# WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

JULY 1956

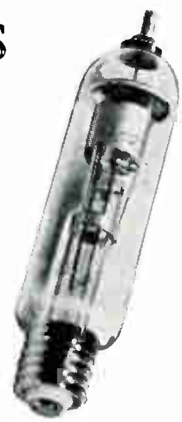
VOL. 33 No. 7 · THREE SHILLINGS AND SIXPENCE

# *Valves for R.F. Heating*

## POWER OSCILLATORS

*The increasing use in industry of R.F. heating has led to the development by the English Electric Valve Company of these two products. They are designed for R.F. generators of 6kW and upwards, and are particularly suitable for operation under factory conditions. Both the 10 kW and 20 kW types are available in air-cooled or water-cooled versions.*

## POWER RECTIFIERS



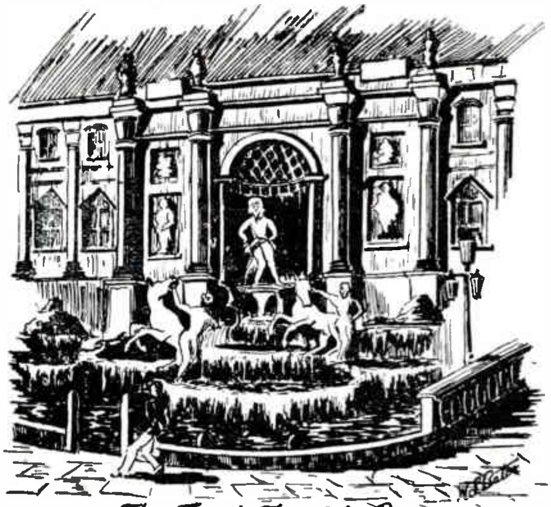
*These two power rectifiers, of 36 kW and 90 kW output, are particularly suitable for use with the power oscillators shown above. The English Electric Valve Company's range includes mercury-vapour filled and xenon filled rectifying valves with outputs from 7 kW to 630 kW. Full data will be sent on request.*

**'ENGLISH ELECTRIC'**

**ENGLISH ELECTRIC VALVE CO. LTD.**

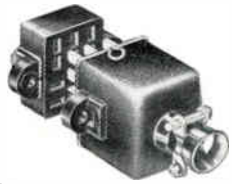
*Waterhouse Lane, Chelmsford*
*Telephone : Chelmsford 3491*

AP 300/38

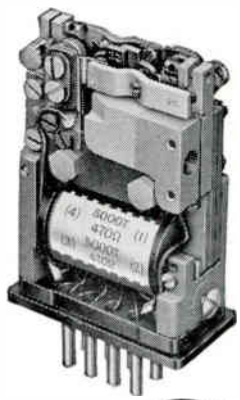


*The Trevi Fountain Rome.*

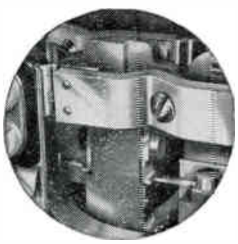












Consistency of Performance

# TRIAL BY STEAM

Sweltering in superheated steam may be some people's way of achieving perfection—Welwyn find this method ideal for *ensuring* it. For to test their hermetic sealing, Welmet metal film resistors undergo a Turkish Bath treatment in a pressure of two atmospheres. A drastic test indeed, but it proves beyond all doubt whether the vital gold-platinum alloy element is effectively protected. And it's part and parcel of the quality control that Welwyn practise with all their products.


