WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

FEBRUARY 1956

VOL. 33 No. 2 · THREE SHILLINGS AND SIXPENCE

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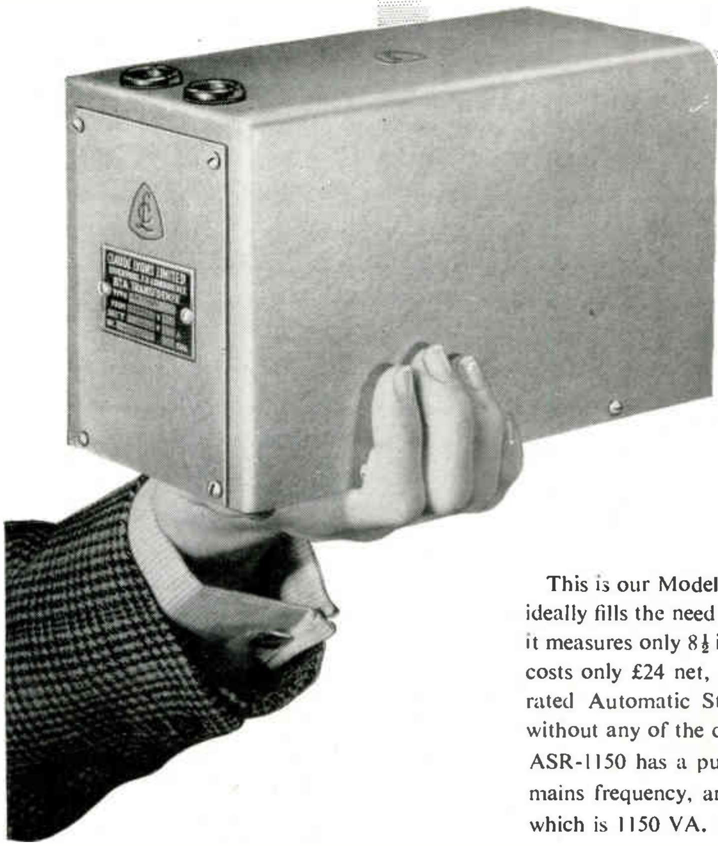

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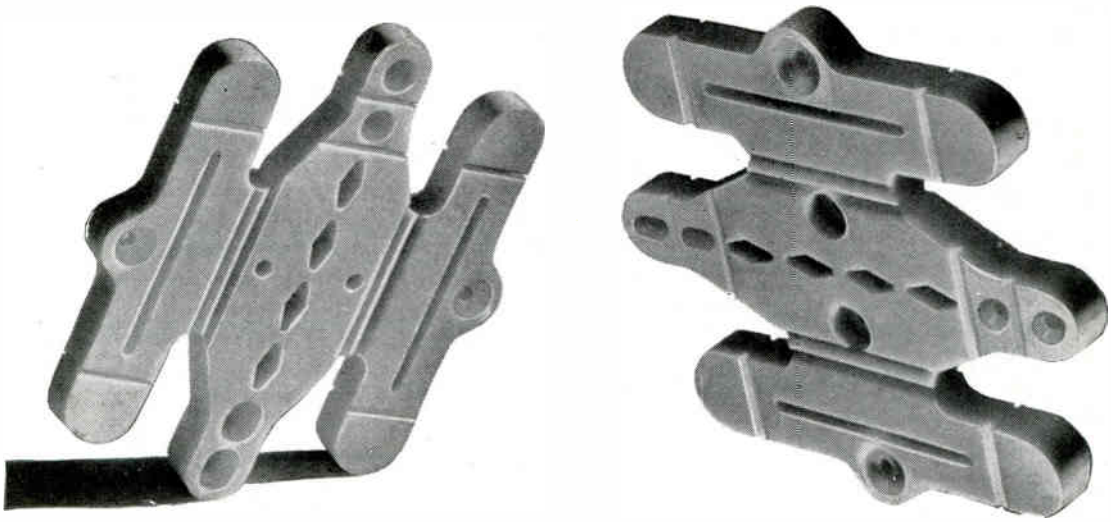

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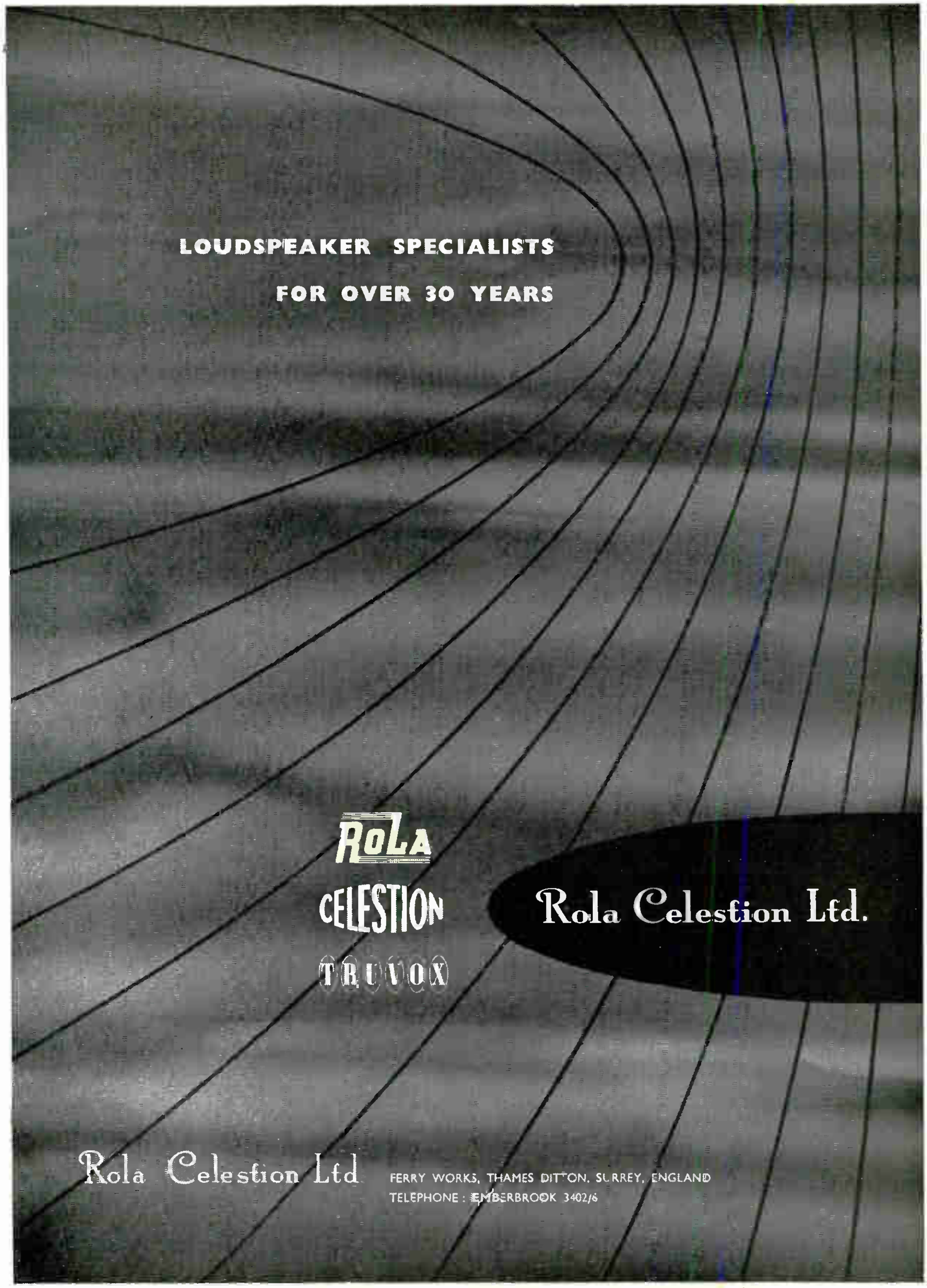
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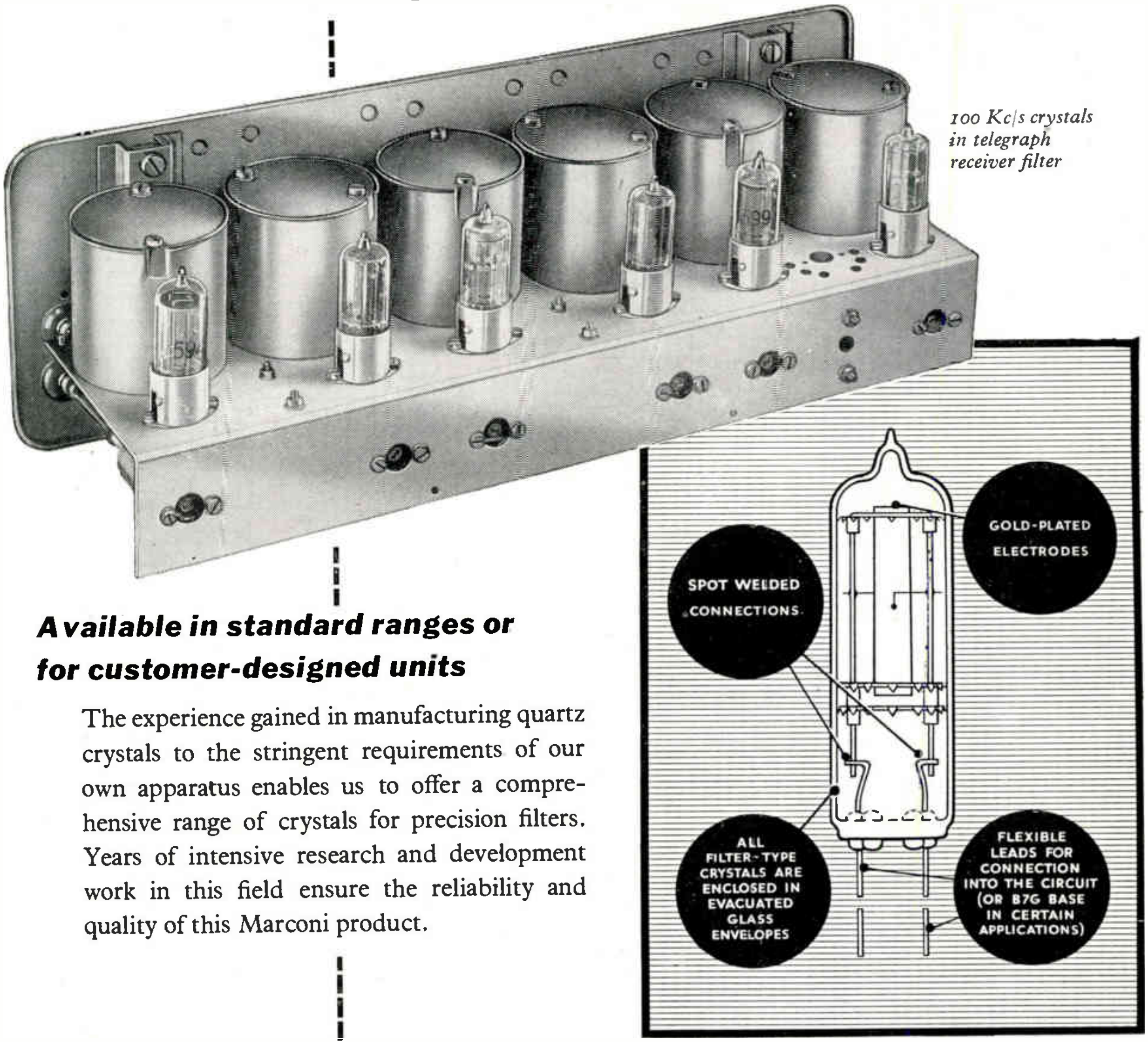

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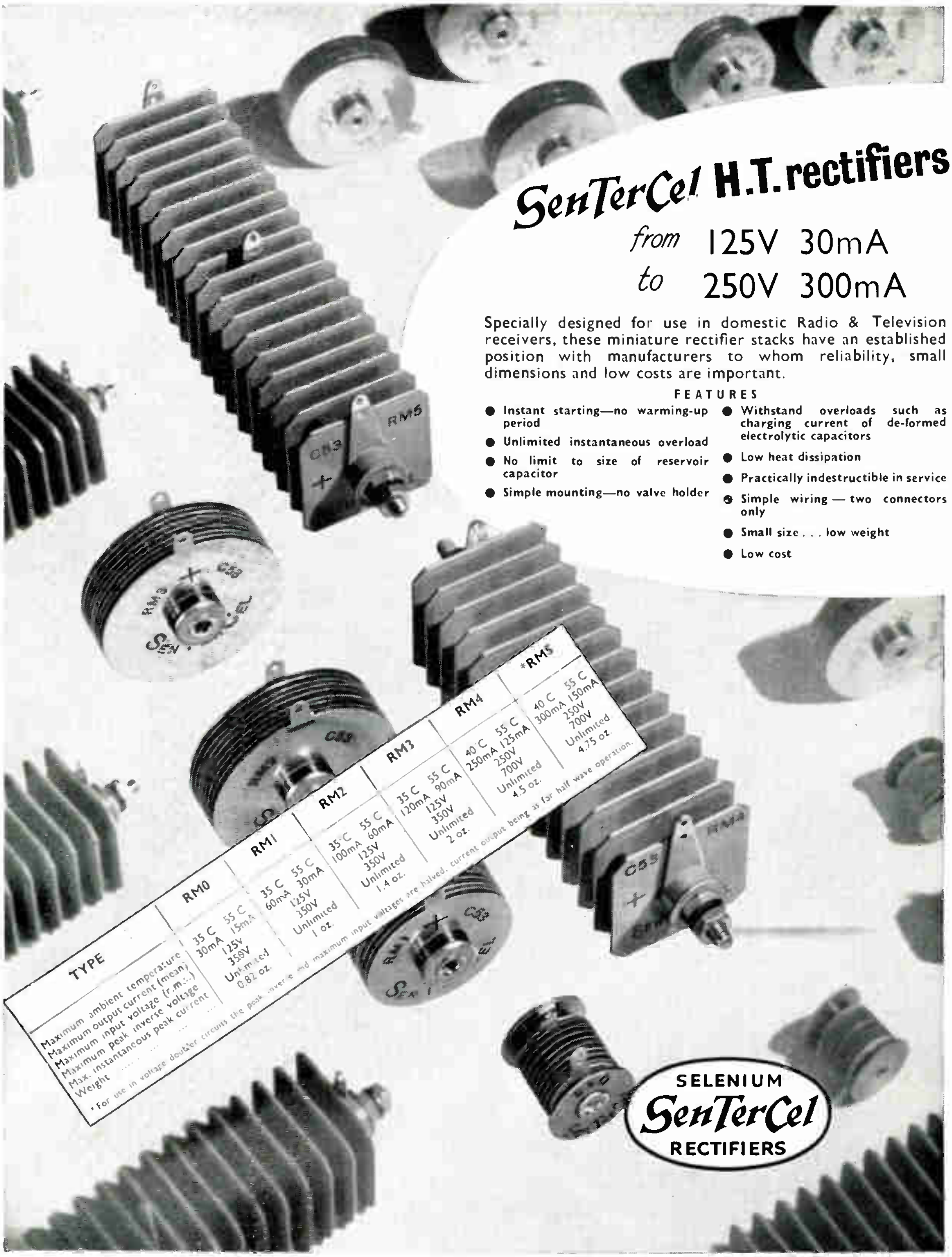

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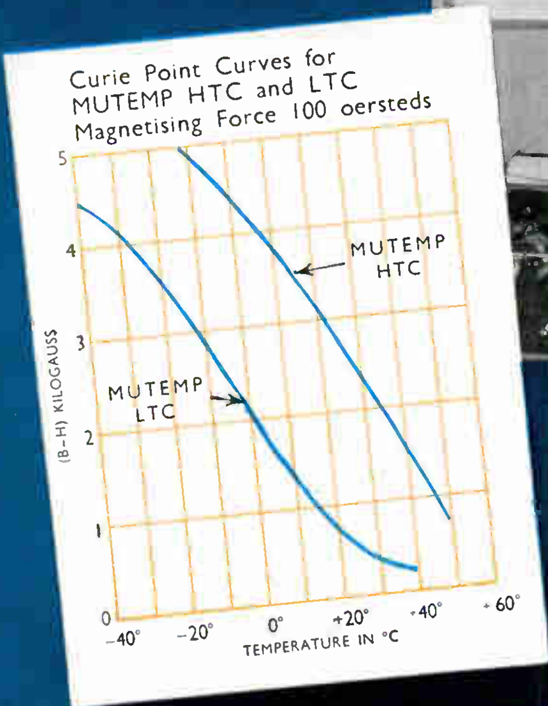
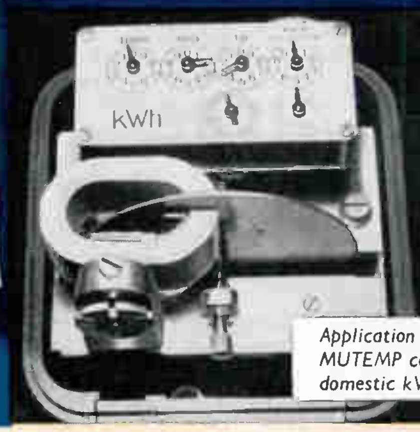


Measurement of the change in characteristics with temperature.



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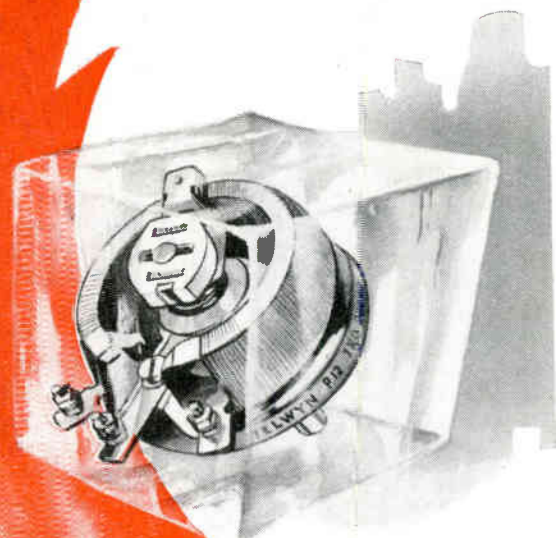

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The Transistor Amplifier

IT is well known that the inclusion of an unbypassed resistor in the cathode circuit of a thermionic valve reduces the voltage amplification considerably. The external behaviour of a transistor is closely analogous to that of a valve and one naturally expects, therefore, that the influence of such a resistance in the emitter circuit would have a similar effect.

In practice, it is usually found that it does reduce the amplification, but not always as much as one expects. Sometimes the reduction is large; sometimes it is quite small. In theory, however, the usual formula shows that the current amplification should be very little affected by an emitter resistance.

There thus seems to be a contradiction between theory and practice. As usual in such a case, it turns out that the theory is incomplete or incorrectly applied.

Fig. 1.

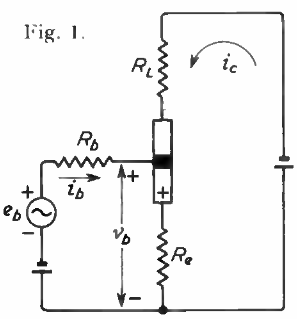

Fig. 1 shows the circuit of a p-n-p junction transistor with an emitter resistance R_e, working into a load resistance R_L and fed from a source of e.m.f. e_b having an internal resistance R_b. Fig. 2 shows one form of equivalent circuit. In this, we have used the symbol ρ for the internal resistances, since r is commonly employed for the earthed-base connection. The relevant equations are:—

$$e_b = i_b R_b + v_b$$

$$v_b = i_b(\rho_b + \rho_e + R_e) + i_c(\rho_e + R_e)$$

$$i_b \rho_m = i_c(\rho_c + \rho_e + R_e + R_L) + i_b(\rho_e + R_e)$$

whence

$$A_c = \frac{i_c}{i_b} = \frac{\rho_m - \rho_e - R_e}{\rho_c + \rho_e + R_e + R_L}$$

and

$$\rho_{in} = \frac{v_b}{i_b} = \rho_b + (\rho_e + R_e)(1 + A_c)$$

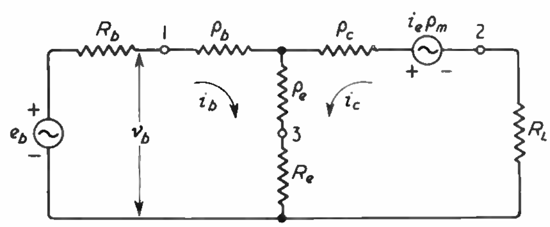

Fig. 2.

In practice, the current amplification factor a is more often quoted than ρ_m. This is, in effect, the value of A_c when $R_e = R_L = 0$. Therefore, $\rho_m - \rho_e = a(\rho_c + \rho_e)$ and we can write

$$A_c = \frac{a(\rho_c + \rho_e) - R_e}{\rho_c + \rho_e + R_e + R_L}$$

Generally, $\rho_e \ll \rho_c$ and R_e will not often be comparable with $a\rho_c$ or $\rho_c + R_L$. For example, we might have $\rho_b = 500\ \Omega$, $\rho_e = 7\ \Omega$, $\rho_c = 13\ \text{k}\Omega$ and $a = 45$. The load R_L is generally of the order of 1 kΩ and R_e will not often be more than 1 kΩ. Therefore, with $R_e = 0$, we have $A_c = 585/14 = 41{\cdot}8$ and with $R_e = 1\ \text{k}\Omega$ we have $A_c = 584/15 = 39$. Even with R_e as great as 10 kΩ the amplification would drop only to 24. The change is much less than one seems to get in practice.

The equations show that the current amplification, as defined, is nearly independent of R_e over the normal range of component values. If the input circuit of the transistor is so arranged that i_b is constant, then i_c will hardly be affected by R_e and it is unnecessary to bypass R_e. If the input voltage v_b is kept constant, however, matters are very different. Then $i_b = v_b/\rho_{in}$ and ρ_{in} depends on R_e.

Taking the values given, with $R_e = 0$ we have $\rho_{in} = 0{\cdot}5 + 0{\cdot}007 \times 42{\cdot}8 = 0{\cdot}8$ kΩ, while with $R_e = 1$ kΩ, we find $\rho_{in} = 0{\cdot}5 + 1{\cdot}007 \times 40 = 40{\cdot}78$ kΩ. The input currents are changed in the ratio of $40{\cdot}78/0{\cdot}8 \approx 51$.

This is, therefore, the explanation of why the apparent gain of a transistor stage depends quite markedly upon R_e, although the true current gain as normally defined is hardly affected. It becomes, too, clear why the magnitude of the effect seems to vary, for it depends upon the resistance of the source feeding the transistor; that is, upon the value of R_b in Figs. 1 and 2.

Expressed in this way, the mechanism appears quite different from that in a thermionic valve. There, the grid–cathode voltage is the difference between the input and cathode voltages, so that increasing the last by increasing a cathode resistance reduces the gain because it reduces the grid–cathode voltage. Actually, however, precisely the same effect occurs in the transistor. Referring to Fig. 2, the true input voltage to the transistor is the voltage between 1 and 3 and v_b is really the input voltage of the amplifier stage, not of the transistor itself. The voltage between 1 and 3 is $v_b - (i_b + i_c)R_e$ and falls as the emitter voltage increases with increasing R_e.

There is a difference between the valve and the transistor in practice, however, in that the value of the source impedance plays a large part in the action. Even this is not foreign to the valve, though, for in the feedback circuit of Fig. 3 the voltage amplification between grid and anode is substantially independent of the feedback resistance R_f. The input resistance becomes quite low because of R_f, however, and affects the voltage which can be developed on the grid from a source of given impedance.

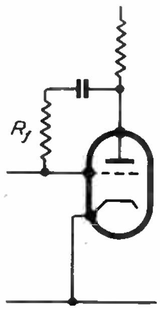

Fig. 3.

Reverting to the transistor, the input current is

$$i_b = \frac{e_b}{R_b + \rho_{in}} = \frac{e_b}{R_b + \rho_b + (1 + A_c)(\rho_e + R_e)}$$

If we bypass R_e we can replace this term by $Z_e = R_e/(1 + j\omega C_e R_e)$ and, treating A_c as a constant, we get as the ratio of output at any frequency to the output at infinite frequency ($Z_e = 0$).

$$S = \sqrt{\left[\frac{B^2 + \omega^2 C_e^2 R_e^2}{1 + \omega^2 C_e^2 R_e^2}\right]}$$

Where

$$B = 1 + \frac{(1 + A_c)R_e}{R_b + \rho_b + (1 + A_c)\rho_e}$$

This expression is exactly the same as the one given by Sturley[1] for the valve save that, in his case, the value of B is $1 + R_k(1 + \mu)/(r_a + R_L)$. The family of universal curves which he gives (his Fig. 9.10) is, therefore, applicable also to the transistor. Using the values given earlier with $R_b = 5$ kΩ we have $B = 8{\cdot}35$ for $R_e = 1$ kΩ. Interpolating from Sturley's curves we find $\omega C_e R_e$ must be about 11 for a drop in response of 2 dB. At 50 c/s, $C_e R_e = 11/314 = 0{\cdot}035$ in farads and ohms. So for $R_e = 1$ kΩ, we need $C_e = 35\,\mu$F, which is the same sort of value that one would use with a valve.

We thus conclude that a transistor requires that any emitter circuit resistance should be bypassed to avoid a loss of effective gain under normal conditions. If the source impedance of the base circuit can be kept high enough, however, bypassing can become unnecessary.

W.T.C.

[1] K. R. Sturley, "Radio Receiver Design", Part 2, p. 20 (1st Edn.), Chapman & Hall.

GLOW-DISCHARGE TUBES

Initial Drift and Running-Voltage/Temperature Characteristics

By **F. A. Benson**, M.Eng., Ph.D., A.M.I.E.E., M.I.R.E. and **L. J. Bental***, B.Sc., Dipl.Ing., M.Eng.

(*The University of Sheffield*)

SUMMARY.—Measurements have been made to determine the influence of various tube parameters on the magnitude and duration of the initial drifts and on the running-voltage/temperature curves of glow-discharge stabilizers. Tubes differing in cathode material, gas filling, gas pressure and construction have been specially manufactured for the investigations. The results of the work are presented here and discussed.

Introduction

DURING recent years the demand for glow-discharge voltage-regulator tubes of high stability has risen considerably. It is well known that such tubes form simple and inexpensive methods of voltage stabilization and are also extensively used in electronic stabilizers of the degenerative type for providing a reference voltage. For both these purposes the ideal tube should, among other things, have no drift in running voltage, either due to changes in temperature or other causes, when operated for any length of time.

A good deal of information is now available on the behaviour of certain tubes when operated under conditions of varying ambient temperature[1–9] and many measurements have also been made of the high rate of drift in running voltage which occurs in all tubes during the first few minutes of operation after striking[2–6].

The maximum and average temperature coefficients of running voltage for many tubes of various types have previously been reported by Benson, Cain and Clucas[1] and Benson[2–5]. In all these cases the tubes were run at constant current through a variation of ambient temperature from about 20°C to something approaching 100°C by placing them in either a water bath or an electrically-heated oven. It was then assumed, in order to calculate the temperature coefficient of each tube, that the change of running voltage between these two temperatures was linear. Most of the tubes so tested exhibited a negative temperature coefficient (i.e., the running voltage dropped as the temperature was increased) although three types showed positive ones. Tubes of the same type gave widely different results and some tubes had a nearly-constant running voltage throughout the whole temperature range. Kirkpatrick[6] has made measurements on five tubes of each of the American types VR75, VR105 and VR150 as the temperature of the insulated box in which they were placed was raised to 100°C. The voltage across one tube of each type was recorded continuously during the tests and measurements were made on the other tubes only at room temperature, at 100°C and then again at room temperature. From these readings an average temperature coefficient was computed, except in the case of the VR105 type where the changes in tube voltages with temperature were too erratic for this to be possible.

It has also been suggested[7] that some tubes have temperature coefficients which are of opposite signs for deviations above and below room temperature and this has been confirmed for a small number of tube types by Benson and Bache[8].

Further detailed and more recent measurements have been carried out by Benson and Mayo[9] on a number of other tube types. Running-voltage/temperature characteristics of nine British types of tube and one German type have been given and discussed by them. Many of these curves exhibit minima; i.e., the temperature coefficient of running voltage changes from negative, through zero, to positive values. It was concluded from this work that the kind of gas filling appears to be an important factor in deciding whether a given tube will show a positive or a negative temperature coefficient. The assumption, that the change of running voltage with temperature is linear, made in previous calculations to determine temperature coefficients, is not, in general, valid when the coefficient shows a change of sign.

The authors have now investigated, in detail, the effect of changing various tube parameters on the magnitude and duration of the initial drift and on the running-voltage/temperature curve. For this purpose many of the tubes examined had to be specially manufactured so that the influence of one parameter at a time could be observed. Tests have been carried out on a large number of tubes differing in cathode material, gas filling, gas pressure and construction. The results of the work are presented here and discussed.

Measurements

The methods used for measuring the initial drift and running-voltage/temperature characteristic have already been described[3, 9].

MS accepted by the Editor, March 1955

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Each tube was fed in turn from a d.c. supply through a suitable series resistor. A meter in the anode lead was used to measure the current while decade resistance boxes across the tube stepped down the running voltage so that it could be measured on a vernier potentiometer. The ambient temperature was varied by immersing the tube in an electrically-heated oil bath (a special stirring device was used to maintain a uniform temperature in the bath).

In order to obtain further information a number of new commercial tubes have been tested, differing in gas filling and in cathode material.

Some typical results of these tests are given in Fig. 1. To give a clear picture, only one curve has been plotted for each type of tube, representing the mean running-voltage/temperature characteristic. Also the running voltage at 30°C has arbitrarily been chosen as the zero point for change of running voltage. The characteristics

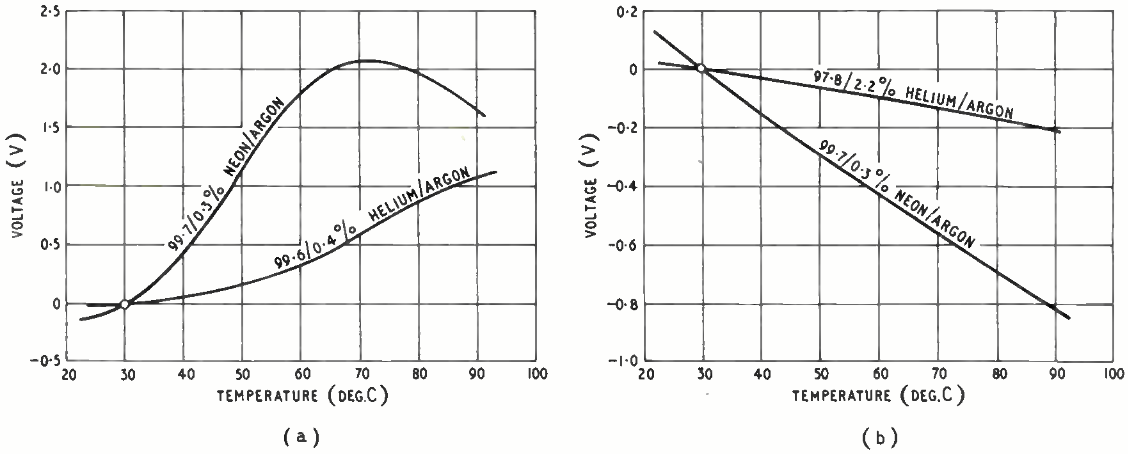


Fig. 1. *Voltage/temperature characteristics of commercial stabilizers having nickel cathodes (a) and with cerium-alloy cathodes (b).*

It should be noted that while each tube was operated at a suitable mean current, the input voltage was kept constant and not the current. This was achieved by using a regulated power supply with a stabilization of 0·2%. Change of temperature produced a variation in the running voltage and in the current through the tube (the latter being small in practice). Thus the tubes were operated under conditions similar to those met with in practice.

In each case the tube was operated at room temperature until the initial drift was complete (in several cases drifts for periods over six hours have been observed). After this the bath was heated in steps of about 10°C up to a temperature approaching 100°C. Before each reading was taken the temperature was kept constant for a few minutes to allow a steady running voltage to be reached.

Experimental Results

(1) *Commercial Stabilizers*

A number of commercial tubes had already been tested before the present measurements were made. The results obtained[9] seemed to suggest that the gas filling of the tube had a marked effect on the running-voltage/temperature characteristic as mentioned earlier.

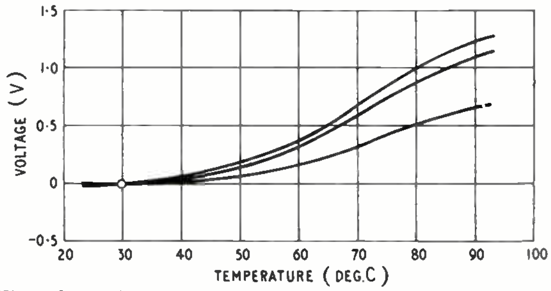


Fig. 2. *Voltage/temperature characteristics of three identical tubes each having a nickel cathode and a 99·6/0·4% helium/argon gas filling.*

represented in each figure are of tubes with identical construction and the same cathode material but different gas fillings. Fig. 1(a) is for tubes with nickel cathodes and (b) for a commercial stabilizer having a cerium-alloy* cathode.

These results show clearly the different running-voltage/temperature characteristics which can be observed in tubes with different cathode materials and different gas fillings.

A word of warning must be added about the spread of the results obtained. In this article only the mean characteristic is given and it should be remembered that the spread of characteristics of

* This alloy is called mischmetal and consists of 45% cerium, 45% iron, 5% of various rare earths and 5% of impurities.

individual tubes of the same type is often very large. This spread is illustrated by Fig. 2 which shows the running-voltage/temperature characteristics of three identical commercial tubes. The characteristics given in the various figures merely show the general shape of the curves and should not be taken as an absolute measure of the running-voltage/temperature coefficient.

(2) *Tubes with Different Cathode Materials*

To determine the influence of the cathode material on the running-voltage/temperature characteristic, a number of tubes with different cathode materials were specially produced. All these tubes were of identical construction. They were of the miniature type with a cylindrical cathode, the anode being a wire at the axis. The different cathode materials used were copper, nickel, molybdenum, zirconium and tantalum. Six tubes of each type were obtained, of which three were filled with a 99·7/0·3% neon/argon mixture and three with a 99·55/0·45% helium/argon mixture.

Since large differences in the initial drifts, as well as different running-voltage/temperature characteristics, have been observed for the tubes, it was thought to be desirable to present curves for the different types. These are given on Figs. 3, 4 and 5.

Fig. 4 shows that tubes with molybdenum, zirconium or tantalum cathodes and neon-gas fillings exhibit a falling running-voltage/temperature characteristic. Furthermore, this characteristic is very nearly a straight line. On the other hand copper and nickel cathodes with neon-gas fillings exhibit a steep rising characteristic. Also the absolute change in the running voltage is much greater in the case of copper and nickel than with the other cathode materials (note the different scale for copper on Fig. 4).

