ELECTRONIC & RADIO ENGINEER

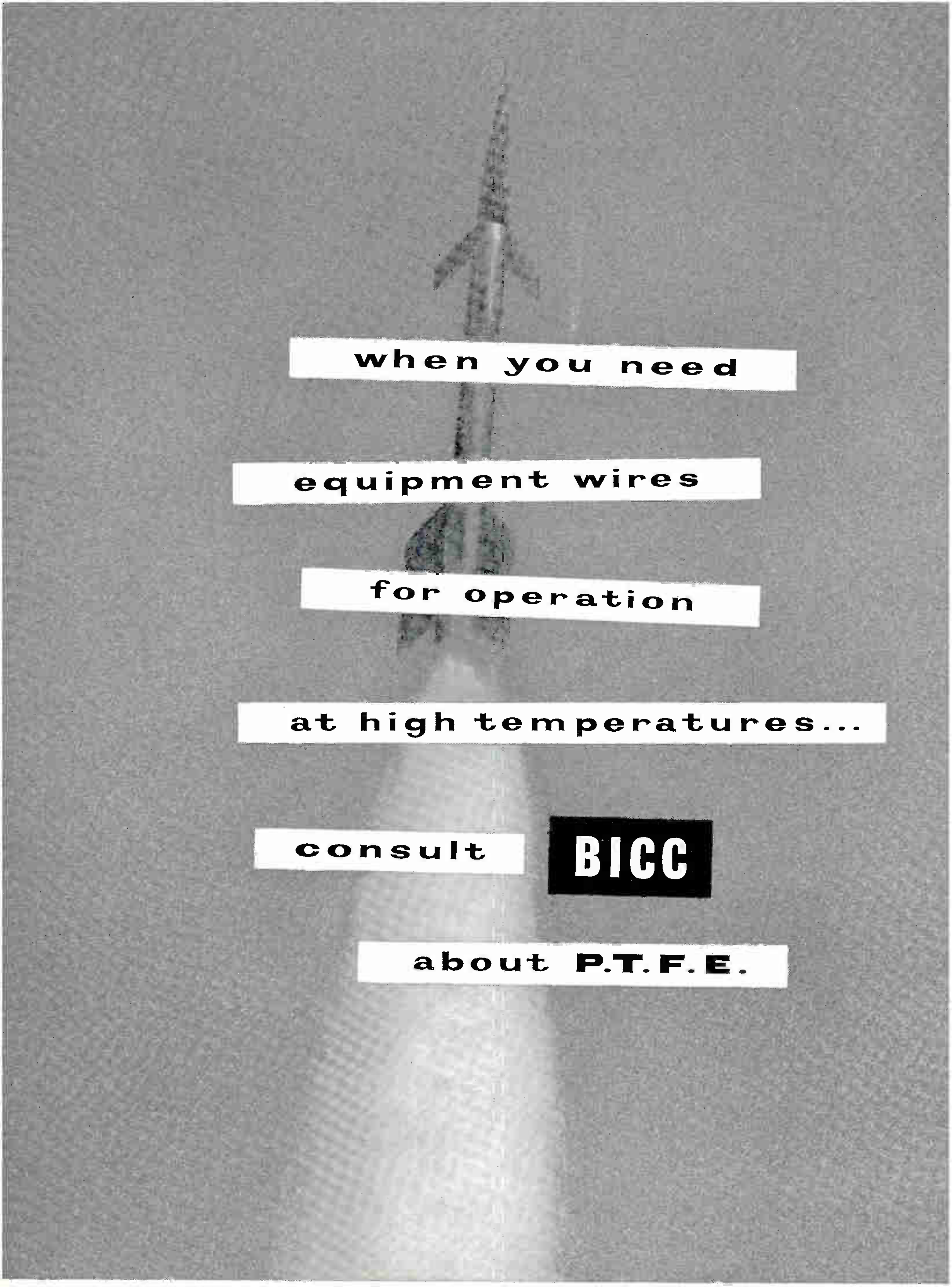
Incorporating **WIRELESS ENGINEER**

In this issue

Low-Noise Stabilized D.C. Supplies
Tachometer Noise Reduction
Terminated Circular Loop Aerial
Characteristics of H.F. Signals

Three shillings
and sixpence

SEPTEMBER 1957 Vol 34 *new series* No 9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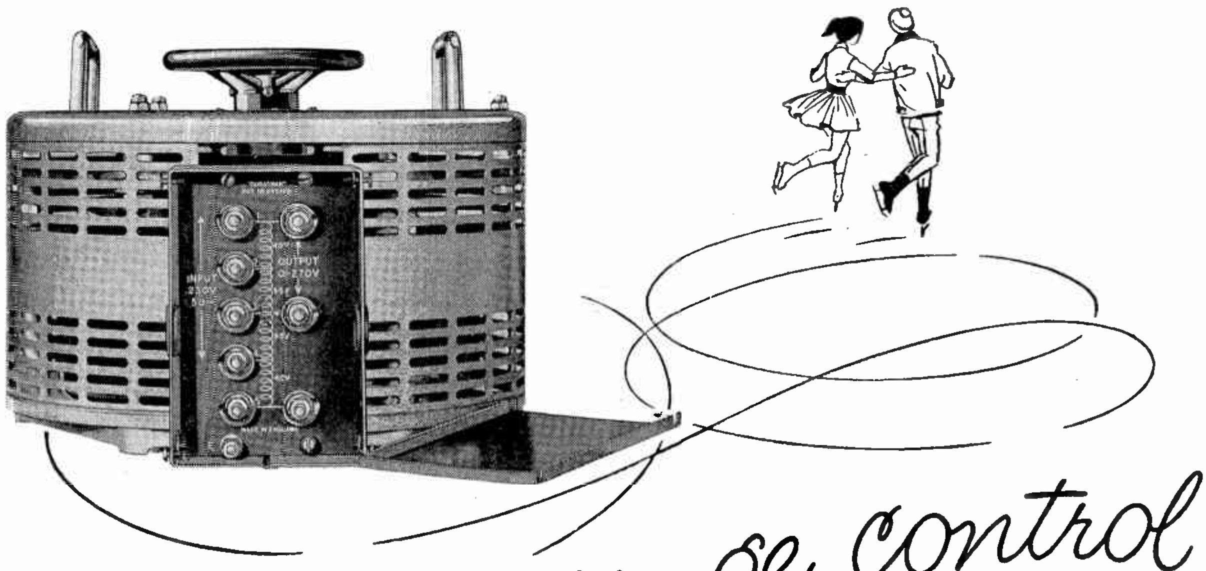

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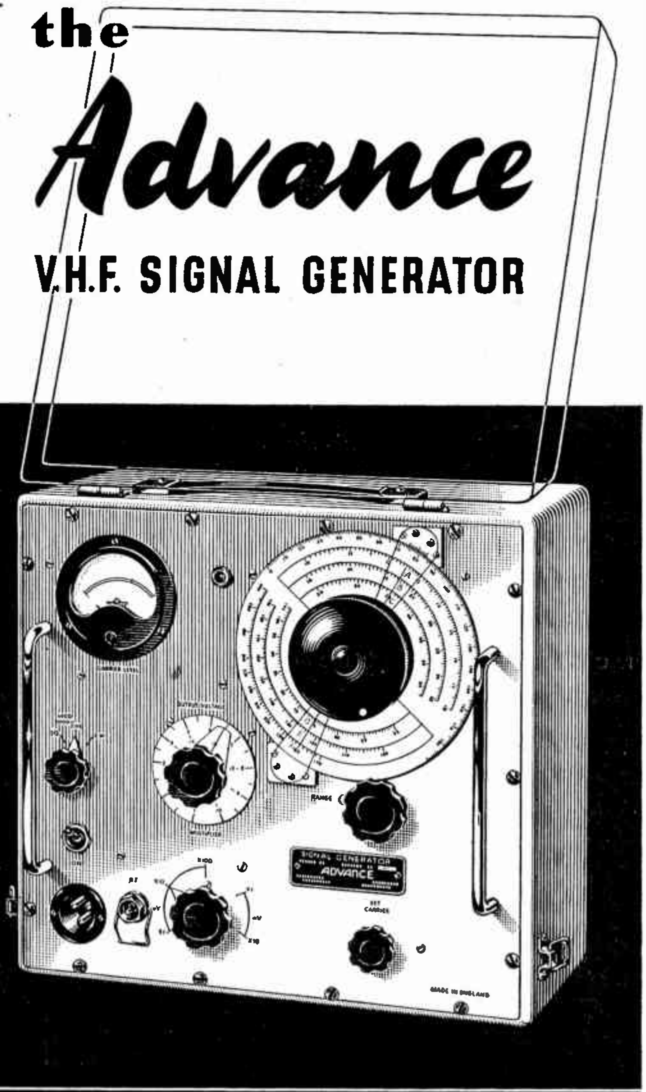

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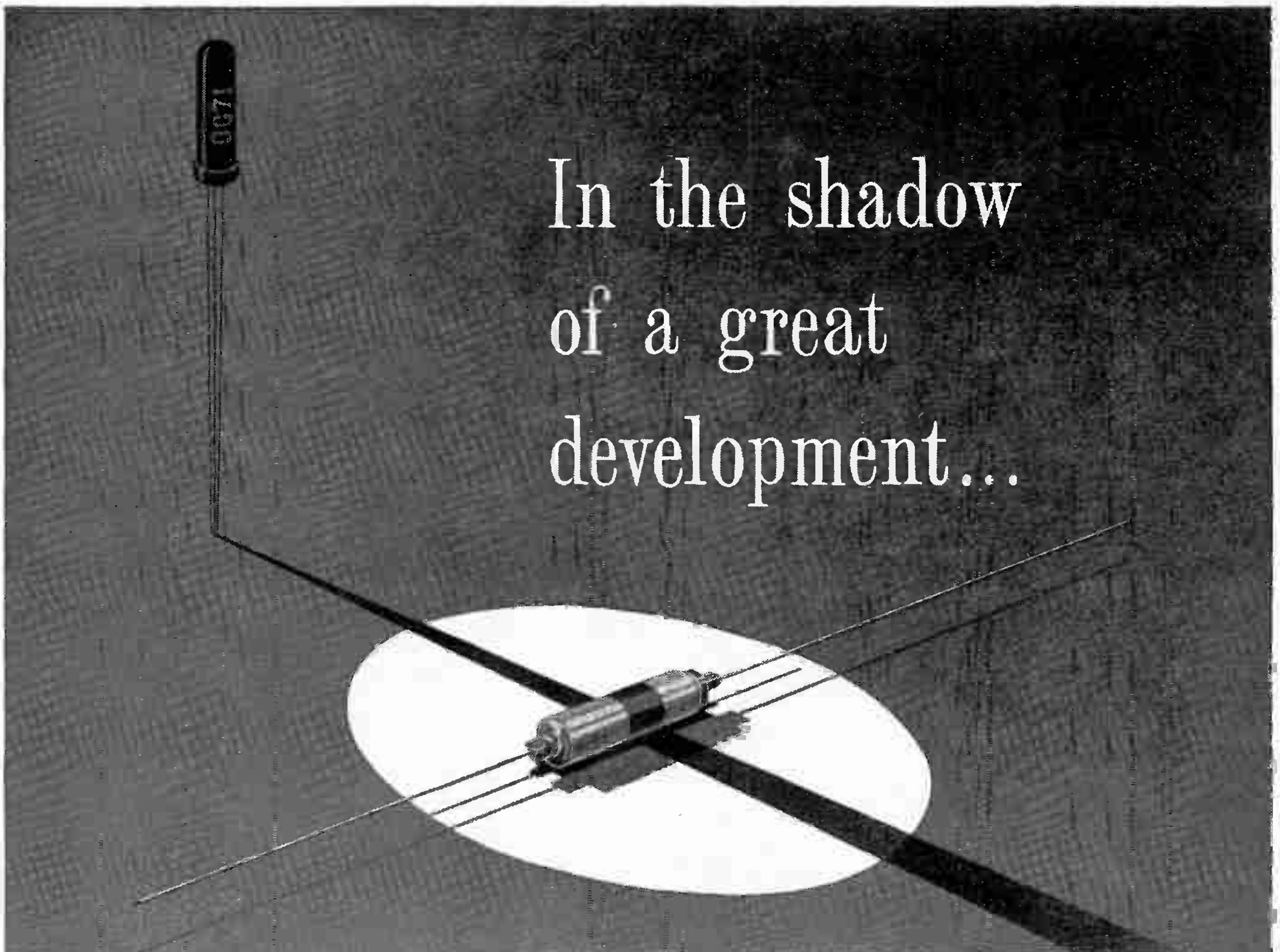

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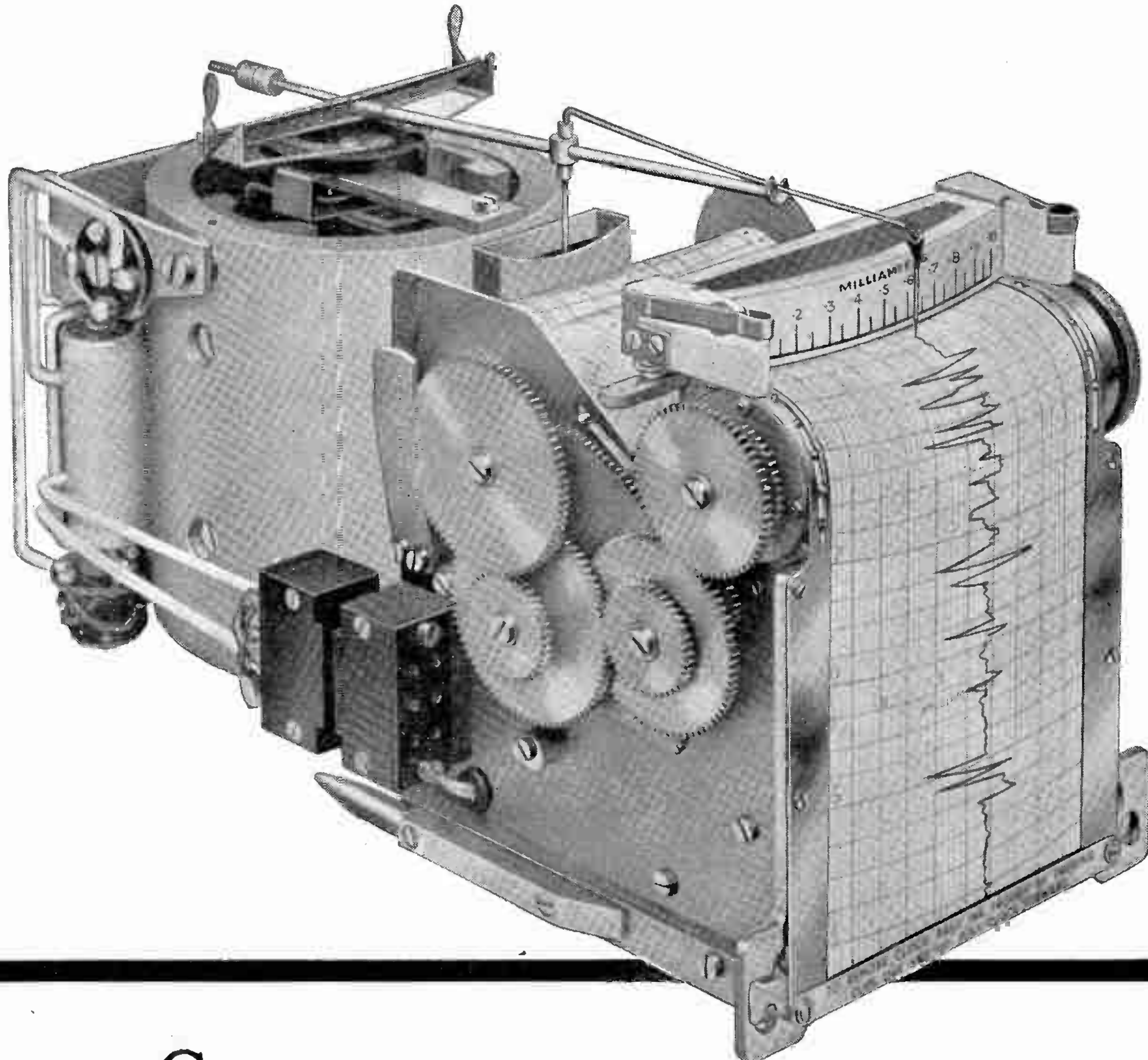

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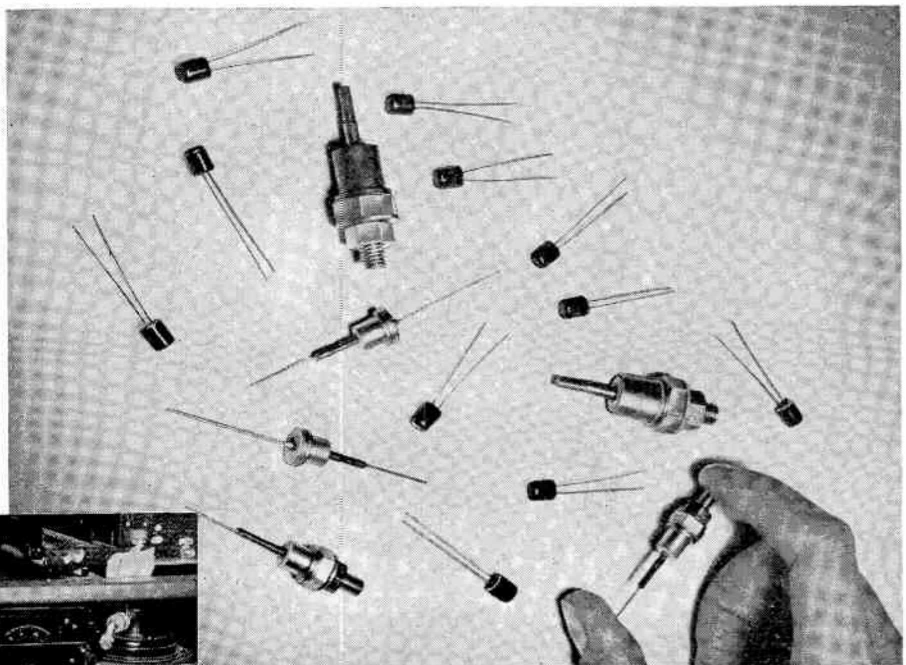

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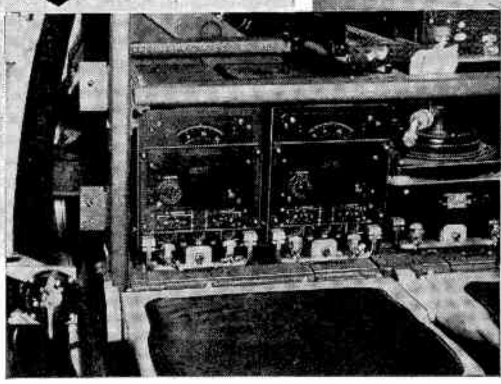

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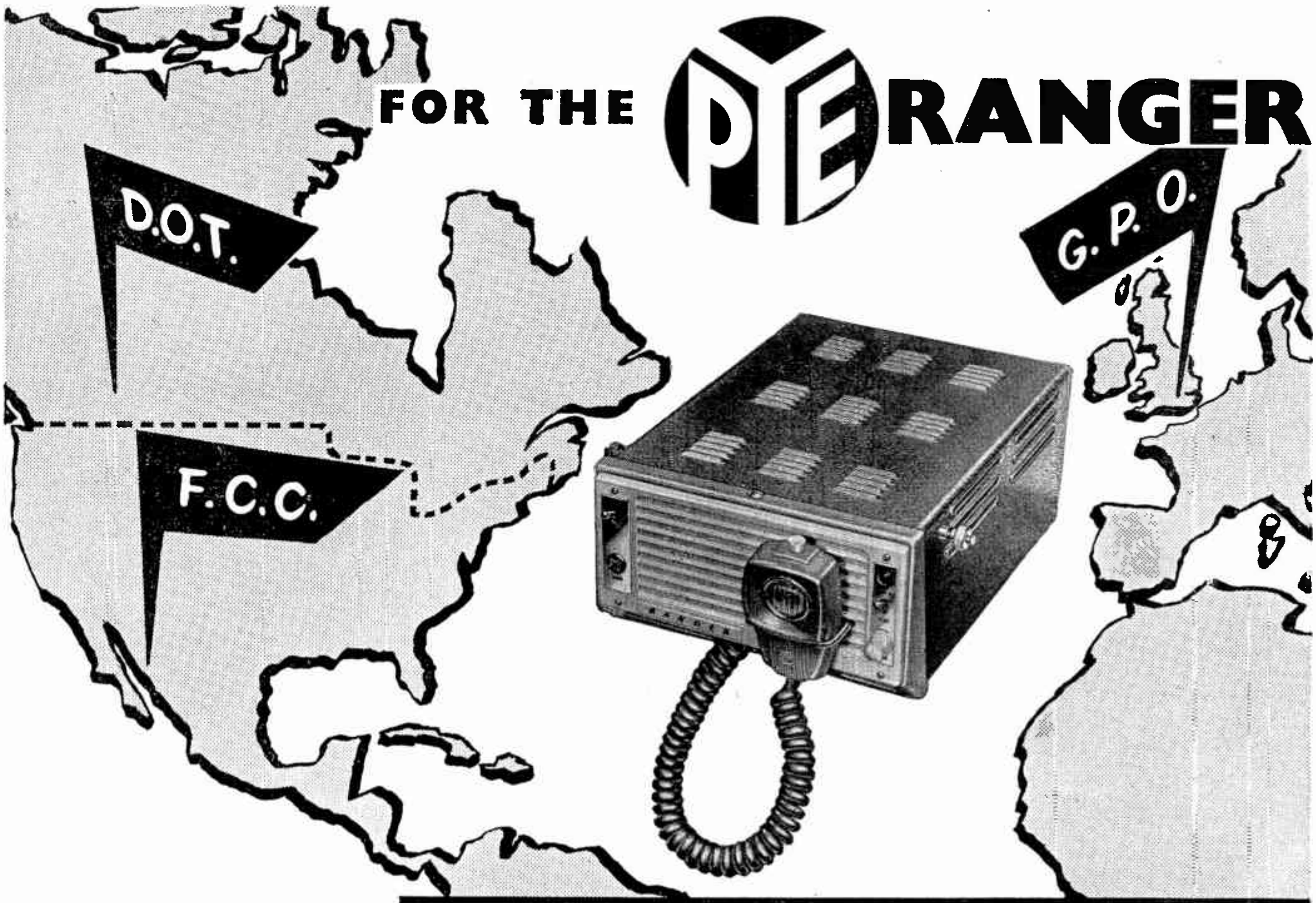

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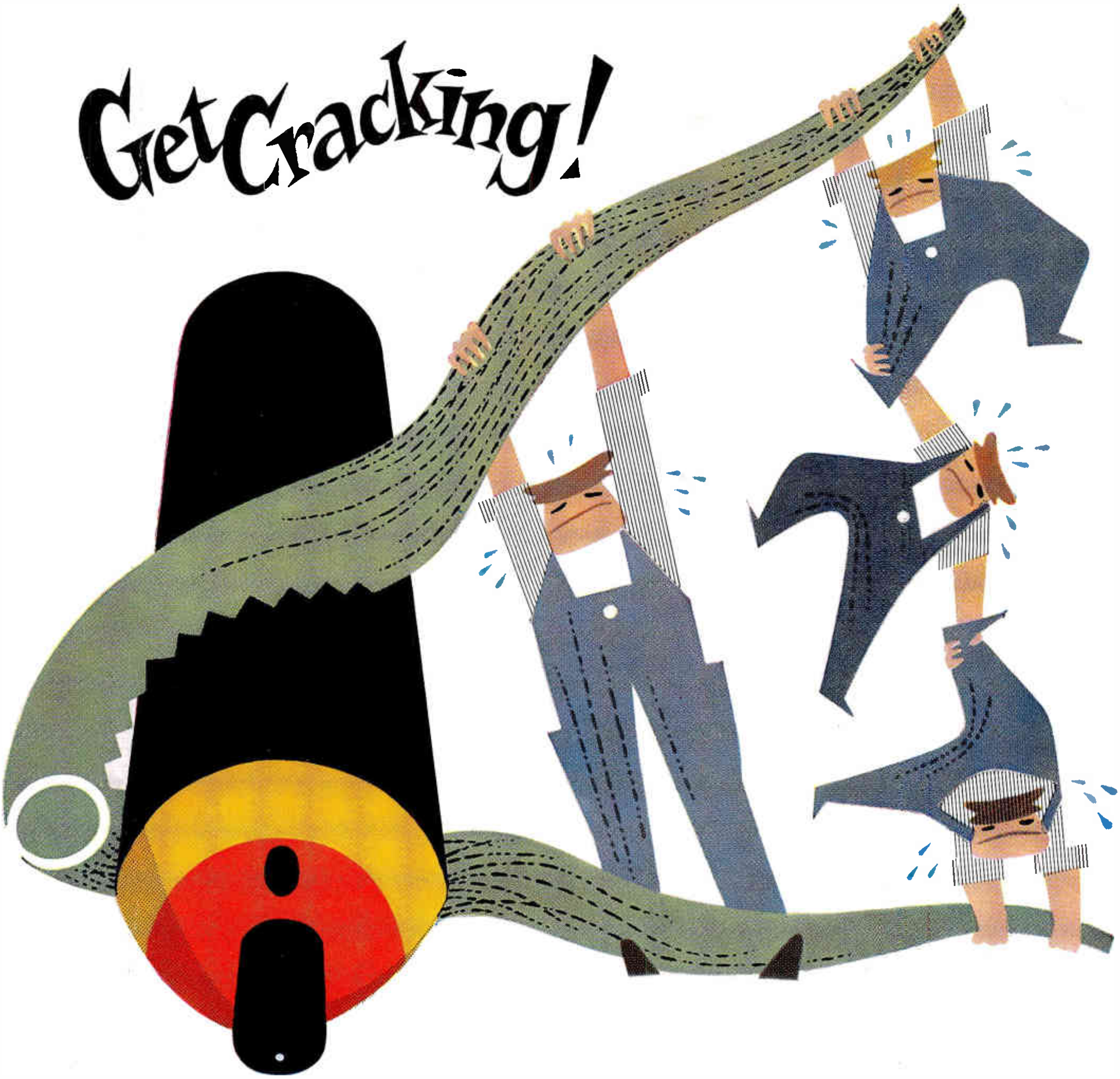

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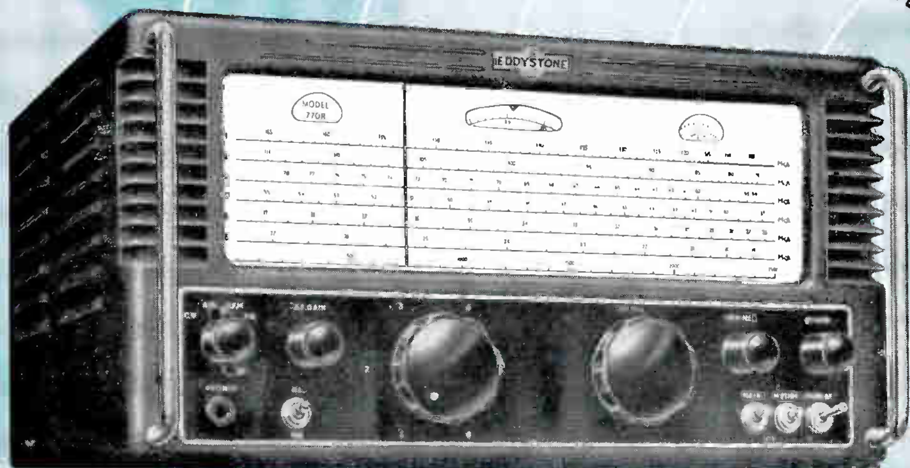

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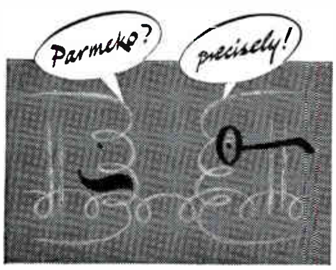

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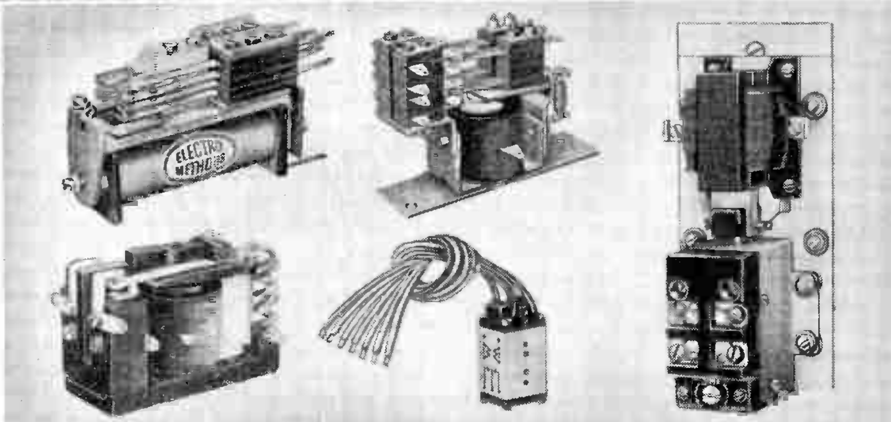

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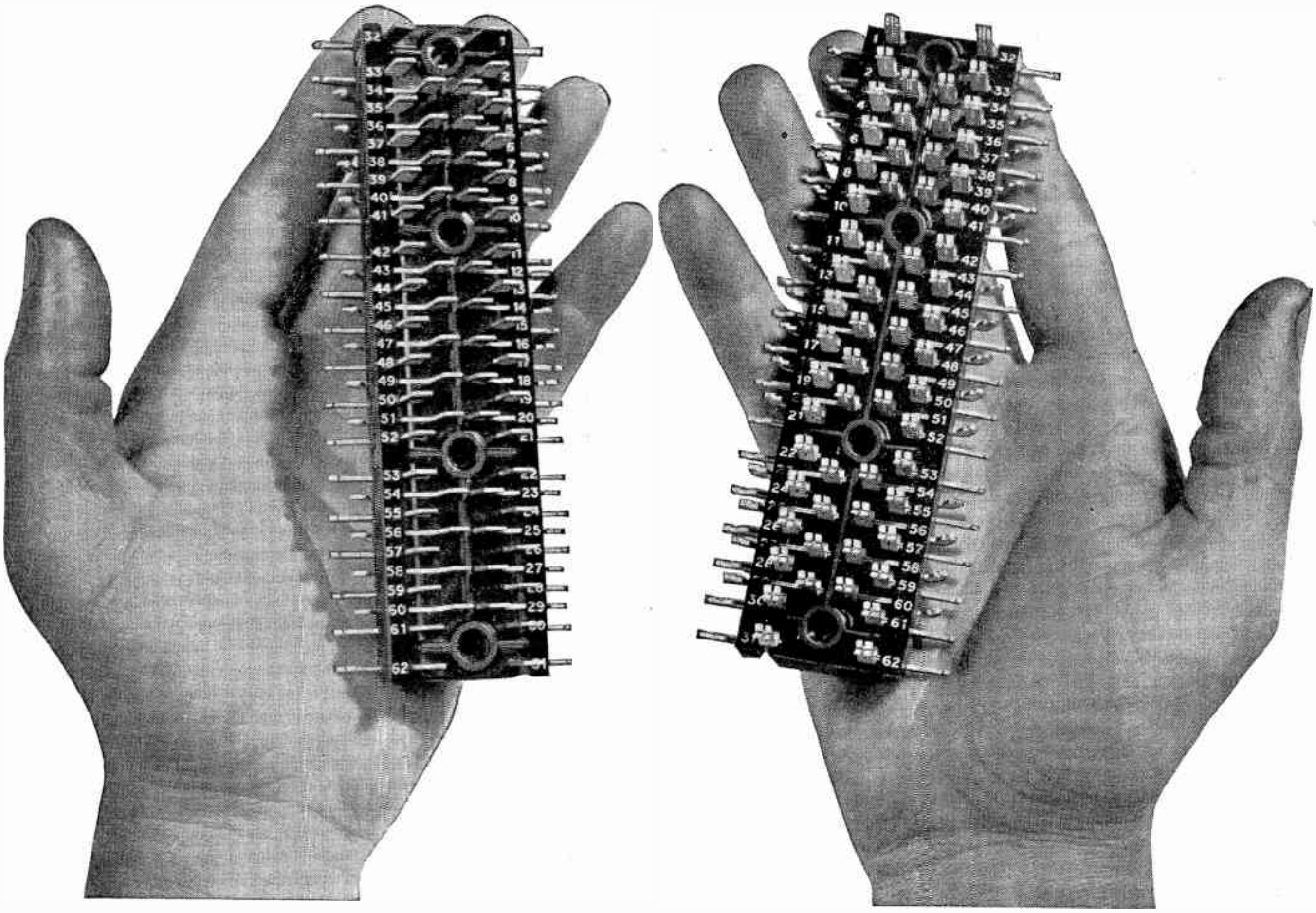

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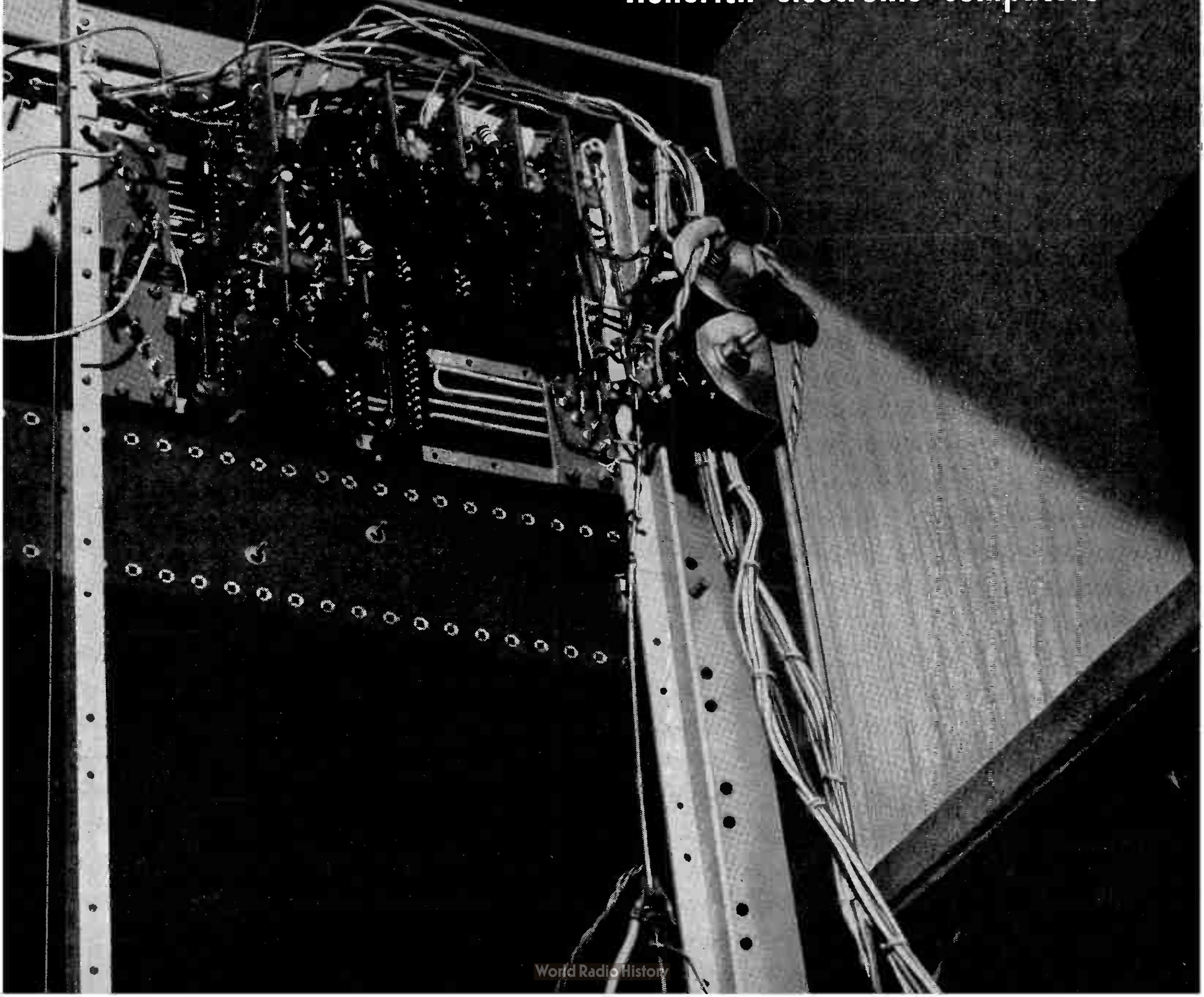

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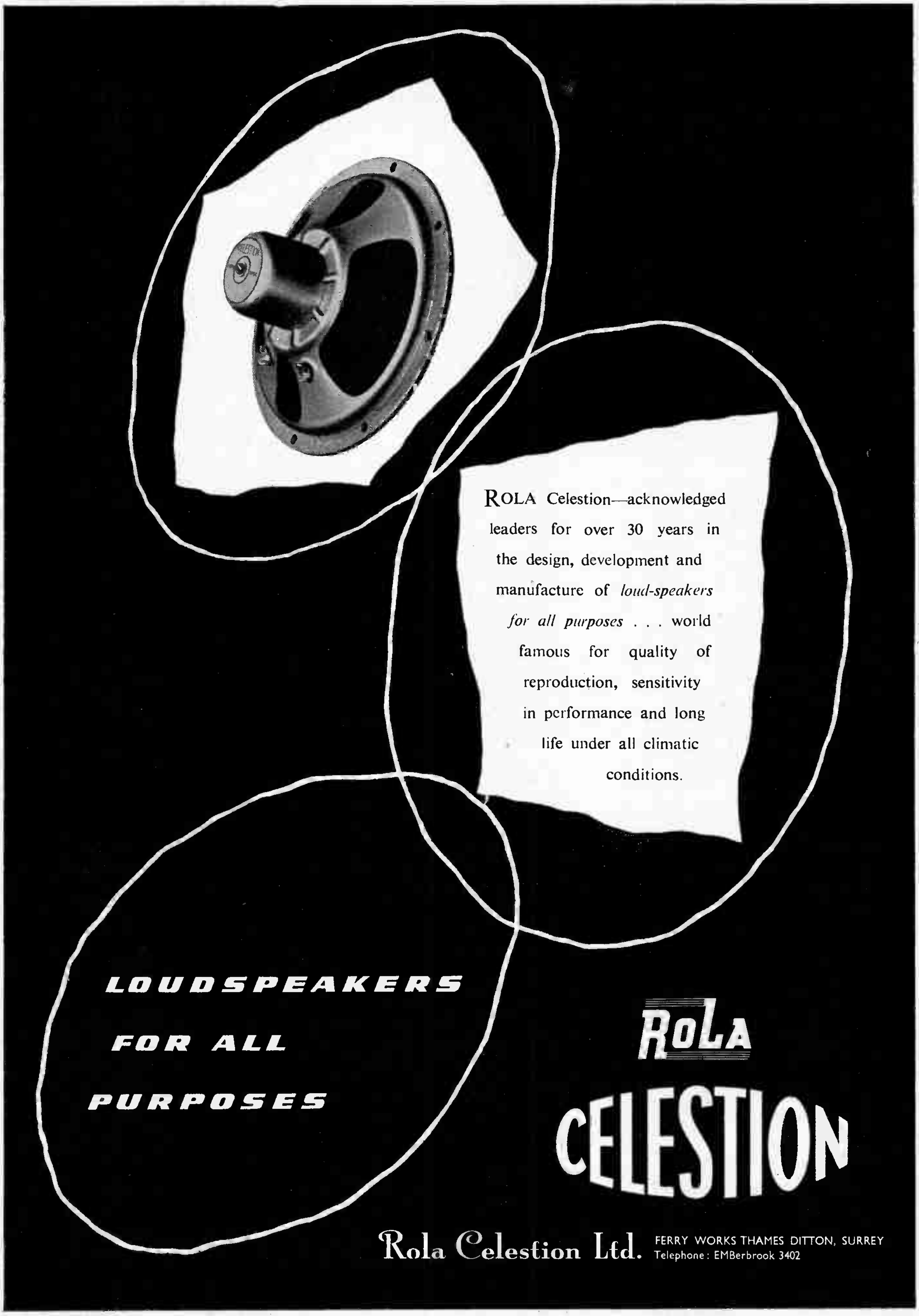
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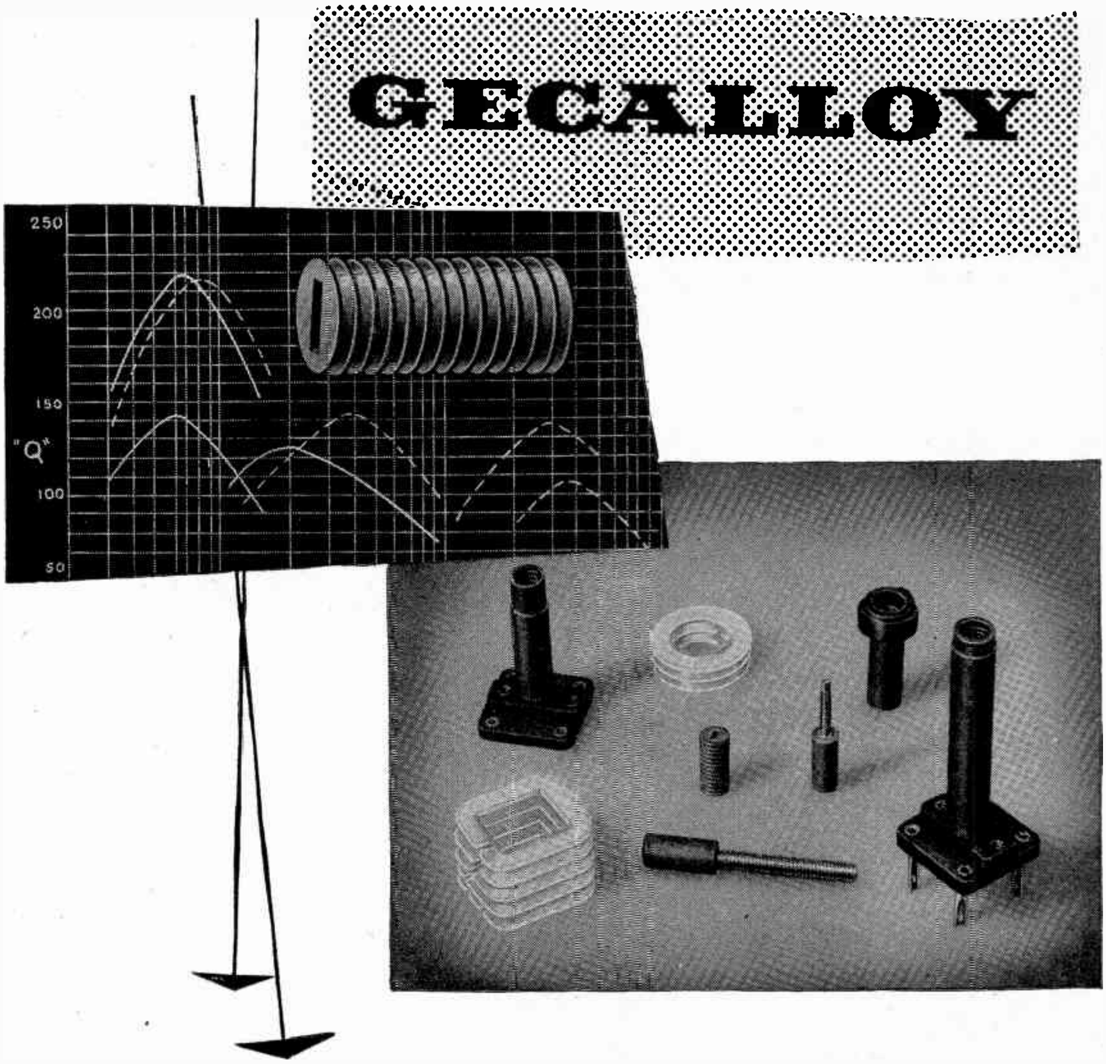

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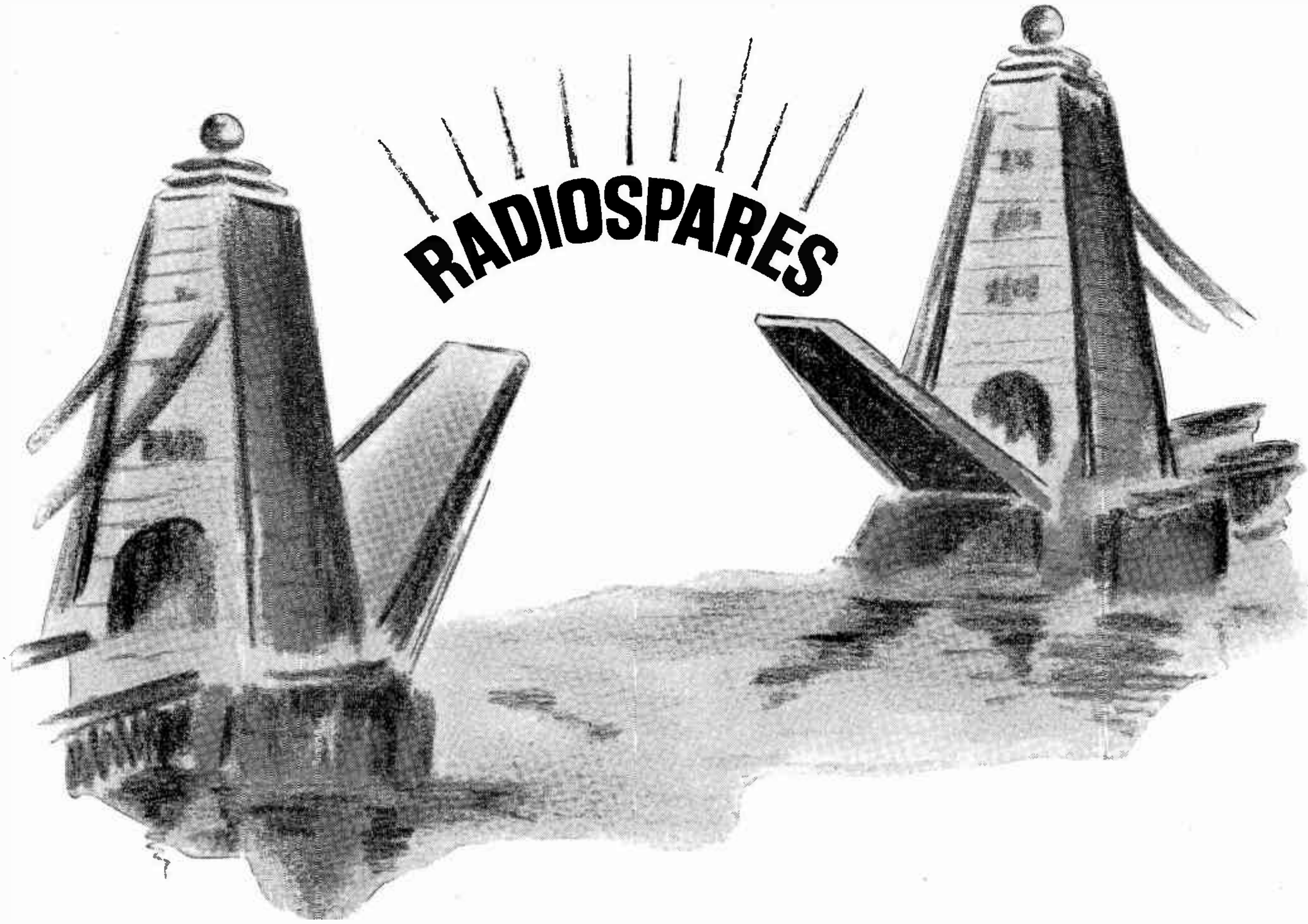

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ELECTRONIC & RADIO ENGINEER

VOLUME 34 NUMBER 9

SEPTEMBER 1957

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Filter Theory

IN recent years a great deal has been written about filter theory and much of it is so very highly mathematical that we have sometimes doubted its utility to the engineer. We have felt that to be practically useful much of it requires to be interpreted.

We have, therefore, been particularly interested in an article "Applied Circuit Theory" (W. Norris Tuttle, *I.R.E. Transactions on Circuit Theory*, June 1957) in which a comparison is made between filters of different types. The standard is a two-section Zobel low-pass filter, the design method for which is still the one most used by engineers in spite of the fact that considerable difference exists between its theoretical attenuation and its actual insertion loss.

The difference arises because the simple theory ignores dissipation and assumes perfect matching. It results in the designer having to do a certain amount of experimental work to achieve the desired performance. Because of this he is left with the feeling that perhaps he has not achieved the best that could be done.

The newer methods seek to avoid this experimental work by enabling the designer to calculate his final values. Tuttle points out that some of them are too difficult mathematically for the average engineer and others are very laborious. More important, perhaps, he gives curves to show that in spite of this the final result is filters with a performance inferior to one designed by the Zobel method.

The superficial view is that the mathematicians are wasting their time in producing methods which are little or no use to the engineer. We do not subscribe to that view, for we feel that the real trouble is that they have not yet gone far enough. The requirement is for a method at least as easy to apply as the Zobel but more accurate, and which produces at least as good a final filter.

When the method is found it is improbable that it will be mathematically easy, but that does not mean that it could not be made so by the use of charts and nomograms. Much more use could in fact be made of this method of computation than is commonly done. The charts which do exist are all too often for simple things which can be done at least as easily with the slide rule. One thing which always militates against the production of such computational aids in our field is the ease with which experimental work can be carried out. It is perhaps too easy to vary *LC* values experimentally and to watch the effect on a c.r. tube display!

Low-Noise Stabilized D.C. Supplies

OBTAINING VERY LOW HUM AND D.C. DRIFT

By D. W. W. Rogers, Grad.Brit.I.R.E.

SUMMARY. *The special precautions and wiring are described which are necessary to eliminate the various forms of hum injection into power-unit feedback amplifiers, and a representative type is explained having very low hum and drift. A novel three-valve stabilized supply is also described.*

The use of thermionic valve circuits for stabilizing the voltage or current output of a d.c. power unit is well known. In general, these circuits employ a valve as a variable resistance in series with the output of the power unit. The electrode d.c. resistance of the valve is controlled by a voltage applied to its grid from a control d.c.-amplifier circuit. Deviations from the normal desired output voltage are detected by comparing a fraction of the output voltage with a suitable voltage reference, the net difference being applied to the control d.c. amplifier. The stability of the output voltage approaches that of the reference.

Such degenerative, series-control power units provide a highly stable source of d.c. power with very low source impedance and small hum content. In commercially available instruments the hum level at the output of a 250-volt 500-mA power pack is of the order of 1–5 mV r.m.s. For certain applications even lower levels are required, and it has been found possible to design production types having less than 10-μV hum r.m.s. and with drifts of the order of 0·04% over a period of twelve hours. In nuclear spectrometry, for example, an extremely pure and constant d.c. focusing current is often required to obtain the necessary high order of definition.

Referring to Fig. 1, a formula has been derived for the hum-reduction factor V_0/V_i

$$I_a = g_m\,(-AI_aR_a - I_aR_a) + \frac{V_i - I_aR_a}{r_a}$$

and

$$\frac{V_0}{V_i} = \frac{I_aR_a}{V_i} = \frac{R_a}{R_a[(A+1)\mu + 1] + r_a}$$

$$\approx \frac{1}{A\mu} \text{ for large } A.$$

This factor brings out the need for a high-gain stabilizing amplifier, and a high-μ series-control valve. The latter requirement may be realized in practice by using either a beam tetrode or pentode. An additional advantage is now provided inasmuch as the relatively small screen current allows the use of a large-inductance choke for the screen feed. Since the anode current is directly related to the screen voltage, the overall effective smoothing may be greatly improved by this means. For d.c. stabilization, however, the decoupling is ineffective and it is preferable to use a fairly heavy current bleeder, one end being tied to the zero-volt line in order to keep the screen voltage constant. Again, if valve economy is not important, improved d.c. stabilization may be obtained by supplying the screen voltage of the series-control valve from a stabilizer tube. A similar case arises in the stabilizing amplifier. If pentodes are used, as in Fig. 2, the screen needs a heavy current bleeder to obtain the maximum gain:

$$\text{Pentode gain} = G_mR_L\frac{r_{sg}}{r_{sg} + \dfrac{R_1R_2}{R_1+R_2}}$$

Unfortunately, this low-resistance bleeder network is difficult to decouple for hum and, for this reason, double

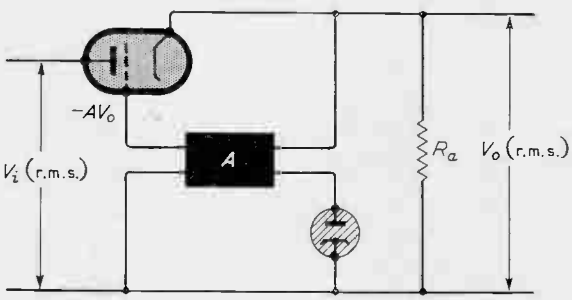
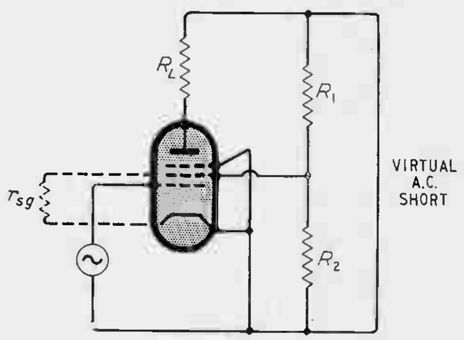


Fig. 1. *Basic stabilizer with amplifier*

Fig. 2. *Pentode amplifier with screen voltage supplied from a potentiometer*



triodes are to be preferred on the grounds of their comparable gain, simplicity and envelope economy.