MANUFACTURERS OF WELWYN ELECTRICAL COMPONENTS

**PROPERTIES OF THE WELMET INCLUDE:**

A load stability of 0·1%

No resistance change under tropical conditions

A rating of 1 watt at 70°C

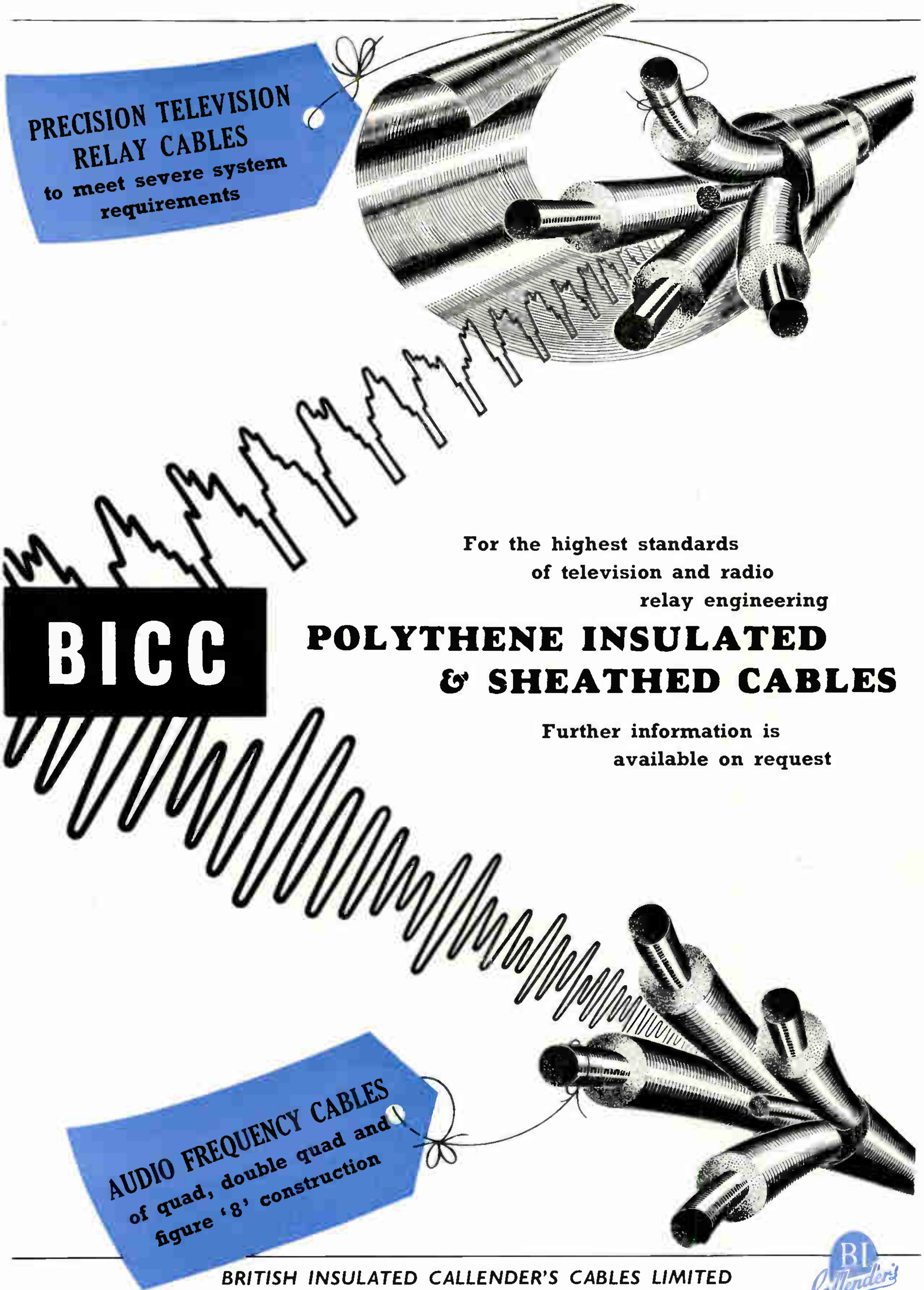
A range of values from 1000Ω to 1MΩ

Selection tolerances of ±1%, ±2% and ±5%

The maximum voltage is defined only by the dissipation

**WELWYN ELECTRICAL LABORATORIES LTD • BEDLINGTON • NORTHUMBERLAND**

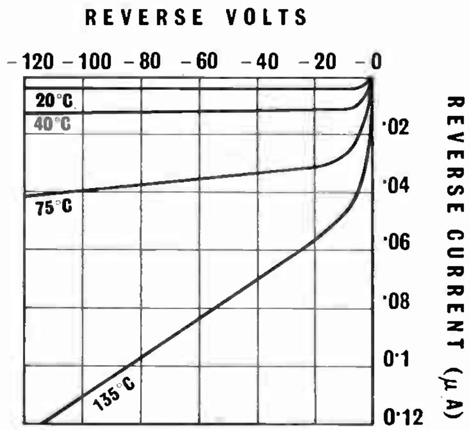
*On Admiralty, Ministry of Supply (A.I.D. approved) and Post Office Lists*


PRECISION TELEVISION RELAY CABLES
to meet severe system requirements
BICC
For the highest standards of television and radio relay engineering
POLYTHENE INSULATED & SHEATHED CABLES
Further information is available on request
AUDIO FREQUENCY CABLES
of quad, double quad and figure '8' construction
BRITISH INSULATED CALLENDER'S CABLES LIMITED
21 BLOOMSBURY STREET · LONDON, W.C.1
BI Callender's

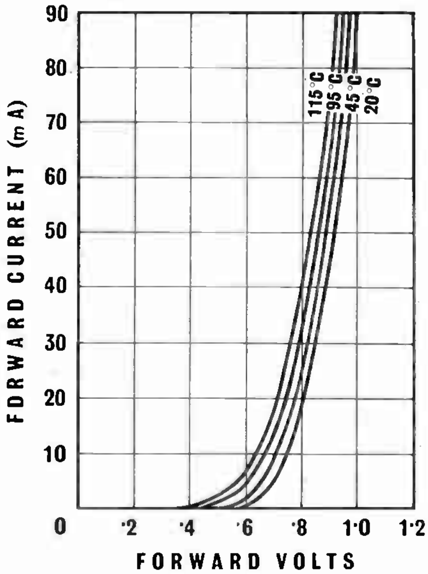
# Now in production!

