by a small plate stencilled with the chosen sign. The plate masks the sensitive surface from the scanning-ray at the transmitting end, and produces a corresponding bright replica at the corresponding corner of the fluorescent screen on the receiver. Alternatively the stencil may be cut to superpose an advertising symbol on the received pictures.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.