Smoothing Filters

The choice of full-wave rectification is naturally influenced by considerations of minimum ripple. The smoothing factor per section of an LC, L-type filter will then be $4\omega^2LC - 1$, where ω is the circular mains input frequency. Optimum smoothing is now obtained when the available LC product is shared equally between each section. This division is based upon the mathematical fact that for any given sum of numbers their product is a maximum when the numbers are equal. In the same way, although of lesser significance, it may be argued that for a given sum of L and C a section gives optimum smoothing when $L = C$. In practice it is customary to make the value of C as large as possible consistent with size and cost.

At this point it may be as well to summarize the low hum features that have been discussed so far.

1. Use optimum smoothing filters consistent with size and cost.

2. Choose a beam tetrode or pentode for the series-control valve, smoothing the screen supply rather than the anode supply.

3. Use double triodes in the stabilizer amplifier. Make the overall gain as high as possible.

'Second Order' Noise Sources

Previously this article has outlined what might be termed under a broad heading 'first-order smoothing', and the reader may feel it is a comparatively simple matter to produce a power supply with very low hum, providing some care is taken with layout and the amplifier gain is large enough. Experience shows, however, that he will almost certainly be disappointed. Several of the writer's well-intentioned initial attempts gave uninspiring hum levels of more than one millivolt r.m.s. It is characteristic when this region of hum is being approached, rather than an absolute level, that hum-dingers, further screening and short grid leads give little or no improvement. Even supplying the heater of the first valve of the stabilizer amplifier with d.c. instead of a.c. has no effect. At this stage the engineer may feel with some justification that he has scraped the bottom of the barrel. Thus, the question arises whether he should tidy up the circuit and accept the inevitable.

A clue to the source of residual hum is given by adjusting the 'hum-dinger' in parallel with the filament of the first valve. If the hum were derived from the heater of this valve, a sharp minimum would be obtained with the wiper of the hum-dinger at the electrical mid-point of resistance. In practice this does not occur, but rather a broad minimum is obtained, the centre of which does not occur with the wiper at the midpoint. This implies that the first-stage hum comes from sources other than the heater supply. The remainder of this article will be chiefly concerned with these interfering sources of noise, their elimination, and some special circuits giving very low hum and drift. (*See* References, J. L. Lawson, V. H. Attree.)

Sources of Pickup Voltage

The sources of pickup in the stabilizer amplifier may be divided into two classes:

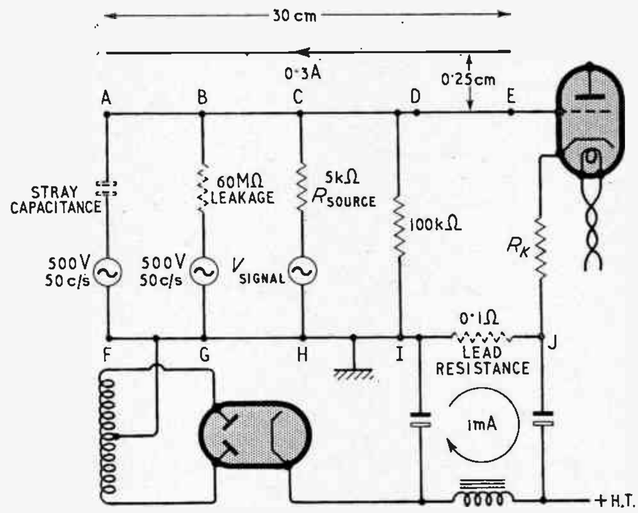


Fig. 3. *Sources of hum.* V_{IJ} *conductive* $= 100\ \mu V$, V_{AE} *magnetic* $= 25\ \mu V$, V_{AF} *electrostatic* $= 42\ \mu V$, V_{BG} *leakage* $= 42\ \mu V$

Internal. (1) Ripple voltages and harmonics, 0° and 180° of phase, and in quadrature.
(2) Noise from the voltage reference tube.
(3) Random noise.

External. (1) Mains surges disturbing the stabilizer amplifier.
(2) Electrostatic and magnetic fields disturbing the stabilizer amplifier.

Ripple-Voltage Source

Internal pickup from ripple-voltage sources may be almost entirely eliminated by correct wiring and, as this source of pickup is the most serious, it will be considered in some detail. This form of pickup occurs in four different ways, which will now be defined.

Conductive Pickup

Conductive pickup takes place when the currents flowing in isolated circuits flow through a common resistance.

Leakage Pickup

Leakage pickup occurs when otherwise isolated circuits have poor insulation between them. It is, of course, an indirect form of conductive pickup.

Electromagnetic Pickup

Electromagnetic pickup takes place when the magnetic field of a current carrier, such as a wire or transformer, cuts a closed loop. The voltage pickup induced is dependent upon the closeness of the loop and carrier, and the magnitude of the current concerned, but not the impedance of the loop.

Electrostatic Pickup

Electrostatic pickup is due to the stray capacitance existing between otherwise isolated circuits.

Fig. 3 shows schematically the estimated effects of these four interfering sources. Fig. 4 shows the same circuit rewired for minimum hum. Fig. 5 illustrates the technique applied to a long-tailed pair. The long-tailed

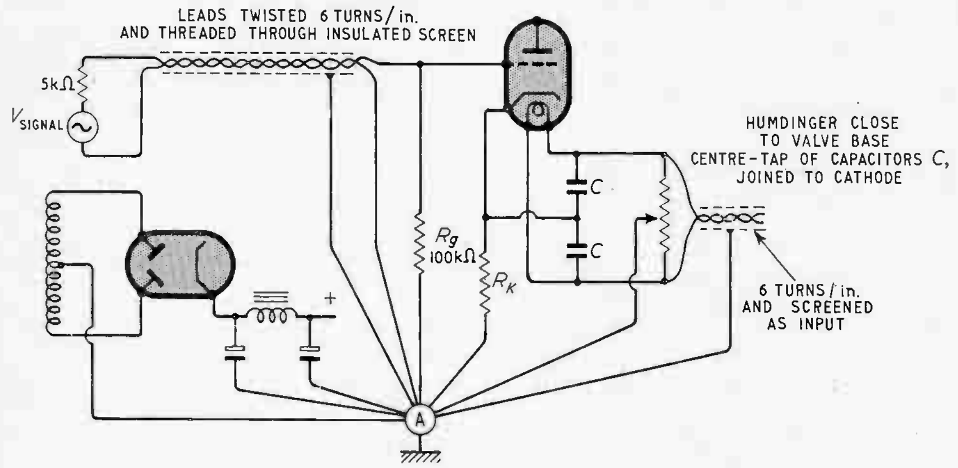


Fig. 4. *Methods of reducing hum*

pair is employed for the first valve of the stabilizer amplifier in order to balance out hum and to obtain its well-known lower drift properties.

Ripple-Voltage Source Elimination

Conductive pickup can be avoided by using separate supply leads for each circuit. An obvious corollary of this statement is that all earth returns should be earthed at one point. In the intermediate case, where higher levels of pickup may be tolerated, two earth returns only may be employed, one for heavy currents and the other for low values of current. Leakage pickup may be minimized by reducing circuit impedance levels, by reducing the surface contact area of first valve leads and, of course, by using good insulators; e.g. a good quality valve-holder must be used. Reducing circuit impedance level also minimizes capacitive pickup.

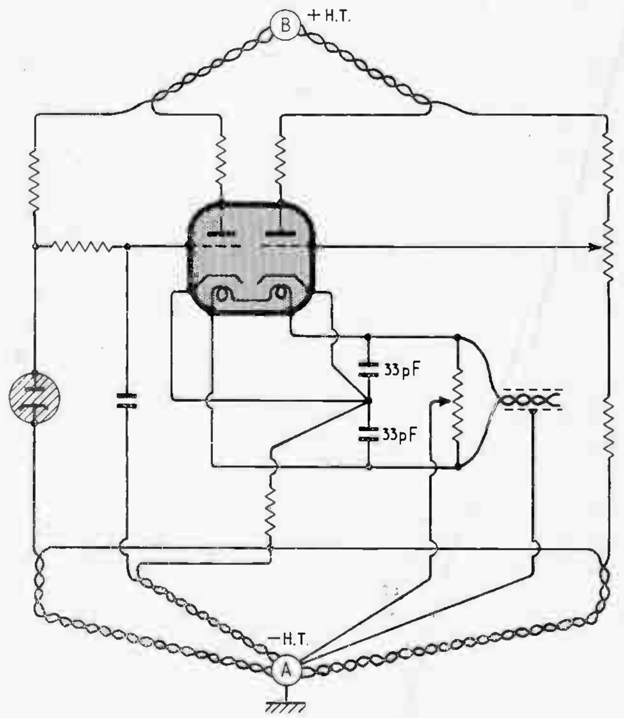


Fig. 5. *Long-tailed pair showing wiring technique employed to obtain a hum content smaller than* $5\ \mu V$ *r.m.s.*

Electrostatic pick-up may be efficiently eliminated by electrostatic shielding. It is important to earth the screen at one point only and this should be at the one particular earthing point chosen, in order to avoid conductive pickup into the screen itself.

Electromagnetic pickup may be balanced out by twisting the input and earth-return wire as tightly as possible. Experience shows that at least five twists to an inch is essential. An insulated screened lead is also very effective if the screen is used as the earth return. In this way electrostatic shielding is inherently provided as well. In general, the live and return a.c. or d.c. leads of each high-voltage pair should be twisted together. In Fig. 5 the cathode resistance of a long-tailed pair has three separate earth returns, each one of which is separately twisted in turn with each grid-circuit return, in order to obtain a very fine degree of electromagnetic balance. This technique can produce hum levels of less than $5\ \mu V$ r.m.s. It will be interesting at this stage to calculate the hum voltage induced in Fig. 3 from 30 cm of heater wire parallel to AE as shown and carrying 0·3 A. The mutual inductance,

$$M = 2\left[l \log_e \frac{l + \sqrt{l^2 + d^2}}{d} - \sqrt{l^2 + d^2} + d\right]$$

$$M \simeq 2\left[30 \log_e \frac{30 + 30}{1/4} - 30\right]$$

$$= 270\ \text{m}\mu\text{H}$$

Voltage induced in AE $= 6{\cdot}28 \times 50 \times 0{\cdot}27 \times 0{\cdot}3 \times 10^{-6} = 25{\cdot}4\ \mu$ V at 50 c/s.

It is obvious that a higher mains-input frequency is not conducive to low magnetic pickup and, in practice, more than offsets the better smoothing obtainable in the post-rectifier filters.

Valve Hum

The four main types of pickup may occur inside the valve although, in general, only two types prevail in the long-tailed pair. Electrostatic pickup occurs because the capacitance from cathode to heater is unbalanced about either end of the heater. Because this capacitance is quite small, of the order of 2–4 pF, the unbalance may be swamped by using a capacitive hum-dinger as shown in Fig. 5. Two 33-pF ± 2% capacitors are employed. This balance is particularly important at frequencies appreciably greater than 50 c/s. The amount of hum caused by heater emission is some 10 dB below 1 μV r.m.s. It is essential in order to obtain minimum hum to connect the wiper arm of the hum-dinger to the common point A shown in Fig. 5.

Electromagnetic pickup interferes in two ways. First, from parallel heater to cathode induction, and secondly, due to direct modulation of the electron stream by magnetic fields. The former can be small with magnetically well-balanced double-triode cathodes, but the latter may be serious. With metal-screened valves it may be reduced some 10–20 dB, if the interfering flux vector is perpendicular to the valve axis and normal to the plane of the grid side rods. Interior valve hum is reduced if the anode current is well below 1 mA. It may be necessary to demagnetize a valve which has become magnetized.

Reference Valve Noise

The gas stabilizer valve 85A2 has a mean noise voltage of 100 μV in a passband of 0–20 kc/s. In Fig. 6 a very effective low-pass *RC* filter is used to apply the reference potential to the high-impedance input of a long-tailed pair, thereby reducing this noise to negligible proportions.

Although the 85A2 provides an exceptionally stable reference voltage, it requires itself a very constant current feed to achieve this order of stability. The basic stabilizer circuit shown in Fig. 6 has a long-term d.c. output voltage constant within ± 0·1% providing its d.c. voltage supply is constant within about ± 2%. Its short-term stability, however, is subject to spontaneous jumps of about half a volt. These fluctuations are not only objectionable as a form of low-frequency noise, but integrate over a small period of time to give a varying d.c. drift. By cascading two such stabilizing circuits, as shown in Fig. 7, the d.c. drift of this modified circuit is only a few parts in a hundred thousand.

Random Noise

In practice the internal random-noise output of the power supply is rather more than merely the random noise of the first valve but, in any case, it is rarely greater than 3 μV or so. Recent research and the author's empirical results show that the rugged 12AX7 or CV 4004 is the most suitable valve with regard to low hum, drift and anti-microphony. Noise from the 'flicker effect' is from 6 to 8 dB below 1 μV r.m.s.

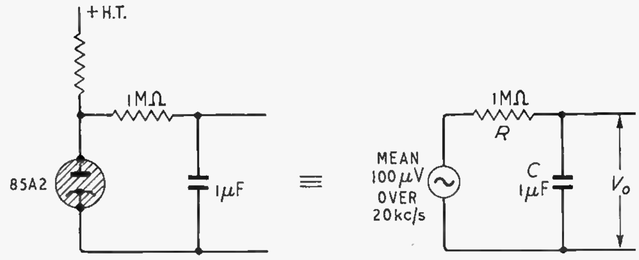


Fig. 6. *Equivalent noise generator of gas-filled voltage reference tube. Mean noise voltage* V_0 =

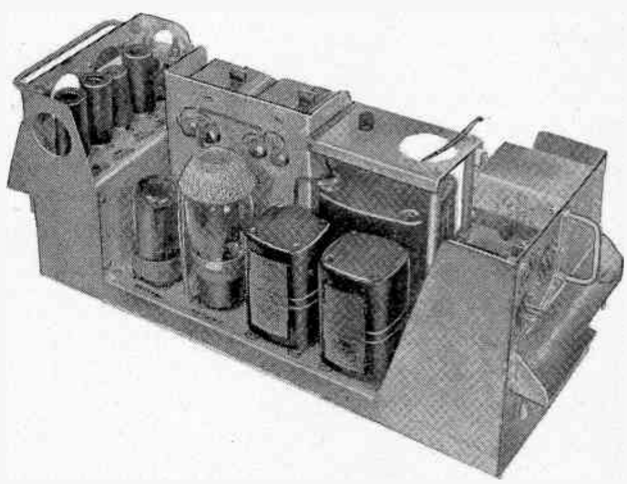
$$\sqrt{af_0\int_0^{20}\frac{dx}{1+x^2}} = \sqrt{af_0\Big[\tan^{-1}x\Big]_0^{20}}$$

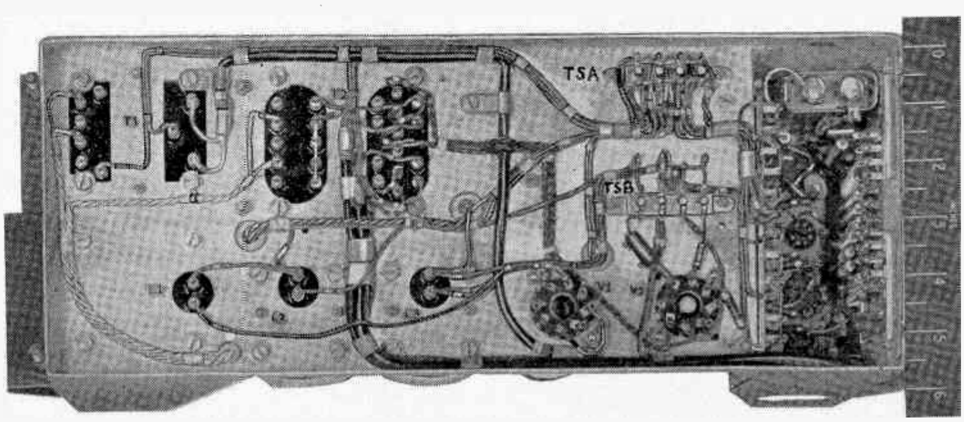
where a = (*noise voltage*)^2/*cycle and* $f_0 = \dfrac{1}{2\pi CR}$

$$= \sqrt{\frac{a\,.\,\pi}{2\pi\,.\,2}} = \frac{a^{\frac{1}{2}}}{2} = \frac{1}{400}\,\mu V;$$ *i.e., negligible noise output*

External Noise

A substantial amount of noise originates in the mains supply from commutation and switching. Because these low-hum stabilizer amplifiers have voltage gains of the order of 80 dB, the attenuated mains transient produces a comparatively large non-linear output swing, and so introduces a d.c. shift. In short, the valves act as detectors. It is likely to be thought that the large degree of negative feedback would sufficiently reduce any non-





(*Right*) *Stabilized* 250-*V* 150-*mA power pack,* 10 *μV hum showing the spiral wiring technique described; note* (*a*) *TSA common earthing point,* (*b*) *TSB common h.t. + point,* (*c*) *black screened coaxial enclosing heater leads to stabilizer amplifier* (*top left-hand corner*), (*d*) *carefully routed cable forms*

(*Above*) *Component layout showing the isolation of chokes and mains transformers from stabilizer amplifier*

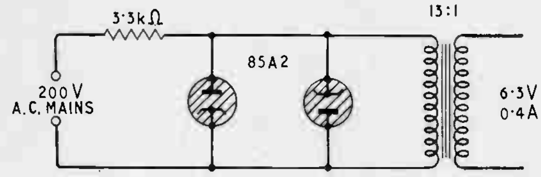


Fig. 8. *Arrangement for obtaining stable heater-voltage supply*

linearity. This would be true but for the fact that the peak in the high-frequency response due to negative feedback is not only very pronounced but the stability margin is very small. Experimentally, excessive mains transients have been found to produce high-frequency damped waves, with an accompanying change in d.c. level. This form of interference can be avoided quite simply by the usual r.f. filters in the mains supply.

Another important point is that the usual *RC* step circuits must be carefully chosen so that the amplifier is immune from any forced oscillations that might be initiated by such transients and subsequently become self-supporting.

The same type of noise and drift may be introduced by external electromagnetic and electrostatic fields acting both on the d.c. amplifier and the voltage reference valves. Since the voltage reference valves and the output voltage potentiometer network have many connections to the control amplifier, they may both be placed in the same screened box as the amplifier, so that only a few mica feed-through capacitors are required for r.f. filtering.

A Practical Example

The 470-volt 300-mA stabilized supply shown in Fig. 7 has the following performance:

(a) Output voltage constant within $\pm$ 0·1% for $\pm$ 6% mains input variation.

(b) Hum content smaller than 20 μV r.m.s.

(c) Drift better than $\pm$ 0·15% over eight hours.

If even smaller drift is required the simple circuit shown in Fig. 8 for supplying separately the heaters of V_{11} will reduce the drift from $\pm$ 0·15% to $\pm$ 4 parts in ten thousand. This circuit is an improvement upon the popular balanced heater circuit of Fig. 9.

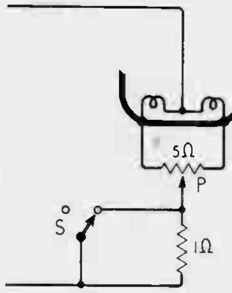


Fig. 9. *Balanced heater circuit. Switch S is closed and opened, P being simultaneously adjusted until the drift produced is a minimum*

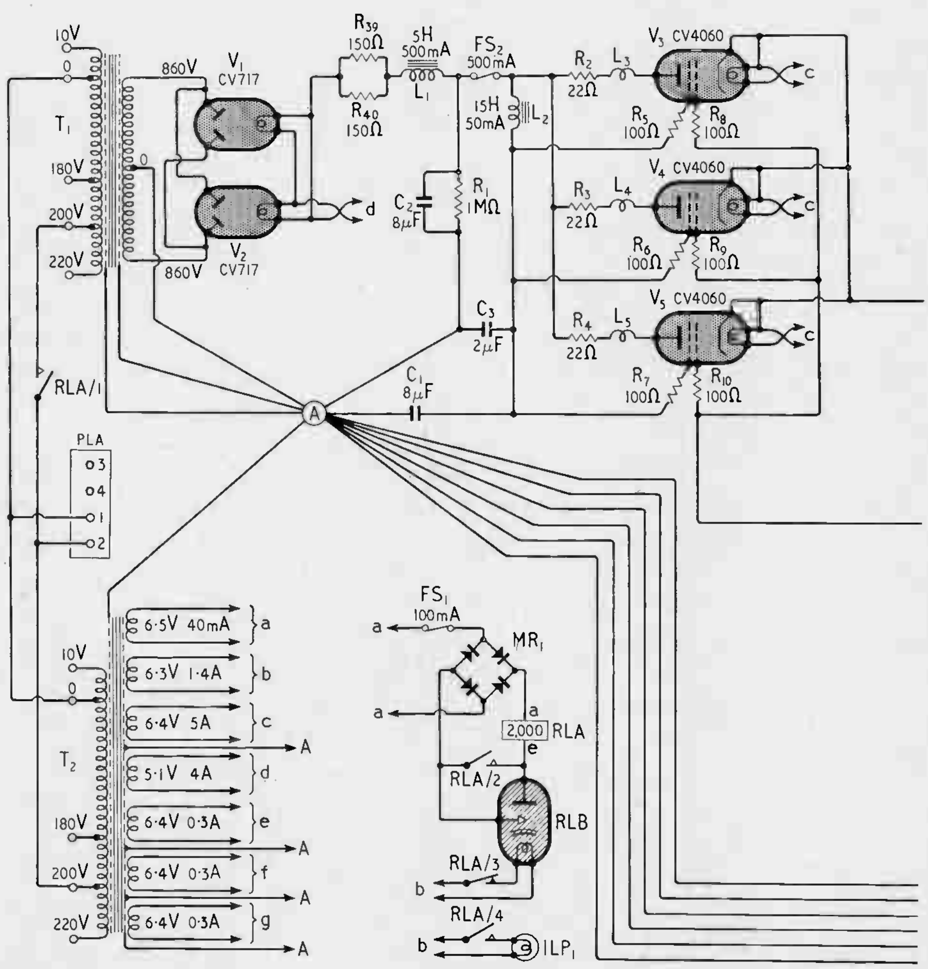


Fig. 7. *Circuit of low-noise stabilized supply*

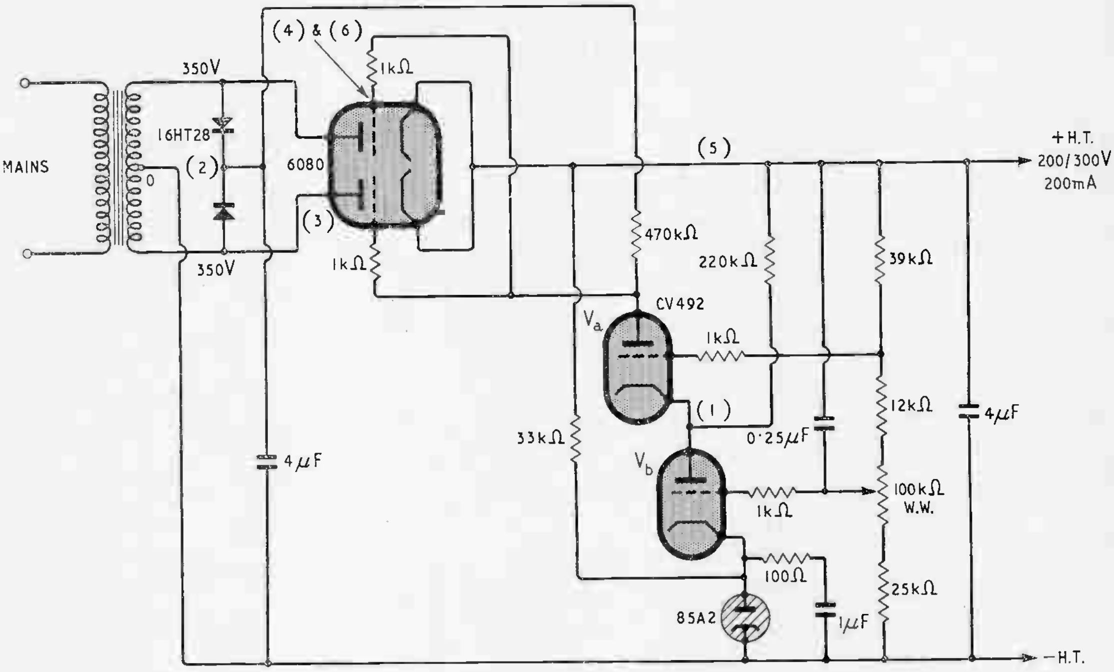


Fig. 10. *Economical stabilized supply. Heaters of CV492 earthed to negative h.t. (Maximum heater to cathode voltage is 200 volts)*

Various types of mean level feedback with direct coupling were tried. No further improvement could be obtained with regard to hum level and drift. Consequently the author attributes the low hum in particular to the special wiring technique.

An Economical Stabilized Power Supply

A very efficient stabilized power supply for ordinary applications is shown in Fig. 10. It has the following characteristics:

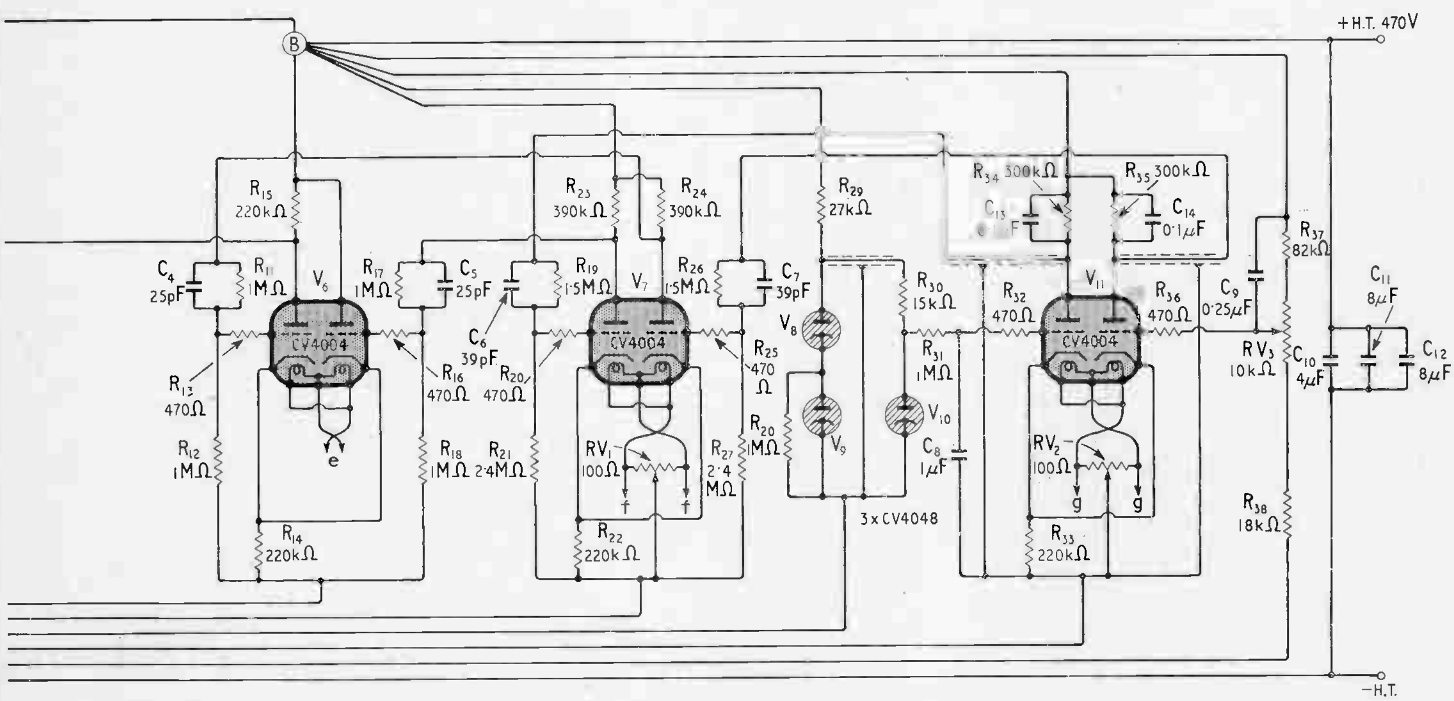
(1) Rectifiers serve dual purpose as series control valves.

(2) There are only three valves and no smoothing choke.

(3) Output impedance is 1 ohm with a hum content of 0·5 V r.m.s.

In this stabilized power supply (see References, B. J. Perry) the series-control valve is supplied with raw a.c., whereas in the type of stabilized supply previously discussed the series-control valve is fed with reasonably pure d.c. In order to avoid breaking the feedback loop each half-cycle of the mains frequency a full-wave system is employed. Typical waveforms are shown in Fig. 11, although the non-sinusoidal rectifier anode waveform was mainly due to a poor mains supply and should be examined as a phase reference only.

Attree's cascode amplifier stabilizer is utilized in view of its high gain and low h.t. consumption. In order,



however, to take advantage of a high-gain control amplifier, it is essential to exclude the smoothing choke normally used for post-rectifier filtering. This forced economy is necessary for the following reason. The inclusion of a smoothing choke, either in the h.t. positive or negative line, combines with the output capacitance to form a series-tuned circuit. This acts at low frequencies in such a way as to produce positive feedback and, hence, instability in the control amplifier. The possibility of relaxation oscillations (*see* References, F. A. Benson and G. G. Mayo) due to the 85A2 is prevented by the 100-Ω resistor in series with the shunt capacitor.

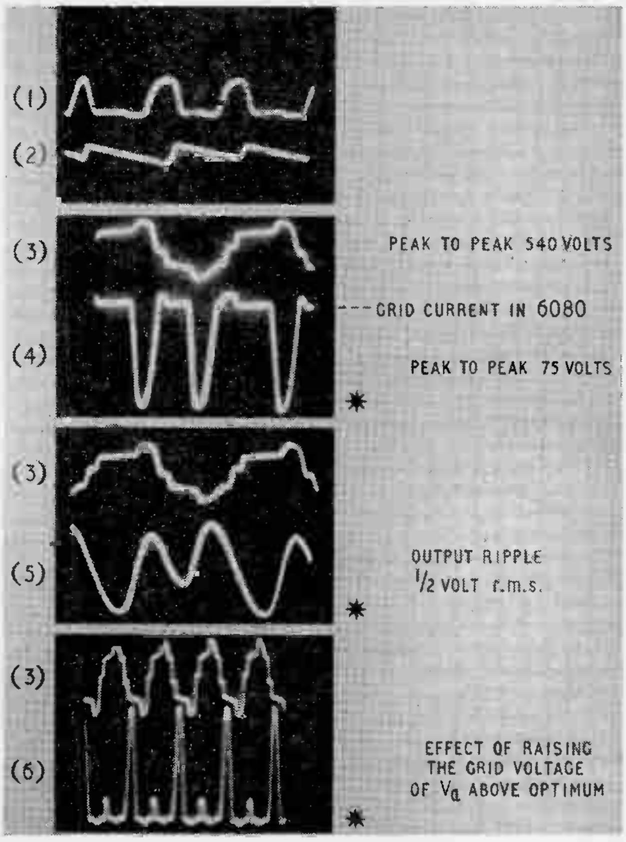


Fig. 11. *Waveforms in circuit of Fig. 10*

Acknowledgment

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Colour Television Transmission

RECEIVER CIRCUITS FOR TWO-SUB-CARRIER SYSTEM (*concluded from p. 286 August issue*)

By K. Teer

Matrixing

In the receiver three display signals—which will be denoted as E'_R, E'_G and E'_B—have to be formed from the wide-band luminance signal and the narrow-band red and blue colour signal derived from the composite signal. For this purpose, a matrixing system is included in the t.s.c. system receiver which consists of the addition of mixed highs to the colour signal and the establishment of a green signal from the luminance and colour signals.

It may be asked how the addition of high frequencies of the luminance signal must be arranged for a particular frequency-band limitation of the colour signal. The answer can be derived from the requirement that for a black-and-white picture the three display signals must equal the luminance signal.

Let E_R, E_G, E_B and E_Y be the primary signals and the luminance signal at the transmitter with channel bandwidth and which are all supposed to vary between 0 and

1. If the effect of the overall video characteristic for the red signal on this signal is represented by the operator W', then, at the receiver, the signal $W'E_R$ is available. For a monochrome picture this signal is $W'E_R = W'E_Y$ as then $E_Y = E_R = E_B = E_G$.

For a monochrome picture, mixed highs have to be added in the receiver to $W'E_R = W'E_Y$ in such a way that the red display signal E'_R equals the luminance signal. However, a certain delay with respect to the signal at the transmitter E_Y can be tolerated. Therefore, the display signal for a black-and-white picture can be represented by $V'E_Y$, where the delay is indicated by the operator V'.

It follows from this that the high frequencies to be added are defined by

$$(V' - W')E_Y$$

where the delay V' must be specified more precisely. The effect of this delay is shown in Fig. 13. Here a transient in a black-and-white picture and the corresponding colour signal, added highs and display signal are represented. The bandwidth limitation is supposed to be the simplest one, viz. a band limitation by an RC element. Two values for the delay are considered: zero delay and a delay of RC sec. Apart from a certain shift in time for a black-and-white picture, there is no difference in picture quality in the two cases.

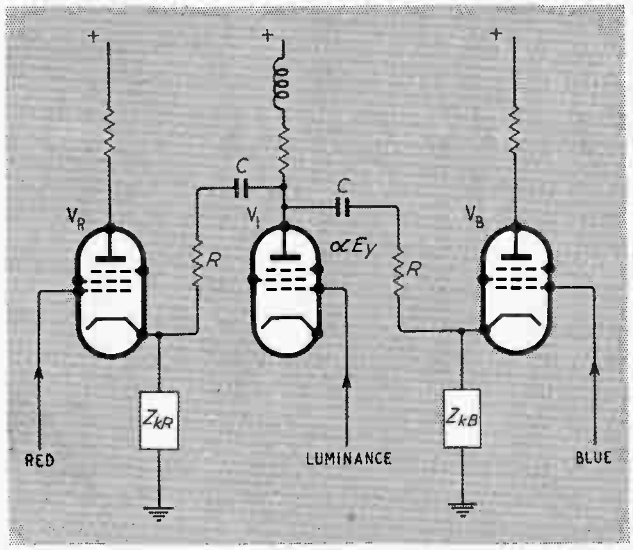
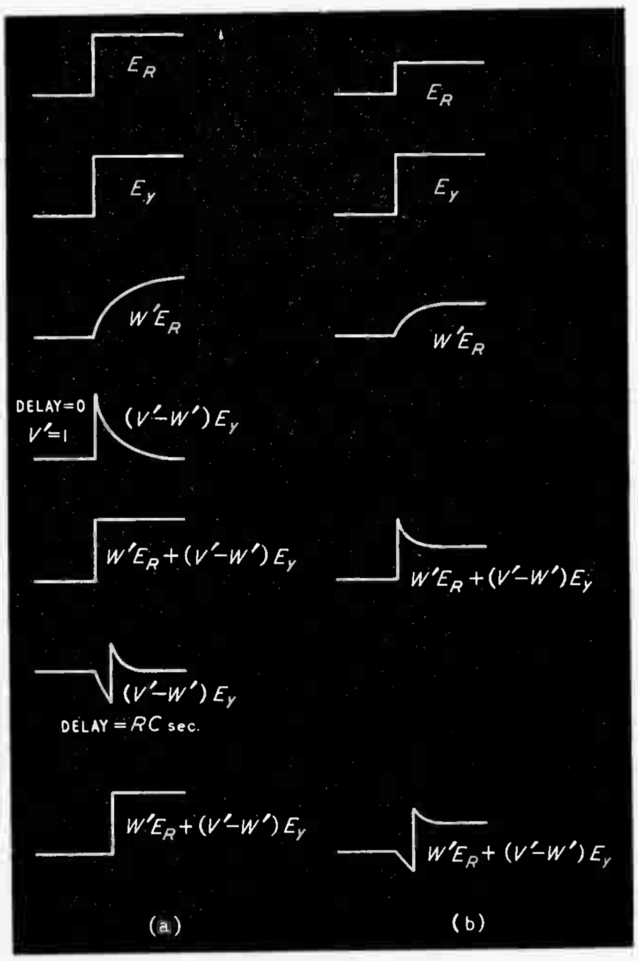


Fig. 14. *Colour-signal low-pass filter and mixed highs matrixing in a single valve*

Fig. 13. *The addition of mixed highs with and without a delay of the luminance signal: (a) black-and-white picture; (b) colour picture*



In a colour picture, however, in general the transients in E_R and in E_Y are of unequal height and an error will occur in the transition—only affecting the colour—which is proportional to $(V' - W')E_Y$.

For a colour picture, therefore, the picture fidelity in transients depends on the delay V'. If this delay is zero $(V' = 1)$ the whole distortion is on one side of the transient. For a delay of RC sec., errors occur on both sides of the transient of opposite sign. The latter form will usually be less annoying.

It follows from the foregoing that in $(V' - W')E_Y$ an optimum value of V' can be chosen, giving the least visible effect of the bandwidth reduction of the colour signals. In general this will correspond to the delay which is involved in W'.

We shall now consider practical methods of matrixing the mixed highs.

There are two possible methods of forming the display signal

$$E'_R = W'E_R + (V' - W')E_Y.$$

In the first place we may try to derive $(V' - W')E_Y$ by one filter, which must be complementarily matched to W'. In the second place the signal $-W'E_Y$ and $V'E_Y$ may be formed separately.

In both cases the bandwidth reduction W', applied to the colour signal in the entire transmission process, must be accurately known. It is evident that this will be rather difficult where many stages in transmitter and receiver influence the colour-signal characteristics. For this reason it is good practice to arrange the transmission in such a way that the ultimate transmission characteristic for the colour signal is determined by simple well-defined circuitry in the receiver, preferably by a single low-pass filter after detection. If the bandwidths of the transmitter and early stages of the receiver are all wide enough, the bandwidth of the colour signals will be accurately known. Matching of the high frequencies is then much easier, especially when the second-mentioned method of deriving $(V' - W')E_Y$ is used.

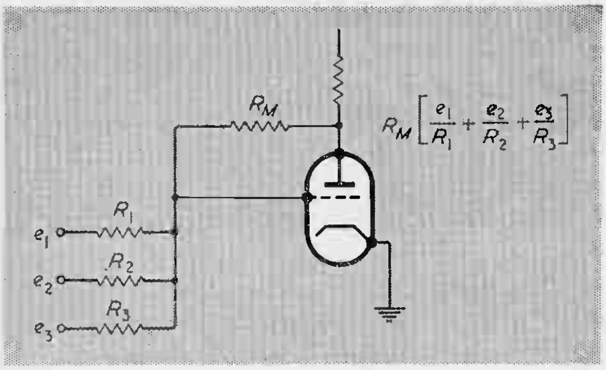


Fig. 15. *Feedback summation*

A very simple way to form complementary signals—but one that is also restricted to rather flat filtering—can be obtained by using the complementary relation between the anode currents of a grid-driven valve and a cathode-driven valve.

In Fig. 14 a mixed-highs matrix is illustrated. The luminance signal at the anode of V_1 is coupled to the cathode of V_R by means of an *RC* coupling. The value of *R* is large compared with the maximum value of Z_k, and $1/RC$ is small with respect to the lowest frequencies to be added. In the anode circuit of V_1 an *LR* network is introduced in order to correct for the coupling.

The grid signal delivers an anode current component

$$E_R g_m \frac{1}{1 + g_m Z_k}$$

The luminance signal αE_Y delivers an anode-current component in V_R

$$-\frac{\alpha E_Y}{R}\frac{1/g_m Z_k}{1/g_m + Z_k} g_m = -\alpha E_Y \frac{g_m}{R g_m}\left[1 - \frac{1}{1 + g_m Z_k}\right]$$

So if $1/(1 + g_m Z_k) = W'$ and $\alpha/R g_m = 1$ we get the red display signal at the anode of V_R. An advantage of this circuit is that matching of the low-pass and the high-pass filter is automatically correct and the addition takes place in V_R, so that the display gun does not have to be used as a matrix unit.

On the other hand, it is a disadvantage that $V' = 1$ and that the low-pass filter characteristic must be obtained by a single impedance Z_k, which leads to slow-down filters.

Green signal matrixing can be carried out in several ways. In general, it has to fulfil the following relation

$$0{\cdot}6E'_G = V'E_Y - 0{\cdot}3E'_R - 0{\cdot}1E'_B$$

or $$E'_G = 1{\cdot}7V'E_Y - 0{\cdot}5E'_R - 0{\cdot}2E'_B \quad \ldots (1)$$

or $$E'_G = 1{\cdot}7V'E_Y - 0{\cdot}5W'_R E_R - 0{\cdot}2W'_B E_B - 0{\cdot}5(V' - W'_R)E_Y - 0{\cdot}2(V' - W'_B)E_Y \quad \ldots (2)$$

or $$E'_G = V'E_Y - 0{\cdot}5W'_R E_R - 0{\cdot}2W'_B E_B + 0{\cdot}5W'_R E_Y + 0{\cdot}2W'_B E_Y$$

or $$= V'E_Y - 0{\cdot}5W'_R(E_R - E_Y) - 0{\cdot}2W'_B(E_B - E_Y) \quad \ldots (3)$$

There are three possible combinations of signals:

(1) The luminance signal and the red and blue display signal. See Fig. 14.

(2) The luminance signal, colour signals and corresponding mixed highs.

(3) The luminance signal and colour difference signals.

The synthesis can be effected in a resistance network, if enough signal amplitude is available, or in a valve preferably with feedback summation (Fig. 15) or in the display tube itself.

Automatic Ratio Control

In order to avoid deviations of the correct colour balance in the receiver picture the ratios between the peak values of luminance signal and sub-carrier amplitudes have to be kept constant throughout the transmission. Therefore an 'automatic ratio control' is needed in the receiver. For this purpose, reference signals like the 'colour burst' of the N.T.S.C. system are also introduced in the t.s.c. system. The bursts of both sub-carriers occur alternately on successive lines; i.e., one line has only a reference signal for one sub-carrier, whereas on the following line a reference signal is present for the other signal. Owing to pre-emphasis and cross-talk compensation the sub-carrier amplitudes can be chosen at such a level that bursts of maximum sub-carrier amplitude on the back porch can be tolerated. This makes it easy to measure the burst-pulse height in the receiver, because the reference voltages can be found by peak detection of the colour signal. The reference voltages derived in this manner are compared with the peak value of the luminance signal and the resulting voltage controls the amplification of the colour-signal channel.

The measurement of the luminance-signal peak value is rather difficult. Unless a special reference signal is introduced in the luminance signal too—for instance, a peak-white pulse immediately after the back porch—variations are always possible which are not involved in the measurement. For instance, the amplitude of the picture carrier at sync level may be used as a reference, as in normal a.g.c., but then variations of modulation depth and video amplification are not represented in the control signal. Another possibility is to determine the sync amplitude at the end of the video channel, but then the video channel must have a large linear range, so that the relative height of the sync pulse is not affected.

In the following, several proposals for a.r.c. will be described in somewhat more detail.

In Fig. 16 the general form of an a.r.c. network is represented. At the end of the video channel the burst pulses in the colour signal are detected, resulting in a

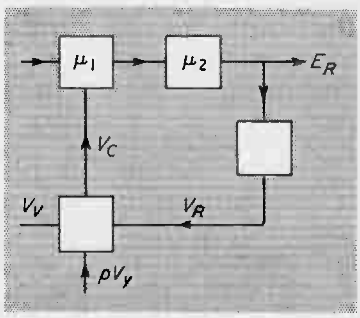


Fig. 16. *The general form of an a.r.c. circuit*

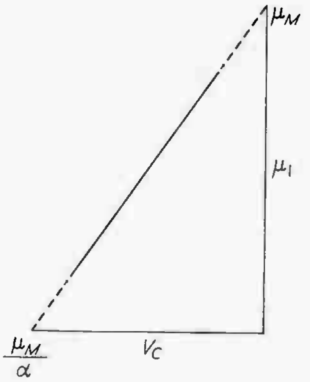


Fig. 17. *Characteristic of the control stage*

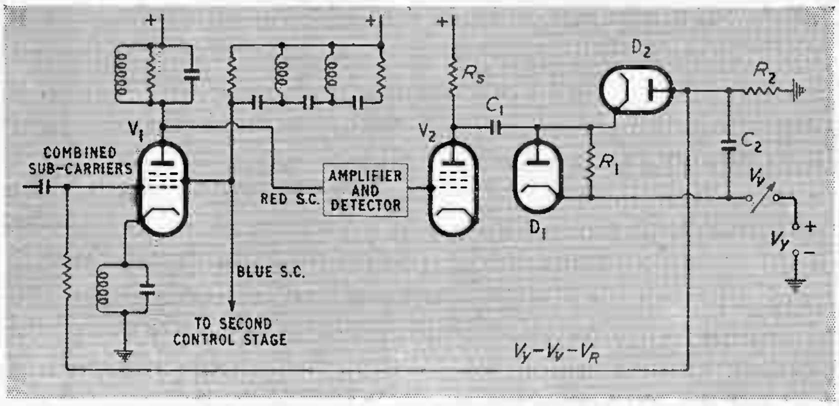


Fig. 18. *First control stage and burst detector in t.s.c. receiver*

direct voltage V_R which equals the maximum value of the colour signal. At some position in the receiver a reference for the luminance signal pV_Y is obtained, where V_Y is the maximum value of the luminance signal. Colour balance is obtained if $V_R = V_Y = V_B$.

The amplification in the colour-signal channel is obtained by a control stage amplification μ_1 and an additional amplification μ_2. The control stage is assumed to show a characteristic

$$\mu_1 = \mu_M - \alpha V_C \text{ (Fig. 17)}$$

So V_R is

$$V_R = \mu_2 \, [\mu_M - \alpha V_C] V_i,$$

where V_i is the peak value of the input signal. The voltage V_C is a combination of V_R, pV_Y and a voltage V_V for adjustment. As a decrease of V_R must cause increased amplification in the colour channel and a decrease of V_Y a decreased amplification, the voltages V_R and V_Y are combined with opposite sign:

$$V_C = V_V + V_R - pV_Y$$

and thus

$$V_R = \mu_2[\mu_M - (V_V + V_R - pV_Y)\alpha] V_i$$

For planned conditions, the peak values are denoted by V_{R0}, $V_{Y0}(= V_{R0})$ and V_{i0} and the overall amplification by μ_0.

$$V_R = V_{R0} + \triangle V_R,\ V_Y = V_{Y0} + \triangle V_Y,\ V_i = V_{i0} + \triangle V_i$$

Hence

$$V_{R0} + \triangle V_R = \mu_2[\mu_M - \alpha(V_V + V_{R0} - pV_{Y0})$$
$$- \alpha(\triangle V_R - p\triangle V_Y)]\,(V_{i0} + \triangle V_i)$$

$$\triangle V_R = \mu_0 \triangle V_i - \mu_2(\triangle V_R - p\triangle V_Y)\alpha V_i$$

$$\triangle V_R = \frac{\mu_0 \triangle V_i}{1 + \mu_2 \alpha V_i} + \frac{p\triangle V_Y}{1 + 1/(\mu_2 \alpha V_i)}$$

The following conclusions can be drawn from this relation:

(1) Due to the feedback the variations in V_R caused by variation in input signal and valve characteristics are reduced by a factor $1/(1 + \mu_2 \alpha V_i)$, where $\mu_2 \alpha$ is the change in amplification per volt of control potential.

(2) If $\mu_2 \alpha V_i$ is sufficiently large, a luminance-signal variation causes a colour-signal variation $p\triangle V_Y$. As V_R has to be kept equal to V_Y, the value of p must be chosen unity; in other words, luminance signal and colour signals of the same level have to be compared in order to get a constant ratio between these two signals.

In practical experiments an EF85 was used as a regulated amplifier. The mean value of g_m in this circuit was 3 mA/V and dg_m/dV was about 1 mA/V². The values of V_{R0} and V_{i0} were 60 V and 0·5 V respectively.

Under these circumstances an input of $V_{i0}/2$ instead of V_{i0} delivers $\triangle V_R$ of 3 V, and an output of $2V_{i0}$ instead of V_{i0} delivers a deviation of 1·5 V.

This control action is acceptable. Of course, the deviation can be reduced by more amplification in the colour channel.

Up to now the colour signal in the a.r.c. has been denoted as the red signal E_R. It is obvious that the blue channel needs a similar control. However, the use of two identical controlled colour channels is possibly not the best arrangement. As the sub-carrier frequencies are close together, a change in signal level will usually occur for both sub-carriers at the same time and in the same direction (for instance, due to fading or mistuning). It seems, therefore, better to pass the combined sub-carriers through a first control stage, controlled by the red reference voltage, and to pass the separated blue signal through a second control stage, controlled by the blue reference voltage. As most variations in the blue sub-carrier are already reduced in the first stage, less control is needed in the second and less maximum amplification is therefore needed in the blue channel.

In Fig. 18 the first control stage is shown. Both sub-carriers are fed to the EF85, V_1. The grid bias is formed by V_Y, V_R and the red contrast setting V_V. The cathode is earthed via an *LC* trap tuned to the sound carrier. The two sub-carriers are separated by networks in the anode and in the screen-grid circuit. The anode impedance is formed by the de-emphasis circuit for the red sub-carrier and an adjacent sub-carrier trap. A large amplification can be obtained due to the rather high *Q* of the de-emphasis circuit.

For blue sub-carrier separation a high-pass filter is used in the screen-grid circuit. This sub-carrier is amplified only about twice because this signal is fed to the input of the second control stage, where a rather small input signal is required. Moreover, the influence of the screen-grid signal on the anode signal has to be kept small.

The reference voltage V_R is derived from the output of the red channel by a peak detecting circuit using two diodes. The blanking level of the colour signal is clamped at a potential level $V_Y + V_V$ by the first diode D_1, whereas the second diode D_2 rectifies burst pulses, delivering across C_2 the desired voltage V_R.

It is very important to keep the load of the red-channel output, caused by the peak detecting circuit, as small as possible. This means that the leak currents have to be small which is why the leak resistance R_2 is earthed instead of being coupled to $V_Y + V_V$. In this way, the voltage across R_2 is reduced from the burst amplitude (60 V), to a few volts which constitutes the negative bias of the control valve. A second advantage is that the control valve is protected against a rise of grid potential above earth potential.

A calculation for the load applied to the channel output and the efficiency of rectification shows that practical values of R_1 and R_2 (Fig. 18) can be chosen which ensure efficient peak detection.

Apart from the diode circuit it is also possible to apply the usual a.g.c. circuit of black-and-white receivers, to derive the V_R reference voltages. The burst level of the sub-carrier, detected by a special peak detector, is then fed to the grid of a triode or pentode which is pulsed in the anode circuit by flyback pulses.

In this case, only variations in the first part of the colour-signal channel are involved, because the reference voltage is derived before the demodulator.

In order to get a reference voltage V_Y, several possibilities exist.

In the first place, the picture carrier peak amplitude can be detected and this voltage can be amplified up to the appropriate value in a d.c. amplifier. By means of a stabilizing tube, a stabilized adjustable voltage has to be subtracted from the output voltage of the amplifier (Fig. 19).

An important disadvantage of this arrangement, apart from the use of the amplifier and stabilizer, is that variations in the video channel of the luminance signal are not taken into account. The colour balance is adversely affected by fluctuating supply voltage, the luminance-signal amplification being highly sensitive to this.

In the second place the reference voltage $V_R - V_Y$ can be obtained by measuring the difference between sync and burst pulse in the colour-difference signal.

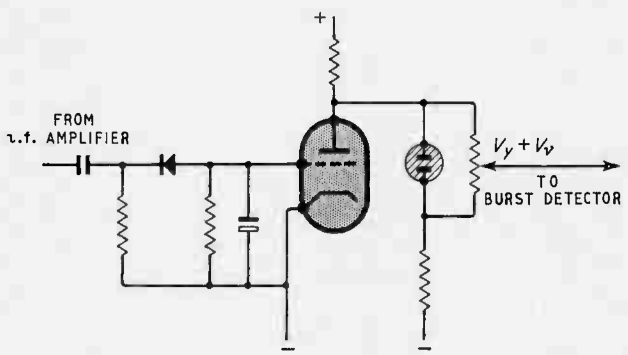


Fig. 19. *The luminance reference voltage V_Y derived from peak level of the picture carrier*

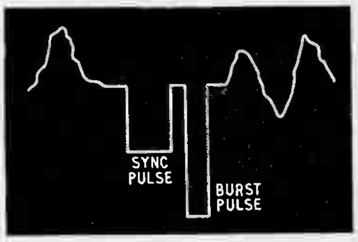


Fig. 20. *Appearance of sync and burst pulse in colour difference signal*

The colour-difference signal has then to be formed and is of the type represented in Fig. 20. If sync level is clamped at a certain potential, the burst-pulse height reaching beyond the sync pulse can be measured.

As the sync pulse is about half the black-to-white range of the luminance signal, a reference voltage $\frac{1}{2}V_Y - V_R$ can be obtained in this way. As $V_Y - V_R$ is desired, it is necessary for a correct a.r.c. to add $+ \frac{1}{2}V_R$ in order to get the correct a.r.c. regulating voltage.

The advantage of using the sync-pulse height as a reference for luminance-signal level instead of using the picture carrier amplitude is, of course, that variations in the video amplifier are represented in the reference voltage. However, this is only correct if the right sync-pulse height is maintained in the transmitter independently of the luminance-signal content and if the amplification of the sync pulse in the video part is independent of the luminance-signal level.