## FERRANTI SILICON JUNCTION DIODES

| TYPE No. :— | | ZS10A. | ZS10B. | ZS20A. | ZS20B. |
|---|---|---|---|---|---|
| Max. P.I.V. | | 60 | 60 | 120 | 120 volts |
| Max. Voltage for 100mA. Forward Current | | 1·5 | 1·5 | 1·5 | 1·5 volts |
| Max. Reverse Current | | | | | |
| for — 50 volts at | 25°C | 0·05 | 0·5 | — | — μA |
| | 100°C | 1·0 | 5·0 | — | — μA |
| for — 120 volts at | 25°C | — | — | 0·05 | 0·5 μA |
| | 100°C | — | — | 1·0 | 5·0 μA |
| Max. Mean Dissipation at 20° C | | 150 | 150 | 150 | 150 mW |
| Max. Operating Temp. | | 150 | 150 | 150 | 150°C |

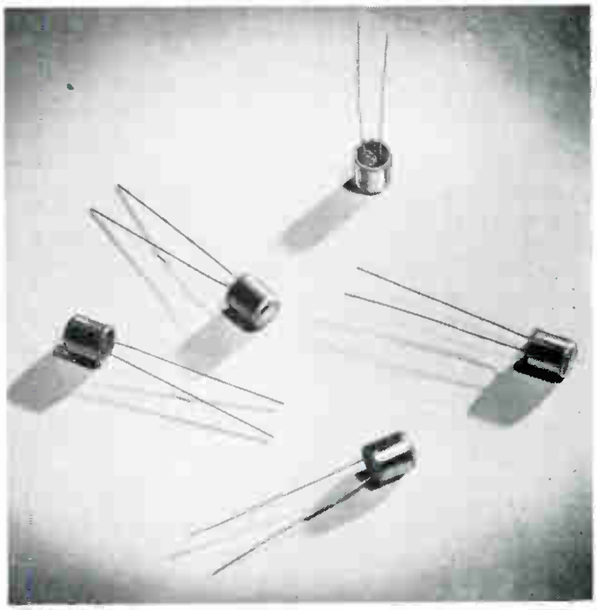



TYPICAL REVERSE CHARACTERISTICS




TYPICAL FORWARD CHARACTERISTICS

- LOW REVERSE CURRENT
- HIGH FORWARD SLOPE
- HIGH TEMPERATURE OPERATION
- SMALL PHYSICAL DIMENSIONS
- HIGH MECHANICAL STRENGTH



Overall length (including leads) 35 mm.

**FERRANTI LTD · GEM MILL · CHADDERTON · OLDHAM · LANCS**

*London Office* : KERN HOUSE, 36 KINGSWAY, W.C.2

FE165

# WIRELESS ENGINEER

**The Journal of Radio Research and Progress**

ESTABLISHED 1923

Managing Editor: HUGH S. POCOCK, M.I.E.E. Editor: W. T. COCKING, M.I.E.E.
Technical Consultant: Professor G. W. O. HOWE, D.Sc., LL.D., M.I.E.E.


---




Volume 33 Number 7


## CONTENTS


JULY 1956



Editorial: Television Picture Quality .. .. .. **157**

Oblique Transmission by the Meteoric E-Layer
*by R. Naismith* .. .. .. .. .. .. **159**

Klystron Control System (*Continued*)
*by R. J. D. Reeves* .. .. .. .. .. .. **162**

Parallel-T RC Networks
*by G. V. Buckley* .. .. .. .. .. .. **168**

D.F. Plotting Aid
*by H. G. Hopkins, B.Sc., Ph.D.* .. .. .. .. **173**

Correspondence .. .. .. .. .. .. **175**

MSF Standard Frequencies Expressed in Terms of the Caesium Resonance
*by L. Essen, D.Sc., Ph.D.* .. .. .. .. .. **178**

Abstracts and References. Nos. 1928-2270 .. **A.143-A.166**



*Published on the fifth of each month*

Annual Subscription: Home and overseas £2 9s. 0d.; Canada and U.S.A. $7.50
(*Including Annual Index to Abstracts and References*)