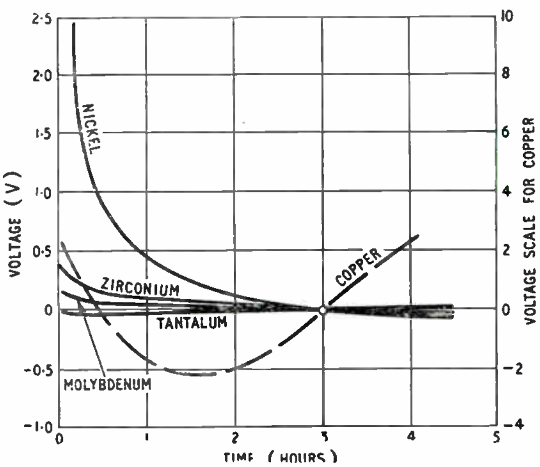


Fig. 3. *Voltage drift of experimental tubes having different cathode materials and neon/argon gas fillings.*

Fig. 3 shows a similar difference for the initial drifts. Tubes with copper and nickel cathodes have an initial drift which is many times that of the other types.

For tubes with helium-gas fillings, the difference between the running-voltage/temperature characteristics of the different types is not so marked. All types of cathodes exhibit a rising running-voltage/temperature characteristic [Fig. 5(b)]. In this case it is only the tubes with copper cathodes which show a much larger change in the running voltage than those with cathodes of other materials.

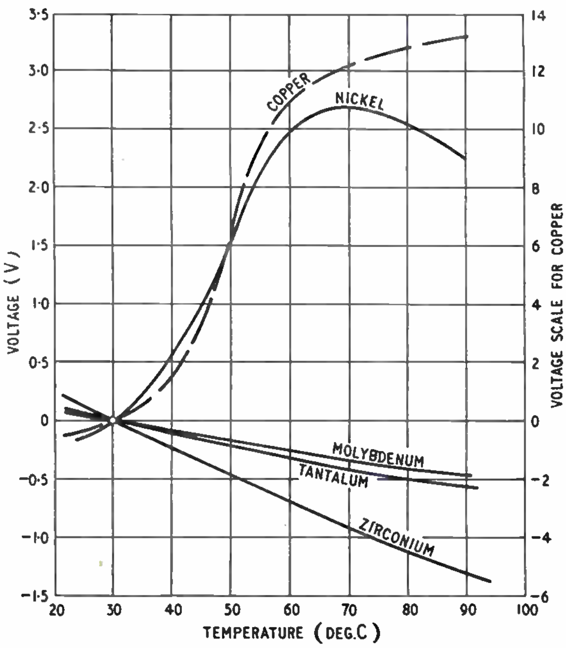


Fig. 4. *Voltage/temperature characteristics of experimental tubes having different cathode materials and neon/argon gas fillings.*

(3) *Tubes with Different Gas Fillings*

The previous tests indicated to what extent the running-voltage/temperature characteristic depends on the gas filling of the tube. It remained to show that a gradual change in the gas filling from pure neon to pure helium would produce a corresponding change in the running-voltage/temperature characteristic.

Measurements were made with two groups of tubes. Group A had cerium-alloy cathodes and gas fillings of 45 mm neon; 30 mm neon + 10 mm helium; 20 mm neon + 20 mm helium; 8 mm neon + 32 mm helium: 40 mm helium. To the pure neon 0·67% argon was added; in all other gas fillings the argon content was 2·5%. Group B had nickel cathodes and fillings of 40 mm neon; 30 mm neon + 10 mm helium;

20 mm neon + 20 mm helium; 10 mm neon + 30 mm helium; 40 mm helium. To each gas filling 0·5% argon was added.

Three to six tubes of each type have been tested and the mean results are represented in Fig. 6.

Tests made on Group A (cerium-alloy cathode) verified the above deductions. Fig. 6(a) shows that the negative temperature coefficient observed for this type decreases when the gas filling is changed from pure neon to helium. The variation of temperature coefficient is not, however, always gradual. There is a large decrease in the temperature coefficient when the gas is changed from pure neon to 30 mm neon + 10 mm helium. This may be due to the difference in argon content in the two gas fillings. For 20 mm neon + 20 mm helium, the temperature coefficient is similar though slightly greater than for 30 mm neon + 10 mm helium. A further increase in the helium percentage results in a positive temperature coefficient. (In this region the change becomes a gradual one.)

For group B (nickel cathode) the results obtained are not well defined. Fig. 6(b) suggests that the positive temperature coefficient which is observed for this group is smaller for a 50/50% neon/helium mixture than for either pure neon or pure helium. However, this may be due to the very large spread of results. The individual characteristics observed for the different types are actually overlapping.

(4) *Tubes with Different Gas Pressures*

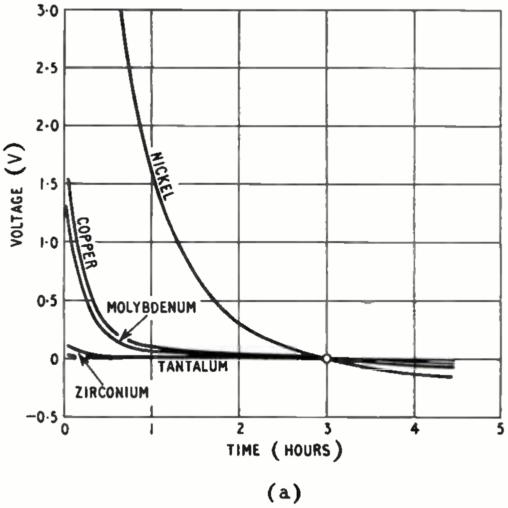
Tests to determine the influence of gas pressure on the temperature coefficient have been carried out as a result of reading an Australian patent[10]. This claims that a plot of temperature coefficient against gas pressure gives an S-shaped curve, which cuts the zero axis at a number of points. Furthermore the patent states that the temperature coefficient is proportional to the initial drift.

Measurements were made with tubes having cerium-alloy cathodes and 99·33/0·67% neon/argon gas fillings. Four tubes of each of the pressures 30, 35, 40, 45 and 50 mm of mercury were tested. This type seemed suitable because the observed running voltage/temperature characteristic is very nearly a straight line.

Previous measurements have already shown that, in general, tubes which exhibit a large change in running voltage with change of temperature have also large initial drifts of running voltage. However, it seems most unlikely that the initial drift may generally be taken as an absolute measure of the temperature coefficient. On a considerable number of tubes similar drifts but different running-voltage/temperature characteristics and vice versa have been observed.

Lower and upper limits of the temperature coefficients for different gas pressures are plotted in Fig. 7. The figure shows a considerable spread of results and it can be seen that, from a practical point of view, between 35 mm and 50 mm of mercury, the influence of gas pressure on the temperature coefficient is negligible.

Similar tests were made with tubes having a 97·8/2·2% helium/argon gas filling. The results show that the running-voltage/temperature characteristics obtained for different gas pressures are well within the limits of spread observed for tubes of the same type.



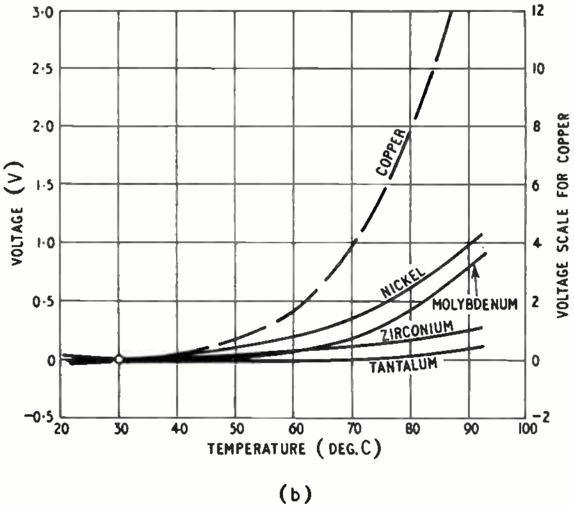


Fig. 5. *Voltage drift (a) and voltage/temperature characteristics (b) of experimental tubes having different cathode materials and helium/argon gas fillings.*

These tests thus do not substantiate the claims made in the Australian patent.

(5) *Tubes with Different Dimensions*

There seemed to be some doubts as to whether the construction of the tube influences its running-voltage/temperature characteristic. Therefore, a number of tubes having different dimensions but identical cathode materials and gas fillings, were tested. Four batches of tubes were obtained, each one having a cylindrical cathode made of cerium-alloy and the anode consisting of a wire at the axis.

Particulars about the approximate dimensions of the different batches are summarized in Table 1.

TABLE 1

Batch No.	Anode Dia. (mm)	Cathode Dia. (mm)	Cathode Length (mm)	Gas Volume (cm^3)
1	1·5	20	36	31·5
2	1·0	20	28·5	42
3	1·0	12·5	21·5	6·9
4	1·0	12·5	19·5	6·9

The gas filling consisted of a 97·8/2·2% helium/argon mixture at a pressure of 40 mm of mercury. All batches had gone through identical production processes.

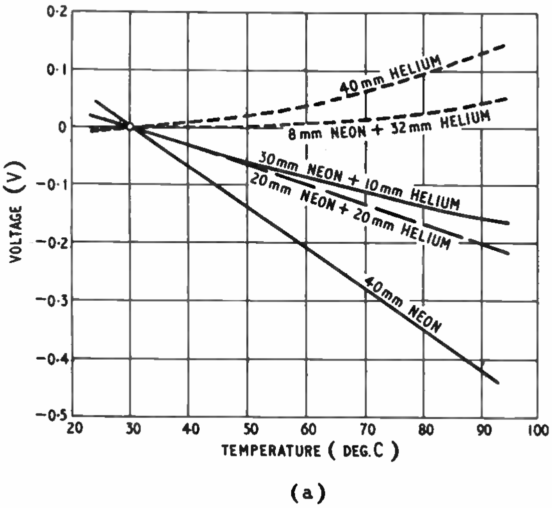
Fig. 8 shows the running-voltage/temperature characteristics obtained. Only one curve for each type of construction is represented. It will be seen that from a practical point of view the dimensions do not seem to affect the running-voltage/temperature characteristic of the tube.

Discussion of Results

Summarizing, it may be stated that the tests made with various batches of specially designed tubes show that:—

(a) The influence of gas pressure and tube dimensions on the temperature coefficient is negligible.

(b) The running-voltage/temperature characteristic depends on the cathode material and the gas filling of the tube.



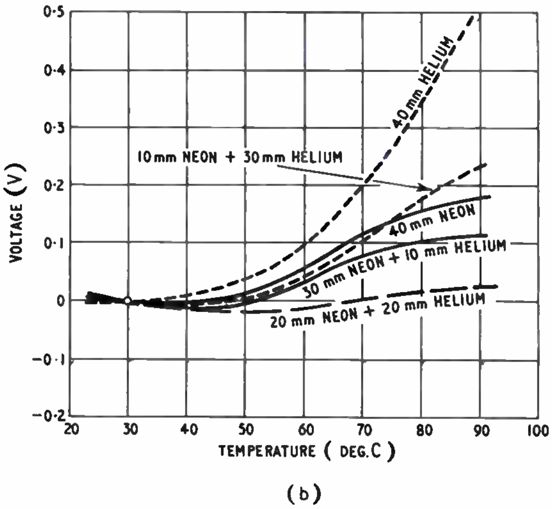


Fig. 6. *Voltage/temperature characteristics of cerium-alloy* (*a*) *and nickel* (*b*) *cathode tubes with different gas fillings.*

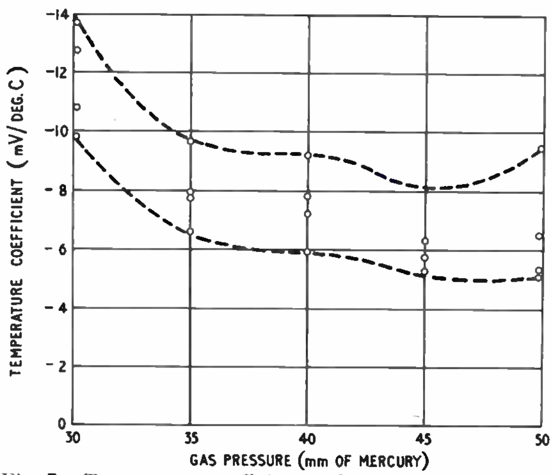


Fig. 7. *Temperature coefficient as function of gas pressure for cerium-alloy cathode tubes having neon/argon gas fillings.*

Positive temperature coefficients have been observed for tubes having copper, nickel, molybdenum, tantalum and zirconium cathodes and helium-gas fillings. Tubes with cerium-alloy, molybdenum, tantalum and zirconium cathodes and neon-gas fillings exhibited negative coefficients, while those with copper and nickel cathodes showed a steep rising running-voltage/temperature characteristic.

Jurriaanse[11] explained theoretically the variation of running voltage with temperature by considering the change in gas density produced by the temperature. He concluded that a negative coefficient should always be obtained and confirmed this by testing a nickel cathode tube with a 99·5/0·5% helium/argon gas filling.

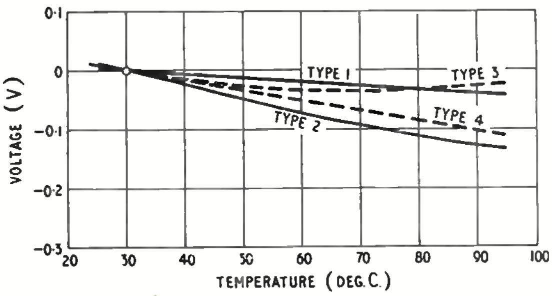


Fig. 8. *Voltage/temperature characteristics of tube types with different dimensions.*

Differences between this theory and the experimental running-voltage/temperature characteristics observed on various types of tubes have been ascribed[8, 9] to impurities and/or adsorbed gases. These impurities, released in these tests with rising temperature, produce changes in the gas mixture and in the cathode surface and may, therefore, influence the running voltage considerably.

According to this assumption, the spread of the obtained results is due to small and inevitable differences in the impurities. The similarity between voltage drifts and running-voltage/temperature characteristics can thus be explained, both being due to the same cause.

An interesting observation may be pointed out. A batch of standard stabilizers, with cerium-alloy cathodes and helium/argon gas fillings was tested. A small positive temperature coefficient was obtained. Later on, another batch of these stabilizers was produced. The tubes were exactly the same as those of the previous batch, except that they had undergone a slightly different production process. A very small negative temperature coefficient was observed for this batch.

Nevertheless, there are still some points which are not easily explained satisfactorily. Tests made on tubes with different gas fillings show clearly that the gas influences the temperature coefficient. In many cases positive temperature coefficients have been observed for helium while those for neon were negative. The effect of the gas filling was stated by Jurriaanse[11] to be due to different running-voltage/gas-density curves for neon and helium. However, as pointed out before, the temperature coefficient should be negative in both cases. Benson and Mayo[9] explained the positive temperature coefficients now observed for helium-gas fillings. Since, however, the percentage of impurities is small and similar in neon and helium gases as supplied to valve manufacturers, the completely different characteristics are difficult to explain. Moreover, the various running-voltage/temperature characteristics observed for different batches of tubes can only be ascribed to differences in the effect of the impurities on the different cathode materials. It seems difficult to believe that the extremely large differences observed in the running-voltage/temperature characteristics of, for instance, nickel- and tantalum-cathode tubes can be explained in this way.

It should be noted that the aim of the work described here was to obtain information about the effect, which is likely to be expected in practice, of ambient temperature changes on the running voltage of a glow-discharge stabilizer, having a given cathode material and gas filling. Generalization is, however, difficult because of the considerable spread of running-voltage/temperature characteristics even for nominally identical tubes.

Acknowledgments

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COMPATIBLE COLOUR-TELEVISION

Part 2—*Comparison of Two Sub-Carrier and N.T.S.C. Systems*

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(Concluded from p. 9, January issue)

SUMMARY.—In this part the two sub-carrier (t.s.c.) system, described in Part 1, is compared with the American N.T.S.C. system. Particular attention is paid to shortcomings of the transmission characteristics, signal-to-noise conditions, crosstalk, sub-carrier annoyance and receiver complexity.

HAVING described the two sub-carrier system in Part 1, it will now be compared with the American N.T.S.C. system, which employs only one sub-carrier.

The N.T.S.C. signal can be written as[21]

$$E_y + E_Q \sin(\omega t + 33°) + E_I \cos(\omega t + 33°)$$

where

$$\begin{aligned} E_y &= \alpha_0 E_G + \beta_0 E_R + \gamma_0 E_B \\ E_Q &= 0{\cdot}41\,(E_B - E_y) + 0{\cdot}48\,(E_R - E_y) \\ E_I &= -\,0{\cdot}27\,(E_B - E_y) + 0{\cdot}74\,(E_R - E_y) \end{aligned} \qquad \ldots \quad (1)$$

For rather low colour-difference frequencies the signal can be represented as

$$E_y + K_1\,(E_R - E_y)\cos\omega t + K_2\,(E_B - E_y)\sin\omega t \qquad \ldots \quad (2)$$

In the receiver the display signals are formed according to

$$\begin{aligned} &(E_R - E_y) + E_y \\ &(E_G - E_y) + E_y \\ &(E_B - E_y) + E_y \end{aligned} \qquad \ldots \quad (3)$$

where

$\alpha_0\,(E_G - E_y) = -\,\beta_0\,(E_R - E_y) - \gamma_0\,(E_B - E_y)$.

The video signal of the system using two sub-carriers (t.s.c. system) can be written as

$$E_y + x_1 E_R \cos\left(\omega_1 t \pm \frac{\pi}{4}\right) + x_2 E_B \cos\left(\omega_2 t \pm \frac{\pi}{2}\right) \qquad \ldots \quad (4)$$

The sub-carriers are supposed to be single-side-band modulated (Fig. 5) for this system produces the best signal-to-noise conditions for the colour signal transmission. (See paragraph: "Signal-to-noise conditions".)

In the receiver, the display signals are formed according to

$$\begin{aligned} &E_R + E_y' \\ &E_B + E_y' \\ &E_G + E_y' \end{aligned} \qquad \ldots \quad (5)$$

where $\alpha_0 E_G = E_y - \beta_0 E_R - \gamma_0 E_B$ and E_y' denotes the higher frequencies of the luminance signal (mixed highs).

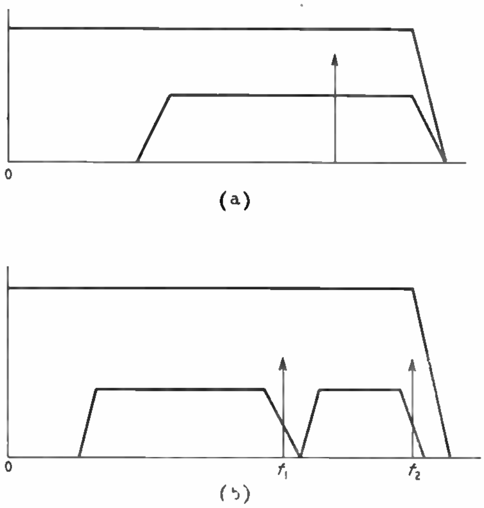

Fig. 5. *Video-frequency spectrum of N.T.S.C. signal (a) and of t.s.c. signal (b).*

Shortcomings in Luminance Signal Transmission

In the first place we want to discuss the influence of defects in the luminance signal transmission.

In the N.T.S.C. system distortion of the luminance signal will only give rise to a corresponding distortion of picture brightness; the colour hue will be unaffected.

This property can be verified as follows:—

If a distortion Δ is present in the luminance signal, the signal fed to the display will be

$$\begin{aligned} &(E_R - E_y) + E_y + \Delta \\ &(E_B - E_y) + E_y + \Delta \\ &(E_G - E_y) + E_y + \Delta \end{aligned} \qquad \ldots \quad (6)$$

Because signal components which are the same for all three display guns will deliver a white-light contribution the colour reproduced by (6) can be described as a superposition of the original colour and a white-light component Δ.

In the t.s.c. system, distortion of the luminance signal will affect the hue as well as the brightness in the colour picture (apart from distortion in the 'mixed highs' which, in principle, can have no influence on colour reproduction).

Introducing again a distortion Δ, the display signals in the t.s.c. receiver will be

$$E_R\, ;\ E_B\, ;\ E_G + \frac{1}{\alpha_0}\Delta \quad .. \quad .. \quad .. \quad (7)$$

So colour as well as brightness will be affected.

It may be asked how the colour signals have to be chosen in order to assure that the hue is not affected.

This can be found by introducing colour signals E_{C1} and E_{C2} of generalized form:

$$\begin{aligned} E_{C1} &= \alpha_1 E_G + \beta_1 E_R + \gamma_1 E_B \\ E_{C2} &= \alpha_2 E_G + \beta_2 E_R + \gamma_2 E_B \quad .. \quad (8) \end{aligned}$$

and determining the expressions for the display signals.

These expressions have to equal

$$\begin{aligned} & E_R + \Delta \\ & E_B + \Delta \\ & E_G + \Delta \quad .. \quad .. \quad .. \quad (9) \end{aligned}$$

It will be found that these conditions are satisfied if

$$\alpha_1 + \beta_1 + \gamma_1 = 0 = \alpha_2 + \beta_2 + \gamma_2 \quad .. \quad (10)$$

Consequently, the colour signals have to be

$$\left.\begin{aligned} E_{C1} &= \alpha_1 E_G + \beta_1 E_R - (\alpha_1 + \beta_1) E_B \\ E_{C2} &= \alpha_2 E_G + \beta_2 E_R - (\alpha_2 + \beta_2) E_B \end{aligned}\right\} \quad (11)$$

The colour signals of the two sub-carrier system being E_R and E_B and thus different from (11) may be altered but it is not possible to introduce colour signals like (11) because these signals may take negative values. If in $E_C \cos \omega t$ the signal E_C has a negative value the sub-carrier is overmodulated and it is impossible to recover the right signal E_C at the receiver by non-synchronous detection. Though a d.c. component might be added to E_{C1} and E_{C2} in order to prevent negative values, this is not an advisable proposition because the peak value of the sub-carrier in the video signal is increased and a rather large sub-carrier amplitude will be present in dark areas of the picture. On the other hand, freedom from hue distortion, due to luminance signal distortion, is not a very important matter. This is because a luminance signal distortion in the first megacycle of the video signal has itself a serious affect on picture quality and an additional colour error will not make the effect much worse.

Shortcomings of the Sub-Carrier Transmission

As a luminance signal is transmitted, in neither system does the picture brightness depend on the other two transmitted signals. (This principle is known as the 'constant luminance' principle.) Therefore, picture brightness is unaffected by distortion of the sub-carrier's transmission and only the hue and the saturation are altered[22, 23].

Variation of the Relative Sub-Carrier Amplitude

If the ratio between sub-carrier amplitude and the luminance signal level at the demodulators departs from the right value, the N.T.S.C. colour picture shows a fault in colour saturation whereas the colour hue remains correct. This property can be verified in the same way as is done for shortcomings in the luminance signal. In the t.s.c. system, however, a deviation of relative sub-carrier amplitude affects the hue as well as the saturation.

Shortcomings in the amplitude-frequency characteristic of the transmission path may cause the sub-carrier amplitude to be wrong and may occur due to misadjustment of the i.f. amplifier, mistuning or selective fading. As these faults may appear rather frequently, it seems advisable, especially in the t.s.c. system, to prevent a wrong relative sub-carrier amplitude by automatic gain control of the sub-carriers.

As already mentioned in Part 1 for this purpose reference signals, like the burst of the N.T.S.C. signal, can be introduced for the two sub-carriers. If there are two bursts occurring at different times (for example, alternating on successive lines), their amplitudes can possibly be as high as the peak values of the sub-carriers so that these values can easily be obtained by normal peak detection of the red and blue signal. The peak values of the sub-carriers derived in this manner can be compared with the peak value of the luminance signal (for instance, by measuring the sync pulse magnitude) which comparison controls the amplification of the colour channels.

Variation of the Relative Sub-Carrier Phase

In the N.T.S.C. system there may occur a phase error of the sub-carrier arriving at the demodulator with respect to the phase of the synchronized decoding signal. This error in relative sub-carrier phase will affect the hue in the colour picture. According to American publications a deviation of more than 15° seems to be intolerable[24].

In the t.s.c. system the sub-carrier phase is quite unimportant.

A deviation of the relative sub-carrier phase may occur due to

(1) 'differential phase', which means that the phase-frequency characteristic depends on the luminance signal level[25].

(2) sensitivity of decoding phase to burst amplitude variations which is present in many local sub-carrier oscillators.

In the latter case indirectly the sub-carrier phase, and so the hue, is affected by imperfections in the amplitude characteristic of the transmission path though in principle in the N.T.S.C.

system the hue is independent of sub-carrier amplitude.

Mutual Cross-Talk

Cross-talk between the three transmitted signals may occur due to faults in the transmission characteristics.

(a) In both systems the sub-carrier amplitudes will depend on the luminance signal level if the transmission path shows some non-linearity (differential gain). So a component proportional to $E_y \cdot E_c$ will then be present in the colour channels.

(b) In the N.T.S.C. system mutual cross-talk of the colour signals will occur if the amplitude characteristic is not flat and if the phase characteristic is curved[26].

In the t.s.c. system these distortions do not cause any cross-talk.

(c) In both systems, due to vestigial-sideband transmission of the r.f. vision carrier, the sub-carrier amplitude will depend on the luminance signal level and the latter on the sub-carrier amplitude. However, these imperfections turn out to be rather unimportant. Also, in the compatible picture of both systems, contrast deterioration is not noticeable[25].

(d) In both systems a beat may occur between the sound and vision carriers especially when the vision-carrier detector is non-linear. Experimentally, the t.s.c. system turns out to be somewhat less sensitive to this effect than the N.T.S.C. system[27].

Apart from these shortcomings in the signals, of course, imperfections in the amplitude and phase characteristic deteriorate the transient responses of these signals, just as they do in black and white television.

Lastly, we should mention that for both systems a variation in the overall phase characteristic affects the time coincidence of the luminance and colour signals[28].

Signal-to-Noise Conditions

In order to compare the two systems, the following situation is supposed to exist after the second detector in the receiver.

(1) The peak values of E_y, E_R, E_B and E_G are unity.

(2) In both the N.T.S.C. and t.s.c. receivers the two colour signals have the same bandwidth. In both receivers the bandwidths are f_c cycles per second.

(3) In the N.T.S.C. receiver the signals E_{R-y} and E_{B-y} are detected.

The noise added to the video signal has a uniform energy distribution over the whole band and the r.m.s. value is U_N per $2f_c$ cycles.

The signal-to-noise ratio after demodulation of a double-sideband modulated sub-carrier $E_R \cos \omega t$ whose colour signal E_R has a bandwidth f_c and a peak value E_{Cmax} will be

$$\frac{E_{Cmax}}{U_N}$$

If, however, the received sub-carrier is single-sideband modulated, the bandpass filter of the detector may be $(1 + \delta) f_c$ instead of $2f_c$. See Fig. 6.

Therefore, for equal peak values and modulation depths of the received sub-carriers the single-sideband modulation delivers a better signal-to-noise ratio, being

$$\frac{E_{Cmax}}{U_N} \frac{\sqrt{2}}{\sqrt{1+\delta}}$$

In the N.T.S.C. system, no single-sideband modulation of the sub-carrier can be applied, because mutual cross-talk of the recovered colour signals will occur if only one sideband is present.

If each colour signal is modulated on a separate sub-carrier, single-sideband modulation is possible. The noise component in the luminance signal is only considered for the band 0–f_c because above the frequency f_c the conditions in both systems are the same (only luminance information is transmitted). The r.m.s. value of this luminance noise component is $U_N/\sqrt{2}$.

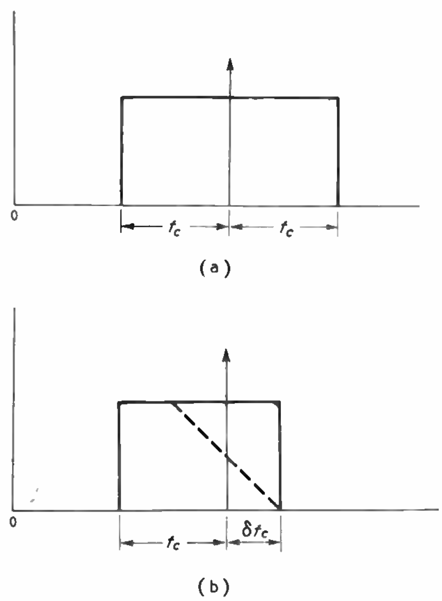

Fig. 6. *Bandpass filter in receiver for sub-carrier with double-sideband modulation (a) and single-sideband modulation (b).*

Denoting the noise components in the luminance signal and in the colour signals by N_y, N_{R-y},

N_{B-y}, N_R and N_B respectively, the three signals available in the N.T.S.C. receiver can be written as

$$E_y + N_y;\ K_1(E_R - E_y) + N_{R-y};$$
$$K_2(E_B - E_y) + N_{B-y}$$

and in the two sub-carrier system receiver as

$$E_y + N_y;\ x_1 E_R + N_R;\ x_2 E_B + N_B$$

The r.m.s. value of N_y is $U_N/\sqrt{2}$.

The r.m.s. values of N_{R-y} and N_{B-y} are both U_N, whereas for N_R and N_B this value equals

τU_N where $\tau = \sqrt{\dfrac{1+\delta}{2}}$

due to the single-sideband modulation in the two sub-carrier system.

In the N.T.S.C. receiver the output signals acting on the guns of the display unit are formed according to

$$(E_R - E_y) + E_y$$
$$(E_B - E_y) + E_y$$
$$(E_G - E_y) + E_y$$

The signal $E_G - E_y$ is obtained by matrixing:

$$\alpha_0(E_G - E_y) = -\beta_0(E_R - E_y) - \gamma_0(E_B - E_y)$$

So a noise component

$$-\frac{\beta_0}{\alpha_0 K_1} N_{R-y} - \frac{\gamma_0}{\alpha_0 K_2}(N_{B-y})$$

will be present in this signal.

The three signals fed to the display are:

$$(E_R - E_y) + E_y + N_y + \frac{1}{K_1} N_{R-y}$$
$$(E_B - E_y) + E_y + N_y + \frac{1}{K_2} N_{B-y}$$
$$(E_G - E_y) + E_y + N_y - \frac{\beta_0}{\alpha_0 K_1} N_{R-y} - \frac{\gamma_0}{\alpha_0 K_2} N_{B-y} \quad \ldots \quad (12)$$

In the two sub-carrier system the red and blue signals are delivered directly by the demodulators whereas the green signal is obtained by matrixing according to

$$\alpha_0 E_G = E_y - \beta_0 E_R - \gamma_0 E_B$$

It contains a noise component

$$N_y - \frac{\beta_0}{x_1} N_R - \frac{\gamma_0}{x_2} N_B$$

So the three signals fed to the display are (neglecting the mixed highs)

$$E_R + \frac{\tau}{x_1} N_R$$
$$E_B + \frac{\tau}{x_2} N_B$$
$$E_G + \frac{1}{\alpha_0} N_y - \frac{\beta_0 \tau}{x_1 \alpha_0} N_R - \frac{\gamma_0 \tau}{x_2 \alpha_0} N_B \quad \ldots \quad (13)$$

In order to compare the noise levels in both systems, the values of α_0, β_0, γ_0, K_1, K_2, x_1, x_2 and τ have to be known. α_0, β_0 and γ_0 are determined by the sensitivity of the human eye for the three primary colours. In the N.T.S.C. system these constants are

$$\alpha_0 = 0{\cdot}59 \qquad \beta_0 = 0{\cdot}3 \qquad \gamma_0 = 0{\cdot}11$$

K_1 and K_2 are also known from N.T.S.C. system specification and are

$$K_1 = \frac{1}{1{\cdot}14}, \quad K_2 = \frac{1}{1{\cdot}14 \times 1{\cdot}78}$$

The constants x_1 and x_2 will be chosen in such a way that, as well as the relative peak values of the combined sub-carriers, the ratios of the three noise contributions in the three channels are nearly equivalent in both systems.

In this way the values

$$x_1 = 0{\cdot}41, \qquad x_2 = 0{\cdot}23$$

are obtained.

The constant $\tau = \sqrt{\dfrac{1+\delta}{2}}$ is supposed to be $0{\cdot}8$ ($\delta = 0{\cdot}25$).

Substituting all these values in (12) and (13) gives the following r.m.s. values for the noise in the three colour channels at the receiver.

	N.T.S.C.	T.S.C.
green	$0{\cdot}99\ U_N$	$1{\cdot}65\ U_N$
red	$1{\cdot}34\ U_N$	$1{\cdot}96\ U_N$
blue	$2{\cdot}16\ U_N$	$3{\cdot}50\ U_N$

So in the two sub-carrier system the signal-to-noise ratio in all channels is somewhat lower than in the N.T.S.C. system.

However, this difference in signal-to-noise values is not equivalent to an equal decrease in signal-to-noise ratio in black-and-white television. The visual effect of the three noise components together depends on their combined action in the colour picture. For instance, it will make a great difference in picture appreciation if this concerted action leads to luminance fluctuations only or to fluctuations in hue only.

The result of the superposition of the three noise components is determined by their mutual correlation. If this correlation is different in two colour transmissions the noise figures cannot be compared directly.

In the N.T.S.C. system the correlation and its visual consequences can be easily understood.

The noise components are

$$\text{Red} \quad N_y + \frac{1}{K_1} N_{R-y}$$
$$\text{Blue} \quad N_y + \frac{1}{K_2} N_{B-y}$$
$$\text{Green} \quad N_y - \frac{\beta_0}{\alpha_0 K_1} N_{R-y} - \frac{\gamma_0}{\alpha_0 K_2} N_{B-y}.$$

The three noise contributions N_y give rise to fluctuations which do not affect the hue because equal signals in the three display channels represent a black-and-white picture. The other noise components give rise to fluctuations which do not affect the luminance due to the constant luminance principle. So the noise can be easily split into a 'luminance noise' and 'colour noise'.

In the t.s.c. system this discrimination is not so obvious, nevertheless, in this system also the noise can be split into a luminance and a colour part.

The noise components in the t.s.c. system are

Red $\frac{\tau}{x_1} N_R$

Blue $\frac{\tau}{x_2} N_B$

Green $\frac{1}{\alpha_0} N_y - \frac{\beta_0 \tau}{x_1 \alpha_0} N_R - \frac{\gamma_0 \tau}{x_2 \alpha_0} N_B$

Due to the constant luminance the components $\frac{\tau}{x_1} N_R$, $\frac{\tau}{x_2} N_B$ and $-\frac{\beta_0 \tau}{x_1 \alpha_0} N_R - \frac{\gamma_0 \tau}{x_2 \alpha_0} N_B$ together do not affect the luminance.

The remaining component $\frac{1}{\alpha_0} N_y$ in the green signal affects luminance as well as hue. However, we can add $N_y - N_y$ to the noise in the red and blue channels so writing the noise components as

Red $N_y + \frac{\tau}{x_1} N_R - N_y$

Blue $N_y + \frac{\tau}{x_2} N_B - N_y$

Green $N_y - \frac{\beta_0 \tau}{x_1 \alpha_0} N_R - \frac{\gamma_0 \tau}{x_2 \alpha_0} N_B + \left(1 - \frac{1}{\alpha_0}\right) N_y$

Now the components $-N_y$, $-N_y$ and

$$\left(1 - \frac{1}{\alpha_0}\right) N_y$$

represent a colour noise component as the luminance effect in red, blue and green is proportional to β_0, γ_0 and α_0 and therefore the combined luminance effect is

$$-\beta_0 N_y - \gamma_0 N_y + (\alpha_0 - 1) N_y = 0$$
$$(\alpha_0 + \beta_0 + \gamma_0 = 1)$$

In this way we can also in the t.s.c. system separate colour noise from luminance noise.