A third way of maintaining a constant ratio between the automatic gain-controlled colour signals and the luminance signal is to stabilize the amplification of the luminance signal in i.f. and video stages—so that the luminance-signal level becomes largely independent of variations in input signal, valves and supply voltages—and to couple the luminance contrast setting to the adjustment of the colour signal a.g.c.

For this purpose the following provisions were made in a receiver:

The amplification in the luminance signal a.g.c. circuit was increased with respect to usual values.

The a.g.c. circuit was coupled to the supply voltage in such a way that a change in luminance-signal level, due to a supply-voltage variation, was eliminated by a counteracting variation of the a.g.c. voltage.

The luminance-contrast potentiometer was connected mechanically to potentiometers in the inputs of the burst detectors.

This last solution of the a.r.c. problem is the simplest one and in our opinion also the most attractive.

Receiver Diagrams

In Fig. 21 a complete diagram is given of the video part of an experimental t.s.c. system receiver.

The radio-frequency, intermediate-frequency and audio stages are conventional. After the i.f. amplifier there are two detectors, one for the luminance signal and the other for the chrominance and sound signals.[8]

The detector output signals are indicated in the diagram by 'luminance input' and 'chrominance input'. The luminance input is coupled to the first video stage by a delay line.

The a.g.c. for the sub-carriers is obtained by two

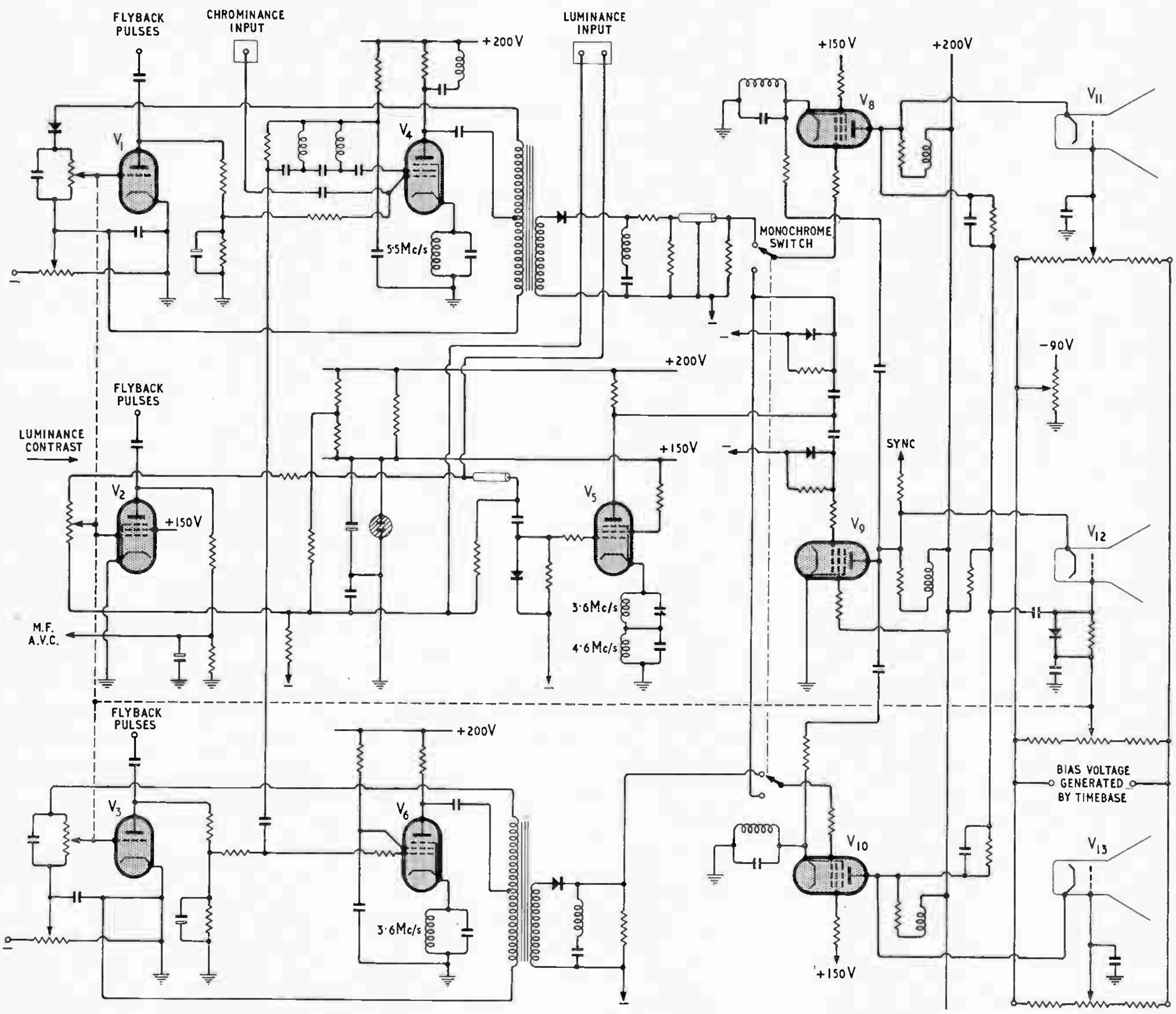


Fig. 21. *Receiver diagram*

EF85 valves, V_4 and V_6; V_4 acts on both sub-carriers, corresponding to the red reference voltage; V_6 acts on the blue sub-carrier corresponding to the blue reference voltage. These reference voltages are obtained by means of triodes V_1 and V_2, which are gated by means of fly-back pulses applied to their anodes.

The a.g.c. for the luminance signal is similarly established by means of the pentode V_2. The luminance a.g.c. circuits for the sub-carriers are mechanically coupled to the luminance contrast control.

The luminance-signal amplification is independent of the h.t. voltage. The grid return of the a.g.c. valve V_2 is connected via a suitable tap to the h.t. supply.

Each sub-carrier is detected by a single diode. In the red sub-carrier detector circuit a delay line is included.

A projection system with dichroic mirrors is used for the display (V_{11}, V_{12}, V_{13}).

The red and blue display signals are formed by the joint application of the colour signals and the mixed highs to the grid and cathode of the colour signal video output valves V_8 and V_{10} as shown in Fig. 14. The green display signal is formed by appropriate addition of the luminance signal and the red and blue display signals. The latter are added in a resistance matrix and fed to the cathode of the green picture tube. The luminance signal is derived from the anode of the luminance signal video valve V_9. As this signal is clamped on sync tops (by the grid diode of V_9), the blanking level will depend on contrast setting. In order to avoid green background change for contrast variation, the bias of the green tube grid-signal is coupled to the contrast control in such a way that the change in blanking level of the cathode signal is compensated by an equal change in blanking level of the grid signal.

The luminance signal is amplified by V_5 and V_9. The red colour information passes through V_4 and V_8, the blue information through V_4, V_6 and V_{10}. In both channels sub-carrier transformers are used for grid bias and a.g.c. purposes.

Sub-carrier traps are placed in the cathode leads of V_5 and V_6 and in the anode of V_4 combined with the de-emphasis circuit for the red sub-carrier.

For monochrome reception the output signals of V_8 and V_{10} can be replaced by a luminance signal by means of a single switch so that only luminance information is fed to the display.

The following manual controls are on the front panel:

1. Tuning
2. Master contrast (grid voltage of V_2)
3. Master brightness
4. Red brightness
5. Blue brightness
6. Volume.

Behind a small hinged door the following knobs are available:

1. Red contrast (grid bias V_1)
2. Blue contrast (grid bias V_2)
3. Horizontal and vertical hold
4. Master focus
5. Monochrome switch.

At other points in the receiver further controls are located, such as horizontal and vertical sweep, linearity and focus for each projection tube.

Acknowledgment

The author wishes to thank Messrs. G. Menkveld and N. J. P. Klijn for their assistance in the development and construction of the experimental two-sub-carrier system. They are responsible for the solution of many practical problems which arose during the investigation, as well as in the design of the laboratory equipment and experimental colour-television receivers.

Airborne Geophysical Survey Equipment

Prospecting for minerals on the ground is a slow, tedious and expensive business, especially in remote areas and difficult terrain. For this reason, it is becoming customary nowadays to carry out preliminary surveys from the air. In the case of Hunting Geophysics Ltd.'s equipment, three quantities are measured and recorded simultaneously: magnetic flux density, the conductivity of the ground, and gamma radioactivity. The last two give a direct indication of the presence of conducting and radioactive ore bodies, while the first is used principally indirectly for structure mapping; all three types of data require expert interpretation.

In practice it is essential to photograph the area under survey, at the same time recording the three measured quantities and the height of the aircraft above ground, so that a precise record of the aircraft's track may be made. In this way exact correlation is made between geophysical measurements and the ground flown over, and contour lines of the measured quantities can thus be accurately plotted on a photographic mosaic map.

[*Courtesy Hunting Geophysics Ltd.*]

Measurement of magnetic flux density is effected by means of a 'flux-gate'. This is essentially a balanced second-harmonic type of magnetic modulator in which the signal is the earth's field, modified by the ground over which the aircraft is flying. Three flux-gates are employed. Two of these respond to the components of the earth's field in the vertical and horizontal planes, and provide signals for a servo system which holds the third flux-gate in the position in which it experiences the maximum field. The output of the third is amplified, detected, and the resulting direct current passed through a winding which produces a field in opposition to the measured field, so that the device is self-balancing. The current, which varies with the field strength and, therefore, with the remanent and induced magnetism of the rocks, is recorded. Changes of 10^{-5} gauss can be detected.

The conductivity of the ground is measured by an arrangement of coupled circuits. Alternating current energizes a large coil carried by the aircraft, and the resulting field sets up eddy currents in the ground below. The field due to these eddy currents is picked up by a second coil trailed behind the aircraft. The problem is to distinguish between the feeble signals and the direct pickup which results from coupling between the energizing and pickup coils. Use is made of the fact that the phase shift between the two tuned circuits is 90° at resonance if the coupling is purely reactive. Since the ground has an appreciable resistance, the phase shift due to useful signals is not exactly 90°. The useful signals can, therefore, be detected by a phase-sensitive detector supplied with a reference voltage suitably phased to reject the quadrature component.

The photograph shows a D.C.3 search aircraft. The boom at the tail houses the flux-gate magnetometer, while the energizing coil for conductivity measurements is slung round the aircraft, the pickup coil being in the 'bird' below.

THE LAW OF INVERSE SQUARES

A recent letter (P. Hammond, *Electronic and Radio Engineer*, August 1957, p. 313), with its reference to "Newton's attraction theorem about the force inside a closed container" sent me back to have another look at the "Principia", and at Clerk Maxwell's "Treatise", and then diverted me on to a fairly recent refinement of Maxwell's repetition of Cavendish's experiment.

The formal analogy between Newton's law of universal gravitation and Coulomb's law for the mechanical force between electric charges is of course complete. In both cases we are dealing with single quantities located at mathematical points, which would make things very difficult were it not for the fact that *with an inverse square law* we do not have to identify any individual points in order to test it. It might be argued that Coulomb's law implies in itself that electric charges possess mass, but nobody nowadays would quarrel on this point; the observations with his torsion balance were of forces between charged conductors, which certainly had the necessary masses for the forces to act on. It looks, indeed, as if the apparently direct attempt to verify Coulomb's law with a torsion-balance is rather less straightforward than the Cavendish-type experiment!

Newton's Theorem

The deduction of the law of *universal* inverse-square law gravitation makes rather a long story, for Newton with his caution and thoroughness showed not only that this law worked, but that it was the only possible one that could. Starting with the planets circulating round the sun in ellipses, and treating them as massive *points*, several laws of force are in the first place possible. Thus, a particle will describe an ellipse under a force towards the *centre* that is directly proportional to the distance from the centre. It will describe a circle under an attractive force towards any chosen point S if the force is proportional to the square of the distance from S, to the cube of the chord passing through the particle and S, and inversely proportional to the square of the diameter of the circle. But the law of force *ad umbilicum ellipseos*, to the focus, the very navel of the orbit, in which the sun is situated, can only be that of a force varying inversely as the square of the distance between sun and planet.

This also is the only alternative which fits in with *all* Kepler's laws of planetary motion; but when (to the non-astronomer, at least) the planetary orbits are so nearly circular, and focus and centre so relatively close to one another, admiration at the discovery itself is heightened by the care with which the other laws were so scrupulously examined and discarded.

This, of course, is not a demonstration of *universal* gravitation so far; it is the mechanics of point-masses forming a solar system. The two important theorems in which Newton really commits himself to *universal* gravitation between every pair of particles in the universe are Theorem 30 of Book I, where he shows that, under such universal inverse-square law attraction, a particle within a hollow uniform sphere (Fig. 1) experiences no resultant force; and Theorem 31, proving that a uniform sphere attracts particles outside it just as if the whole of its mass were concentrated at the centre. He then gets down thoroughly to business with the satellites of Saturn and Jupiter, the motion of the moon, the tides, and Halley's comet; but he does not show that the inverse square law is the only one which would give *the results of Theorems* 30 *and* 31. Why should he have done so anyhow?

Maxwell says that Laplace, in his "Mécanique Celeste", first established that *only* an inverse-square law could lead to the result of Theorem 30, which is the important thing from our point of view. But Colin Maclaurin, in his interpretation of the "Principia" (1748), had already investigated the effect of other laws of force for the case of Theorem 31, and showed that for an inverse *n*th law of attraction a uniform sphere would attract a body at its surface with a force $\frac{3 \times 2^{(2-n)}}{(3-n)\,(5-n)}$ times that which would be found if the whole mass of the sphere were concentrated at its centre. Not that this is of any interest in the electrical case, or could be used for any practicable kind of test! Only if $n = 2$ is Theorem 31 possible, though.

Maxwell's Experiment

Cavendish in 1773 used a Leyden jar to charge the outer of two conductors which were connected; disconnected them; removed the outer conductor; and tested the inner for charge with a pith-ball electrometer. From Theorem 30, taken over to the electrical case, Coulomb's law shows that there should be no charge remaining. The apparatus was sensitive enough to show that if the law of force is proportionality to r^n, then n differed from -2 by less than 1 part in 50.

Maxwell, in his repetition of the experiment with

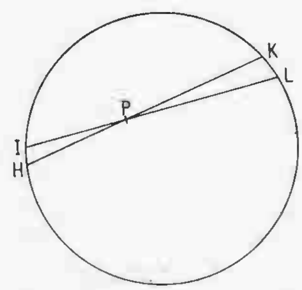


Fig. 1. *The diagram illustrating Newton's Theorem 30. The masses of the elements KL and HI of the spherical surface are proportional to their areas, and as they subtend the same solid angle at P their gravitational pulls under an inverse square law are equal and opposite. Similarly for every pair of elements into which the surface is divisible, so that there is no resultant force at P, wherever it is taken*

concentric spheres, used a quadrant electrometer, improved the insulation of the inner conductor, and instead of dismantling the outer one after disconnecting the two, simply earthed it. He showed that, if the index n is written as $(q-2)$, B the potential of the inner sphere at the end, V the common potential at the beginning, and a and b the radii of the spheres, then

$$B = \tfrac{1}{2}Vq\left(\log\frac{4a^2}{a^2-b^2} - \frac{a}{b}\log\frac{a+b}{a-b}\right),$$

and he found that q was certainly less than 1 part in 21600.

Almost as interesting as the result is the underlying view of the nature of electricity. Maxwell quotes Cavendish as thinking of the particles of "electric fluid" being squashed together in regions of great charge density, and thus acting on one another with a force possibly different from an inverse square law when at very close quarters. And he himself develops the theory in terms of the "repulsion between two units of matter". Good, solid stuff this, as they say.

Plimpton and Lawton's Experiment

Maxwell's expression for B shows that if a very large V can be obtained, and a very small B detected, then the method might be improved along these lines to narrow down the value of q more precisely. However, spontaneous ionization sets a limit to V, and contact potentials reduce the accuracy to which B may be found. S. J. Plimpton and W. E. Lawton (*Physical Review*, 1936, Vol. 50, p. 1066) overcame these two difficulties by evacuating the space between the two conductors, and by detecting B by apparatus *within* the inner conductor, having first satisfied themselves that this disposition would not affect the Maxwell calculation.

Fig. 2 shows a general view of their apparatus. The outer conductor A was 5 feet, and the inner one B was 4 feet, in diameter. The detecting system D comprised a lightly-damped galvanometer with a natural frequency of about 2 c/s, with an amplifier which was exploited to the limit allowed by Johnson noise. The conductor A gave a completely closed conducting surface, the window W being covered with a layer of salt solution. The problem of *electromagnetic* interaction between A and B due to mutual induction had to be faced, and was found to be below the noise level at the very low frequency employed. The method was to apply a high sinusoidal voltage at 2 c/s to A, thus effectively charging and discharging it continuously; any induced voltage on B, applied at the natural frequency of the galvanometer, would cause resonance. When the window was completely covered with brine, nothing was detected; complete continuity of the outer conductor was found to be essential, and they checked that the apparatus was indeed working by observing the deflection when the brine layer was blown aside! The alternating high voltage was supplied by a 'condenser-generator', a suitably shaped set of vanes being motor-driven to move between two sets of charged stator plates.

The minimum detectable voltage (B) was one microvolt, and the peak values of V more than 3 000 volts; putting in the values of the radii, Maxwell's equation shows that this would have detected a value of q as small as 2×10^{-9}.

The Meaning of the Inverse Square Law

I wish I understood what an inverse-square law really means. Like most people, I have taken it for granted and hardly bothered to think about it since the day when I met it in my very first lesson on electricity. It is possible nowadays, of course, that people who are taught along the lines of Prof. Graham Nicholson's 'uniform field' approach wouldn't meet it at that stage; it is not the only possible starting-point for a treatment of electricity.

Nevertheless, it is the one really basic law of electricity, in that it identifies something which we call electric charge, as distinct from a mere quantity of electricity $\int I\,dt$, or from a field which can only manifest itself by its effect on charges. We believe that electric charges, electrons and protons, are 'real', as real as the sun and the planets (if this is not inverting the proper order of precedence). And, using the special theory of relativity, but invoking no other result from electrical experiment, it is possible to obtain the whole of electromagnetic theory from Coulomb's law *deductively*, as shown for example in E. G. Cullwick's "Fundamentals of Electromagnetism".

I said that Coulomb's law 'identifies' electric charge. So far, we have concentrated on the denominator,

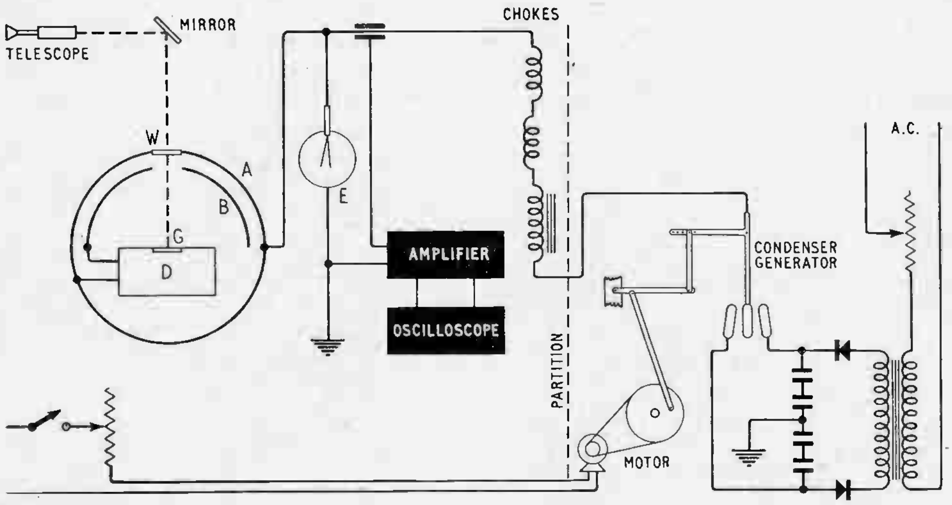


Fig. 2. *Apparatus of Plimpton and Lawton. The purpose of the choke was to remove higher-frequency components from the 2-c/s applied voltage, the amplitude of which was measured on the Braun electrometer E. The oscilloscope was for monitoring the waveform. The galvanometer vibration was observed by telescope and mirror*

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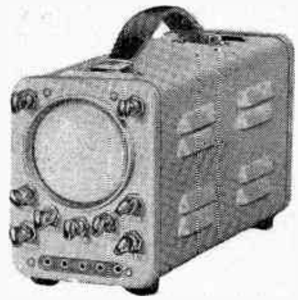

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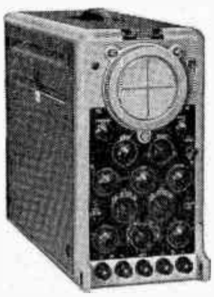
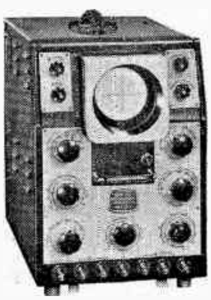


MODEL 1052—DOUBLE BEAM OSCILLOGRAPH

With similar amplifiers having continuously variable gain controls. Sensitivities of 9, 33 and 180 mV peak-to-peak/cm. Frequency response 15 c/s to 5 Mc/s (− 6 dB). Time Base for either triggered or repetitive operation. Sweep duration 5 microseconds to 200 milliseconds. 4-in. dia. flat screen tube operates at 1 kV. Power units designed for operation from all Services and domestic supplies. C-core transformer, canned and oil-filled. (Leaflet CL. 137.)



MODEL 1035 MK. II—DOUBLE BEAM OSCILLOGRAPH

Two independent amplifiers with frequency ranges 20 c/s to 7 Mc/s and 20 c/s to 100 kc/s. The 4-in. dia. flat screen tube operates at 2 kV. Time Intervals and Input Voltages may be measured on either beam by means of the calibrated controls. Time base for repetitive, triggered or single-stroke scan with velocity 150 milliseconds to 15 microseconds. (Leaflet CL. 122.)

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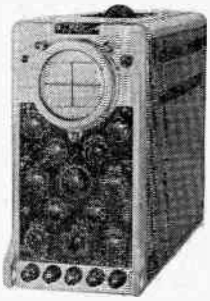
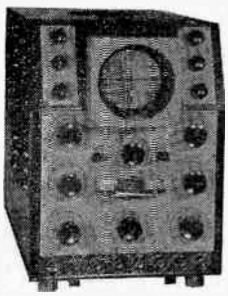


MODEL 1058—SINGLE BEAM OSCILLOGRAPH

This Model is fitted with a 4-in. dia. tube with post-deflection acceleration and direct-coupled Y amplifier with a sensitivity of 0.25 V/cm and bandwidth 0—6 Mc/s (— 50%). An X amplifier of gain five times is provided. The time base is repetitive or triggered and a special facility provides synchronisation from either frame or line sync. pulses with a 1 V double amplitude pulse (positive) television signal. (Leaflet CL. 149.)

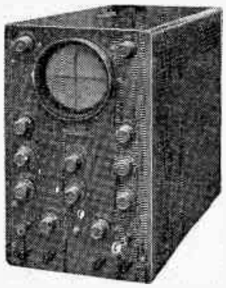


MODEL 1049 MK. IIIA—DOUBLE BEAM OSCILLOGRAPH

With direct-coupled amplifiers of gains 900 and 30 operating from d.c. to 400 kc/s and 800 kc/s respectively. Stabilised power supplies provide alternative tube operating voltages of 2 kV and 4 kV. Voltages and Time Intervals may be measured on either beam. Direct-coupled time base provides a repetitive, triggered or single-stroke scan with a time range of 1.5 sec. to 150 μ sec. Provision is made internally for Z modulation of the traces. (Leaflet CL. 112.)

MODEL 1063—HYDRAUDYNE

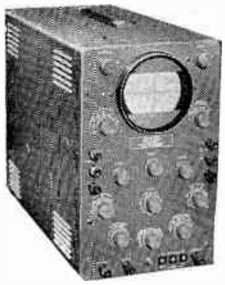
This pressure-testing equipment is compact and portable and permits the display, analysis and measurement of static and dynamic pressure conditions in all pneumatic and hydraulic systems. Complete with Transducer and all necessary ancillary items, the Hydraudyne is normally fed from alternating current mains supplies but may be driven from a rotary converter fed by a 12-volt accumulator. (Leaflet CL. 182.)



MODEL 1045K—KIT OSCILLOSCOPE

This up-to-date single-beam Oscilloscope, utilising printed circuits, is offered in kit form for construction by the purchaser. A marked economy is thus achieved whilst valuable technical experience of this type of instrumentation is automatically gained. (Leaflet CL. 215.)

COSSOR INSTRUMENTS LTD



MODEL 1071K

A double-beam Oscilloscope in kit form providing two identical Y Amplifiers of bandwidth d.c.—3 Mc/s with a sensitivity of 0.5 V/cm. A Pre-amplifier is included to increase sensitivity to 5 mV/cm up to 500 kc/s. The repetitive or triggered time base has a range of velocity from 10 msec./cm to 0.05 μsec./cm and an X Amplifier providing up to 5 screen diameters is included. Y calibration. (Leaflet CL. 207.)

MODEL 1042A

Model 1042A Oscillograph has been designed especially for the Radar field and provides an amplifier of bandwidth d.c. to 5 Mc/s with a sensitivity of 1 V d.c./cm. The triggered time base provides spot velocities from 0.066 cm/msec. to 2 cm/μsec. with direct calibration. Velocities for delayed sweep are provided. A low frequency amplifier of bandwidth 10 c/s to 4 kc/s is provided to increase the sensitivity to 20 mV peak/peak/cm.

MODEL 1065

Designed for the display and measurement of pulse phenomena and employing an amplifier of bandwidth 0-14 Mc/s (– 50%) providing a useful deflection up to 20 Mc/s. The sensitivity is better than 250 mV/cm. Time base velocities from 40 cm/sec. to 5 cm/μsec. with continuously variable delay of time base start when desired. Calibration of voltage and time by Y and X shifts. A 25 Mc/s oscillator provides intensity modulation pips spaced at 0.04 μsec. intervals for accurate measurement of pulse rise-times.

MODEL 1050A—OSCILLOGRAPH TROLLEY

Strongly constructed of steel tubing and fitted with rubber-tyred swivel castors, this trolley provides a very convenient mobile stand for Cossor Oscillographs, enabling them to be wheeled easily to any location in laboratory or factory. (Leaflet CL. 121.)

without worrying about the numerator; but this is really the more important layer. We started with gravitation and the solar system, and formal analogies, so we may as well finish in the same way. The inverse-square law of gravitation contains a good deal more than the $1/r^2$ part which is, when you come to think of it, simply the geometry of spherical symmetry. In the numerator is a definition (implicit, as most things seem to be) of that very obscure concept 'gravitational mass'.

At the root of all mechanics is the important fact that the gravitational mass of a body is proportional to its inertia-mass, but two particular examples of the use of the law will show the point I am really trying to make. These are the planets Neptune and Pluto—the more recently discovered members of the solar system that were located by, so to speak, tracing back an unexpected gravitational pull until the *mass* that was its starting-point in each case was found. Newton's law of universal gravitation really means, then, that when we find a gravitational field we can proceed confidently to look for and locate its source. Similarly, Coulomb's law surely means that when we find a steady electric field spreading out in space in the same kind of way, we know that if we trace along it in the right direction we may find it starting from, or ending up on, a small body that we call a free electric charge. If you can offer any better picture of the concepts of mass and charge—I don't mean text-book or B.S.I. definitions—I shall be only too glad to pick your brains. For I can do no better myself.

Characteristics of H.F. Signals*

RECEPTION IN THE U.K. OF TRANSMISSIONS FROM INDIA AND CEYLON

By A. F. Wilkins, O.B.E., M.Sc., M.I.E.E. and F. Kift

SUMMARY. *Measurements at various daytime periods between October* 1952 *and January* 1954 *of the angles of elevation of* (*a*) *both pulse and telegraph signals from Negombo, Ceylon, and Kirkee, India, and* (*b*) *telegraph signals only from New Delhi, India, showed that on frequencies lying between* 15 *and* 19 *Mc/s the energy was received most strongly and most often within the angular range* 7° ± 2°. *In particular, components of the pulsed signals from Negombo during* 1953 (16·16 *Mc/s*) *were within the range* 7° ± 2° *for* 98% *of the observing time; i.e.,* 1030 *to* 1530 *G.M.T. on one day per week excluding June to September* (*when the signals were too weak to measure*). *It is concluded that receiving arrays in the United Kingdom should be designed accordingly. Although* 7° ± 2° *was the best overall elevation range for all the stations concerned, measurements of Kirkee signals showed a decrease to* 5° ± 2° *during the summer* (1954). *Evidence from back-scatter observations at both Ceylon and Slough suggest that this change may be associated with the summer increase in sporadic-E ionization at the European end of the path.*

In h.f. signalling over long distances the waves travel between transmitter and receiver by reflection between the earth and the ionosphere and it is usually possible for them to traverse this path by several routes of various lengths. The total received signal is thus the resultant of the signals travelling by these different modes of propagation and it will change in character as the number of possible modes changes. These modes will themselves be governed by variations in the state of the ionosphere over the path. Thus there may be variations in the length of a received signalling element in telegraph operation with resulting variation in the possible speed of signalling, or, in telephony, the variations in the character of the fading caused by the interference of the modes may be such as to vary the degree of intelligibility.

Another important characteristic of the signal is the angle of elevation of its various components which correspond to the various modes of propagation and their variation with time. It is often found that one of these components is of predominating amplitude for considerable periods and such a characteristic is used in the MUSA (multiple-unit steerable antenna) aerial

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

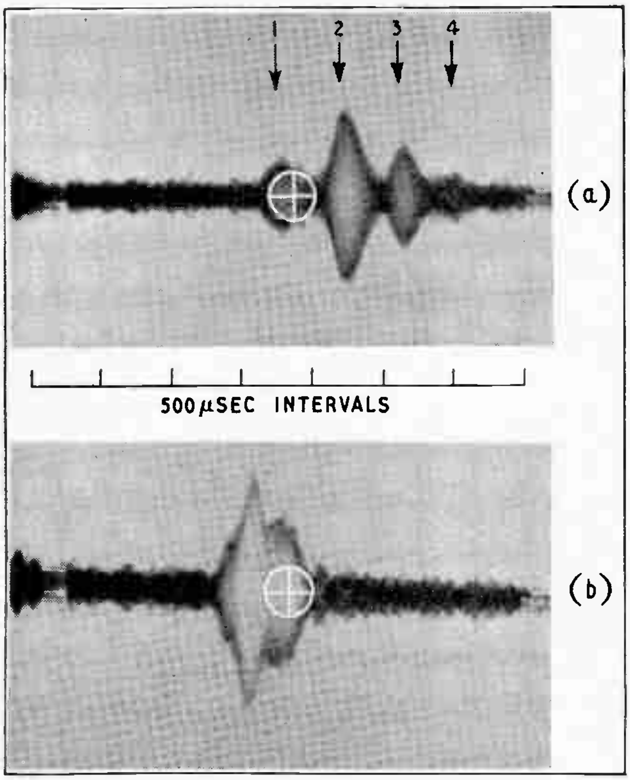


Fig. 1. *Echo patterns obtained on* 16·16-*Mc/s pulse transmissions from Ceylon on* 6*th November* 1953. (*a*) 1126 *G.M.T. shows four* F_2*-layer multiple reflections;* (*b*) 1515 *G.M.T. shows complex echo group*

system in which it is possible to adjust the main lobe of the vertical radiation pattern to produce maximum pick-up on the strongest incoming signal component. With receiving aerials of fixed radiation pattern it is desirable to design for maximum pick-up over an arc in the vertical plane corresponding to the most frequently occurring angles of elevation. By so doing it has been found possible in some cases to extend the period of operation on a given frequency and also to improve the signal-to-interference ratio, a matter of some importance in the existing congestion of the h.f. band.

The experiments described were performed with the object of providing information of the type mentioned above on the important circuits between India and Ceylon and the United Kingdom.

Most of the measurements of the Ceylon signals have been made using pulse transmissions on 16·16 Mc/s from the Royal Air Force station near Negombo; telegraph signals from this station have also been used. The Indian measurements have been made using both pulse and telegraph transmissions from Kirkee on a frequency of 18·42 Mc/s. Other measurements have been made on telegraph signals from New Delhi on 15·59 Mc/s. Measurements of angle of elevation have been made on all these signals. The echo pattern received during the pulse transmissions has also been photographed with the object of identifying the various modes of propagation involved and measuring the echo spread. In some instances the field-strength variations of the telegraph signals have been recorded during the angle of elevation measurements.

It should be noted that the angles of elevation of the weaker components of a signal may be obscured on c.w. measurements.

Experimental Procedure

The apparatus used and the method of recording the angle of elevation measurements was that described by Wilkins and Minnis[1] in which a comparison is made of the amplitudes of the signal e.m.fs produced in two horizontal loop aerials placed one above the other on a wooden mast 105 feet high. The loop e.m.fs are amplified in separate receivers with a common beat oscillator; adjustments are provided for the equalization of the characteristics of the receivers. The receiver i.f. outputs are connected to the othogonal deflecting plates of a cathode-ray oscilloscope; the inclination of the trace on the oscillograph screen gives the ratio of the e.m.fs in the two aerials from which the angle of elevation of the arriving signals may be calculated.

For the recording of the echo pattern obtained during pulse reception the i.f output of one of these receivers was applied to a cathode-ray oscilloscope which also displayed a linear time-base, and arrangements were provided for photographing the resulting pattern.

Field-strength variations of the telegraph signals were measured by means of a separate receiver using a vertical aerial and a pen recorder worked by the second detector anode current.

Schedule of Observations

Measurements were made on transmissions as follows:

Station	Frequency Mc/s	Type of Transmission	Period of Observation
Negombo, Ceylon	18·935	Six-channel, single-sideband telegraphy	Once per week between 10.10.52 and 19.12.52 at 0900 to 1300 G.M.T.
,,	18·79	Pulse	16.1.53 between 1042 and 1425 G.M.T. 14.4.53 between 1406 and 1510 G.M.T.
,,	16·245	Six-channel, single-sideband telegraphy	Between 0900 and 1800 G.M.T. on 12 days in period 17.10.52 at 10.4.53
,,	16·16	Pulse	Between 1030 and 1530 G.M.T. once per week in period 16.1.53 to 6.11.53
,,	9·995	Six-channel, single-sideband telegraphy	4 periods in late afternoon between 11.52 and 1.53
Kirkee, India ATZ2	18·42	Pulse	28.6.54 to 2.7.54 between 1100 and 1500 G.M.T.
,,	18·42	Double-current cable code telegraphy	Once per week between 30.10.54 and 29.1.55 at 1000 to 1200 G.M.T.
New Delhi, India ATL3	15·59	Frequency-shift telegraphy	Once per week between 30.10.54 and 29.1.55 at 1000 to 1200 G.M.T.

Results of the Observations on Negombo, Ceylon

Telegraph Signals

(*a*) 18.935 *Mc/s*

During each of the five days of measurement the strongest component of the incoming radiation had a mean angle of elevation of 7·5° and little variation occurred during the two-month period concerned. Weaker components were always present of which the next in strength was at about 12° elevation angle.

No significant daily or monthly variations about the mean were noted.

(*b*) 16.243 *Mc/s*

During all the periods of measurement the angle of elevation of the strongest rays lay within the range 7° to 9° except that, on 17th October 1953, during the period 1125 to 1345 G.M.T. the strongest rays lay in the range 18° to 21°, the 7° to 9° rays then being absent. Similar behaviour has been observed during the reception of the 16·16 Mc/s pulse transmissions from this station and is referred to below.

Other rays on this frequency have been observed at 11°, 13° to 15°, and 17°, but their strength was usually 6 to 20 dB below that of the 7° to 9° components.

(*c*) 9·995 *Mc/s*

The signals on this (night) frequency were observed for periods of about one hour immediately after the close of the normal day-time circuit on 16·245 Mc/s. No measurements have been made during the period when the whole path was in darkness and, because of this fact and of the small number of observations, the results cannot be regarded as typical of normal conditions on the circuit. During the four periods of measurement, the angle of elevation lay within the range of 12° to 14°, and there was no evidence of any component of comparable strength at any other angle.

Pulse Signals

Most of the pulse transmissions from Negombo were observed on a frequency of 16·16 Mc/s but a few observations were also made on 18·79 Mc/s. All pulses were of 100 microseconds duration. They showed that the strongest ray was arriving at 7·5° angle of elevation along with other weaker echoes.

16·16 *Mc/s*

Twenty-four transmissions yielded useful information. During the period 12th June to 11th September 1953 no useful signals were observable on the angle of elevation system. Recordings of the signal strength of the 16·245-Mc/s telegraph transmissions received during the pulse experiments showed that the field-strength dropped 12 to 15 dB during the summer months, and this fact, together with the low peak power of the pulse transmitter (3·5 kW) and the low pick-up of the aerials of the angle of elevation system, doubtless accounts for the inability to make measurements.

Multi-path propagation was evident throughout the tests ; the echo pattern showed an overall time spread which varied from 250 to 2 500 microseconds with a mean of about 900 microseconds. A fairly simple echo distribution was frequently seen in which the individual echoes were probably produced by multiple-hop F-layer transmissions. An example of such an echo pattern is shown in Fig. 1(a). Up to four multiply-reflected echoes have been identified as present at any one time. In addition, other echoes have been

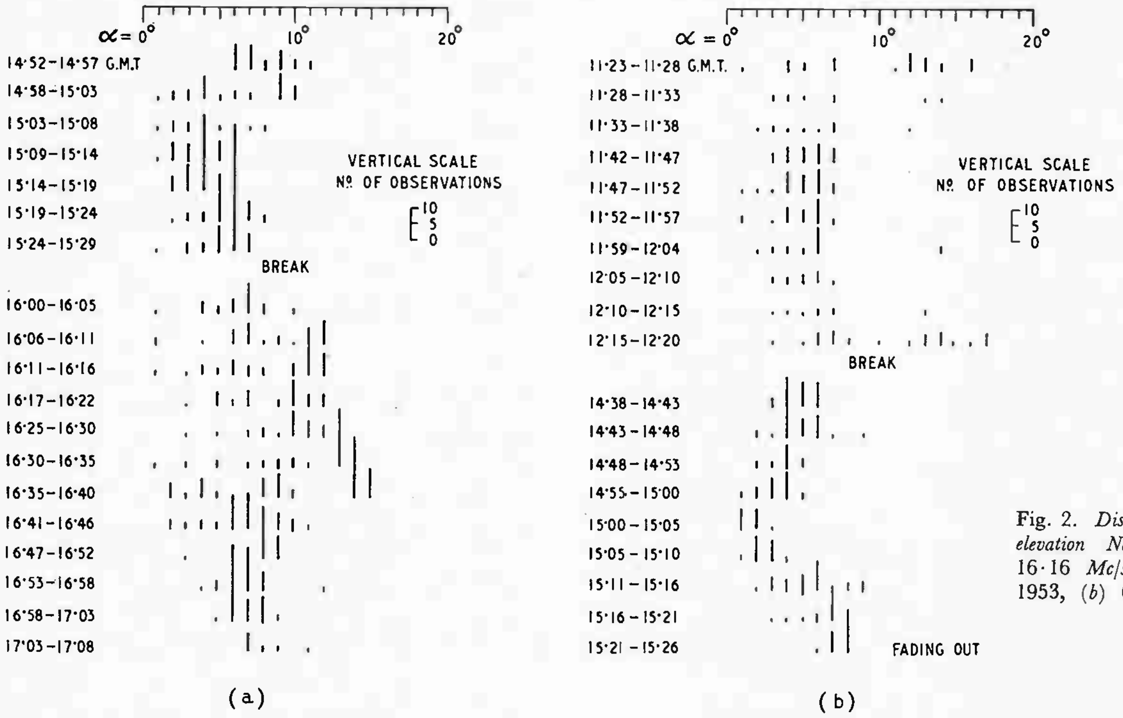


Fig. 2. *Distribution of angles of elevation Negombo–Slough: f =* 16·16 *Mc/s.* (*a*) 9th *October* 1953, (*b*) 6*th November* 1953

noted, but their identity could not readily be established; it is considered likely that they correspond to modes involving reflection by both F_2 and E_s layers. An example of this type of echo pattern is shown in Fig. 1(b).

Angles of elevation measured during the whole period, summer excepted, range from about 4° to 19°, where the lower value probably corresponds to a third-order and the upper value to a fifth-order reflection from the F_2 layer. Examples of the results obtained during two periods of observation of angles of elevation are shown in Figs. 2(a) and (b).

Analysis of the angle of elevation measurements made between 13th February and 6th November 1953, excluding the period 12th June to 11th September, has shown that angles of 7° ± 2° occurred for 98% of the observing time. The field strength of the echoes within this range was, on the average, 6 dB or more greater than that of the others. Fig. 3 shows the frequency of occurrence of rays arriving at angles within the range 3° to 11°. In this connection it should be remembered that the very low angles of elevation are discriminated against by the transmitting and receiving aerials.

Observation of the echo patterns indicated that the various components were not present simultaneously throughout the whole of a test transmission ; on many days components other than those at about 8° angle of elevation (which were nearly always present) came and went apparently at random. Thus, on 6th November 1953 [Fig. 2(b)], components at angles within the range 10·5° to 17·5° appeared for short periods during the morning. On a few occasions the lower angle rays have weakened to below noise level leaving strong echoes at angles of 15° to 19°. This type of behaviour has existed for periods of upwards of an hour.

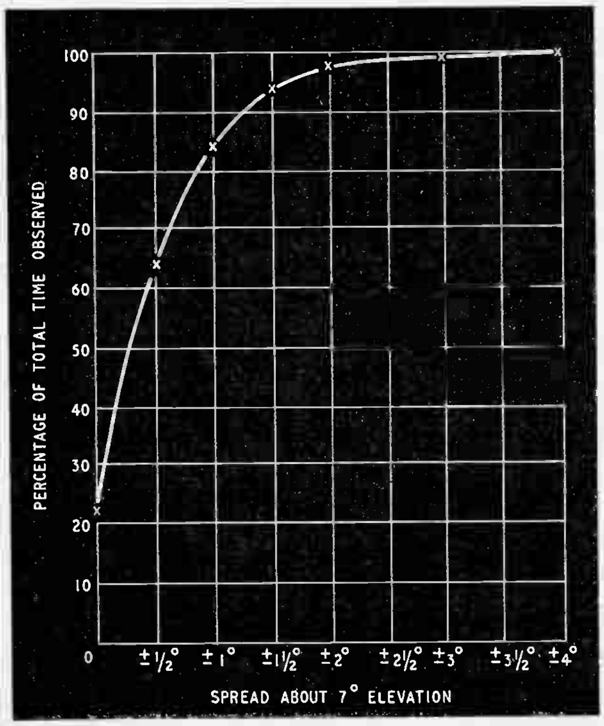


Fig. 3. *Angles of elevation on transmissions from Negombo observed at Slough, February–October* 1953; *frequency* 16·16 *Mc/s. Example:* 6°–8° *(inc.) was present during* 84% *of all observing time*

Results of the Observations on Indian Stations

Pulse Signals from Kirkee

Pulse transmissions on 18·42 Mc/s from this station were made during the period 28th June to 2nd July 1954. Many measurements of the angles of elevation of the received rays were made during the daily period of 11.00 to 15.00 G.M.T., in addition to recording the echo pattern. Complex echo groups were seen throughout the tests and positive identification of individual components was difficult. The maximum recorded time-spread of the echo pattern was 1500 microseconds with a mean spread of about 600 microseconds.

The results of the angle of elevation measurements may be stated as follows :

28th June

The strongest echoes were confined to the angular range 5° ± 2° except between 1403 and 1438 G.M.T. when an additional group at 10° ± 2° appeared. The strength of the echoes in this second group appeared to vary between about 3 and 10 dB below those in the lower angle group.

29th June

The angles were again confined to the range 5° ± 2°. During the interval 1220 to 1430 G.M.T. low signal strength precluded measurement.

30th June

Once again the group centred on 5° was present during the whole transmission. Echoes at larger angles were more in evidence especially between 1310 and 1425 G.M.T. when values up to 12·5° were recorded ; their strength was much less than that of the echoes in the 5° group.

1st July

The angle of elevation remained between 3° and 9° during the whole transmission. A small but well-defined change in the modal value of the angle was noted between 1100 and 1300 G.M.T. (see Fig. 4). At 1100 G.M.T. the value was about 5·5° ; a slow increase to about 7·5° at 1220 G.M.T. followed and by 1300 G.M.T. the angle had returned to 5·5°. At 1220 G.M.T. the spread of observed angles was 4·5° to 9° with signs of rays incident at 10·5°.

2nd July

Angles of between 3° and 9° were measured with no sign of any higher values except during the period 1133 to 1210 G.M.T. when weak rays of up to 14° angle of elevation were noted.

Telegraph Signals

(*a*) *Kirkee,* 18·420 *Mc/s*

Measurements of angle of elevation of the Kirkee telegraph signals on 18·420 Mc/s were commenced on 30th October 1954 and continued until 29th January 1955 mainly with a view to comparing the results with those obtained in the earlier pulse measurements (described above) in order to decide whether any seasonal variation existed in angular distribution of the arriving energy. This station is employed on the telegraph circuit to the United Kingdom and the normal signals were used for the measurements which were made on Saturdays between 0930 and 1200 G.M.T. Supplementary measurements were made at the same time on the New Delhi telegraph signals on 15·59 Mc/s.

This resumption of observations on the Kirkee signals showed that, although there were signs of rays arriving at angles of about 5° as noted during the earlier pulse tests, the strongest components were being received at angles of about 7° and weak components at angles up to 15° were also present. The distribution of angle measurements towards the conclusion of the experiments was, in fact, substantially similar to that previously observed on the 16·16 Mc/s signals from Negombo. Analysis of the measurements of Kirkee signals showed that an angle of elevation of 7½° ± 2° was present for 99% of the time of observation and this, in general, was the strongest ray; over the whole period of observation the total spread of angle of elevation did not exceed 3° to 11°.

(*b*) *New Delhi*, 15·59 *Mc/s*

Analysis of the angles of elevation measured on the New Delhi signals showed that, for 95% of the time of observation, an angle of 8½° ± 1° was present and that the spread of angle for the whole period did not exceed 4° to 14°. The strongest rays were most frequently at angles of elevation of about 9°.

Summary of Results—India and Ceylon

The results of the angle of elevation measurements, for the dates and times given above were:

Transmitter	Frequency Mc/s	Transmitting Aerial and Main Lobe Vertical Width	Predominating Angle of Elevation	Other Angles of Elevation (dB down on Predominating Angle)
Negombo, Ceylon (8700 km)	18·935	Rhombic 7½° ± 3°	7½°	12° and above (usually 6 to 10 dB)
	18·79	Rhombic 7½° ± 3°	7½°	Insufficient observations
	16·245	Rhombic 9° ± 4°	8° ± 1°	11°–17° (usually 6 to 10 dB)
	16·16	Rhombic 9° ± 4°	7° ± 2°	10½°–17½° (usually 6 to 20 dB)
	9·995	Rhombic 15° ± 6°	11° ± 1°	None measurable (very few observations)
Kirkee, India ATZ2 (7200 km)	18·42	Early type Franklin (angle not known)	5° ± 2° (Summer)	8°–14° (usually 6 to 20 dB)
	18·42	Early type Franklin (angle not known)	7½° ± 2° (Winter)	3°–4° & 10°–15° (usually 6 to 20 dB)
New Delhi, India ATL3 (6700 km)	15·59	Unknown	8½° ± 1°	4°–7° & 10°–14° (usually 6 to 20 dB)

Back-Scattering Observations in Ceylon

In order to check the radiated power of the Negombo transmitter when working on pulses, reception was carried out near Negombo using an array directed towards the United Kingdom. In addition to receiving the ground wave it was found that back-scattered

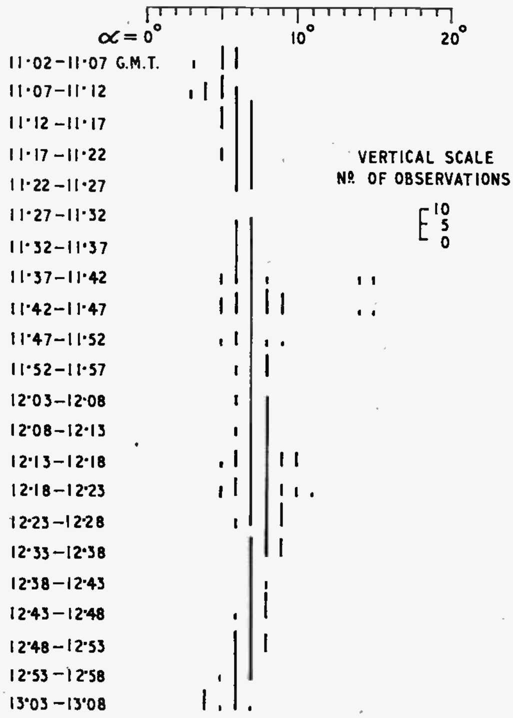


Fig. 4. *Distribution of angles of elevation, Kirkee–Slough, 1st July* 1954; f = 18·42 *Mc/s*

signals of useful strength could be received. Photographic records of this back-scattering were obtained on each transmission between 26th June and 16th October 1953 and have been studied to find out if they add to the knowledge of the mechanism of propagation over the path concerned. The theoretical and practical aspects of back-scattering from the ground propagated by way of the ionosphere have been considered by several workers (e.g., Shearman[2,3]). Briefly, the back-scatter technique of ionospheric investigation depends on the fact that energy radiated from the transmitter is returned to the ground at a distance after reflection at the ionosphere. The bulk of the energy incident at the ground is reflected and travels onwards from the transmitter. A small portion of the incident energy is, however, scattered by ground irregularities and some of it returns to the position of the transmitter along the path taken on the outward journey. Owing to the focusing of energy at the skip distance a considerable back-scattered signal is usually received from that range and somewhat beyond it. In addition, scattered signals are frequently receivable from the region where focusing occurs at the ground after the waves have travelled two or more hops between ground and ionosphere. The skip distance for one-hop propagation as deduced from the back-scattered signals is usually in good agreement with the value calculated in terms of the ionospheric characteristics measured at vertical incidence at the region of reflection.

In the present experiments the back-scattering records obtained near Negombo were compared with ionospheric characteristics estimated for the area of reflection from the data obtained at the Bombay, Madras and Tiruchirapalli recording stations of All

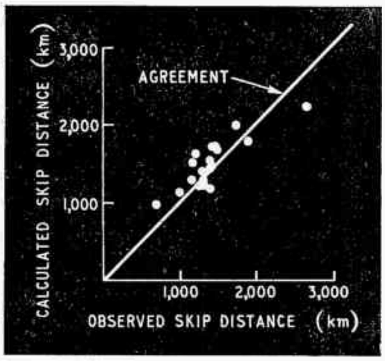


Fig. 5. *Comparison of observed and calculated skip distances (F_2 layer) for Negombo,* 16·16 *Mc/s, June–October* 1953

India Radio. Observed and estimated skip distances for the echoes propagated by way of the F_2-layer were in reasonable agreement (see Fig. 5), but it was also apparent that, for nearly all the records, other scatter patches were present which must have corresponded to ground scattering propagated by way of the E_s-layer. No check of this was possible because of the lack of E_s-layer data from the observations mentioned. The existence of E_s ionization in amount sufficient to transmit back-scattering on the frequency concerned (16·16 Mc/s) suggests the likelihood of modes of propagation over the Negombo-Slough path of the $E_s + F_2$ type if not of multiple reflections purely from the E_s layer. These back-scattering observations do not permit the optimum angle of projection of the transmitter beam to be determined, but it is possible to obtain the upper limit of this angle above which value all energy is wasted. This was found for the present data by determining the skip distance from the back-scattering records by application of the methods given by Shearman[2] and determining the corresponding angle of projection by methods involving the Appleton and Beynon[4] theory. It was concluded from this that, on 16·16 Mc/s at the times and seasons concerned, any radiation leaving the Negombo aerial at an angle of projection greater than about 15° would almost invariably be wasted.

Back-Scattering Observations at Slough

Similar observations of back-scattering were made at Slough during the transmissions from Negombo between 12th June and 23rd October 1953. These observations, which were made on a frequency of 16·3 Mc/s, showed that until the end of August the recorded scattering was probably confined almost entirely to that which had been propagated by reflection from E_s- and F_1-layers. From September onwards the main scattering was propagated by F_2-layer reflections with occasional signs of E_s-layer components. Such seasonal behaviour has been reported by Shearman[3] who found that, during June 1953, E_s-propagated scattering was present during 75% of the noon observing periods on frequencies from about 10 Mc/s to 25 Mc/s. No back-scattering which could be attributed to F_2-layer propagation was seen during that month, but back-scattering propagated by the F_1-layer was frequently seen. This behaviour was expected in view of the density and frequency of appearance of E_s ionization in the summer, while propagation predictions (e.g., those given in Bulletin A of the Radio Research Station) indicated that no F_2-layer propagation on frequencies between 10 Mc/s and 25 Mc/s should have been possible, because all energy at angles of elevation above the critical angle for F_1-layer reflection would penetrate the F_2-layer.

A comparison has been made of the calculated skip distances for scatter propagated by reflection at the E_s-layer using data recorded at Lindau (Germany) and de Bilt (Holland) observatories, both of which lie very near to the Slough-Negombo great circle. The observed and calculated values of skip distance for various times in the middle of the day are plotted in Fig. 6. They show reasonable agreement having regard to the irregular horizontal distribution of E_s-layer ionization and the uncertainty as to whether the observed back-scattering was being returned along the axis of the transmitted beam.

Between the end of August and October back-scattering propagated by the F_2-layer began to appear.