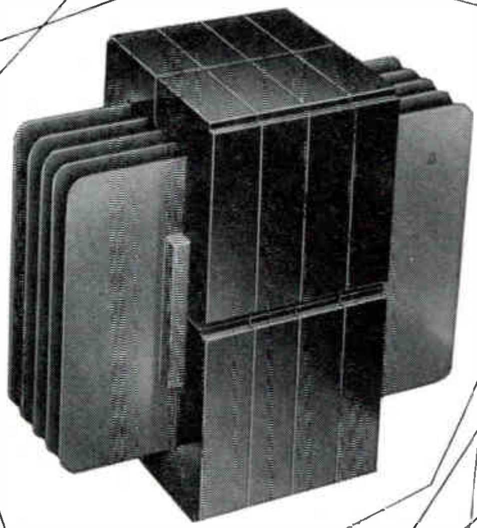
**Published by Iliffe & Sons Ltd.**

**Editorial, Advertising and Publishing Offices: Dorset House, Stamford Street, London, S.E.1**

*Telephone: Waterloo* 3333 (60 *lines*) · *Telegrams: Wirenger, Sedist, London*

---

BRANCH OFFICES AT BIRMINGHAM · MANCHESTER AND GLASGOW



# H.F. POWER TRANSFORMERS

H.F. power transformers of outstanding efficiency are the latest additions to the Mullard range of high quality components designed around Ferroxcube magnetic cores.

Utilising the unique characteristics of Ferroxcube to the full, Mullard H.F. transformers are smaller, lighter, and less costly than transformers using alternative core materials. These advantages are particularly marked in transformers required to handle powers of up to 2kW, between the frequency range 2kc/s to 2Mc/s.

Mullard transformers are already finding wide use in applications as diverse as ultrasonic H.F. power generators and aircraft power packs operating from an aircraft's normal A.C. supply. In the latter application, the low leakage field of Ferroxcube can eliminate the need for external screening, thereby reducing the size and weight of the transformer even further.

As with all Mullard high quality components, these H.F. power transformers are designed and built to engineers' individual specifications. Write now for details of the complete range of components available under this service.

**RATING . . . . . . . . . . . . UP TO 2 kW**

**FREQUENCY RANGE . . . . 2 Kc/s to 2 Mc/s**

**Mullard**

**'Ticonal' permanent magnets**
**Magnadur ceramic magnets**
**Ferroxcube magnetic cores**

MULLARD LTD • COMPONENTS DIVISION • CENTURY HOUSE • SHAFTESBURY AVENUE • WC2

MCIA

# WIRELESS ENGINEER

Vol. 33 JULY 1956 No. 7

## Television Picture Quality

ALTHOUGH there is no immediate prospect of a colour television system coming into operation in this country, there is a good deal of discussion going on about the standards which should be adopted. There is a school of thought which considers that compatibility with the present black-and-white television service is unnecessary and that when colour does come it can be, or even should be, on different standards.

A view which is quite often expressed is that Great Britain should adopt the same colour standards as the Continent and there is good reason to believe that this means a 625-line version of the American N.T.S.C. system. There is, of course, no suggestion that the present 405-line system should be abandoned so far as monochrome transmissions in Bands I and III are concerned. The suggestion is that no attempt should be made to introduce colour into these, but that colour should be developed as a parallel service in Bands IV and V.

Although superficially attractive, there are a good many objections which can be raised against such a scheme. We do not propose to discuss them now, however, for we are more concerned with the underlying idea that 625 lines is a more suitable standard for television than 405 lines. In some circles, it seems to be taken for granted that it is greatly superior. The fact that the Continent only adopted 625 lines after a lengthy examination of our 405-line and the American 525-line systems is often thought to be evidence of its superiority.

We ourselves think that they made a mistake in choosing their standards. We thought so at the time and, having seen 625-line television, we still think so. We do not mean that the 405-line system is better than the 625-line. What we do mean is that the 625-line system does not make the best use of the 5-Mc/s bandwidth allotted to it. We feel strongly that, for this bandwidth, the number of lines should be around 500 and that this would give better pictures than either 405 lines or 625.

The important factors concerned with this matter of lines are not always as clearly realized as they should be. We propose, therefore, to compare them for the two existing systems.

First of all, in the 405-line system, there are 377 active lines; that is, lines conveying visible picture information. In the 625-line system, there are 575 active lines. There is no doubt at all that, in respect of vertical definition, the 625-line system is $575/377 = 1{\cdot}53$ times as good as the 405 line. This improvement of 53% in vertical definition is accompanied by a proportional reduction in the visibility of the line structure, which is in itself a good thing. Too much importance should not be attached to it, however, for methods exist (e.g., spot-wobble) by which the visibility of the line structure can be reduced.

In the horizontal direction, the definition depends on the velocity of the scanning spot and the bandwidth. It is quite usual to assess horizontal definition in terms of a chess-board type of pattern. The fundamental component of the waveform produced by scanning such a pattern is a sinusoid of which one cycle corresponds to two adjacent elements of the chess-board. If the duration of the active part of a line is $\tau_1$ and there are $n$ elements per line, the duration of one cycle of this sine wave is $2\tau_1/n$.