Again comparing both systems, we see that there is only a difference in colour noise. This will be clear because, due to the constant luminance principle, the luminance can only be affected by the luminance signal itself.

Based on the values of the coefficients given above the colour noise components are found to be

	N.T.S.C.	T.S.C.
Red	1·14	2·08 = 1·83 × 1·14
Blue	2·04	3·56 = 1·74 × 2·04
Green	0·7	1·25 = 1·84 × 0·7

So in the t.s.c. system the colour noise is about 1·8 times as much as in the N.T.S.C. system.

This difference in signal to colour noise conditions is due to the fact that in the N.T.S.C. system synchronized detection is used and therefore the sub-carrier can be transmitted with a minimum peak value. Moreover the amplitudes of the two sub-carriers $E_R \cos \omega_1 t$ and $E_B \cos \omega_2 t$ add linearly whereas the amplitudes of the components $(E_R - E_y) \cos \omega t$ and $(E_B - E_y) \sin \omega t$ add quadratically.

Up to this point the comparison of noise contributions has been based on the supposition that in both systems both colour signals have the same bandwidths. This is not quite correct, however, because in the N.T.S.C. system the I-signal bandwidth is about twice as large as the Q-signal bandwidth. However, if the unequal bandwidths are taken into account and a similar situation is supposed to exist in the t.s.c. system the ratio of noise contributions in both systems is almost the same as found above.

Of course, the effect of increased colour noise on picture quality depends on the relative importance of colour noise with respect to brightness noise. In an article called "A Subjective Study of Colour Synchronization Performance" by Burgett[29] some measurements are described which have been carried out in order to determine the sensitivity of colour picture-quality in the N.T.S.C. system for noise added to the synchronizing and information signals present in the receiver. It turned out that the ratio between the signal-to-noise ratios in luminance and colour channels, might be decreased two or three times (7 to 10 dB) before the annoyance value of brightness noise is equivalent to that produced by colour noise.

It follows from this that the visual-effect of the higher colour noise level in the two sub-carrier system certainly affects picture quality less than an equivalent increase of noise level in monochrome television.

We conclude therefore that the signal-to-noise ratio in the colour is worse in the t.s.c. system by a factor around 1·8 but that this disadvantage can be tolerated as it does not increase the signal-to-noise requirements in a transmission path above those needed for black-and-white transmission.

Apart from the random noise, there is the interference due to cross-talk between signal components, caused by incomplete separation of the three signal spectra. This interference has a visual effect similar to random noise because these components vary in phase and cancel out in successive lines, frames and pictures. (See Part 1.)

In the first place there is an interference in the colour signals caused by the luminance signal components present in the frequency range of the sub-carriers.

To some extent this interference has the same character as colour noise; it only affects picture colour. Similar calculations to those given for colour noise show that its relative value will be about 1·65 times as large in the two sub-carrier system as in the N.T.S.C. system. It is somewhat more for the lower sub-carrier, somewhat less for the higher sub-carrier because the luminance components decrease with increasing frequency. However, the visual effect of this interference is less important and usually hardly perceptible.

In the second place, in the t.s.c. system, mutual cross-talk can occur between colour signals if the separating bandpass filters do not cut off sharply enough and pass some sideband components of the undesired sub-carrier. Interference will occur in the picture details and picture contours, showing the pattern of Fig. 7. However, this interference is usually barely visible.

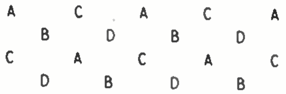

Fig. 7. *Pattern of mutual cross-talk of colour signals in t.s.c. system.*

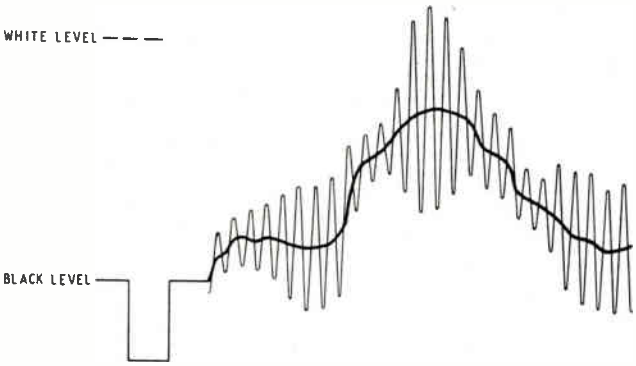

Fig. 8 (above). *"Overswing" of sub-carrier beyond the white and black levels.*

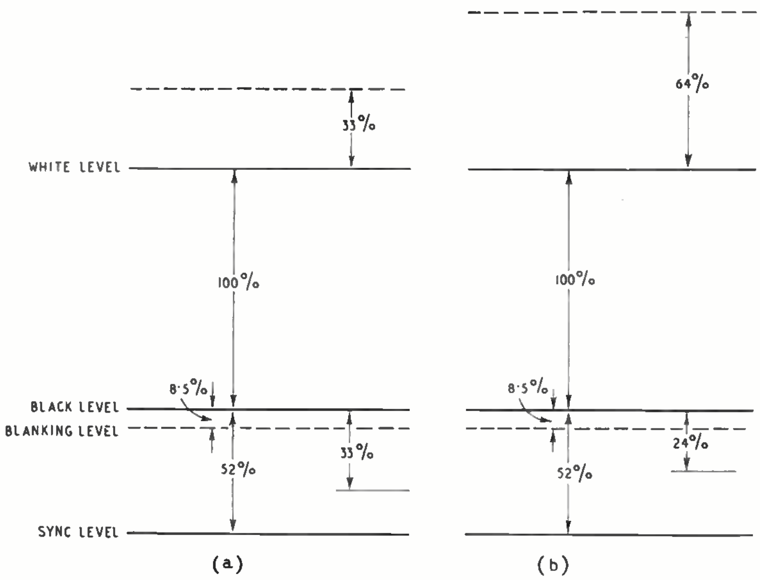

Fig. 9 (right). *Maximum "overswing" in N.T.S.C. system (a) and in t.s.c. system (b).*

Sub-Carrier Annoyance

We now wish to draw attention to the annoying effects caused by the presence of sub-carrier in the video signal of the colour-television transmission system.

As mentioned before, the video signal of the two sub-carrier system under discussion contains an amount of sub-carrier equivalent to that in the N.T.S.C. signal. The peak value of the combined sub-carriers is 64% of the luminance signal peak value.

However, this peak value will appear under circumstances which are very different in the two systems. In the N.T.S.C. signal, the sub-carrier amplitude is large if colour is highly saturated. The peak value is reached for primary colours. In the two sub-carrier system, large values of sub-carrier amplitudes occur if the red and blue components are large.

The annoying effects of the sub-carrier(s) in the video signal are of two kinds.

First, the sub-carrier may reach beyond the black and white levels of the luminance signal, as in Fig. 8. If sub-carrier is present in the sync area the line synchronization may be affected and the cancellation of the visual effect of the sub-carrier in black and white reception will be poor. If the sub-carrier reaches above white level the picture carrier may be over-modulated.

In the N.T.S.C. system the overswing beyond black level is 33% and happens if E_G has maximum value and E_B and E_R are zero. The overswing beyond white level is also 33% and happens if E_G is zero and E_B and E_R have maximum value. See Fig. 9.

In the two sub-carrier system, the maximum amount of overswing beyond black level is 24% if

E_G is zero and E_B and E_R have maximum values.

Beyond white level the overswing is 64% if E_G, E_B and E_R have maximum amplitude.

Secondly, the visual effect of sub-carrier in the picture of an existing black-and-white receiver has to be considered.

In order to have some information about this matter, experiments were carried out to determine the relation between viewing distance at which the sub-carrier becomes imperceptible and relative sub-carrier amplitude.

Naturally, these measurements are rather subjective and show large spread. However, it was possible to ascertain that:

(1) the viewing distance at which a sub-carrier is just invisible is practically independent of picture brightness, if the relative sub-carrier amplitude is maintained constant.

(2) the curve representing the increase of critical distance with increasing relative sub-carrier amplitude shows the form indicated in Fig. 10.

(3) if the N.T.S.C. sub-carrier has a frequency equal to the lower sub-carrier frequency of the t.s.c. system there is only a slight difference between the perceptibility of the single N.T.S.C. sub-carrier and the combination of two sub-carriers. The pattern of the N.T.S.C. sub-carrier appears to be finer than the combination pattern of the two sub-carriers, but the effect of this on visibility is more or less cancelled by the more striking stroboscopic effects in the N.T.S.C. pattern.

Of course, these experimental results give only a small amount of information for comparing the two systems. The annoyance to the observer depends on the mean sub-carrier amount during the transmission, which depends on the mean value of hue, saturation and brightness. In the N.T.S.C. system, unsaturated colours give rise to a low sub-carrier level. In the two sub-carrier system, sub-carrier amplitude is small for colours with large green and small red and blue light components.

In our opinion rather extensive experiments are needed to determine the superiority of one system over the other in this respect.

Colour Receiver Circuitry

Another aspect which needs discussion is the construction of the colour receiver.

It will be plain that, whereas the r.f., i.f. and colour-display circuitry of both systems will show only slight differences in principle, the video circuit of the two sub-carrier system will be much simpler than that of the N.T.S.C. system. Though it is rather difficult to give to this quality a figure of merit we can get an impression by considering the number of valve functions which have to be added to the normal black-and-white receiver[30].

In the N.T.S.C. system the following valve functions are needed:

Separation of sub-carrier from video signal	1
Demodulation of sub-carrier	2
Video amplification	3
Burst gating and amplification	1
Sub-carrier oscillator	1
Sub-carrier frequency control	1
Sub-carrier amplification	1
Total	10

In the two sub-carrier system:

Separation of sub-carriers from video signal	1
Double detection (only applied to the lower sub-carrier)	1
Video amplification	3
Total	5

The detection of the sub-carriers is obtained by simple germanium diodes.

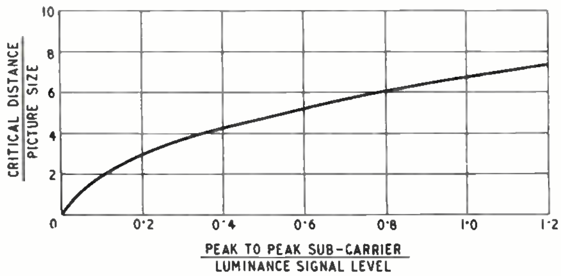

Fig. 10. *Visibility of sub-carrier versus relative sub-carrier amplitude.*

It will be noted that the valve functions mentioned for the two sub-carrier system are all of simple and conventional type. The N.T.S.C. system, however, involves rather complicated valve functions unknown in normal receiver technique; such as, synchronized detection, sub-carrier oscillator and sub-carrier frequency control.

For both systems, only the most essential valve functions have been mentioned. At this point it should be noted that in principle the N.T.S.C. receiver circuitry, without any modification or addition, is suitable for black-and-white reception whereas the two sub-carrier system receiver will reproduce the black-and-white transmission as a green picture if no special measures are taken. However, due to the disturbing effect of luminance signal components passing through the colour channels it seems to be desirable to provide a N.T.S.C. receiver with a so-called 'colour killer', cutting off the colour channels if no sub-carrier is present. So the difference between the two receivers for black-and-white reception is of minor importance because, after all, special circuitry has to be added in both receivers in order to assure good compatibility with black-and-white transmission.

The regular functioning and the sensitivity to misadjustment are also important properties of the colour receiver.

The two sub-carrier receiver will be rather sensitive to mistuning if no automatic gain control is applied, because the relative sub-carrier amplitude will be wrong.

As mentioned before, in principle a wrong sub-carrier amplitude transmission in the N.T.S.C. system only affects colour saturation, but the hue can also be disturbed if phase of decoding depends on burst-amplitude.

On the other hand, the N.T.S.C. transmission is more sensitive to phase errors in the frequency characteristic of the transmission channel. Further, a third synchronization is needed with a rather critical phase adjustment in the synchronized detection.

Finally, it must be mentioned that the two sub-carrier system may be locked to the mains whereas the N.T.S.C. system has to be free running because the sub-carrier frequency must be constant within about 0·005%.

The comparison of the various aspects of the colour transmission systems is summarized in Table 1.

It is not the intention of the authors to draw any conclusion about the choice of system from this comparison. It can give only a provisional idea about the merits of the systems until extensive comparative experiments have been carried out. Several properties of a practical system are not fully known, so that during experiments certain aspects of colour transmission not mentioned here may turn out to be very important to the choice of the system.

TABLE 1

	N.T.S.C.	T.S.C.
Colour-picture:		
Colour reproduction	=	=
signal-to-noise: luminance noise	=	=
signal-to-noise: colour noise	1	1·80
Monochrome picture:		
sub-carrier annoyance: critical distance	=	=
sub-carrier annoyance: pattern	stroboscopic effects	more coarse
mean sub-carrier amplitude	?	?
Transmission:		
luminance signal wrong	luminance wrong	luminance, hue } wrong
sub-carrier amplitude wrong	constant luminance saturation wrong	constant luminance hue wrong
sub-carrier phase wrong	hue wrong	—
wrong phase or amplitude characteristic	cross-talk	no cross-talk
overswing	white: 33% black: 33%	white: 64% black: 24%
Locked to the mains	not possible	possible
Receiver; extra number of valve functions	10 rather complicated circuitry	5 simple circuitry

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ARRIVAL ANGLE OF H.F. WAVES

Improved Method of Measuring Waves Reflected from the Ionosphere

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(Official communication from D.S.I.R. Radio Research Station, Slough)

SUMMARY.—Apparatus is described for measuring the angle of elevation of h.f. waves arriving at the ground after transmission by way of the ionosphere. The system involves the comparison of the amplitudes of the signals received by two vertically-spaced horizontal loop aerials at heights above the ground of about 33 metres and 12·5 metres. The comparison is effected by amplifying the signal e.m.fs in a twin-channel receiver and applying the i.f. voltages to the deflecting plates of a cathode-ray oscilloscope. It is shown that, if a single ray is incident on the system, the e.m.fs produced in the two aerials are in phase irrespective of their height above ground, so that the corresponding oscilloscope pattern is a straight line, the slope of which is a simple function of the angle of elevation of the ray.

Calibrations of the system over the band 10–20 Mc/s have shown that its behaviour is very close to that expected from the simple theory and that there is no noteworthy change in the calibration with azimuth.

Methods of observation for the general case of the arriving signal consisting of more than one ray are considered.

1. Introduction

In an earlier paper[1] one of the present authors described a method of measuring the angle of elevation at the ground of h.f. signals received after reflection from the ionosphere. This method had been developed with the object of providing data to facilitate the design of aerial arrays for reception of transatlantic telephone signals and, for this purpose, it proved very satisfactory.

It recently became necessary to set up equipment for measuring angles of elevation in connection with the general study of the characteristics of h.f. signals received from long distances; there has also been a revival of interest by the radio engineer in the angles of elevation on certain important radio circuits.

Because of the necessity in both these requirements of making measurements on signals arriving from stations situated in different parts of the world, it was not considered satisfactory to use the method described in reference 1, which involved the measurement of the phase difference of the e.m.fs produced by the signals in two parallel, fixed, horizontal aerials spaced horizontally at equal heights above the ground. This method is most accurate for waves arriving from directions normal to each aerial but the accuracy falls to zero at right angles to these directions.

In order to overcome this weakness, attempts were made to use a similar system in which portable vertical loop aerials, set up at ground level, were substituted for the fixed horizontal aerials previously used. This system was found, however, to suffer severely from site errors presumably caused by re-radiation from trees and other local objects and it was, moreover, found to be a lengthy undertaking to set up the loops and line-up aerial with the necessary accuracy in new positions.

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Other methods were therefore considered and, of these, the only ones which appeared to be able to satisfy the requirements were those depending on the comparison of the signal e.m.fs produced in two aerials whose vertical radiation patterns are different. Such methods have been reported by Friis, Feldman and Sharpless[2] and by Kusunose and Namba[3].

One of the systems described in reference 2 consisted of two horizontal dipoles situated at heights above the ground of one-quarter wavelength and one wavelength respectively and connected separately to receivers, the outputs from which operated pen-writing recorders. At the beginning of an observation the two aerials were placed at the same height above ground level and the readings of the recorders equalized. The angle of elevation of the downcoming waves was subsequently determined from the ratio of the recorder deflections obtained when the aerials were at their operating heights.

In the method of Kusunose and Namba, two horizontal aerials at heights $(h + d)$ and $(h - d)$ are connected in parallel and the amplitude (E_1) of the resultant signal e.m.f. is compared with that (E_2) generated in a single horizontal aerial at height h. Assuming that there is no mutual coupling between the aerials and that both aerials are matched into equal load impedances, the ratio (R_A) of the e.m.fs produced by the two aerials is given by:—

$$R_A = \frac{\sqrt{2}\,E_1}{E_2} = \sqrt{2}\cos\left(\frac{2\pi d}{\lambda}\sin\alpha\right)$$

where λ = wavelength and α = angle of elevation.

Similarly the ratio (R_B) of the e.m.fs E_3 and E_4 generated in two single horizontal aerials at heights $2d$ and d respectively is given by:—

$$R_B = \frac{E_3}{E_4} = 2 \cos\left(\frac{2\pi d}{\lambda} \sin \alpha\right)$$

Since $\frac{dR_B}{d\alpha} = \sqrt{2}\,\frac{dR_A}{d\alpha}$, the Japanese system described is the less sensitive to changes in α. To obtain the same sensitivity for both systems, it would be necessary to increase the spacing of the two-element array used by Kusunose and Namba. Since this would entail using a higher mast, the simpler method of merely comparing the e.m.fs on single aerials appears to be preferable.

Kusunose and Namba compared the sum and difference of the two e.m.fs instead of comparing them directly. This makes the system much more sensitive to changes in angle of elevation; however, this advantage is a real one only if it is possible to guarantee a corresponding increase in the precision of the line-up procedure and in the stability of the receivers, particularly in the sum-and-difference unit. On balance, the additional complication of the sum-and-difference technique did not appear to be fully justified for the present application and it was decided simply to compare the two voltages directly.

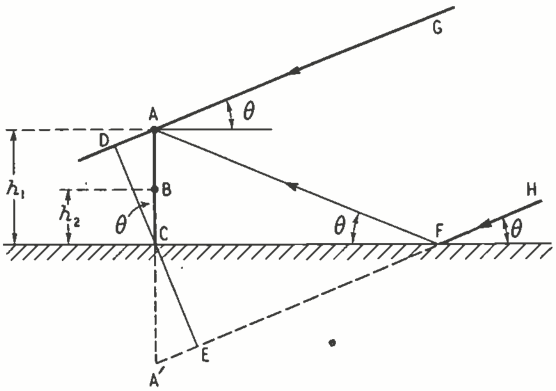


Fig. 1. *Illustrating principle of angle of elevation measuring system.*

In 1936 one of the present authors suggested the use of the method involving the comparison of the e.m.fs produced in two horizontal aerials at different heights above the ground as a means of determining the angle of elevation of aircraft by radar. It was pointed out that an important feature of such a system when the upper aerial is vertically above the lower is that the aerial e.m.fs are in phase for signals at any angle of elevation provided the ground surrounding the system can be regarded as of perfect conductivity and is flat over a sufficiently large area. Such a property is of practical value as it permits the e.m.f. comparison to be made either by goniometer or by using twin-channel receiver technique with cathode-ray oscilloscope display. Radar elevation-measuring systems using goniometer comparison were developed by the authors and used on a large scale during the late war and have been described by Ratcliffe[4]. The height of the masts (73 metres) used in one of those radar systems was such that angles of elevation on suitable sites could be measured down to 1·5° to 2° on a working frequency of about 22 Mc/s and to 0·75° on 50 Mc/s.

Although it was impracticable to construct a system with comparable characteristics for the present purpose on acccunt of mast-height limitations, the calculated performance of a system employing 30-metre masts for measurement on frequencies of about 15 Mc/s upwards was promising enough to warrant its construction.

2. Theory of the System

In Fig. 1, A represents a horizontal aerial at height h_1 above ground. It will be assumed that the source of the radiation arriving at the aerial is so far away that the incident rays may be considered to be parallel. Two rays will arrive at A, namely, the direct ray GA at angle of elevation θ, and a ray reflected at the ground, HFA. If HF be continued to A′ and DCE be drawn at right angles to GD and FA′ then AD = A′E = $h_1 \sin \theta$. This is equivalent to a phase change of $\frac{2\pi h_1 \sin \theta}{\lambda}$ which would represent the phase angle by which the direct ray would lead and the reflected ray lag on the phase of a ray arriving at C assuming no phase change on reflection at the ground.

If it may be assumed that the ground is of high conductivity, the reflection coefficient for horizontally-polarized radiation will be substantially unity and the phase change at reflection will be about 180° for the range of θ with which we are concerned (up to 30° and for frequencies of about 10–30 Mc/s). If, therefore, the electric field of the direct ray at C be represented by $e = E \sin \omega t$, the field at A will be

$$e_A = E \sin\left(\omega t + \frac{2\pi h_1 \sin \theta}{\lambda}\right) + E \sin\left(\omega t - \frac{2\pi h_1 \sin \theta}{\lambda} - \pi\right)$$

$$= 2E \sin\left(\frac{2\pi h_1 \sin \theta}{\lambda}\right) \cos \omega t$$

Similarly for another aerial, B, at height h_2

$$e_B = 2E \sin\left(\frac{2\pi h_2 \sin \theta}{\lambda}\right) \cos \omega t$$

Thus, as already pointed out, the phase of the resultant field is independent of the height of the aerial.

3. Description of the Practical System

In view of the requirement for efficient working on signals arriving from any azimuth, it was considered desirable to use horizontal loops rather than dipoles as the signal pick-up elements. Mechanical difficulties would have been experienced in rotating dipoles into the direction normal to the plane of incidence to give maximum pick-up and to eliminate pick-up from vertically-polarized components of the field.

As pointed out by Ross[5] and elaborated by Horner[6], a loop aerial whose perimeter is not small compared with the operating wavelength, and which therefore carries a non-uniform current, may be regarded as consisting of a uniform-current loop or a magnetic dipole, and an electric dipole. In the present case it was decided to support the loop aerials on a guyed, timber lattice mast the cross-section of which limited the dimensions of the loops used to 1 metre square. For such loops Horner shows that the moment of the magnetic dipole is only about 40% greater than that of the electric dipole and that the electric dipole is parallel to the side of the loop containing the terminals.

In the general case of an angle of elevation system consisting of two such square loops one above the other, the horizontal electric field in the downcoming wave will produce in-phase e.m.fs in them of differing amplitudes. The electric field in the plane of incidence will, however, produce e.m.fs in the electric dipoles which differ in both amplitude and in phase from those produced in the magnetic dipole by the horizontal field unless the electric dipole is normal to the plane of incidence, in which case they will receive no signal. Such effects would be likely to affect the accuracy of the measurements except at the smallest angles of elevation where the component of 'vertical' field along the electric dipole would be small. To overcome this difficulty it was arranged to rotate the loops about a vertical axis so as to orientate the electric dipole in a direction normal to the plane of propagation of the signal to be measured and thus to eliminate the pick-up due to components of field other than the horizontal electric field.

The aerial system consists of two horizontal, single turn, screened loops at heights above ground of 32·6 metres and 12·6 metres respectively. Each loop is capable of rotation about a vertical axis and is driven by an electric motor controlled from the ground; the orientation of the loop is indicated to the operator by means of electrical repeating devices.

Each loop is connected separately to the receiving equipment by twin lead-sheathed transmission lines of equal length; these lines, the cables supplying power to the motors, and the wiring from the repeating apparatus are strapped together and run vertically downwards through the centre of the loops to obviate the induction of unwanted e.m.fs into the loops by currents on the various cables.

The e.m.fs of the two loops are amplified separately in superheterodyne receivers with a common beat oscillator; the characteristics of the receivers can be made identical stage by stage. If, then, equal co-phasal e.m.fs are generated in the loops which, with their associated transmission lines, are identical, the receiver i.f. outputs will also be equal and co-phasal. Consequently if the orthogonal deflecting plates of a cathode-ray oscilloscope are connected to the i.f. output terminals of the receivers, a straight line at 45° to the axes of deflection will be produced. In the case of a single ray incident on the aerial system, the pattern on the oscilloscope will be a straight line the inclination of which is a function of the angle of elevation of the incident ray.

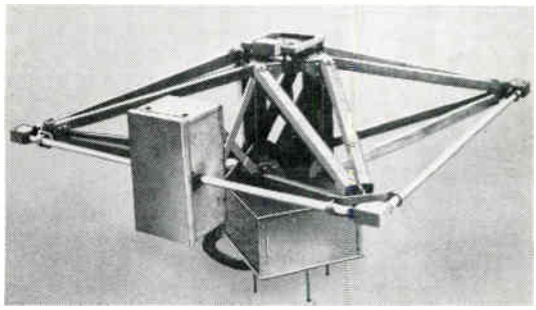


Fig. 2. *View of receiving and lining-up loops above turning-motor housing.*

To check the equality of characteristics of the receiving-loop–transmission-line systems and receivers, small line-up aerials are installed above each receiving loop. These consist of single-turn, screened loops each 10 cm square and they are arranged with their planes parallel to and 10 cm above those of their associated receiving loops (Fig. 2). The two loops are supplied with current at the signal frequency by a coaxial transmission-line system arranged as shown in Fig. 3; the current flowing in each loop is measured by means of a thermocouple and microvoltmeter. Great care was taken in the construction of those parts of the lining-up arrangements above and below the feed point X in Fig. 3 because the equality of characteristics of these two parts is relied upon to obtain co-phasal currents in the two line-up loops. In operation a current at the signal frequency is applied at X and the currents in each line-up loop measured. If the currents are equal, as has been found in practice to be the case, the receivers are adjusted to give a straight line at 45° to the deflection axes of the oscilloscope. Should the currents be unequal, due to some slight dissimilarity in the two line-up systems, the equipment would be lined up to give a line deflection at the inclination appropriate to the measured loop currents.

Resistances of 72 Ω are inserted in the coaxial line near X to reduce circulating currents in the line-up loops and coaxial line and thus to minimize coupling between the receiving loops by way of the lining-up circuit. This coupling has been found to be quite negligible as is also the coupling between one line-up loop and the remote receiving loop.

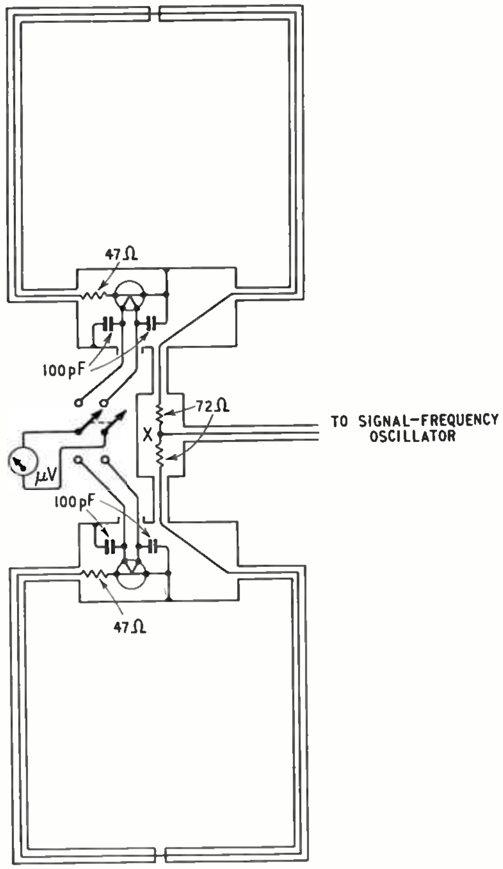


Fig. 3. *Schematic diagram of line-up loop arrangements.*

4. Tests and Calibration of the System

For testing the efficacy of the scheme for eliminating pick-up on the electric dipoles from vertically-polarized electric-field components in the incident signal a vertical transmitting aerial was set up at a distance of about 100 metres from the mast carrying the whole system and was energized at a number of frequencies in the h.f. band in turn. There should be no signal pick-up on the magnetic dipole but the electric dipole will receive a signal except when it is in a position normal to the plane of propagation. Tests showed that such conditions obtained, provided that the planes of the receiving loops were accurately horizontal and that there was no spurious radiation from local wires and other metallic objects. It is worthy of note that the mast was originally guyed with steel cable broken by insulators into 4-metre lengths and that, with that arrangement, it was impossible to obtain a good minimum on rotating loops while receiving signals from the vertical transmitting aerial. Reductions of the guy sections to 2 metres eliminated the majority of the spurious radiation and deep minima were then obtainable.

The system was calibrated by means of signals radiated from a balloon-supported transmitter feeding a horizontal dipole and capable of operation at a maximum height of 200 metres. Because of this height limitation and the desire to calibrate up to at least 20° angle of elevation, the balloon had to be operated at a distance from the aerial

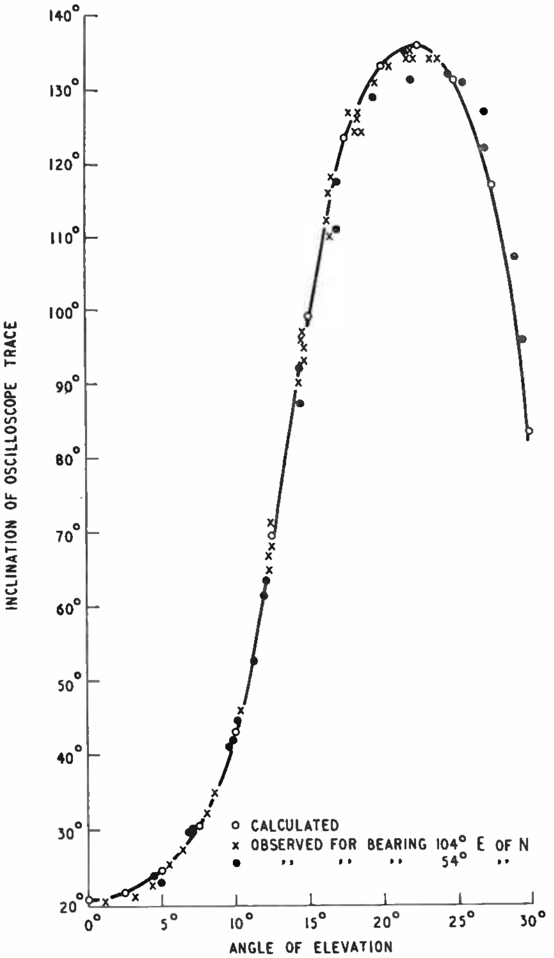


Fig. 4. *Calibration curve of angle of elevation system for* 18·40 *Mc/s.*

system of about 500 metres. In these circumstances the rays incident on the system are not parallel, as assumed in the theory, and this gives rise to a very small difference between the calculated fields at a given height for the two cases. The resultant fields at each aerial will also not be in quadrature with the field at C in Fig. 1. Calculations for the range of frequencies of interest show that, for angles of elevation up to 20°, the difference between the calculated inclination of the line on the oscilloscope for the parallel-ray case and the inclination of the major axis of the thin ellipse calculated for the conditions of calibration is about 1° maximum for angles of elevation of 10°–20° and a fraction of a degree for angles of elevation less than 5°. These differences are not likely to lead to any notable error in measuring angles of elevation in the range 5° to 20°.

Figs. 4 and 5 show calibrations of the system on two frequencies, each for two azimuths, and the calibration calculated on parallel-ray theory. It will be noted that the correspondence between observation and calculation is very close over the whole range of angle of elevation covered and that there is no substantial difference in the calibrations for the two azimuths.

Calibrations made over a frequency band of about 10 Mc/s to 20 Mc/s and over a wide range of azimuths show results as satisfactory as those of Figs. 4 and 5.

It was concluded from these results that the system could be used with a single calculated calibration curve for any given frequency for any azimuth and for elevation angles up to about 20°. There appears to be no reason why the theoretical calibration should not be extended for use at larger angles.

The agreement between the calculated and observed calibrations is partly due to the nature of the site which is of high conductivity clay and is substantially flat in all directions for at least 400 m. Although there are some large trees in several directions, the nearest is about 200 m distant from the aerials. A wire fence 1 m in height which runs close to the aerials has not given rise to any difficulties.

The electrical and mechanical stability of the system has been found to be of a high order; recent calibrations made on a number of frequencies have been found to agree very closely with those made on the same frequencies about eighteen months earlier.

A disadvantage of the system as described is the possibility of ambiguity in its indications. Thus, the calculated calibration curve of the present system for 18·40 Mc/s (see Fig. 4) shows that a signal giving a line pattern on the oscilloscope at, say, 100° could be incident at an angle of elevation of 15·1° or 29°. This ambiguity could be resolved by the addition of a third loop below the lower one in the present installation; measurements would be made in turn on the present pair of loops and on the lower pair and the angle common to the two measurements taken as the true value. This method of resolving ambiguity was used successfully in the radar installations referred to in Section 2. For the experiments for which the present system was designed it was expected from previous experience that the angles obtaining would not exceed 20° for frequencies above about 15 Mc/s, but for general use it is recommended that the third loop should be installed.

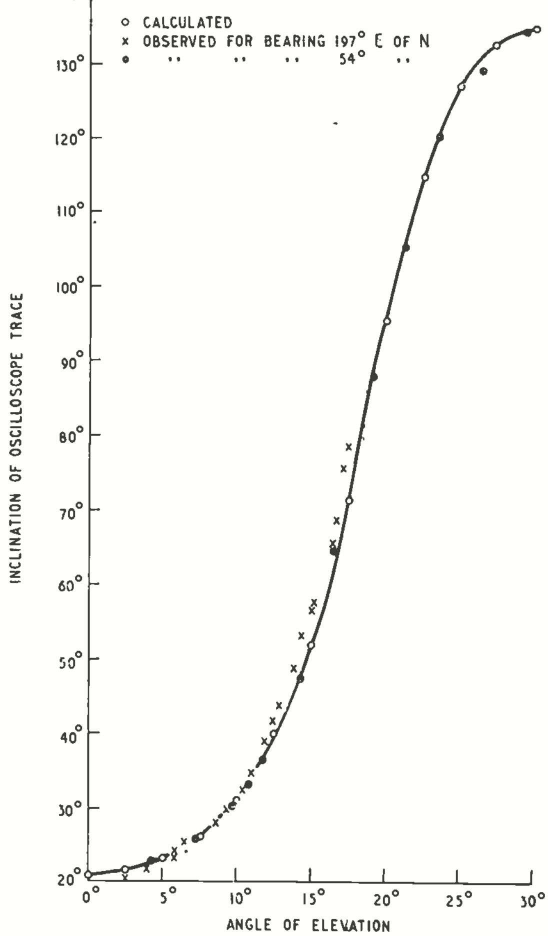


Fig. 5. *Calibration curve of angle of elevation system for 13·75 Mc/s.*

5. Method of Operation of the Equipment

After lining up the apparatus in the manner indicated, it is ready for operation on the signal to be measured. In order to facilitate the measurement of the inclination of the signal trace, the oscilloscope screen is provided with a circular protractor the centre of which corresponds to the

C

origin of the deflecting axes. A rotatable disk on which a radial line is drawn is mounted in front of the screen with its centre over the centre of the protractor.