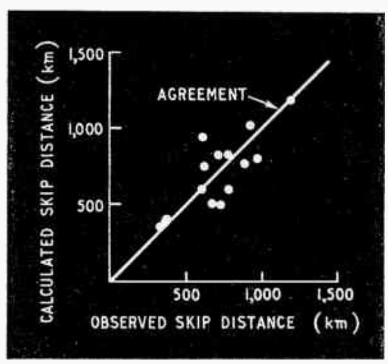


Fig. 6. *Comparison of observed and calculated skip distances (E_s layer) for Slough,* 16·3 *Mc/s, June–October* 1953

Fig. 7 shows a plot of the observed skip distance against the corresponding calculated value; it will be noted that the observed values are, on the average, somewhat higher than the calculated values in this case and in that of Fig. 5. A similar discrepancy has been noted by Shearman[3]; the explanation has not definitely been established.

These and other back-scattering observations made at the Radio Research Station show quite clearly the important effect of the E_s- and F_1-layers on the propagation of h.f. waves during the summer in daytime. From considerations of the characteristics of the ionosphere measured in Europe during the summer of 1953 it has been concluded that, during the bulk of the daily period of measurement of the signals here considered, propagation would normally have been by E_s- or F_1-layer reflection at the European end of the path. This conclusion is also of importance in connection with the maximum usable frequency (m.u.f.) on which circuits can be operated on frequencies well above the predicted m.u.f. obtained by application of the two control-point method and taking into account F_1-, F_2- and E-layers. When E_s-layer propagation is considered, the discrepancy between observed and predicted m.u.fs is often reduced, but whether the existence of E_s ionization on a path is the whole explanation of the discrepancy cannot yet be stated.

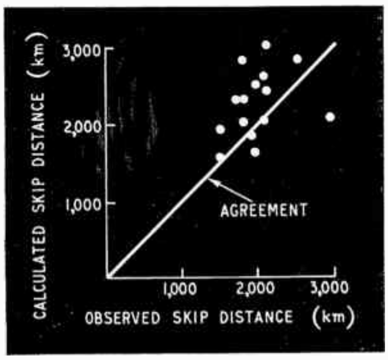


Fig. 7. *Comparison of observed and calculated skip distances* (F_2 *layer*) *for Slough*, 16·3 *Mc/s*, *August–October* 1953

No data exist from which conclusions relating to the middle of the Slough–Negombo path may be drawn.

Conclusions

It may reasonably be concluded from the measurements of angle of elevation of the 16-Mc/s Negombo signals that the strongest ray arrived at $7° \pm 2°$ during the whole period of observation in 1953 except for the summer when measurements could not be made, and that an array designed for receiving these signals in the United Kingdom should have its maximum pick-up in that angular range. A similar range would also apply during the same period for the 18-Mc/s signals from Kirkee. For the summer months the Kirkee measurements suggest that the angle of elevation of the main ray is about 5°. This lowering of the angle during the summer can probably be explained by changes in the mode of propagation at the European end of the path possibly brought about by the presence of denser E_s ionization. Although no measurements could be made during the summer on the Negombo signals it is likely that the angle of elevation of the main ray would also be similarly depressed. This conclusion is supported by measurements made on the 16·245-Mc/s Negombo transmissions during the summer of 1955 which indicate the presence of strong rays at 5°–6° angle of elevation.

The angles of elevation of the strongest rays quoted above apply, strictly speaking, only to the radiation pattern set up at the receiver by the transmitting aerials in use during the experiments. The aerial in use at Negombo was a rhombic at 90 feet above ground level, while that at Kirkee was an early-pattern Franklin employing series coil phasing and in which the upper end of the radiating system extended to 193 feet above the ground. The question arises as to how the measurements at the receiver would be affected by changes in the vertical radiation pattern of the transmitting aerial. The modes of propagation which are possible for the path concerned will be governed by the state of the ionosphere along the path, but the relative amplitudes of the signal components travelling by each mode will be dependent on the vertical radiation pattern of the transmitting aerial as well as on the state of the ionosphere. The optimum angle of projection of the transmitting aerial can readily be found from the measurements quoted, although horizontal gradients in the ionosphere may sometimes cause the angle of elevation of a certain ray measured at the receiver to differ appreciably from its corresponding angle of projection at the transmitter. The upper limit of angle of projection has been deduced from the back-scattering measurements at Negombo, but it is not possible to say whether a much higher transmitting aerial would increase the strength of the lowest-order modes of propagation, enough to make an important contribution to the resultant signal. Even if such a contribution were possible, it is likely that the aerial supports would be so high as to become an uneconomic proposition.

Acknowledgements

The authors desire to acknowledge the assistance received from the Air Officer Commanding, 90 Group, Royal Air Force, through whose courtesy the pulse transmissions from Negombo were arranged, and from Mr. S. R. Kantebet, Director General of the Indian Overseas Communication Service, who arranged the pulse transmissions from Kirkee.

The back-scatter measurements in Ceylon were obtained through the co-operation of Messrs. A. M. Humby and D. A. R. Jackson of the Royal Naval Scientific Service.

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Tachometer Noise Reduction

USE OF AUXILIARY ACCELEROMETER

By John C. West, Ph.D., D.Sc., A.M.I.E.E.*

The continued development of servomechanisms has created a demand for many types of measurement transducer element, producing electrical signals proportional to some physical quantity. One of the most important elements required is for the measurement of the angular rotation of a shaft and, for this purpose, the so-called 'd.c. tachometer generator' has been developed. Basically, this is a separately-excited d.c. machine on no load, the field being held constant and the armature coupled to the shaft whose speed is to be measured. Because of the small current required it is possible to increase the sensitivity by using a large number of turns of small-diameter wire on the armature. Brush-ripple noise from the commutator is also important and it is found necessary to make the brush-ripple frequency as high as possible and well above the probable frequency of variation of shaft speeds. Thus, the commutator is constructed with a large number of segments.

Typical characteristics are:[1, 2]

$e_t = Gs$ volts	where s is the angular rotation in radians per sec. and e_t is the terminal voltage of the tacho.†
Field	24 V, 100 mA.
Armature	0 – 5 mA (max).
Signal	0·025 volts/r.p.m. or $G = 0{\cdot}24$ volts per radian per sec.
Commutator	52 segments.
Linearity	$\pm$ 0·016%.

The main uses of this 'tacho' are for measurement of output speed in speed control devices, for stabilization purposes where 'velocity feedback' is employed and in electro-mechanical analogue computers such as the integrator element in predictors.

The disadvantage of this type of measuring element is the large amount of noise produced, which sets an upper limit, in the majority of feedback systems in which it is incorporated, to the loop gain and hence limits the performance of the whole system. The noise can be analysed into various components produced by different effects. Commutation ripple is the largest component and is caused by the reversal of current in a commutator segment passing under a brush. The fundamental frequency is zn where z is the number of commutator bars and n is the rotational speed in revs/sec. In addition, there are:

Brush noise produced by bouncing of the brushes and by imperfect and fluctuating contact.

Jitter fluctuations due to unequal spacing of the segments.

Asymmetric noise produced by dynamic mechanical unbalance.

Fig. 1 shows the graph of the signal, the total noise and the noise component at rotational frequency as a function of speed for one particular device.

A commutatorless (but not brushless) machine has been developed based on the homopolar[3] generator but the signals are so small that a high-gain d.c. amplifier is required. The drift problems of this amplifier are usually of more serious consequence than the noise of a normal tacho.

In a few applications it is permissible to smooth the tacho-generator signal by a simple filter having, say, a

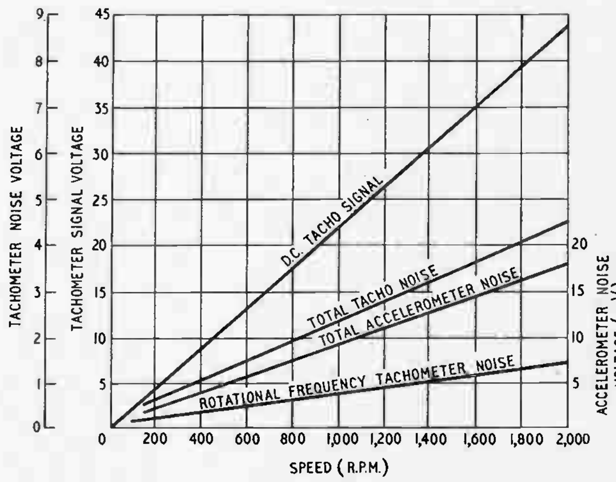

Fig. 1. *Tachometer and accelerometer characteristics*

transfer function $1/(1 + T_s p)$. Thus, the high-frequency portion of the brush noise will be attenuated but the tacho transfer function will now contain a large lag due to T_s of the form: $e = Gs/(1 + T_s p)$, where e is the output signal from the filter. This will appear in the loop

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† This is not necessarily the open-circuit condition. A fixed resistor may be used as a small load of such a value that the armature current never exceeds the rated value.

transfer function where it may make the system unstable or operable only at reduced performance. The use of a filter in this manner is clearly very limited.

It has been shown previously[4] that if an acceleration signal $e_a = Kps$ were available and added to the tacho signal before smoothing, then improved results could be obtained without introducing additional time lags. The combined signal would be:

$$e_0 = \frac{e_a + e_t}{1 + T_s p} = \left\{\frac{G}{1 + T_s p} + \frac{Kp}{1 + T_s p}\right\} s$$

and if it were arranged that K/G was made equal to T_s, then $e_0 = Gs$, the lag time constant being cancelled out. Thus, a true velocity signal is obtained on the output side of a large smoothing filter which is attenuating noise produced in the tacho.

In reference 4 the acceleration signal was obtained only approximately by utilizing the control signal at an appropriate point in the servo system. This ignored the adverse effects of loading and friction and was for this reason not altogether satisfactory. The development of a transducer for the measurement of angular acceleration giving a d.c. signal proportional to acceleration with a brushless low-noise machine makes this combined method attractive.

The Brushless Accelerometer

The brushless accelerometer is a two-axis machine as shown schematically in Fig. 2. It can be identical in construction to an a.c. tacho of the 'drag cup' type.[2] The principle of operation is, however, different. The vertical field is maintained constant by excitation from a d.c. supply and the other field coil at right angles is arranged to have no mutual coupling at rest. The rotor is a cylinder of copper usually with one and sometimes two end discs. When rotating at constant speed the induced e.m.fs produce currents in the direction shown, which in turn set up a flux ϕ_2 (the cross flux) which links the output field coil. This flux is exactly proportional to the speed of rotation. If the speed changes, ϕ_2 changes and a voltage e_a appears across the coil. Since

$$e_a = K_1 \frac{d\phi_2}{dt}$$

and $$\phi_2 = \frac{K_2}{1 + T_r p} s$$

where s is the instantaneous speed of rotation and T_r is a small time-constant due to the inductance and resistance of the rotor current path.

Then

$$e_a = \frac{K_1 K_2}{1 + T_r p} \frac{ds}{dt}$$

Since T_r is small (of the order of 2×10^{-4} sec.), it will be neglected in the following analysis and hence

$$e_a = K_3 \frac{ds}{dt}$$

The constant K_3 for the particular instrument chosen, which was an a.c. tacho but used for this purpose, was $1{\cdot}6 \times 10^{-4}$ volts per radian per sec^2. Thus, an acceleration of 10^4 r.p.m. per sec would give rise to 0·167 V. Signals of this magnitude will need amplification before use in any feedback system.

The noise in this device is again almost proportional to the speed of rotation and is shown for one particular device in Fig. 1. It is produced mainly by dynamical asymmetry of the mechanical arrangement and by the vibration in various modes of the copper cylinder. It also reproduces the noise on the d.c. field.

Combined Tacho and Accelerometer

The noise produced by the tacho can be seen (Fig. 1) to be proportional to speed and is composed of many frequency components. Thus it could be represented in the form:

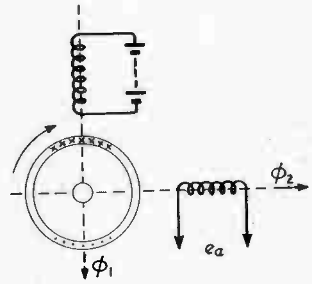
$$a_1\omega + a_2(n_2\omega) + \ldots a_3(n_3\omega) + \ldots = N_T . \omega$$

each term being a harmonic of the rotational speed

$$\omega = 2\pi n = s$$

The noise could be reduced by filtering. A simple RC smoothing filter would have a transfer function

Fig. 2. *The brushless accelerometer*



$1/(1 + T_s p)$ and the signal and noise would be operated on by the same function. The signal would now be

$$e_t = \frac{G}{1 + T_s p} . s$$

and the noise amplitude

$$\frac{N_T \omega}{\sqrt{1 + T_s^2 \omega^2}}$$

To be effective, T_s would have to be large and the extra lag time factor $1/(1 + T_s p)$ would become undesirable from a stability point of view in any feedback system.

This is compensated for by use of the accelerometer in addition to the tacho, as shown in Fig. 3. The accelerometer signal e_a is amplified by a factor A and added to the tacho signal e_t before filtering. Thus the output signal is:

$$e_0 = \frac{(e_t + Ae_a)}{1 + T_s p}$$

$$= \frac{G\left\{s + \frac{AK_3}{G}\frac{ds}{dt}\right\}}{1 + T_s p}$$

$$= \frac{G\left\{1 + \frac{AK_3}{G} p\right\}}{1 + T_s p} . s$$

If the amplifier gain A is chosen so that

$$\frac{AK_3}{G} = T_s$$

then

$$e_0 = G_s$$

and the unwanted time-constant has been eliminated.

The combined device can be considered to work in two modes. At very low speeds where $T_s\omega < 1$ the signal is taken mainly from the tacho-generator and there is no drift trouble. At normal speeds in the working range, and at high speeds, for $T_s\omega > 1$, the major portion of the output signal comes from the accelerometer with the filter acting as an integrator changing acceleration to velocity.

The noise from both instruments is filtered by the RC network. Thus, if $N_a\omega$ is the noise from the accelerometer then the output noise is

$$N_0 = \frac{N_t\omega + A \,.\, N_a\omega}{(1 + T_s^2\omega^2)^{1/2}}$$

and for $T_s\omega > 1$

$$N_0 \approx \frac{N_t + AN_a}{T_s}$$

By design A has already been chosen to be

$$T_sG/K_3$$

Hence

$$N_0 \approx \frac{GN_t}{K_3A} + \frac{G}{K_3}N_a$$

and it is seen that the bigger the gain A and, hence, the filter constant T_s the smaller will be the noise component produced by the tacho N_t. This is the right way round, since N_t produced by brushes and commutation is several hundred times greater than the noise produced by the brushless accelerometer. It is also seen that the factor G/K_3 is a constant and it is therefore not profitable to make T_s much larger than that value required to make the two noise components of comparable magnitude.

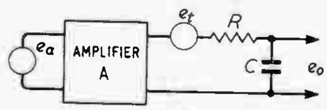


Fig. 3. *Arrangement of tacho and accelerometer*

Results

In a particular practical example it was decided to make the filter have a bandwidth from zero frequency up to 1 c/s, attenuating high frequencies. This occurs when

$$T_s\omega = 1 \text{ where } \omega = 2\pi f = 2\pi \text{ rad/sec.}$$

$$\text{Hence } T_s = \frac{1}{2\pi} = 0{\cdot}159 \text{ sec.}$$

Thus from the data already given, the gain of the amplifier required for the accelerometer is

$$A = \frac{GT_s}{K_3} = \frac{0{\cdot}24}{2\pi \,.\, 1{\cdot}6 \times 10^{-4}} \approx 240$$

This is quite reasonably obtained by a two-stage amplifier. The noise coefficients N_t and N_a can be obtained from the curves in Fig. 1.

A speed of R r.p.m. gives rise to an angular frequency $\omega = 2\pi\ R/60$ rad/sec and hence the noise generated at this speed is given by

$$N_t\omega = N_t2\pi R/60$$

$$N_a\omega = N_a2\pi R/60$$

The slopes of the graphs in Fig. 1 are then

$$N_t2\pi/60 \text{ and } N_a2\pi/60$$

giving $N_t = 2{\cdot}11 \times 10^{-2}$ volts/rad/sec.

$N_a = 9{\cdot}54 \times 10^{-5}$ volts/rad/sec.

$$N_t + AN_a = 2{\cdot}11 \times 10^{-2} + 2{\cdot}29 \times 10^{-2} = 4{\cdot}4 \times 10^{-2}$$

The output noise after filtering is then

$$N_0 \approx \frac{N_t + AN_a}{T_s} = 2\pi \times 4{\cdot}4 \times 10^{-2} \simeq 0{\cdot}27 \text{ volt.}$$

This value corresponds to the noise generated by the tacho-generator alone at about 60 r.p.m. Hence, there is a reduction of noise by using this combination for all speeds above this. For example, at 1,000 r.p.m. the velocity signal is 22 volts and the tacho noise is 2·2 volts, the signal-to-noise ratio is 10 but, using the combination, the noise falls to 0·27 volt and the signal-to-noise ratio increases to 80. At 3,000 r.p.m. the tacho signal-to-noise ratio is still 10 but with the combination it is 240, a reduction of noise by a factor of 24.

The operation of the combination virtually makes use of the accelerometer only for speeds greater than 60 r.p.m. or frequencies greater than 1 c/s. Hence, it was thought possible that the amplifier A associated with it could be made RC-coupled, thus having zero gain at very low frequencies and d.c. This makes the amplifier design simpler and eliminates troubles due to drift occurring in d.c. amplifiers. An experimental system with an amplifier with a low frequency cut-off at 0·25 c/s (i.e., four times less than the filter bandwidth of 1 c/s) performed extremely satisfactorily.

Further improvement in the performance can be obtained by increasing the gain A of the amplifier with a corresponding increase in the filter time-constant T_s. Limitation will occur when the RC-coupled amplifier has such a large coupling time constant that drift in the performance becomes appreciable. The accelerometer used was a converted a.c. tachometer; it is possible to obtain greater sensitivity with a machine designed specifically as an accelerometer.

The experimental work described in this paper is contained in greater detail in, and forms part of, a thesis[5] and the author gratefully acknowledges the help of Mr. Whitehead for his contribution.

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Operational Calculus: I.—General Principles

Most engineers will have noticed the way in which Heaviside's operational calculus or Laplace transforms now appear frequently in technical literature, though twenty years ago they were seldom used. They are, however, still on the whole unfamiliar to engineers.

We shall discuss here the Heaviside calculus only. The Laplace system is so closely related that only confusion would be caused if we attempted to use both systems. In a later article we shall refer again to the Laplace system and show how readily one can pass from one to the other. Our preference for the Heaviside system is based mainly on its logical association with Heaviside's idea that all electrical phenomena can be regarded as starting suddenly at zero time as the result of the closing of a switch.

In theory, it is possible to solve any electrical problem by means of classical methods of manipulating differential equations. The merit and justification of operational calculus are that the solution is obtained more easily, and by processes which have a clearer physical significance.

In electrical problems we commonly need to know how the output current (or voltage) of some network varies with time in response to an input voltage (or current) which also varies with time. The operational-calculus solution is obtained by 'translating' the problem from the time world into a 'p-world' where the answer is obtained (in terms of p) by applying a generalization of Ohm's Law, and then using mere algebra. This p-answer is then 'translated' back into the time world.

The initial 'translation' of the input voltage into the 'p-world' can usually be done by means of a table of corresponding functions in the two worlds, like Table 1. The same table can be used in reverse to do the final 'translation' of the 'p-answer' obtained for the output current into the time world. Considerable extension of Table 1 is possible by means of the simple rules given at the beginning, that integration in the time world corresponds to dividing by p, and differentiation to multiplying by p (with an extra term if the time function is not zero at zero time).

Some of the items in Table 1 are therefore redundant since, for example, item 6 can be deduced from item 5 by differentiation and item 7 from item 5 by integration. The redundant items have been included with the object of saving labour for the reader.

In these articles we shall assume that Table 1 can be taken for granted. Most books on the subject are concerned mainly with the mathematical processes involved in the construction of such a table *ab initio*. This is a job which the engineer can safely leave to mathematicians

TABLE 1

Corresponding Functions in Time World and p-World (Heaviside System*)

General Notes

p is closely related to $j\omega$ and d/dt. If $h(t)$ corresponds to $f(p)$, then

(a) $dh(t)/dt$ corresponds to $pf(p) - ph(0)$

(b) $\int_0^t h(\tau)d\tau$ corresponds to $f(p)/p$

All time functions listed below must be replaced by zero for negative values of t.

	Time Function $h(t)$		p-World Counterpart $f(p)$
1.	$0\ (t < 1)\ a\ (t > 1)$		a
2.	$t^n/n!$		$1/p^n$
3.	$(1 - e^{-\alpha t})/\alpha$		$1/(p + \alpha)$
4.	$e^{-\alpha t}$		$p/(p + \alpha)$
5.	$\sin \omega t$		$p\omega/(p^2 + \omega^2)$
6.	$\cos \omega t$		$p^2/(p^2 + \omega^2)$
7.	$1 - \cos \omega t$		$\omega^2/(p^2 + \omega^2)$
8.	$[1 - (1 + \alpha t)e^{-\alpha t}]/\alpha^2$		$1/(p + \alpha)^2$
9.	$te^{-\alpha t}$		$p/(p + \alpha)^2$
10.	$(1 - \alpha t)\ e^{-\alpha t}$		$p^2/(p + \alpha)^2$
11.	$t^{n-1}e^{-\alpha t}/(n - 1)!$		$p/(p + \alpha)^n$
12.	$\dfrac{1}{\alpha\beta} + \dfrac{\alpha e^{-\beta t} - \beta e^{-\alpha t}}{\alpha\beta(\beta - \alpha)}$		$1/\{(p + \alpha)\ (p + \beta)\}$
13.	$(e^{-\beta t} - e^{-\alpha t})/(\beta - \alpha)$		$p/\{(p + \alpha)\ (p + \beta)\}$
14.	$(\beta e^{-\beta t} - \alpha e^{-\alpha t})/(\beta - \alpha)$		$p^2/\{(p + \alpha)\ (p + \beta)\}$
15.	$\dfrac{\sin(\omega t - \theta) + e^{-\alpha t}\sin\theta}{\omega(\alpha^2 + \omega^2)^{1/2}}$ where $\sin\theta = \omega/(\alpha^2 + \omega^2)^{1/2}$		$\dfrac{p}{(p^2 + \omega^2)(p + \alpha)}$
16.	$\dfrac{1}{\omega_0^2}\left[1 - \left(\cos\omega_1 t + \dfrac{\alpha}{\omega_1}\sin\omega_1 t\right)e^{-\alpha t}\right]$, $\omega_1 = (\omega_0^2 - \alpha^2)^{1/2}$	$\omega_0 > \alpha$	$\dfrac{1}{p^2 + 2\alpha p + \omega_0^2}$
	$\dfrac{1}{\omega_0^2}\left[1 - (1 + \alpha t)e^{-\alpha t}\right]$	$\omega_0 = \alpha$	
	$\dfrac{1}{\omega_0^2}\left[1 - \left(\cosh\gamma t + \dfrac{\alpha}{\gamma}\sinh\gamma t\right)e^{-\alpha t}\right]$, $\gamma = (\alpha^2 - \omega_0^2)^{1/2}$	$\omega_0 < \alpha$	
17.	$\dfrac{1}{\omega_1}\sin\omega_1 t\ .\ e^{-\alpha t}$	$\omega_0 > \alpha$	$\dfrac{p}{p^2 + 2\alpha p + \omega_0^2}$
	$te^{-\alpha t}$	$\omega_0 = \alpha$	
	$\dfrac{1}{\gamma}\sinh\gamma t e^{-\alpha t}$	$\omega_0 < \alpha$	
18.	$\left(\cos\omega_1 t - \dfrac{\alpha}{\omega_1}\sin\omega_1 t\right)e^{-\alpha t}$	$\omega_0 > \alpha$	$\dfrac{p^2}{p^2 + 2\alpha p + \omega_0^2}$
	$(1 - \alpha t)e^{-\alpha t}$	$\omega_0 = \alpha$	
	$\left(\cosh\gamma t - \dfrac{\alpha}{\gamma}\sinh\gamma t\right)e^{-\alpha t}$	$\omega_0 < \alpha$	

*The Laplace system is similar to the Heaviside but is based upon a unit impulse instead of a unit step. The method of converting from one system to the other will be explained in a later article.

just as he leaves the compilation of logarithmic and trigonometrical tables to them.

In the Heaviside calculus, the input voltage is assumed to start suddenly at time zero, as if a switch were then closed. The simplest input voltage is unit step, that is to say, a voltage which is zero for $t < 0$ and then changes suddenly to unity, and remains unity for all $t > 0$. For the remainder of this article we shall assume that the input voltage is v_0 times unit step, so that the p-world counterpart of this input voltage is simply v_0; other input voltages will be considered in the next article. For negative values of the time, all the time functions mentioned in Table 1 must be replaced by zero.

The starting point is a knowledge of the applied stimulus as a function of time from zero time onwards. We shall assume that this stimulus is a voltage $V(t)$. Our first step is to find the corresponding function $V(p)$ from Table 1; at present we are assuming that $V(p)$ is a mere constant v_0.

We next require the operational 'impedance' $Z(p)$ of the circuit in terms of p. The operational impedance of a resistance R ohms is R, the operational impedance of an inductance L henrys is pL and the operational impedance of a capacitance C farads is $1/(pC)$; the unit for all these impedances is an ohm. It is thus seen that if p is replaced by $j\omega$ we obtain the ordinary reactances of a.c. theory. Operational impedances in series or in parallel are combined in just the same way as in a.c. theory, so that the operational impedance $Z(p)$ can be obtained by first finding the steady-state a.c. impedance $Z(j\omega)$ and then replacing $j\omega$ by p (or ω by $-jp$) and ω^2 by $-p^2$. The fundamental equation which now enables us to obtain the p-world counterpart $I(p)$ of the current is a generalization of Ohm's Law, namely,

$$I(p) = V(p)/Z(p) \quad \text{(1a)}$$

$$= v_0/Z(p) \text{ (for input step-voltage } v_0 \text{ applied at } t = 0) \quad \text{(1b)}$$

and within the p-world, (1a) applies no matter what kind of voltage $V(t)$ is applied.

Now consider Fig. 1 as an example; we suppose that the voltage v_0 is suddenly applied at zero time to the input terminals and thereafter maintained constant, and

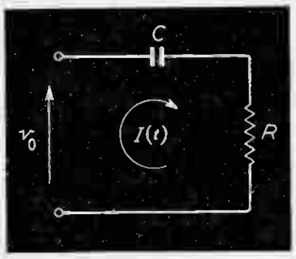


Fig. 1. *Simple RC circuit employed to illustrate the use of the Heaviside transforms*

we require to know the voltage $V(t)$ across R at any later time. Let the current flowing in the circuit be $I(t)$, and $I(p)$ its p-world counterpart; let the p-world counterpart of $V_R(t)$ be $V_R(p)$. Then the ordinary a.c. impedance is:

$$Z(j\omega) = R + 1/(j\omega C) \quad \text{(2a)}$$

and the operational impedance is

$$Z(p) = R + 1/(pC) \quad \text{(2b)}$$

so that, applying Ohm's Law (1a) to the whole circuit of Fig. 1, we have

$$I(p) = v_0/Z(p) = v_0/(R + 1/pC) \quad \text{(3)}$$

Also

$$V_R(p) = RI(p) \quad \text{(4a)}$$

$$= \frac{Rv_0}{R + 1/pC} = \frac{pv_0}{p + 1/CR} \quad \text{(4b)}$$

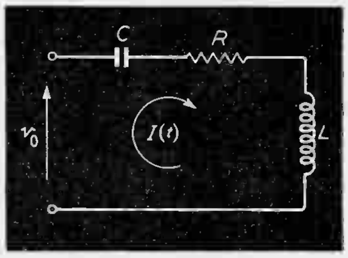
Hence from Table 1 it follows immediately that

$$V_R(t) = v_0 e^{-t/CR} \quad \text{(5)}$$

Now consider the slightly more complicated circuit of Fig. 2; suppose we now require $I(t)$. Proceeding as before, we have

$$I(p) = \frac{v_0}{R + pL + 1/pC} = \frac{pv_0}{L\left(p^2 + \frac{R}{L}p + \frac{1}{LC}\right)} \quad \text{(6)}$$

Fig. 2. *This circuit with two energy-storage elements leads to a second-degree equation in p*



The denominator of (6) can be put into the standard form $p^2 + 2\alpha p + \omega_0^2$ given in Table 1 by writing

$$\alpha = R/2L \text{ and } \omega_0^2 = 1/LC \quad \text{(7)}$$

and we thus obtain three formally different answers for $I(t)$ from Table 1 according to the relative values of α and ω_0, namely

$$\left.\begin{aligned} I(t) &= \frac{v_0}{\omega L} e^{-\alpha t} \sin \omega t \\ \text{where} \\ \omega &= (\omega_0^2 - \alpha^2)^{1/2};\ \omega_0 > \alpha;\ R^2 < 4L/C \end{aligned}\right\} \quad \text{(8a)}$$

$$I(t) = v_0 t e^{-\alpha t}/L;\ \omega_0 = \alpha;\ R^2 = 4L/C \quad \text{(8b)}$$

and

$$\left.\begin{aligned} I(t) &= \frac{v_0}{\gamma L} e^{-\alpha t} \sinh \gamma t \\ \text{where} \\ \gamma &= (\alpha^2 - \omega_0^2)^{1/2};\ \omega_0 < \alpha;\ R^2 < 4L/C \end{aligned}\right\} \quad \text{(8c)}$$

It is worth noting that (8a) is very similar to (8b) for small t if ω is small and that (8c) is likewise similar to (8b) if γ is small.

In more complicated cases, where the voltage input is not a step-function or the impedance $Z(p)$ has a denominator of higher degree, we shall obtain an expression corresponding to (6) which is not immediately expressible in one of the forms given in Table 1. Our main task in such cases is the algebraic manipulation of $I(p)$ so that it is broken up into the sum of a number of terms each of which is given in Table 1. This is considered in our next article.

It is usually easiest to express our results in terms of the factors of the denominator of $I(p)$. This may mean that it is not possible to express the results explicitly in terms of the network elements in the general case. In a numerical case the factors of the denominator can be found as explained in an earlier article. As in (8a), (8b) and (8c), the result may be formally different according to the relative values of certain quantities associated with the network. It may also be possible to obtain a useful answer by expanding $I(p)$ in descending powers of p, and repeatedly using item 2 of Table 1 to obtain a corresponding series for $I(t)$. Such series, which will be discussed in a later article, are usually rapidly convergent; whether they provide a useful solution or not depends upon the nature of the problem. Sometimes they are very useful indeed. Again, operational calculus can be used advantageously in cases where the initial conditions are not that the circuit is 'dead' until a certain time.

Terminated Circular Loop Aerial

By S. Balaram Rao, B.E., M.Sc.(Eng.)

SUMMARY. *The radiation field at any point in space due to a terminated circular loop aerial of any radius is derived for free space conditions, assuming an unattenuated travelling wave along the loop. The theoretical relative field intensity pattern in the plane of the loop has been verified experimentally for cases where the circumference of the loop is less than a wavelength.*

The circular loop aerial has been investigated in detail in current literature.[1–4] However, the terminated circular loop aerial does not appear to have been referred to, barring the reference by Bergman and Schultz,[5] who are reported to have investigated azimuthal radiation patterns of such loops.

By a terminated circular loop aerial is meant a loop aerial terminated by a load (usually a resistance), diametrically opposite the feeding end (see Fig. 1). The termination is such that the loop carries only a travelling wave, which is assumed to be unattenuated. The radiation field at any point in space due to such an aerial is derived in terms of the θ and ϕ components.

The relative field intensity pattern in the plane of the loop has been verified experimentally for loops of

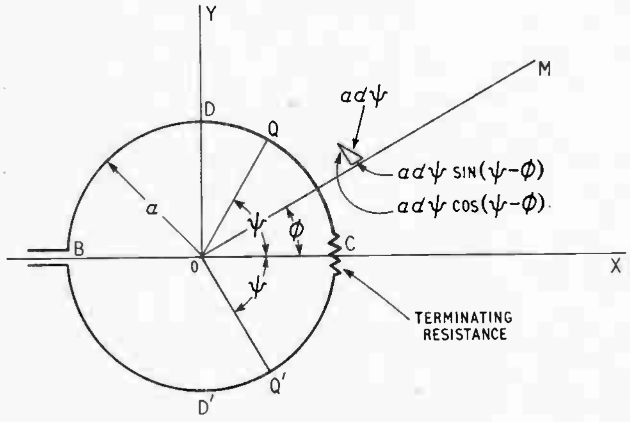


Fig. 1. *The terminated circular loop aerial*

LIST OF SYMBOLS

The following is a list of symbols used; all quantities are in m.k.s. units:

a = radius of loop
f = frequency of radiated wave
λ = wavelength of radiation
$A = \dfrac{2\pi a}{\lambda}$
$\omega = 2\pi f$
c = velocity of radiation in space
v = velocity of radiation along the loop
$p = \dfrac{c}{v}$
r_0 = OP (Fig. 2)
$\beta = \dfrac{2\pi}{\lambda}$
θ = /ZOP (Fig. 2)
ϕ = /XOM (OM is perpendicular to PM, Fig. 2)
$k = A \sin\theta$
s = any positive even integer including 0, and q = any positive odd integer
$J_1(k), J_q(k), J_s(k)$, etc., are Bessel functions of the first kind

$$k_q = \frac{J_q(k) + J_{q+2}(k)}{p^2A^2 - (q+1)^2}$$
$$k_s = \frac{J_s(k) + J_{s+2}(k)}{p^2A^2 - (s+1)^2}$$
$$k'_q = \frac{J_q(k) - J_{q+2}(k)}{p^2A^2 - (s+1)^2}$$
$$k'_s = \frac{J_s(k) - J_{s+2}(k)}{p^2A^2 - (q+1)^2}$$

I_0 = current at D, the midpoint of the arc BDC of the aerial

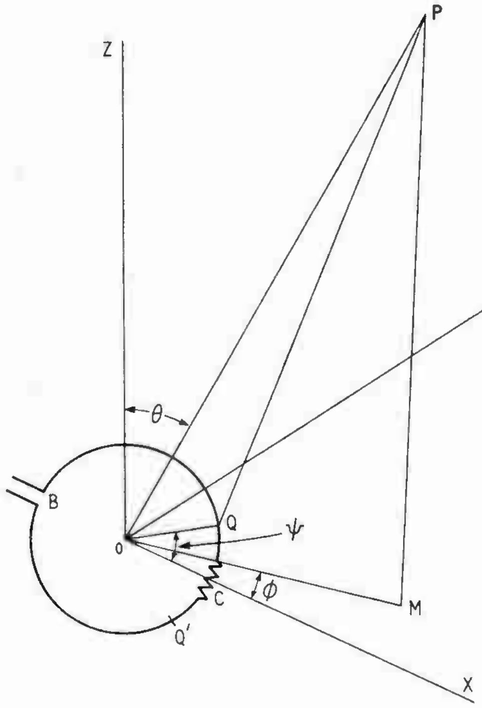


Fig. 2. *Co-ordinate system used in the derivation*

circumference less than a wave wavelength. The effect of varying the terminating resistance is indicated.

Derivation of the Radiation Pattern

Fig. 1 shows the terminated circular loop aerial. It is fed at *B* and terminated at the diametrically opposite end with a resistance equal to the characteristic impedance of the transmission line so that the loop carries only a travelling wave. It is assumed that the wave is unattenuated.

The current at any point *Q* of the aerial on the arc *BDC* is given by

$$I = I_0 e^{-jpA\left(\frac{\pi}{2} - \psi\right)} \quad .. \quad .. \quad .. \quad .. \quad (1)$$

where $\psi = \angle XOQ$

The positive direction of current is assumed clockwise round the loop.

Next we compute the approximate distance, r, between the point P where the field is being considered and the point Q on the loop. Since we are considering the field at a large distance, the lines QP and OP can be considered to be parallel.

$$r = r_0 - a \cos(\psi - \phi) \sin\theta \quad .. \quad .. \quad (2)$$

Next we have to compute the field at P due to a differential element of the aerial $ad\psi$ at Q. To facilitate the computation, the differential aerial length is split up into two components, one along OM and the other perpendicular to OM. The component along OM gives the θ component of the field at P and the component perpendicular to OM gives the ϕ component of the field at P. Calling these two electric field-components due to the differential length of the aerial at Q, $dE'\phi$ and dE'_θ we have,

$$dE'_\theta = V_1 e^{-jpA\left(\frac{\pi}{2} - \psi\right)} \sin(\psi - \phi) \cos\theta e^{-j\beta r} d\psi \quad (3)$$

$$dE'\phi = -V_1 e^{-jpA\left(\frac{\pi}{2} - \psi\right)} \cos(\psi - \phi) e^{-j\beta r} d\psi \quad (4)$$

Where $V_1 = \frac{60\pi I_0 a}{\lambda r_0} \cdot e^{j\omega t}$

Substituting for r from Equation (2) and integrating the expressions (3) and (4) we obtain the field due to the arc BDC of the aerial.

$$E'_\theta = \int_0^\pi dE'_\theta = V\cos\theta \Big\{ \sum_{q=1,3,\ldots} 2k_q [(q+1)\cos(q+1)\phi + jpA \sin(q+1)\phi] \sin pA\frac{\pi}{2} (-1)^{\frac{q-1}{2}} + \sum_{s=0,2,4,\ldots} 2k_s [(s+1)\cos(s+1)\phi + jpA\sin(s+1)\phi] \cos pA\frac{\pi}{2} (-1)^{\frac{s+2}{2}} \Big\} \quad .. \quad .. \quad .. \quad (5)$$

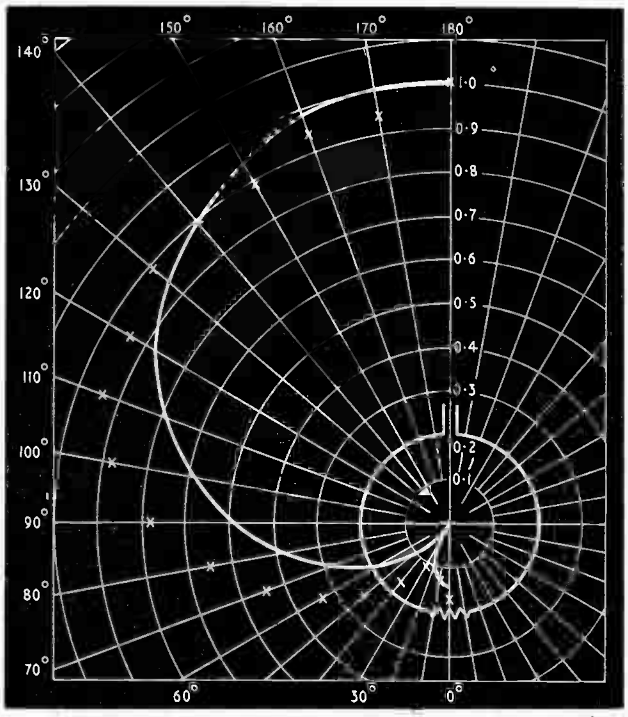
$$E'_\phi = \int_0^\pi dE'_\phi = -V \Big\{ \sum_{q=1,3,\ldots} 2k'_q [jpA\cos(q+1)\phi - (q+1)\sin(q+1)\phi] \sin\frac{pA\pi}{2} (-1)^{\frac{q-1}{2}} + \sum_{s=0,2,4,\ldots} 2k'_s [jpA\cos(s+1)\phi - (s+1)\sin(s+1)\phi] \cos p\frac{A\pi}{2} (-1)^{s/2} + 2j\frac{J_1(k)}{pA} \sin p\frac{A\pi}{2} \Big\} \quad .. \quad (6)$$

where $V = V_1 e^{-j\beta r_0}$

In an identical fashion we have for a corresponding point Q' on the arc $BD'C$,

$$dE''_\theta = -V_1 e^{-jpA\left(\frac{\pi}{2} - \psi\right)} \sin(\psi + \phi) \cos\theta e^{-j\beta r'} d\psi \quad .. \quad .. \quad .. \quad (7)$$

Fig. 3. *Horizontal radiation pattern of terminated loop; A* = 0·5; x, *observed values*



$$dE''_\phi = -V_1 e^{-jpA\left(\frac{\pi}{2}-\psi\right)} \cos(\psi+\phi)\, e^{-j\beta r'}\, d\psi \quad \ldots \quad (8)$$

where dE''_θ is the θ-component of the electric field due to a differential length of the aerial at Q,

dE''_ϕ is the ϕ-component of the electric field due to a differential length of the aerial at Q',

$r' = r_0 - a\cos(\psi+\phi)\sin\theta$

$\psi = \underline{/XOQ'}$.

In Equs. (7) and (8) the positive direction of current is assumed clockwise round the loop.

On integrating the expressions (7) and (8) we have

$$E''_\theta = -V\cos\theta\left\{\sum_{q=1,3,\ldots} 2k_q(q+1)\cos(q+1)\phi - jpA\sin(q+1)\phi\right] \sin p\frac{A\pi}{2}(-1)^{\frac{q+1}{2}}$$
$$+\sum_{s=0,2,\ldots} 2k_s\left[(s+1)\cos(s+1)\phi - jpA\sin(s+1)\phi\right]$$
$$\sin p\frac{A\pi}{2}(-1)^{\frac{s+2}{2}}\Big\} \quad \ldots \quad (9)$$

$$E''_\phi = -V\left\{\sum_{q=1,3,\ldots} 2k_q'\left[jpA\cos(q+1)\phi\right.\right.$$
$$\left.+(q+1)\sin(q+1)\phi\right]\sin p\frac{A\pi}{2}(-1)^{\frac{q-1}{2}}$$
$$+\sum_{s=0,2,\ldots} 2k'_s\left[jpA\cos(s+1)\phi + (s+1)\sin(s+1)\phi\right]$$
$$\cos p\frac{A\pi}{2}(-1)^{\frac{s}{2}} + 2j\frac{J_1(k)}{pA}\sin pA\frac{\pi}{2}\Big\} \quad \ldots \quad (10)$$

Fig. 4. *Horizontal radiation pattern of terminated loop; $A = 0{\cdot}75$; x, observed values*

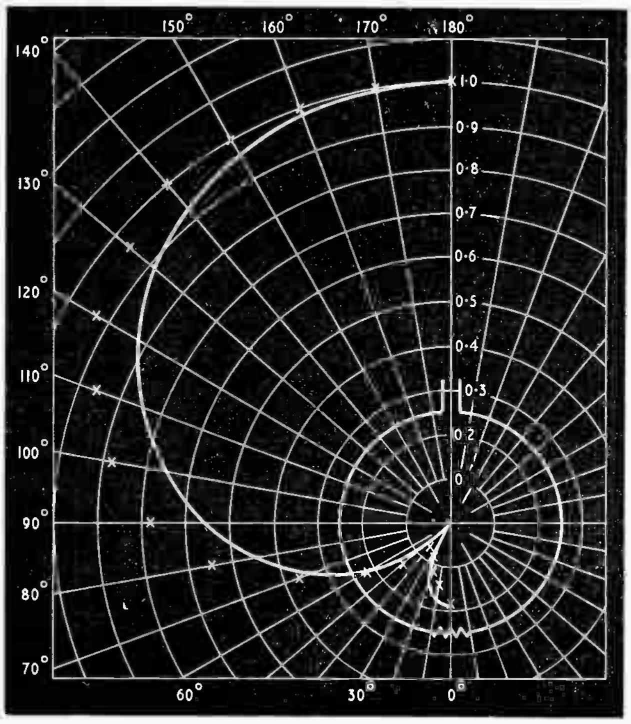


TABLE 1

$A = 0{\cdot}5$

Nominal value of resistance	Forward field	Backward field	Ratio of the forward to backward field
200 Ω	15	40	0·375
300 Ω	15	40	0·375
400 Ω	7·5	45	0·167
500 Ω	8	42·5	0·181
2000 Ω	15	40	0·375

TABLE 2

$A = 0{\cdot}75$

Nominal value of resistance	Forward Field	Backward field	Ratio of the forward to backward field
250 Ω	30	62·5	0·480
300 Ω	22·5	65	0·346
400 Ω	15	65	0·231
500 Ω	12·5	70	0·143

The total field at P due to the entire aerial is given by

$E_\theta = E'_\theta + E''_\theta$

$E_\phi = E'_\phi + E''_\phi$

Performing the additions indicated, we have

$$E_\theta = j4V\cos\theta pA\left\{\Sigma k_q \sin(q+1)\phi \sin p\frac{A\pi}{2}(-1)^{\frac{q+1}{2}} + \Sigma k_s \sin(s+1)\phi\cos p\frac{A\pi}{2}(-1)^{\frac{s+2}{2}}\right\} \quad \ldots \quad (11)$$

$$E_\phi = j4VpA\left\{\Sigma k'_q \cos(q+1)\phi(-1)^{\frac{q+1}{2}} + \Sigma k'_s\cos(s+1)\phi(-1)^{\frac{s+2}{2}} + \frac{J_1(k)}{p^2A^2}\sin p\frac{A\pi}{2}\right\} \quad \ldots \quad (12)$$

The following observations about the radiation pattern may be made.

(*i*) The field in the planes, $\theta = 90°$, and $\phi = 0°$, is horizontally polarized, since the E_θ component vanishes.

(*ii*) The pattern of E_θ and E_ϕ for any constant value of θ and varying values of ϕ is not symmetrical about the plane YOZ.

(iii) The field pattern is symmetrical about the plane XOY.

(iv) The field pattern is symmetrical with respect to the plane XOZ.

The equations of the radiation patterns as given by (11) and (12), though cumbersome for large values of A, are manageable for values of A up to about 2.

Experimental Verification

In Fig. 3 we have the theoretical and experimental relative field intensities plotted for a loop whose circumference is half the wavelength. Fig. 4 illustrates the case where the circumference is 0·75λ. The aerials were used as receiving aerials and the frequency was 110 Mc/s.

In both cases the aerials are more directive towards the feeding end. The value of p was assumed to be 1.

The effect of varying the terminating load is shown in the accompanying Tables. The terminating load which gave the optimum ratio of the forward to backward field was chosen for obtaining the detailed field pattern. The terminating loads were carbon composition resistors.*

From the Tables it can be observed that, while the backward field is relatively unaffected by varying the termination, the variation in the forward field is considerable.

* The behaviour of carbon composition resistors at v.h.f. has been studied by Dummer.[6] His studies reveal that carbon composition resistors are substantially resistive provided they are small in size and value.

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5 W. J. Bergman and F-V. Schultz, "The Circular Travelling Wave Antenna" (Summary), *Proc. Inst. Radio Engrs.*, March, 1955, Vol. 43, pp. 354.

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APPENDIX

The method of evaluation of the integrals occurring in the paper is briefly indicated here.

Ignoring the constants, the integrals to be evaluated are of the form

$$f(\psi) = \cos(\psi - \phi)\, e^{-jpA\left(\frac{\pi}{2} - \psi\right)}\, e^{-jk\cos(\psi - \phi)}$$

The last exponential factor is expanded in terms of the well-known Fourier-Bessel series and simplified. We thus obtain

$$f(\psi) = e^{-jpA\left(\frac{\pi}{2} - \psi\right)} \left\{ \sum_{n=0}^{n=\infty} \left[J_n(k) - J_{n+2}(k) \right] j^n \cos(n+1)(\psi - \phi) + jJ_1(k) \right\}$$

On integrating $f(\psi)$ with respect to ψ we obtain

$$\int f(\psi)d\psi = e^{-jpA\left(\frac{\pi}{2} - \psi\right)} \left\{ \sum_{n=0}^{n=\infty} \frac{[J_n(k) - J_{n+2}(k)]j^n}{p^2A^2 - (n+1)^2} \cdot [jpA\cos(n+1)(\psi - \phi) + (n+1)\sin(n+1)(\psi - \phi)] + \frac{J_1(A)}{pA} \right\}$$

Inserting the limits π and 0, separating the odd and even value of n, and multiplying by the constant factors we obtain the value of $E'\phi$. The evaluation of E'_θ is similar.

Valve Analyser

The Cossor Valve Analyser Model 1070 has been designed to provide information, hitherto unobtainable, on certain dynamic characteristics of valves.

With the advance of pulse techniques, the requirement has arisen for rigid analysis of blocking oscillator and similar circuits. Some mathematical data for the design of such circuits are available, but one of the most important components, the valve, is seldom taken into account seriously. This is presumably due to the fact that no characteristic curves have so far been available providing the necessary information under the special working conditions encountered.

Provided that the maximum dissipation of valve electrodes is not exceeded, there is no reason why control grids should not be driven positively and, if pulsed, large anode currents drawn. With the advent of rapid rise-time requirements it is, therefore, as essential as when operating in the negative grid region to know the functional limitations and peculiarities of valves working in the positive-grid region.

The new valve analyser provides characteristic curves displayed on a 6-inch double-gun c.r.t. Single curves or swept families on either or each gun can be selected, with a swept X-axis of V_{g1} or V_a.

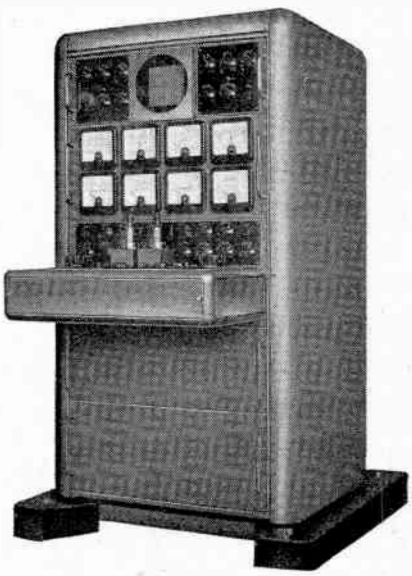
Stepping facilities enable the curve families to be displayed with V_{g1} or V_{g2} as variable parameters, curves of grid, anode or screen current being switch-selected.

Continuously-variable short-duration pulses from −50 to +100 V are available for application to the control grid, enabling display of conventional negative-grid as well as positive-grid characteristics. Voltages V_a and V_{g2} can be continuously varied over the range 0–450 V and suppressor-grid voltage from −100 to +100 V. Grid current is measurable up to 1 A and anode and screen currents to 5 A. Peak emission may be tested up to 18 A at 500 V.

The tube-face graticule is illuminated as required for visual or photographic work and is simply pre-calibrated, the X axis for the voltage sweep range in use, the current Y axis once calibrated on any range being correct for all current ranges.

When spot readings to meter accuracy are preferred, the step and sweep facilities are removed, current and voltage values then being indicated on large meters.

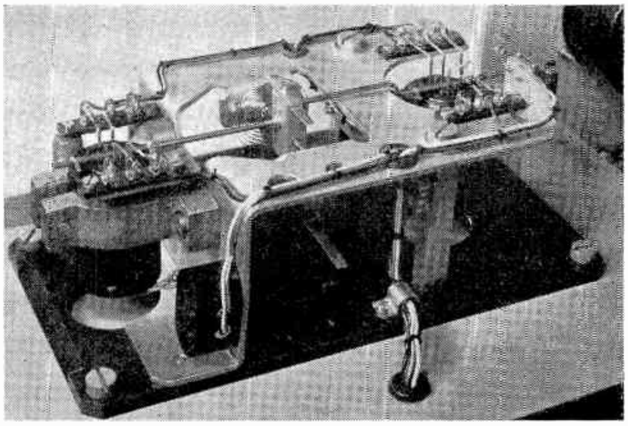
The equipment is supplied with a 35-mm camera, enabling characteristic curves as displayed on the c.r.t. to be recorded and catalogued.



The Cossor valve analyser model 1070

Balanced-Beam Computing Device

ELECTRO-MECHANICAL SYSTEM



View of Evershed computer showing the balanced beam

The analogy between a simple balance and an equation is the basis of an ingenious computing device made by Evershed & Vignoles. If the beam of the balance is pivoted at its centre, then balance is obtained when the weights W in each pan are equal. Thus the arrangement is the analogue of the equation $W_1 = W_2$.

Substitution of magnetic attraction or repulsion for weights results in the much more versatile arrangement of Fig. 1. The beam carries small electromagnets at each end. The cores of the electromagnets are also subject to the fields of two fixed electromagnets. A bias spring is provided; this enables the effect of standing currents through the coils to be balanced out.

Shunting resistors across each coil enable suitable coefficients to be inserted.

If the fixed magnets are operated with constant and equal currents then, at balance,

$$ax + by + S = pu + qv,$$

S being the force exerted by the spring and u, v, x and y those due to coil currents. Any of the quantities can, of course, be made negative. Balance is detected by means of a pair of contacts at one end of the beam.

If the currents through the fixed coils are also variable, then the force between each fixed coil and the associated moving coil will depend upon the product of the two field strengths. Thus, at balance,

$$(ax + by)\,cz + S = (pu + qv)\,rw.$$

By assigning suitable values to the quantities in the equation, any of the normal arithmetic operations can be performed. For example, if $cz = rw$, $S = 0$, then

$$ax + by = pu + qv$$

or, reversing the sense of the pu coil,

$$ax + by + pu = qv;$$

i.e., the sum of three inputs is indicated by the size of the current in coil q. If the constants are arranged such that $ax \times cz = rw$, where $ax = cz$, then $rw = ax^2$ and, conversely, $ax = \sqrt{rw}$.

The computer can be made part of a control system. In this application (Fig. 2), an unbalance causes the grid bias on the valve to be varied. The cathode current of the valve is passed through the coils M in the correct sense to restore balance. At the same time, the valve current operates a controller, the effect of which is to modify the process variable giving rise to the x input, The final result, therefore, is that deviations in x are corrected and balance restored.

In practice, x may be some function of several inputs, as described above.