B

The frequency is thus $n/2\tau_1$ and this is taken as the upper limit of the video bandwidth.

This is rather an arbitrary relation, but it is practically useful and, in any case, it is valid for comparing different systems. With 405 lines, the frequency is 3 Mc/s and $\tau_1$ is 80·95 μsec. Therefore, $n = 2 \times 3 \times 80{\cdot}95 = 485{\cdot}7$ elements per line. With 625 lines, the frequency used is 5 Mc/s and $\tau_1$ is 52·32 μsec, so $n = 2 \times 5 \times 52{\cdot}32 = 523{\cdot}2$ elements per line. The horizontal definition is thus $523{\cdot}2/485{\cdot}7 = 1{\cdot}075$ times that of the 405 line; that is, an improvement of 7·5%.

The facts are thus, that 625 lines gives 53% better vertical and 7·5% better horizontal definition than 405 lines. For this, it requires a greater bandwidth. The video bandwidth is greater in the ratio of $5/3 = 1{\cdot}66$ and the channel bandwidth (i.e., the band occupied by both sound and vision transmissions) in the ratio $7/5 = 1{\cdot}4$.

The aspect ratio is 4/3 in both cases. With 405 lines, there are $485{\cdot}7 \times 3/4 = 364$ elements in the same linear distance as the 377 active lines. The definition is thus virtually the same in both the vertical and horizontal directions. With 625 lines, there are $523{\cdot}2 \times 3/4 = 392$ elements in the same linear distance as the 575 active lines. The vertical definition is thus $575/392 = 1{\cdot}46$ times as good as the horizontal.

It is clear that the 625-line system gives better definition than the 405 line but at the expense of 40% more channel width. The improvement is almost entirely in vertical definition. For practical purposes, the two are virtually the same in horizontal definition.

If the bandwidth is kept constant, altering the number of lines improves the definition in one direction across the picture at the expense of the other. It is clear that there must be an optimum number of lines and it is not unreasonable to suppose that it occurs when the definitions in the two directions are the same, as in the 405-line system. If the two are not the same, in which direction should the definition be the better? We ourselves feel that horizontal definition is more important.

In support of this view, we instance the following:—

(a) In the cinema, the tendency is all to wide screens, emphasizing the horizontal direction.

(b) In laboratory tests of 405-line and 625-line pictures, each having the bandwidth of its particular standard, we find it hard to say with certainty which is which, unless there is a direct comparison.

(c) In laboratory tests of the 405-line system with unrestricted bandwidth against 625 lines with 5-Mc/s bandwidth, we find that the 405-line system gives the better picture.

In the 625-line system, the extra 2 Mc/s of bandwidth is used almost entirely to increase the vertical definition. It is this that we think wrong. We think that 405 lines with a 5-Mc/s bandwidth would give a better picture. We do not say, however, that the proper number of lines for this bandwidth is 405. Probably the right thing to do is to keep the definition in both directions the same and, for 5-Mc/s bandwidth, that means about 500 lines, as we said earlier.

It should be unnecessary but, in view of the figure of 500, perhaps we should point out that this does not mean that we think the American 525-line standard is the right one. That has a 60-c/s frame frequency and a 4-Mc/s bandwidth and gives inferior horizontal definition to the 405-line system.

In saying all this, we are not advocating any change of standards by anyone. So far as monochrome television is concerned, that is impracticable. What we are concerned about is that, if the introduction of colour is made on standards other than 405 lines, the new standards should be the right ones. If it is practicable to have different standards for colour, we do not think that 625 lines with 5-Mc/s bandwidth is right. For this bandwidth, 500 lines or so would be better but, better still, would be 625 lines with the 7·4-Mc/s bandwidth necessary to equalize the definition in the two directions.

W. T. C.

# OBLIQUE TRANSMISSION BY THE METEORIC E-LAYER

**By R. Naismith, M.I.E.E.**

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

**SUMMARY.**—This paper describes the results of observations made on transmissions between England and Norway on frequencies of 22·7, 25 and 27 Mc/s over distances of 900 to 1,900 km. The observations, which were made in the winter of 1951 and the summer of 1952, indicate that propagation took place by way of that part of the ionosphere which has been designated the meteoric E-layer. Measurements of the conditions in this layer made at vertical incidence near one end of the transmission path provide some confirmation that this mode of propagation was effective during the period of the experiments. It is concluded that this meteoric E-layer may enable communication to be maintained over certain distances at frequencies higher than those normally propagated by way of the E and F layers.