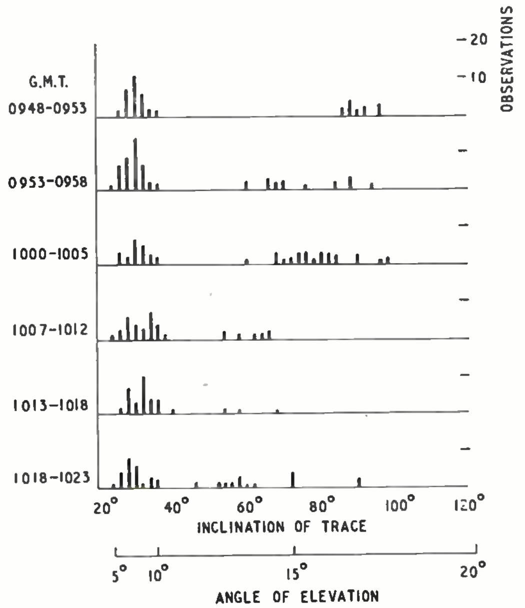


Fig. 6. *Observations of angle of elevation of* 16·245-*Mc/s signals from Colombo on* 12*th December* 1952.

In general, signals consist, not of a single ray as considered in Section 3, but of several rays which have travelled by different paths between transmitter and receiver. It is because of this fact that pulse transmission is much to be preferred in that the oscilloscope display then usually consists of a number of straight line deflections at inclinations to the oscilloscope axes corresponding to the angles of elevation of the individual rays. The measurement is not, in fact, greatly handicapped by interference effects between the various rays constituting the total signal but it may sometimes be found that such interference between two or more echoes overlapping in time of arrival cause the pattern to include ellipse forms of varying eccentricity and inclination. In such cases it is usually possible to observe the fading of the individual echoes and to read the inclination when one of them predominates in amplitude.

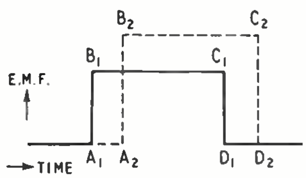
When telephone and telegraph signals are observed, the oscilloscope pattern will almost always consist of an ellipse of varying eccentricity and inclination. The method adopted in dealing with such cases is to read the inclination of the straight line or thin ellipse which often forms and lasts for a few seconds when the fading signal reaches its peak amplitude. This condition is assumed to correspond to the momentary preponderance in amplitude of one of the modes of propagation comprising the signal; readings are not taken if the straight line or thin-ellipse condition only lasts for a fraction of a second as such a condition might merely indicate a passage through the in-phase condition of two or more e.m.fs of random phase relationship.

It has been found convenient to take as many readings as possible during consecutive intervals of five minutes of the inclination of the straight-line traces in the case of pulse reception, or of the line or thin-ellipse traces at signal maximum with telephone and telegraph reception. The results are then plotted in the form of a histogram and an example of measurements taken in this way is shown in Fig. 6 for the case of reception at Slough of telegraph signals from Colombo on a frequency of 16·245 Mc/s. It may be concluded from this example that rays were present at an angle of elevation of about 8° (the most prominent group) and at various angles between 13° and 18°.

The justification for the observing procedure adopted for c.w. transmissions is apparent if pulse and c.w. transmissions from the same station can be observed alternately. Provided the pulse-echo pattern displays only a few components of comparable amplitude, it is found that their angles of elevation correspond closely to those measured on the c.w. signal in the manner described. If there are many echoes of similar amplitude the probability of one echo predominating for a period long enough to give a steady straight line or thin ellipse is remote and in such conditions reliable measurements would be impossible.

A more direct justification is provided by the following phenomenon. It has frequently been observed during the reception of high-speed telegraph signals that, in addition to the normal bright ellipse, the oscilloscope pattern includes a number of faint straight lines or thin ellipses, the largest of which are comparable in amplitude to the axes of the bright ellipse. The bright pattern corresponds to the resultant of all the rays composing the signal, while the fainter patterns

Fig. 7. *Illustrating the reception of a morse dot by two different paths.*



correspond either to the individual rays or to interference effects between two or more rays. The explanation of the phenomenon is probably as follows. In Fig. 7, $A_1 B_1 C_1 D_1$ represents, in idealized form, the e.m.f. applied to the receiver by a single morse dot which has arrived after reflection by the ionosphere. $A_2 B_2 C_2 D_2$ represents the same dot on arrival by way of a slightly longer trajectory. During the interval $A_1 A_2$ an e.m.f. $A_1 B_1$ will be applied to the receiver and, as this is produced by a single incident ray, the oscilloscope pattern will be a straight line of low brilliance because of the shortness of the interval $A_1 A_2$. During the longer interval $A_2 D_1$ the oscilloscope will display a much brighter pattern corresponding to the interference effects of e.m.fs $A_2 B_2$ and $A_1 B_1$. In the brief interval $D_1 D_2$ a pulse corresponding to the later-arriving component will be seen as a straight line at a different inclination from that produced in the interval $A_1 A_2$. When there are three or more different trajectories and corresponding components in the received signal, similar arguments lead to the conclusion that the first and last components to arrive will be displayed as straight lines and that ellipses of low brilliance will also be present corresponding to the short periods at the beginnings and ends of the dots and dashes when fewer than the maximum number of components are present. The phenomenon is very useful in that it helps to elucidate the mode of propagation of some of the components of the signal, and facilitates the measurements of their angles of elevation. It may readily be seen from a study of the variations of the pattern on the oscilloscope how the behaviour of the bright ellipse is related to the strength of the less brilliant 'pulse' deflections and, in particular, how the bright pattern develops into a straight line overlaying the corresponding pulse deflection when the other echoes decrease to a relatively low amplitude.

Acknowledgments

The assistance is acknowledged of Messrs. F. Kift and C. Medhurst in the development of the system and of Messrs. A. G. Wilson and R. A. J. Savage, B.E.M., in the design and construction of the equipment.

The work was carried out as part of the programme of the Radio Research Board and this paper is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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[5] W. Ross, "The Development and Study of a Practical Spaced-Loop Direction Finder for High Frequencies", *J. Instn elect. Engrs*, Part III, 1947, Vol. 94, p. 99.

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CORRESPONDENCE

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

High-Stability Oscillators

SIR,—Referring to my letter, published in the September 1955 issue of *Wireless Engineer*, I wish to correct an error which has crept into the formulae, and which arose when changing the notation used in my original paper* to that given in my letter. In the formula for the series-resonance circuit the expression $R_o{}^2\omega^2C_aC_g$ should read $R_a{}^2\omega^2C_aC_g$ and consequently the factor C_o/C disappears in the simplified formula. This means that the formula for a series-resonance oscillator becomes similar to that for an ordinary Colpitts oscillator, and therefore the conclusion contained in the four last lines of my paper is not correct.

What I say concerning better reduction of the grid voltage harmonics by a series-resonance circuit, is, generally speaking, right; in case of small amplitudes, however, the influence of these harmonics is negligible in comparison with that of harmonics caused by the non-linearity of the anode-current characteristic for fundamental grid excitation. In conclusion, one must concede that actually the value of Q and not of the ratio L_o/C_o has the decisive influence on the frequency stability of both types of oscillators with respect to the non-linear effects, this being in agreement with Commander Bernard's statement.

JANUSZ GROSZKOWSKI

Radio Institute,
Warsaw Technical University.

7th October, 1955.

*J. Groszkowski, "Frequency Stability of *LC* Oscillators with Large Grid and Anode Capacitances". *Bull. Acad. Polon. Sci.*, 1955, *Vol. 3, No. 3.*

SIR,—Since both Mr. Gouriet and Mr. Clapp* have conceded that the theoretical development, with which I took issue, was incorrect I was surprised to see the letters of Dr. Groszkowski and Mr. Reid published in *Wireless Engineer* for September 1955.

It is true that the percentage of the anode harmonic voltage which will be impressed upon the grid of a series-tuned oscillator will be less than in the case of a Colpitts, but the amount of harmonic voltage developed at the anode of a Colpitts oscillator for a given harmonic anode current will be correspondingly less, so that the net voltage at the grid for the same anode current will be the same in either case. Dr. Groszkowski made an error in assuming that the harmonic voltages at the anode could be the same. It is customary practice to operate the oscillator valve into an impedance much lower than its anode impedance at the operating frequency. At a harmonic of the oscillator frequency this circuit impedance from anode to cathode would be much lower so that the valve anode can accurately be described as a constant-current generator.

W. B. BERNARD

U.S. Navy Electronics Laboratory,
San Diego,
California, U.S.A.

10th October 1955.

[In its original form this letter contained a mathematical appendix but, in view of the general agreement that appears to have been reached, it has been omitted. Ed.]

Proc. Inst. Radio Engrs, July and August 1955.

SIR,—By a coincidence W. B. Bernard and I wrote on the same day, respectively to *Wireless Engineer* and to *Proc. Inst. Radio Engineers*, pointing out that in the circuits discussed by Gouriet and Clapp, the frequency change due to a phase change of the fundamental anode current should be independent of the L/C ratio. On this particular point Clapp has gracefully admitted that he followed the error of Gouriet, so here there is general agreement.

However, Bernard's correspondence with Clapp in *Proc. Inst. Radio Engineers* of August 1955 seems to me less helpful because of the uncertainties both of terminology and of the assumptions made.

Bernard's new letter (10th October 1955) to *Wireless Engineer* deals with the effect of harmonic currents in the resonator system which is a different and more difficult subject and one I am now able to discuss.

The letter from Professor Groszkowski (*Wireless Engineer*, September 1955) also deals with harmonic currents in the resonator system and, as he has for many years been somewhat of an authority on this subject, I shall read his promised paper with interest.

I must confess, however, that I am now much less interested in harmonic effects because close adherence to Class A operation is not difficult, and because instabilities due to electrode capacitances, cathode-interface impedances, and electrode transit times, are predominant.

The letter of D. G. Reid (*Wireless Engineer*, September 1955) suggests that stability is a function of the L/C ratio, not in the presence of any harmonic effects but in the presence of an electrode capacitance instability. The argument put forward is surely valid only if constant loop resistance be assumed rather than constant Q value.

For resonators of equal excellence (Q), R will be proportional to L, and to maintain oscillations with a larger R we must either decrease C_2 or increase g_m. If the former alternative be adopted the effect of the unstable C_g will be independent of the L/C ratio, and if the latter plan be used we will obtain much the same result because in practice we cannot increase g_m without increasing the instability of C_m.

NORMAN LEA

Research Division,
Marconi's Wireless Telegraph Co. Ltd.,
Chelmsford.
24th October 1955.

Equivalent Equalizer Circuits

SIR,—In his paper in *Wireless Engineer*, December 1955, p. 323, Mr. Rowlands describes a parallel-path equalizer circuit and shows that, for any setting of the variable tappings, it is possible to find a tandem connection of simple constant-resistance equalizers which gives an identical transmission characteristic.

Unfortunately, both the title and the method of treatment may lead the reader to suppose that the converse is also true, namely, that given a tandem connection of simple constant-resistance equalizers one could duplicate its performance by choosing suitably the time constants and tappings in Mr. Rowlands' circuit.

The reason why this is not so is as follows. The natural modes of the tandem-connected equalizer are restricted only in that they must lie in the left half of the complex p-plane. The natural modes of Mr. Rowlands' circuit, on the other hand, being the negative reciprocals of the time constants, must all lie on the negative real axis in the p-plane. If, therefore, the tandem-connected equalizer has any complex natural modes, as it may well do if it contains any resonant sections, there is no possibility whatsoever of providing these with Mr. Rowlands' circuit.

The point can be seen more specifically by examining that part of the Table, given in the paper, which deals with 2nd-order networks. Here, S_1 and S_2, the natural modes of the equivalent parallel-path circuit are given explicitly in terms of the parameters of the constant-resistance resonant equalizer. If these latter are such that $(\omega_0 L) < 2(R + r)$ then the values required for S_1 and S_2 are complex and hence unrealizable.

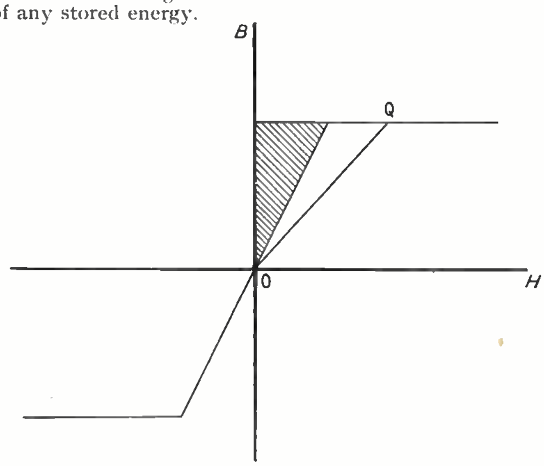
H. J. ORCHARD

Post Office Research Station,
London, N.W.2.
6th January 1956.

Saturable-Reactor Frequency Divider

SIR,—In reading the interesting note by Court and Scollay on the "Saturable-Reactor Frequency Divider" (*Wireless Engineer*, Dec. 1955) I was surprised by the two statements on p. 329 that ". . . at point P . . . the value of inductance falls from L_u to L_s . . ." and " . . . the inductance . . . has a store of energy, and when L_u is replaced by L_s, this energy will be dissipated . . ."

Inductance, like permeability, needs special definition when the magnetic circuit is non-linear and, in the absence of any definition by the authors, I can only consider three obvious possibilities. The first is incremental inductance, corresponding to incremental permeability, and this does fall sharply at saturation, but it is irrelevant to the total stored energy of the core. The second is the mean inductance, or ratio of total flux linkages to total magnetizing current; this is represented graphically by the slope of the line OQ in the diagram, which joins the origin to any point in question, and does *not* fall rapidly as Q moves into the saturation region. The third is an 'energy inductance' L_e obtained by equating the total core energy to $\frac{1}{2}L_e i^2$. Now the core energy per unit volume is $\int HdB$ which, for the point Q, is represented by the shaded area in the diagram: this makes it clear that taking the core into the saturation region does not involve the elimination of any stored energy.



Perhaps the operation of the circuit could be somewhat as follows. If the core of L saturates before C is discharged to zero potential, the remainder of the discharge of C will be controlled by r alone, since with B constant in the saturated core there can be no e.m.f. in the coil. This results in (a) a pulse of output voltage across r and (b) an increased dissipation in r which means that on the return swing the coil will not be able to re-charge the capacitor to the potential it would have attained had L remained unsaturated throughout the cycle. Therefore the amplitude of the next cycle will not be sufficient to saturate L. The number of cycles to the next output pulse should then depend partly on R, through which the resonant circuit must acquire energy from the source in order to rebuild its amplitude of oscillation to the saturation level.

D. A. BELL

Birmingham.
12th January 1956.

NEW BOOKS

Vacuum Valves in Pulse Technique

By P. A. Neeteson. Philips' Technical Library. Pp. 170 + viii. Cleaver Hume Press Ltd., 51 Wright's Lane, London, W.8. Price 27s.

The title of this book is a little misleading, for it carries with it an implication that the book might be about the special characteristics of valves for pulse generation; e.g., high peak current but low mean current ratings, magnetrons, klystrons and the like. The book does not deal at all with these things, however; it deals with ways of analysing the *RC* circuits used in pulse generation and exemplifies them by detailed analyses of multivibrators.

The early chapters all deal with the calculation of the response of *RC* circuits under various conditions of switching. The use of the valve as a switch is then briefly discussed. Chapter 5 is on operational calculus and is followed by nearly 50 pages on fundamental treatment of electron tubes as switching elements. The treatment is thorough and covers the effects of grid current.

In the rest of the book bistable, monostable and astable multivibrators are analysed in detail.

The treatment throughout is highly mathematical in the sense that there is hardly a page which does not bear at least one equation and there are many which are nearly full of them. The level of mathematics is not at all a difficult one, however, there being little beyond second-order differential equations or their equivalent.

This use of mathematics and, in particular, the wide-spread references by symbols, makes the book difficult reading.

It is a book more for study than for reference, for one cannot readily follow the argument until one has got the meaning of the more important symbols firmly into one's head. There is no summary of conclusions and the designer of a multivibrator can hardly hope to use the book as a short cut. He must study it in detail in order to extract design information from it.

W. T. C.

Proceedings of the Symposium on Printed Circuits

Pp. 122. Engineering Publishers, G.P.O. Box 1151, New York 1, N.Y., U.S.A. Price $5.

F.M. Explained

By E. A. W. Spreadbury, M.Brit.I.R.E. Pp. 37. Trader Publishing Co. Ltd., Dorset House, Stamford Street, London, S.E.1.

A Study of the Double Modulated F.M. Radar

By Mahomed Abd-El Wahab Ismail. Mitteilungen aus dem Institut für Hochfrequenztechnik, No. 21. Pp. 112. Verlag Leeman, Arbenzstrasse 20, Postfach Zürich 34, Switzerland. Fr. 10.40.

Television Principles and Practice (2nd Edition)

By F. J. Camm. Pp. 215. George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Price 25s.

The Mobile Manual for Radio Amateurs

Pp. 313. American Radio Relay League, West Hartford, Connecticut, U.S.A. Price $3.

B.B.C. Handbook 1956

Pp. 287. The British Broadcasting Corporation, 35 Marylebone High Street, London, W.1. Price 5s.

Radio Operating Questions and Answers (12th Edition)

J. L. Hornung and A. A. McKenzie. Pp. 571 + xii. McGraw-Hill Publishing Co. Ltd., 95 Farringdon Street, London, E.C.4. Price 34s.

Instruments for Measurement and Control

By Werner G. Holzbock. Pp. 371 + vi. Chapman & Hall Ltd., Essex Street, London, W.C.2. Price 80s.

This is an American book which is descriptive in its first half of instruments for measuring temperature, humidity, moisture, pressure, flow, liquid level, density, viscosity and speed. The second half of the book deals with methods of control under the influence of the initial measurement. The methods described are mainly non-electrical

Fixed Resistors

By G. W. A. Dummer, M.B.E., M.I.E.E. Pp. 187 + xi. Sir Isaac Pitman & Sons Ltd., Parker Street, Kingsway, London, W.C.2. Price 28s.

This book, which is Vol. 1 of a series dealing with radio and electronic components, deals chiefly with wire-wound, general purpose, and high-stability fixed resistors. It describes their constructional form and explains their characteristics. Methods of measurement are also described.

Static and Dynamic Electron Optics

By P. A. Sturrock, Ph.D. Pp. 240 + x. Cambridge University Press, 200 Euston Road, London, N.W.1. Price 30s.

Part 1 covers static electron optics in five chapters, headed:—The variational equation, Classical geometrical optics, Instrumental electron optics, The rotationally symmetrical system and Systems of minor symmetry. Part 2, in two chapters, deals with uniform and periodic focusing of particle acceleration. The treatment is mathematical.

INDEX TO ABSTRACTS AND REFERENCES

The annual indexes to Abstracts and References appearing in *Wireless Engineer* for the years 1946–1953 inclusive have been reprinted under one cover by the Institute of Radio Engineers. Copies can be obtained from the Institute of Radio Engineers, 1 East 79th Street, New York 21, N.Y., U.S.A., at the price of $2.25 in U.S.A. and Canada and $2.35 elsewhere. Special rates of $1.65 in U.S.A. and Canada and $1.75 elsewhere are available to colleges, public libraries and subscription agencies.

NEW YEAR HONOURS

In the New Year Honours List, Air Commodore W. E. G. Mann (Director-General of navigational services, Ministry of Transport and Civil Aviation) and W. J. Richards (Director of the Radar Research Establishment) have been appointed Companions of the Order of the Bath.

Captain Charles F. Booth (Assistant Engineer-in-Chief, G.P.O.) has been promoted to Commander of the Order of the British Empire.

C. W. Oatley (Fellow of Trinity College, Cambridge) becomes an O.B.E. and A. Bowen (B.T-H. electronics engineering dept.), R. G. Hodges (Senior experimental officer, Radar Research Establishment), D. C. Rogers (Standard Telephones & Cables) become Members of the Order of the British Empire.

"WIRELESS ENGINEER" BINDING

Binding cases for *Wireless Engineer* can be supplied at 7s. 6d. (postage 6d.). The cost of binding is 22s. 6d. (postage 1s. 6d.) per volume including binding case.

EXHIBITIONS

6th–8th March. Television Society's Exhibition. At the Royal Hotel, Woburn Place, London, W.C.1. The first day is reserved for members; admission on the other days is by ticket obtainable from the Television Society, 164 Shaftesbury Avenue, London, W.C.2.

10th–12th April. R.E.C.M.F. Exhibition. At Grosvenor House, London, W.1. There will be a preview on the afternoon of 9th April for overseas and other specially invited guests. Application for admission has to be made in advance to the Radio and Electronic Component Manufacturers' Federation, 21 Tothill Street, London, S.W.1.

13th–15th April. London Audio Fair. At the Washington Hotel, Curzon Street, London, W.1. Admission by invitation card, obtainable from radio dealers or from London Audio Fair, 17 Stratton Street, London, W.1.

23rd April–4th May. British Industries Fair (Electrical Section). At Olympia, London, W.14. Open to the public in the afternoon.

25th and 26th April. Public Address Show (Association of Public Address Engineers). At Conway Hall, Red Lion Square, Holborn, London, W.C.1. Open to the public each afternoon.

9th–19th May. Mechanical Handling Exhibition. At Earls Court, London, S.W.5. Open to the public.

14th–17th May. Physical Society's Exhibition. At Royal Horticultural Hall, Westminster, London, S.W.1. Application for tickets should be made to the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

26th and 27th May. B.S.R.A. Exhibition. At the Waldorf Hotel, Aldwych, London, W.C.2. Application for tickets should be made to the British Sound Recording Association, 295 Regent's Park Road, London, N.3.

12th–18th July. Institution of Electronics Exhibition. At the College of Technology, Manchester. Applications for tickets should be made to W. Birtwistle, 78 Shaw Road, Thornham, Rochdale.

22nd August–1st September. National Radio and Television Exhibition. At Earls Court, London, S.W.5. There will be a preview on 21st August for overseas and other specially invited guests. Open to the public daily, except Sunday.

3rd–10th September. Farnborough Air Show (Society of British Aircraft Constructors). At Farnborough, Hants. Open to the public.

MEETINGS

I.E.E.

8th February. "Pulse Techniques with particular reference to Line and Radio Communication", by E. M. Deloraine, Dr.Ing.

20th February. "Ultrasonics in Industry", talk with films and demonstrations by C. F. Brockelsby.

1st March. Discussion on "Recruitment to the Engineering Profession" and the film "The Inquiring Mind".

These meetings will commence at 5.30 at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2.

Brit.I.R.E.

29th February. "Technique of Microwave Measurements", discussion to be opened by E. M. Wareham at 6.30 at the London School of Hygiene & Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.

The Television Society

21st February. "Some Problems in a Band-Sharing Colour Television System", by A. V. Lord, B.Sc.

28th February "Development of 21″ Colour Television Receiver" by H. A. Fairhurst.

These meetings will be held at 7 o'clock at the Institute of Education, Malet Street, London, W.C.1. Admission 2s. 6d. for non-members.

Society of Instrument Technology

9th February. "The Scope for Feedback Control and Automatic Calculation in Industrial Mechanization", by Professor A. Tustin, M.Sc., at 6 o'clock at Manson House, 26 Portland Place, London, W.1.

British Kinematograph Society

8th February. "Practical Acoustics and Cinema Auditoria", by J. Carson.

15th February. "Synchronous Sound Recording using the Syncropulse Process", by N. Leevers, B.Sc., A.C.G.I.

These meetings will be held at the Borough of Holborn Town Hall, High Holborn, London, W.C.1, and will commence at 7.15.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Values for December 1955

Date 1955 December	Frequency deviation from nominal: parts in 10^8	
	MSF 60 kc/s 1429-1530 G.M.T.	Droitwich 200 kc/s 1030 G.M.T.
1	−0·2	+2
2	−0·2	+2
3	NM	+2
4	−0·2	+1
5	−0·2	+2
6	−0·2	+3
7	−0·2	+3
8	−0·2	+3
9	−0·2	+3
10	−0·2	+4
11	−0·2	+2
12	−0·2	+3
13	−0·2	+4
14	−0·2	+4
15	−0·2	+5
16	−0·2	−3
17	−0·2	−2
18	−0·2	−2
19	−0·2	−2
20	−0·2	−2
21	−0·2	−3
22	−0·1	−2
23	−0·2	−3
24	NM	NM
25	NM	NM
26	NM	NM
27	NM	−2
28	−0·1	−2
29	−0·1	−1
30	−0·1	−1
31	−0·1	−2

The values are based on astronomical data available on 1st January 1956.

N.M. = Not Measured.

ABSTRACTS and REFERENCES

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research and published by arrangement with that Department.

The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. U.D.C. numbers marked with a dagger (†) must be regarded as provisional. The abbreviations of journal titles conform generally with the style of the World List of Scientific Periodicals. An Author and Subject Index to the abstracts is published annually; it includes a selected list of journals abstracted, the abbreviations of their titles and their publishers' addresses.

ACOUSTICS AND AUDIO FREQUENCIES

534 : 061.3(47) **305**

Conference on Physical Acoustics and Ultrasonics, Moscow, 3rd-7th March 1955.—(*Akust. Zh.*, April–June 1955, Vol. 1, No. 2, pp. 182–190.) Abstracts are given of over 40 papers presented at the conference. See also *Uspekhi fiz. Nauk*, July 1955, Vol. 56, No. 3, pp. 445–456 (Tartakovski).

534.1 **306**

Emission of Sound by the Vibrating Sides of an Arbitrary Wedge.—G. D. Malyuzhinets. (*Akust. Zh.*, April–June & July–Sept. 1955, Vol. 1, Nos. 2 & 3, pp. 144–164 & 226–234.) An exact solution is obtained for the sound-pressure field inside the wedge, using Sommerfeld's integral. Analysis is presented first assuming the whole of each side to vibrate with the same velocity, and next taking account of nonuniform velocity distribution along the sides. The connection is shown between the given problem and that of diffraction by a rigid wedge. The effects of the edge on the radiated power are considered.

534.2-13 : 551.596.1 **307**

Propagation of Sound in Turbulent Atmosphere.—G. Skeib. (*Z. Met.*, Aug. 1955, Vol. 9, No. 8, pp. 225–234.) Measurements were made over paths of lengths 50–150 m at frequencies from 100 c/s to 4 kc/s. From the results, the order of magnitude of the damping due to the turbulence can be determined as a function of frequency and wind velocity, and conclusions can be drawn regarding the structure of the turbulence.

534.2-14 **308**

Investigation of the Sound Shadow in a Medium with a Vertical Gradient of Sound Velocity.—A. N. Barkhatov. (*Akust. Zh.*, April–June 1955, Vol. 1, No. 2, pp. 121–125.) An experimental investigation is reported of the propagation of sound in water with a vertical temperature gradient. Results are presented graphically.

534.2-14 **309**

Diffraction of Sound at a Thin Bounded Plate in a Liquid.—L. M. Lyamshev. (*Akust. Zh.*, April–June 1955, Vol. 1, No. 2, pp. 138–143.) A calculation is made of the scattering of sound by a thin plate fixed in an infinite rigid screen immersed in a liquid, taking account of the vibrations set up in the plate.

534.232-8 : 537.228.2 **310**

Electrostriction in Liquids and the Generation of Ultrasonics by an Electrostrictive Method.—H. Goetz. (*Z. Phys.*, 20th July 1955, Vol. 141, No. 3, pp. 277–293.)

534.61-8 : 534.522.1 **311**

Useful Ultrasonic Output of a Quartz Radiator in various Liquids [determined] by an Optical Method.—S. Parthasarathy, M. Pancholy & C. B. Tipnis. (*Z. Phys.*, 27th Aug. 1955, Vol. 142, No. 1, pp. 14–20.)

534.7 : 621.39 **312**

The Relation between Quantitative Transmission Quality and Transmission Characteristic to the Japanese Language.—T. Miura. (*Rep. elect. Commun. Lab. Japan*, July 1955, Vol. 3, No. 7, pp. 14–24.) Articulation tests were made on women's speech transmitted by microphone to a measuring system. Consideration of the results indicates that a different method of calculating the score is required from that used for other languages.

534.7 : 621.395.813 **313**

Tonal Method of Determining the Intelligibility of Speech Transmitted by Communication Paths.—A. D. Tkachenko. (*Akust. Zh.*, April–June 1955, Vol. 1, No. 2. pp. 171–180.) The method described is based on the analysis of results of intelligibility tests in each of twenty frequency bands which together cover the a.f. range from 117 c/s to 10 kc/s. The theory is given and an example of the practical determination of intelligibility is described in some detail. The results obtained by this method were found to be in close agreement with those obtained by the more laborious 'articulation-index' test method.

534.86 : 621.3.018.783 **314**

Nonlinear Distortion of Nonperiodic Signal in an Electroacoustic Path.—A. V. Rimski-Korsakov. (*Akust. Zh.*, April–June 1955, Vol. 1, No. 2, pp. 165–170.) The nonlinear response characteristic is approximated by an exponential polynomial. Expressions are then obtained for the spectral density of the 2nd- and 3rd-order distortion and for the 2nd- to 5th-order distortion of input signals with rectangular or bell-shaped spectral characteristics respectively.

534.874.1 : 621.395.623.7 **315**

Directional Properties of Sound-Dispersive Lenses.—L. N. Bondareva & M. I. Karnovski. (*Akust. Zh.*, April–June 1955, Vol. 1, No. 2, pp. 126–133.) The angular distribution of sound pressure is calculated for plano-ellipsoidal and plano-hyperboloidal acoustic lenses for several values of the refractive index, aperture angle and distance from the virtual focus. The calculated curves are compared with experimental results. Such lenses are useful for improving the directional characteristics of loudspeakers.

621.395.623.743 **316**

The Electrostatic Loudspeaker.—L. J. Bobb & E. C. Gulick. (*Audio*, Sept. 1955, Vol. 39, No. 9, pp. 22–24.) A semicylindrical e.s. loudspeaker for the upper register of a high-fidelity commercial reproducer uses a light-weight polyester 0·0005 in. thick for the diaphragm.

621.395.623.8 **317**

Stereophonic Sound System covers Hollywood Bowl.—O. Berliner. (*Audio*, Aug. 1955, Vol. 39, No. 8, pp. 14–16, 52.) Description of a large open-air sound-reinforcement system.

621.395.625.3 : 621.317.4 **318**

Absolute Measurements in Magnetic Recording.—E. D. Daniel & P. E. Axon. (*B.B.C. Engng Div. Monographs*, Sept. 1955, No. 2, pp. 1–9.) Measurement of the absolute magnitude of the surface induction of the tape is discussed in relation to the standardization of recorded level. Consideration is given to the possibility of measuring the absolute sensitivity of the various parts of the recording-reproducing chain, with a view to formulating an unequivocal representation of tape sensitivity.

AERIALS AND TRANSMISSION LINES

621.315.212.011.21 **319**

The Choice of Impedance for Coaxial Radio-Frequency Cables.—W. T. Blackband. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 804–814.) Cable design is considered in relation to attenuation per unit length, voltage rating and power ratings based on thermal and voltage limitations. A method is presented for determining the optimum proportioning to satisfy a specification of two or more cable properties. The criterion of a specified attenuation with minimum diameter is satisfactory for practical purposes. The best value of characteristic impedance is 75 Ω for low-loss air-spaced cables and 50 Ω for general-purpose thermoplastic cables. See also 2299 of 1954 (Gutzmann).

621.372 **320**

The Launching of a Plane Surface Wave.—G. J. Rich. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 824–825.) Discussion on 1548 of 1955.

621.372.029.6 **321**

Microwave High-Speed Continuous Phase Shifter.—W. Sichak & D. J. Levine. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1661–1663.) A phase shifter is described comprising two helices, wound in the same sense, inside a circular waveguide, one of the helices being rotated at a desired rate. A model designed for operation at 9·4 Mc/s is $5\frac{1}{2}$ in. long and 1 in. in diameter, excluding the motor drive, and rotates at 3 600 r.p.m.

621.372.2 **322**

Reflection in Helical Lines at a Change in the Helix Pitch: Part 1—Calculation Results and their Physical Significance.—G. Piefke. (*Arch. elekt. Übertragung*, Aug. 1955, Vol. 9, No. 8, pp. 369–374.) An investigation relevant to the design of travelling-wave valves with band-pass characteristics. Analysis taking account of higher modes is simplified by assuming the pitch in one portion of the helix to have the limiting value 90°. When the changes of pitch are not too great, the phase angles, which depend on all the modes, can be neglected, and only the fundamental wave considered.

621.372.8 : 621.318.134 **323**

Magneto-optical Phenomena in a Rectangular Waveguide containing a Ferrite Plate.—A. L. Mikaelyan. (*Bull. Acad. Sci. U.R.S.S., sér. tech. Sci.*, March 1955, No. 3, pp. 139–149. In Russian.) Results are presented graphically of calculations of the propagation characteristics of H-waves, of frequency of the order of 10 kMc/s, in a waveguide partly filled with ferrite, in the presence of a transverse magnetic field. The effects of position and thickness of the ferrite plate, the dielectric constant, magnetization, frequency and waveguide dimensions are considered. Propagation in waveguides containing a ferrite/dielectric composite plate or a ferrite plate and isotropic layers is also considered. See also 925 of 1955.

621.372.8 : 621.318.134 **324**

Theory of New Ferrite Modes in Rectangular Waveguide.—B. Lax & K. J. Button. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, pp. 1184–1185.) Exact theory is presented for propagation in a waveguide containing one or two transversely magnetized ferrite slabs adjacent to the walls.

621.372.8 : 621.318.134 **325**

New Ferrite Mode Configurations and their Applications.—B. Lax & K. J. Button. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, pp. 1186–1187.) The mode configurations of the electric fields corresponding to the various solutions given in 324 above are illustrated.

621.396.67 : 621.396.932 **326**

The Use of a Ring Array as a Skip-Range Antenna.—J. D. Tillman, W. T. Patton, C. E. Blakely & F. V. Schultz. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1655–1660.) The problem discussed is the development of a shore aerial for shore-to-ship communication at distances of 40–500 miles. An omnidirectional ring array of vertical $\lambda/4$ aerials is used with alternative excitation so as to concentrate the energy (*a*) into the ground wave for daytime communication and for communication over distances less than about 200 miles at night, or (*b*) into the sky wave for night-time communication over greater distances. Range calculations are presented based on a 3-kW transmitter and an operating frequency of 3 Mc/s.