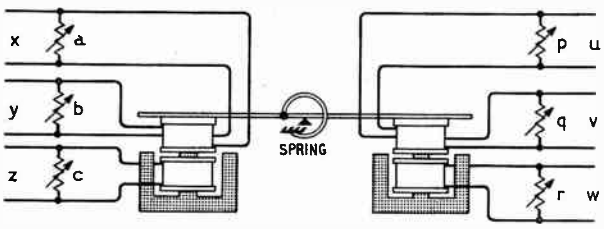


Fig. 1. *Essentials of the balanced-beam device*

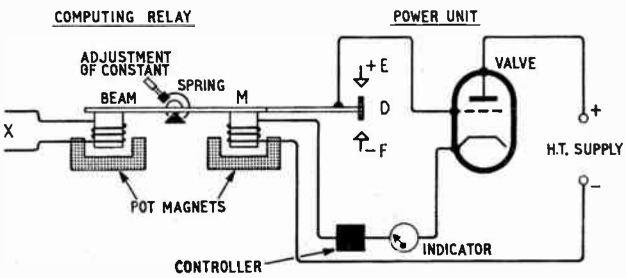


Fig. 2. *Combination of computer and control device*

MANUFACTURERS' LITERATURE

Muirhead Magslips: Applications and Methods of Use. Pp. 55 + vi. Chapters on history; fundamental principles; types of magslips; magslip systems and circuits; design and layout of new applications; computing elements; electrical details and power supplies; mechanical details; measurements, tests and fault location. Numerous illustrations, and an index.

Muirhead Synchros. Pp. 4. Folder listing synchros to MIL specification.

Both the above from *Muirhead & Co. Ltd., Beckenham, Kent.*

Short's General Purpose Analogue Computer. Pp. 8. Description and specification of d.c. analogue computer.

Short Brothers & Harland Ltd., Belfast.

P.E.T. Terminations. Folder containing catalogue leaflets specifying cable connectors.

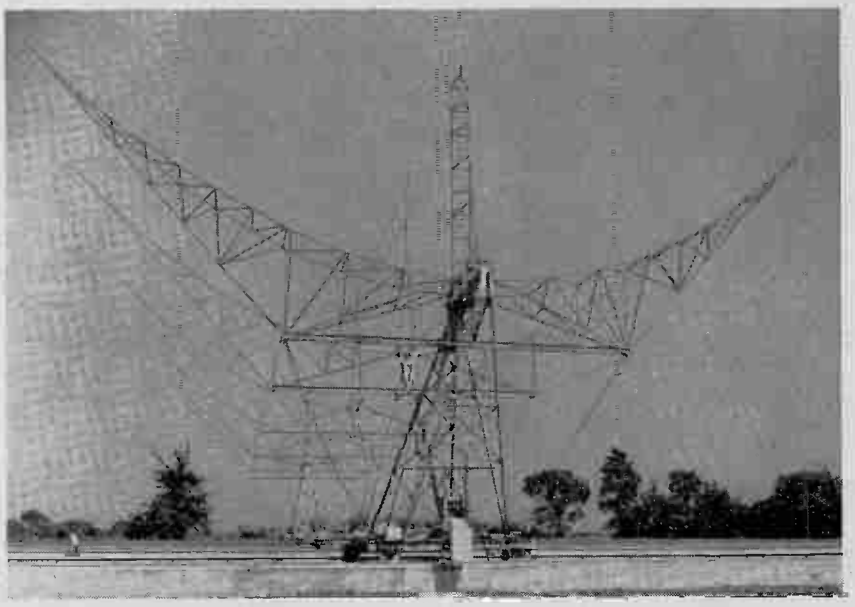
Precision Electronic Terminations Ltd., Buckhurst Avenue, Sevenoaks, Kent.

Electronic Instruments: Short form Catalogue. Pp. 7.

A. E. Cawkell, Southall, Middlesex.

Radio Astronomy

NEW OBSERVATORY AT CAMBRIDGE



Moving section of the 1·7-m array

ON 25th July, the Mullard Radio Astronomy Observatory at Cambridge was officially opened by Sir Edward Appleton. The observatory is part of the Cavendish Laboratory. The cost is being borne partly by the Department of Scientific and Industrial Research and partly by the University of Cambridge but about half of it by Mullard Ltd., who are giving £100,000 over ten years.

The site is at Lord's Bridge, about five miles from Cambridge, and is a triangle of some 180 acres. It contains a building for the electronic equipment and two aerial arrays, one for use at 1·7 metres and the other for 7·9 metres. The first is intended for measurements on radio stars and the second is for use on galactic background radiation.

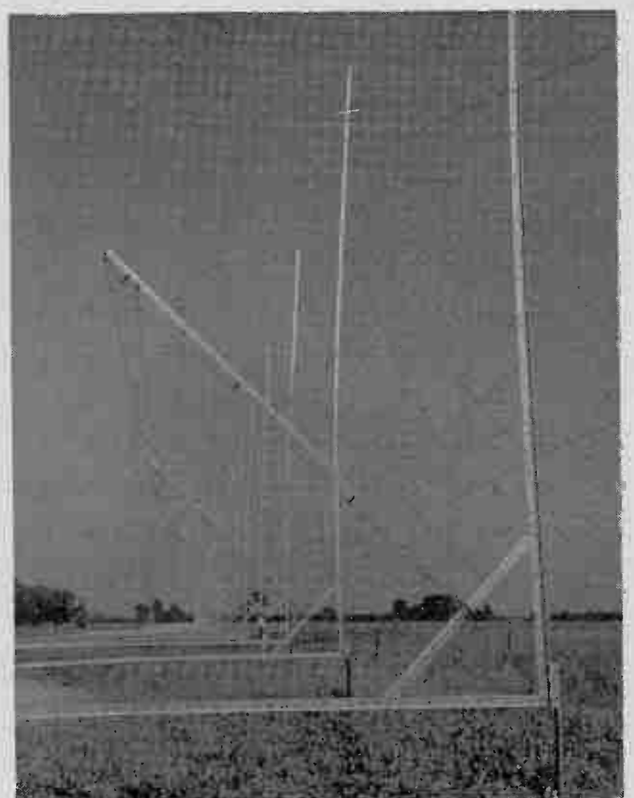
Each aerial is in two parts and comprises a large fixed part and a relatively small moving one. In the case of the 7·9-m array, the fixed section comprises a corner reflector of 40-ft. aperture and 3,200 ft. long. The aerials within it are centre-fed full-wave dipoles mounted end to end, but spaced apart. They are fed by a twin-wire transmission line.

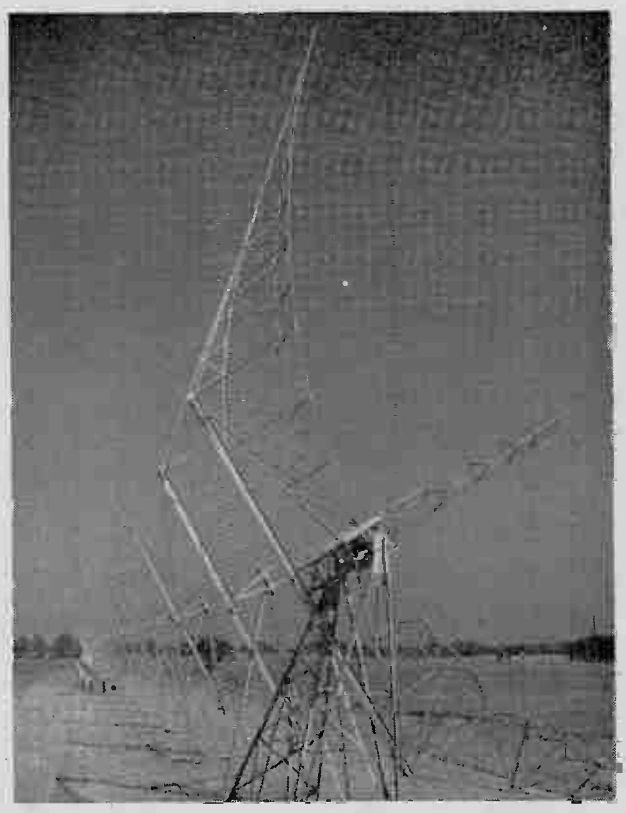
The reflector comprises parallel wires stretched between V supports which hold the dipoles on internal members. The whole is supported at the apices on stakes driven into the ground and is maintained in position by guy wires. Although the system normally points vertically upwards, it can be tilted by adjusting the guy wires.

The moving part of this array is of similar construction, but much shorter. Movement is restricted to tilting the assembly on its supports.

The 1·7-metre array is of the same basic form although it differs

Left: Part of the 7·9-m array. This fixed section is under construction and is tilted 45° from its normal operating position. Right: Fixed aerial of the 1·7-m array tilted sideways while under construction





mechanically. The reflector is comprised of stretched wires but has a parabolic section with an aperture of 65 ft. and a length of 1,450 ft. The moving part is 190-ft. long and is mounted on six lines of railway track so that it can be moved slowly by electric traction over a distance of 1,000 ft.

Both aerial arrays operate on the interferometer principle[1] and also provide aperture synthesis[2]. This is a method of operation by means of which the effect of a much larger aerial is secured.

An aerial system can be regarded as being composed of a large number of elemental aerials. Normally, the total output e.m.f. is the vector sum of the e.m.fs produced in the elements. If an aerial system is built with two only of these elemental aerials, the output is naturally merely the vector sum of the e.m.f.s produced by these two. However, if the source of radiation is scanned by these two elements so that they take up in turn all the positions of the elements of a full aerial, there is obtained a sequence of e.m.fs corresponding to all pairs of elements.

The summation of these e.m.f.s, with due regard to their phase, will then provide an output which is the same as that given by a full aerial. It is, of course, a necessary requirement that the source of radiation remains constant over the scanning period.

In the Cambridge apparatus the aerials used are larger than mere elements, but are small compared with the equivalent normal aerials. The 7·9-metre system, for instance, is stated to be the equivalent of a paraboloid of 2,000 ft. diameter.

The summation is not done electrically, but mathematically. The aerial is set to scan a particular line of sky, the aerial movement being effected by the earth's rotation and the output operates a pen recorder. The next day the position of the movable part of the aerial is altered and a second scan of an adjacent line of sky is obtained.

Over a period of some weeks the full area is scanned and the information from the records is fed to an electronic computer which carries out the summation.

The electronic equipment at the observatory is fairly simple and comprises little more than sensitive receivers equipped with pen recorders.

REFERENCES

[1] Bernard Lovell and J. A. Clegg, "Radio Astronomy", p. 152. (Chapman & Hall)
[2] M. Ryle, "The Mullard Radio Astronomy Observatory, Cambridge", *Nature*, 20th July 1957

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.

Some Matrix Theorems

SIR.—In a discussion of matrix products, Wilson[1] has recently given the very useful form for the nth power of a matrix whose determinant is unity

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^n = \begin{bmatrix} \cosh nu + k \sinh nu & \mu\sqrt{1-k^2} \sinh nu \\ \frac{1}{\mu}\sqrt{1-k^2} \sinh nu & \cosh nu - k \sinh nu \end{bmatrix} \quad \ldots (1)$$

with the definitions

$$\left.\begin{aligned} \cosh u &= \tfrac{1}{2}(a_{11} + a_{22}) \\ k \sinh u &= \tfrac{1}{2}(a_{11} - a_{22}) \\ \mu^2 &= \frac{a_{12}}{a_{21}} \end{aligned}\right\} \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2)$$

which can be applied; e.g., to cascaded four-terminal networks. What amounts to the above formula has been used before in discussions of such networks, but often not in matrix notation, and usually with the restriction that the sections be symmetrical, so that $k = 0$. Formulæ analogous to Equ. (1) were also derived for tapered chains of cascaded four-terminal networks.

While u involves the signal frequency, the elements of the matrix cannot be transcendental functions of frequency, if sections formed of lumped elements are being considered, but must be rational. This is easily seen in an alternative form, which may be of some interest. The elements are of the form[2]

$$\left.\begin{aligned} \cosh nu &= \cosh n \operatorname{arccosh}\left(\frac{a_{11}+a_{22}}{2}\right) = \cosh nj \arccos\left(\frac{a_{11}+a_{22}}{2}\right) \\ &= \cos n \arccos\left(\frac{a_{11}+a_{22}}{2}\right) = T_n\left(\frac{a_{11}+a_{22}}{2}\right) \\ \sinh nu &= j \sin n \arccos\left(\frac{a_{11}+a_{22}}{2}\right) = jU_n\left(\frac{a_{11}+a_{22}}{2}\right) \end{aligned}\right\} \quad (3)$$

$T_n(x)$ and $U_n(x)$ are the Tchebychev functions of degree n, $T_n(x)$ being a polynomial and $U_n(x)$ the product of a polynomial and a surd. (As the functions appear in the matrix, the surds will cancel or multiply out, to make the result rational.)

A further modification is sometimes interesting. Often $a_{11} + a_{22}$ takes a simple form as a function of frequency; for an L-section; e.g., with a series inductance L and shunt capacitance C, one has

$$\frac{a_{11}+a_{22}}{2} = 1 - \frac{\omega^2 LC}{2} = -T_2\left(\frac{\omega\sqrt{LC}}{2}\right) \quad \ldots \quad \ldots \quad \ldots (4)$$

Since[2]

$$T_m\{T_n(x)\} = T_{mn}(x),\ U_m\{T_n(x)\} = U_{mn}(x),$$

$T_n(-x) = (-1)^n T_n(x)$, and $U_n(-x) = (-1)^{n+1}U_n(x)$, in this case one finds

$$\left.\begin{aligned} \cosh nu &= (-1)^n T_{2n}\left(\frac{\omega\sqrt{LC}}{2}\right) = (-1)^n T_{2n}\left(\frac{\omega}{\omega_0}\right) \\ \sinh nu &= (-1)^{n+1} jU_{2n}\left(\frac{\omega\sqrt{LC}}{2}\right) = (-1)^n jU_{2n}\left(\frac{\omega}{\omega_0}\right) \end{aligned}\right\} \quad (5)$$

so that Equ. (1) would become

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^n = (-1)^n \begin{bmatrix} T_{2n}\left(\frac{\omega}{\omega_0}\right) - jkU_{2n}\left(\frac{\omega}{\omega_0}\right) & -j\mu\sqrt{1-k^2}U_{2n}\left(\frac{\omega}{\omega_0}\right) \\ -\frac{j}{\mu}\sqrt{1-k^2}U_{2n}\left(\frac{\omega}{\omega_0}\right) & T_{2n}\left(\frac{\omega}{\omega_0}\right) + jkU_{2n}\left(\frac{\omega}{\omega_0}\right) \end{bmatrix} \quad \ldots \quad \ldots (6)$$

This representation makes it easy to see how the low-pass filter properties of a chain of such sections can arise, since $T_n(x)$ and $U_n(x)$ are oscillatory for $|x| \leqslant 1$, and for $|x| > 1$ increase in absolute value monotonically and ultimately as $|x^n|$, $T_n(x)$ being real and $U_n(x)$ imaginary.

Sometimes it is desired to represent matters in terms of $p = j\omega$. Then, by using Klein's definitions of the hyperbolic Tchebychev functions, $Th_n(x)$ and $Uh_n(x)$, one gets

$$\left.\begin{aligned} T_{2n}\left(\frac{p}{j\omega_0}\right) &= (-1)^n\, Th_{2n}\left(\frac{p}{\omega_0}\right) \\ U_{2n}\left(\frac{p}{j\omega_0}\right) &= j\,(-1)^n\, Uh_{2n}\left(\frac{p}{\omega_0}\right) \end{aligned}\right\} \quad \ldots \quad \ldots \quad \ldots (7)$$

so that the results can be expressed in terms of these functions. (Note that ω_0 is real.) Then Equ. (6) becomes

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^n = \begin{bmatrix} Th_{2n}\left(\frac{p}{\omega_0}\right) + kUh_{2n}\left(\frac{p}{\omega_0}\right) & \mu\sqrt{1-k^2}Uh_{2n}\left(\frac{p}{\omega_0}\right) \\ \frac{1}{\mu}\sqrt{1-k^2}Uh_{2n}\left(\frac{p}{\omega_0}\right) & Th_{2n}\left(\frac{p}{\omega_0}\right) - kUh_{2n}\left(\frac{p}{\omega_0}\right) \end{bmatrix} \quad \ldots \quad \ldots (8)$$

A similar result can be derived for the tapered case.

Equations (6) and (8) are seen to provide rather neat expressions for powers of a matrix. On the other hand, these forms give little or no advantage in actual computation. The situation would be changed if charts of the ordinary or hyperbolic Tchebychev functions of complex arguments should become available, as they now are for hyperbolic and circular functions. In this case, the Tchebychev representation might offer real advantages.

H. L. ARMSTRONG

REFERENCES

[1] W. Proctor Wilson, *Electronic & Radio Engineer*, June 1957, Vol. 34, p. 229.
[2] W. Klein, *Archiv fur Elektrotechnik*, 1950, Vol. 39, p. 647.

Pacific Semiconductors, Inc.,
Culver City, California, U.S.A.

20th July 1957.

New Books

The Theory of Networks in Electrical Communications and Other Fields

By F. E. Rogers, A.M.I.E.E. Pp. 560. Macdonald & Co. (Publishers) Ltd., 16 Maddox Street, London, W.1. Price 65s.

The author is lecturer in telecommunications, electronics and electrical measurements at the Polytechnic (London), and he intends his book for students of final-year Engineering Degree or Diploma standard. It has 12 chapters headed: Introduction, The foundations of network theory, The general theory of multi-mesh networks, Network theorems, Concerning the structure of the fundamental types of network, Network equivalences, Two-terminal networks, Transmission along uniform lines and cables, The transmission parameters of four-terminal networks, Insertion loss and impedance matching, The principles of filter networks and Measurements on linear networks.

The early part of the book covers elementary circuit theory and lays the foundations for a systematic approach to more complex networks. Great stress is placed upon circuit equivalence and the use of Thévenin's theorem. Determinants are introduced quite early in the book but mainly to illustrate some of their applications in network theory, for they are by no means extensively employed anywhere.

The later part of the book carries the discussion into transmission lines and filters and, from the very nature of the subjects, is more complex. Generally, however, the treatment is clear, but a fair mathematical knowledge is needed to grasp the full implications of the argument.

Throughout the outlook is analytic and the author's aim seems to be to give his readers an understanding of the subject. In this he has succeeded and the book is a most useful addition to the literature. It is not one especially valuable to the designer, however, whose aim is usually to synthesize rather than to analyse. W.T.C.

The Services Textbook of Radio. The Services Textbook of Electrical Engineering. Vol. 1: Electrical Fundamentals

By G. R. Noakes, M.A.(Oxon), F.Inst.P. Pp. 645. Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2. Price 30s.

This book, which covers material fundamental to both radio and electrical engineering, is intended to serve as the first volume of each of the Services' Textbooks. The mathematics employed is for the most part elementary. The more difficult passages of the book are marked with a special sign, and the design is such that these parts can be skipped without breaking the continuity. Supplementary analyses and proofs are contained in appendixes.

"Where this book differs from others is in the treatment (of the material), for a special endeavour has been made to explain everything very fully and clearly". Material has been repeated in some places to avoid cross references. More space than is usual in a work of this nature has been given to electrical machinery, illumination, semiconductors and measuring instruments.

Industrial Electronics Circuits

By R. Kretzmann. Pp. 144. Philips' Technical Library, distributed in the U.K. by Cleaver Hume Press Ltd., 31 Wright's Lane, Kensington, London, W.8. Price 35s.

This book is a sequel to the author's "Industrial Electronics Handbook", and contains about 100 circuits (not 200 as stated on the wrapper). These are grouped under the headings Photo-electrically Controlled Apparatus, Counting Circuits, Stabilizing Circuits, Contact and Control Devices, Oscillator and Amplifier Circuits, and Rectifier and Motor Control Circuits. "Stabilizing Circuits" include thermostats as well as stabilized voltage supplies.

The author has interpreted the term "Industrial Electronics" liberally for, in addition to devices such as counters and metal detectors, he has included u.h.f. oscillators and transmitter amplifiers. He states in the preface that "most of the circuits have been developed in the laboratory". One cannot help wondering whether some of them have ever been outside it. For example, on p. 81, there is a circuit for stabilizing valve heater supplies which contains nine valves, but no information is given about the amount of stabilized current available from this device. A passage beginning "To calculate the size of the output transformer" merely states how its turns ratio can be calculated. Essential information, such as the value of the h.t. required in a circuit, is frequently omitted, and the author's warning that specified valves and components may not be available should be heeded.

Most circuits have been previously described elsewhere and a bibliography is included. Not enough basic design information is included to make the book of much use to the designer and there is certainly not enough constructional information to enable the production engineer to apply the circuits. G.W.S.

British Scientific and Technical Books 1935-1952

Published for ASLIB by James Clarke & Co. Ltd., 33 Store Street, London, W.C.1. Pp. 364. Price 63s.

A classified bibliography, author and subject indexes, for the use of librarians and students of science and technology.

Receiving Aerial Systems

By I. A. Davidson, B.A. Pp. 152. Heywood & Co, Ltd., Ingersoll House, 9 Kingsway, London, W.C.2. Price 21s.

An elementary book on aerials for domestic radio and television.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Deviations from nominal frequency for July* 1957

Date 1957 July	MSF 60 kc/s 2030 G.M.T. parts in 10^9	Droitwich 200 kc/s 1030 G.M.T. parts in 10^8
1	+ 2	+ 2·1
2	+ 2	+ 2·4
3	+ 2	+ 2·7
4	+ 2	+ 3·1
5	+ 1	+ 3·5
6	+ 2	+ 4·0
7	+ 3	+ 4·2
8	+ 3	− 0·3
9	+ 3	− 1·6
10	+ 3	− 1·3
11	+ 3	− 0·9
12	+ 3	+ 0·4
13	+ 3	+ 0·8
14	+ 3	+ 1·1
15	+ 4	+ 1·4
16	+ 4	+ 1·7
17	+ 4	+ 1·6
18	N.M.	+ 2·3
19	+ 4	+ 2·6
20	+ 5	+ 2·8
21	N.T.	+ 3·3
22	N.T.	+ 3·4
23	N.T.	+ 3·7
24	N.T.	+ 3·9
25	N.T.	+ 4·1
26	N.T.	− 1·8
27	N.T.	− 1·6
28	N.T.	− 1·5
29	− 4	− 0·9
30	− 4	− 0·8
31	− 4	− 0·5

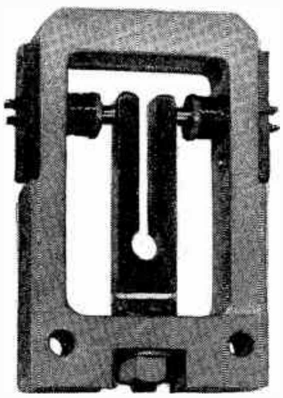
* *Nominal frequency is defined to be that frequency corresponding to a value of* 9 192 631 830 *c/s for the N.P.L. caesium resonator. N.M. = Not Measured. N.T. = No Transmission.*

Note.—The continuing repairs to the long-wave aerials at Rugby made it necessary to suspend the MSF 60-kc/s transmissions on the 21st July. On the 29th July the service was resumed with a temporary aerial whose effective height is about one fifth of normal. This arrangement will continue for at least six months and may last for as long as a year.

New Products

Valve-Maintained Tuning Fork

A tuning fork for use in conjunction with valves is manufactured by S. G. Brown Ltd. The frequency stability is stated to be 7·5 parts in 10^6 per degree centigrade. The electrical circuit is completed by means of two coils (see photograph) whose cores are part of the fork. The insertion loss is 18–22



dB, and 0·3-volt drive is required across a 10-Ω coil. The mechanical Q is 9,000–14,000, and the frequency range 2,000–2,200 c/s.

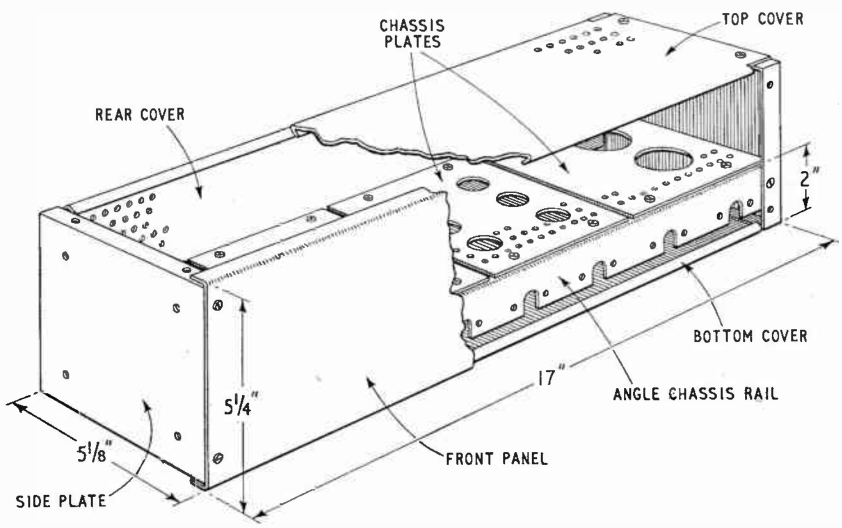
Tuning forks are supplied in hermetically-sealed containers, pressurized to 20 lb./sq. in., in stacks of 1 to 12 forks.

S. G. Brown Ltd.,
Shakespeare Street, Watford, Herts.

Pre-Fabricated Chassis

A selection of pre-fabricated chassis parts is obtainable from All-Power Transformers Ltd. These can be put together in a variety of ways without drilling, punching or cutting. The makers claim that the time taken to prepare a chassis from a circuit diagram to the stage at which it is ready for wiring is less than one hour. Chassis plates with holes for octal, B7G, B9A, etc., valve-holders are attached to chassis rails, which contain slots to accommodate variable resistors, jacks, and so forth. End plates, covers, front panels and rack brackets are also available, so that a completed equipment can be put into service.

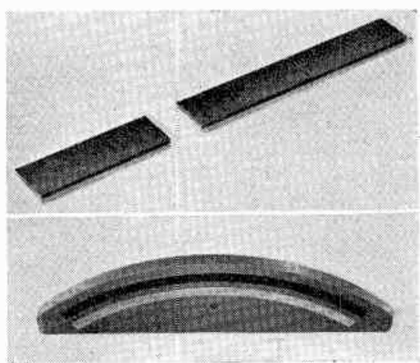
All-Power Transformers Ltd.,
Chertsey Road, Byfleet, Surrey.



Variable Resistive Elements

Plessey have recently produced a range of precision resistive elements, made by their special moulded-carbon technique. Elements produced so far cover values ranging from 25 ohms to 10 megohms. They are suitable for industrial applications such as machine-tool control, movement indication and control, liquid level control and remote indication, high-speed switching, and stepped attenuators, where reliability is essential, and resistance and linearity tolerances are to fine limits.

Elements can be produced in a variety of shapes and sizes. All laws are available, the

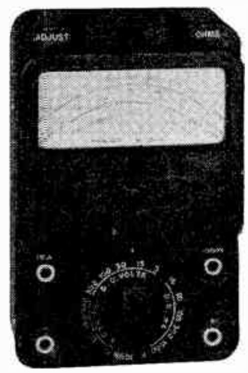


tolerance on linearity being ±2%. Elements are claimed to have successfully withstood 10 million operations and to be capable of operation at temperatures from 40°C to 100°C. Illustrated are straight-line and arc-shaped resistive elements.

The Plessey Co. Ltd.,
Ilford, Essex.

Pocket Multimeter

A pocket-sized multi-range test meter has been introduced by Taylor Electrical Instruments Ltd. Its dimensions are 4⅞ in. × 3⅛ in. × 1⅞ in., and it weighs 14 oz. Sensitivity is 5,000Ω/V and there are 18 ranges, covering 3–1,500 V d.c., 15–1,500 V.



a.c., 15 mA–15 A d.c., and 10Ω–1 MΩ. Accuracy is quoted as 2% d.c., 3% a.c.

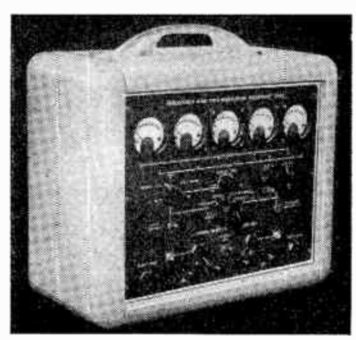
The same firm now have a range of 5 in. panel-mounting meters.

Taylor Electrical Instruments Ltd.,
Montrose Avenue, Slough, Bucks.

Transistor Frequency and Time-Measuring Equipment

Venner Electronics Ltd. are now producing a transistor frequency and time-measuring equipment incorporating plug-in units. The equipment is claimed to be capable of measuring any frequency in the range 10 c/s to 50 kc/s, the period of any waveform from 0·00001 c/s to 10 kc/s, and the time interval between two consecutive pulses from the same or independent sources from 1/10,000th of a second to 11½ days. It can also be used to determine the open or closed time of a pair of contacts in the same range. Digital presentation is employed, the indicator for each decade being a meter calibrated from 0–9.

When set to measure frequency, any of the three gating times —0·1 sec, 1 sec or 10 sec—may be selected. Six standard output frequencies are also available. An automatic timer is fitted so that repetitive



measurements may be made. The display time is variable from 0·5 sec to 5 sec.

When set to period measurement, the output of an internal 10-kc/s crystal oscillator is counted for the duration of one input cycle of the unknown frequency. In this way, accurate measurements can be made of frequencies from 0·00001 c/s to 100 c/s.

With the equipment set up for pulse interval timing, a pulse fed to a 'start' socket opens an internal gate, permitting the feeding of any of the six internal frequencies to the counting stages. This permits a wide range of timing to be carried out with optimum accuracy.

A 'contact timing' position on the function selector enables ten different types of timing to be carried out from virtually any combination of contacts.

The techniques in this equipment are digital throughout.

Venner Electronics Ltd.,
Kingston By-Pass, New Malden, Surrey.

X-Band Test Set

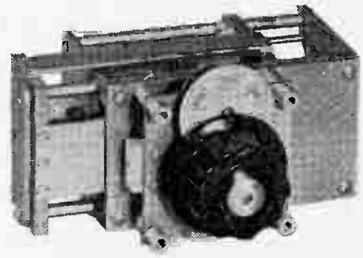
An equipment for testing radar systems operating in the frequency range 8,500–9,600 Mc/s, or for use in the laboratory, is available from G. & E. Bradley Ltd. It can be used as a signal generator, a sweep generator, a frequency meter and a power meter. The signal generator uses a reflex

klystron, the output power being −7 to −83 dBm ± 2 dB. The frequency meter is of the absorption type, accuracy being ±2·5 Mc/s. Power measurements (±2 dB) are made with a thermistor bridge and attenuator.

G. & E. Bradley Ltd.,
Beresford House, Mount Pleasant,
Alperton, Middx.

Coaxial Turret Attenuator

Illustrated is an Advance turret attenuator of the type mentioned in our June issue p. 226. Points from the makers' specification are as follows: attenuation range, 0–50 dB in 10-dB steps; accuracy ±1 dB 0–1,000 Mc/s; v.s.w.r. less than 1·2 up to 3,000 Mc/s for 20–50-dB attenuation, and up to 1,000 Mc/s for 0–20 dB; 1·7 at 3,000 Mc/s at zero attenuation; power rating 1 watt for continuous sine-wave inputs; input and output impedances 75 Ω; temperature

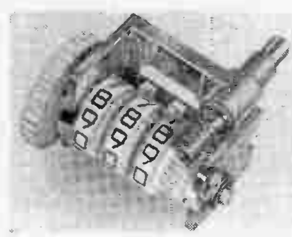


coefficient of attenuation about 0·005 dB per degree centigrade.

Advance Components Ltd.,
Roebuck Road, Hainault, Essex.

Tape Position Indicator

A device for registering the position of a magnetic recording tape has been produced



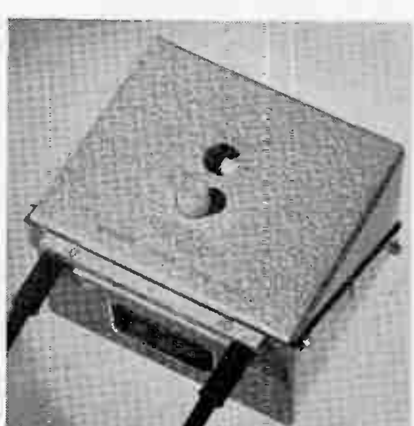
by English Numbering Machines. This is a 3-figure resettable revolution counter. It is claimed that operation at high speeds during re-winds is possible, and that the incorporation of nylon gears makes the device silent in use.

English Numbering Machines Ltd.,
25 *Queensway, Enfield, Middx.*

Process Timer

The Airmec Process Timer Type N237 is claimed to provide an accurately-timed switching facility for industrial control purposes over the ranges 1 to 10 and 10 to 100 seconds.

The starting signal may consist of a connection or disconnection of a pair of contacts and may be either a short pulse or a contact longer than the timing period. The timer may also be connected in a number of different ways; e.g., two timers back to back, two or more in tandem or three or more in a ring circuit.



The unit is housed in a small robust case and can be supplied with the time control adjustable by means of a knob on the front panel or a sealed screwdriver slot to prevent tampering.

Airmec Ltd.,
High Wycombe, Bucks.

Light and Powerful Servo Units

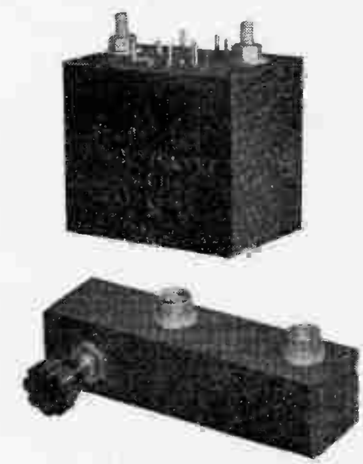
Harvey Electronics Ltd., of Farnborough, have produced a new range of servo units which are claimed to develop greater operating power and have more accurate and rapid response than existing types of similar size.

The smallest type is stated to measure 3·5 in. × 2·1 in. × 1.35 in. It has a stalled torque of 1 lb-ft and a rate of response of 60°/sec on no load. The accuracy of repeatability is 0·1% full scale.

Harvey Electronics Ltd.,
Farnborough Road, Farnborough, Hants.

Pulse Components

Encapsulated lumped-constant delay networks and pulse transformers are manufactured by Atkins, Robertson & Whiteford Ltd. Delay lines may be either fixed or variable in 10 steps, with a maximum delay of 10 μsec ±2%. Pulse transformers have



four similar windings; the rise-time is given as less than 0·1 μsec, and the maximum pulse duration 100 μsec. The peak working voltage is 300 V.

Atkins, Robertson & Whiteford Ltd.,
Industrial Estate, Thornliebank, Glasgow.

Radio Tape Measure

A pocket-sized metal tape measure which facilitates aerial measurements is available from Aveley Electric. In addition to markings in inches and centimetres, it has a scale showing frequencies corresponding to quarter wavelengths.

Aveley Electric Ltd.,
Ayron Road, Aveley Industrial Estate, South Ockendon, Essex.

Correction

The Digital Trace Reader described in the New Products section of the July issue was attributed to Southern Instruments Ltd., instead of to Southern Instruments Computer Division. Both are of Frimley Road. Camberley, Surrey.

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. Copies of articles or journals referred to are not available from Electronic & Radio Engineer. *Application must be made to the individual publishers concerned.*

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ACOUSTICS AND AUDIO FREQUENCIES

534.2-14 2652

On Wave Propagation in a Random Inhomogeneous Medium.—D. S. Potter & S. R. Murphy. (*J. acoust. Soc. Amer.*, Feb. 1957, Vol. 29, No. 2, pp. 197–198.) A derivation of the coefficient of variation of intensity.

534.2-14-8 2653

Double Relaxation Effects.—R. T. Beyer. (*J. acoust. Soc. Amer.*, Feb. 1957, Vol. 29, No. 2, pp. 243–248.) Expressions are derived for the velocity of ultrasonic waves in fluid media and the excess absorption coefficient assuming two relaxation processes. The results are discussed for several special cases.

534.2 : 621.395.623.52 2654

Analysis of the Wave Parameters of the Exponential Horn.—J. Kacprowski. (*Archiwum Elektrotech.*, 1956, Vol. 5, No. 4, pp. 719–755. English summary, pp. 757–758.) The wave parameters of an exponential horn of finite length are evaluated on the basis of the general theory of four-terminal networks using matrix algebraic methods, and the results obtained are extrapolated for horns of infinite length. The concept of wave impedance of a horn is discussed. The transformation properties of the horn are analysed.

534.24 2655

On Scattering and Reflection of Sound by Rough Surfaces.—V. Twersky. (*J. acoust. Soc. Amer.*, Feb. 1957, Vol. 29, No. 2, pp. 209–225.) A detailed analysis which extends the original work of Rayleigh and the previous work of the author (e.g. *J. appl. Phys.*, May 1953, Vol. 24, No. 5, pp. 659–660).

534.24 2656

On the Reflection of Sound at an Interface of Relative Motion.—J. W. Miles. (*J. acoust. Soc. Amer.*, Feb. 1957, Vol. 29, No. 2, pp. 226–228.) An analysis of reflection of a plane wave at an interface between two perfect fluids. The errors and limitations of previous work are discussed.

534.52 2657

Scattering of Sound by Sound.—P. J. Westervelt. (*J. acoust. Soc. Amer.*, Feb. 1957, Vol. 29, No. 2, pp. 199–203.) The effects of interaction are calculated by means of a scattering source function.

534.6 : 534.241 2658

The Development of 'Echo-Parameter' Measuring Equipment.—H. Niese. (*NachrTech.*, Dec. 1956, Vol. 6, No. 12, pp. 545–552.) This parameter was defined earlier (670 of March) as the ratio of disturbing sound energy to total sound energy (useful + disturbing) received at the point of observation. A source of sound pulses (2324 of August) and special microphone are used to produce automatically an echo oscillogram from which the parameter can be derived.

534.78 2659

Note on the Design of 'Terminal-Analogue' Speech Synthesizers.—J. L. Flanagan. (*J. acoust. Soc. Amer.*, Feb. 1957, Vol. 29, No. 2, pp. 306–310.) The synthesis of vowel sounds by lumped-constant electrical networks having transfer functions similar to the transmission properties of the vocal tract is considered.

534.86 : 534.76 2660

Influence of Noise upon the Equivalence of Intensity Differences and Small Time Delays in Two-Loudspeaker Systems.—D. M. Leakey & E. C. Cherry. (*J. acoust. Soc. Amer.*, Feb. 1957, Vol. 29, No. 2, pp. 284–286.) The effect is measured with speech and wide-band noise.

621.395.613.386 2661

Ear-Insert Microphone.—R. D. Black. (*J. acoust. Soc. Amer.*, Feb. 1957, Vol. 29, No. 2, pp. 260–264.) Results are presented of an investigation of factors which make possible the use of a microphone in the ear to pick up the voice of the wearer.

621.395.614 2662

Piezoelectric Ceramic 'Bimetal' Strips used as Electroacoustic Transducers : Microphones.—J. Peyssou. (*Ann. Radioélect.*, Jan. 1957, Vol. 12, No. 47. pp. 33–44.) A formula is derived for the e.m.f. generated by a cantilever formed by a twin strip of piezoelectric materials which is subjected to a bending moment. This effect is utilized in a form of microphone and various means of modifying its impedance are discussed. A circular 'biceramic' diaphragm is designed, but the rectangular strip used as cantilever with its free end acting on the metal diaphragm of a microphone is a more efficient transducer.

621.395.614 : 546.289 **2663**
Piezoresistive Semiconductor Microphone.—F. P. Burns. (*J. acoust. Soc. Amer.*, Feb. 1957, Vol. 29, No. 2, pp. 248–253.) Design and constructional data are given for a germanium rod microphone. Performance is compared with that of a standard carbon button transmitter.

621.395.616 : 534.612.2 **2664**
Condenser Microphones for Measurement of High Sound Pressures.—J. K. Hilliard & W. T. Fiala. (*J. acoust. Soc. Amer.*, Feb. 1957, Vol. 29, No. 2, pp. 254–260.)

621.395.625.3 **2665**
The Characteristics of Magnetic Recording Heads and Tapes.—H. P. Spring. (*J. Brit. Instn Radio Engrs*, April 1957, Vol. 17, No. 4, pp. 217–233.) The fundamental principles, operating conditions and limitations are discussed. Some novel designs are described and the effect of head and tape wear on frequency response is measured.

AERIALS AND TRANSMISSION LINES

621.372.2 : 621.385.16 **2666**
The Attenuation of the Helical Wire Line.—G. Schiefer. (*Arch. elekt. Übertragung*, Jan. 1957, Vol. 11, No. 1, pp. 35–40.) The propagation of an infinite number of partial modes along an inhomogeneous delay line based on Sensiper's model (1247 of 1955) is considered so as to determine the attenuation constant of the helical line. Some of the results calculated differ considerably from previous solutions obtained by considering the fundamental mode only. Diagrams are given for finding the attenuation constant as a function of line dimensions, wavelength and wire conductivity.

621.372.2.029.6 **2667**
The Mode Conversion Phenomena of Laminated Transmission Lines and their Influence on the Transmission by Single or Coupled Sections.—H. E. Martin. (*Arch. elekt. Übertragung*, Jan. & Feb. 1957, Vol. 11, Nos. 1 & 2, pp. 7–16 & 81–96.) The problem is considered of coupling power from coaxial into laminated lines, and vice versa, using graded potentials to reduce mode conversion losses [see also 328 of 1955 (Kaden & Martin)]. The influence of the dimensions and the transitions is investigated and methods of measuring transmission characteristics are discussed. Approximate formulae are derived for transmission coefficients of an arrangement consisting of several series-connected laminated line sections.

621.372.21 : 621.315.213 **2668**
Theory of the Microstrip.—T. T. Wu. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, pp. 299–302.) A discussion of the current distribution of the lowest mode of a transmission line consisting of a thin metallic strip pasted on the dielectric coating of a second and extensive conductor.

621.372.22 **2669**
Computation of the Impedances of Nonuniform Lines by a Direct Method.—L. A. Pipes. (*Commun. & Electronics*, Nov. 1956, No. 27, pp. 551–554.) The impedances are computed by solving first-order non-linear differential equations of the Riccati type. Special cases which include the uniform line, the Bessel line, and the Heaviside-Bessel line are discussed.

621.372.8 : 538.566.2 **2670**
Orthogonality Relation for Gyrotropic Waveguides.—L. R. Walker. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, p. 377.) A generalization of a simpler theorem which is applicable to guides partially filled with ferrite or plasma.

621.372.8 : 621.317.352 **2671**
Equipment for Measuring Attenuation of the H_{01} Wave in Short Sections of Waveguides by the Cavity Resonance Method.—V. M. Vakhnin & T. F. Kolodina. (*Radiotekhnika i Elektronika*, Dec. 1956, Vol. 1, No. 12, pp. 1485–1491.) A method is described of measuring the attenuation in cylindrical waveguides, with diameters of 50 mm, at a wavelength of 3·2 cm. The method is based on a comparison of the resonance curve of the measured volume with the frequency characteristic of an integrating *RC* circuit. Random errors are less than 1%. The equipment is suitable for the determination of the influence of various factors, such as surface treatment, on the attenuation. A section drawing and photograph of the resonator are shown and a block diagram of the *Q* meter is given.

621.396.674.1 **2672**
Impedance of Thin-Wire Loop Antennas.—J. E. Storer. (*Commun. & Electronics*, Nov. 1956, No. 27, pp. 606–619.) Hallén's rigorous Fourier-series solution is modified to avoid convergence difficulties. Calculated loop impedances for various wire gauges and aerial circumferences up to $2\frac{1}{2}\lambda$ are tabulated, and curves for the computation of field patterns and current distribution are given.

621.396.677 **2673**
A Limiting Case in the Design of an Excited-Reflector Antenna.—V. A. Krishnaswamy. (*J. Instn Telecommun. Engrs, India*, Dec. 1956, Vol. 3, No. 1, pp. 38–42.) A discussion of a limitation in the use of an excited reflector in a two-element broadside array.

621.396.677 : 621.396.933.2 **2674**
D.F. Aerial System for Decimetre Wavelengths.—C. Clarke. (*Electronic Radio Engr*, July 1957, Vol. 34, No. 7, pp. 238–245.) The development and performance of two aerial systems, for vertically and horizontally polarized waves respectively, are described. They are designed to work with a twin-channel c.r.-tube instrument having an azimuthal coverage limited to a selected 90° sector.

621.396.677.3 : 523.16 : 523.72 **2675**
Interferometer for the Study of Localized Solar Sources of Centimetre Waves.—Alon, Kundu & Steinberg. (See 2733.)

621.396.677.833 : 523.16 **2676**
A New Form for a Giant Radio Telescope.—Head. (See 2736.)

621.396.677.833.012.12 **2677**
A Method of Measuring the Directivity Characteristics of Radiotelescopes with High Resolving Power.—N. A. Esepkina. (*C. R. Acad. Sci. U.R.S.S.*, 1st March 1957, Vol. 113, No. 1, pp. 94–96. In Russian.) Equations given relate the directivity characteristic of a system comprising a primary radiator at the focus of a parabolic mirror to that of a system in which the radiator is displaced from the focus along the axis of the mirror. Results are given of an experimental verification on a system comprising a primary radiator of 3-cm-λ radiation and a parabolic mirror with aperture 150 cm and focal length 50 cm; directivity curves obtained from measurements at a distance of 150 m with the primary radiator at the focus agree closely with those obtained at 13 m with the primary radiator displaced by 3 cm.

621.396.677.833.2 : 621.396.96 **2678**
A New Type of Surveillance [radar] **Aerial: a Paraboloid Illuminated by a Slotted Waveguide.**—L. Thourel. (*Ann. Radioélect.*, Jan. 1957, Vol. 12, No. 47, pp. 3–13.) The production of a radiation pattern of given shape by means of a paraboloidal reflector illuminated by an equiphase linear source, such as a slotted waveguide, is described. Calculation and construction methods are indicated. The gain obtained with a reflector 1·3 m high is comparable to that of a double-curvature reflector of 2·5-m height.

AUTOMATIC COMPUTERS

681.142 **2679**
The Principles of Universal Numerical Computers.—F. H. Raymond. (*Onde élect.*, Oct. 1956, Vol. 36, No. 355, pp. 838–841 & Jan. 1957, Vol. 37, No. 358, pp. 68–78.) Continuation and conclusion of paper included in the Electronic Computer issue of the journal (see 997 of April).

681.142 **2680**
Designing for Reliability.—N. H. Taylor. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 811–822.) A discussion of reliability as applied to digital computer technology. The choice of components, their application, and considerations of design are discussed in detail. The design of a high-speed, vacuum-tube flip-flop is considered as a practical example.

681.142 **2681**
Punched-Card Transcriber for Automatic Computers.—(*Tech. News Bull. nat. Bur. Stand.*, March 1957, Vol. 41, No. 3, pp. 38–39.) The unit described is intended for use with the SEAC computer (see 385 of 1951).

681.142 **2682**

Magnetic Data Recording Theory: Head Design.—A. S. Hoagland. (*Commun. & Electronics*, Nov. 1956, No. 27, pp. 506–512.) The relation of the read-back waveform to bit density is examined and basic theoretical expressions are derived. The design of a recording head for magnetic disks is discussed with the aid of experimental results.

681.142 **2683**

Number Systems for Computers.—I. J. Gabelman. (*Electronic Ind. Tele-Tech*, Dec. 1956, Vol. 15, No. 12, pp. 32–33 . . 118.) Decimal, binary, octal, bi-quinary, coded-decimal and excess-three systems are considered.

681.142 : 519.283 **2684**

The Generation of Random Numbers on Automatic Computers.—S. von Hoerner. (*Z. angew. Math. Phys.*, 25th Jan. 1957, Vol. 8, No. 1, pp. 26–52.) Some mathematical methods are summarized and a new one, which avoids the formation of stable cycles and degeneration, is discussed. The theory of random-number generation using γ radiation is confirmed by means of the experimental arrangement described.

681.142 : 621.374.3.001.4 **2685**

Locating 'Open Heaters' in Computer Circuitry.—R. L. Ives. (*Electronic Ind. Tele-Tech*, Dec. 1956, Vol. 15, No. 12, pp. 46–47 . . 102.)

681.142 : 621.374.32 : 621.314.7 **2686**

Computer Switching with Micro-alloy Transistors.—J. B. Angell & M. M. Fortini. (*Electronic Ind. Tele-Tech*, Dec. 1956, Vol. 15, No. 12, pp. 38–39 . . 126.) Transistor characteristics are discussed in relation to flip-flop circuits.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.011.21 **2687**

Contribution on the Calculation of the Total Impedance of Parallel-Connected Impedances.—F. R. Belot. (*Rev. gén. Élect.*, Dec. 1956, Vol. 65, No. 12, pp. 675–676.) Outline of a slightly modified version of Boesch's method (991 of 1956) and description of a purely graphical method for rapidly obtaining results of adequate accuracy.

621.3.049 **2688**

High-Temperature Subassembly Design.—R. B. Kieburtz. (*Electronics*, 1st May 1957, Vol. 30, No. 5, pp. 158–161.) A component-by-component survey of the problems involved and progress to date in achieving reliable operation at 500°C.

621.314.26 **2689**

Frequency Conversion by means of a Special Electronic Device.—V. P. Tychinski. (*Radiotekhnika i Elektronika*, Dec. 1956, Vol. 1, No. 12, pp. 1525–1526.) The changes of frequency produced by the application of a modulating voltage to the helix of a travelling-wave valve [1808 of 1956 (Beck)] are discussed with reference to the application of this phenomenon in a frequency changing device.

621.372.22 **2690**

Theory of Inhomogeneous Transmission Lines.—S. I. Orlov. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2361–2372.) An expression is derived for the coefficient of reflection at the input of an arbitrary inhomogeneous line connected to an arbitrary complex impedance. For small inhomogeneities in a lossless line the problem of determining the law of change of the wave impedance along the line, is approximately solved, given the reflection coefficients at the input and output of the line as functions of frequency. The analysis is based on the classical theory of inhomogeneous transmission lines.

621.372.412 **2691**

Crystal-Controlled Oscillators.—G. Becker. (*Arch. elekt. Übertragung*, Jan. 1957, Vol. 11, No. 1, pp. 41–47.) The characteristics of a number of oscillator circuits are discussed with reference to the criteria for the basic series-resonance and parallel-resonance types (see also 2048 of July).

621.372.5/.6 **2692**

Topological Analysis of Linear Nonreciprocal Networks.—S. J. Mason. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 829–838.)

621.372.5 **2693**

Time and Frequency Characteristics of Linear Pulse Systems with Variable Parameters.—G. P. Tartakovski. (*Radiotekhnika i Elektronika*, Dec. 1956, Vol. 1, No. 12, pp. 1463–1473.) Theoretical paper. The application of the concepts introduced is illustrated by a discussion of a *RC* circuit under the influence of a pulsed f.m. signal.

621.372.5 : 512.9 **2694**

Circuit Analysis by Normalization.—J. J. Hupert. (*Electronic Engng*, May 1957, Vol. 29, No. 351, pp. 226–230.) A method of network analysis based on a normalization procedure similar to that used in the concept of the normalized resonance curve.

621.372.6 **2695**

The Interconnection of Two Multipoles.—W. Ruppel. (*Arch. elekt. Übertragung*, Jan. 1957, Vol. 11, No. 1, pp. 33–34.) A method is described of determining the scattering matrix of a 2*n*-terminal network consisting of two parts, if the matrices of the partial 2*n*-terminal networks are known.

621.373 + 621.375.9] : 538.561.029.6 **2696**

Negative-Temperature Reservoir Amplifiers.—Motz. (See 2726.)

621.373 : 621.396.822 **2697**

Noise in Nonlinear Oscillators.—M. A. Garstens. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, pp. 352–356.) An approximate solution is obtained of a nonhomogeneous nonlinear differential equation of van der Pol type for a noise-driven oscillator.

621.373.029.42 **2698**

A Two-Phase Low-Frequency Oscillator: Part 2.—E. F. Good. (*Electronic Engng*, May 1957, Vol. 29, No. 351, 210–213.) Part 1 : 2372 of August.

621.373.4 **2699**

Oscillators Unaffected by Load Impedance.—E. Frisch & W. Herzog. (*Nachrichtentech. Z.*, Jan. 1957, Vol. 10, No. 1, pp. 35–38.) Oscillator circuits with frequency and amplitude independent of load impedance are examined (see also 1367 of May). Measurements on two experimental 100-kc/s oscillator circuits show that frequency changes are of the order of 0·1% and do not exceed 0·35% irrespective of load impedance.

621.373.421 **2700**

Investigations of the Nyquist Effect.—H. Barkhausen & E. G. Woschni. (*Hochfrequenztech. u. Elektroakust.*, May 1956, Vol. 64, No. 6, pp. 180–184.) Results of theoretical and experimental investigations on a Hartley-type oscillator are discussed.

621.373.421.11 **2701**

Variable-Frequency Generator of High Frequency Stability.—S. Ryzko, R. Nowak & J. Fórmaniak. (*Archiwum Elektrotech.*, 1956, Vol. 5, No. 4, pp. 759–766. English summary, p. 767.) An oscillator for the 1·5–3-Mc/s frequency range is designed on the basis of Groszkowski's analysis (2337 of 1956) of the Gouriet-Clapp oscillator (1627 of 1950 and 3170 of 1954). The temperature coefficient of frequency is $+ 4 \times 10^{-6}$/°C, and short-period frequency fluctuations are less than $\pm 3 \times 10^{-6}$.

621.373.421.14 : 621.372.413 **2702**

Excitation of Oscillations in a High-*Q* Cavity Resonator by an Oscillator.—A. P. Fedotov & B. K. Shembel'. (*Radiotekhnika i Elektronika*, Dec. 1956, Vol. 1, No. 12, pp. 1474–1477.) A calculation of an antiparasitic ('quenching') resistor in the line connecting the oscillator with the high-*Q* cavity resonator is presented.