THE term meteoric E-layer refers to a layer situated in the lower part of the ionosphere which is observable for about 85% of the time. It is an inferior reflector of radio waves. The following observations were planned to confirm the suggestion[1] that it would enable higher frequencies than those normally reflected from the ionosphere to be received at distances up to the limit of a first reflection (i.e., about 2,000 km) when high-power transmitters were used. Suitable sources of such high power are the radar stations along the east coast of England, some of which had already been used by Eastwood and Mercer[2] to demonstrate that individual echoes could be observed back at the transmitter after reflection at oblique incidence. They further concluded that the reflections they observed originated in a thin layer situated at a uniform height which we may now associate with the meteoric E-layer. Since, however, the limit of resolution of their equipment was reached when the echo duration was less than 0·3 second, the present observations may also be regarded as extending their work to determine if the integrated effect of the many shorter duration echoes would result in a quasi-continuous signal over an oblique path. In this case it would be necessary to make the observations abroad to ensure that the receivers were out of range of the direct ray from the radar stations.

An arrangement was therefore made between the British Air Ministry and the Norwegian Defence Research Establishment which enabled observations on the radar stations to be made in Norway during a winter period in 1951 and a summer period in 1952. The orientation of the radar beam and the power used were unknown so far as this experiment is concerned and no effort was made to extend the observations by measuring the strength of the signals. It was convenient to use an AR88 type of receiver although its comparatively narrow bandwidth was not very suitable for the reception of radar signals. If it were possible to receive the signals under such unfavourable conditions the suggestion would be proved correct.

MS accepted by the Editor, July 1955

The frequencies used were 22·7, 25 and 27 Mc/s and the distances varied from 900 to 1,900 km. The observing stations were near Oslo, Trondheim and Bardufosse. The latter, situated at latitude 70°N, was the farthest north at which radar transmissions were observed. Since the Norwegian mountains were in the path of any direct signals it is quite certain that the signals received at Trondheim and Bardufosse travelled by reflection in the ionosphere. Also, by receiving different radar stations at one place it proved unnecessary to be directly in the line of maximum radiation.

An unsuccessful effort was made to receive the signals at latitude 78°N. It is possible that the distance, which was over 3,000 km, was too great to be covered in a single hop and the low reflection coefficient made it impossible to receive a twice-reflected signal. Observations were also unsuccessful over a ground distance of 600–700 km and this may be attributed to a skip effect. Thus, the range of distances over which the signals were received conforms to the idea of a single reflection in the ionosphere.

The observations were made on the normal radar transmissions and covered a total of 1,000 hours (445 in winter and 555 in summer). They were made by observing each frequency in turn and not by continuously monitoring on a single frequency. The latter would have shown a longer period of reception since the comparatively weak signals were, at times, difficult to separate from the general noise. The figures in the Table show the percentage of the total number of hours of transmission during which the stations were received, and indicate that for 33–54% of these hours it was possible to record radar signals over distances of about 1,000 km in both summer and winter.

The number of observations is too small to enable the variations with frequency, season, distance and latitude to be assessed but the percentages shown would, of course, be improved upon if complete control of the transmitters and receivers were possible. The observations show quite definitely that radar signals intended for reception only within the range of direct transmission may be received at distances up to 2,000 km and at places well within the Arctic circle even in midwinter.

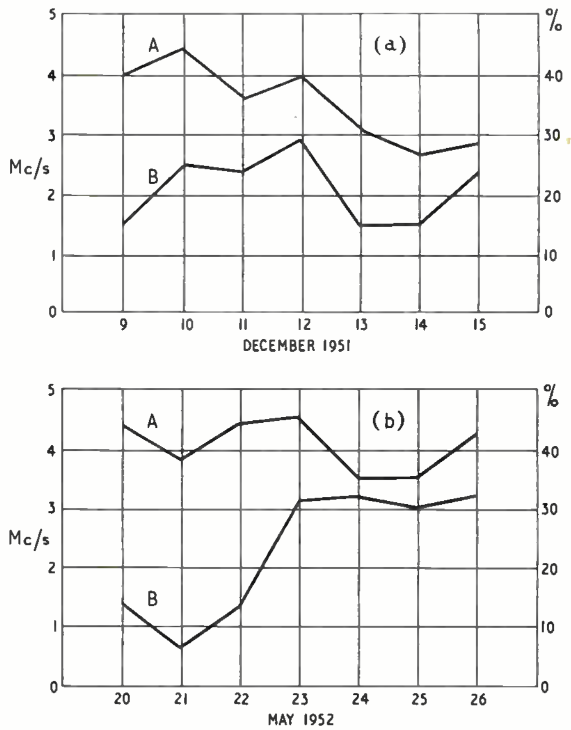



Fig. 1. *Results for December (a) and May (b). In each case, curve A is the daily average of fEM and B is the daily percentage reception in hours.*

## Conditions of Meteoric E-Layer

Since the suggested experiment arose from a study of the characteristics of the meteoric E-layer it is worth while setting down the conditions in that layer as they were observed at Slough during the progress of the experiment.