621.396.67 : 621.866 **327**

Special Winches for the New Aerial Installation of the Schwarzenburg Short-Wave Transmitter.—H. R. Lerch. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st Aug. 1955, Vol. 33, No. 8, pp. 312–316. In German and French.) The aerial system discussed comprises seven masts of heights between 40 and 120 m forming a three-arm star with two masts supporting flat-top aerials in each arm around a central mast. Instead of the customary stationary winch associated with each mast, two mobile winches were used; these are described and illustrated; they have given satisfactory service since autumn 1953.

621.396.67.012.12 **328**

Helicopter measures Antenna Patterns.—H. Brueckmann. (*Electronics*, Nov. 1955, Vol. 28, No. 11, pp. 134–136.) The measuring equipment described comprises a small signal source located at the centre of a dipole aerial suspended from the helicopter by means of a nylon string; a constant-intensity signal is transmitted and the helicopter flies in circles round the aerial under test, ground equipment being provided to track the helicopter position. The radiation pattern of a complex aerial system can be plotted in under 3 h, accurate to within 20%. Sources of error are discussed.

621.396.67.029.62 : 621.397.62 **329**

Dual-Band Television Aerials.—F. R. W. Strafford. (*Wireless World*, Nov. & Dec. 1955, Vol. 61, Nos. 11 & 12, pp. 539–542 & 607–610.) The inefficiency of band-I dipole aerials on band-III frequencies and the results of various modifications are shown by curves obtained experimentally.

621.396.677.3 : 621.396.93 **330**

Design for Wide-Aperture Direction Finders.—R. C. Benoit, Jr, & M. W. Furlow. (*Tele-Tech & Electronic Ind.*, Sept. 1955, Vol. 14, No. 9, pp. 60–62 ..108.) The aerial system of the U.S.A.F. direction finder AN/GRD-9 is described. It is developed from the German Wullenweber u.h.f. system and produces a pattern equivalent to that of a rotating planar array by means of a number of fixed elements arranged in a circle, with an inner circle of reflectors, the signals being picked up by a rotating commutator and appropriately delayed so that all arrive in phase at a common mixing point. For the experimental model described the frequency range covered is wider than 225–400 Mc/s, the beam width being 6°; bearings can be determined to within ±1°.

621.396.677.71 **331**

Radiation Characteristics of Axial Slots on a Conducting Cylinder.—J. R. Wait. (*Wireless Engr*, Dec. 1955, Vol. 32, No. 12, pp. 316–323.) "An extensive set of radiation patterns is presented for a narrow axial slot on a circular conducting cylinder of infinite length with a circumference up to 21 wavelengths. The results are also applicable to arrays of axial slots with an arbitrary distribution of transverse voltage. The effect of finite slot width is discussed and the external conductance of the slot is also considered."

621.396.677.833 **332**

Determination of Aperture Phase Errors in Microwave Reflectors.—D. K. Cheng & P. Grusauskas. (*J. Franklin Inst.*, Aug. 1955, Vol. 260, No. 2, pp. 99–105.) "Using the vector notation of differential geometry, a general expression is obtained for the phase error in an aperture plane of any given reflector when the equation of the incident wavefront is known. For the special case of a point source, the formula can be readily applied to determine the aperture phase distribution for any source location."

AUTOMATIC COMPUTERS

681.142 **333**

An Attempt to simplify Coding for the Manchester Electronic Computer.—R. A. Brooker. (*Brit. J. appl. Phys.*, Sept. 1955, Vol. 6, No. 9, pp. 307–311.) Two main simplifications are made, both at the cost of increased machine time. To ensure that all quantities involved in a calculation are represented to the required degree of accuracy, every number occurring is associated with its own scale factor. Again, in using the two levels of storage provided, arrangements are made so that 'instructions' are written out as if for a one-level store. A program in the simplified form is described.

681.142 **334**

A Magslip Isograph.—G. M. Parker & R. W. Williams. (*J. sci. Instrum.*, Sept. 1955, Vol. 32, No. 9, pp. 332–335.) The terms of a polynomial equation to be solved are represented by alternating voltages of varying time phases obtained from magslip transmitters. The instrument described is capable of solving sixth-degree equations having real coefficients, and may be used for the evaluation of polynomials.

681.142 **335**

A Flutter Computer with Low Gain Amplifiers.—K. E. Wood & I. V. Hansford. (*Electronic Engng*, Nov. 1955, Vol. 27, No. 333, pp. 477–481.) Low-gain d.c. amplifiers are used, thus avoiding drift troubles. The principle of the computer is to shift all the poles of the solution to the left in the complex p plane, $F(p)$ being a stable solution of the problem. The method is useful in low-stiffness problems.

681.142 : 621.3.002.2 **336**

Basic Chassis for Experimental Work.—N. M. Emslie. (*Electronics*, Nov. 1955, Vol. 28, No. 11, pp. 166–168.) Design details are given for a universal unit for use in computers, for manufacture in small quantities.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.012 **337**

An Approximate Method for obtaining Transient Response from Frequency Response.—H. H. Rosenbrock. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 744–752.) A rapid method for finding the transient response of a linear system whose frequency response is known numerically, but not as an analytical function, involves use of a specially constructed transparent cursor. The technique can also be used to deal with the inverse problem or to derive an analytical function representing the behaviour of a system of which either the frequency response or the transient response has been measured.

621.314.22 : 621.372.5 **338**

Transformer Design on Insertion-Loss Principles.—H. Schilling. (*Telefunken Ztg.*, March 1955, Vol. 28, No. 107, pp. 5–14. English summary, pp. 58–59.) Wide-band-transformer data can be calculated using the normalized values for the circuit elements of high-pass and low-pass networks derived from insertion-loss theory for reactive quadripoles, examples of which are tabulated. By considering the transformer equivalent circuit as part of a Tchebycheff filter network of higher order, significant improvements can be made in the transmission characteristic. By introducing special low-permittivity layers between windings further improvement is possible.

621.318.43 : 621.318.134 **339**

Perpendicularly Superposed Magnetic Fields.—R. Heartz & H. O. Buelteman, Jr. (*Elect. Engng, N.Y.*, Aug. 1955, Vol. 74, No. 8, p. 661.) Digest of a paper to be published in *Trans. Amer. Inst. elect. Engrs, Communication and Electronics*, 1955. Theory is outlined for a 'cross-field reactor' comprising a hollow ferrite toroid carrying one annular winding internally and one toroidal winding externally. The device can be used as a low-level d.c. converter or modulator, as a variable inductance, or as a frequency multiplier or divider.

621.318.43 : 621.375.3 340
Analysis of Optimum [core] Shape for Magnetic Amplifiers.—B. D. Bedford, C. H. Willis & G. C. Dodson. (*Elect. Engng, N.Y.*, Aug. 1955, Vol. 74, No. 8, p. 694.) Digest of paper to be published in *Trans. Amer. Inst. elect. Engrs, Communication and Electronics*, 1955.

621.318.57 : 621.374.32 341
Composite Multistable Circuit with Natural Quinary Cycle.—R. Favre. (*Helv. phys. Acta*, 31st Aug. 1955, Vol. 28, No. 4, pp. 442–446. In French.) A circuit composed of binary and ternary stages is used, based on design principles described previously (3485 of 1954). Details are given of a decade unit embodying the circuit.

621.37/.39(083.74) 342
NBS-BuAer Preferred Circuits Program.—(*Tech. News Bull. nat. Bur. Stand.*, Oct. 1955, Vol. 39, No. 10, pp. 134–136.) Report of investigations made by the N.B.S., in conjunction with the U.S. Navy Bureau of Aeronautics, of the feasibility of standardizing the circuits used in electronic equipment. A similar account is also given in *Elect. J.*, 9th Dec. 1955, Vol. 155, No. 24, pp. 1939–1941.

621.372 343
Topological and Dynamical Invariant Theory of an Electrical Network.—T. C. Doyle. (*J. Math. Phys.*, July 1955, Vol. 34, No. 2, pp. 81–94.)

621.372.029.6 : 621.3.018.75 344
Linear Transmission of Pulses at Centimetre Wavelengths.—E. Ledinegg. (*Arch. elekt. Übertragung*, Aug. 1955, Vol. 9, No. 8, pp. 363–368.) Analysis for the transmission of pulses of arbitrary shape by waveguide and cavity-resonator systems is based on use of Laplace transforms. Using theory presented previously [1700 of 1954 (Ledinegg & Urban)] a calculation is made of the transfer function for a system of weakly coupled cavity resonators.

621.372.029.64 : 538.569.4 345
The Maser—New Type of Microwave Amplifier, Frequency Standard, and Spectrometer.—Gordon, Zeiger & Townes. (See 403.)

621.372.412 : 549.514.51 346
Influence of the Order of Overtone on the Temperature Coefficient of Frequency of AT-Type Quartz Resonators.—R. Bechmann. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1667–1668.)

621.372.413 : 538.221 : 621.318.134 347
Magnetic Fields in Small Ferrite Bodies with Applications to Microwave Cavities containing Such Bodies.—A. D. Berk & B. A. Lengyel. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1587–1591.) An analysis is presented of the field inside small spheres and cylinders of ferrite excited by circularly or linearly polarized magnetic fields in cavities. The formulae derived are used to calculate the detuning and change of Q value of the cavity on introducing the ferrite body, or conversely to determine the ferrite permeability tensor from the observed changes in the cavity characteristics.

621.372.413.029.64 : 538.569.4 348
Increasing the Q Factor of the Cavity Resonator by Regeneration.—N. G. Basov, V. G. Veselago & M. E. Zhabotinski. (*Zh. eksp. teor. Fiz.*, Feb. 1955, Vol. 28, No. 2, p. 242.) A brief note on the cavity resonator used in conjunction with the molecular-beam oscillator [100 of 1955 (Gordon et al.) and 2275 of 1955 (Basov & Prokhorov)]. A Q factor of 5×10^6 has been obtained for periods of up to 20 min.

621.372.5 349
The Graphical Determination of the Geometrical Parameters of Loss-Free Linear Quadripoles.—J. de Buhr. (*Arch. elekt. Übertragung*, Aug. 1955, Vol. 9, No. 8, pp. 350–354.) The methods described previously (2864 and 3523 of 1955) are applied to determine the iterative impedance and iterative transfer constants.

621.372.5 : 538.652 350
Application of the Wiedemann Effect to the Magnetostrictive Coupling of Crossed Coils.—U. F. Gianola. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, pp. 1152–1157.) An electromechanical quadripole is described comprising a tubular magnetostrictive ferrite core carrying crossed coils, one wound toroidally and the other as an external helix. Theory is presented in terms of an equivalent circuit. The device can be used for filtering, gating, phase-reversing, etc. Successful experiments with ferroxcube IV E cores operating at frequencies between 25 and 150 kc/s are reported.

621.372.54 351
Catalogue of Power-Law and Tchebycheff-Type Filters up to Order n = 5.—E. Glowatzki. (*Telefunken Ztg.*, March 1955, Vol. 28, No. 107, pp. 15–22. English summary, p. 59.) Four tables give the circuit diagrams and the normalized values of the circuit elements in maximally-flat-response and Tchebycheff-type filters (*a*) terminated, and (*b*) with a short or open circuit at one end, for different values of the pass-band reflection coefficient. Corresponding attenuation characteristics are given in 15 diagrams. The application of the tables is illustrated in five numerical examples. See also 1903 of 1955.

621.372.54.029.3 : 621.372.57 352
Electrically-Controlled Audio Filters.—L. O. Dolanský. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1580–1586; *Convention Record Inst. Radio Engrs*, 1955, Vol. 3, Part 7, pp. 41–48.) Design theory based on the work of Linvill (1711 of 1954) is presented for a low-pass and a high-pass filter both having cut-off frequencies continuously variable between 200 c/s and 1 kc/s. The cut-off characteristic may be controlled by the a.f. signal for investigating the structure of speech signals. Experimental results are reported.

621.372.543.2.029.62/.63 353
U.H.F. Multiplexer uses Selective Couplers.—H. J. Carlin. (*Electronics*, Nov. 1955, Vol. 28, No. 11, pp. 152–155.) An arrangement is described comprising directional couplers incorporating filter properties combined to form a system enabling several transmitters and receivers to be operated with a single aerial in the frequency range 225–400 Mc/s. A coaxial-line construction with tuned cavity resonator is used. A four-coupler system with separation of 3 Mc/s between channels can provide adjacent-channel reduction of 60 dB with insertion loss of 1 dB.

621.372.55 354
Equivalent Equalizer Networks.—R. O. Rowlands. (*Wireless Engr*, Dec. 1955, Vol. 32, No. 12, pp. 323–327.) The various types of frequency-response curves obtainable with practical networks of the derivative-equalizer type [1936 of 1953 (Gouriet)] are analysed and the equivalent constant-resistance networks are determined.

621.373.4 : 621.316.726 **355**

Improvement of Stabilized Pound Oscillator.—J. Hervé. (*C. R. Acad. Sci., Paris*, 19th Sept. 1955, Vol. 241, No. 12, pp. 746–749.) Adjustment of the oscillator is facilitated by means of a sawtooth generator with switching arrangements such that it can be interpolated at various points in the circuit, the attainment of the desired oscillator characteristic being indicated on a c.r.o.

621.373.431.2 : 621.373.52 : 621.314.7 **356**

Junction-Transistor Blocking Oscillators.—J. G. Linvill & R. H. Mattson. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1632–1639.) Circuits have been designed producing pulses with rise times $< 0{\cdot}1\ \mu s$, using transistors with α-cut-off frequencies of a few Mc/s. Details of the regenerative transformer coupling are discussed. Triggering requirements and the effects of loading are evaluated. Experimental results support the theory.

621.373.444 **357**

Stabilization of Pulse Duration in Monostable Multivibrators.—A. C. Luther, Jr. (*RCA Rev.*, Sept. 1955, Vol. 16, No. 3, pp. 403–422.) Pulse-duration stabilization of triggered circuits by d.c. feedback is described. Practical circuits suitable for frequency division and pulse generation in television equipment are illustrated.

621.373.52 : 621.314.7 **358**

Transistor Pulse Generators.—W. S. Eckess, J. E. Deavenport & K. I. Sherman. (*Electronics*, Nov. 1955, Vol. 28, No. 11, pp. 132–133.) Numerical design data are given for four circuits using Ge junction transistors and one using a Si transistor. Pulse rise times as low as $0{\cdot}1\ \mu s$ are attainable at repetition frequencies up to 50 000 pulses/sec; pulse durations are variable from 0·4 to 9 μs.

621.374.4 : 621.318.435 : 621.396.96 **359**

Saturable-Reactor Frequency Divider.—G. W. G. Court & C. I. C. Scollay. (*Wireless Engr*, Dec. 1955, Vol. 32, No. 12, pp. 328–329.) A saturable reactor is used in conjunction with a *RC* network to provide a circuit capable of producing a pulse output at the frequency, or a submultiple of the frequency, of a sinusoidal input. A circuit providing synchronizing pulses for a radar modulator at half the frequency of the 400-c/s power supply is described.

621.375.2.024 **360**

Automatic Drift Compensation in D.C. Amplifiers.—I. Cederbaum & P. Balaban. (*Rev. sci. Instrum.*, Aug. 1955, Vol. 26, No. 8, pp. 745–747.) The circuit discussed is similar to that described by Offner (3511 of 1954). It may be used in systems where periodic interruption of the input and noncontinuous compensation are permissible, as in analogue computers, sampling amplifers, etc.

621.375.221.2 **361**

Optimum Tube Utilization in Cascaded Distributed Amplifiers.—A. I. Talkin & J. V. Cuneo. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1668–1669.) Analysis is presented taking account of the bandwidth-narrowing factor introduced by cascading stages; this factor is evaluated for an amplifier using constant-*R* bridged-T lines. A numerical example is discussed.

621.375.227 **362**

Rejection Factor of Difference Amplifiers.—G. Klein. (*Philips Res. Rep.*, Aug. 1955, Vol. 10, No. 4, pp. 241–259.) Analysis shows that the rejection factor of a differential amplifier can be made arbitrarily large without necessitating pre-selection of valves or exact equality of the two halves of the circuit. The theory is supported by experimental results. The parameter termed 'rejection factor' is the same as that termed 'transmission factor' by Parnum (1636 of 1950).

621.375.3 **363**

Magnetic Amplifiers as Control Components.—W. La Pierre. (*Product Engng*, Aug. 1955, Vol. 26, No. 8, pp. 129–133.) The advantages and limitations of magnetic amplifiers for voltage and current control, switching and amplifying are compared with those of various other devices; important properties are tabulated.

621.375.3 : 621.383.5 : 621.314.63 **364**

A Germanium Diffused-Junction Photoelectric Cell.—Waddell, Mayer & Kaye. (See 615.)

621.375.327.024 **365**

Low Level Magnetic Amplifier.—F. Gourash. (*Tele-Tech & Electronic Ind.*, Aug. 1955, Vol. 14, No. 8, pp. 90–91 .. 160.) A two-stage push-pull d.c. amplifier is described in which a high degree of negative feedback is used to obtain stability and linearity, with high input impedance. By careful balancing of components the zero drift, measured in terms of input power, is reduced to the order of 10^{-12} W.

621.375.4 : 621.314.7 **366**

Transistor Power Amplifiers.—R. A. Hilbourne & D. D. Jones. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 763–774. Discussion, pp. 786–792.) Discussion of conditions for *p-n-p* junction transistors handling sinusoidal signals indicates that the maximum possible output is not necessarily limited by the maximum allowable collector dissipation; limitations set by the variation of current gain with emitter current become particularly significant in class-B amplifiers because of their very high efficiencies. Push-pull class-B operation is preferred to class-A; of the three possible basic connections the common-collector arrangement is preferred as providing the best compromise between gain and distortion and permitting the simplest design of output transformer. No great advantage is found by using complementary *n-p-n* and *p-n-p* transistors. Applications involving nonsinusoidal signals are discussed briefly.

621.375.4 : 621.314.7 **367**

Predictable Design of Transistor Amplifiers.—R. B. Hurley. (*Tele-Tech & Electronic Ind.*, Aug. 1955, Vol. 14, No. 8, pp. 74–75 .. 168.) The transfer characteristic of a multistage low-frequency amplifier using junction transistors may be made independent of the transistor characteristics by the use of degenerative current feedback, at the same time improving linearity. The importance of stable biasing arrangements is emphasized.

621.375.4 : 621.314.7 **368**

Simplified Design Procedures for Tuned Transistor Amplifiers.—C. C. Cheng. (*RCA Rev.*, Sept. 1955, Vol. 16, No. 3, pp. 339–359.)

621.375.4 : 621.314.7 **369**

Maximum Power Transfer in Transistor Amplifiers.—G. L. Fougere. (*Electronic Engng*, Nov. 1955, Vol. 27, No. 333, pp. 492–493.) The theoretical treatment of transistor-amplifier performance is simplified by restricting consideration to the condition of maximum power transfer, when it is possible to make a rapid assessment of the available power gain for a particular configuration, in terms of the transistor parameters. Curves show the relation between maximum power gain, current gain and transistor constants for grounded-base and grounded-collector arrangements.

621.375.9 : 621.385.032.216 **370**

Properties of Pore Conductors.—Forman. (See 630.)

GENERAL PHYSICS

530.112 **371**

Some Considerations regarding the Principle of Phase Invariance.—F. A. Kaempffer. (*Canad. J. Phys.*, Aug. 1955, Vol. 33, No. 8, pp. 436–440.) It is shown that the conservation laws characterizing the ether can be derived from the principle of phase invariance provided a complex field is used to describe the ether.

530.145 : 539.153 : 548.0 **372**

Tamm Equations of State of Electrons at the Surface of a Crystal and Surface Oscillations of Lattice Atoms.—I. M. Lifshits & S. I. Pekar. (*Uspekhi fiz. Nauk*, Aug. 1955, Vol. 56, No. 4, pp. 531–568.) A review. About half of the 68 references are to Russian work.

535.215 **373**

Photo [-electric] Effect in Metals.—S. V. Vonsovski, A. V. Sokolov & A. Z. Veksler. (*Uspekhi fiz. Nauk*, Aug. 1955, Vol. 56, No. 4, pp. 477–530.) A critical survey with particular reference to the theoretical development of the subject. 65 references.

535.376 **374**

Electroluminescence excited by Short Field Pulses.—F. Matossi & S. Nudelman. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1100–1103.) An extension of a previous investigation [1307 of 1955 (Nudelman & Matossi)] is reported; pulses of duration 40–2 500 μs were used. The luminescence decay rate is highest for the shortest pulses. Results are consistent with previous conclusions regarding polarization effects [2898 of 1955 (Matossi)]; a threshold pulse duration of about 700 μs is estimated to be necessary for the accumulation of polarization charges.

535.376 **375**

Dependence of Light Amplification in Phosphors on Light Intensity.—F. Matossi. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1332–1333.)

535.623 : 621.397.5 **376**

Differential Chromaticity Thresholds in the Direction of Primary Blue in a Trichromatic-Synthesis System.—Billard. (See 583.)

537.226 **377**

Dielectric Properties of Ice at Very Low Frequencies and the Influence of a Polarizing Field.—H. Gränicher, C. Jaccard, P. Scherrer & A. Steinemann. (*Helv. phys. Acta*, 31st Aug. 1955, Vol. 28, No. 4, pp. 300–303. In German.) Measurements at frequencies down to 0·7 c/s are reported. The loss factor passes through a low-frequency maximum which is distinguishable from that associated with the dipole dispersion by its different temperature dependence. The effect of impurities is to shift the maximum towards higher frequencies. Application of a unidirectional field does not affect the permittivity of the pure crystals but eliminates the low-frequency dispersion when impurities are present. The observations are consistent with MacDonald's theory (1024 of 1954).

537.226.2 **378**

The Dielectric Constant of an Imperfect Non-Polar Gas.—A. D. Buckingham & J. A. Pople. (*Trans. Faraday Soc.*, Aug. 1955, Vol. 51, No. 392, pp. 1029–1035.)

537.311.31 **379**

Electron-Phonon Interaction in Metals.—J. Bardeen & D. Pines. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1140–1150.) "The role of electron-electron interactions in determining the electron-phonon interaction in metals is investigated by extending the Bohm-Pines collective description to take into account the ionic motion."

537.311.31 : 537.312.8 **380**

Single Band Motion of Conduction Electrons in a Uniform Magnetic Field.—P. G. Harper. (*Proc. Phys. Soc.*, 1st Oct. 1955, Vol. 68, No. 430A, pp. 874–878.)

537.311.31 : 537.312.8 : 538.113 **381**

The General Motion of Conduction Electrons in a Uniform Magnetic Field, with Application to the Diamagnetism of Metals.—P. G. Harper. (*Proc. Phys. Soc.*, 1st Oct. 1955, Vol. 68, No. 430A, pp. 879–892.)

537.311.37 : 537.562 **382**

Theory of the Electrical Conductivity of a Plasma.—H. Schirmer. (*Z. Phys.*, 27th Aug. 1955, Vol. 142, No. 1, pp. 1–13.) The calculation presented is based on integration of the Boltzmann equation in which the atoms, ions and electrons are not treated as rigid, perfectly elastic spherical scattering centres.

537.312.8 **383**

The Importance and the Origin of Modes of Description of Magnetogalvanic Effects.—A. L. Perrier. (*Helv. phys. Acta*, 31st Aug. 1955, Vol. 28, No. 4, pp. 312–316. In French.) See also 2337 of 1955 (Perrier & Ascher).

537.5 **384**

Statistical Description of Assemblies with Collective Interaction: Part 3.—The Various Formulations of the Carrier Kinetics.—G. Ecker. (*Z. Phys.*, 20th July 1955, Vol. 141, No. 3, pp. 294–306.) The range of validity of approximations made in analyses by other workers is discussed. Parts 1 & 2: 2907 of 1955.

537.5 **385**

Pulse-Controlled Cathode Sputtering and Electron Emission.—A. Güntherschulze. (*Z. Phys.*, 20th July 1955, Vol. 141, No. 3, pp. 346–353.)

537.5 **386**

Electron Liberation by Low-Energy Ions at Metal Surfaces and in Gases.—H. Fetz. (*Brit. J. appl. Phys.*, Aug. 1955, Vol. 6, No. 8, pp. 288–291.) Two experimental methods of investigation are described; the disturbing influence of photo-ionization was completely eliminated. Results indicate that in certain cases ionization in the gas by collision of ions may be important.

537.52 **387**

Mechanism of Uniform Field Breakdown in Hydrogen.—A. Wilkes, W. Hopwood & N. J. Peacock. (*Nature, Lond.*, 29th Oct. 1955, Vol. 176, No. 4487, pp. 837–838.)

537.523 **388**

Growth of Current between Parallel Plates.—P. M. Davidson. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1072–1074.) Analysis for the initial stages of a discharge involving secondary electron emission is presented in an alternative form to that given previously [3262 of 1953 (Dutton et al.; mathematical appendix by Davidson)].

537.525.8 : 535.215 **389**

Reduction of the Cathode Fall [of potential] **of a Normal Glow Discharge by Illumination of the Cathode.**—W. Kluge & A. Schulz. (*Z. Phys.*, 27th Aug. 1955, Vol. 142, No. 1, pp. 83–86.) Experimental results indicate that the relation between the normal cathode fall U_{kn}, the cathode work function Φ_a and the current density due to illumination j_o is given by $U_{kn} = A\,\Phi_a - Bj_o$, where A is a constant whose magnitude depends on the ionization potential of the gas and B is another constant. A special Ag-based cathode with KH and adsorbed K layers was used (585 of 1955).

537.525.8 : 537.212.082.72 **390**

Measurement of Electric Fields as applied to Glow Discharges.—R. W. Warren. (*Rev. sci. Instrum.*, Aug. 1955, Vol. 26, No. 8, pp. 765–770.) A magnetically compensated zero-deflection electron-beam method is described. Using automatic recording, field strengths between 1 000 V/cm and 0·2 V/cm can be rapidly measured and tube-wall potentials can simultaneously be recorded.

537.533 **391**

Electron Emission from Cathode Surfaces after Glow Discharges.—R. Röhler. (*Naturwissenschaften*, Aug. 1955, Vol. 42, No. 16, pp. 459–460.) Brief account of experiments made to elucidate exo-electron-emission phenomena.

537.533 **392**

T-F [temperature and field] **Emission: Experimental Measurement of the Average Electron Current Density from Tungsten.**—W. P. Dyke, J. P. Barbour, E. E. Martin & J. K. Trolan. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1192–1195.) The results of the experiments reported support the theory presented previously [88 of 1955 (Dolan & Dyke)].

537.533 : 530.145 **393**

Quantum Effects in the Interaction between Free Electrons and Electromagnetic Fields.—P. S. Farago & G. Marx. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1063–1064.) A discussion of the possibility of arranging experiments so that the spread of an electron beam in a transverse r.f. field due to the quantum dispersion of the energy exchange can be distinguished from that due to practical experimental factors.

537.533 : 535.31 **394**

Two Problems in Geometrical Optics and Application of the Results in Electron Trajectory Calculations.—S. V. Yadavalli. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1670–1671.)

537.56 **395**

A Semi-empirical Expression for the First Townsend Coefficient of Molecular Gases.—R. W. Crowe, J. K. Bragg & J. C. Devins. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, pp. 1121–1124.) The formula derived by Druyvesteyn & Penning (*Rev. mod. Phys.*, April 1940, Vol. 12, No. 2, pp. 87–174) is discussed and is modified on the basis of different assumptions regarding the energy dependence of the scattering cross-sections of the gas molecules.

537.56 **396**

Atomic Negative-Ion-Photodetachment Cross-Section and Affinity Measurements.—S. J. Smith & L. M. Branscomb. (*J. Res. nat. Bur. Stand.*, Sept. 1955, Vol. 55, No. 3, pp. 165–176.) "The spectral distributions of the H^- and O^- cross sections for photodetachment have been measured. The H^- measurements are consistent with the theory of Chandrasekhar. A curve has been fitted to the results for O^-. The threshold of this cross section, the affinity of O^-, is found to be 1·48 ± 0·10 electron volts. No evidence is found for resonance at the threshold or for the existence of excited O^- ions. The apparatus is described in detail."

538.114 **397**

Dipolar Ferromagnetism at 0°K.—M. H. Cohen & F. Keffer. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1135–1140.)

538.566 : 517 **398**

Asymptotic Expansions of Solutions of $(\nabla^2 + k^2)u = 0$.—F. G. Friedlander & J. B. Keller. (*Commun. pure appl. Math.*, Aug. 1955, Vol. 8, No. 3, pp. 387–394.) The equation investigated is important in the theory of wave propagation. A direct method is developed for obtaining more general asymptotic expansions than those given previously [646 of 1952 (Kline)].

538.566 : 535.42 **399**

Strict Theory of the Diffraction of Electromagnetic Waves by Plane Screens.—K. Westpfahl. (*Z. Phys.*, 20th July 1955, Vol. 141, No. 3, pp. 354–373.) Analysis is based on the Hertz, or Fitzgerald, vector, which can be represented by a double Fourier integral; the Fourier amplitudes giving the angular distribution of the far field are derived from a system of simultaneous integral equations which can be solved approximately by developing in certain orthogonal systems. An alternative method of solution is an iteration process based on the Kirchhoff approximation. The relation with Huyghens' principle and with the variation problem of diffraction theory is established.

538.566 : 535.42 **400**

Diffraction of Microwaves by Long Metal Cylinders.—A. W. Adey. (*Canad. J. Phys.*, Aug. 1955, Vol. 33, No. 8, pp. 407–419.) Report of an experimental investigation at about 3 cm λ, using parallel-plate equipment based on that described by El-Kharadly (e.g. 1261 of May) and cylindrical obstacles of transverse dimensions comparable with λ. Calculated and experimental results for circular cylinders are in good agreement and are used as a basis for studying diffraction by square and rectangular cylinders. The method gives reliable information about scattering from obstacles of forms such that no exact theoretical solutions are available.

538.566 : 535.43 **401**

On the Scattering Cross Section of an Obstacle.—D. S. Jones. (*Phil. Mag.*, Sept. 1955, Vol. 46, No. 380, pp. 957–962.) The relation between the scattering cross-section and the scattered amplitude for an obstacle in an incident plane wave, previously discussed by van de Hulst (601 of 1950), is here established by a calculation of the energy flow. When the incident wave emanates from a point source, the sum of the scattering and absorption cross-sections is determined by the value of a certain field in the neighbourhood of the source. The discussion is presented in terms of an e.m. wave, but is adaptable to sound waves or atomic collisions.

538.569.4 : 621.372.029.64 **402**

Possible Methods of obtaining Active Molecules for the Molecular Generator.—N. G. Basov & A. M. Prokhorov. (*Zh. eksp. teor. Fiz.*, Feb. 1955, Vol. 28, No. 2, pp. 249–250.) The use is suggested of an auxiliary h.f. field to produce resonance transitions between the energy levels in the molecules such as to increase the fraction of active molecules in the beam. See also 348 above and back references.

538.569.4 : 621.372.029.64 **403**

The Maser—New Type of Microwave Amplifier, Frequency Standard, and Spectrometer.—J. P. Gordon, H. J. Zeiger & C. H. Townes. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1264–1274.) Experimental results with the device described previously (100 of 1955) are compared with predictions from theory. Particular attention is given to operation with ammonia molecules. An amplifier noise figure of unity should be attainable under certain conditions.

539.15.098 : 538.569.4 **404**

Influence of an Inhomogeneity of the High-Frequency Field in Nuclear Magnetic Resonance.—H. Pfeifer. (*Z. angew. Phys.*, Aug. 1955, Vol. 7, No. 8, pp. 389–391.) Theoretical results show that, to a first-order approximation, the inhomogeneity has no effect on the signal amplitude provided that the conditions for a maximal signal in a homogeneous field are fulfilled.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.16 **405**

Radio Stars and their Cosmological Significance.—M. Ryle. (*Observatory*, Aug. 1955, Vol. 75, No. 887, pp. 137–147.) A survey presented as the 1955 Halley lecture. See also 3588 of 1955 (Ryle & Scheuer).

523.16 : 523.4 **406**

Location on Jupiter of a Source of Radio Noise.—C. A. Shain. (*Nature, Lond.*, 29th Oct. 1955, Vol. 176, No. 4487, pp. 836–837.) Earlier records of r.f. radiation and of visually observed activity on Jupiter are discussed in relation to the observation of a r.f. source by Burke & Franklin (2933 of 1955); this r.f. source is probably identifiable with the visibly disturbed region observed by Fox (*J. Brit. astr. Assoc.*, 1952, Vol. 62, p. 280).

523.16 : 523.45 **407**

On the Great Importance of the R.F. Radiation from the Planet Jupiter.—Q. Majorana. (*R.C. Accad. naz. Lincei*, July/Aug. 1955, Vol. 19, Nos. 1/2, pp. 17–22.) Continuation of the previous discussion (3591 of 1955) of the observations reported by Burke & Franklin (2933 of 1955). The cyclic variation of relative position of points on Jupiter and on the earth is examined. Based on considerations of temperature and composition, the hypothesis is advanced that the observed radiation is produced by continuous eruption of solid electrified blocks of iron with linear dimensions of the order of $\lambda/4$; such eruptions could be expected in the vicinity of the large red spot on Jupiter. The relevance of the hypothesis to astronautical problems is briefly indicated.

523.16 : 546.11.02 **408**

Monochromatic Radiation of Deuterium at a Wavelength of 91·6 cm from the Centre of the Galaxy.—G. G. Getmantsev, K. S. Stankevich & V. S. Troitski. (*C. R. Acad. Sci. U.R.S.S.*, 11th Aug. 1955, Vol. 103, No. 5, pp. 783–786. In Russian.) A brief report is presented of observations indicating the presence of deuterium in the interstellar space; the concentration is about 3×10^{-2} that of the non-ionized hydrogen. A block diagram is given of the equipment used in conjunction with a $\lambda/2$ dipole aerial at the focus of a 4-m-diameter parabolic reflector.

523.5 **409**

Note on the Electrophysical Determination of the Velocities of Meteors.—C. Hoffmeister. (*Naturwissenschaften*, Aug. 1955, Vol. 42, No. 16, p. 458.) The question is briefly discussed whether the trail is electrically reflecting immediately after passage of the meteor or only after the ionized cylinder has expanded to a certain diameter. The answer is decisive for the theory of the origin of the interplanetary material.

523.53 : 621.396.96 **410**

The Giacobinid Meteor Stream.—J. G. Davies & A. C. B. Lovell. (*Mon. Not. R. astr. Soc.*, 1955, Vol. 115, No. 1, pp. 23–31.) An account is given of the systematic radio-echo observations in the years 1947–1954; the unexpected return of the meteor shower during the daytime in 1952 and the significance of its absence in 1953 are discussed.

523.7 : 621.396.822.029.6 **411**

Influence of the Age of [solar] R.F. Centres on their Radiation at Centimetre Wavelengths.—B. Vauquois. (*C. R. Acad. Sci., Paris*, 19th Sept. 1955, Vol. 241, No. 12, pp. 739–740.) Continuation of investigation reported previously (2939 of 1955). The r.f. flux from an active centre appears to vary directly as its sunspot area for the first 15 days of its life, after which it decreases more slowly than the sunspot area. The corresponding 'aging function' is shown graphically.