621.373.444.1 **2703**

A Millimicrosecond Timebase.—M. W. Jervis & R. T. Taylor. (*Electronic Engng*, May 1957, Vol. 29, No. 351, pp. 218–219.) Circuit and performance of a hard-valve timebase producing a rate of change of voltage of 5×10^{11} V/sec are described.

621.373.52 **2704**

Transistor Relaxation Oscillations.—F. J. Hyde & R. W. Smith. (*Electronic Engng*, May 1957, Vol. 29, No. 351, pp. 234–236.) The continuous relaxation oscillations occurring in a point-contact transistor circuit using a *CR* combination in shunt with the emitter input are studied as functions of emitter bias and ambient temperature. A method of temperature compensation is described.

621.373.52 : 621.373.431.1 **2705**

Multivibrator with Point-Contact Semiconductor Triode.—K. S. Rzhevkin & M. A. Abdyukhanov. (*Radiotekhnika i Elektronika*, Dec. 1956, Vol. 1, No. 12, pp. 1478–1484.) The operation of a transistor multivibrator is briefly analysed and design formulae are given. Calculated and experimental values are tabulated for comparison.

621.374.3 : 621.314.7 **2706**

Transistorized Low-Level Chopper Circuits.—R. B. Hurley. (*Electronic Ind. Tele-Tech*, Dec. 1956, Vol. 15, No. 12, pp. 42–43 . . 112.) Improved performance is obtained by the use of stabilizing and compensating resistances in collector and emitter circuits.

621.374.32 : 621.316.8.012.7 **2707**

Tolerance Limit of Resistors in Binary Scaling Units.—B. M. Banerjee & S. Choudhury. (*Electronic Engng*, May 1957, Vol. 29, No. 351, pp. 237–241.) An experimental investigation shows that limits of ±20% are permissible if optimum values are chosen for the cathode resistor.

621.374.33 **2708**

Linear Gate of 200 Millimicrosecond Duration.—E. L. Garwin & A. S. Penfold. (*Rev. sci. Instrum.*, Feb. 1957, Vol. 28, No. 2, pp. 116–119.) The circuit gives an inverted output with a gain very close to unity and has a linearity within 1% for pulses in the range 1 to 70 V.

621.375.2 **2709**

Operation of a Valve in a Grounded-Grid Circuit.—A. Smoliński. (*Archiwum Elektrotech.*, 1956, Vol. 5, No. 4, pp. 621–642. English summary, pp. 643–644.) Theoretical analysis.

621.375.3 **2710**

Magnetic - Amplifier Control of Switching Transistors.—H. W. Collins. (*Commun. & Electronics*, Nov. 1956, No. 27, pp. 585–589.) The circuits described use a magnetic amplifier to control the average output power of switching transistors by pulse-width modulation combined with high-gain amplification.

GENERAL PHYSICS

535.13 : 537.122 **2711**

Particle Aspect of the Electromagnetic Field Equations.—R. H. Good, Jr. (*Phys. Rev.*, 15th March 1957, Vol. 105, No. 6, pp. 1914–1919.) Maxwell's theory of the electromagnetic field in vacuum can be stated in a form closely similar to Dirac's theory of the electron.

536.7 **2712**

Fluctuations and Irreversible Thermodynamics.—L. Tisza & I. Manning. (*Phys. Rev.*, 15th March 1957, Vol. 105, No. 6, pp. 1695–1705.) The theory of kinetic (time-dependent) fluctuation problems is developed on the basis of the kinetic analogue of the Boltzmann-Einstein principle given by Onsager & Machlup (*ibid.*, 15th Sept. 1953, Vol. 91, No. 6, pp. 1505–1515).

537.122 : 539.15 : 621.315.61 **2713**

Effective Mass Approximation for Excitons.—G. Dresselhaus. (*Phys. Chem. Solids*, Sept./Oct. 1956, Vol. 1, Nos. 1/2, pp. 14–22.)

537.221 **2714**

Contact Electrification across Metal/Dielectric and Dielectric/Dielectric Interfaces.—G. S. Rose & S. G. Ward. (*Brit. J. appl. Phys.*, March 1957, Vol. 8, No. 3, pp. 121–126.) The transfer of charge, across the interface produced when spherical and planar specimens are pressed into contact, has been measured.

537.31 **2715**

A [dielectric] **Cylinder in the Field of a Point Source of Electric Current.**—B. P. D'yakonov. (*Bull. Acad. Sci. U.R.S.S., sér. géophys.*, Jan. 1957, No. 1, pp. 116–121. In Russian.) Theoretical calculation of the effect of an infinitely long cylinder of conducting dielectric embedded in a medium containing the point source of current.

537.311.1 **2716**

Electron and Lattice Conduction in Metals.—I. I. Hanna & E. H. Sondheimer. (*Proc roy. Soc. A*, 26th Feb. 1957, Vol. 239, No. 1217, pp. 247–266.) Simple expressions are derived for the conduction magnitudes which are exact at high and low temperatures and are assumed to be approximately valid for all temperatures.

537.312.62 **2717**

Superconductivity.—(*Wireless World*, July 1957, Vol. 63, No. 7, pp. 326–330.) A discussion of the principles and applications.

537.52 : 621.317.382.029.63/.64 **2718**

Effect of Microwave Signals Incident upon Different Regions of a D.C. Hydrogen Glow Discharge.—Udelson. (See 2866.)

537.525 **2719**

On the Measurement of Ionic Densities in Electric Discharges at High Frequency by means of Perforated Probes.—A. Pozwolski. (*C. R. Acad. Sci., Paris*, 25th March 1957, Vol. 244, No. 13, pp. 1744–1746.) Measurements on hydrogen and argon discharges show negative and positive currents rising to a maximum at a pressure of about 0·05 mm Hg and dying away asymptotically as the pressure rises.

537.533.72 : 621.385.833 **2720**

Graphical-Analytical Construction of Space Trajectories of Charged Particles in Electrostatic Fields by the Method of Radii of Curvature.—N. I. Shtepa. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2281–2286.)

537.533.8.08 **2721**

Reverse Current in Apparatus of the Spherical-Capacitor Type.—M. Ya. Mandel'shtam. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2234–2242.) In investigations of the energy distribution of secondary electrons by bombardment of a target in a spherical collector, elastically reflected electrons may cause secondary electron emission from the collector; in investigations of the photoemissive effect emission may occur from the collector due to diffusely scattered light. The dependence of the reverse current on the potential difference between the collector and the target is calculated.

538.2 : 621.318.134 **2722**

Dispersion Relations for Tensor Media and their Application to Ferrites.—B. S. Gourary. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, 283–288.) "The well-known Kronig-Kramers integral relations between the real and imaginary parts of the susceptibility are generalized to the case where the susceptibility is a tensor. The consequences of the principle of energy conservation are discussed. The case of a ferrite is discussed in some detail."

538.221 **2723**

Criterion for Uniform Micromagnetization.—W. F. Brown, Jr. (*Phys. Rev.*, 1st March 1957, Vol. 105, No. 5, pp. 1479–1482.) An initial uniform state is compared with all neighbouring states, uniform or nonuniform, as an initially large applied field decreases.

538.221 : 538.569.4 **2724**

Ferromagnetic Relaxation by the Exchange Interaction between Ferromagnetic and Conduction Electrons.—A. H. Mitchell. (*Phys. Rev.*, 1st March 1957, Vol. 105, No. 5, pp. 1439–1444.) The relaxation time calculated from this mechanism is too long to account for the observed line width in nickel. The exchange reaction may be dominant in other materials having narrower lines than nickel.

538.56 : 535.42 **2725**

Extension of Babinet's Principle to Absorbing and Transparent Materials, and Approximate Theory of Back-Scattering by Plane, Absorbing Disks.—H. E. J. Neugebauer. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, pp. 302–307.) Calculations are made for circular disks of various reflection coefficients from zero to unity. Experimental results of Severin & v. Baeckmann (2693 of 1951) support the theory.

538.561.029.6 : [621.373 + 621.375.9 **2726**

Negative-Temperature Reservoir Amplifiers.—H. Motz. (*J. Electronics*, May 1957, Vol. 2, No. 6, pp. 571–578.) Theoretical discussion of the principles of maser operation, with application to the conditions for oscillation in a cavity and for amplification in a transmission line.

538.569.4 : 535.33/.34 **2727**

Plane Parallel Plate-Transmission-Line Stark Microwave Spectrograph.—S. A. Marshall & J. Weber. (*Rev. sci. Instrum.*, Feb. 1957, Vol. 28, No. 2, pp. 134–137.)

538.569.4 : 621.372.029.64 2728

Molecules and Microwaves.—(*Electronic Radio Engr*, July 1957, Vol. 34, No. 7, pp. 254–257.) The basic principles of molecular absorption and emission of energy with particular reference to ammonia is discussed and the operation of molecular amplification by stimulated emission of radiation is described.

538.569.4.029.6 : 621.372.413 2729

A Precision Paramagnetic-Resonance Spectrometer.—K. D. Bowers, R. A. Kamper & R. B. D. Knight. (*J. sci. Instrum.*, Feb. 1957, Vol. 34, No. 2, pp. 49–53.) An accuracy within 3 parts in 10^6 is claimed.

537/539 2730

Solid-State Physics. [Book Review]—F. Seitz & D. Turnbull (Eds). Publishers: Academic Books, London; Vol. 1, 1955, 469 pp., 80s; Vol. 2, 1956, 469 pp., 80s. (*Phys. Chem. Solids*, Sept./Oct. 1956, Vol. 1, Nos. 1/2, p. 128.) First of a series of volumes reviewing progress in different fields and planned to appear initially twice a year.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.16 2731

A Survey of Cosmic Radio Emission at 600 Mc/s.—J. H. Piddington & G. H. Trent. (*Aust. J. Phys.*, Dec. 1956, Vol. 9, No. 4, pp. 481–493.) The celestial sphere was surveyed at Sydney, Australia, between declinations 90° S and 51° N using a 3·3° wide beam. When reduced to isophotes and plotted in celestial coordinates (epoch 1955), the results determined a galactic pole at $l \approx 330°$, $b = 89 \cdot 1°$ (Lund coordinates) with the sun at about 50 parsecs north of the galactic plane. See also 2707 of 1956.

523.16 2732

An Investigation of the Radio Source 06N2A in Gemini.—H. Rishbeth. (*Aust. J. Phys.*, Dec. 1956, Vol. 9, No. 4, pp. 494–504.) During a lunar occultation the intensity of the source was reduced by over one fifth. The emission at metre wavelengths is mainly nonthermal.

523.16 : 523.72 : 621.396.677.3 2733

Interferometer for the Study of Localized Solar Sources of Centimetre Waves.—I. Alon, M. R. Kundu & J. L. Steinberg. (*C. R. Acad. Sci., Paris*, 25th March 1957, Vol. 244, No. 13, pp. 1726–1729.) The interferometer has two aerials 60 m apart on an east-west line. It was used for observations at 3·23 cm λ. Sources have an apparent diameter of 1′.

523.16 : 523.74 2734

Observation of Radio-Frequency Solar Storms by means of the Great Nançay Interferometer.—Y. Avignon, E. J. Blum, A. Boischot, R. Charvin, M. Ginat & P. Simon. (*C. R. Acad. Sci., Paris*, 11th March 1957, Vol. 244, No. 11, pp. 1460–1463.) The diameter, duration, altitude and conditions of formation were established by daily observations. See also 3644 of 1956 (Blum et al.).

523.16 : 551.510.535 : 538.566 2735

Refraction of Extraterrestrial Radio Emission in the Atmosphere.—N. A Belyaev. (*Astronom. Zh.*, July/Aug. 1955. Vol. 32, No. 4, pp. 359–372.) Refraction due to a quiet unperturbed ionosphere and atmosphere is considered assuming that the electron-density height distribution in the layers is parabolic. Calculations indicate that below about 100 Mc/s ionospheric refraction exceeds molecular refraction.

523.16 : 621.396.677.833 2736

A New Form for a Giant Radio Telescope.—A. K. Head. (*Nature, Lond.*, 6th April 1957, Vol. 179, No. 4562, pp. 692–693.) The main reflector is a hemisphere of 250 ft radius which may be partly below ground. A small reflector designed to focus beams from the main reflector rotates in equatorially mounted bearings which are supported by a tripod and mounted at the centre of the hemisphere. This form is claimed to be easier to construct than the usual steerable parabolic reflector of 250 ft or larger diameter.

523.5 : 621.396.67.012.12 : 621.396.11.029.62 2737

Height-Gain in the Forward Scattering of Radio Waves by Meteor Trails.—Hines & O'Grady. (See 2892.)

523.53 : 621.396.96 2738

Radio Echo Observations of Meteor Activity in the Southern Hemisphere.—C. D. Ellyett & C. S. L. Keay. (*Aust. J. Phys.*, Dec. 1956, Vol. 9, No. 4, pp. 471–480.) Most meteoric matter incident on the southern hemisphere down to magnitude + 4·5, is confined to direct orbits closely following the plane of the ecliptic. Increase of observation sensitivity shows that many of the meteors previously regarded as sporadic represent the upper limit of showers of minor-sized particles, which are present during months normally regarded as devoid of showers.

523.72 2739

Solar Radiation and Atmospheric Attenuation at 6-Millimetre Wavelength.—R. N. Whitehurst, J. Copeland & F. H. Mitchell. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, pp. 295–298.) A Dicke-type radiometer was used. The total vertical attenuation on clear summer days is 1·2 dB and is 1 dB higher for a thin overcast. The effective solar temperature in mid 1956 was 4 500° K.

523.74/.75 2740

Determination of the Velocity of Corpuscles, Ejected from the Active Regions of the Sun, from the Time of Delay of Phenomena on the Earth.—V. A. Petukhov. (*Bull. Acad. Sci. U.R.S.S., sér. géophys.*, Jan. 1957, No. 1, p. 124. In Russian.) Brief note drawing attention to the fact that the corpuscles are not necessarily ejected radially from the sun.

523.74 + 523.72] : 551.510.535 2741

Relations between the Sun and the Ionosphere.—(*Nature, Lond.*, 20th April 1957, Vol. 179, No. 4564, pp. 804–806.) Summarized report of a discussion at the Royal Astronomical Society on 22nd February 1957, where short papers were read dealing with the great solar flare of 23rd February 1956 and the solar-cycle variation of the sun's ionizing radiation.

550.37/.38 : 53.083 2742

Experimental Investigation of the Natural Electromagnetic Field of the Earth in the Frequency Spectrum from 2 to 300 c/s.—B. S. Enenshtein & L. E. Aronov. (*Bull. Acad. Sci. U.R.S.S., sér. géophys.*, Jan. 1957, No. 1, pp. 62–70. In Russian.) Apparatus for the determination of the horizontal electric and the three magnetic components is described and its use in field measurements is outlined. Oscillograms of some typical records are shown. The field strength varied considerably with time with a mean value of about 30–50 μV/km for the horizontal components of the electric field; the field strength of the horizontal magnetic components was of the order of 10^{-9} oersted.

550.371 : 523.5 2743

Influence of the Meteoric Stream of the Perseids on the Electric Field of the Earth's Atmosphere.—M. V. Okhotsimskaya. (*Bull. Acad. Sci. U.R.S.S., sér. géophys.*, Jan. 1957, No. 1, pp. 122–123. In Russian.) Records at the Alma-Ata station situated at a height of 1 800 m above sea level indicate that the percentage decrease of the potential gradient on August 18th–19th relative to the normal value was 28% in 1952, 31% in 1953, 10% in 1954 and 24% in 1955. The observed effect may be due to processes occurring in the E layer by telemeteorites or by their screening effect.

551.510.5 : 551.593 : 537.5.08 2744

A Spectrophotometric Investigation of the Air Afterglow.—D. T. Stewart. (*J. atmos. terr. Phys.*, 1957, Vol. 10, Nos. 5/6, pp. 318–319.) Further evidence that the spectral continuum having a short-wavelength limit at 3 700 Å can be attributed to the nitrogen dioxide molecule.

551.510.5 : 551.594.5 2745

The Red and Near-Infrared Auroral Spectrum.—A. Omholt. (*J. atmos. terr. Phys.*, 1957, Vol. 10, Nos. 5/6, pp. 320–331.) The results of intensity measurements in the range 5 400–8 800 Å.

551.510.5 : 551.594.5 : 621.396.822 2746

Low-Frequency Radio Emission from Aurorae.—G. R. Ellis. (*J. atmos. terr. Phys.*, 1957, Vol. 10, Nos. 5/6, pp. 302–306.) A possible contribution to the level of continuous noise observed at hundreds of kc/s may be Cherenkov radio emission originating from the incidence of auroral particles on the upper ionosphere. If the Cherenkov process is valid, the frequency range of the emission would extend from a few hundred kc/s to the low audio frequencies.

551.510.535 **2747**

The Present State of Knowledge concerning the Lower Ionosphere.—A. H. Waynick. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 741–749.) A review of recent progress resulting from radio measurements and rocket sounding. 78 references.

550.510.535 **2748**

Analysis of Fading Records from Four Spaced Receivers for Ionospheric Wind Measurements.—M. S. Rao & B. R. Rao. (*J. atmos. terr. Phys.*, 1957, Vol. 10, Nos. 5/6, pp. 307–317.) The advantages of a four-receiver system and an improved method of analysing results are discussed.

551.510.535 **2749**

Diffraction Microscopy and the Ionosphere.—G. L. Rogers. (*J. atmos. terr. Phys.*, 1957, Vol. 10, Nos. 5/6, pp. 332–337.) Improvements in the interpretation of existing Mitra fading patterns, used in the determination of ionospheric movement, through the application of diffraction microscopy technique are shown to be slight; but with aerial spacings of 3–10 λ improvements might be substantial.

551.510.535 **2750**

Movements of Ionospheric Irregularities Observed Simultaneously by Different Methods.—I. L. Jones, B. Landmark & C. S. G. K. Setty. (*J. atmos. terr. Phys.*, 1957, Vol. 10, Nos. 5/6, pp. 296–301.) Horizontal movements of large F-layer and E-layer irregularities were traced by recording 'bursts' of amplitude received from three transmitters about 15 km apart, and by other methods. It was concluded that the large irregularities had the same movements as those irregularities producing ordinary fading.

551.510.535 **2751**

Motion in the Night-Time E_s Region at Brisbane.—J. A. Thomas & M. J. Burke. (*Aust. J. Phys.*, Dec. 1956, Vol. 9, No. 4, pp. 440–453.) Speeds of movement are grouped about 70 m/s, and the winds are predominantly towards the north.

551.510.535 **2752**

Double-Layer Phenomena in the E_s Region.—J. A. Thomas. (*Aust. J. Phys.*, Dec. 1956, Vol. 9, No. 4, pp. 574–577.) $P'f$ and $P't$ records are shown on which both 'sequential E_s' and 'constant-height E_s' are present. Occasional records also show 'stacks' of E_s echo traces which are attributed to multiple hops between the two E_s layers.

551.510.535 **2753**

The Behaviour of a Chapman Layer in the Night F_2 Region of the Ionosphere, under the Influence of Gravity, Diffusion, and Attachment.—R. A. Duncan. (*Aust. J. Phys.*, Dec. 1956, Vol. 9, No. 4, pp. 436–439.) "It is shown that, in the presence of diffusion, gravity, and attachment, a Chapman layer, no matter what its height, maintains its shape, decaying uniformly with an effective attachment coefficient equal to the true attachment coefficient at the height of the electron density maximum; and that, at the same time, the layer drifts bodily towards an equilibrium height. It is then shown that a uniform vertical tidal drift will alter the equilibrium height of a Chapman layer."

551.510.535 : 621.396.11 **2754**

Reflection at a Sharply-Bounded Ionosphere.—I. W. Yabroff. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 750–753.) "A quantitative description of the waves transmitted into and reflected from a sharply-bounded, anisotropic ionosphere with losses is given. Given curves show the effects of the earth's field and losses for a particular model of the night-time E layer at v.l.f."

551.594.22 **2755**

The Dependence of Point-Discharge Currents on Wind as Examined by a New Experimental Approach.—M. I. Large & E. T. Pierce. (*J. atmos. terr. Phys.*, 1957, Vol. 10, Nos. 5/6, pp. 251–257.) "Experiments are described in which a metal point mounted in the open air is artificially raised to a high potential V and the resulting point-discharge current I is measured. The relation $I = A\,(V-V_0)\,(W^2 + c^2V^2)^{\frac{1}{2}}$, where A and c are constants, W the wind speed, and V_0 the onset potential, is found to fit the results reasonably well."

551.594.22 **2756**

Point Discharge from an Isolated Point.—J. R. Kirkman & J. A. Chalmers. (*J. atmos. terr. Phys.*, 1957, Vol. 10, Nos. 5/6, pp. 258–265.) The discharge current I from a point mounted on a mast was measured and related to wind speed W and natural potential gradient F. The results and those of earlier workers are shown to fit a formula $I = K\,(W+c)(F-M)$, where c and M are constants.

551.594.6 **2757**

Relations between the Character of Atmosphereics and their Place of Origin.—J. Chapman & E. T. Pierce. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 804–806.) Waveforms of atmospherics from similar distances but different directions have been found to differ even when the ionospheric conditions along the two paths were apparently similar. The different conductivities of land and sea offer one possible explanation.

551.594.6 **2758**

Atmospheric Waveforms with Very-Low-Frequency Components below 1 kc/s known as Slow Tails.—F. Hepburn. (*J. atmos. terr. Phys.*, 1957, Vol. 10, Nos. 5/6, pp. 266–287.) Observed characteristics are explained by a critical application of Hales' waveguide theory (2888 of 1948) for propagation between the earth and a homogeneous layer with a lower boundary. The height of this boundary during the day is different from that at night.

551.594.6 : 621.317.35 **2759**

A Technique for the Rapid Analysis of Whistlers.—J. K. Grierson. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 806–811.) A proposal for a machine in which the whistlers are recorded magnetically, and successive small samples are played back repeatedly, at high speed, through a filter of rapidly varying frequency.

551.594.6 : 621.396.11.029.45 **2760**

Very-Low-Frequency Radiation from Lightning Strokes.—E. L. Hill. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 775–777.) Derivation of the frequency spectrum and total radiated power from an idealized model of the return stroke.

551.594.6 : 621.396.822 **2761**

Noise Investigation at V.L.F. by the National Bureau of Standards.—W. Q. Crichlow. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 778–782.) A brief description of new equipment for the measurement of atmospheric noise, and a discussion of the most recent presentation of data on a world-wide basis.

551.594.6 : 621.396.822 **2762**

Some Recent Measurements of Atmospheric Noise in Canada.—C. A. McKerrow. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 782–786.) Measurements of noise power at 10 kc/s and 107 kc/s, and a comparison with previous data. Highest noise levels were in summer but a smaller maximum occurred in winter.

551.594.6 : 621.396.822 **2763**

Characteristics of Atmospheric Noise from 1 to 100 kc/s.—A. D. Watt & E. L. Maxwell. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 787–794.) The frequency spectrum of the radio energy of a lightning flash is derived from the waveform of the current distribution. The results are combined with propagation data to determine the field at a distance. Amplitude probability distributions of received noise are plotted.

523.78 : 551.510.535 **2764**

Solar Eclipses and the Ionosphere. [Book Review]—W. J. G. Beynon & G. M. Brown (Eds). Publishers: Pergamon Press, London & New York, 1956, 330 pp., 140s. (*Nature, Lond*, 6th April 1957, Vol. 179, No. 4562, p. 711.) An account of the proceedings at a symposium held in London, August 1955, giving 53 formal papers in full, brief accounts of discussions and a comprehensive bibliography.

LOCATION AND AIDS TO NAVIGATION

621.396.933 **2765**

Automatic Position Plotting.—(*Engineer, Lond.*, 1st March 1957, Vol. 203, No. 5275, p. 344.) A system of automatic triangulation of a number of bearings by means of luminous traces on a glass screen to determine the position of aircraft is briefly described. High-intensity projection c.r. tubes are used and the bearing information can be transmitted via telephone circuits or radio links.

621.396.933.2 : 621.396.677 **2766**

D.F. Aerial System for Decimetre Wavelengths.—Clarke. (See 2674.)

621.396.96 : 621.396.677.833.2 **2767**

A New Type of Surveillance [radar] **Aerial: a Paraboloid Illuminated by a Slotted Waveguide.**—Thourel. (See 2678.)

621.396.96 : 621.396.822 : 621.317.3 **2768**

Measurement of Noise Factor in Centimetric Radar.—N. N. Patla. (*J. Instn Telecommun. Engrs, India*, Dec. 1956, Vol. 3, No. 1, pp. 32–37.) A description of methods in which the noise factors of the i.f. amplifier and the complete receiver are measured by means of noise diodes and gas-discharge tubes respectively.

621.396.962.21 **2769**

Note on an Approximation Method of Forecasting the Distortion of Equiphase Hyperbolae where they Cross Coast Lines.—P. Hugon. (*Ann. Radioélect.*, Jan. 1957, Vol. 12, No. 47, pp. 78–83.) Approximate formulae for the coast-line correction were applied to a provisional Decca chain in Southern France; fair agreement with practical measurements was found.

621.396.963.083.7 **2770**

Remote Presentation of Radar Information by Microwave Link.—G. J. Dixon & H. H. Thomas. (*J. Brit. Instn Radio Engrs*, April 1957, Vol. 17, No. 4, pp. 193–209.) The basic problems and possible systems are reviewed. An equipment operating at 4 kMc/s using pulse time modulation is described in detail.

621.396.965.088 : 621.396.677.859 **2771**

Measuring Radome Tracking Error.—J. B. Damonte & A. F. Gaetano. (*Electronic Ind. Tele-Tech*, Jan. 1957, Vol. 16, No. 1, pp. 66, 128 . . 132.) A quick and accurate method of measuring the error.

MATERIALS AND SUBSIDIARY TECHNIQUES

535.215 : 546.368.63 **2772**

The Characterization and Crystal Structure of Caesium Antimonide, a Photoelectric Surface Material.—K. H. Jack & M. M. Wachtel. (*Proc. roy. Soc. A*, 12th Feb. 1957, Vol. 239, No. 1216, pp. 46–60.) X-ray investigation shows that it is a 'normal-valency' intermetallic compound with a small range of homogeneity near to the composition Cs_3Sb. The atomic arrangement is pseudo-body-centred cubic with a defect structure based upon the B32 sodium thallide type (NaTl).

535.215 : 546.471.241 **2773**

CdS-Type Photoconductivity in ZnTe Crystals.—R. H. Bube & E. L. Lind. (*Phys. Rev.*, 15th March 1957, Vol. 105, No. 6, pp. 1711–1715.) Photoconductivity measurements on ZnTe single crystals show that the mechanism proposed for photoconductivity phenomena in CdS and CdSe may also be applied to ZnTe.

535.215 : [546.817.231 + 546.817.241 **2774**

PbSe and PbTe Infrared Detectors.—T. Piwkowski. (*Acta phys. polon.*, 1956, Vol. 15, No. 4, pp. 271–274. In English.) PbTe photoconductive and photovoltaic layers prepared by a known evaporation method retain their properties when exposed to the air but similar PbSe layers do not. A new evaporation method of preparing PbSe layers overcomes this disadvantage. 19 references.

535.215 : 546.817.231 **2775**

Photoconductivity of Lead Selenide: Theory of the Mechanism of Sensitization.—J. N. Humphrey & R. L. Petritz. (*Phys. Rev.*, 15th March 1957, Vol. 105, No. 6, pp. 1736–1740.) Various models for the mechanism of photoconductivity are examined in relation to experimental results on the sensitization of PbSe films by O, S, Se and the halogens. It is concluded that the only satisfactory model is one in which minority-carrier traps are introduced and the majority-carrier lifetime increased by the sensitizing agent.

535.37 **2776**

A Note on the Diffusion-Controlled Processes in Luminescent Solutions.—A. Jabłoński. (*Acta phys. polon.*, 1956, Vol. 15, No. 4, pp. 263–266. In English.)

535.37 : [546.472.21 + 546.482.21 **2777**

De-excitation of ZnS and ZnCdS Phosphors by Electric Fields.—H. Kallmann & P. Mark. (*Phys. Rev.*, 1st March 1957, Vol. 105, No. 5, pp. 1445–1450.) The effect of strong applied a.c. and d.c. fields on the rise and decay of photoconductivity in ZnS and ZnCdS phosphors is described. The electron fields accelerate the de-excitation process. This phenomenon is attributed to the reduction of retrapping of excited electrons.

535.37 : 546.561-31 **2778**

A New Luminescence Emission in Cu_2O.—J. Bloem, A. J. Van der Houven van Oordt & F. A. Kröger. (*Physica*, Dec. 1956, Vol. 22, No. 12, pp. 1254–1256.) Infrared luminescence characteristics measured at 77° and 20° K are shown as a function of oxygen pressure during preparation.

535.376 **2779**

Electroluminescence Deterioration.—W. A. Thornton. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, pp. 313–316.) The slow decrease in luminescence with time has been studied in conjunction with various associated effects. The observations are consistent with trap and donor depletion by electrolysis.

535.376 **2780**

Crystal Mount and Techniques for Measuring High-Frequency-Induced Electroluminescence.—G. G. Harman. (*Rev. sci. Instrum.*, Feb. 1957, Vol. 28, No. 2, pp. 127–129.) The apparatus includes a simple optical system for irradiation and for separation of excitation and luminescence spectra. Excitation frequencies ranging from d.c. to 400 Mc/s, and also in selected microwave bands, may be used.

537.226/.227 : 546.431.824-31 **2781**

Activation Field and Coercivity of Ferroelectric Barium Titanate.—H. H. Wieder. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, pp. 367–369.) Measurements obtained from hysteresis loop data may be used to calculate the activation field. The fields calculated lead to conclusions relating to the properties of the crystals.

537.226/.227 : 547.476.3 **2782**

Electric Strength of Rochelle Salt Crystals at a Constant, Alternating (50 c/s) or Pulse Voltage of 10^{-4}–10^{-7} sec Duration.—K. M. Kevroleva. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2243–2247.) The dependence of breakdown voltage gradient on the thickness of the crystals, crystal axis, temperature and time was investigated experimentally. Results show that the breakdown strength decreases with increasing thickness, that it is independent of temperature in the range −60° C to 50° C and no changes occur at the Curie temperatures (−18° C and + 24° C), that it is independent of the crystallographic axis, and that it increases with decreasing pulse duration.

537.226.3 **2783**

Mechanism of Dielectric Relaxation Losses in Crystals with Polar Molecules.—I. Ts. Lyast. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2293–2301.) The complex permittivity is calculated assuming the following mechanism: the relaxation dielectric losses are connected with the migration of polar molecules to unoccupied positions; this movement is, in general, accompanied by rotation of the polar molecule, resulting in relaxation polarization of the crystal. Theoretical and experimental results are compared for gypsum.

537.226.31 **2784**

Dielectric Losses in Dense Amorphous Structures.—V. Kh. Kozlovski. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2254–2258.) The losses are considered theoretically taking into account the inertia of ions. The frequency characteristic of the real and imaginary parts of the dielectric constant is calculated for particular cases.

537.227/.228 : 061.3 (47) **2785**

1st Conference on Ferroelectricity (Leningrad, 19th–24th June 1956).—(*Bull. Acad. Sci. U.R.S.S., sér. phys.*, Feb. 1957, Vol. 21, No. 2, pp. 233–292. In Russian.) Texts are given of the following five papers presented at the conference:

Brief Review of Some Results of Investigations of Ferroelectrics in Recent Years.—G. A. Smolenski (pp. 233–263).

Orientation of Domains and Macrosymmetry of Properties of Ferroelectric Single Crystals.—I. S. Zheluder & L. A. Shuvalov (pp. 264–274).

Crystal Chemistry of Ferroelectrics with Perovskite-Type Structure.—Yu. N. Venevtsev & G. S. Zhdanov (pp. 275–285).

The Characteristic of the Change of Domain Structure of Rochelle Salt in Alternating Electric Fields.—I. S. Zheludev & R. Ya. Sit'ko (pp. 286–288).

Some Details of Domain Structure of Rochelle Salt Crystals (from Optical Observations).—M. A. Chernysheva (pp. 289–292).

537.227 : 546.431.824-31 **2786**

Infrared-Absorption Studies on Barium Titanate and Related Materials.—J. T. Last. (*Phys. Rev.*, 15th March 1957, Vol. 105, No. 6, pp. 1740–1750.) Absorption bands, arising from normal vibrations of the TiO_3 group, have been measured; they are centred on wave numbers of 495 cm^{-1} and 340 cm^{-1}.

537.311.31 : 538.63 **2787**

Magnetoresistance Effects in the Group I Metals at High Fields.—R. G. Chambers. (*Proc. roy. Soc. A*, 8th Jan. 1957, Vol. 238, No. 1214, pp. 344–357.) Resistivity and Hall coefficient were measured in Cu, Ag and Au at 4° K in fields up to 25 kG.

537.311.31 : 538.63 **2788**

Magnetoresistance—New Tool for Electrical Control Circuits.—R. K. Willardson & A. C. Beer. (*Elect. Mfg*, Jan. 1956, Vol. 57, No. 1, pp. 79–84.) Review of principles and applications.

537.311.33 **2789**

General Semiconductor Junction Relations.—N. H. Fletcher. (*J. Electronics*, May 1957, Vol. 2, No. 6, pp. 609–610.) General carrier density relations are derived for an abrupt junction between two sections of semiconductor with arbitrary impurity contents and with an arbitrary applied bias.

537.311.33 **2790**

Drift of Minority Carriers in the Presence of Trapping.—A. K. Jonscher. (*Proc. phys. Soc.*, 1st Feb. 1957, Vol. 70, No. 446B, pp. 223–229.) Expressions are derived for the densities of free carriers, N, and trapped carriers, N_t, as functions of distance and time, ignoring the effects of diffusion. The N/time-response curve depends critically on the steady-state carrier lifetime, the trapping time constants and on the distance of the collector from the emitter.

537.311.33 **2791**

Diffusion of Minority Carriers in the Presence of Trapping.—A. K. Jonscher. (*Proc. phys. Soc.*, 1st Feb. 1957, Vol. 70, No. 446B, pp. 230–234.) For constant-level carrier density the diffusion is little affected by trapping in extrinsic material; if the density varies sinusoidally the effective diffusion length is the same as for the trap-free case at low and high frequencies but is appreciably less at intermediate frequencies.

537.311.33 **2792**

Possible Mechanism for Radiationless Recombination in Semiconductors.—L. Bess. (*Phys. Rev.*, 1st March 1957, Vol. 105, No. 5, pp. 1469–1478.) Two Auger-type processes are described and evaluated whereby the trapping of a hole or electron results in the emission of an energetic hole or electron instead of a photon. These radiationless processes predominate over the radiative process under nearly all operating conditions for a wide class of semiconductors.

537.311.33 **2793**

Fluctuations in the Number of Electrons and Holes in a Semiconductor.—D. J. Oliver. (*Proc. phys. Soc.*, 1st Feb. 1957, Vol. 70, No. 446B, pp. 244–247.) Statistical mechanics are used to extend previous work [793 of 1956 (Burgess)] to include semiconductors in which electrons and/or holes form a degenerate assembly.

537.311.33 **2794**

Theory of Semiconductors of Type $A^{III}B^{V}$.—A. I. Gubanov. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2170–2178.) Critical comment on Seraphin's theory (1379 of 1955). A semiquantitative model is presented clarifying the widening of the forbidden zone in compounds of the $A^{III}B^{V}$ type in comparison with iso-electron elements of Group IV.

537.311.33 **2795**

Electronic Properties of Aromatic Hydrocarbons: Part 3—Diffusion of Excitons.—O. Simpson. (*Proc. roy. Soc. A*, 8th Jan. 1957, Vol. 238, No. 1214, pp. 402–411.) A method is described by which the migration of excitons in anthracene can be observed. For Parts 1 & 2, see 2093 of 1956.

537.311.33 : 061.3(47) **2796**

8th All-Union Conference on Semiconductors (Leningrad, 15th–21st November, 1955).—(*Bull. Acad. Sci. U.R.S.S., sér. phys.*, Dec. 1956, Vol. 20, No. 12, pp. 1467–1580; Jan. & Feb. 1957, Vol. 21, Nos.1 & 2, pp. 1–159 & 161–224. In Russian.) Texts are given of papers presented in the following sections: (*a*) electrical and thermal properties of semiconductors, (*b*) theory of semiconductors, (*c*) chemistry of semiconductors, and (*d*) semiconductor catalysis. The papers include:

Thermal Equilibrium of Electrons in Surface and Bulk Levels in a Semiconductor.—V. E. Lashkarev (pp. 1469–1478).

Thermoelectric Phenomena in Semiconductors with a Non-equilibrium Concentration of Current Carriers.—Ya. Tauts [Tauc] (pp. 1479–1483).

Appearance of Photoelectromotive Force in an Illuminated Semiconductor in an Inhomogeneous Magnetic Field.—Ya. Tauts [Tauc] (pp. 1484–1485).

Structure and Electrical Properties of Indium Antimonide in Thin Layers.—I. D. Konozenko & S. D. Mikhnovski (pp. 1486–1490).

Investigation of the Peltier Effect and Thermoelectromotive Forces in Germanium.—M. Shtenbek & I. I. Baranski (pp. 1491–1493).

New Vitreous Semiconductors.—N. A. Goryunova & B. T. Kolomiets (pp. 1496–1500).

Semiconductor Properties of Magnesium-Bismuth Alloys.—A. K. Kikoin & G. D. Fedorov (pp. 1501–1508).

Electrical Properties of Manganese-Germanium Alloys.—I. G. Fakidov, N. P. Grazhdankina & V. N. Novogrudski (pp. 1509–1518).

New Type of Thermal Acceptors in Germanium.—V. A. Zhidkov & V. E. Lashkarev (pp. 1521–1525).

Diffusion of Antimony and Zinc from the Vapour Phase into Germanium.—V. E. Kosenko (pp. 1526–1532).

Thermomechanical Phenomena in Thin Layers of Semiconductors.—I. G. Nekrashevich (pp. 1533–1540).

Temperature Dependence of the Electrical Conductivity of Organic Semiconductors.—A. T. Vartanyan (pp. 1541–1547).

Dependence of the Mobility of Current Carriers in Germanium on the Concentrations of Antimony and Phosporus.—P. I. Baranski (pp. 1548–1549).

Theory of Electric Strength of Germanium and Silicon.—V. A. Chuenkov (pp. 1550–1552).

Electron Density Distribution and Electrical Conductivity of Cadmium Sulphide Crystals.—Yu. N. Shuvalov (pp. 1553–1559).

An Attempt to Determine the Increase of Current-Carrier Temperature Caused by an Electric Field in Germanium.—M. Shtenbek (pp. 1560–1562).

Formation of Vacancies in a Crystal Lattice.—N. P. Kalabukhov (pp. 1563–1568).

Production of Phosphors by means of Recrystallization in Electron Migration.—Z. D'yulai (pp. 1569–1570).

Electrical Properties and Uses of Silicon Carbide.—N. P. Bogoroditski, V. V. Pasynkov, G. F. Kholuyanov & D. A. Yas'kov (pp. 1571–1580).

Spur Method for Conduction Electrons in Semiconductors: Part 1—Weak Interaction of Electrons with Oscillations. Part 2—Variational Method.—M. A. Krivoglaz & S. I. Pekar (pp. 3–32).

Influence of the Polaron Effect on the Thermodynamics of Conduction Electrons in Semiconductors.—M. A. Krivoglaz & S. I. Pekar (pp. 33–36).

Interaction of Excitons with a Molecular Lattice.—E. I. Rashba (pp. 37–47).

Investigation of Crystal Micro-theory.—K. B. Tolpygo (pp. 48–64).

Theory of Excitons in Ionic Crystals.—I. M. Dykman (pp. 65–67).

Interaction of Localized Electrons with Acoustic Vibrations in Homopolar Crystals.—M. F. Deigen (p. 68).

Recombination in a Collision of Current Carriers in Semiconductors.—L. Sosnovski [Sosnowski] (pp. 70–73).

Excited States of Two-Electron Colour Centres in Ionic Crystals of α and β Bands.—O. F. Tomasevich (pp. 74–77).

Energy Spectrum of Exciton in Ionic Crystal.—I. P. Ipatova (pp. 78–86).

A Recombination Mechanism of Current Carriers in Strongly Alloyed Semiconductors.—V. L. Bonch-Bruevich (pp. 87–96).

Some Peculiarities in the Thermodynamics of the Phonon and the Electron Gas in a Solid Body.—Yu. N. Obraztsov (pp. 97–102).

Mean Free Path of an Electron in Liquid and Amorphous Conductors.—A. I. Gubanov (p. 104).

Interaction of Electrons of a Semiconductor with Lattice Vibrations at Very Low Temperatures.—L. E. Gurevich (pp. 105–111).

Some Electroacoustic Effects.—L. E. Gurevich (pp. 112–119).

Some Problems of the Crystal Chemistry of Compounds with Zinc Blende Structure. —N. A. Goryunova (pp. 120–132).

Theory of Phases [of compounds] of Variable Composition with Zinc Blende Structure (Investigation of Possible Range of Homogeneity of Type A^{III} B^{V} Compounds).—B. F. Ormont, N. A. Goryunova, I. I. Ageeva & N. N. Fedorova (pp. 133–140).

Physico-chemical Analysis of some Semiconductor Systems.—N. Kh. Abrikosov (pp. 141–145).

Crystallization of Single-Crystal Layers of Silicon and Germanium from the Gaseous Phase.—N. N. Sheftal', N. P. Kokorish & A. V. Krasilov (pp. 146–152).

Production of Single-Crystal Specimens of Cuprous Oxide.—Yu. I. Gritsenko (pp. 153–157).

Investigation of the Coefficients of Self-Diffusion of I and K Ions in Alkali Halide Crystals Irradiated by X Rays.—V. V. Mumladze (pp. 158–159).

Effect of Adsorption on the Electrical Conductivity and Work Function of a Semiconductor.—V. B. Sandomirski (pp. 211–219).

Absorption of Light in Crystals of Mercury Halides.—E. F. Gross & A. A. Kaplyanski (pp. 220–224).

537.311.33 : 535.215 **2797**

Kinetics of the Bipolar Photo-e.m.f. in a Semiconductor with Metal Electrodes.—E. I. Kaplunova & K. B. Tolpygo. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2165–2169.)

537.311.33 : 535.34 **2798**

The Anomalous Skin Effect and the Optical Absorptivity of Semiconductors : Part 2.—R. B. Dingle. (*Physica*, Dec. 1956, Vol. 22, No. 12, pp. 1237–1241.) More general expressions are derived by solving the integro-differential equation of the anomalous skin effect. Part 1 : 1116 of April.

537.311.33 : 537.324 : 546.87.24.23 **2799**

Solid Solutions Bi_2Te_3–Bi_2Se_3 as Materials for Thermoelements.—S. S. Sinani & G. N. Gordyakova. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2398–2399.) Brief note. The solid solutions, with various impurities, have a conductivity σ 490–900 $\Omega^{-1}.cm^{-1}$, thermoelectric coefficient α −225 to −180 $\mu V/^{\circ}C$ and thermal conductivity χ $2 \cdot 6$–$3 \cdot 0 \times 10^3$ $cal.cm^{-1}. deg^{-1}. s^{-1}$.

537.311.33 : 528.21 **2800**

Magnetic Properties of Pure and *n*-Type Germanium at Liquid-Helium Temperatures.—F. T. Hedgcock. (*J. Electronics*, May 1957, Vol. 2, No. 6, 513–528.) Susceptibility measurements at temperatures between 4·2° K and room temperature are reported for *n*-type Ge samples of various charge-carrier densities. In high-purity material an anomalous low-temperature paramagnetism was observed. For non-degenerate samples in a particular impurity concentration range, the results are consistent with the usual activation process, but below this concentration it seems necessary to suggest the existence of conduction in an impurity band.

537.311.33 : 538.6 **2801**

D.C. Magnetoconductivity and Energy Band Structure in Semiconductors.—R. M. Broudy & J. D. Venables. (*Phys. Rev.*, 15th March 1957, Vol. 105, No. 6, pp. 1757–1763.) A general method is described for experimentally obtaining all components of the magnetoresistivity and hence the magnetoconductivity tensor. Expressions for determining the mass ratio K have been derived. The known band structures of *n*-type Ge and Si have been verified by the method and K has been determined for Ge from 65° K to 200° K.

537.311.33 : 538.6 **2802**

The Galvanomagnetic and Thermomagnetic Effects in Semiconductors.—R. Mansfield. (*Proc. phys. Soc.*, 1st Feb. 1957, Vol. 70, No. 446B, pp. 240–243.) The values of the coefficients are calculated for a semiconductor in which the charge centres are scattered by ionized impurity centres.

537.311.33 : 538.63 **2803**

Theory of the Hall and Nernst Effects in a Semiconductor with an Impurity Zone.—M. I. Klinger, V. G. Novikova & V. N. Agarkova. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2185–2194.) The Hall effect, R, and the Nernst effect, Q, are first considered for a metal with a narrow conduction zone and then for a semiconductor with an impurity zone. The functions $R(T)$ and $Q(T)$ are investigated and experimental results are compared with theory.

537.311.33 : 538.63 **2804**

Measurement of Gauss Effect in Various Semiconductors at 10, 300 and 600 Mc/s.—P. Ramer, M. J. O. Strutt & F. K. von Willisen. (*Arch. elekt. Übertragung*, Jan. 1957, Vol. 11, No. 1, pp. 1–7.) The Gauss effect is a galvanomagnetic effect in which the resistance of a semiconductor increases in a transverse magnetic field; it is connected with the Hall effect. Measurements on samples of InAs, InSb and Ge show a slight decrease in galvanomagnetic effects at 10 Mc/s and very pronounced falls at 300 and 600 Mc/s compared to the values obtained at zero frequency. The experimental methods and errors and the limitations of existing theory are discussed.

537.311.33 : 538.632 **2805**

A Simple Graphical Method of Calculating the Density of Current Carriers in a Semiconductor from the Hall Coefficient.—T. S. Robinson, M. Smollett & R. G. Pratt. (*Brit. J. appl. Phys.*, March 1957, Vol. 8, No. 3, pp. 130–131.)

537.311.33 : [546.28 + 546.289 **2806**

Energy Band Structure in *p*-Type Germanium and Silicon.—E. O. Kane. (*Phys. Chem. Solids*, Sept./Oct. 1956, Vol. 1, Nos. 1/2, pp. 82–99.) Energy-band calculations are made for the three valence bands in Si and Ge in terms of the cyclotron resonance parameters. The energy in the band measured from $k = 0$ is not assumed small compared with the spin-orbit splitting. Matrix elements for direct optical transitions between valence bands and the free-carrier absorption are calculated.

537.311.33 : 546.28 **2807**

Energy Levels in Electron-Bombarded Silicon.—G. K. Wertheim. (*Phys. Rev.*, 15th March 1957, Vol. 105, No. 6, pp. 1730–1735.) "Electron bombardment of *n*- and *p*-type silicon reduces the lifetime of minority carriers and decreases the carrier concentration. This paper presents evidence that: (*a*) an electron trapping level is located 0·16 eV below the conduction band and a hole-trapping level 0·29 eV above the valence band, (*b*) the recombination centres responsible for the reduction of lifetime in *n* type are located 0·31 eV from a band edge, and those in *p* type approximately 0·24 eV from a band edge, (*c*) lattice imperfections are produced at a rate of 0·18 per electron-cm of bombardment at 700 keV."

537.311.33 : 546.28 **2808**

Electrical and Optical Properties of Heat-Treated Silicon.—W. Kaiser. (*Phys. Rev.*, 15th March 1957, Vol. 105, No. 6, pp. 1751–1756.) The effects of oxygen impurity in Si crystals pulled from a quartz crucible have been investigated by optical and electrical means after heat treatment at 450° C and 1 000° C.

537.311.33 : 546.28 **2809**

Absorption Spectra of Impurities in Silicon : Part 1—Group III Acceptors.—E. Burstein, G. Picus, B. Henvis & R. Wallis. (*Phys. Chem. Solids*, Sept./Oct. 1956, Vol. 1, Nos. 1/2, pp. 65–74.) The spectra give information about the ionization energies and excited states of the impurity centres. The results are compared with a simple theoretical model.

537.311.33 : 546.28 **2810**

Absorption Spectra of Impurities in Silicon : Part 2—Group V Donors.—G. Picus, E. Burstein & B. Henvis. (*Phys. Chem. Solids*, Sept./Oct. 1956, Vol. 1, Nos. 1/2, pp. 75–81.) These spectra were measured at liquid helium temperature, and ionization energies and term schemes for these materials have been determined from the data. Part 1 : 2809 above.

537.311.33 : [546.28 + 546.289] : 536.21 **2811**

The Thermal Conductivity of Germanium and Silicon between 2 and 300° K.—J. A. Carruthers, T. H. Geballe, H. M. Rosenberg & J. M. Ziman. (*Proc. roy. Soc. A*, 29th Jan. 1957, Vol. 238, No. 1215, pp. 502–514.) Measurements on single crystals of pure *n*-type and *p*-type Ge containing from 10^{14} to 10^{19} Group III impurity atoms per cm^3 and on pure *n*-type and gold-doped *p*-type Si are reported.

537.311.33 : 546.281.26 : 535.3 **2812**

Absorption of Light in Alpha SiC Near the Band Edge.—W. J. Choyke & L. Patrick. (*Phys. Rev.*, 15th March 1957, Vol. 105, No. 6, pp. 1721–1723.)

537.311.33 : 546.289 **2813**

Vacuum Technology for Germanium.—Z. Majewski. (*Archiwum Elektrotech.*, 1956, Vol. 5, No. 4, pp. 769–779.) The technological process used in the production of metallic Ge from the oxide of Polish origin is described and the equipment used in the production of single crystals is discussed. The methods of resistivity and lifetime measurement used in various stages of manufacture are briefly described and the results are given.

537.311.33 : 546.289 **2814**

Thermal Acceptors in Germanium.—H. Letaw, Jr. (*Phys. Chem. Solids*, Sept./Oct. 1956, Vol. 1, Nos. 1/2, pp. 100–116.) Thermal acceptors in Ge are identified as vacancies with an energy of formation of 2 eV. In the annealing of Ge divacancies are initially formed, followed by clusters of higher order.

537.311.33 : 546.289 **2815**

Storage of Injected Carriers at Surfaces of Germanium.—B. H. Schultz. (*Philips Res. Rep.*, Feb. 1957, Vol. 12, No. 1, pp. 82–96.) The effects of surface storage are calculated using standard space-charge theory. Measurements of the relaxation of photoconductance show the storage to be appreciable although the surface layer is very thin. The results are in qualitative agreement with theory.

537.311.33 : 546.289 **2816**

Investigation of Surface Conductivity and Surface Recombination in Germanium Specimens.—A. V. Rzhanov, I. G. Neizvestnyi & V. V. Roslyakov. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2142–2153.) Results of an experimental investigation are reported. A correlation is established between the changes in surface conductivity and the surface recombination velocity in Ge specimens in various gas media. This correlation is shown to be connected with changes in the surface potential, which is evaluated.

537.311.33 : 546.289 **2817**

Field Effect on an Illuminated Ge Surface and Investigation of the Surface Recombination Process.—S. Wang & G. Wallis. (*Phys. Rev.*, 1st March 1957, Vol. 105, No. 5, pp. 1459–1464.) From measurements of surface conductivity and photoconductivity on an etched Ge sample in the Brattain-Bardeen ambient cycle, values of surface potential and surface recombination velocity were derived. Dominant recombination centres with discrete levels were found near the centre of the gap with a ratio of hole to electron capture probabilities of 9. The effect of a normal electric field was also studied and good agreement between theory and experiment obtained. This effect can be used as an additional tool to study the surface recombination centres.

537.311.33 : 546.289 **2818**

Recombination Radiation from Deformed and Alloyed Germanium *p-n* Junctions at 80° K.—R. Newman. (*Phys. Rev.*, 15th March 1957, Vol. 105, No. 6, pp. 1715–1720.) The recombination radiation from Ge *p-n* junctions shows an intrinsic band, peaked at 0·7 eV, and also a band peaked at about 0·5 eV which is attributed to mechanical strain. Junctions containing Cu show a radiation band at 0·59 eV.

537.311.33 : 546.289 : 537.32 **2819**

Some Aspects of Peltier Heating at Liquid/Solid Interfaces in Germanium.—W. G. Pfann, K. E. Benson & J. H. Wernick. (*J. Electronics*, May 1957, Vol. 2, No. 6, pp. 597–608.) Uses of Peltier heating in growing single crystals, in producing *n-p-n* and *n-p-n-p* junctions in semiconductors, and in temperature-gradient zone melting, are discussed. The Peltier coefficient at the interface between the solid and liquid phases of a substance, may be determined from the velocity of interface movement due to Peltier heating.

537.311.33 : 546.289 : 538.639 **2820**

Nernst-Ettingshausen Effect in Germanium.—R. I. Bashirov & I. M. Tsidil'kovski. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2195–2199.) Measurements on specimens of *n*- and *p*-type Ge in the temperature range 125–650° K are reported and the results are discussed.

537.311.33 : 546.289 : 545.7 **2821**

Determination of Gaseous Impurities in the Surface Layers of Germanium.—S. M. Fainshtein & V. I. Fistul'. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2162–2164.) A mass-spectrometer used in conjunction with a vacuum extraction system was used. The method used and results obtained are briefly described.

537.311.33 : 546.561-31 **2822**

Diffusion of Chemical Admixtures in Cuprous Oxide and their Influence on its Rectification Properties.—A. V. Sandulova & A. I. Andrievski. (*Radiotekhnika i Elektronika*, Dec. 1956, Vol. 1, No. 12, pp. 1492–1502.) Results are presented of an experimental determination of the diffusion coefficients for P^{32}, S^{35}, I^{131} and Au^{198} in cuprous oxides with various structures and of the influence of Ag^{110}, S^{35} and I^{131} impurities and of excess oxygen on the electrical parameters of cuprous oxide rectifiers.