The hourly values of the highest frequency on which echoes were received from the meteoric E-layer at vertical incidence (fEM) have been averaged over the day and plotted for each day of the tests in Fig. 1 (a) and (b). The percentage of the hours of reception of the radar transmissions has been treated similarly and plotted on the same graphs. During three days (20th–22nd May) absorption obscured all but a few E-region echoes at vertical incidence at Tromso, which is situated near Bardufosse. Taking this into account there appears to be a general correspondence between the average values of fEM and the average number of hours of reception. For 75% of the days the values of fEM observed at Slough increased and decreased as the number of hours of reception of the radar signals in Norway increased and decreased. For the remaining 25% of the time the values are not in opposition. There are insufficient observations to make a statistical interpretation significant; it is necessary, therefore, to leave the observations in the above form. This shows that meteoric E-echoes were present during the tests and that, with a sufficiently powerful transmitter, reception would be expected to occur in the circumstances of the experiment as described.

## Turbulence

There is little doubt that a certain amount of turbulence is present in all regions of the ionosphere. Indeed, even if no other source of turbulence were present, the incidence of sporadic and shower meteors would cause it. The large amount of local heating and the high peak values of ionization produced are quite certain to produce turbulence effects. So far as I know only one experiment has been performed which might have been expected to demonstrate the effect of turbulence. On 9th July 1945 a solar eclipse occurred in which the totality belt passed near to the north of Scotland. A chain of radar stations which had already reported the frequent reception of meteor bursts was suitably situated for observation of the occurrence of these bursts in this region of totality and I suggested that this should be done to determine, if possible, whether the eclipse of the sun would affect the burst formation.

This experiment was carried out under R.A.F. auspices and the results carefully analysed by

**TABLE**

| Station | December 1951 | | | May 1952 | | | Approx. Distance (km) |
|---|---|---|---|---|---|---|---|
| | 22·7 Mc/s | 25·1 Mc/s | 27 Mc/s | 22·7 Mc/s | 25·1 Mc/s | 27 Mc/s | |
| Oslo | 17 | 25 | 38 | 7·5 | 50 | 33 | 900 |
| Trondheim | 54 | 0 | 0 | 33 | 29 | 26 | 1,100 |
| Bardufosse | 13 | 8·5 | 2·5 | 17 | 41 | 21 | 1,900 |

Eastwood and Mercer who concluded[2] that the burst activity throughout the eclipse period failed to reveal any significant departure from the averages established on the two control periods each of seven days' duration, on either side of the eclipse day.

As another part of the same experiment we measured the critical frequency for the E-region (fE) at Loth in the north of Scotland where the sun was 75% obscured at the maximum phase of the eclipse. A drop of 40% in the ionization in this region occurred. This made the value of fE at 1430 LMT (local mean time) on the eclipse day, correspond to 1800 LMT on a normal day. This corresponds roughly to a difference of 8 dB in the field strength reported for June 1951 by Bailey et al[3]. Actually, the reduction would be much greater than this in the totality belt and some of the meteor observations were made in or near to that region. The conclusions reached by Eastwood and Mercer are therefore most significant from the turbulence aspect of this problem.

Again, if turbulence were a predominant characteristic of the ionosphere one might expect to see some effects in the $F_2$ region particularly on a winter morning in the northern hemisphere when both the amount of ionization present and the rate of increase should give rise to favourable conditions for the creation of turbulence effects. The absence of any confirmatory reports of turbulence effects in the $F_2$ region is therefore surprising. We also know that there are considerable movements observable—sometimes at high speeds—on frequencies reflected from the $F_2$ region in the more normal manner.

On the other hand, the meteor-type of signal has been observed on a winter night at latitude 70°N when only a vestigial amount of ionization remained in the normal E-region and when, therefore, the turbulence effect seemed unlikely.

Further simultaneous observations on the meteoric E-region at oblique incidence to the north of Aberdeen and to the south of Weymouth have shown no systematic difference in the number of echoes observed due to sporadic meteors, although the scattering centres would be about 1,000 km apart. The amount of ionization in the region in which turbulence could occur was much greater at the more southerly observing site.

This uniformity over large areas may well be a characteristic of observations on sporadic meteors. Lovell[4] estimated the number of sporadic meteors arriving in the earth's atmosphere as $8 \times 10^9$ over 24 hours and their limiting velocity as 72 km/sec. Thus meteor dust particles take only one or two minutes to travel the distance from the United Kingdom to the United States and it is unlikely, therefore, that there will be any significant difference in the amount of this dust arriving over large areas of the world. We may relate this suggestion to the following observation on a frequency higher than the maximum usable for either regions E or F.