523.72 : 551.510.535 **412**

Brightening of the Solar Limb in the Far Ultra-Violet.—C. M. Minnis. (*Nature, Lond.*, 1st Oct. 1955, Vol. 176, No. 4483, pp. 652–653.) Locations and relative intensities of sources controlling the E and F_1 layers, as provisionally determined from measurements of electron density made at Slough and Inverness during the solar eclipse of 30th June 1954, indicate brightening of the solar limb near the equator and darkening of the limb at the poles. The intensity distribution over the solar disk is similar to that found by Christiansen & Warburton (2606 of 1955) for radiation on 21 cm λ.

550.3 **413**

Electromagnetic Induction in a Two-Layer Earth.—B. K. Bhattacharyya. (*J. geophys. Res.*, Sept. 1955, Vol. 60, No. 3, pp. 279–288.) The theory developed by Price (1617 of 1951) is extended to determine the induced field on the surface of a medium whose conductivity is a function of depth. The results are applied to evaluate the field induced when an oscillating magnetic dipole is placed on the surface of a flat two-layer earth.

550.380.8 **414**

A Measurement of the Earth's Magnetic Field by Nuclear Induction.—G. S. Waters. (*Nature, Lond.*, 8th Oct. 1955, Vol. 176, No. 4484, p. 691.) The free-precession technique outlined by Packard & Varian (*Phys. Rev.*, 15th Feb. 1954, Vol. 93, No. 4, p. 941) is used.

550.385 **415**

Daytime Enhancement of Size of Sudden Commencements [SC's] and Initial Phase of Magnetic Storms at Huancayo.—S. E. Forbush & E. H. Vestine. (*J. geophys. Res.*, Sept. 1955, Vol. 60, No. 3, pp. 299–316.) Statistical analysis of data for the period 1922–1946 shows that the frequency of occurrence of SC's is independent of the time of day, but that the average size of

SC's and of initial phases of magnetic storms is greater during daylight hours. The size is also found to vary directly with the amplitude of the diurnal variation of *H*. Both phenomena may be due to electrojets in polar latitudes caused by the sun.

550.385 : 523.78 **416**

Magnetic Effects during Solar Eclipses.—A. M. van Wijk. (*J. geophys. Res.*, Sept. 1955, Vol. 60, No. 3, pp. 297–298.) Records taken in South Africa at the time of the annular eclipse of the sun on 25th December 1954 show a decrease in intensity of the geomagnetic-field horizontal component, in accordance with theory, but also an increase in the vertical component.

551.510.5 **417**

Observation of an 'Ozone Hole' over the Alps.—H. K. Paetzold & H. Zschörner. (*Z. Met.*, Aug. 1955, Vol. 9, No. 8, pp. 250–251.) Observations are reported which throw light on the relations between vertical air streams in the stratosphere and the vertical distribution of ozone.

551.510.535 **418**

Movements of Irregularities in the E Region.—T. Obayashi. (*J. Radio Res. Labs, Japan*, Jan. 1955, Vol. 2, No. 7, pp. 59–67; *Rep. Ionosphere Res. Japan*, June 1955, Vol. 9, No. 2, pp. 105–113.) Summer-night observations of fading patterns of transmissions from three broadcasting stations spaced about 150 km apart at the vertices of a triangle are consistent with large-scale movements in the E region, from east to west, with velocities of 50–150 m/s. Rapid fading, with a duration of a few hours, is considered to be due to scattering by E_s clouds showing turbulent velocities of 10–15 m/s.

551.510.535 **419**

World-Wide Daily Variations in the Height of the Maximum Electron Density of the Ionospheric F_2 Layer.—T. Shimazaki. (*J. Radio Res. Labs, Japan*, Jan. 1955, Vol. 2, No. 7, pp. 85–97.) A formula relating h_pF_2 to (M 3000) F_2 is applied to determine world-wide latitudinal variations of h_pF_2 for 1952, the results so obtained being in good agreement with results published by local observatories. In middle and higher latitudes h_pF_2 rises in summer daytime and falls in winter daytime. Near the equator there is a daytime rise throughout the year.

551.510.535 **420**

A Discussion on the Variation of F-Region Height.—B. Chatterjee. (*J. geophys. Res.*, Sept. 1955, Vol. 60, No. 3, pp. 325–327.) Further evidence is adduced in support of the author's suggestions regarding the distribution of ionization in the F region (2939 of 1954).

551.510.535 **421**

Contribution to the Study of the Effect of Geomagnetism on the F_1 Layer.—R. Eyfrig. (*C. R. Acad. Sci., Paris*, 19th Sept. 1955, Vol. 241, No. 12, pp. 759–761.) Results of an analysis of observations for 1943, 1944 and 1954 confirm the dip in the value of f_0F_1 at the magnetic equator reported by Ghosh (1983 of 1955). There is also a minimum in the values of the (M 3000)F_1 factor and the m.u.f. at the magnetic equator.

551.510.535 : 523.16 **422**

Radio Star Scintillations and the Ionosphere.—T. R. Hartz. (*Canad. J. Phys.*, Aug. 1955, Vol. 33, No. 8, pp. 476–482.) "The observed intensity at the surface of the earth of radiation at a frequency of 50 Mc/s from a radio star has been studied. A relationship is shown to exist between the fluctuations, or scintillations, in this observed radiation intensity and the angle of its incidence on the 400 km level of the earth's ionosphere. The occurrence of these scintillations is compared with other ionospheric phenomena as determined by vertical soundings from the earth. The probable cause of the fluctuations has been localized to a source in the high ionospheric regions."

551.510.535 + 550.385] : 523.75 **423**

Effect of Radiation from Solar Flares on the Ionosphere and the Earth's Magnetic Field.—R. N. Sedra & I. B. Hazzaa. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1070–1072.) "Variation in the earth's magnetic field and the corresponding variations in the ionic density of the F_1 layer due to solar flares are recorded. The value of the intensity of ultraviolet radiation before it enters the atmosphere is obtained. The constant relating the ionic density and the accompanying magnetic variation is also estimated."

551.510.535 : 550.38 **424**

Geomagnetic Distortion of the F_2 Region on the Magnetic Equator.—M. Hirono & H. Maeda. (*J. geophys. Res.*, Sept. 1955, Vol. 60, No. 3, pp. 241–255.) See 3257 of 1955.

551.510.535 : 550.38 **425**

Researches on the Geomagnetic Distortion in the Ionosphere.—(*Rep. Ionosphere Res. Japan*, June 1955, Vol. 9, No. 2, pp. 59–104.)

Part 1—Observed Facts of the Geomagnetic Distortion in the Ionosphere.—H. Maeda (pp. 59–70).

Part 2—Theoretical Study on the Geomagnetic Distortion in the F_2 Layer.—K. Maeda (pp. 71–85).

Part 3—Characteristics of the F_2 Layer on the Magnetic Equator.—M. Hirono & H. Maeda (pp. 86–94).

Part 4—Effect of Gravity and Ionization Pressure Gradient on the Vertical Drift in the F_2 Region.—M. Hirono (pp. 95–104).

World-wide observations made during the sunspot minimum period (1953–1954) and during the second Polar Year (1932–1933) are analysed and discussed theoretically. The anomalous distribution in the F_2 region above the magnetic equator may be explained by vertical electron drifts caused by the electric field. An ionospheric model consistent with the results of rocket experiments is used. The particle density at altitude 300 km must be of the order of 10^{10}/cm^3.

551.510.535 : 550.385 **426**

Studies on the Disturbances in F_2 Layer associated with Geomagnetic Disturbances.—K. Sinno. (*J. Radio Res. Labs, Japan*, Jan. 1955, Vol. 2, No. 7, pp. 69–76.) Earlier work is summarized and discussed. See also 3258 of 1955.

551.593.5 **427**

Day Sky Brightness to 220 km.—O. E. Berg. (*J. geophys. Res.*, Sept. 1955, Vol. 60, No. 3, pp. 271–277.) Measurements made with rocket-borne stereocameras suggest that the brightness is due entirely to Rayleigh scattering by air molecules. There is no evidence of high-altitude clouds.

551.594.5 : 621.396.11 **428**

Double-Doppler Radar Investigations of Aurora.—A. G. McNamara. (*J. geophys. Res.*, Sept. 1955, Vol. 60, No. 3, pp. 257–269.) The power spectra of auroral echoes of signals on 90·7 Mc/s are compared with observations of the visible aurorae and with simultaneous echoes of signals on 56 and 106 Mc/s, using standard high-resolution radar equipment. A number of auroral models are considered in a discussion of the results.

551.594.5 : 621.396.11 429

Auroral Echoes observed North of the Auroral Zone on 51·9 Mc/s.—R. B. Dyce. (*J. geophys. Res.*, Sept. 1955, Vol. 60, No. 3, pp. 317–323.) At a site north of the accepted auroral-zone maximum, radar echoes on a frequency of 51·9 Mc/s were readily obtained from the north, but practically none from the south; the range of the reflecting points was from 500 to 1100 km. These results are in agreement with the theory of reflection by aurorae suggested by Moore (*Trans. Inst. Radio Engrs*, 1952, PGAP-3, pp. 217–230) and developed by Booker et al. (1986 of 1955), requiring near-perpendicularity of radio ray paths to the lines of the earth's magnetic field. On transmitting towards the south, across visible aurorae, on 51·7 Mc/s, propagation associated with aurora was almost nonexistent, as required by the theory.

551.594.6 : 621.396.11 430

Measurement of the Arrival Angle of 'Whistlers'.—D. D. Crombie. (*J. geophys. Res.*, Sept. 1955, Vol. 60, No. 3, pp. 364–365.) It is suggested that Storey's theory on the origin of whistling atmospherics (142 of 1954) could be tested by determining their arrival angle by a phase-measurement method based on that of Ross et al. (2804 of 1951), using a pair of aerials spaced 15 km apart along the direction of the horizontal component of the geomagnetic field.

LOCATION AND AIDS TO NAVIGATION

621.396.93 : 621.396.677.3 431

Design for Wide-Aperture Direction Finders.—Benoit & Furlow. (See 330.)

621.396.932 432

Explanation of Difficulties in Direction-Finding on Ships when using Short or Intermediate Wavelengths.—G. Ziehm. (*Frequenz*, Sept. 1955, Vol. 9, No. 9, pp. 310–318.) See 1045 of 1955 (Troost).

621.396.933 433

Air Navigational Facilities.—H. S. Christensen. (*Proc. Radio Cl. Amer.*, 1955, Vol. 32, No. 1, pp. 3–8.) An outline of the method and equipment used in the U.S.A. for guiding and directing aircraft during flight, airport approach and landing.

621.396.933 434

Radio Navaids.—'Radiophare'. (*Wireless World*, Dec. 1955, Vol. 61, No. 12, pp. 576–577.) A comparison of the Decca and TACAN (125 of January) short-range radio-navigation systems.

621.396.96 : 551.578.1 435

Airborne Weather-Surveillance Radar.—(*Elect. J.*, 12th Aug. 1955, Vol. 155, No. 4026, pp. 546–548.) Description of commercially available equipment for installation in the nose of an aircraft. Operating wavelength is 5·6 cm for one type and 3·2 cm for another. The most important advantage for the pilot is the possibility of avoiding the centre of a storm. See also 1048 of 1955.

621.396.96 : 621.317.763.029.64 436

A Simplified Form of Microwave Interferometer for Speed Measurements.—Court. (See 533.)

621.396.96 : 621.374.4 : 621.318.435 437

Saturable-Reactor Frequency Divider.—Court & Scollay. (See 359.)

621.396.96 : 621.396.11 438

Determination of the Reflection Coefficient of the Sea, for Radar-Coverage Calculation, by an Optical Analogy Method.—G. W. G. Court. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 827–830.) The problem of the reflection of radio waves from a rough sea surface is considered by analogy with the reflection of light waves from a ground-glass surface. A typical radar vertical-coverage diagram derived by this method shows the effect of the variation of sea-surface conditions.

621.396.96 : 621.396.62 439

On the Problem of Optimum Detection of Pulsed Signals in Noise.—A. H. Benner & R. F. Drenick. (*RCA Rev.*, Sept. 1955, Vol. 16, No. 3, pp. 461–479.) "A detection philosophy is introduced which distinguishes only the presence or absence of a pulsed signal, avoiding the designation of signal location. This so-called interval detector is formulated statistically as a composite hypothesis problem and solved by decision function theory. The optimum decision rule is derived, its superiority in principle to others is proven, and an illustrative mechanization is described. The explicit evaluation of this optimum relative to other detection procedures has been achieved only in special border cases, one of which is included as an example."

MATERIALS AND SUBSIDIARY TECHNIQUES

531.788.7 440

Oscillographic Measurement of the Penning-Gauge Characteristics.—M. Varićak. (*J. sci. Instrum.*, Sept. 1955, Vol. 32, No. 9, pp. 346–348.) Optimum working conditions for the Penning vacuum gauge are readily attained by adjusting in accordance with an oscilloscope display of curves showing the variation of discharge current with magnetic field strength in the gauge.

535.215 : 537.311.33 441

Infrared Quenching and a Unified Description of Photoconductivity Phenomena in Cadmium Sulfide and Selenide.—R. H. Bube. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1105–1116.) An apparent paradox in the results presented by Rose (2002 of 1955) is discussed. A theoretical and experimental investigation shows that infrared quenching, 'superlinear' photocurrent, and the particular temperature dependence of photocurrent in CdS and CdSe may all be associated with the filling and emptying of a specific set of defect levels, as indicated by the location of the calculated Fermi level. Values are determined for the energy levels involved.

535.37 : 546.472.21 442

Determination of Effective Cross-Sections of Capture and Recombination of Thermal Electrons in ZnS-Cu,Co Phosphors.—Syui Syui-Yun. (*C. R. Acad. Sci. U.R.S.S.*, 1st Aug. 1955, Vol. 103, No. 4, pp. 585–588. In Russian.)

535.37 : 546.472.21 443

Effects of Infrared on Emission of ZnS:Cu Phosphors.—K. Nakamura. (*J. phys. Soc. Japan*, Aug. 1955, Vol. 10, No. 8, pp. 715–716.) Hex-ZnS:Cu phosphors containing 0·009% Ag, 2·5% NaCl and between 0 and 0·3% Cu, excited at various temperatures between $-25°$ and $+25°$C by ultraviolet radiation, show a spectral shift towards green under infrared illumination and towards blue under red light. These results are not consistent with Bube's conclusions (648 of 1951).

535.37 : 621.385.832 444

Transparent Phosphor Coatings.—F. J. Studer & D. A. Cusano. (*J. opt. Soc. Amer.*, July 1955, Vol. 45, No. 7, pp. 493–497.) Coatings of various materials have been deposited on glass surfaces by chemical reaction of the components in the vapour state. The most satisfactory material is ZnS, activated with As, Cu, Mn, P or Zn. Under cathode-ray excitation brightness values as high as 400 foot-lamberts are obtained at 20 kV and 1 μA/cm². Under ultraviolet excitation the response is low.

535.376 **445**

Reversible Impairment of Phosphors by Positive Ions.—W. Berthold. (*Naturwissenschaften*, Aug. 1955, Vol. 42, No. 15, pp. 436–437.) The decrease of luminescence of a ZnS-Ag phosphor bombarded by H_2^+ ions and its recovery on subsequent excitation by electrons were studied using specially gettered tubes with the screen deposited on a transparent conducting layer to facilitate photoelectric measurements. Under ionic bombardment the decrease of luminescence was first exponential and later in accordance with the expression $1/(1 + cNt)$, where N is the number of bombarding ions per sec and c is a parameter indicating the degree of impairment, its value depending on the energy of the bombarding ions. The recovery effect on subsequent electron bombardment varies inversely with the energy of the bombarding ions. The results indicate that part of the damage caused by the ions is permanent.

535.376 **446**

Influence of Alternating Electric Fields on the Light Emission of some Phosphors.—I. T. Steinberger, W. Low & E. Alexander. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1217–1222.) Experiments were made with various ZnS and ZnS:CdS phosphors. The brightness wave-form during fluorescence consists of two different pulses per cycle; the pulses corresponding to positive polarity are similar for all phosphors, those corresponding to negative polarity differ. Mechanisms affording possible explanations of the observations are discussed.

537.22 : 549.514.5 **447**

Adhesion and Charging of Quartz Surfaces.—W. R. Harper. (*Proc. roy. Soc. A*, 6th Sept. 1955, Vol. 231, No. 1186, pp. 388–403.) Experiments are reported which indicate that the charging of quartz surfaces by each other results from different orientation with respect to the crystal axes.

537.226 **448**

Conditions for Forming and Stability of [interface] Layers near Electrodes in Dielectrics.—Ya. N. Pershits. (*Zh. eksp. teor. Fiz.*, Feb. 1955, Vol. 28, No. 2, pp. 181–190.) An experimental investigation is reported on layers with unidirectional conductivity formed at the electrode/dielectric interface, and of the effects on the properties of these layers of various heat pretreatments and electric fields. The dielectrics included porcelain, eternit, mica and asbestos; quartz and alkali halides were investigated earlier (*ibid.*, 1947, Vol. 17, p. 251).

537.226/.227 : 546.48.882.5 **449**

Specific Heat Anomaly of Ferroelectric Cadmium Niobate at the Curie Temperature.—H. R. Danner & R. Pepinsky. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1215–1217.)

537.226.2 : 621.317.335.029.63 **450**

Decimetre-Wavelength Measurements of the Dielectric Behaviour of Various Clays as a Function of their Water Content.—E. Deeg & O. Huber. (*Naturwissenschaften*, Sept. 1955, Vol. 42, No. 18, p. 507.)

537.226.31 : 549.514.51 **451**

Dielectric Losses of Various Monocrystals of Quartz at Very Low Temperatures.—J. Volger, J. M. Stevels & C. van Amerongen. (*Philips Res. Rep.*, Aug. 1955, Vol. 10, No. 4, pp. 260–280.) Measurements were made on (*a*) clear, (*b*) irradiated, and (*c*) naturally smoky quartz and on (*d*) amethyst, at frequencies of 1 and 32 kc/s. Maxima exhibited by the dielectric-loss/temperature curve at temperatures between 14° and 150°K are related to lattice defects.

537.227 : 546.431.824-31 **452**

Optical Observations of the First-Order Transition of Barium Titanate Single Crystal at the Curie Point.—A. Nishioka. (*J. phys. Soc. Japan*, July 1955, Vol. 10, No. 7, pp. 535–540.)

537.227 : 546.431.824-31 **453**

Thermal Transition of Transparency in Ferroelectric Single Crystal of Barium Titanate.—T. Horie, K. Kawabe, M. Tachiki & S. Sawada. (*J. phys. Soc. Japan*, July 1955, Vol. 10, No. 7, pp. 541–549.)

537.227 : 546.431.824-31 **454**

Electrical Behaviour of Barium Titanate Single Crystals at Low Temperatures.—H. H. Wieder. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1161–1165.) Measurements were made over a temperature range including the phase transitions from tetragonal to orthorhombic at -5°C and from orthorhombic to rhombohedral at -92°C. As the temperature decreases through a transition, the coercivity, polarization-reversal time and spontaneous polarization decrease discontinuously. Dielectric constant varies linearly with switching time; this supports the theory of a relaxation mechanism for polarization reversal.

537.228.1 : 538.569.4 **455**

Radio-Frequency Absorption Spectra of [lattice] Vibrations of some Piezoelectric Solids.—J. Duchesne & A. Monfils. (*C. R. Acad. Sci., Paris*, 19th Sept. 1955, Vol. 241, No. 12, pp. 749–750.) Data for Rochelle salt, quartz and some organic substances of importance in biology are presented and discussed.

537.311.31 **456**

Resistance of Metals at High Current Densities.—V. V. Bondarenko, I. F. Kvartskhava, A. A. Plyutto & A. A. Chernov. (*Zh. eksp. teor. Fiz.*, Feb. 1955, Vol. 28, No. 2, pp. 191–198.) Results of an experimental investigation indicate that Ohm's Law is obeyed with an error of less than $\pm 7\%$ at current densities up to 10^7 A/cm² in Cu, Ag, Pt, Al, W and Fe at temperatures from a few tens of degrees C up to and beyond the melting point.

537.311.31 + 537.311.33] : 539.16 **457**

A Survey of Irradiation Effects in Metals.—J. W. Glen. (*Advances Phys.*, Oct. 1955, Vol. 4, No. 16, pp. 381–478.) Attention is confined to those changes which seem to be caused by disrupting the lattice of a solid without changing the nature of the molecules of which it is composed; the properties discussed include electrical conductivity, diffusion and thermoelectricity. A brief survey of the effects of radiation on semiconductors is also included. Over 200 references.

537.311.33 **458**

Theory of Equations of Transport in Strong Electric Fields.—I. M. Tsidil'kovski & F. G. Bass. (*Zh. eksp. teor. Fiz.*, Feb. 1955, Vol. 28, No. 2, p. 245.) Brief critical comment on 3519 of 1954 (Avak'yants). (Note: The original author's name was previously given erroneously as Abak'yants.)

537.311.33 459

To intensify the Study of Semiconductor Electronics.—A. Ioffe. (*Radio, Moscow*, Aug. 1955, No. 8, pp. 4–7.) Includes short summaries of papers on semiconductor physics read at the April 1955 meeting of the physico-mathematical section of the U.S.S.R. Academy of Sciences.

537.311.33 460

Graphical Treatment of Degeneracy in an Intrinsic Semiconductor.—G. Busch. (*Helv. phys. Acta*, 31st Aug. 1955, Vol. 28, No. 4, pp. 320–321. In German.) See also 1453 of 1954 (Mooser).

537.311.33 461

Recombination of Injected Carriers at Dislocation Edges in Semiconductors.—J. P. McKelvey & R. L. Longini. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1227–1232.) "The boundary conditions for carrier recombination at a lineage boundary in a semiconductor in the presence of a constant electric field are derived from kinetic considerations. A non-recombination probability, or 'transmission coefficient' T for a single charge carrier is assumed initially, and 'recombination velocities' at the lineage boundary are expressed in terms of this quantity. A simple experiment to determine the transmission coefficient is suggested. The relationship between the transmission coefficient and the cross section for recombination is investigated, . . ."

537.311.33 : 538.2 462

Relation of Magnetic Structure to Electrical Conductivity in NiO and Related Compounds.—R. R. Heikes. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1232–1234.) "A qualitative theory is presented in an effort to understand the insulating properties of NiO. If one generalizes this theory to include all stoichiometric binary compounds, having a transition element as cation and an element from group V or VI as anion, a rather startling correlation between the magnetic and electric properties is predicted. Ferromagnetic compounds should be good conductors with a positive temperature coefficient of resistivity while antiferromagnets should be insulators with a negative temperature coefficient of resistivity. The available data indicate that this correlation does exist."

537.311.33 : 546.26-1 463

Preliminary Study of the Electrical Properties of a Semiconducting Diamond.—J. J. Brophy. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1336–1337.)

537.311.33 : [546.28+546.289 464

Hot Electron Problem in Semiconductors with Spheroidal Energy Surfaces.—M. Shibuya. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1189–1191.) The 'hot-electron' problem, so named by Shockley (1011 of 1952), deals with departures from Ohm's law in semiconductors in strong electric fields. Discrepancies between experimental and theoretical results for Si and Ge are reduced by taking account of ellipsoidal energy surfaces in the Brillouin zone and of scattering by shear modes of vibration.

537.311.33 : [546.28+546.289 465

Intrinsic Optical Absorption in Single-Crystal Germanium and Silicon at 77°K and 300°K.—W. C. Dash & R. Newman. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1151–1155.) Absorption is assumed to take place by direct and indirect transitions; values of the energy thresholds corresponding to these transitions are estimated from the absorption spectra.

537.311.33 : 546.289 466

Dislocations in Germanium.—S. G. Ellis. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, pp. 1140–1146.) A microscope study of etched Ge crystals is reported, with photographic illustrations. Crystal dislocations forming networks are general; screw dislocation with large Burgers vectors are observed in some cases.

537.311.33 : 546.289 467

Rate-Grown Germanium Crystals for High-Frequency Transistors.—H. E. Bridgers & E. D. Kolb. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, pp. 1188–1189.) The production of *n-p-n* crystals for experimental tetrode transistors oscillating at frequencies > 1 kMc/s is described. Boron, with a segregation coefficient > 1, is used as an acceptor impurity.

537.311.33 : 546.289 468

Fast Neutron Bombardment of *p*-Type Germanium.—J. W. Cleland, J. H. Crawford, Jr, & J. C. Pigg. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1170–1181.) An extensive experimental investigation has been made. Analysis of the observed conduction indicates that the bombardment introduces three vacant states below the middle of the forbidden band. Changes observed after prolonged bombardment or room-temperature aging are discussed. Some bombardments were performed at temperatures from −165° to −90°C; complex relaxation effects were observed on warming. See also 3647 of 1955.

537.311.33 : 546.289 469

Properties of Grain Boundaries in Gold-Doped Germanium.—A. G. Tweet. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1182–1189.) Measurements were made of the variation of Hall effect with temperature in high-resistivity specimens of Au-doped Ge containing grain boundaries of known orientation; a new permanent-magnet apparatus used for the measurements is described. The results indicate the existence of a path of relatively low resistivity along the grain boundary, such as would be produced by an array of acceptor levels. A tentative explanation of the observed phenomena is based on Bardeen's theory of surface states (3086 of 1947). See also *ibid.*, pp. 1245–1248.

537.311.33 : 546.289 470

Hall Effect and Density of States in Germanium.—E. M. Conwell. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1195–1198.) An analysis is made of corrections required in calculations of activation energy of impurities, and of density of states, to take account of known complexities in the energy-band structure.

537.311.33 : 546.289 471

Avalanche Breakdown in Germanium.—S. L. Miller. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1234–1241.) Results of experiments support theory presented by Wolff (746 of 1955).

537.311.33 : 546.289 472

Magnetic Indications of Electronic Structure of the Conduction Band in Ge.—J. H. Crawford, Jr, H. C. Schweinler & D. K. Stevens. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1330–1331.) Data on the magnetic susceptibility of the charge carriers afford a means of deciding whether the energy surfaces in the conduction band of Ge are best represented by four or eight ellipsoids.

537.311.33 : 546.289 **473**

Methods for revealing *P-N* Junctions and Inhomogeneities in Germanium Crystals.—J. I. Pankove. (*RCA Rev.*, Sept. 1955, Vol. 16, No. 3, pp. 398–402.) Various methods are described involving etching during immersion in an electrolyte.

537.311.33 : 546.289 : 536.21 **474**

Thermal Conductivity of Germanium at Ambient Temperatures.—K. A. McCarthy & S. S. Ballard. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, p. 1104.) Measurements over the temperature range 5°–95°C are reported; the thermal conductivity varies approximately linearly over this range.

537.311.33 : 546.289 : 539.3 **475**

The Determination of the Elastic Constants of Germanium by Diffuse X-Ray Reflexion.—S. C. Prasad & W. A. Wooster. (*Acta cryst., Camb.*, 10th Aug. 1955, Vol. 8, Part 8, pp. 506–507.)

537.311.33 : 546.289 : 621.383.5 **476**

Influence of Diffusion Length and Surface Recombination on the Barrier-Layer Photoelectric Effect in Germanium.—Harten & Schultz. (See 614.)

537.311.33 : 546.682.86 : 538.63 **477**

On the Galvanomagnetic Effects in *n*-type Indium Antimonide.—Y. Kanai. (*J. phys. Soc. Japan*, Aug. 1955, Vol. 10, No. 8, pp. 718–719.) Because of the high charge-carrier mobility μ of InSb, usual theory valid for $\mu H \ll 10^8$ is expected not to apply above a certain value of field strength H. The Hall coefficient and the magnetoresistance effect were investigated at field strengths up to 9 kG, at temperatures of the order of − 150°C. The Hall coefficient was constant and independent of field strength; the magnetoresistance variations were inconsistent with the usual theory. The results are consistent with quantization of the electron orbit.

537.311.33 : 546.811-17 **478**

Manganese Impurity Centres in Grey Tin.—G. Busch & K. A. Müller. (*Helv. phys. Acta*, 31st Aug. 1955, Vol. 28, No. 4, pp. 319–320. In German.) Measurements of Hall effect in several samples at temperatures between 90° and 260°K give results consistent with the conclusion reached previously by Busch & Mooser (1476 of 1954) that the Mn is incorporated in lattice sites in α-Sn. The solubility of Mn in grey tin is considerably greater than in Ge.

537.311.33 + 535.215] : 546.863.221 **479**

Photoconductivity of Stibnite (Sb_2S_3).—S. Ibuki & S. Yoshimatsu. (*J. phys. Soc. Japan*, July 1955, Vol. 10, No. 7, pp. 549–554.) Experimental results indicate that stibnite is an *n*-type semiconductor. The peak spectral sensitivity at room temperature occurs at a wavelength of 770 mμ, the thermal activation energy determined from the temperature variation of the dark current between room temperature and 200°C is 0·48 eV, and the response time-lag is about 3 ms for variations of photocurrent around a steady value of 10 μA. The results are presented graphically.

537.311.33 : 621.396.822 **480**

Phenomenological Approach to 'Current Noise'.—D. A. Bell. (*Brit. J. appl. Phys.*, Aug. 1955, Vol. 6, No. 8, pp. 284–287.) Available experimental data on current noise in semiconductors are reviewed. The noise is associated with bulk conductivity rather than with contact phenomena. The inverse-frequency spectrum could be due either to a complicated diffusion process or, more probably, to the law relating mean-square perturbation and time for the whole population of carriers which is not to be regarded as an equilibrium system.

538.221 **481**

On an Empirical Formula for the Ferromagnetic Anisotropy Constant in Cubic Crystals.—M. Yamamoto. (*J. phys. Soc. Japan*, Aug. 1955, Vol. 10, No. 8, pp. 725–726.) Values derived from a formula presented previously (1077 of 1955) are compared with values found experimentally for Ni-Co and Ni-Cu alloys.

538.221 **482**

Effect of Nitrides on the Coercive Force of Iron.—J. Kerr & C. Wert. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, pp. 1147–1151.) Measurements indicate that the effect of including flat particles of nitride is most marked for particles whose largest dimensions are comparable with domain-wall thickness.

538.221 **483**

On the Loss of Texture in Tapes of a 50 Pct Ni-50 Pct Fe Alloy.—S. Spachner & W. Rostoker. (*J. Metals, N.Y.*, Aug. 1955, Vol. 7, No. 8, pp. 921–922.) Comparison of the crystal structures of annealed tapes of thickness 2, 1, ½, ¼ and ⅛ mil indicates loss of the characteristic texture associated with a square hysteresis loop at thicknesses < 1 mil. No explanation of the effect is yet established.

538.221 **484**

The Smallest Size of Weiss-Heisenberg Domains in Cobalt.—A. Knappwost. (*Naturwissenschaften*, Aug. 1955, Vol. 42, No. 16, p. 459.) A brief discussion indicates a volume equivalent to a cube of side about 16 Å as the smallest volume for spontaneously magnetized domains in Co. A full account is to be published in *Z. phys. Chem.*

538.221 **485**

Theory of Néel's Spikes and of the Coercive Force associated with the Development of Tubular Secondary Domains ('Schlauchziehen').—R. Brenner. (*Z. angew. Phys.*, Aug. 1955, Vol. 7, No. 8, pp. 391–397.)

538.221 : 538.569.4.029.6 **486**

Frequency Dependence of Magnetic Resonance in α-Fe_2O_3.—H. Kumagai, H. Abe, K. Ôno, I. Hayashi, J. Shimada & K. Iwanaga. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1116–1118.) Measurements in the wavelength range 5·4 mm–6·2 cm are reported.

538.221 : 538.632 **487**

Hall Effect in Permalloys.—S. Foner. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1079–1081.) Results of measurements on two different permalloys are compared with results on other alloys and are discussed in relation to the band structure of the materials.

538.221 : 546.73.241 **488**

Magnetic Properties of Cobalt Telluride.—E. Uchida. (*J. phys. Soc. Japan*, July 1955, Vol. 10, No. 7, pp. 517–522.) Experimental results presented indicate that the magnetic properties of this compound are closely similar to those of MnAs. The saturation magnetization is 7·52 G/g.

538.221 : 621.318.134 **489**

Magnetic Ferrites with Perminvar-Type [hysteresis] Loops.—M. Kornetzki, J. Brackmann & J. Frey. (*Naturwissenschaften*, Sept. 1955, Vol. 42, No. 17, p. 482.) Ni and Ni-Zn ferrites with small additions of MnO and

CoO exhibit the hysteresis-loop constriction characteristic of perminvar. If these ferrites are cooled slowly in a magnetic field, a rectangular hysteresis loop is obtained. A full account of the work is to be published in *Siemens-Z.*

538.221 : 621.318.134 490

The Behaviour of Ferrite Cores with Rectangular Magnetization Loop in a Nonuniform Magnetic Field or when provided with Gaps.—M. Kornetzki & H. Burger. (*Frequenz*, Sept. 1955, Vol. 9, No. 9, pp. 306–309.) Measurements are reported on MgMn-ferrite toroidal cores with (*a*) relatively small internal diameters, (*b*) nonuniform cross-sections, or (*c*) gaps. Where only a high remanence value is important, slight nonuniformities thus introduced are tolerable; highly rectangular loops can only be obtained with thin, continuous cores, but some nonuniformity of cross-section is tolerable. The results indicate that the rectangular loop in ferrites is a consequence of numerous individual magnetization reversals occurring within a narrow range of magnetic-field values.

538.221 : 621.318.134 491

Ferromagnetic Resonance in Magnesium-Manganese Aluminum Ferrite between 160 and 1 900 Mc/s.—H. Suhl, L. G. Van Uitert & J. L. Davis. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, pp. 1180–1182.) Measurements are reported on a disk specimen of stated composition magnetized normal to its plane. Graphs show the variation of resonance frequency with applied field, and the variation of μ'' with applied field at 310 and at 843·64 Mc/s.

538.221 : 621.318.134 : 538.569.4 492

Ferromagnetic Resonance in Two Nickel-Iron Ferrites.—W. A. Yager, J. K. Galt & F. R. Merritt. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1203–1210.) Further observations of (*a*) the variation of resonance field-strength with crystal orientation, and (*b*) the variation of the width of the resonance line as a function of temperature, support the conclusions reached previously [2446 of 1954 (Galt et al.)] regarding the mechanism producing losses in ferrites.

538.221 : 621.318.134 : 538.6 493

Peculiarities of the Faraday Effect in Paraffin-Ferrite Mixtures.—V. A. Fabrikov. (*C. R. Acad. Sci. U.R.S.S.*, 11th Aug. 1955, Vol. 103, No. 5, pp. 807–809. In Russian.) The Faraday effect was investigated at frequencies between 2·2 and 3 kMc/s at magnetic field strengths up to 1 500 oersted, using disks of paraffin-ferrite mixture with a typical composition 70% paraffin, 16% Ni-Zn ferrite and 14% rutile, added to increase the dielectric constant. The rotation of the plane of polarization was in a sense opposite to that observed in ferrite disks. The rotation was found to depend on the dimensions of the disks, the field strength, the frequency and the concentration of the ferrites in the mixture. The results are discussed on the basis of theories of the permeability tensor of ferromagnetics.