537.311.33 : 546.621.86 **2823**

Electrical and Optical Properties of Aluminium Antimonide; Action of Lithium.—F. Kover & A. Quilliet. (*C. R. Acad. Sci., Paris*, 25th March 1957, Vol. 244, No. 13, pp. 1739–1741.) Alloying Li to the pure substance greatly increases the resistivity. It is suggested that the pure substance is composed of slightly more atoms of Al than of Sb and that Li atoms may fill the resulting gaps in its structure. See also 178 of January (Kover).

537.311.33 : 546.681.23.19 **2824**

Arsenoselenides of Gallium.—N. A. Goryunova & V. S. Grigor'eva. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2157–2161.) Brief report on X-ray, surface microstructure and quantitative analysis of compounds in the *m*GaAs. $(1-m)Ga_2Se_3$ system. An electrical-conductivity/composition curve is also given.

537.311.33 : 546.682.86 : 535.215 **2825**

Theory of the Spectral Distribution of Recombination Radiation from InSb.—T. S. Moss. (*Proc. phys. Soc.*, 1st Feb. 1957, Vol. 70, No. 446B, pp. 247–250.) The theory explains satisfactorily the observed spectral distribution and indicates that 20% of the total recombinations are radiative.

537.311.33 : 548.0 : 621.385.833 **2826**

The Examination of *p-n* Junctions with the Scanning Electron Microscope.—C. W. Oatley & T. E. Everhart. (*J. Electronics*, May 1957, Vol. 2, No. 6, pp. 568–570.) A technique for showing up junctions is described, with discussion of factors affecting contrast.

537.311.33 : 549.351.12 **2827**

Measurement of Electrical Conductivity of Crystals. Case of Chalcopyrite.—M. Wintenberger. (*C. R. Acad. Sci., Paris*, 25th March 1957, Vol. 244, No. 13, pp. 1801–1803.) Valdes' four-probe method for measuring conductivity (1502 of 1954) is applied to study the anisotropy of resistivity of $CuFeS_2$. It is suggested that this increases with purity.

537.533.8 : 546.331.31 **2828**

Secondary Electron Emission from a NaBr Single Crystal.—T. L. Matskevich. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2399–2400.) The secondary emission coefficient σ was determined at 20, 50 and 300° C at normal primary electron beam incidence and at 20° C also at an angle of incidence of 50°. At 20° C, normal incidence and primary electron potential U_p 1 800 V, $\sigma_{max} = 24 \pm 2$, at 20° C, 50° incidence, $U_p \geqslant 3\,000$ V, $\sigma_{max} >$ 30. The coefficient is strongly temperature dependent.

537.533.8 : [546.77 + 546.74 **2829**

Secondary Electron Emission of Nickel and Molybdenum at Low Primary Electron Energies.—A. R. Shul'man & E. I. Myakinin. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2223–2233.) Results show that there is a threshold value for secondary electron emission close to the work function. At primary electron energies $V_p > \phi$ secondary electrons appear, their average energy increasing with increasing V_p. This can be explained by assuming spherically symmetric scattering at low V_p values, i.e. different from the distribution at higher V_p values.

537.58 : 546.832 **2830**

Thermionic Constants and Sorption Properties of Hafnium.—H. D. Hagstrum. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, pp. 323–328.)

538.221 **2831**

Analysis of Ferromagnetic and Antiferromagnetic Second-Order Transitions.—J. A. Hofmann, A. Paskin, K. J. Tauer & R. J. Weiss. (*Phys. Chem.*

Solids, Sept./Oct. 1956, Vol. 1, Nos. 1/2, pp. 45–60.) Gives methods of separating the magnetic contribution to the specific heat of these materials.

538.221 **2832**

Effect of the Interaction between Magnetic Particles on the Critical Single-Domain Size.—A. H. Morrish & L. A. K. Watt. (*Phys. Rev.*, 1st March 1957, Vol. 105, No. 5, pp. 1476–1478.)

538.221 **2833**

The Electronic Properties of Nickel-Palladium Alloys.—E. P. Wohlfarth. (*Phys. Chem. Solids*, Sept./Oct. 1956, Vol. 1, Nos. 1/2, pp. 35–38.) Theoretical predictions are made about the specific heat of these alloys, their electrical and magnetic properties, and the effect of compression on their Curie point.

538.221 **2834**

Reproducing the Properties of Alnico Permanent-Magnet Alloys with Elongated Single-Domain Cobalt-Iron Particles.—F. E. Luborsky, L. I. Mendelsohn & T. O. Paine. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, pp. 344–351.) A description of the synthesis of the magnetic properties of alnico alloys using fine-particle compacts.

538.221 **2835**

Magnetic Alloy of High Permeability and Low Hysteresis Loss.—(*Engineer, Lond.*, 15th March 1957, Vol. 203, No. 5277, p. 427.) Note of the magnetic properties of 'supermendur', an alloy of 49% Fe, 49% Co and 2% Va developed by Bell Laboratories. Maximum permeability is 66 000 at 20 kG, remanence 21·5 kG, and coercive force 0·26 oersted.

538.221 **2836**

Dynamax, a New Crystal and Domain-Oriented Magnetic Core Material.—G. H. Howe. (*Commun. & Electronics*, Nov. 1956, No. 27, pp. 548–550. Discussion p. 551.) The high-permeability material described contains approximately 65% Ni, 2% Mo and 33% Fe. It is available as thin tape for toroidal cores; its dynamic characteristics are superior to those of other commercial rectangular-loop materials. The best values obtained are 1 780 000 maximum permeability, 11·95 kG residual flux density, and 0·0053 oersted coercive force.

538.221 **2837**

Superposed Magnetic Fields in Materials with Rectangular Hysteresis Loops.—C. B. Wakeman & F. J. Beck. (*Commun. & Electronics*, Nov. 1956, No. 27, pp. 562–569.) Report of experimental investigations of tubular, tape-wound specimens of Ni-Fe alloys, one containing 50% Ni, and the other 79% Ni and 4% Mo.

538.221 : 621.317.411.029.63 **2838**

On the Complex Permeability of Iron-Nickel Alloys at High Frequencies.—J. C. Anderson & B. Donovan. (*Proc. phys. Soc.*, 1st Feb. 1957, Vol. 70, No. 446B, pp. 186–191.) The internal resonance frequency in the anisotropic field varies with the composition; it is a minimum for 70% Ni. The resonance curve for pure Ni has multiple peaks.

538.221 : 621.318.124 **2839**

Ceramic Magnets.—R. A. Scholten. (*Product Engng*, Dec. 1956, Vol. 27, No. 13, pp. 143–148.) The characteristics and unit costs of barium ferrite magnets and the various grades of alnico magnets are tabulated for comparison. Some data are given on ceramic-magnet applications, particularly those utilizing their high coercivity.

538.221 : 621.318.124 **2840**

Magnetic-Induction and Coercive-Force Data on Members of the Series $BaAl_xFe_{12-x}O_{19}$ and Related Oxides.—L. G. Van Uitert. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, pp. 317–319.) The anisotropy field of the series increases with Al content causing ferromagnetic resonance to move to higher frequencies. Materials with extremely high coercive forces can thus be realized.

538.221 : 621.318.134 **2841**

Magnesium-Copper-Manganese-Aluminium Ferrites for Microwave Applications.—L. G. Van Uitert. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, pp. 320–322.) The preparation of these ferrites is discussed and data presented on the saturation inductions, Curie temperatures, densities and d.c. resistivities.

538.221 : 621.385.833 : 548.0 **2842**

Observation of the Domain Structure of a Ferromagnetic Material by means of Photoelectrons.—G. V. Spivak, T. N. Dombrovskaya & N. N. Sedov. (*C. R. Acad. Sci. U.R.S.S.*, 1st March 1957, Vol. 113, No. 1, pp. 78–81. In Russian.) A photoelectron microscope and its applications are briefly described. The image on the fluorescent screen is obtained by magnetically focused photoelectrons emitted by the illuminated antimony-caesium film which covers the ferromagnetic material.

538.245 **2843**

Spontaneous Magnetization and Magnetic Susceptibilities of an Anti-ferromagnetic with Foreign Ions in Both Sublattices.—K. F. Niessen. (*Philips Res. Rep.*, Feb. 1957, Vol. 12, No. 1, pp. 69–81.)

538.245 **2844**

Formation of Magnetic Texture by a Magnetic Field in Thin Layers of Iron Obtained by the Electrolytic Method.—N. V. Kotel'nikov. (*C. R. Acad. Sci. U.R.S.S.*, 1st March 1957, Vol. 113, No. 1, pp. 97–99. In Russian.)

538.632 **2845**

The Hall Effect in the Silver-Palladium Alloy System.—A. I. Schindler. (*Phys. Chem. Solids*, Sept./Oct. 1956, Vol. 1, Nos. 1/2, pp. 42–44.)

538.65 **2846**

The Interrelation of Magneto-mechanical Phenomena and their Practical Applications.—P. Ross. (*Rev. gén. Élect.*, Dec. 1956, Vol. 65, No. 12, pp. 689–694.) After summarizing the theory underlying these effects the conditions are derived for obtaining the maximum magnetoelastic sensitivity and magneto-mechanical coupling coefficient for a given ferromagnetic material.

539.23 : 537.311.3 **2847**

Influence of the Support on Electrical Conductivity of Very Thin Films of Gold. Measurement of the Condensation Factor.—Sen-Sik Minn & S. Offret. (*C. R. Acad. Sci., Paris*, 18th March 1957, Vol. 244, No. 12, pp. 1624–1626.) An experimental study using supports of bismuth oxide, MgF_2 and glass.

539.23 : 546.87 : 538.63 **2848**

Magnetoresistance of Thin Bismuth Films.—P. Huet & A. Colombani. (*C. R. Acad. Sci., Paris*, 18th March 1957, Vol. 244, No. 12, pp. 1626–1629.) Experimental results are given in graphical form for fields up to 35 000 oersted and thicknesses between 25 and 2 800 Å. See also 2532 of August and back references.

621.315.5/.6 : 539.16 **2849**

Designing Electronics to Resist Nuclear Energy.—H. L. Morgan. (*Electronics*, 1st May 1957, Vol. 30, No. 5, pp. 155–157.) Materials and components must be selected that will function under conditions of high nuclear radiation and temperature, and low susceptibility to secondary radiation is essential to permit servicing of equipment. The properties of some materials are tabulated and discussed.

621.315.611 : 546.623-31 **2850**

Electric Strength of Thin Layers of Aluminium Oxide.—S. N. Koikov & A. N. Tsikin. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2248–2253.) An experimental investigation is reported of the dependence of electric strength on (*a*) the polarity of electrodes, (*b*) thickness of the oxide film in the range 15–30 μ, and (*c*) temperature in the range 300–2 000° K. The breakdown of the oxide in air at normal temperatures is probably due to the breakdown of the air in the pores of the film; in vacuum the breakdown occurs (*a*) in the vacuum in the pores of the film and (*b*) along the surface of the pores. A thermal breakdown mechanism may be operative above 1 300–1 400° K.

621.315.612.6 : 537.52 **2851**

The Electric Strengths of Glasses with Different Sodium Contents.—J. Vermeer. (*Physica*, Dec. 1956, Vol. 22, No. 12, pp. 1247–1253.)

621.315.612.6 : 537.52 **2852**

The Electrical Conduction of Glass at High Field Strengths.—J. Vermeer. (*Physica*, Dec. 1956, Vol. 22, No. 12, pp. 1257–1268.) The d.c. ionic conductivity of four kinds of glass has been measured at different temperatures. Above $\approx$100 kV/cm the final conductivity increased exponentially with field strength.

621.315.612.6 : 537.52 **2853**

On the Relation between Ionic Conductivity and Breakdown Strength of Glass.—J. Vermeer. (*Physica*, Dec. 1956, Vol. 22, No. 12, pp. 1269–1278.)

MATHEMATICS

517.9 : 519.47 **2854**

Relation between a Criterion of Realizability and Functional Transformations.—I. Gumowski. (*C. R. Acad. Sci., Paris*, 11th March 1957, Vol. 244, No. 11, pp. 1466–1468.) See also 1674 of June.

519.272 **2855**

A Scatter Diagram which Gives the Complex Correlation Coefficient for Normal Variables.—N. F. Barber. (*N.Z. J. Sci. Tech. B*, Jan. 1957, Vol. 38, No. 4, pp. 366–374.) "The correlation coefficient between two complex variables $u(t)$ and $v(t)$ can, in certain cases, be estimated by forming a scatter diagram of the variable $[u^x(t) + v(t)]$. An experimental example is given."

MEASUREMENTS AND TEST GEAR

526.2 : 535.22 **2856**

Precision of the Geodimeter as Affected by the Speed of Light in Air.—D. T. Williams & J. R. Williams. (*Rev. sci. Instrum.*, Feb. 1957, Vol. 28, No. 2, pp. 108–115.) An analysis of the limitations imposed by uncertainties in the velocity of propagation of light in the atmosphere.

536.531 : 546.289 **2857**

Germanium Resistance Thermometers Suitable for Low-Temperature Calorimetry.—J. E. Kunzler, T. H. Geballe & G. W. Hull. (*Rev. sci. Instrum.*, Feb. 1957, Vol. 28, No. 2, pp. 96–98.) Details are given of their construction including the preparation of the crystal 'bridges' and their manner of mounting inside a platinum capsule. The measured electrical properties of several samples are also given.

621.3.018.41(083.74) + 529.786] : 538.569.4 **2858**

Frequency Shift in Ammonia Absorption.—K. Matsuura, Y. Sugiura & G. M. Hatoyama. (*J. phys. Soc. Japan*, Dec. 1956, Vol. 11, No. 12, p. 1301.) A shift in the frequency of the centre of a microwave absorption line of ammonia was observed with change of state of the gas.

621.3.018.41(083.74) : 621.396.11.029.45 **2859**

Intercontinental Frequency Comparison by Very-Low-Frequency Radio Transmission.—J. A. Pierce. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 794–803.) Discussion of the frequency stability of a 16-kc/s signal over paths 5 200 km and 18 700 km long. Measurements accurate to a few parts in 10^9 are possible in less than an hour.

621.317.2 : 621.373.421.13.029.63 **2860**

A Crystal-Controlled Signal Generator.—M. T. Stockford. (*Electronic Engng*, May 1957, Vol. 29, No. 351, pp. 202–205.) Detailed description of equipment with an output of 5 W at 937·5 Mc/s designed to drive a klystron Type VX8175 [2915 of 1956 (Norris)].

621.317.3 : 621.314.63 **2861**

Dynamic Methods of Testing Semiconductor Rectifier Elements and Power Diodes: Part 2.—A. H. B. Walker & R. G. Martin. (*Electronic Engng*, May 1957, Vol. 29, No. 351, pp. 220–224.) 'Approximate' methods using normally available instruments are described. Direct comparison is made in certain cases between these measurements and those using the specialized equipment described in Part 1 (2544 of August). A useful test summary is tabulated.

621.317.3 : 621.396.822 : 621.396.96 **2862**

Measurement of Noise Factor in Centimetric Radar.—Patla. (See 2768.)

621.317.34.029.62 **2863**

Measurement of Group Delay in the 95- to 115-Mc/s Band.—A. C. H. Borsboom. (*Philips Telecommun. Rev.*, Jan. 1957, Vol. 17, No. 3, pp. 90–99.) Description of an instrument measuring delay variations with an accuracy of 10^{-9} sec.

621.317.35 : 551.594.6 **2864**

A Technique for the Rapid Analysis of Whistlers.—Grierson. (See 2759.)

621.317.35.029.426 **2865**

A Continuous Amplitude/Time Analyser.—W. A. P. Young. (*Electronic Engng*, May 1957, Vol. 29, No. 351, pp. 206–209.) A twin-channel amplifier and integrator for the band 16–30 c/s for analysing encephalographic records.

621.317.382.029.63/.64 : 537.52 **2866**

Effect of Microwave Signals Incident upon Different Regions of a D.C. Hydrogen Glow Discharge.—B. J. Udelson. (*J. appl. Phys.*, March 1957, Vol. 28, No. 3, pp. 380–381.) The change in voltage drop across a series resistor might be used to measure microwave power.

621.317.42 **2867**

Instrument for Relative Measurements of Constant Magnetic Fields.—I. S. Shpigel', M. D. Raizer & E. A. Myae. (*Radiotekhnika i Elektronika*, Dec. 1956, Vol. 1, No. 12, pp. 1515–1519.) The instrument, which utilizes the magnetic resonance absorption phenomenon, is designed for relative measurements of weakly inhomogeneous magnetic fields. The maximum measurable difference in the magnetic field is $\Delta H_{max} = \pm 5\%$, where H is the field strength. The error in ΔH is ± 3–4%. Measurements were made of the injection-field distribution ($H_0 = 150$ oersted) of the new 10 -kMev synchrophasotron of the Academy of Sciences.

621.317.726 : 621.385.832 **2868**

The Measurement of Peak Voltage using a Cathode-Ray Tube.—E. S. Fairley. (*Brit. J. appl. Phys.*, March 1957, Vol. 8, No. 3, pp. 101–102.) A null method is used, a balance against an accurately determined direct voltage being achieved.

621.317.75 : 538.569.4 **2869**

Direct Measurement of the Characteristic Moments of the Line Structure in Paramagnetic Resonance: Sinusoidal Sweep and Harmonic Analysis of the Signal.—J. Hervé. (*C. R. Acad. Sci., Paris*, 11th March 1957, Vol. 244, No. 11, pp. 1475–1478.)

621.317.755 : 621.385.029.63/.64 **2870**

The Wamoscope—a Microwave Display Device.—D. E. George. (*Sylvania Technologist*, Jan. 1957, Vol. 10, No. 1, pp. 5–7.) The 'wamoscope' is a travelling-wave valve combined with a c.r. tube screen in such a way as to make the brightness at the screen a function of the microwave power input.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

621.365.92 **2871**

Radio-Frequency Carbonization.—S. W. Taylor. (*Research, Lond.*, March 1957, Vol. 10, No. 3, pp. 108–115.) Apparatus for r.f. heating giving an extremely uniform distribution of heat is briefly described and results of experiments on various coals are given.

621.384.612 **2872**

Strong Focusing in Particle Accelerators: Alternating-Gradient Synchrotrons.—P. Lapostolle. (*Onde élect.*, Jan. 1957, Vol. 37, No. 358, pp. 41–47.) Outline of underlying principles and brief description of 200-m-diameter, 25-kMeV synchrotron for CERN in Geneva [see also 3371 and 3372 (Grivet) of 1955].

621.384.622.1 : 535.42 **2873**

Linear Accelerator with Preliminary Electron Bunching: Application to Electron Diffraction between 0·5 and 1 MeV.—M. Papoular. (*Ann. Phys., Paris*, Nov./Dec. 1956, Vol. 13, No. 1, pp. 914–958.) Detailed description of the development and construction of a particle accelerator which incorporates a special device for preliminary bunching by velocity modulation to improve the energy spectrum (see also 1267 of April). Its application in electron diffraction techniques is outlined and illustrated by experimental results.

621.384.622.2 **2874**

The 28-MeV Electron Accelerator Project for the Nuclear Research Centre at Saclay [France].—H. Leboutet, E. Picard & J. Vastel. (*Onde élect.*, Jan. 1957, Vol. 37, No. 358, pp. 28–35.) Basic design data of the linear accelerator and general description of the installation.

621.385.832 **2875**

Tristable Gate moves C.R.O. Line Drawings.—P. A. Ryan. (*Electronics*, 1st

May 1957, Vol. 30, No. 5, pp. 178–180.) A means for producing simple contours on the face of a conventional c.r.o.

621.385.833 **2876**

Properties of Two-Aperture Electron Lenses.—G. D. Archard. (*Brit. J. appl. Phys.*, March 1957, Vol. 8, No. 3, pp. 127–130.) "Spherical and chromatic aberrations and focal properties of two-aperture (immersion) electron lenses are investigated theoretically, and the results are presented graphically as functions of lens geometry and voltage ratio."

621.398 : 621.396.934 **2877**

Missile Telemeter uses Transistor Amplifier.—J. H. Porter. (*Electronics*, 1st May 1957, Vol. 30, No. 5, pp. 170–171.) "Chopper-type d.c. amplifier uses available channels to indicate missile temperatures in an airborne telemetering system. Unit has voltage gain of 1 000 with 5 V d.c. output and linearity within 2% over the full output range. Input impedance is 100 Ω and response is flat from zero to 10 c/s. Stability is within 2% up to 10 *g* vibration at 1 000 c/s or over temperature range from −65° C to 85° C."

642.6 : 681.142 **2878**

Some of the Engineering Aspects of the Machine Translation of Language.—R. E. Wall, Jr. (*Commun. & Electronics*, Nov. 1956, No. 27, pp. 580–584. Discussion, p. 585.)

621.385.833 + 537.533.72 **2879**

Proceedings of the Third International Conference on Electron Microscopy, London, 1954. [Book Review]—E. Ross (Ed.). Publishers: Royal Microscopical Society, London, 1956, 705 pp., 90s. (*Nature, Lond.*, 20th April 1957, Vol. 179, No. 4564, pp. 797–798.)

PROPAGATION OF WAVES

621.396.11 **2880**

Radio Propagation Fundamentals.—K. Bullington. (*Bell Syst. tech. J.*, May 1957, Vol. 36, No. 3, pp. 593–626.) Nomograms and graphs are included which permit numerical estimates of field strength to be made. All frequency bands of practical importance are discussed. 34 references.

621.396.11 **2881**

Spectrum of Turbulent Fluctuations Produced by Convective Mixing of Gradients.—A. D. Wheelon. (*Phys. Rev.*, 15th March 1957, Vol. 105, No. 6, pp. 1706–1710.) The spectrum is calculated on the basis of the turbulent mixing of an established gradient of a passive scalar quantity (e.g. electronic density). The resulting expression is consistent with experimental results on radio wave scattering by tropospheric and ionospheric irregularities.

621.396.11 **2882**

A Reflection Theory for Propagation Beyond the Horizon.—H. T. Friis, A. B. Crawford & D. C. Hogg. (*Bell Syst. tech. J.*, May 1957, Vol. 36, No. 3, pp. 627–644.) The atmosphere is assumed to contain fairly sharp gradients of refractive index having limited dimensions and random positions and orientations. This model gives good agreement with experimental data.

621.396.11 : 551.510.535 **2883**

The Fading of Radio Waves Reflected from the E Layer.—B. Landmark. (*J. atmos. terr. Phys.*, 1957, Vol. 10, Nos. 5/6, pp. 288–295.) Simultaneous measurement of phase path and amplitude of waves reflected vertically from the E region are analysed. A temporary increase in phase path was associated with an enhancement of amplitude, indicating focusing by a moving concavity in the layer.

621.396.11 : 551.510.535 **2884**

High-Frequency Back-Scatter Observations at Salisbury, South Australia.—C. G. McCue. (*Aust. J. Phys.*, Dec. 1956, Vol. 9, No. 4, pp. 454–470.) By measuring simultaneously angles of elevation and time delays of strobed back-scatter signals, seven different back-scatter modes were noted, of which the most frequent was the ground-scatter single F_2 hop. Transmissions directed to four characteristic types of scattering area showed that at low angles of elevation land is a more prominent source of back-scatter than sea, and that extremely large changes in land roughness result in increased back-scatter amplitude.

621.396.11.029.45 : 551.510.535 **2885**

The Geometrical Optics of V.L.F. Sky-Wave Propagation.—J. R. Wait & A. Murphy. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 754–760.) Data are tabulated to facilitate the computation of received field strengths by combining ground and ionospheric waves. Comparison of some calculated values with experimental results leads to values of ionospheric refractive index differing from those previously published.

621.396.11.029.45 : 551.510.535 **2886**

The Mode Theory of V.L.F. Ionospheric Propagation for Finite Ground Conductivity.—J. R. Wait. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 760–767.) A mathematical formulation of the theory and graphical presentation of typical conclusions. Good agreement between calculated and measured fields is shown.

621.396.11.029.45 : 551.510.535 **2887**

The Attenuation vs Frequency Characteristics of V.L.F. Radio Waves.—J. R. Wait. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 768–771.) Attenuation factors are presented graphically as a function of various ionospheric parameters.

621.396.11.029.45 : 551.510.535 **2888**

The 'Waveguide Mode' Theory of the Propagation of Very-Low-Frequency Radio Waves.—K. G. Budden. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 772–774.) Some apparent discrepancies between previous treatments are shown to be due to differences in the assumed ionospheric parameters and in the terminology for the modes.

621.396.11.029.45 : 551.594.6 **2889**

Very-Low-Frequency Radiation from Lightning Strokes.—Hill. (See 2760.)

621.396.11.029.45 : 621.3.018.41(083.74) **2890**

Intercontinental Frequency Comparison by Very-Low-Frequency Radio Transmission.—Pierce. (See 2859.)

621.396.11.029.53 **2891**

The Ionospheric Attenuation of Hectometric Wave Propagation (550–1 600 kc/s).—M. Scholz. (*Nachrichtentech. Z.*, Jan. 1957, Vol. 10, No. 1, pp. 6–11.) Field-strength curves for night-time propagation in the medium-wave band obtained from various sources covering the past 22 years are compared. Other data plotted for comparison and brief discussion are the statistical distribution of field-strength variations, seasonal fluctuations and the mean fading rate.

621.391.11.029.62 : 523.5 : 621.396.67.012.12 **2892**

Height-Gain in the Forward Scattering of Radio Waves by Meteor Trails.—C. O. Hines & M. O'Grady. (*Canad. J. Phys.*, Jan. 1957, Vol. 35, No. 1, pp. 125–127.) Calculated curves are presented which show the detection rate of meteors and the mean signal level for forward transmission. The quantities are given as a function of aerial height and meteor-formation height.

RECEPTION

621.376.2 **2893**

The Demodulation of Linearly Distorted A.M. Spectra.—H. Schneider & G. Petrich. (*NachrTech.*, Dec. 1956, Vol. 6, No. 12, pp. 552–556.) The effect of amplitude and phase changes on the demodulating action of a receiving diode is investigated theoretically; the results are discussed with reference to the tuned selective circuit and the purely inductive h.f. channel.

621.376.333 **2894**

Some Problems in the Theory of the Ratio Detector.—I. Kesler. (*Archiwum Elektrotech.*, 1956, Vol. 5, No. 4, pp. 591–619. English summary, p. 620.) Theoretical and practical aspects of compensating amplitude variations of the input signal are discussed.

621.396.62 : 621.314.7 **2895**

Portable Transistor Receiver.—S. W. Amos. (*Wireless World*, May & July 1957, Vol. 63, Nos. 5 & 7, pp. 241–246 & 340–346. Correction, *ibid.*, Aug. 1957, Vol. 63, No. 8, p. 377.) A discussion of general principles of design and a stage-by-stage examination of a complete circuit, full details of which are given.

621.396.621.54 **2896**

A New Approach in R.F. Front-End Design.—B. B. Bycer. (*Electronic Ind. Tele-Tech*, Jan. 1957, Vol. 16, No. 1, pp. 82–84 . . 141.) The design is based on permeability tuning and the use of a triode Type 6021 as a reactance modulator for operation at 205 Mc/s.

621.396.812.3 **2897**

The Effect of the Recorder Time on the Apparent Speed of Fading of a Radio Signal.—S. A. Bowhill. (*J. atmos. terr. Phys.*, 1957, Vol. 10, Nos. 5/6, pp. 338–339.)

621.396.822 : 551.594.6 **2898**

Noise Investigation at V.L.F. by the National Bureau of Standards.—Crichlow. (See 2761.)

621.396.822 : 551.594.6 **2899**

Some Recent Measurements of Atmospheric Noise in Canada.—McKerrow. (See 2762.)

621.396.822 : 551.594.6 **2900**

Characteristics of Atmospheric Noise from 1 to 100 kc/s.—Watt & Maxwell. (See 2763.)

621.396.823 : 537.523.3 **2901**

The Radio Interference Produced by Corona Discharge.—M. I. Large. (*J. atmos. terr. Phys.*, 1957, Vol. 10, Nos. 5/6, pp. 245–250.) The spectrum of interference observed on a receiver showed peaks of noise at harmonics of the corona pulse repetition frequency, these noise peaks merging above the tenth harmonic. The spectrum conforms to that expected for pulses of variable interval.

621.396.823 : 537.523.3 **2902**

A Relaxation Oscillation Maintained by Discharge Corona.—M. I. Large. (*Nature, Lond.*, 6th April 1957, Vol. 179, No. 4562, pp. 707–708.) During an investigation of interference due to negative corona from a receiver aerial (2901 above), a fine wire point a few millimetres from a plane at high potential was observed to oscillate, producing in a receiver a musical tone at twice the frequency of mechanical oscillation.

STATIONS AND COMMUNICATION SYSTEMS

621.376.3/.4 : 621.396.822 **2903**

Power Spectrum of a Carrier Modulated in Phase or Frequency by White Noise.—R. Hamer & R. A. Acton. (*Electronic Radio Engr*, July 1957, Vol. 34, No. 7, pp. 246–253.) "Measurement of the power spectrum of a carrier, modulated either in phase or in frequency by a uniform Gaussian noise signal, is described, and the results are interpreted in the light of existing theory. A combination of measured and theoretical results is used to prepare generalized curves of f.m. and ph.m noise spectra."

621.39.001.11 **2904**

Instantaneous Companding of Quantized Signals.—B. Smith. (*Bell Syst. tech. J.*, May 1957, Vol. 36, No. 3, pp. 653–709.) An extension of the analysis of Panter & Dite (1488 of 1951) permits the calculation of the quantizing error power as a function of a number of parameters. These calculations lead to the proper combination of the number of digits per code group and companding characteristic for quantized speech communication systems. Theoretical and experimental studies are compared.

621.39.001.11 **2905**

Geometric Interpretation of some Results of Channel Capacity Calculations.—C. E. Shannon. (*Nachrichtentech. Z.*, Jan. 1957, Vol. 10, No. 1, pp. 1–4.) Translated and amplified version of an English paper published in *Nachrichtentech. Fachberichte*, 1957, Vol. 6, pp. 13–15. The capacity of discrete channels not containing memory devices is investigated.

621.396.2 : 551.510.52 **2906**

Communications Potentialities of Tropospheric Scatter.—M. Telford. (*Point to Point Telecommun.*, Feb. 1957, Vol. 1, No. 2, pp. 29–52.) The calculation of received signal level is discussed and charts are given. F.m., s.s.b., and diversity systems are considered together with an appraisal of the possibilities in relaying television.

621.396.4 **2907**

Introduction to Channelling Systems on H.F. Radio Circuits.—A. W. Cole. (*Point to Point Telecommun.*, Feb. 1957, Vol. 1, No. 2, pp. 5–12.) The history and trends of development in frequency-division and time-division channelling are briefly reviewed as an introduction to later articles.

621.396.4 : 621.396.72.029.62 **2908**

Radio-System Surveying on Very High Frequencies.—D. C. H. Mellon. (*Point to Point Telecommun.*, Feb. 1957, Vol. 1, No. 2, pp. 13–27.) Factors governing the choice of sites for multichannel v.h.f. systems are considered, and site testing is discussed.

621.396.41 : 621.396.72 **2909**

Experience with Single-Sideband Mobile Equipment.—R. Richardson, O. Eness & R. Dronsuth. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 823–829.) The performance of the equipment, designed to operate at 159 Mc/s, is compared with that of narrow-band f.m. equipment.

621.396.61/.62 : 621.314.7 : 621.311.6 **2910**

Transistor Equipment using Freely Available Power Supplies.—Hollmann. (See 2916.)

621.396.65.029.64 **2911**

The Use of the Lower Centimetric Wavelengths for Radio Communication.—G. Megla. (*Hochfrequenztech. u. Elektroakust.*, May 1956, Vol. 64, No. 6, pp. 194–199.) An examination of the microwave absorption by atmospheric gases and precipitation indicates that attenuation is sufficiently low for radio links at wavelengths down to 2 cm. Systems operating at 4 cm λ over a 33 km path using various forms of guided transmission are compared with a free-space transmission system; the latter has great economic advantages.

SUBSIDIARY APPARATUS

621-526 **2912**

An Introduction to the Study of Nonlinear Control Systems.—J. F. Coales. (*J. sci. Instrum.*, Feb. 1957, Vol. 34, No. 2, pp. 41–47.) The nonlinearities may be used to improve the system performance provided they occur in the forward loop outside the load and are instantaneous, i.e. there is no applicable delay between input changes and output response.

621.3.064 **2913**

Activation of Electrical Contacts by Organic Vapours.—L. H. Germer & J. L. Smith. (*Bell Syst. tech. J.*, May 1957, Vol. 36, No. 3, pp. 769–812.) Carbon from the decomposed vapours may make it impossible to protect contacts against arcing by conventional *RC* networks. The activation process is discussed.

621.3.078 : 621.316.825 : 621.383 **2914**

A Thermistor Device as Automatic Gain Control in Lamp-Photocell Transducer Systems.—A. M. Hardie. (*J. sci. Instrum.*, Feb. 1957, Vol. 34, No. 2, pp. 58–62.) Stabilization to within 0·03% is achieved if the light beam is modulated symmetrically.

621.311.6 : 621-526.001.4 **2915**

Power Amplifier for Servo Testing.—J. M. Diamond. (*Electronics*, 1st May 1957, Vol. 30, No. 5, pp. 176–177.) A cathode follower supplies 90 W at 400–2 600 c/s.

621.311.6 : 621.396.61/.62 : 621.314.7 **2916**

Transistor Equipment using Freely Available Power Supplies.—H. E. Hollmann. (*Hochfrequenztech. u. Elektroakust.*, May 1956, Vol. 64, No. 6, pp. 168–180.) The equipment described includes portable transmitters and receivers drawing power from solar batteries, hand-driven dynamos, sound energy and the r.f. energy of a local broadcasting transmitter. See also 1893 of June.

621.311.69 : 537.311.33 : 535.215 **2917**

Photoelectric Converters of Solar Energy of *p*-Type Silicon.—Yu. P. Maslakovets, S. A. Poltinnikov, G. B. Dubrovski & V. K. Subashiev. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2396–2397.) Brief note on experimental results. Efficiencies up to 2·8% were obtained.

621.311.69 : 621.362 **2918**

Conversion of Radiations into Electricity.—V. B. Veinberg & Yu. V. Mal'tsev. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2373–2377.) Calculation of the efficiency of converting solar radiation into electrical energy via a heat engine. Numerical data are tabulated for various heater systems; efficiencies 3–4 times greater than those of thermoelectric converters are indicated.

621.314.6 + 621.316.72 **2919**

The Valve in Power Supply Units.—K. Steimel. (*Telefunkenröhre*, Dec. 1956, No. 34, pp. 1–246.) The problems of stability and stabilization in electronic voltage and current supplies are discussed in detail. A section deals with rectification as a function of different circuit characteristics; other chapters describe and compare numerous basic valve circuits used for various stabilizing purposes including special applications of more elaborate circuitry.

TELEVISION AND PHOTOTELEGRAPHY

621.397.5 **2920**

Horizontal versus Vertical Resolution.—L. C. Jesty. (*Wireless World*, July 1957, Vol. 63, No. 7, pp. 304–306.) No data appear to be available which suggest that greater sharpness is desirable in one direction rather than any other. The vertical/horizontal resolution is discussed; the number of lines should be increased beyond 405 to achieve equal resolution in these two directions.

621.397.5 : 389.6 **2921**

The Results of the 8th General Assembly [of the C.C.I.R.] **(Warsaw 1956) in the Field of Black-and-White Television.**—J. Müller. (*Nachrichtentech. Z.*, Jan. 1957, Vol. 10, No. 1, pp. 27–30.)

621.397.5 : 535.623 **2922**

The Information Content and Frequency Bandwidth of the Chrominance Signal in a Subcarrier System of Colour Television.—P. Neidhardt. (*NachrTech.*, Dec. 1956, Vol. 6, No. 12, pp. 529–533.) Problems arising from the adaption of the N.T.S.C. system to the 625-line standard are considered.

621.397.5 : 535.623 **2923**

The Efforts of the C.C.I.R. concerning a European Standard for Colour Television.—F. Kirschstein, J. Müller & K. O. Schmidt. (*Nachrichtentech. Z.*, Jan. 1957, Vol. 10, No. 1, pp. 1–4.) Report on the discussions of a C.C.I.R. study group and on its visit to the U.S.A., France, Great Britain and the Netherlands.

621.397.5 : 535.623 **2924**

Colour TV in U.S.A.—C. G. Mayer. (*Wireless World*, July 1957, Vol. 63, No. 7, p. 325.) A favourable review of the status of colour television with respect to that of black-and-white, implies that there is no longer any basis for the 'colour-blindness' which seems to prevail in Britain today.

621.397.6.001.4 : 535.623 **2925**

Simultaneous Colour-TV Test Signal.—R. C. Kennedy. (*Electronics*, 1st May 1957, Vol. 30, No. 5, pp. 146–149.) Differential gain, phase characteristic, flag-burst and chroma amplitudes of monitor or receiver can be determined using a test signal transmitted simultaneously with the program. The signal occupies three horizontal lines, one line displaced above top of picture.

621.397.611.2 **2926**

Transmission Defects of the Image Orthicon Television Camera Tube.—R. Theile & F. Pilz. (*Arch. elekt. Übertragung*, Jan. 1957, Vol. 11, No. 1, pp. 17–32.) The causes are investigated of the characteristic spurious signals originating in this type of tube which give rise to picture distortion and loss of definition. These defects are due to capacitive coupling between adjacent picture elements and the deflection of scanning electrons by the potential pattern of the stored charge. Modifications of the construction and operation of the tube are suggested.

621.397.62 : 535.8 **2927**

A New Optical Viewfinder for Television Cameras.—P. Lindner & E. Kosche. (*NachrTech.*, Dec. 1956, Vol. 6, No. 12, pp. 538–544.) Description of optical viewfinder in which correctness of focusing is indicated over the whole image. Its advantages over electronic viewfinders are evident from a point-by-point comparison.

621.397.62 : 621.374.33 **2928**

Noise Gating Tube for A.G.C. and Sync.—J. G. Spracklen, W. J. Stroh & G. C. Wood. (*Electronics*, 1st May 1957, Vol. 30, No. 5, pp. 172–175.) "Single miniature tube performs entire functions of sync clipping, generating a.g.c. voltage and giving high degree of noise immunity to both these sections of a television receiver. Type 6BU8 contains common cathode, grid and screen with separate plates and No. 3 grids."

621.397.621 : 778 **2929**

Construction of Equipment for the Photography of Single Frames of Television Pictures.—K. Kröner. (*Elektronik*, Jan. 1957, Vol. 6, No. 1, pp. 12–15.) The equipment described is based on the circuit of Dillenburger & Wolf (586 of 1956).

621.397.621.2 : 535.623 **2930**

The Choice of Colour Phosphors and the Occurrence of Colour Information Losses.—I. Bornemann. (*NachrTech.*, Dec. 1956, Vol. 6, No. 12, pp. 534–537.) The requirements governing the choice of phosphors for use in tricolour c.r. tubes are discussed. The use of the Valensi diagram for determining information losses is proposed.

621.397.74(44) **2931**

The French Television Network.—Leschi. (*Télév. franç.*, Jan. 1957, No. 138, pp. 9–22.) Outline of the development planned by the R.T.F. with lists of stations and maps showing their coverage; details of the individual transmitters are also given.

VALVES AND THERMIONICS

621.314.63 + 621.314.7 **2932**

The High Current Limit for Semiconductor Junction Devices.—N. H. Fletcher. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 862–872.) At very high current densities new formulae must be derived considering previously neglected effects. Predictions of the theory for particular devices are in good agreement with experiment and show how the available parameters should be varied to achieve specific results.

621.314.63 **2933**

The Forward Voltage/Current Characteristic of a Junction-Type Rectifier for Large Currents.—E. I. Rashba & K. B. Tolpygo. (*Zh. tekh. Fiz.*, July 1956, Vol. 26, No. 7, pp. 1419–1427.) A theoretical discussion is presented, in which an equation is derived for the voltage/current characteristic of a *p-n* junction-type diode of arbitrary thickness for large currents, on the assumption that the barrier layer is flooded with carriers and that the main voltage drop occurs in the bulk of the semiconductor. A numerical example showing the application of the equation to a germanium diode is included, and the accuracy of the method proposed is estimated.

621.314.63 : 537.311.33 **2934**

Theory of the Metal/Semiconductor Contact.—S. U. Umarov & L. G. Gurvich. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2179–2184.) A calculation of the current/voltage characteristics is presented, taking into account the current across the junction and the degree of ionization of the impurity centres. The calculation is approximate and does not take account of the influence of the change of the average kinetic energy of the electron gas under the influence of the electric field.

621.314.63 : 546.28 : 539.18 **2935**

Effects of Irradiation upon Diodes of the Silicon Junction Type.—R. Gorton. (*Nature, Lond.*, 27th April 1957, Vol. 179, No. 4565, p. 864.) After irradiation by slow and fast neutrons, a progressive change in the forward characteristics occurred accompanied by a distinct reduction of minority-carrier storage. There was no significant change in the reverse characteristics.

621.314.63 : 546.289 **2936**

Measurements of Current as a Function of Temperature in Germanium *n-p* Junctions.—M. Bernard. (*J. Electronics*, May 1957, Vol. 2, No. 6, pp. 579–596. In French.) Measurements of reverse current in grown Ge *p-n* junctions at temperatures above 10° C agree well with Shockley's theory. Below 10° C the reverse current arises from electron-hole generation in the space-charge layer. This mechanism is also used to explain the forward current characteristics measured between −50° C and liquid-nitrogen temperatures.

621.314.63 : 546.289 **2937**

Some Properties of Diodes of Germanium with Gold Admixture.—A. A. Lebedev, V. I. Stafeev & V. M. Tuchkevich. (*Zh. tekh. Fiz.*, Oct. 1956, Vol. 26, No. 10, pp. 2131–2141.) An experimental investigation of the I/V and breakdown-voltage characteristics at temperatures down to 78° K is reported.

621.314.63 + 621.314.7] : 621.396.822 **2938**

Theory and Experiments on Shot Noise in Semiconductor Junction Diodes and Transistors.—W. Guggenbühl & M. J. O. Strutt. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 839–854.) A general theory of shot noise, for low current densities, and its dependence on frequency in the l.f. and h.f. bands. Experimental results at low-level injection agree well with the theory, but some deviation is apparent at high levels.

621.314.63.012.8 **2939**

Theoretical Consideration of the Physical Basis for the Equivalent Circuit of Semiconductor Diodes at High Current Densities.—W. Guggenbühl. (*Arch. elekt. Übertragung*, Nov. 1956, Vol. 10, No. 11, pp. 483–485.) Consideration of the transient response of junction diodes in the high-current region is based on Herlet's theory of their d.c. performance (*Z. Naturf.*, June 1956, Vol. 11a, No. 6, pp. 498–510). This accounts for the inductive part of the a.c. characteristics of a *p-n*-junction diode at high injection levels. Experimental results agree satisfactorily with theory.

621.314.7 **2940**

Transistor Circuit Symbols.—E. H. Cooke-Yarborough. (*Wireless World*, July 1957, Vol. 63, No. 7, 333–334.) The need to use symbols which distinguish between point-contact and junction transistors (1942 of June) is emphasized, together with the need for keeping to the 'negative down' polarity convention already established with valve circuits.

621.314.7 : 621.374.32 : 681.142 **2941**

Computer Switching with Micro-alloy Transistors.—Angell & Fortini. (See 2686.)

621.314.7 : 621.375.4 **2942**

Transistor Operating-Point Stabilization.—A. Cramwinckel. (*Philips Telecommun. Rev.*, Jan. 1957, Vol. 17, No. 3, pp. 100–107.) A method of stabilizing transistors against increased collector leakage current caused by a rise in temperature. A d.c. negative-feedback method is described which is effective up to about 80° C for Ge transistors.

621.314.7 : 621.375.4.029.5/.6 **2943**

Transistors in High-Frequency Amplifiers.—W. Guggenbühl & M. J. O. Strutt. (*Electronic Radio Engr*, July 1957, Vol. 34, No. 7, pp. 258–267.) A discussion of the frequency dependence of transistor parameters is followed by a review of the qualities of h.f. transistors and of the various problems which arise in their use. 29 references.

621.314.7 : 621.396.822 **2944**

Abnormal Noise in Junction Transistors during Secondary Ionization.—R. B. Jackson & A. K. Walton. (*Proc. phys. Soc.*, 1st Feb. 1957, Vol. 70, No. 446B, p. 251.)

621.314.7.002.2 **2945**

The Depth of Diffused Layers.—W. L. Bond. (*Bell. Lab. Rec.*, Jan. 1957, Vol. 35, No. 1, pp. 1–5.) An interference fringe technique is described for measuring the depth of conductivity layers diffused into semiconductor crystals in transistor fabrication.

621.383.2 **2946**

On the Constancy of the Spectral Characteristics of Oxygen-Caesium and Antimony-Caesium Vacuum Photocells.—V. S. Khazanov & S. G. Yurov. (*Zh. tekh. Fiz.*, June 1956, Vol. 26, No. 6, pp. 1170–1173.) The effect of the magnitude of the applied voltage on the spectral sensitivity of the photocell was investigated experimentally. The data so obtained are compared with those of other authors.

621.383.2 **2947**

The Energy Distribution of Photoelectrons in the External Photoeffect of the Antimony-Caesium Cathode.—Yu. K. Shalabutov & N. S. Maslennikova. (*Zh. tekh. Fiz.*, June 1956, Vol. 26, No. 6, pp. 1166–1169.) Measurements of spectral response and energy distribution of photoelectrons are reported. The $(dN/dE)/E$ curves, where E is the energy, show maxima near 0·6 and 0·2 eV for photoelectrons liberated by 530 mμ irradiation.

621.383.27 **2948**

Fluctuations in Photomultipliers and Statistical Properties of Secondary Emission.—P. Moatti. (*C. R. Acad. Sci., Paris*, 25th March 1957, Vol. 244, No. 13, pp. 1742–1744.) Statistical treatment to determine the number of electrons comprising an output pulse when emission is initiated by (*a*) a single electron, (*b*) a group of electrons with Poisson distribution.

621.383.27 **2949**

Synchronization Accuracy Obtainable with Multiplier Phototubes.—L. Levi. (*Commun. & Electronics*, Nov. 1956, No. 27, pp. 603–606.) The jitter in photomultiplier synchronization systems is analysed to determine the effect of bandwidth, type of photocell and optical parameters.

621.383.4 **2950**

A New Photocell for Long-Wave Infrared Radiation.—E. Suchel. (*Elektronische Rundschau*, Nov. 1956, Vol. 10, No. 11, pp. 296–298.) The characteristics of the PbS cell Type 61SV for use in the wavelength range 0·3–3·5 μ are given; its sensitivity is greatest at 2·5 μ. Some typical applications are indicated.

621.383.42 **2951**

Influence of Temperature on the Height of the Potential Barrier of Selenium Photocells.—G. Blet. (*C. R. Acad. Sci., Paris*, 25th March 1957, Vol. 244, No. 13, pp. 1754–1756.) The barrier potential determined from measurements of the e.m.f. of a cell in vacuum is independent of temperature in the range 125°–300° K.

621.383.5 : 546.23 : 621.396.822 **2952**

Flicker Effect in Selenium Photovoltaic Cells.—M. Téboul & N. Nifontoff. (*C. R. Acad. Sci., Paris*, 18th March 1957, Vol. 244, No. 12, pp. 1631–1633.) To a first approximation the flicker effect does not appear to be influenced by the illumination of the cell when the voltage across the rectifying contact is held constant.

621.383.5 : 546.817.221 **2953**

A Single-Crystal Photodiode of Lead Sulphide.—J. Starkiewicz, G. Bate, H. Bennett & C. Hilsum. (*Proc. phys. Soc.*, 1st Feb. 1957, Vol. 70, No. 446B, pp. 258–259.) A photovoltaic cell with a time constant $< 1\ \mu$s.

621.385 : 621.396.822 **2954**

An Investigation into the Flicker Effect.—A. M. Malakhov & V. E. Dubrovin. (*Zh. tekh. Fiz.*, July 1956, Vol. 26, No. 7, pp. 1451–1455.) The flicker voltage developed across a resistance in the anode circuit of the valves was measured over a frequency range from 0·5 to 120 c/s, and the spectral density of the fluctuations was determined. The dependence of the intensity of the flicker effect and the form of its spectrum on the operating conditions of the valve, and, in particular, on residual gas in the valve is briefly discussed. A theoretical interpretation of the results obtained is given.

621.385.001.4 : 534.1 **2955**

White-Noise Vibration Test for Electron Tubes.—J. D. Robbins. (*Sylvania Technologist*, Jan. 1957, Vol. 10, No. 1, pp. 10–12.)

621.385.004.2 **2956**

The Effects of Overload and Operation at High Altitudes on Electron-Tube Life.—H. C. Pleak & A. V. Baldwin. (*Sylvania Technologist*, Jan. 1957, Vol. 10, No. 1, pp. 2–4.)

621.385.029.6 **2957**

Interchannel Interference due to Klystron Pulling.—H. E. Curtis & S. O. Rice. (*Bell Syst. tech. J.*, May 1957, Vol. 36, No. 3, pp. 645–652.) Expressions are derived for the magnitude of the interference when the speech load is simulated by random noise.

621.385.029.6 **2958**

The Measurement of Space-Charge Wavelength in an Electron Beam.—D. Walsh. (*J. Electronics*, March 1957, Vol. 2, No. 5, pp. 436–440.) "A method is described of measuring the wavelength of space-charge waves in an electron beam by comparing the klystron gain between cavities unequally spaced along the beam."

621.385.029.6 **2959**

On Space-Charge Waves.—R. H. C. Newton. (*J. Electronics*, March 1957, Vol. 2, No. 5, pp. 441–449.) The wave equation for an electron beam in a collimating magnetic field is derived. The analysis is applicable when there is no positive space charge and is not entirely restricted to small-signal conditions.

621.385.029.6 2960

High-Order Space-Charge Waves in Klystrons.—A. H. W. Beck. (*J. Electronics*, March 1957, Vol. 2, No. 5, pp. 489–509.) Theoretical expressions are obtained for cylindrical and annular beams focused with an infinite magnetic field. The calculations are simplified by the use of finite Hankel transforms. Beams in finite magnetic fields are closely similar provided that the focusing field is somewhat greater than the Brillouin field for the same current, voltage and beam diameter.

621.385.029.6 2961

Space-Charge Waves along Magnetically Focused Electron Beams.—J. Labus. (*Proc. Inst. Radio Engrs*, June 1957, Vol. 45, No. 6, pp. 854–861.) Two procedures in the analysis of wave propagation along electron beams are compared by consideration of different displacements of the beam surface.

621.385.029.6 2962

Space Harmonics in Electron Streams.—R. Müller. (*Arch. elekt. Übertragung*, Dec. 1956, Vol. 10, No. 12, pp. 505–511.) The formation is considered of space-charge waves in electron beams travelling along specially shaped paths or under periodically changing d.c. conditions. The application of this phenomenon for generating high harmonic frequencies is briefly discussed.

621.385.029.6 2963

On the Spreading of Bunches of a Space Charge.—O. P. Beguchev. (*Zh. tekh. Fiz.*, July 1956, Vol. 26, No. 7, pp. 1483–1486.) A rigorous mathematical description is given of the process of the spreading of bunches of an uncompensated space charge.

621.385.029.6 2964

On the Space Charge Affected by the Magnetic Field: Part 2.—Y. Yasuoka. (*J. phys. Soc. Japan*, Dec. 1956, Vol. 11, No. 12, pp. 1292–1295.) A more advanced treatment of Part 1 (2575 of 1956) taking into account the effect of the magnetic field on the scattered electrons. Better agreement is obtained with experimental values.

621.385.029.6 2965

On the Shape of Electron Trajectories in a Magnetron under Static Conditions.—B. Ya. Moizhes. (*Zh. tekh. Fiz.*, Aug. 1956, Vol. 26, No. 8, pp. 1836–1840.) The equation of motion of electrons in a cylindrical magnetron, with an anode-radius/cathode-radius ratio approaching unity is derived taking into account the space charge, and trajectories in magnetic fields exceeding the critical value are considered.

621.385.029.6 2966

Minimum Noise Coefficient of Double-Stream Valve.—S. K. Lesota. (*Radiotekhnika i Elektronika*, Sept. 1956, Vol. 1, No. 9, pp. 1288–1291.) The calculation presented takes into account the correlation of fluctuations of the current and voltage in the double electron stream. A linear approximation and lossless-multipole theory are used. Results show that the minimum noise coefficient is higher for the double-stream valve than for a travelling-wave valve operating under similar conditions for fluctuations in the potential minimum.

621.385.029.6 2967

Theory of Nonlinear Phenomena in Travelling-Wave Amplifiers.—A. A. Vedenov. (*Radiotekhnika i Elektronika*, Oct. 1956, Vol. 1, No. 10, pp. 1377–1378.) The limitation of the increase in amplitude is deduced from general energy relations without recourse to a concrete model.

621.385.029.6 2968

Developments of the Strophotron.—H. Häggblom & S. Tomner. (*Ericsson Tech.*, 1956, Vol. 12, No. 2, pp. 165–184.) This transit-time valve was originally described by Alfvén & Romell (3398 of 1954). Experimental results are reported for different types including the coaxial strophotron and the simplified theory is outlined. Oscillator efficiencies of 30% at 1 000 Mc/s and 10% at 5 000 Mc/s have been achieved.

621.385.029.6 : 621.375.2 : 621.396.65 2969

Design Considerations for Output Stages using Travelling-Wave Valves in Radio-Link Equipment.—M. Müller. (*Nachrichtentech. Z.*, Jan. 1957, Vol. 10, No. 1, pp. 11–15.) On the basis of theoretical considerations travelling-wave valve operating and design data are tabulated for mid-band frequencies of 2, 4, 6 and 10 kMc/s and outputs of about 1 to 200 W for a focusing field of 600 G.