538.221 : 621.318.134 : 538.652 494

Magnetostriction and Permeability of Magnetite and Cobalt-Substituted Magnetite.—L. R. Bickford, Jr, J. Pappis & J. L. Stull. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1210–1214.) Measurements are reported for ferrites of various compositions at temperatures from 120° to 300°K. The substitution of small amounts of Co for divalent Fe produces an upward shift in the temperature at which maximum initial permeability occurs; this maximum is always associated with a change in the direction of easy magnetization.

538.221 : 621.318.134 : 621.372.413 495

Measurement of Susceptibility Tensor in Ferrites.—J. O. Artman & P. E. Tannenwald. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, pp. 1124–1132.) Detailed description of technique outlined previously (769 of 1954) in which a determination is made of the perturbation produced in cavity resonators by introducing ferrite specimens. Measurements on ferramic 1331 at 9·165 kMc/s are reported. Experimental results are discussed in relation to magnetic resonance theory.

538.221 : 621.395.625.3 496

Remanence Curve of Single-Domain Ferromagnetic Particles: Application to the Coatings of Sound-Recording Tapes.—E. P. Wohlfarth. (*Research, Lond.*, Aug. 1955, Vol. 8, No. 8, Supplement, pp. S42–S44.) An investigation is made of the dependence on applied field strength of the remanent magnetization of an assembly of randomly oriented particles with uniaxal anisotropy. There is some evidence that the characteristic curve of acicular particles is more suitable than that of nonacicular particles for purposes of magnetic recording.

538.221 : 681.142 497

Ferromagnetic Computer Cores.—C. F. Devenny, Jr, & L. G. Thompson. (*Tele-Tech & Electronic Ind.*, Sept. 1955, Vol. 14, No. 9, pp. 58–59 .. 94.) Recent improvements in the properties of rectangular-hysteresis-loop cores are illustrated by characteristic curves relating to 4–79 permalloy and 48% Ni-Fe alloy tape cores.

538.23 498

Reversible and Irreversible Magnetization Changes along the Hysteresis Loop.—M. Kersten. (*Z. angew. Phys.*, Aug. 1955, Vol. 7, No. 8, pp. 397–407.) The review presented refers mainly to the physics of the quasistatic hysteresis loop. 37 references include seven to other recent reviews.

538.23 499

Theory of Hysteresis Losses in the Rotating Magnetic Field.—M. Kornetzki & I. Lucas. (*Z. Phys.*, 27th Aug. 1955, Vol. 142, No. 1, pp. 70–82.) Experimental evidence indicates that hysteresis losses in a weak rotating field are greater, while those in a strong rotating field are smaller, than in an alternating field of the same strength. This is explained on the basis of Bloch-wall movements at low field strength; these walls disappear at high field strength.

546.87 : 538.632 500

Dependence of Hall Effect in Bismuth on Pressure.—L. F. Vereshchagin & A. I. Likhter. (*C. R. Acad. Sci. U.R.S.S.*, 11th Aug. 1955, Vol. 103, No. 5, pp. 791–794.) Measurements are reported at pressures up to 10 000 kg/cm² in magnetic fields up to 10 000 oersted; the Hall e.m.f. decreases with increasing pressure.

621.315.612 501

Materials used in Radio and Electronic Engineering. Ceramics. (*J. Brit. Instn Radio Engrs*, Oct. 1955, Vol. 15, No. 10, pp. 506–517.) A survey including tables of properties of various classes of ceramics and 111 references.

621.315.612.6 : 538.569.4 502

Paramagnetic Resonance Absorption in Glass.—R. H. Sands. (*Phys. Rev.*, 15th Aug. 1955, Vol. 99, No. 4, pp. 1222–1226.)

621.372.412.002.2 : 549.514.51 503

Vacuum-Plating Equipment for the Manufacture of Quartz Resonators.—H. Awender, E. Becker & K. Sann. (*Telefunken Ztg.*, March 1955, Vol. 28, No. 107, pp. 34–38. English summary, pp. 60–61.) Three receptacles on a turntable are (*a*) charged with crystal and evaporation metal, (*b*) roughly evacuated, (*c*) connected to oil diffusion pumps. Beneath each receptacle is an oscillatory circuit. When the nominal frequency of the crystal is attained the evaporation is interrupted by a magnetically actuated shutter. The frequency range covered is 50 kc/s–70 Mc/s.

537.311.33 504

Elektronische Halbleiter. [Book Review]—E. Spenke. Publishers: Springer, Berlin, 1955, 379 pp., D.M.34.50. (*Naturwissenschaften*, Aug. 1955, Vol. 42, No. 15, p. 448.) An authoritative introduction to the physical bases of dry rectifiers and transistors.

MATHEMATICS

51 505

On Perturbation Methods involving Expansions in Terms of a Parameter.—R. Bellman. (*Quart. appl. Math.*, July 1955, Vol. 13, No. 2, pp. 195–200.) The effectiveness of the method of expanding a solution of an equation in a power series in terms of a parameter may in many cases be greatly increased by expanding in terms of a suitably chosen function of the parameter; this is particularly the case when only positive values of the parameter enter. Examples treated to illustrate the method include van der Pol's equation.

512 506

Solution of Quartic Equations.—E. Astuni. (*Ricerca sci.*, Aug. 1955, Vol. 25, No. 8, pp. 2295–2312.) A method is described similar to that used for solving cubic equations (194 of January).

517 507

Confluent Hypergeometric Functions.—F. G. Tricomi. (*Z. angew. Math. Phys.*, 25th July 1955, Vol. 6, No. 4, pp. 257–274.) Discussion of a class of functions by means of which second-order linear differential equations can be integrated in closed form.

517 : 538.566 508

Asymptotic Expansion of Solutions of $(\nabla^2 + k^2)u = 0$.—Friedlander & Keller. (See 398.)

517 : 621.396.822 509

On Middleton's Paper "Some General Results in the Theory of Noise Through Nonlinear Devices".—J. S. Shipman. (*Quart. appl. Math.*, July 1955, Vol. 13, No. 2, pp. 200–201.) The hypergeometric functions in Middleton's formulae (3238 of 1948) can in some cases be reduced to polynomials or combinations of complete elliptic integrals which are special cases of 'Bennett functions' tabulated by Sternberg et al. (1779 of June).

518.3 510

Three-Dimensional Nomograms.—D. P. Adams. (*Product Engng*, Aug. 1955, Vol. 26, No. 8, pp. 186–191.)

517 511

Mathieusche Funktionen und Sphäroidfunktionen. [Book Review]—J. Meixner & F. W. Schäfke. Publishers: Springer, Berlin, 1954, 414 pp., D.M. 52.60. (*Z. angew. Phys.*, Aug. 1955, Vol. 7, No. 8, p. 408.)

517(083.5) 512

Tables des Fonctions de Legendre Associées, Calculées pour le Centre National d'Études des Télécommunications. [Book Review]—Publishers: Édition de la Revue d'Optique, Paris, 1952, 291 pp. (*Z. angew. math. Phys.*, 25th July 1955, Vol. 6, No. 4, p. 344.) The tables presented are useful for the numerical solution of potential problems in spherical co-ordinates.

MEASUREMENTS AND TEST GEAR

531.761 + 529.7 513

Definition of the Second of Time.—H. S. Jones. (*Nature, Lond.*, 8th Oct. 1955, Vol. 176, No. 4484, pp. 669–670.) The relations between the value of the second as defined by the International Astronomical Union [200 of January (Essen)], the value corresponding to the Universal time system and that corresponding to the Cs standard [3686 of 1955 (Essen et al.)] are discussed. When the relation between the mean solar second at the present time and the second as newly defined has been satisfactorily determined it will be possible immediately to relate the mean solar second to the fundamental unit of time by means of the Cs standard.

621.3.018.41(083.74) + 621.396.91 514

Standard Frequency Transmissions.—L. Essen. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 825–826.) Discussion on 3289 of 1954.

621.3.018.41(083.74) 515

Standard Frequency Transmission Equipment at Rugby Radio Station.—H. B. Law. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 825–826.) Discussion on 1724 of 1955.

621.3.018.41(083.74) : 621.317.761 516

The Standard Frequency Monitor at the National Physical Laboratory.—J. McA. Steele. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 825–826.) Discussion on 1725 of 1955.

621.317.3 : 621.3.018.75(083.74) 517

IRE Standards on Pulses: Methods of Measurement of Pulse Quantities, 1955.—(*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1610–1616.) Standard 55 I.R.E. 15.S1.

621.317.32.024 518

A Superconducting Modulator.—I. M. Templeton. (*J. sci. Instrum.*, Aug. 1955, Vol. 32, No. 8, pp. 314–315.) "A new type of d.c. amplifier for use at liquid helium temperatures, based on a magnetically modulated tantalum wire, is described. The input impedance is approximately $10^{-3}\Omega$, and noise figures down to approximately 2×10^{-11} V are fairly easily obtained. The application of this instrument as a null detector for the measurement of very small voltages in a liquid helium bath is described."

621.317.328.029.64 519

A New Perturbation Method for measuring Microwave Fields in Free Space.—A. L. Cullen & J. C. Parr. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 836–844.) "A short thin metal rod forms the perturbing element. In order to avoid confusing the reflection from this rod with unwanted reflection the rod is arranged to spin about an axis perpendicular to its length. The perturbation of the field at the source is therefore modulated at a characteristic frequency, and by using an a.c. amplifier, steady reflections can be eliminated. The apparatus described operates at a wavelength of about 3·2 cm. Experimental results are given which verify the theory for linearly polarized waves. Extension of the method to elliptically polarized waves is possible in principle, but inherent ambiguities may be troublesome in practice."

621.317.33 : 541.133 **520**

Measurement of Electrical Resistance of Water and Solutions.—A. G. Mamikonov. (*Bull. Acad. Sci. U.R.S.S., sér. tech. Sci.*, March 1955, No. 3, pp. 154–159. In Russian.) Results are reported of l.f. measurements on 0·1 N–1·0 N solutions of NaCl, $CuSO_4$, Na_2SO_4 and KCl, and on sea water. The effective capacitance with sea water was independent of the distance between the electrodes and of the presence of sand, but did vary with the concentrations of the solutions.

621.317.331 : 621.315.612.6 **521**

A Simple D.C. Method for the Determination of the Electrical Resistance of Glass.—H. E. Taylor. (*J. Soc. Glass Tech.*, Aug. 1955, Vol. 39, No. 189, pp. 193T–204T.) A method suitable at the low current densities obtained at room temperature is based on use of a *p*H meter. Resistivities from 10^8 to 10^{15} Ω.cm are measurable.

621.317.337 **522**

A Q Meter Method of measuring Very Low Reactance at High Frequencies.—J. P. Newsome. (*Electronic Engng*, Nov. 1955, Vol. 27, No. 333, pp. 494–498.) A method due to Lafferty (*Electronics*, Nov. 1951, Vol. 24, p. 126) is developed. Details are given of a circuit designed to measure the reactance of inductances as low as 0·003 μH at 1 Mc/s.

621.317.337 : 621.372.412 **523**

A New Method of determining the Quality Factor 'Q' of Piezoelectric Crystals.—H. Mayer. (*Onde élect.*, July 1955, Vol. 35, No. 340, pp. 692–699.) A fuller account of work described previously (2058 of 1955).

621.317.361 **524**

Designing a Precision Frequency-Measuring System.—A. S. Bagley & D. Hartke. (*Tele-Tech & Electronic Ind.*, Aug. 1955, Vol. 14, No. 8, pp. 84–85 .. 142.) By combining a transfer oscillator and frequency converter with a standard high-speed frequency counter the range from zero frequency to 12·4 kMc/s is covered with an accuracy within 1 part in 10^6.

621.317.382.029.64 **525**

The Measurement of Power at a Wavelength of 3 cm by Thermistors and Bolometers.—J. A. Lane. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 819–824.) "A description is given of measurements made on several thermistors and bolometers at wavelengths of 3·18 and 3·26 cm, using a water calorimeter to investigate their performance as indicators of absolute power. The calorimeter, details of which are given, was designed to measure powers of 2–5 watts; and by means of a 35 dB directional coupler known absolute powers at the milliwatt level were delivered to the thermistor and bolometer mounts. Values of efficiency, defined as the ratio of the power measured in a d.c. calibration to the net input power, of 0·87 to 0·91 were found, with no significant change on varying the operating resistance of the thermistors and bolometers over the range 150–300 ohms."

621.317.7 : 621.314.7 **526**

Simplified Transistor Test Equipment.—A. D. Bentley, S. K. Ghandi & V. P. Mathis. (*Tele-Tech & Electronic Ind.*, Sept. 1955, Vol. 14, No. 9, pp. 56–57 .. 120.) The short-circuit current-amplification factor of *p-n-p* junction transistors is measured by means of a battery-operated single-meter instrument, a 10-μA drop in base current being used as a step-waveform input signal.

621.317.7 : 621.396.822 **527**

Direct-Reading Noise-Figure Indicator.—C. E. Chase. (*Electronics*, Nov. 1955, Vol. 28, No. 11, pp. 161–163.) An instrument for measurements on travelling-wave valves etc. comprises a noise source modulated by a 60-c/s square wave, the noise figure being given by the noise-source power less the difference in dB between the modulated and unmodulated output components, assuming linear amplification and quadratic detection. A special feature is the use of simple circuits to take the logarithms of these two voltages and derive their difference, giving an indication which is linear on a dB scale.

621.317.725 **528**

Square-Law Detector for R.M.S. Voltages.—J. W. Sauber. (*Electronics*, Nov. 1955, Vol. 28, No. 11, pp. 170–172.) A voltmeter of amplifier-detector type is described in which an approximately parabolic characteristic consisting of linear segments is obtained by use of a series arrangement of biased Ge diodes. The voltage range is up to 320 V, the frequency range is from 5 c/s to 500 kc/s.

621.317.733 : [621.373.5+621.375.4 **529**

Low-Cost, Battery-Operated Oscillators and Detectors for A. C. Bridges.—M. D. Armitage. (*J. sci. Instrum.*, Aug. 1955, Vol. 32, No. 8, pp. 300–302.) A transistor oscillator with an output of 1 V across 1 000 Ω and a transistor transformer-coupled amplifier detector which will detect 0·01 mV are described; complete circuit diagrams are given.

621.317.75 **530**

The Writing Speed of Light-Beam Oscillographs.—W. Härtel. (*Frequenz*, Sept. 1955, Vol. 9, No. 9, pp. 319–324.) The performances of cathode-ray and light-beam oscillographs are compared; the maximum writing speed of the latter type is about 1·5 km/s.

621.317.75.088 **531**

The Accuracy of Estimation of Oscillograms.—W. Härtel. (*Frequenz*, Aug. 1955, Vol. 9, No. 8, pp. 264–273.) Discussion of errors in estimating photographed curves, due to inaccuracy of the observer rather than of the measurement apparatus.

621.317.755 : 537.52 **532**

The Plasmograph, a New Instrument for studying Periodically Variable Electric Discharges.—R. Ledrus, M. Hoyaux & A. Vanavermaete. (*Rev. gén. Élect.*, Aug. 1955, Vol. 64, No. 8, pp. 391–403.) Description of a c.r.o. instrument based on application of the theory of the Langmuir probe.

621.317.763.029.64 : 621.396.96 **533**

A Simplified Form of Microwave Interferometer for Speed Measurements.—G. W. G. Court. (*J. sci. Instrum.*, Sept. 1955, Vol. 32, No. 9, pp. 354–356.) The instrument described is suitable for the determination of the Doppler frequency shift due to the motion of a target. One aerial is used and a hybrid ring junction separates the transmitting and receiving paths, leakage from the transmitter providing local-oscillator power for the receiver.

621.317.784.029.62 534

A Wide-Band V.H.F. Wattmeter.—T. Takahashi & M. Arai. (*J. Radio Res. Labs, Japan*, Jan. 1955, Vol. 2, No. 7, pp. 99–105.) A resistance-loop directional coupler working through a coaxial line into a sensitive square-law valve voltmeter shunted by a variable capacitance is used to measure power in a transmission line. Wide-band characteristics are achieved by careful design of the coupler to secure that its resistance does not vary with frequency and by compensation in the measuring circuit for the variation of coupling coefficient with frequency. The instrument described measures power up to 60 W with an accuracy within 5% over the frequency range 30–200 Mc/s.

621.317.794 : 621.396.822 535

A Comparison of Two Radiometer Circuits.—S. J. Goldstein, Jr. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1663–1666.) A comparison is made between Dicke's method of measuring noise radiation (475 of 1947) and the method based on absence of correlation in noise received by two independent receivers. Expressions are derived for the weakest detectable signal in both methods; the two-receiver method is the more sensitive.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

535.24-1.08.7 : 621.383.4 536

Portable Radiation Detectors employing Photoconductive Cells.—J. C. S. Richards. (*J. sci. Instrum.*, Sept. 1955, Vol. 32, No. 9, pp. 340–343.) The design of battery-operated infrared-radiation detectors is discussed. Use of an electromagnetically maintained vibrating-reed shutter for chopping the incident radiation leads to an acceptable signal/noise ratio.

621.3.078(47) : 016 537

List of U.S.S.R. Literature on Automatic Regulation and Related Problems for 1954.—(*Avtomatika i Telemekhanika*, March/April & May/June 1955, Vol. 16, Nos. 2 & 3, pp. 219–224 & 317–320.) A bibliography of about 250 papers.

621.384.612 538

The Glasgow 340-MeV Synchrotron.—W. McFarlane, S. E. Barden & D. L. Oldroyd. (*Nature, Lond.*, 8th Oct. 1955, Vol. 176, No. 4484, pp. 666–669.) Illustrated description of a machine in use for experiments on the photodisintegration of nuclei and for meson physics.

621.385.833 539

The Lower Limit of the Aperture Error in Magnetic Electron Lenses.—W. Tretner. (*Optik, Stuttgart*, 1955, Vol. 12, No. 6, p. 293.) Correction to paper abstracted in 236 of 1955.

621.385.833 540

A Compact Console-Type Electron Microscope.—R. S. Page. (*Metrop. Vick. Gaz.*, Aug. 1955, Vol. 26, No. 433, pp. 248–254.) Description of the Type-EM4 model, a general-purpose instrument which can be used for reflection electron microscopy with non-ferrous specimens, as well as for the transmission type of record.

PROPAGATION OF WAVES

621.396.11 541

Propagation of Electromagnetic Waves over a Flat Earth across a Boundary separating Different Media, and Coastal Refraction.—K. Furutsu. (*J. Radio Res. Labs, Japan*, Jan. 1955, Vol. 2, No. 7, pp. pp. 1–49.) The general equation is formulated for vertically polarized waves in three-dimensional space, based on the Hertz vector, the analysis being valid for the case when the horizontally polarized wave induced at the boundary is negligible. A more general formulation is given in an appendix. The results are essentially the same as those obtained by Clemmow (3688 of 1953) for two-dimensional space. The refraction angle at a coast line is determined and the treatment is extended to propagation across successive lines of discontinuity.

621.396.11 542

Measurement of Field Intensity of Ground Wave over Mixed Paths.—Y. Aono & K. Muramatsu. (*J. Radio Res. Labs, Japan*, Jan. 1955, Vol. 2, No. 7, pp. 51–58.) Observations on frequencies from 1·85 to 4 Mc/s over mixed country near Tokyo, including both land and water, gave results in accordance with the theory of Furutsu (541 above).

621.396.11 543

Automatic Recording of the Direction of Arrival of Radio Waves reflected from the Ionosphere.—J. A. Thomas & R. W. E. McNicol. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 793–799.) The direction of arrival of 2·28-Mc/s echoes was measured using technique based on that of Ross et al. (2804 of 1951) and modified to record automatically the direction of arrival of all the resolved echoes. Signals proportional respectively to the vector sum and difference of the signals induced in two spaced aerials were amplified in separate receivers and the rectified outputs were displayed on a c.r.o. whose timebase was synchronized with the transmitter pulses. The display was photographed with successive 3-min exposures. The system was stable enough to run without attention for a week. Typical records are reproduced.

621.396.11 : 550.372 544

Variations of the Phase Constant of the Ground Wave.—M. Argirovic. (*Onde élect.*, July 1955, Vol. 35, No. 340, pp. 687–691.) Analysis presented previously (3687 of 1953) is extended to deal with propagation at frequencies higher than those used for broadcasting. Curves are presented showing the variation of the field strength and of the equivalent phase constant with distance for different values of ground constants and frequency.

621.396.11 : 551.510.5 545

On the Propagation of the Electromagnetic Waves in an Inhomogeneous Atmosphere.—Y. Nomura & K. Takaku. (*J. phys. Soc. Japan*, Aug. 1955, Vol. 10, No. 8, pp. 700–714.) A rigorous solution is obtained of Maxwell's equations for propagation in an inhomogeneous medium in which the dielectric constant is proportional to r^{2m}, where r is the distance from the centre of the earth. The expression for the dipole field in such a medium is generalized to apply in a medium in which the dielectric constant is an arbitrary function of r and is further transformed into a contour integral in a form convenient for calculations by the saddle-point method. Geometrical expressions are also derived for waves propagated in a duct.

621.396.11 : 551.510.535 546

The Reflexion of Vertically Incident Long Radio Waves from the Ionosphere when the Earth's Magnetic Field is Oblique.—J. Heading. (*Proc. roy. Soc. A*, 6th Sept. 1955, Vol. 231, No. 1186, pp. 414–435.) The ionosphere is considered as comprising a lower region, in which the influence of collision frequency is important, and an upper region in which the influence of the magnetic field predominates. The equations for the lower region are solved for an exponential distribution of electron density; those for the upper region are solved for the case of oblique propagation when the plane of incidence coincides with the magnetic meridian. Expressions are obtained for the reflection and transmission coefficients of the lower region and for the reflection and conversion coefficients of the upper region.

621.396.11 : 551.594.5 547
Auroral Echoes observed North of the Auroral Zone on 51·9 Mc/s.—Dyce. (See 429.)

621.396.11 : 551.594.5 548
Double-Doppler Radar Investigations of Aurora.—McNamara. (See 428.)

621.396.11.029.55 : 621.396.824 549
Some Considerations on Measurement of Bearings of the Incoming Short Waves: Part 2.—I. Kasuya. (*J. Radio Res. Labs, Japan*, Jan. 1955, Vol. 2, No. 7, pp. 77–83.) The measurements described in part 1 (2091 of 1955) were continued during a period of disturbed ionospheric conditions (18th–24th March 1954); previous conclusions regarding the effect of ionosphere tilting on lateral deviation are confirmed. Examples are given of lateral deviations corresponding to tilts in directions other than E–W. Tilting may correspond to curvature of the ionosphere with a space periodicity of 10–100 km.

621.396.11.029.62 : 621.396.82 550
Long-Distance V.H.F. Interference [in Britain].—T. W. Bennington. (*Wireless World*, Dec. 1955, Vol. 61, No. 12, pp. 592–596.) In conditions of abnormal propagation interference may be caused by stations distant 200–1 400 miles. The effect may be due to (*a*) intense ionospheric E_s, which permits propagation of frequencies up to about 60 Mc/s for about 1% of the time, mainly during summer daytime, or more frequently, (*b*) tropospheric inversion layers, which may produce interference over the frequency band 40–100 Mc/s at ranges up to 500 miles. The effects are unlikely to be serious for the f.m. sound services since strong signals in f.m. receivers tend to suppress weaker ones.

RECEPTION

621.396.62 : [621.376.23 + 621.376.33 551
A.M.-F.M. Demodulator.—P. Kundu. (*Wireless Engr*, Dec. 1955, Vol. 32, No. 12, p. 337.) A demodulation method is outlined based on the variation of slope of the flanks of pulses obtained by limiting sinusoidal signals. See also 2737 of 1955 (Das).

621.396.62 : 621.376.3 552
Causes of the 'Spitting' Effect in U.S.W. Transmission.—E. Belger. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, 1955, Vol. 7, Nos. 7/8, pp. 149–150.) Discussion of a defect observed in f.m. reception when the receiver bandwidth is too narrow; the effect is due to spurious amplitude modulation resulting from frequency deviations on the flanks of the filter characteristics.

621.396.62.012.3 553
Noise Factor Nomograph.—S. McCarrell. (*Electronics*, Nov. 1955, Vol. 28, No. 11, p. 174.) A chart for receiver design is presented, relating bandwidth, noise factor and power in the aerial circuit.

621.396.621 554
Sensitive Three-Valve T.R.F. Receiver.—H. E. Styles. (*Wireless World*, Dec. 1955, Vol. 61, No. 12, pp. 616–620.) The receiver incorporates the amplified a.g.c. system described by Amos & Johnstone (1092 of 1952) and the negative-feedback volume control described by Osbourne (*ibid*, April 1954, Vol. 60, No. 4, pp. 165–168).

621.396.621.54 555
On the Principle and Design of a Trigger Circuit of a Signal-Seeking Radio using 'Difference-Voltage'.—Chih Chi Hsu. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1591–1607.) Detailed discussion of the operation of a receiver in which the signal-seeking circuit is switched off, when the signal is found, by a pulse corresponding to the difference between the secondary and primary voltages of the i.f. output transformer. The arrangement provides constant anticipation in face of signal-strength variations; a simple expression is derived for the amount of anticipation. Errors arising in the trigger circuit and those due to nonlinearity of the tuner are examined. Numerical examples are given.

621.396.621.54.029.53/.55 556
Frequency Stability and Setting Accuracy of the Short-Wave Communication Receiver E 104.—W. Hasselbeck. (*Telefunken Ztg.*, March 1955, Vol. 28, No. 107, pp. 39–45. English summary, p. 61.) The receiver is mains-operated and covers the frequency range 1·1–30 Mc/s in 17 bands. The first i.f. is variable, the local oscillator being crystal controlled. The second i.f. is fixed at 525 kc/s. Methods of ensuring high frequency stability are described, including special elastic couplings for the tuning capacitors. The 'setting accuracy' of the frequency adjustment, considering all possible sources of error, is calculated on a basis of 99·7% probability to be within 1·5 kc/s.

621.396.822 557
Statistical Characteristics of Noise in the Presence of a Carrier Wave.—E. Divoire. (*Rev. HF, Brussels*, 1955, Vol. 3, No. 3, pp. 93–106.) Analysis is presented for a system using a linear detector and the results are compared with those obtained experimentally; the assumption of a Gaussian noise distribution appears to be justified.

621.396.822 : 621.317.794 558
A Comparison of Two Radiometer Circuits.—Goldstein. (See 535.)

STATIONS AND COMMUNICATION SYSTEMS

621.39 559
I.R.E. Symposium on Global Communications, Washington, D.C., June 23–25, 1954.—(*Trans. Inst. Radio Engrs*, Nov. 1954, Vol. CS-2, No. 3, pp. 1–112.) The text is given of over 20 papers presented.

621.39 560
I.R.E.-A.I.E.E. Symposium on Military Communications, New York, N.Y., April 28, 1954.—(*Trans. Inst. Radio Engrs*, Nov. 1954, Vol. CS-2, No. 3, pp. 113–173.) The text is given of 12 papers of which all but one were presented at the symposium, and all are reprinted from *Trans. Amer. Inst. elect. Engrs, Communication and Electronics*, November 1954.

621.39 : 621.376.5 **561**

Signal Analysis and Audio Characteristics of Pulse-Slope Modulation.—J. Das. (*Electronic Engng*, Nov. 1955, Vol. 27, No. 333, pp. 482–487.) Further theoretical and experimental work on the method described previously (2737 of 1955) is reported. Working with a pulse repetition frequency of 10 kc/s and pulse duration of 10 μs, the modulation is linear over an input a.f. volume range of 35 dB; the a.f. gain of the system is constant within ± 5 dB up to 3 kc/s and average distortion is $< 5\%$ for an input volume variation of 30 dB.

621.39.001.11 : 621.376.5 **562**

Electrical Pulse Communication Systems: Part 2—Message Encoding and Signal Formation in Pulse Systems.—R. Filipowsky. (*J. Brit. Instn Radio Engrs*, Oct. 1955, Vol. 15, No. 10, pp. 483–504.) "Five specifications should be known of an information source: dimensionality; maximum information content and peak rate of information production; average rate of information production; auto-correlation function; and statistical fine structure of the source. Various sources are discussed with reference to the specifications. Message encoding is split into two distinct operations: space matching and entropy matching. The former process has to reduce the dimensionality of the message space to match the three-dimensional signal space, the latter has to remove redundancy. Signal formation involves sampling, quantization and pulse modulation. The typical pulse waveforms are compared and their frequency spectra are listed. Signal encoding is considered as a linear transformation of the signal space into the channel space for the sole purpose of matching it to the requirements of a noisy channel of limited bandwidth." Part 1: 261 of January.

621.394.5/.6 **563**

Signalling Systems for Submarine Telegraph Circuits.—C. J. Hughes. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 831–835.)

621.396.3 **564**

Multiple-Frequency-Shift Teletype Systems.—D. B. Jordan, H. Greenberg, E. E. Eldredge & W. Serniuk. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1647–1655.) By shifting the carrier to one of a number of different frequencies instead of, as in ordinary frequency-shift keying, only one, it is possible to extend the pulse duration without lowering the transmission rate, so that narrower detection bandwidths can be used, with improved signal/noise ratio and reduced errors. Analysis is presented based on information theory. Detailed calculations are made for a 6-frequency and a 32-frequency system. Two-frequency equipment can be adapted; circuits for coding, filtering, etc. are described and experimental results reported.

621.396.4 : 621.396.65 **565**

An Introduction to some Technical Factors affecting Point-to-Point Radiocommunication Systems.—F. J. M. Laver. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 733–743.) A survey covering information-theory aspects, transmission systems, propagation factors, and coding, modulating and multiplexing methods; 100 references.

621.396.41 : 621.376.5 **566**

Quadriphase—A New Approach to Time-Division Multiplexing.—W. E. Evans & R. F. Lowe. (*Elect. Engng, N.Y.*, Aug. 1955, Vol. 74, No. 8, pp. 685–688.) Digest of paper to be published in *Trans. Amer. Inst. elect. Engrs, Power Apparatus and Systems*, 1955. The control of the timing in the various channels is derived from a system of four sinusoidal oscillations at sampling frequency, with 90° phase spacings, using resistance networks to obtain the intermediate phases.

621.396.41 : 621.396.11.029.6 **567**

System Parameters using Tropospheric Scatter Propagation.—H. H. Beverage, E. A. Laport & L. C. Simpson. (*RCA Rev.*, Sept. 1955, Vol. 16, No. 3, pp. 432–457.) "Accumulated data from published sources and from unpublished research on tropospheric forward scatter propagation are reviewed and condensed for practical application to FM communication systems. Antennas suitable for use on scatter paths are reviewed and the limitations on usable gains are discussed. General design methods for FM systems are presented and reduced to a design chart that includes the relationship of all parameters in a frequency-division multiplexed FM telephone system. Then follow computed values of transmitter power as functions of distance, frequency and antenna size for a number of systems of practical interest using tropospheric forward scatter."

621.396.41 : 621.396.65.029.6 **568**

Wide-Band Microwave Radio Links.—S. Fedida. (*Marconi Rev.*, 3rd Quarter 1955, Vol. 18, No. 118, pp. 69–94.) "A broad survey of the techniques used in the construction of wideband microwave links is given, with particular emphasis on the applications of travelling wave tubes, in these links. Some of the design requirements are examined in the light of the conclusions of the C.C.I.R. Study Group IX, meeting at Geneva, at the end of 1954."

621.396.71 **569**

Rugby Radio Extension.—(*Elect. J.*, 5th Aug. 1955, Vol. 155, No. 6, p. 461.) Brief description of the British Post Office station extension opened in July 1955 and housing 28 30-kW transmitters for the frequency range 4–27·5 Mc/s, controlled from a central cabin.

621.396.931 **570**

The Use of Radiotelephony for the Control of Works Transport.—E. N. Farrar & M. T. O'Dwyer. (*J. Brit. Instn Radio Engrs*, Oct. 1955, Vol. 15, No. 10, pp. 519–525.)

SUBSIDIARY APPARATUS

621-526(083.74) **571**

IRE Standards on Graphical and Letter Symbols for Feedback Control Systems, 1955.—(*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1608–1609.) Standard 55 I.R.E. 26.S1.

621.311.6 : 621.316.722.1 **572**

Low-Ripple Adjustable Regulated Power Supply.—G. Hetland, Jr, & R. R. Buss. (*Electronics*, Nov. 1955, Vol. 28, No. 11, pp. 164–165.) A unit giving an output of 350–1 000 V with an output impedance $\ngtr 10\Omega$ is described.

621.314.1 : 621.373.52 : 621.314.7 **573**

Transistor D.C. Converters.—L. H. Light & P. M. Hooker. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 775–786. Discussion, pp. 786–792.) A transistor in a relaxation oscillator is arranged to interrupt a l.v. circuit; energy is stored in the transformer inductance during the 'on' period and is delivered to the output circuit at an increased voltage during the 'off' period, the circuit thus acting as a step-up device. Design and operation of practical arrangements are discussed. A shorter account of the work is given in *Wireless World*, Dec. 1955, Vol. 61, No. 12, pp. 582–586.

621.314.63 574

Germanium Power Rectifiers.—G. A. Carrick. (*Trans. S. Afr. Inst. elect. Engrs*, July 1955, Vol. 46, Part 7, pp. 197–211. Discussion, pp. 211–217. Paper reprinted in *B.T.-H. Activ.*, Nov./Dec. 1955, Vol. 26, No. 6, pp. 173–185.)

621.316.722.1 575

Improving the Performance of the Series Electronic Voltage Regulator.—G. H. T. Hatton. (*Proc. Instn Radio Engrs Aust.*, Sept. 1955, Vol. 16, No. 9, pp. 308–311.) "Compensating networks for improving the performance of the conventional series electronic voltage-regulator circuit are analysed. The theory is compared with measurements made on a fully compensated circuit."

621.316.722.1 576

Effects of Heater-Voltage Variations of Valves in Certain Stabilizer Circuits.—F. A. Benson & G. V. G. Lusher. (*Electronic Engng*, Nov. 1955, Vol. 27, No. 333, pp. 502–505.) Calculations further to those presented previously (1925 of 1954) show that, in series-parallel stabilizer circuits having a resistor in the cathode lead of the amplifier, the effect of heater-voltage variations is not serious because the two valves produce output-voltage changes of opposite sign.

TELEVISION AND PHOTOTELEGRAPHY

621.397.242 577

Television Transmission on Cables.—K. Barthel. (*Arch. elekt. Übertragung*, Aug. 1955, Vol. 9, No. 8, pp. 341–349.) Distortion produced by s.s.b. transmission can be corrected by (*a*) multiplicative mixing at the far end with a carrier of exactly correct phase, or (*b*) modulation to a depth > 100% so as to provide favourable operating conditions for the line amplifiers. Correction of distortion introduced by the line itself is performed by attenuation and phase equalizers; arrangements appropriate for line sections of average length 9·3 km transmitting frequencies from 300 kc/s to 6·2 Mc/s are briefly indicated.

621.397.26 : 621.396.65.029.6 578

Microwave Television Transmission Systems.—W. L. Wright. (*Marconi Rev.*, 3rd Quarter 1955, Vol. 18, No. 118, pp. 95–118.) The suitability for television purposes of the microwave radio links discussed by Fedida (568 above) is compared with that of cable relay systems. Modulation and demodulation equipment is described with special consideration of the design of f.m. oscillators.