621.385.029.63/.64 2970

A Study of the Broad-Band Frequency Response of the Multicavity Klystron Amplifier.—K. H. Kreuchen, B. A. Auld & N. E. Dixon. (*J. Electronics*, May 1957, Vol. 2, No. 6, pp. 529–567.) "A theoretical method is described for the evaluation of the amplitude-frequency response of a stagger-tuned klystron amplifier. The practical verification of the theoretically predicted response was carried out on a demountable four-cavity S-band klystron amplifier."

621.385.029.63/.64 : 621.317.755 2971

The Wamoscope—a Microwave Display Device.—George. (See 2870.)

621.385.029.63/.64 : 621.317.755 : 621.385.833 2972

Typical Applications of the Wamoscope.—H. Briskin. (*Sylvania Technologist*, Jan. 1957, Vol. 10, No. 1, pp. 8–9.) A radar receiver and microwave television receiver are discussed.

621.385.029.63/.64 : 621.376.3 2973

Voltage-Tuned Magnetron for F.M. Applications.—T. R. Bristol & G. J. Griffin, Jr. (*Electronics*, 1st May 1957, Vol. 30, No. 5, pp. 162–163.) "Stacked metal-ceramic miniature magnetron operating in 2-kMc/s to 4-kMc/s range has average power capabilities up to 10 W. Effects of operation in tapered S-band waveguide and ridged waveguide are given and normal operating characteristics together with present and future applications are discussed."

621.385.029.64 2974

Backward-Wave Oscillators for the 17- to 41-kMc/s Band.—J. A. Noland & R. E. Lepic. (*Sylvania Technologist*, Jan. 1957, Vol. 10, No. 1, pp. 13–16.) Two backward-wave oscillators for use as local oscillators are described; the frequency ranges covered are 17–27 kMc/s and 26·5–41 kMc/s.

621.385.032.2 2975

High-Perveance Electron Guns.—R. Hechtel. (*Arch. elekt. Übertragung*, Dec. 1956, Vol. 10, No. 12, pp. 535–540.) Various methods of obtaining high perveance are outlined. Pierce's formula for calculating perveance was amplified to cover higher values and applied to a gun having a perveance of 5 $\mu A/V^{3/2}$; the calculated results were verified experimentally.

621.385.032.2 : 539.23 : 537.533.9 2976

The Electron Bombardment of Thin Barium Films.—L. Jacob. (*Proc. phys. Soc.*, 1st Feb. 1957, Vol. 70, No. 446B, pp. 235–239.) Describes how barium is deposited as a thin film on a strontium oxide cathode by electron bombardment.

621.385.032.213 2977

Evaporation of Barium from Impregnated Cathodes.—I. Brodie & R. O. Jenkins. (*J. Electronics*, March 1957, Vol. 2, No. 5, pp. 457–476.) For cathodes impregnated with barium aluminate, the evaporation of barium increases rapidly when the barium-oxide/alumina molar ratio exceeds 3. The addition of calcium oxide inhibits the rate of evaporation.

621.385.032.213 2978

Studies on the Mechanism of Operation of the L Cathode: Part 1.—E. S. Rittner, R. H. Ahlert & W. C. Rutledge. (*J. appl. Phys.*, Feb. 1957, Vol. 28, No. 2, pp. 156–167.) The emission, evaporation rate, evaporant composition and consititution of the emitting surface were examined. Activation of the tungsten plug comes from strongly adsorbed BaO issuing from the pores. The active surface consists of a nearly complete oxygen monolayer covered by a complete barium monolayer. The emission approaches the maximum possible for a barium-activated tungsten dispenser cathode.

621.385.032.213 2979

Studies on the Mechanism of Operation of the L Cathode: Part 2.—W. C. Rutledge & E. S. Rittner. (*J. appl. Phys.*, Feb. 1957, Vol. 28, No. 2, pp. 167–173.) An experimental study including the chemistry of carbonate decomposition and barium generation, the origin of BaO in the evaporant, the barium transport mechanism through the porous plug, and the factors determining cathode life.

621.385.032.216 **2980**

Application of a Mass Spectrometer in an Investigation of the Process of Activation of an Oxide Cathode.—N. D. Morgulis & G. Ya. Pikus. (*Zh. tekh. Fiz.*, June 1956, Vol. 26, No. 6, pp. 1174–1176.) A study of the activation processes by gas analysis is reported.

621.385.032.216 : 537.582 : 537.543.2 **2981**

An Investigation into the Distribution of the Work Function over the Surface of an Oxide Cathode.—D. G. Bulyginski & L. N. Dobretsov. (*Zk. tekh. Fiz.*, June 1956, Vol. 26, No. 6, pp. 1141–1149.) A method is proposed for measuring the distribution of the work function in the case of heterogeneous cathodes, and a detailed report is presented on these measurements for various states of activation of an oxide cathode. The data obtained are sufficient for giving a quantitative indication of the maximum and minimum values of the work functions, their variation with temperature, etc. The local work functions have a positive temperature coefficient, the value of which is higher, the greater the work function itself.

621.385.2 **2982**

The Cylindrical Diode.—D. A. Bell & H. O. Berktay. (*J. Electronics*, March 1957, Vol. 2, No. 5, pp. 425–435.) The following features of the cylindrical thermionic diode are reviewed: (*a*) current density, with and without allowance for initial electron velocities, (*b*) the retarding-field characteristic, (*c*) shot noise under space-charge-controlled conditions.

621.385.2 **2983**

Thermal Fluctuations in Space-Charge-Controlled Diodes.—D. A. Bell. (*J. Electronics*, March 1957, Vol. 2, No. 5, pp. 477–488.) If, in the analysis, the conservation of energy is taken into account when compounding the thermal and drift velocities of electrons in transit, then larger fluctuations are predicted than if thermal and drift velocities are linearly superimposed. For both planar and cylindrical diodes the former treatment is more nearly in accord with experimental observations.

621.385.2 **2984**

Initial-Current Establishing Processes in a Planar Diode with an External Magnetic Field.—Yu. V. Pimenov. (*Zh. tekh. Fiz.*, Sept. 1956, Vol. 26, No. 9, pp. 1955–1965.) The initial build-up of current, under space-charge limit conditions, following the application of a pulse voltage to the anode is considered theoretically.

621.385.3 : 621.373.4 **2985**

The Stability of Oscillations of a Triode.—L. Sidériades. (*Onde élect.*, Jan. 1957, Vol. 37, No. 358, pp. 48–54.) The analysis outlined is based on the topological method applied to an equivalent dynamic system. By means of isoclines the cyclic limits of stable oscillation are found. Experimental verification is provided by the integral curves obtained on a c.r.tube screen.

621.385.3 : 621.373.421.14 **2986**

The High-Power Long-Pulse Triode Type TH470 and Associated Circuits.—(*Rev. tech. Comp. franç. Thomson-Houston*, Dec. 1956, No. 24, pp. 9–29.)

Part 1—Special Problems of High-Frequency Pulse Generators Used in Particle Accelerators.—E. P. Courtillot (pp. 11–12).

Part 2—Investigation of Valve Type TH470.—J. Péhé (pp. 13–20).

Part 3—2-MW Peak Pulse Generator.—J. Afanassieff (pp. 21–29).

621.385.3 : 621.373.421.14 **2987**

The Triode Type TH1500 M2.—M. Descarsin. (*Rev. tech. Comp. franç. Thomson-Houston*, Dec. 1956, No. 24, pp. 31–39.) The valve described is used in 100- or 200-Mc/s radar pulse generators.

621.385.4 : 546.817.221 : 621.396.822 **2988**

Investigation of the Noise of Lead Sulphide Photoresistors.—A. I. Goryachev & K. A. Yumatov. (*Radiotekhnika i Elektronika*, Dec. 1956, Vol. 1, No. 12, pp. 1503–1514.) Results are presented of an experimental investigation of the dependence of noise on operational conditions and on the dimensions of the photoresistors. The results are tabulated and presented graphically.

621.385.83 **2989**

Systems with Centrifugal Electrostatic Focusing of the Electron Beam.—Z. S. Chernov. (*Radiotekhnika i Elektronika*, Nov. 1956, Vol. 1, No. 11, pp. 1428–1434.)

621.385.832 **2990**

Errors of Magnetic Deflection: Part 1.—J. Haantjes & G. J. Lubben. (*Philips Res. Rep.*, Feb. 1957, Vol. 12, No. 1, pp. 46–68.) A detailed analysis of the deflection errors in c.r. tubes. With the exception of those due to curvature of the image field, most errors can be reduced by suitable distribution of the deflecting field.

621.385.832 **2991**

Viewing Storage Tubes for Large Displays.—H. O. Hook, M. Knoll & R. P. Stone. (*RCA Rev.*, Dec. 1956, Vol. 17, No. 4, pp. 503–514.) Two experimental tubes are described. One provides a 10-in.-dia. display for direct viewing with 250 foot-lamberts highlight brightness; the second is a projection tube with a $4\frac{1}{2}$-in. spherical luminescent screen providing more than 5 000 foot-lamberts brightness. Resolution is better than 500 lines. For an earlier 4-in. halftone viewing storage tube, see 308 of 1955 (Knoll et al.).

621.385.832 : 621.397.6 **2992**

Calculation of Resolving Power of an Electron-Optical [image] **Converter with Uniform Fields.**—B. E. Bonshtedt, T. G. Dmitrieva & I. I. Tsukkerman. (*Zh. tekh. Fiz.*, Sept. 1956, Vol. 26, No. 9 pp. 1966–1968.) Criticism of an assumption made by DeVore (2385 of 1948) and Wendt (1918 of 1956) in deriving an expression for the resolving power.

621.385.833.032.2 **2993**

A Contribution on the Triode System of the Cathode-Ray-Tube Electron Gun.—M. E. Haine. (*J. Brit. Instn Radio Engrs*, April 1957, Vol. 17, No. 4, pp. 211–216.) An analysis of published experimental data suggests the system suffers from severe spherical aberration, arising from the field close to the cathode. If this limitation were overcome, a reduction in beam diameter and cathode loading would be possible.

621.387 : 621.318.57 **2994**

Cold-Cathode Gas Tubes for Telephone Switching Systems.—M. A. Townsend. (*Bell Syst. tech. J.*, May 1957, Vol. 36, No. 3, pp. 755–768.)

MISCELLANEOUS

001.891 : 621.396 (54) **2995**

Programme for Radio Research in India.—(*J. sci. industr. Res.*, Dec. 1956, Vol. 15A, No. 12, pp. 550–552.) Outline of a 5-year program drawn up on behalf of the Council of Scientific and Industrial Research, India.

061.4 **2996**

Instruments Electronics Automation Exhibition, 1957:—Review of Equipment.—(*Instrum. Practice*, June 1957, Vol. 11, No. 6, pp. 631–656.)

061.6 **2997**

Report of the Max Planck Society for the Advancement of Science, for the Period 1st April 1954 to 31st March 1956.—(*Naturwissenschaften*, Dec. 1956, Vol. 43, No. 24, pp. 545–580.) Summaries of the activities of the Institute for Ionospheric Research and of the Computer Group are included.

538.569.2.047 **2998**

Maximum Permissible Radiation Exposures to Man.—(*Tech. News Bull. nat. Bur. Stand.*, Feb. 1957, Vol. 41, No. 2, pp. 17–19.) A preliminary statement of the U.S. National Committee on Radiation Protection and Measurement on new safe limits. The recommendations on protection against betatron-synchrotron radiations up to 100 MeV are published in *National Bureau of Standards Handbook* H55. A list of other handbooks is appended.

621.3.049.75 **2999**

Testing of Foil-Clad Laminates for Printed Circuitry.—T. D. Schlabach, E. E. Wright, A. P. Broyer & D. K. Rider. (*ASTM Bull.*, May 1957, No. 222, pp. 25–30.) Methods of testing insulation resistance, peel strength, solder-dip resistance, water absorption, volume and surface resistivity by means of specially designed test specimens are described and discussed. An arrangement of these specimens forming a composite test pattern has been developed for etching foil-clad laminates so that the various parameters can be tested on a given sample.

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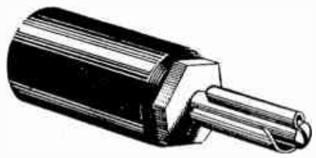

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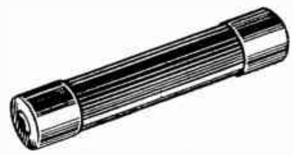

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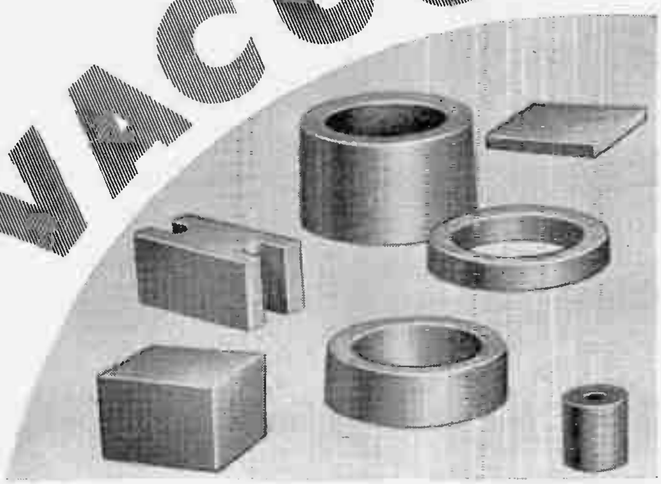

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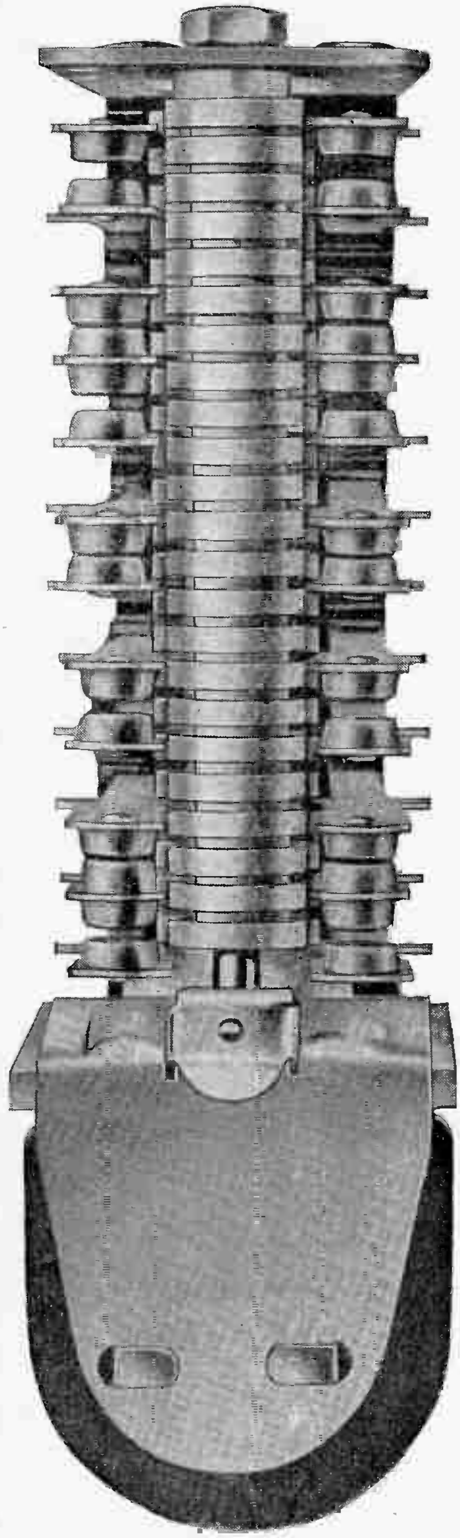

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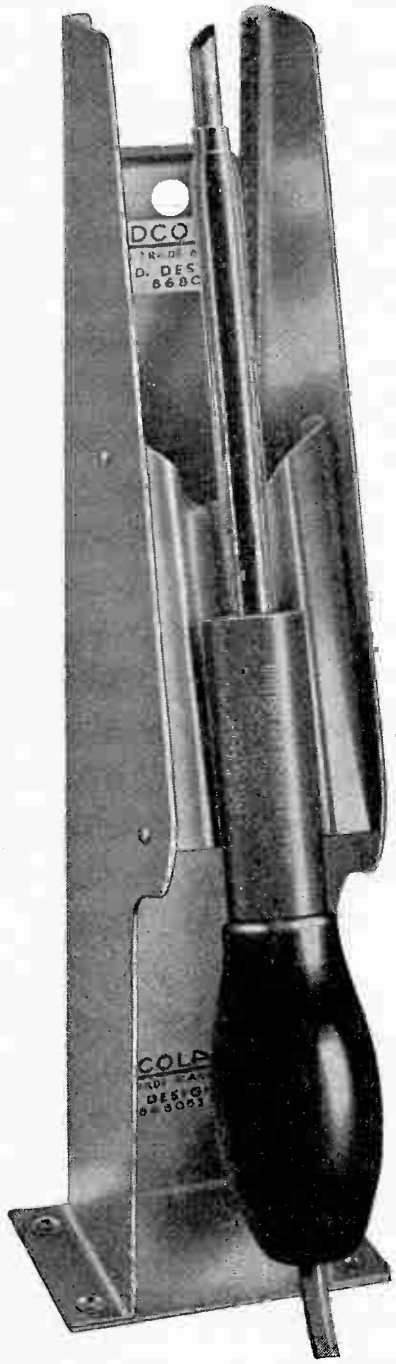

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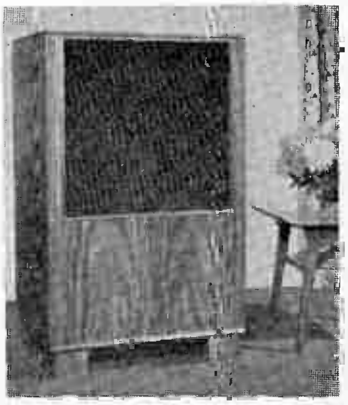

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Accepted as a standard for high-quality monitoring by broadcasting, television and recording studios throughout the world, this cabinet is also suitable in every way for the home.

* THE LOCKWOOD STANDARD LOUDSPEAKER CABINET has been developed from the Monitoring Loudspeaker Cabinet used by the B.B.C. (B.B.C. Patent No. 696,671).

**Wireless World* Nov. and Dec. 1950.

Two versions are available: Major Model . . £35 Minor Model . . £25

Brochure free on request.
Export and Tropical Models available. Trade enquiries invited.

Demonstrations by
City Sale and Exchange Ltd., 93/94 Fleet Street, E.C.4. *Telephone FLE.* 9391/2
Musicraft, 20/22 High Street, Southall, Middx. *Telephone SOUthall* 3828
and 13 King Street, Richmond, Surrey. *Telephone RIChmond* 6798

LOCKWOOD *Acoustically Designed Cabinets*

LOCKWOOD & COMPANY (Woodworkers), LTD., LOWLANDS ROAD, HARROW, MIDDX. *BYRon* 3704

VARIACS for S-M-O-O-T-H Voltage Control

'VARIAC' is the *original*, continuously adjustable auto-transformer—and the only one having 'DURATRAK', a specially treated track surface. For varying the a-c voltage applied to any electrical, electronic, radar or communications equipment a 'VARIAC' offers considerable advantages over any other type of a-c control—it has longer life, absolute reliability, much increased overload capacity, resistance to accidental short-circuits and appreciably greater economy in maintenance. Voltages from zero to 17% above line are obtained by a 320° rotation of the shaft, which is equipped with an accurately calibrated direct-reading dial. Available in various sizes from 170 VA up to 25 kilowatts, including 3-gang assemblies for 3-phase working, 'VARIACS' are competitively priced, and, compared with the losses of resistive controls often save their initial cost within a year.

Most "VARIACS" are now MUCH REDUCED IN PRICE: send for our new, profusely illustrated Catalogue 424-UK/16, which gives complete information on the entire range. HUNDREDS of models — all available promptly — most EX STOCK.

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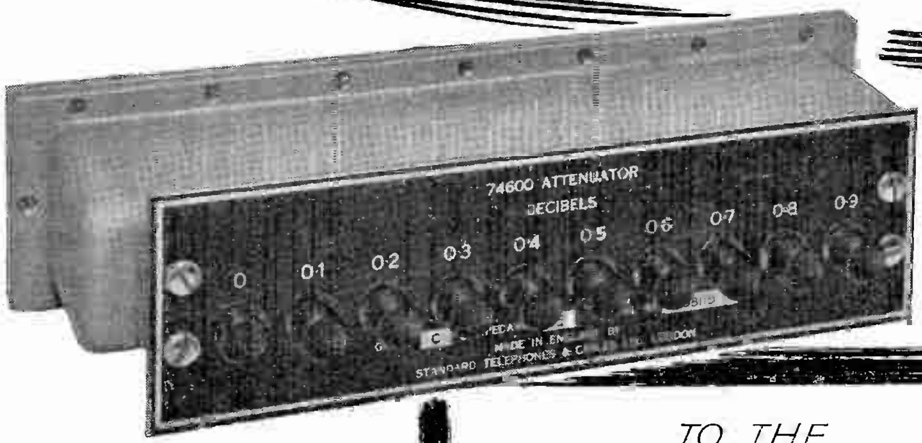
CL31R

A further addition



TO THE

Standard Push Button attenuator RANGE

for

PRECISION ATTENUATION

Model 'C'

0—0.9 db in 0.1 db steps
75 ohm characteristics impedance

D.C. Adjustment - Accuracy
The insertion loss error will not exceed ± 0.002 db per step.

High Frequency Performance
At 50 Mc/s the insertion loss error for 0.9 db setting will not exceed ± 0.015 db.

For other settings this limit falls linearly to a value of ± 0.006 db at the 0.1 db setting.

This attenuator forms part of the 74600 series.

Model A	0—9 db in 1 db steps
Model B	0—90 db in 10 db steps
Model C	0—0.9 db in 0.1 db steps

£25 EACH

OR COMPLETE SET, MODELS A, B & C **£72**

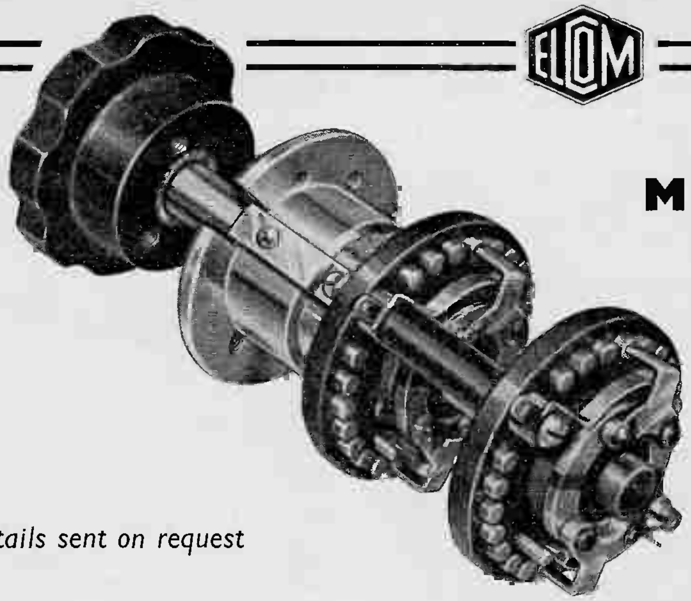
Quantities of 12 or more subject to discount

AVAILABLE FROM PRODUCTION

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

TRANSMISSION DIVISION: NORTH WOOLWICH · LONDON E.16



Full details sent on request

TYPE 200
MINIATURE ROTARY STUD SWITCH

Developed by ELCOM to meet increasing demand for a miniature rotary stud switch, the type 200 is a worthy addition to the ELCOM range of instrument quality stud switches of robust construction and although going far towards miniaturisation, retains all the established design features already well proven in the larger components of this range.

ATTENUATORS • FADERS • ROTARY STUD SWITCHES • PLUGS AND SOCKETS
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ELECTRONIC COMPONENTS

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A selection of the range of standard magnets is illustrated and dimensional details given.

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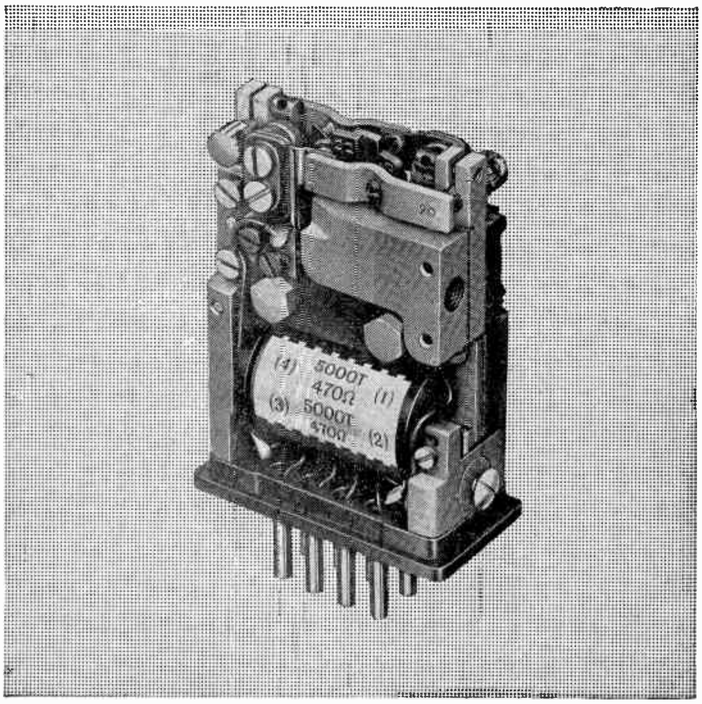
Telephone: Rainham, Essex 3322. Telex 28632. Telegrams: Murex, Rainham-Dagenham Telex
LONDON SALES OFFICE: CENTRAL HOUSE, UPPER WOBURN PLACE, W.C.1.

Now in production!

The Centre-Stable

TYPE 51M CARPENTER POLARIZED RELAY



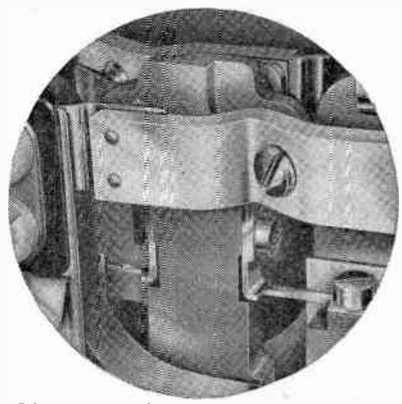
DIMENSIONS (excluding connecting tags and guide pins):
HEIGHT: $2\frac{3}{8}$in. WIDTH: $1\frac{17}{32}$in. DEPTH: $\frac{25}{32}$ in.

This new highly sensitive *centre-stable** polarized relay is a development of the well-known Type 5 Carpenter Relay.

Like its companion—the *each-side-stable* Type 51A relay—the 51M's high performance is due largely to a new form of armature suspension, and the provision of variable slugs for adjusting the flux of the polarizing magnets thereby enabling the magnetic and mechanical parameters to be balanced with greater precision than has hitherto been possible.

With a sensitivity of approximately 10μW, the Type 51M relay is ideally suited for use as a sensing relay in Servo Systems, or as a detector in self balancing bridge circuits. Fitted with S.P.D.T. contact action, the relay is available in sealed or non-sealed forms.

For further details send for leaflet F.3526 which gives information of operating characteristics and the available range of coils.



Close-up of armature suspension —magnet removed

* *In the centre-stable form, the armature of the relay remains in a central position between the side-contacts when the relay is unenergized, and moves to one or other side-contact when current is applied to the coil.*

TMC TRADE MARK

Manufactured by the sole licensees:

TELEPHONE MANUFACTURING COMPANY LTD
HOLLINGSWORTH WORKS, DULWICH, LONDON SE21

Telephone: GIPsy Hill 2211

3 new G.E.C. valves for R.F. heating

ACT 100 · ACT 101 · ACT 102

Features of this new range of R.F. Heating Valves:—

Robust construction techniques have been employed throughout to ensure that these valves are suitable for use under the arduous conditions often experienced in industry.

Long operating life is designed into the generously rated thoriated tungsten filaments.

Efficient performance has been secured without overstressing the capabilities of the grids or using close interelectrode spacings.

Safe electrical ratings are selected to ensure that reasonable overload conditions can be tolerated.

Internal 'flashover' trouble is eliminated by the use of specially selected grid material.

The following table gives brief data concerning these values :

	HEATER		MAXIMUM RATINGS				TYPICAL PERFORMANCE					
	V_f	I_f	V_a	$i_{k(pk)}$	P_a	P_g	V_a	I_a	P_a	P_g	P_{out}	P_{load}
ACT 100	6.5V	95A	8.5kV	20A	5kW	750W	5kV 6kV	3.0A 2.9A	4.1kW 5.0kW	570W 290W	11kW 15kW	8.4kW 12.5kW
ACT 101	7.0V	250A	10kV	35A	10kW	1kW	6.5kV 10kV	5.75A 4.4A	10kW 10kW	800W 350W	27.5kW 34kW	22kW 28kW
ACT 102	9.0V	250A	12kV	45A	20kW	1.25kW	10.5kV 11.5kV	7.55A 7.55A	17.5kW 18.2kW	1.09kW 1.00kW	61.8kW 68.7kW	51kW 56kW

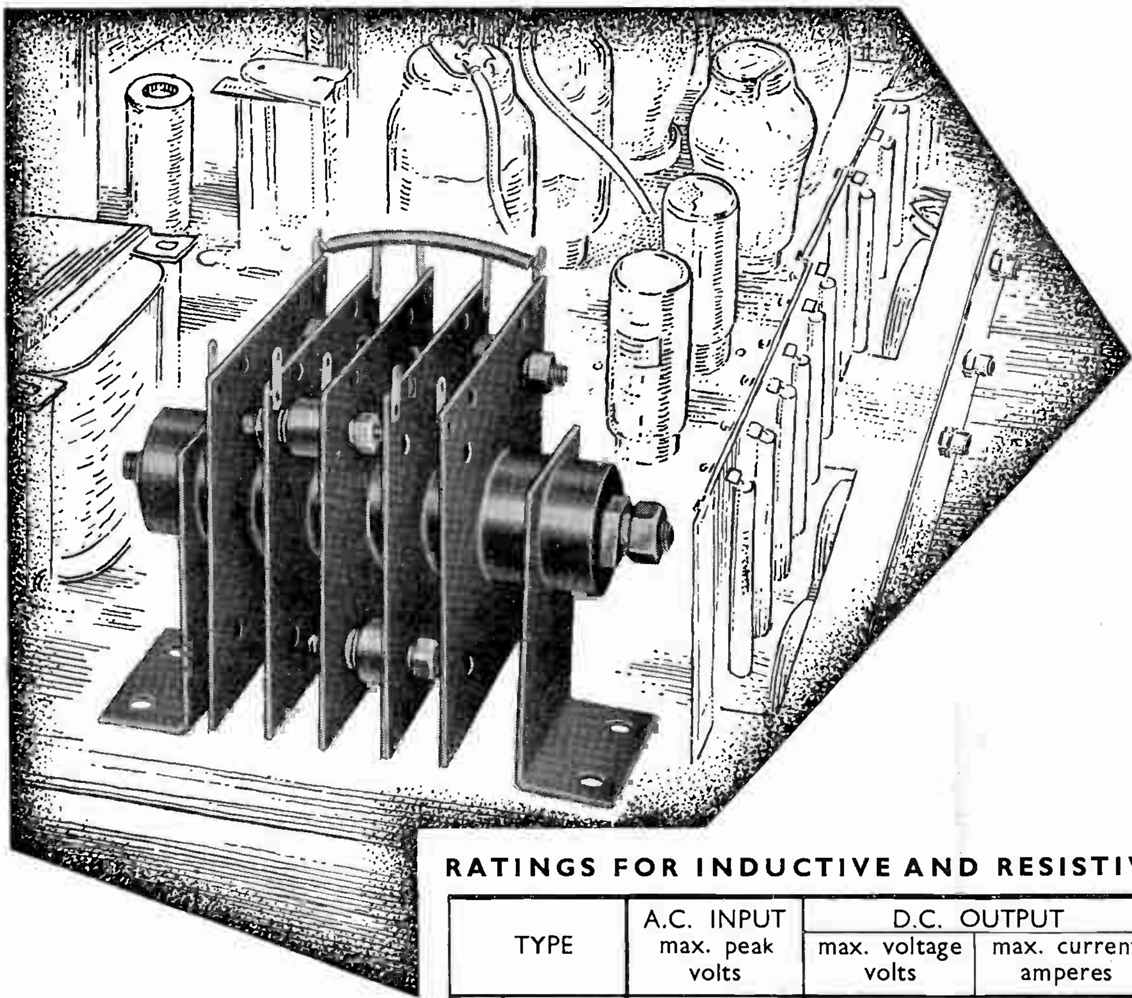
★ *A transfer efficiency of 85% is assumed*

NOTE: Water-cooled versions of the ACT 100, ACT 101 and ACT 102 are also available.

For full particulars write to the G.E.C. Valve and Electronics Dept.

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

GERMANIUM JUNCTION RECTIFIERS
— finned bridge units



RATINGS FOR INDUCTIVE AND RESISTIVE LOADS

	TYPE	A.C. INPUT max. peak volts	D.C. OUTPUT max. voltage volts	D.C. OUTPUT max. current amperes	OVERALL LENGTH inches
SINGLE-PHASE	GA31-A	140	125	2·0 at 40°C	$3\frac{1}{2}$
	GA41-A	53	47	2·0 at 60°C	$3\frac{1}{2}$
	GA51-A	210	187	2·0 at 40°C	$3\frac{1}{2}$
	GA61-A	106	94	2·0 at 60°C	$3\frac{1}{2}$
	GA52-A	340	303	2·0 at 40°C	5
	GA62-A	170	151	2·0 at 60°C	5
	GA53-A	510	455	2·0 at 40°C	$6\frac{1}{2}$
	GA63-A	254	227	2·0 at 60°C	$6\frac{1}{2}$
THREE-PHASE	GB31-A	140	188	3·0 at 35°C	$4\frac{5}{8}$
	GB41-A	53	71	3·0 at 55°C	$4\frac{5}{8}$
	GB51-A	210	283	3·0 at 35°C	$4\frac{5}{8}$
	GB61-A	106	143	3·0 at 55°C	$4\frac{5}{8}$
	GB52-A	340	458	3·0 at 35°C	$6\frac{3}{4}$
	GB62-A	170	229	3·0 at 55°C	$6\frac{3}{4}$

The well-known range of BTH germanium junction rectifiers is now available made up into convenient bridge units ready for incorporation in your equipment.

BRITISH THOMSON-HOUSTON

THE BRITISH THOMSON-HOUSTON CO., LTD., RUGBY ENGLAND

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A5184

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(Foreign Office)

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TWO SCIENTIFIC OFFICERS

Candidates must be British subjects or citizens of the Irish Republic born within the Commonwealth, or in the Irish Republic of parents born within those territories.

The Senior Scientific Officer should possess Honours Degree in Physics or Engineering, or equivalent qualifications, and have at least three years' experience of working on radio or electronic equipment.

Scientific Officers should possess similar qualifications.

Salary:

Senior Scientific Officer: £1,078 rising to £1,265 p.a.
Scientific Officer: £565 rising to £995 p.a.

Closing date for applications ten days from the appearance of this advertisement.

Write, giving age, qualifications and experience to:

CHIEF ESTABLISHMENT OFFICER
DIPLOMATIC WIRELESS SERVICE
FOREIGN OFFICE
LONDON, S.W.1

Digital Data Processing

The SHAPE Air Defense Technical Center is increasing its activity in the field of high-speed digital data-processing.

Applications are invited from suitably qualified persons with interest in one or more of the following fields:

- Digital computation
- High-speed analog-digital conversion
- Computer input and output devices
- Transistor and magnetic-core techniques, applied to computers
- Cathode-ray tube displays.

The basic salaries will be based on the European average for corresponding background and experience. Successful applicants from foreign countries will benefit by a number of privileges, including a foreign allowance of the order of 70% of the basic salary, and reimbursement of the cost of moving their families and household effects to The Hague and back to their country of origin on termination of contract. The total income is tax free in the Netherlands.

Applications, containing detailed information on training and past experience, should be sent as soon as possible to:

The Director
SADTC, P.O. BOX 174, THE HAGUE
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Fairey Aviation want Engineers and Scientists to work on the design and development of:-

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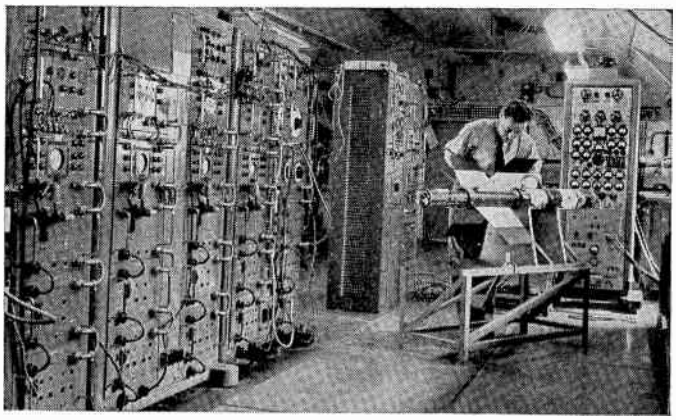
FAIREY'S widespread activities offer numerous opportunities for soundly-qualified men with the right training or experience. If you are confident that you have the qualifications and keenness to join the team that, among other achievements, produced FIREFLASH, Britain's first production guided weapon, write to the address below: give your full details, including your own preference for the more specialised types of work.

Vacancies exist for Aerodynamicists · Physicists · Electronic Engineers · Instrument Design Engineers · Mechanical Test Engineers Stressmen · Graduates (in Engineering or Science) · Draughtsmen (Electronic, Jig and Tool, Mechanical Design and Detail).

The illustration shows functional testing of a FIREFLASH Guided Weapon in the Laboratories—one aspect only of the interesting and varied work awaiting you at Fairey Aviation.



THE FAIREY AVIATION COMPANY LTD
Weapon Division
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ELECTRONIC & RADIO ENGINEER

CLASSIFIED ADVERTISEMENTS

Advertisement Rates. 6*d. per word, minimum charge* 6/-, *each paragraph charged separately. Remittances payable to Iliffe & Sons Ltd., Dorset House, Stamford St., S.E.*1. *Series discount of* 15% *is allowed for* 12 *consecutive insertions.*

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Press date for the October 1957 issue is first post 26th September 1957

SITUATIONS VACANT

APPLICATIONS
are invited for pensionable posts
as
EXAMINERS
in the
PATENT OFFICE

TO undertake the official scientific, technical and legal work in connexion with Patent applications.
AGE at least 21 and under 35 years on 1st January, 1957, with extension for regular Forces' service.
CANDIDATES must have (or obtain in 1957) 1st or 2nd Class Honours in Physics, Organic or Inorganic Chemistry, Mechanical or Electrical Engineering or in Mathematics, or an equivalent qualification, or have achieved a professional qualification, e.g. A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., A.R.I.C. For a limited number of vacancies candidates with 1st or 2nd Class Honours degrees in other subjects—scientific or otherwise—will be considered. Exceptionally, candidates otherwise qualified by high professional attainments will be considered.
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APPLICATION form and further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S128/57 and stating date of birth.
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CHIEF ENGINEER, TELECOMMUNICATIONS DEPARTMENT,
Mauritius

TO be responsible for the Engineering Branch, particularly for the installation and maintenance of C.B. and Automatic Exchanges, training of technical staff and, as necessary, to take charge of the department.
PERMANENT and pensionable appointment or contract appointment for three years. Salary £1,327 10*s.* p.a., plus cost-of-living allowance. Contract gratuity—£50 for each three months' resident service. Free passages for officer, wife and up to three children. Quarters, if available. Generous leave.
CANDIDATES must be A.M.I.E.E. or be exempted from the Institution's examinations, and have considerable practical experience in maintenance and installation of telecommunications equipment particularly automatic exchanges.
WRITE Director of Recruitment, Colonial Office, London, S.W.1, giving age, qualifications and experience, quoting BCD133/52/01. [1111

BOROUGH POLYTECHNIC
Principal: J. E. GARSIDE, M.Sc.Tech., Ph.D., F.R.I.C., F.I.M., M.Inst.F.
Department of Electrical Engineering and Physics

APPLICATIONS are invited, from suitably qualified persons, for inclusion on the panel of part-time teaching staff in all branches of Electrical Engineering and Physics.
FORMS of application may be obtained from the undersigned.
FREDK. J. PACKER, Secretary and Clerk to the Governor, Borough Polytechnic, Borough Road, S.E.1. [1109

SITUATIONS VACANT

AMENDED ADVERTISEMENT
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APPLICATIONS are invited for the following appointments in the School of Electronics of the Automatic Telephone & Electric Company, Limited, Liverpool.

Senior Lecturer ... **One Post**
Lecturer ... ... **Two Posts**

THE work is post-graduate in nature, and involves lecturing on modern electronic technique as applied to communication engineering.
CANDIDATES should possess an honours degree in either
(*a*) Electrical engineering with electronics or telecommunications.
(*b*) Physics, with electronics and/or mathematics.
SALARIES will be in accordance with the Burnham Technical Scale. Persons appointed will be required to join the Company's superannuation scheme. Assistance can be given with housing in suitable cases.
APPLICATION forms and details may be obtained from:
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AUTOMATIC TELEPHONE & ELECTRIC CO., LTD.,
STROWGER WORKS,
LIVERPOOL, 7
[1107

PHYSICIST

AUTOMATIC Telephone & Electric Co., Ltd., Liverpool, have a vacancy for a qualified Physicist for their laboratories at their Main Works at Liverpool.
CANDIDATES should be of graduate standard or equivalent, with reasonable knowledge of chemistry and the work is on projects involving insulating materials, dielectrics, and applied industrial physics. Some experience in this field is desirable, but not essential.
THE post will be on the permanent staff, with generous Contributory Pension Fund.
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A. T. & E. CO., LTD.
STROWGER WORKS,
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[1116

CONTRACT ENGINEER (ELECTRICAL)
required by
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THE appointment offers a high career opportunity for a young man of up to about 30 years of age with a rapidly expanding company which is a member of the A.E.I. Group. The duties cover the administration of large customer contracts for nuclear power station control equipment, clerical industry panels and similar equipment.
APPLICANTS should have served an apprenticeship or have had equivalent practical experience in the Electrical Industry, and must possess at least O.N.C.
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PLEASE apply to the Personnel Officer, Sunvic Controls, Limited, Harlow, Essex. [1104

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VACANCIES exist in the Research Department of a large instrument manufacturing organisation in South-east Essex for
GRADUATE PHYSICISTS
or
ELECTRICAL ENGINEERS
of merit and some years of industrial experience for the investigation of long-term problems associated with Echo-sounding and Non-destructive testing.
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APPLICATIONS, which may be made in strictest confidence, should give full details of qualifications, previous experience, age and salary required, and be addressed to Box 0352. [1093

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ELECTRONICS! Electronic Instruments, Ltd., Lower Mortlake Road, Richmond, Surrey, have vacancies for junior and semi-senior engineers for instrument final testing. These are staff positions offering interesting and various jobs with a bright future in this rapidly expanding company. Five-day week. Pension scheme. Apply to the Company giving qualifications and quoting reference T/ERE/A [1108

IF you are an Electronic Engineer and can write clear, grammatical English, we can offer you an interesting job as a technical writer at an excellent salary. Applicants must be capable of preparing instruction manuals, sales literature and technical articles on electronic laboratory instruments and industrial equipment. Apply, if possible with samples of your work, to Personnel Officer, Airmec, Limited, High Wycombe, Bucks. [1112

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(*a*) Servo analysis and synthesis.
(*b*) Practical investigation into the behaviour of servo systems.
(*c*) Application of simulator techniques to the study of servo systems.
STARTING salary will depend on qualifications and experience, while further progress in an expanding and progressive organisation is limited only by the ability of the individual to take further responsibility. Candidates should write, in confidence, to the Personnel Manager (Ref. 57c), de Havilland Propellers, Limited, Manor Road, Hatfield, Herts. [1105

SITUATIONS VACANT

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SERVICE

ASSEMBLY and Winding Capacity Electronic Equipment supervised by technicians experienced in modern technique applicable to computers, V.H.F. and high voltage oscilatory circuits. D.T.V. Contracts Dept., 134/136 Lewisham Way, New Cross, S.E.14. TIDeway 2330, Ext. 10. [1046

BOOKS, ETC.

"RADIO Laboratory Handbook." By M. G. Scroggie, B.Sc., M.I.E.E. This well-known practical work describing laboratory equipment and methods of operation has been entirely rewritten and greatly enlarged. Among the subjects considered are layout and furnishing of premises, methods of measurements, sources of power and signal measurements. There is a comprehensive reference section and many photographs, diagrams, graphs and tables. 25*s.* net from all booksellers. By post 26*s.* 6*d.* from Iliffe & Sons, Ltd., Dorset House, Stamford Street, S.E.1.

"RADIO Circuits: Step-by-Step Survey of Superhet Receivers," 3rd Edition. By W. E. Miller, M.A. (Cantab), M.Brit.I.R.E., Editor of *The Wireless and Electrical Trader*. Although this book deals mainly with the superhet receiver it is equally applicable to the straight set. The circuit of the superhet is dealt with section by section up to the complete receiver. 5*s.* net from all booksellers. By post 5*s.* 7*d.* from Trader Publishing Co., Ltd., Dorset House, Stamford Street, London, S.E.1.

TEXAS INSTRUMENTS LIMITED
A new British Company

TRANSISTOR APPLICATIONS ENGINEERS

required for the Engineering Division of this United Kingdom Manufacturing Subsidiary of Texas Instruments Incorporated, the world's leading transistor manufacturer.

This is a unique opportunity for qualified engineers or physicists with experience in circuit applications. Previous knowledge of semiconductors is not essential providing good experience has been obtained in any of the following:

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Salaries commensurate with age, ability and experience.

The Company operates a non-contributory Pension Scheme and Life Insurance and Family Medical Benefits.

Reply to:

General Manager (Technical)
Texas Instruments Limited
Dallas Road, Bedford

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"RADIO Interference Suppression: As Applied to Radio and Television Reception." By G. L. Stephens, A.M.I.E.E. 2nd Ed. An up-to-date guide to the various methods of suppressing electrical interference with radio and television reception. Many practical applications are given, particular attention being paid to the problem of interference at television frequencies. Other chapters deal with the design and choice of suppressor components, methods of locating the source of interference, and suppression at the receiver itself. 10*s.* 6*d.* net from all booksellers. By post 11*s.* 1*d.* from Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1.

"SECOND Thoughts on Radio Theory." By *Cathode Ray* of WIRELESS WORLD. Forty-four articles reprinted from popular WIRELESS WORLD series, in which the author examines various aspects of elementary radio science, explains them clearly, and shows that there may be more behind them than is apparent from the usual text-book. This volume deals with basic ideas; circuit elements and techniques; circuit calculations; and some matters in lighter mood. An entertaining and helpful text-book for the student, refresher course for the engineer, and reference book for all, combined. 25*s.* net from all booksellers. By post 26*s.* 2*d.* from Iliffe & Sons, Ltd., Dorset House, Stamford Street, S.E.1.

BOROUGH POLYTECHNIC
Borough Road . S.E.1

TRANSISTORS

A course of twenty lectures on the basic principles of design and operation of transistors and allied devices, and more advanced circuit design will be given on Tuesdays beginning 8th October, 1957. The lectures will be given at afternoon sessions 3.30 to 5.30 p.m. and repeated the same evening 7 to 9 p.m.

Fee for the course £2 10*s.*

Further details from the Secretary

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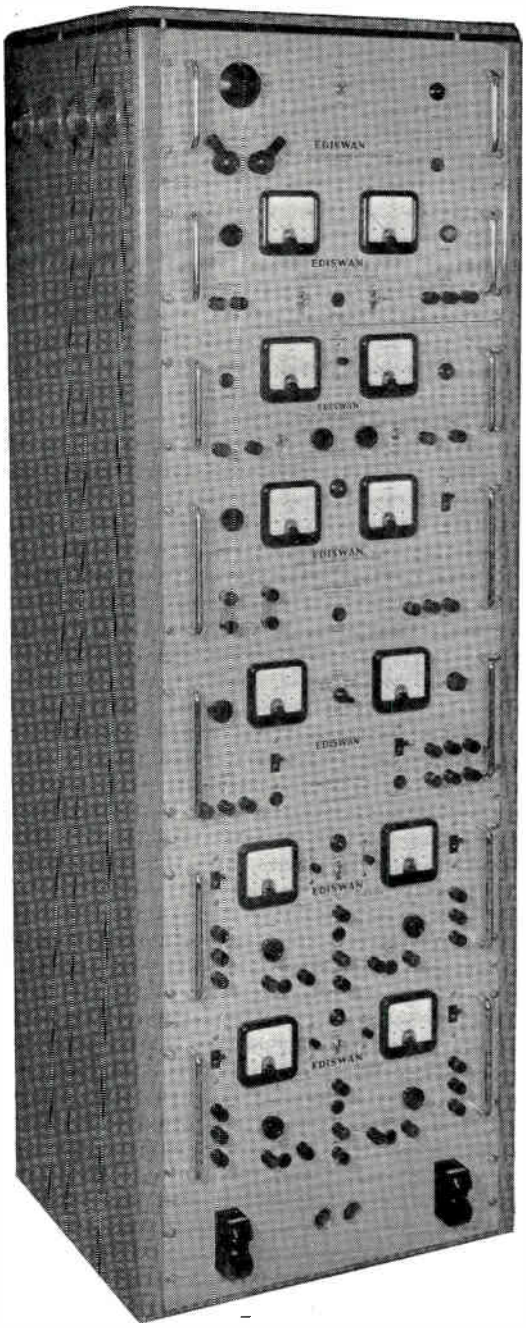

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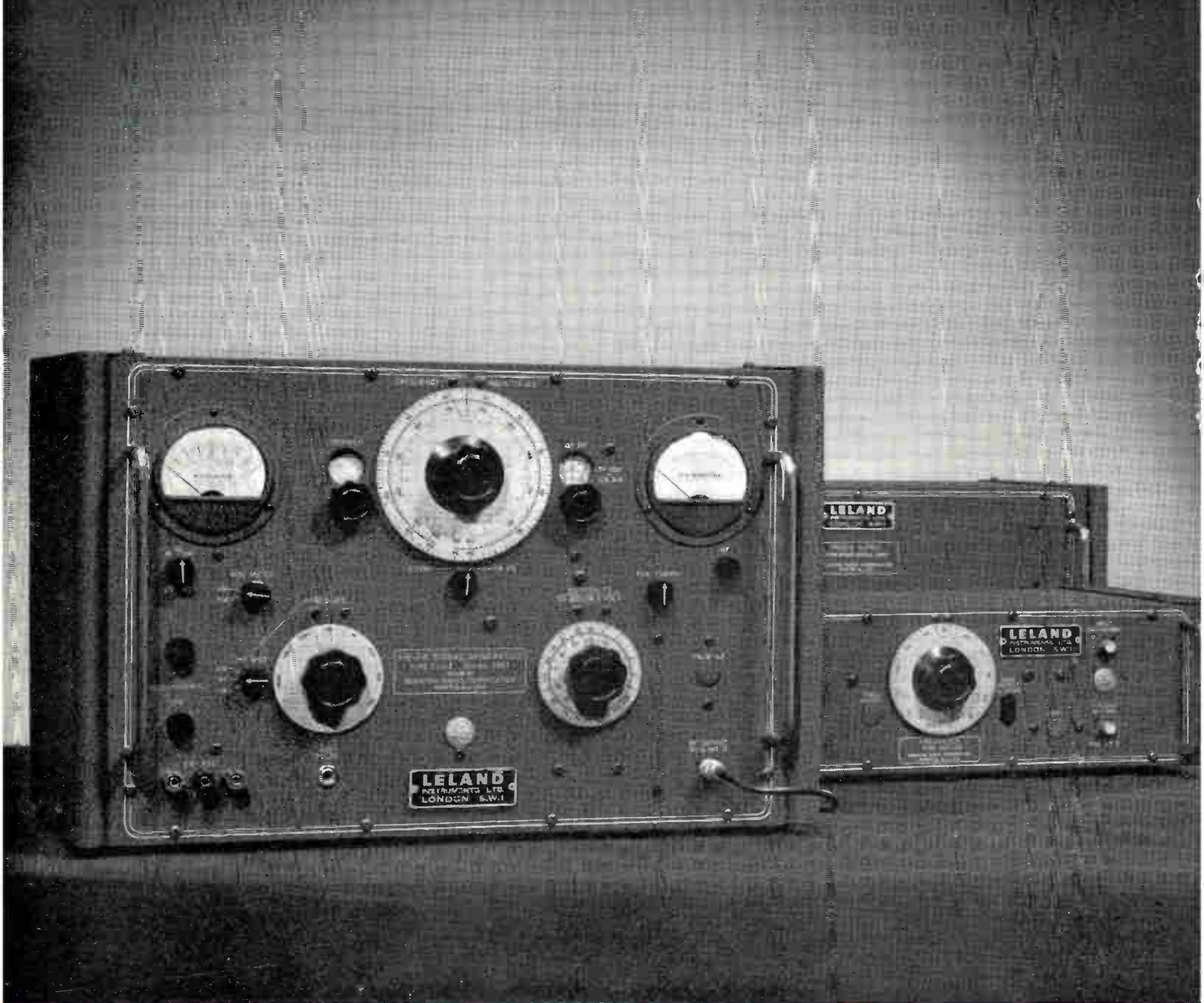
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