621.397.335 : 621.3.018.75 579

Television Sync-Pulse Spectrum.—W. T. Cocking. (*Wireless Engr*, Dec. 1955, Vol. 32, No. 12, pp. 313–315.) Fourier-series calculations relating to nonsinusoidal waveforms can be simplified by adding or multiplying some well known series. The structure of the British television synchronizing signal is considered as an example of application of this method.

621.397.5 : 535.623 580

The ABC's of Color Television.—J. M. Barstow. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1574–1579.) A description of the N.T.S.C. system in a form suitable for nonspecialist engineers.

621.397.5 : 535.623 581

Colour Television in the U.S.A.—C. G. Mayer. (*Electronic Engng*, Nov. 1955, Vol. 27, No. 333, pp. 488–491.) A brief review of progress made since the previous report (3367 of 1954).

621.397.5 : 535.623 582

A Sequential System of Image Transmission in Natural Colours.—A. M. Varbanski. (*Vestnik Svyazi*, 1955, No. 3, pp. 6–9.) The physiology of colour vision is discussed and a sequential system of colour television adopted at the Moscow Experimental Station for Colour Television is described. The distortion peculiar to this type of transmission is considered, and also the special requirements imposed on film transmission.

621.397.5 : 535.623 583

Differential Chromaticity Thresholds in the Direction of Primary Blue in a Trichromatic-Synthesis System.—P. Billard. (*Rev. d'Optique*, July/Aug. 1955, Vol. 34, Nos. 7/8, pp. 371–405.) Detailed report of experiments made in connection with colour-television studies. The results indicate that different colours should be compared at the maximum brightness levels which they can attain in a trichromatic synthesis. This applies particularly for hues close to primary blue; if the comparison is made with the colours at the same brightness level the sensitivity of the eye to small chromaticity differences is overestimated.

621.397.6 584

Phase Pre-correction in Television Transmitters and Receivers.—J. Peters. (*Tech. Hausmitt. Nordw-Dtsch. Rdfunks*, 1955, Vol. 7, Nos. 7/8, pp. 125–128.) Results of a comprehensive investigation are reviewed. Mathematical analysis of transients indicates that picture quality is effectively improved by phase equalization in the video-frequency channel only; these results are confirmed by measurements. Reasons are given for effecting the equalization entirely at the transmitter.

621.397.6 : 622.4 585

Operation of Television Installations in Open-Cast Lignite Mining.—W. Meyer. (*Elektrotech. Z., Edn B*, 21st Aug. 1955, Vol. 7, No. 8, pp. 286–289.) Operation in mines spanning the range from 117 m above sea level to 77 m below sea level is discussed. Television equipment is particularly useful for the dredger-man, since dredgers 90 m long may be used. Equipment is described with special reference to requirements for dust exclusion and proper illumination.

621.397.6 : 778 586

Simple Equipment for obtaining Photographs of Single Television Pictures.—W. Dillenburger & J. Wolf. (*Frequenz*, Sept. 1955, Vol. 9, No. 9, pp. 296–298.) A switching circuit is described for producing a single-scan picture with the same brightness values as in continuous operation.

621.397.6.001.4 587

The Test-Line Technique in Television.—H. E. Fröling. (*Tech. Hausmitt. NordwDtsch. Rdfunks*, 1955, Vol. 7, Nos. 7/8, pp. 129–138.) Details are given of a method in which a special signal for testing transmission characteristics during a programme is inserted at the end of the vertical blanking interval so as not to appear in the ordinary picture. The test waveform may include white, black and grey levels, as well as pulses for testing linearity, reflections and amplitude and phase variations.

621.397.61 : 535.623 588

Matrixing and encoding Color for Telecasting.—H. Taub, J. Rabinowitz, D. Schacher & M. Star. (*Electronics*, Nov. 1955, Vol. 28, No. 11, pp. 140–145.) Details are given of a unit which accepts as inputs the blanking, synchronizing, subcarrier, burst-key and individual colour signals and forms them into the composite signal appropriate for feeding to a transmitter operating on the N.T.S.C. colour-television system.

621.397.61 : 778.55/.6 589

Control of Light Intensity in Television Projectors.—K. Sadashige & B. F. Melchionni. (*J. Soc. Mot. Pict. Telev. Engrs*, Aug. 1955, Vol. 64, No. 8, pp. 416–419.) The problem discussed is that of controlling the intensity of the source illuminating colour film when using a vidicon camera tube, so as to maintain the video signal level independent of the average film density. An equipment is described in which the compensation is effected by controlling the angular position of a filter wedge in the projector condenser lens by means of a servomechanism.

621.397.61.001.4 590

Test Equipment for the Belgian Television Transmitters.—W. Hamoir. (*Rev. HF, Brussels*, 1955, Vol. 3, No. 3, pp. 107–116.)

621.397.611.2 591

The Development of the C.P.S.-Emitron Television Camera Tube.—J. D. McGee. (*Arch. elekt. Übertragung*, Aug. 1955, Vol. 9, No. 8, pp. 355–362.) Refinements incorporated in later versions of this tube include use of a mesh close in front of the target to stabilize the tube against extra-strong illumination, and use of slightly conducting glass as the material for the target plate to increase the storage capacity and thus extend the contrast range without introducing time lag.

621.397.62 592

Circuits and Components for 90° Scanning.—(*Mullard tech. Commun.*, Aug. 1955, Vol. 2, No. 14, pp. 89–111.) The issue includes papers on line and frame timebase circuits for 90° scanning, together with some details of the deflection units, c.r. tubes and valves.

621.397.62 : 621.373.4 593

Frequency Characteristics of Local Oscillators.—W. Y. Pan. (*RCA Rev.*, Sept. 1955, Vol. 16, No. 3, pp. 379–397.) An examination is made of the effect on frequency stability of the heat developed during operation in local oscillators used in v.h.f. and u.h.f television receivers. Compensation methods, especially for the warm-up period, are indicated.

621.397.62 : 621.375.221.029.62 594

Phase-Linear Television Receivers.—A. van Weel. (*Philips Res. Rep.*, Aug. 1955, Vol. 10, No. 4, pp. 281–298.) A receiver with phase-linear i.f. amplifier is described, using conventional circuits and giving normal selectivity. The performance compares favourably with that of receivers in which phase errors are compensated in the video-frequency stages of either transmitter or receiver.

621.397.8 595

The Fixing of Nonlinearity Tolerances for Television Transmission Systems.—S. Funk. (*NachrTech.*, Aug. 1955, Vol. 5, No. 8, pp. 347–350.) The permissible nonlinearity is discussed in relation to the physiology of vision; a maximum picture contrast of about 1 : 100 is assumed, with a grey scale of 20 distinguishable steps. In relation to a normalized system transfer characteristic with unity slope, the tolerance on the slope is about 10% up or down. A special signal and test method are described for adjusting the system to conform to these tolerances.

621.397.8 596

The Influence of the Optical System on the Modulation Depth in Television Pickup Devices.—W. Dillenburger. (*Frequenz*, Sept. 1955, Vol. 9, No. 9, pp. 293–296.) Measurements on known types of objective are reported. It is possible to stop them down so that in practice they have no influence on the frequency variation of modulation depth. Loss of modulation is bound to occur when a television picture is recorded and rescanned or when a standards conversion is effected.

TRANSMISSION

621.396.61 : 621.376.222 597

Series Tube modulates Amplifier Screen-Grid.—W. B. Bernard. (*Electronics*, Nov. 1955, Vol. 28, No. 11, pp. 158–160.) Low-level modulation circuits are discussed in which the modulating valve is in series with the screen-grid supply to the modulated amplifying valve. Modulating signals ranging from d.c. to very high frequency can be handled. Arrangements are described using feedback to correct a nonlinear relation between the screen-grid voltage and the power output. A circuit for protecting the modulated valve is also described. The system simplifies controlled-carrier operation.

VALVES AND THERMIONICS

621.314.63 598

The Dependence of the Current Density of a *p-i-n* Rectifier on the Width of the Intermediate Zone.—A. Herlet. (*Z. Phys.*, 20th July 1955, Vol. 141, No. 3, pp. 335–345.) The current density increases with increasing intermediate-zone width for values of the latter up to twice the carrier-diffusion length, but decreases for intermediate-zone widths greater than this. The mechanism is discussed on the basis that in the first case the separate zones constitute current sources which act in combination, while in the second case the paths in the different zones combine as for ordinary series resistances.

621.314.63 : [546.28 + 546.289 599

On the Inductive Part in the A.C. Characteristic of the Semiconductor Diodes.—Y. Kanai. (*J. phys. Soc. Japan*, Aug. 1955, Vol. 10, No. 8, pp. 719–720.) The susceptance of Si and Ge *p-n* junction diodes was determined at frequencies from 3 kc/s to 5 Mc/s. With a forward bias voltage the susceptance decreased at high frequencies, the experimental results thus deviating from Shockley's theory. This decrease can be explained by postulating a series inductive component associated with the conductivity modulation caused by hole injection.

621.314.63 + 621.314.7] : 621.396.822 600

Theory of Shot Noise in Junction Diodes and Junction Transistors.—A. van der Ziel. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1639–1646.) Noise caused by random diffusion of minority carriers and random recombination of minority and majority carriers is investigated by means of a transmission-line analogy proposed by North, in which the diffusion corresponds to the presence of series noise-voltage generators while the recombination corresponds to parallel noise-current generators. For low frequencies the equivalent circuits thus derived correspond to those derived previously, but for high frequencies the new method gives a more accurate representation of the noise properties. The theory takes account of volume recombination only.

621.314.632 : 621.396.822 **601**

Noise in Silicon Microwave Diodes.—G. R. Nicoll. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 786–792.) Discussion on 294 of 1955.

621.314.7 **602**

Transistors and their Production.—J. Malsch. (*Elektrotech. Z., Edn B*, 21st Aug. 1955, Vol. 7, No. 8, pp. 273–278.) A survey including a brief illustrated account of the production of alloyed-junction transistors.

621.314.7 **603**

'Step' and 'Oscillation' Phenomena in the Collector of A-Type Transistors.—M. Kikuchi & Y. Tarui. (*J. phys. Soc. Japan*, Aug. 1955, Vol. 10, No. 8, pp. 722–723.) Further investigation of the 'step' effect (880 of 1955), using the transistor collector as a diode and the emitter as subsidiary electrode, showed that the 'step' occurred earlier in the presence of hole current from the emitter. An 'oscillation' in the collector voltage was sometimes observed, following just after the 'step'. An oscillogram is shown and a possible explanation of the phenomenon is very briefly discussed. See also 3070 of 1954 (Lempicki & Wood).

621.314.7 **604**

Self-Bias Cut-Off Effect in Power Transistors.—N. H. Fletcher. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, p. 1669.) Analysis is given which is valid for higher levels of injected-carrier density than those discussed previously (2463 of 1955).

612.314.7 : 621.317.7 **605**

Simplified Transistor Test Equipment.—Bentley, Ghandi & Mathis. (See 526.)

621.314.7 : 621.396.822 **606**

Measurements of Junction-Transistor Noise in the Frequency Range 7-50 kc/s.—W. L. Stephenson. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 753–756. Discussion, pp. 786–792.) The measurements were made using a superheterodyne arrangement with narrow-band filter in the i.f. amplifier, giving constant bandwidth over the frequency range; the influence of collector voltage and current and of temperature was studied. Results are analysed on the basis of two equivalent noise generators in the input circuit; they indicate that (*a*) the noise factor exhibits a minimum at about 25 kc/s, (*b*) the optimum source resistance is independent of frequency, (*c*) the optimum source resistance is not directly related to the input resistance, and (*d*) the noise is independent of collector voltage.

621.314.7.012.8 **607**

The Natural Equivalent Circuit of Junction Transistors.—J. Zawels. (*RCA Rev.*, Sept. 1955, Vol. 16, No. 3, pp. 360–378.) The equivalent circuit is derived by considering the details of transistor action, the method being a generalization of that presented previously (300 of 1955). The resulting circuit comprises a passive network in cascade with a frequency-independent amplifier. A method is indicated for computing the parameters of the equivalent circuit from spot measurements of the *h* parameters.

621.383.2 **608**

New Photoemissive Cathodes of High Sensitivity.—A. H. Sommer. (*Rev. sci. Instrum.*, July 1955, Vol. 26, No. 7, pp. 725–726.) Photocathodes consisting of Sb and more than one alkali metal in combination show much higher sensitivity in the visible spectrum, especially to red light, than those containing only one such metal.

621.383.2 **609**

Discontinuities in the Saturation Curves of Vacuum Photocells.—J. S. Preston & G. W. Gordon-Smith. (*Brit. J. appl. Phys.*, Sept. 1955, Vol. 6, No. 9, pp. 329–333.) Conditions under which certain types of photoemissive cell can operate in either of two stable states are discussed. The best conditions for saturation and regular behaviour are obtained if the inner surface of the envelope is highly conducting and is in good connection with the anode, but insulated from the cathode.

621.383.27 **610**

Instability of Photomultipliers.—L. P. de Valencé. (*Brit. J. appl. Phys.*, Sept. 1955, Vol. 6, No. 9, pp. 311–313.) Dark-current instability of certain types of electrostatically focused tubes operated with cathode at high negative potential is ascribed to defocusing effects between the photocathode and first dynode and to positive envelope potentials. Stability is secured by connecting the glass envelope to the cathode or second dynode.

621.383.4 **611**

High-Sensitivity Photoconductor Layers.—S. M. Thomsen & R. H. Bube. (*Rev. sci. Instrum.*, July 1955, Vol. 26, No. 7, pp. 664–665.) Microcrystalline powders of CdS or CdSe fixed with plastic material, or sintered on to suitable surfaces, give large-area layers having most of the desirable characteristics of single crystals, with advantages in increased red sensitivity, in the case of CdS layers, and in the ohmic character of sintered layers with silver-paste electrodes.

621.383.4 **612**

Large-Area High-Current Photoconductive Cells using Cadmium Sulfide Powder.—F. H. Nicoll & B. Kazan. (*J. opt. Soc. Amer.*, Aug. 1955, Vol. 45, No. 8, pp. 647–650.) Photoconducting layers are prepared from CdS powder, with particle sizes $< 50\,\mu$, and a binder such as ethyl cellulose or polystyrene. The layer is applied to a support such as glass by spraying, silk screening, etc. Various possible constructions are described; cells can readily be made capable of carrying photocurrents of 1A or more in room light. Build-up and decay time constants of the order of 0·1 sec have been obtained.

621.383.5 **613**

The Stability of Selenium Photocells.—H. Wörner. (*Z. Met.*, Aug. 1955, Vol. 9, No. 8, pp. 248–250.) Tests made on barrier-layer cells after two years' service indicate an appreciable decrease of sensitivity. The amount of the decrease varies greatly from cell to cell and may be as high as 30%; it depends on both fatigue and aging effects.

621.383.5 : 537.311.33 : 546.289 **614**

Influence of Diffusion Length and Surface Recombination on the Barrier-Layer Photoelectric Effect in Germanium.—H. U. Harten & W. Schultz. (*Z. Phys.*, 20th July 1955, Vol. 141, No. 3, pp. 319–334.) Photovoltaic cells of large area can be produced by evaporating a transparent gold film on to Ge plates. From the sensitivity/wavelength characteristic the diffusion length of the minority carriers can be deduced using 'thick' Ge plates, and the surface recombination velocity can be deduced using 'thin' plates.

621.383.5 : 621.314.63 : 621.375.3 **615**

A Germanium Diffused-Junction Photoelectric Cell.—J. M. Waddell, S. E. Mayer & S. Kaye. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 757–762. Discussion, pp. 786–792.) Descriptions are given of practical forms of a cell in which the *p-n* junction is produced by impurity diffusion; desirable features are low noise, high sensitivity, and extended long-wave response. Temperature rise is more important than absolute temperature level for determining the maximum ratings. Applications discussed include a magnetic amplifier making use of the high forward conductance of the cell.

621.385 + 621.314.7] : 621.396.822 **616**

Characterization of the Noise of Tubes and Transistors by Four Measurable Quantities.—H. Groendijk & K. S. Knol. (*Tijdschr. ned. Radiogenoot*, July 1955, Vol. 20, No. 4, pp. 243–256. In English.) The problem is investigated on the one hand by considering the mechanisms of noise production, and on the other by considering the valve or transistor as a linear quadripole. In general, the four measurable quantities characterizing the noise are not simply related to the physical phenomena giving rise to noise. The frequency dependence of the noise-characterizing quantities is discussed.

621.385.002.2 **617**

Thermionic Valves of Improved Quality for Government and Industrial Purposes.—E. G. Rowe, P. Welch & W. W. Wright. (*Proc. Instn elect. Engrs*, Part B, Nov. 1955, Vol. 102, No. 6, pp. 801–803.) Discussion on 2789 of 1955.

621.385.029.6 **618**

Focusing Electron Beams by Magnetic Fields.—W. Kleen & K. Pöschl. (*Arch. elekt. Übertragung*, July 1955, Vol. 9, No. 7, pp. 295–298.) A simplified analytical method is developed for determining the mean radius and the maximum radial expansion of a cylindrical beam from a concave cathode with either uniform or periodic magnetic focusing.

621.385.029.6 **619**

Theory of Coupled Space-Charge Waves.—F. Paschke. (*Frequenz*, Aug. 1955, Vol. 9, No. 8, pp. 273–279.) Pierce's theory developed for travelling-wave valves is extended by taking account of the displacement current in the direction of the beam. Calculation of the gain is reduced to a simple boundary-value problem. The theory is applicable only for very low beam current, very short wavelengths or very high coupling resistance. Calculations for an amplifier valve with two adjacent flat beams give a gain smaller by a factor of $1/\sqrt{2}$ than for a valve with overlapping beams.

621.385.029.6 **620**

The Carmatron, a New Electronically Tuned Wide-Band Oscillator.—R. Warnecke, J. Nalot, B. Epsztein & O. Doehler. (*C. R. Acad. Sci., Paris*, 12th Sept. 1955, Vol. 241, No. 11, pp. 695–698.) A valve combining desirable features of the magnetron and the M-type carcinotron has an axial cathode surrounded by a coaxial anode constituted by a slightly dispersive interdigital delay line. H.f. energy is extracted by a coaxial line. A magnetic field is applied in a direction such that the output and the end of the delay line are coupled not by the h.f. field but by the circulating electron beam. The valve will oscillate when the electron transit angle is a multiple of 2π. Electronic tuning bands of 25%–30% are possible in conjunction with high efficiencies. The theory has been verified by experiments on a valve for the 3-kMc/s band.

621.385.029.6 **621**

Periodic-Magnetic-Field Focusing for Low-Noise Traveling-Wave Tubes.—K. K. N. Chang. (*RCA Rev.*, Sept. 1955, Vol. 16, No. 3, pp. 423–431.) The beam-focusing arrangements described comprise a magnet producing a uniform field in the gun region, a magnet system producing a space-periodic field in the helix region, and a matching device between the two. Measurements on a valve operating at 3 kMc/s indicate that gain and noise figures are comparable with those for a valve using a uniform focusing field.

621.385.029.6 **622**

Extension of 'The Effect of Initial Noise Current and Velocity Correlation on the Noise Figure of Traveling-Wave Tubes'.—W. R. Beam. (*RCA Rev.*, Sept. 1955, Vol. 16, No. 3, pp. 458–460.) Amendments are proposed to the analysis presented by Bloom (3788 of 1955).

621.385.029.6 **623**

Positive-Ion Drainage in Magnetically Focused Electron Beams.—M. E. Hines, G. W. Hoffman & J. A. Saloom. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, pp. 1157–1162.) Analysis is presented for the focusing of long electron beams when both axial magnetic field and space-charge neutralization by positive ions are operative. The theory is checked by measurements of the ion current collected from a long drift tube at various instants after application of a step signal. Results indicate that positive ions may be trapped at regions along the beam such that the axial variations of beam diameter are enhanced. See also 305 of 1955 (Ginzton & Wadia).

621.385.029.6 **624**

The Cascade Backward-Wave Amplifier: a High-Gain Voltage-Tuned Filter for Microwaves.—M. R. Currie & J. R. Whinnery. (*Proc. Inst. Radio Engrs*, Nov. 1955, Vol. 43, No. 11, Part 1, pp. 1617–1631.) Operation of the backward-wave valve as a narrow-band amplifier is discussed. A 'cascade' arrangement is described in which the beam traverses in succession a modulator helix, a drift tube or other intermediate section, and a demodulator helix. The valve can be tuned over a wide range of frequencies by varying the beam voltage, and the bandwidth can be controlled by stagger-tuning the input and output. The minimum noise figure should be of the same order as that of an ordinary travelling-wave valve, i.e. about 6 dB.

621.385.032.216 **625**

Changes in the Structure of Oxide Cathodes at High Temperatures.—H. P. Rooksby. (*Brit. J. appl. Phys.*, Aug. 1955, Vol. 6, No. 8, pp. 272–276.) Examination by X-ray microbeam technique indicates that as a result of heat treatment, at 900°–1 150°C with BaO and 1 100°–1 250°C with SrO, crystallites of dimensions 2–5 μ are normally developed. A gradual increase in the structure-cell dimensions takes place with increasing temperature of heating in vacuum; this is attributed to a progressive increase in the numbers of lattice defects and in the case of BaO appears to correspond with the process of thermionic activation.

621.385.032.216 **626**

Oxide-Impregnated Nickel-Matrix Cathode.—W. Balas, J. Dempsey & E. F. Rexer. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, pp. 1163–1165.) Description of the preparation and performance of a dispenser-type cathode with properties intermediate between those of the L type and those of the ordinary oxide cathode.

621.385.032.216 **627**

An X-Ray Study of Barium-Strontium-Calcium Triple Oxide.—J. Terada. (*J. phys. Soc. Japan*, July 1955, Vol. 10, No. 7, pp. 555–565.) The experimental results are discussed; the increased emission of the triple oxide over that of a double or single oxide may be due to the increased possibility of crystal distortion by a given heat treatment.

621.385.032.216 **628**

Emission from Hollow Cathodes.—K. M. Poole. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, pp. 1176–1179.) Experimental evidence indicates that the emission from an internally coated hollow cathode includes a component from cathode material deposited round the opening, this subsidiary component becoming saturated at lower anode voltages than the main component.

621.385.032.216 : 546.431/.432]-31 **629**

On the Relations between Electron Emission, Conduction and Noise of Oxide-Coated Cathodes.—J. Nakai, Y. Inuishi & Y. Tsung-Che. (*J. phys. Soc. Japan*, June 1955, Vol. 10, No. 6, pp. 437–443.) Experimental results of measurements on (Ba, Sr)O cathodes are presented graphically and discussed with reference to the pore-conduction mechanism considered earlier by Young (896 of 1953) and others.

621.385.032.216 : 621.375.9 **630**

Properties of Pore Conductors.—R. Forman. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, p. 1187.) Following observations of anomalous conduction in oxide cathodes (2158 of 1955), experiments were made with porous thoria cylinders. At temperatures of 1 500°–1 600°C large transverse magnetoresistance effects were observed at comparatively low field strengths. An amplifying device is outlined based on the change of resistance of an oxide cathode coating subjected to variations of the e.s. field in front of it; the characteristics resemble those of a conventional triode.

621.385.032.216.2 **631**

Surface Treatment of Core Metal used for Oxide-Coated Cathode.—J. Nakai & S. Nakamura. (*J. phys. Soc. Japan*, July 1955, Vol. 10, No. 7, pp. 566–570.) Emission from oxide cathodes coated on to sleeves made of Ni containing 0·10% Mg and 0·17% Si as active materials can be increased by removing the surface contamination on the sleeves by an electrolytic treatment. The increased emission is probably due to the active material in the sleeve producing excess Ba by reduction of the cathode oxide.

621.385.032.24 **632**

Decrease of Grid Emission by Improvement of Electroplating.—T. Hashimoto & A. Yokoyama. (*Rep. elect. Commun. Lab., Japan*, May 1955, Vol. 3, No. 5, pp. 12–14.) An experimental investigation is reported of plating techniques for improving the adhesion of Au coatings deposited on valve grids to inhibit emission. Use of a thin layer of Pt over the Au is discussed. Both Mo and Ni are considered as base materials.

621.385.13 : 621.373.4 : 537.5 **633**

The Appearance of some Oscillating Discharges.—T. K. Allen, R. A. Bailey & K. G. Emeleus. (*Brit. J. appl. Phys.*, Sept. 1955, Vol. 6, No. 9, pp. 320–322.) Hot-cathode rectifiers and thyratrons containing gas at pressures of the order of 10^{-3} mm Hg are found to generate internal oscillations in the cm-λ and dm-λ bands, probably due to interaction between the primary and plasma electrons. Observed phenomena are described and the mechanism of their production is discussed.

621.385.3 **634**

On the Electron-Optical Action of Grid Systems.—A. M. Strashkevich & A. S. Reyzlin. (*Radiotekhnika, Moscow*, Feb. 1955, Vol. 10, No. 2, pp. 66–71.) The design of any multi-electrode valve can be reduced to the design of a number of equivalent triodes. A precise formula is derived for determining the distribution of potential in a plane triode. The dependence of the position of the focus on the electrical and geometrical parameters is investigated.

621.385.4 **635**

A Beam Power Tube for Ultra-high-Frequency Service.—W. P. Bennett. (*RCA Rev.*, Sept. 1955, Vol. 16, No. 3, pp. 321–338.) Details are given of the construction and performance of the Type-6448 tetrode [see also 3770 of 1955 (Koros)]; some appropriate circuit arrangements are outlined.

621.385.832 : 535.371.07 **636**

Sedimentation of Fluorescent Screens in Cathode-Ray Tubes.—F. de Boer & H. Emmens. (*Philips tech. Rev.*, Feb. 1955, Vol. 16, No. 8, pp. 232–236.) The processes involved in sedimentation are discussed. The effect of gelatinizing agents on the screen adhesion is very pronounced; barium salts are preferred to potassium sulphate for their more rapid action in this respect. The use of radioactive tracers to analyse the screen composition is described.

621.385.832 : 535.371.07 **637**

Sticking Potential of C.R.T. Screens.—K. H. J. Rottgardt & W. Berthold. (*J. appl. Phys.*, Sept. 1955, Vol. 26, No. 9, p. 1180.) Experiments further to those described previously by Rottgardt et al. (2167 of 1955) indicate that the sticking potential of screens in sealed-off television tubes is not noticeably influenced by the vapours from the pumps used.

621.385.832.002.2 **638**

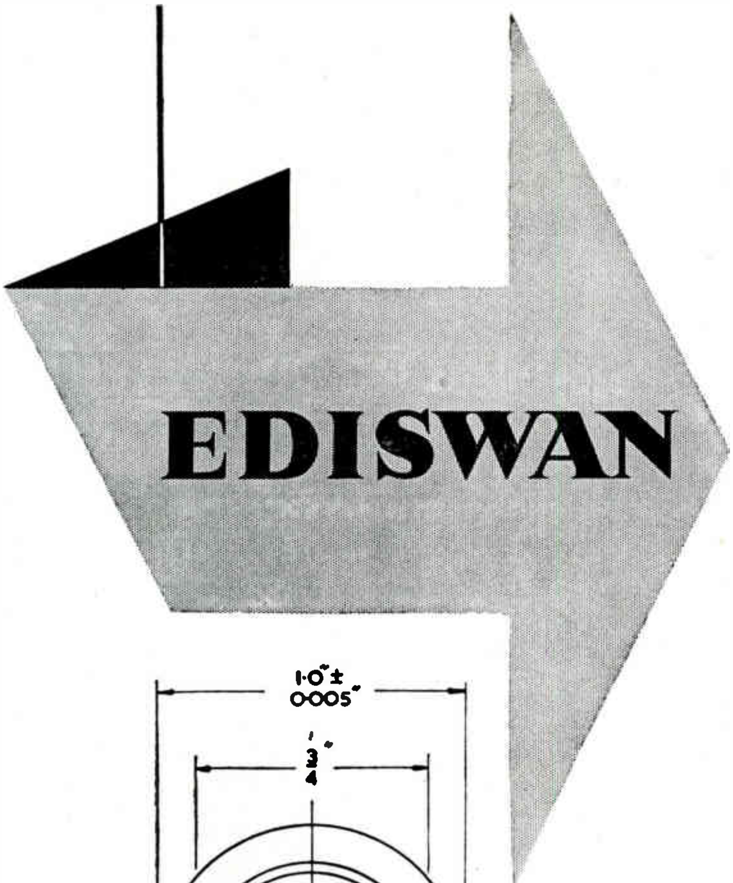
Cathode-Ray-Tube Manufacture.—(*Elect. Rev., Lond.*, 8th July 1955, Vol. 157, No. 2, pp. 86–87.) Brief description of new plant for producing the glass components of c.r. tubes.

621.387 **639**

The Current Rise in Gas [-filled] **Triodes and Tetrodes.**—E. Knoop. (*Z. angew. Phys.*, Aug. 1955, Vol. 7, No. 8, pp. 366–371.) An approximate formula is derived for the exponential current rise. The effects of the anode potential, heater voltage, and nature and pressure of the gas are discussed. Experimental results which are in fair agreement with theory, indicate that valves with fast current rise can be produced using hydrogen or an inert gas of higher atomic number (e.g. Xe); the effect of the electrode geometry on the rise time is small.

621.387 : 621.316.722.1 **640**

Glow-Discharge Stabilizers.—F. A. Benson & L. J. Bental. (*Wireless Engr*, Dec. 1955, Vol. 32, No. 12, pp. 330–336.) Measurements have been made to determine the influence of gas filling, gas pressure and direct operating current on the impedance/frequency characteristics of stabilizer tubes over the range 20 c/s–100 kc/s; the tubes had either Ni or Ce-alloy cathodes. The results indicate that for eliminating low-frequency ripple on a rectifier output, tubes with He filling are best; where there is a high-frequency ripple component. Ne-filled tubes should be used.



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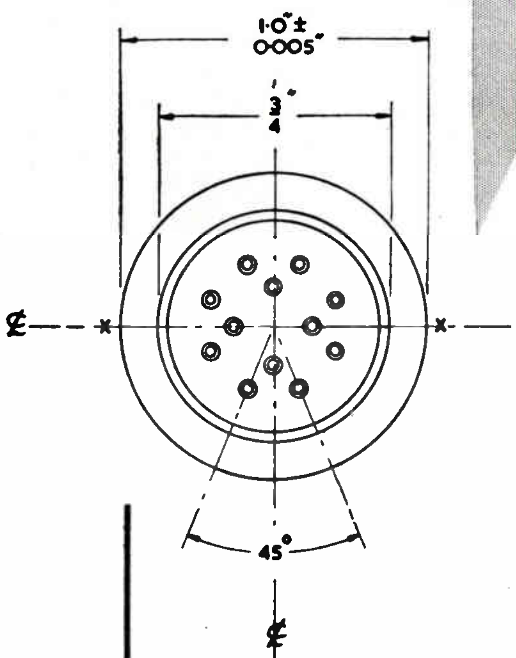

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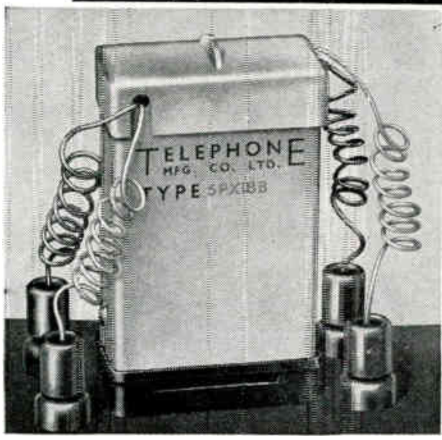

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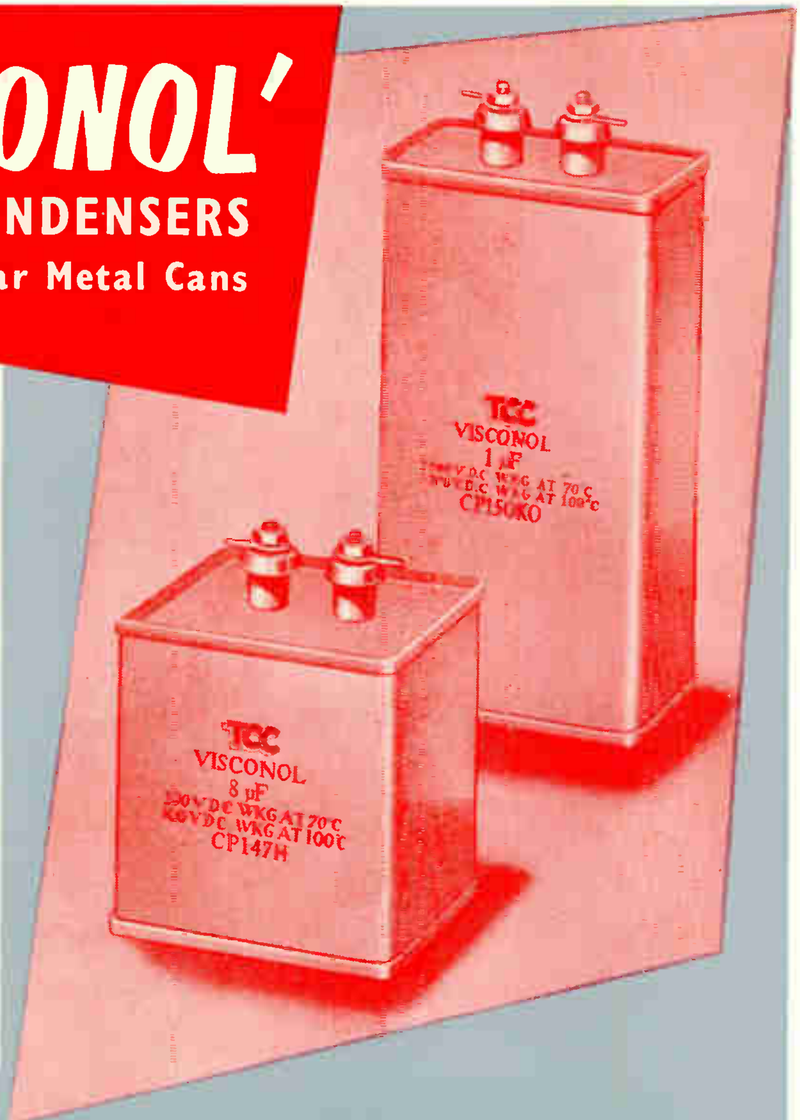

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600 V.	—	—	—	—	CP128T	CP129T	CP130T	CP127T
600 V.	—	—	—	—	CP142T	CP144T	CP147T	CP150T
800 V.	—	CP123V	CP128V	CP128V	CP131V	CP130V	CP132V	—
800 V.	—	—	—	—	CP143V	CP146V	CP149V	CP152V
1000 V.	—	—	CP141W	CP142W	CP145W	CP147W	CP149W	CP153W
1200 V.	—	CP131X	CP131X	CP131X	CP130X	CP132X	CP133X	CP134X
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2500 V.	—	CP144KO	CP146KO	CP147KO	CP150KO	CP153KO	CP154KO	CP155KO
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