Monthly average values of signal strength received on 49·8 Mc/s over a distance of 1,245 km in America have been published for the months of April and June 1951. The authors remark that "some preliminary speculations suggest that the mechanism of this type of propagation may be scattering caused by the ever-present irregularities in the E-region and an appropriate transmission equation is derived in terms of parameters describing inhomogeneities in the E-region". However, they do not rule out the possibility of a contribution made by meteors which could explain some of the characteristics of their observation. If, however, sporadic meteor dust is mainly responsible for this type of radio propagation then we may expect to observe similar monthly average conditions over the United States and over the United Kingdom. On the other hand, we know that scattering arising from turbulence—as observed in tropospheric propagation—is much less likely to give the same monthly average conditions in these two areas and this should also apply in the case of turbulence observed in ionospheric propagation. If it can be shown that a close similarity does, in fact, exist between the fEM measurements at Slough and the American observations referred to above, additional evidence would be deduced for attributing the observations of the reception of British radar signals in Norway to the incidence of sporadic meteors rather than to turbulence.

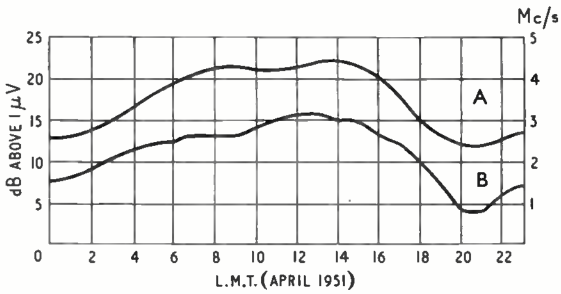



Fig. 2. *Curve A shows the monthly average fEM and B the monthly average signal intensity on 49·8 Mc/s over a distance of 1,245 km.*

In Fig. 2 the American observations and the average values of fEM measured at Slough have been plotted. The similarity of the two graphs is apparent. The pre-sunrise minimum strongly suggests a meteoric origin as the source of the ionization involved in the reflecting process. A comparison of corresponding data for June 1951 gives similar results.

## Conclusion

The suggestion that the meteoric E-layer enables a type of long-distance radio communication on frequencies higher than those normally reflected from regions E and F has been demonstrated. Additional confirmation of the meteoric source of the ionization involved has been deduced from earlier observations of the phenomenon of this type of radio propagation at very high frequencies.

## Acknowledgments

Thanks are due to Mr. C. F. Sutton of Signal Plans, Air Ministry, and to Mr. S. Skribeland of the Norwegian Defence Research Establishment for the care taken in arranging for reliable measurements to be made on the routine radar transmissions.

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

### REFERENCES

[1] R. Naismith, "A Subsidiary Layer in the E Region of the Ionosphere", *J. atmos. terr. Phys.*, 1954, Vol. 5, No. 2.
[2] E. Eastwood and K. A. Mercer, "A Study of Transient Radar Echoes from the Ionosphere", *Proc. Phys. Soc.*, 1948, Vol. 61, p. 122.
[3] D. K. Bailey et al., "A New Kind of Radio Propagation at V.H.F. observable over Long Distances", *Phys. Rev.*, 1952, Vol. 86, p. 141.
[4] A. C. B. Lovell, "The New Science of Radio Astronomy", *Nature*, 1951, Vol. 167, p. 94.

# KLYSTRON CONTROL SYSTEM

**By R. J. D. Reeves**

*(E. K. Cole, Ltd., Malmesbury, Wilts)*

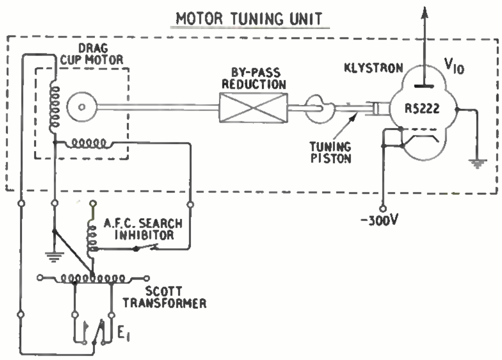
*(Continued from p. 143, June issue)*

### Part 3—Specimen Design for A.F.C.

### General

FIG. 13 shows a complete circuit diagram for an A.F.C. system embodying the features described in Part 2. It was designed for a radar with a ½ μsec pulse and a repetition rate of 2 kc/s, and the period of the sinusoid was chosen to be 20 μsecs. The local oscillator V10 is a R5222, which has an external resonant cavity and therefore affords full freedom of mechanical design. The frequency sweep is about 500 Mc/s in the X band (3 cm). The motor tuning unit is shown Fig. 14(a), and the rest of the control system is divided into two parts; the frequency discriminator unit Fig. 14(b), and the klystron control unit Fig. 14(c).

A negative supply of 300 V is necessary for the klystron and is freely employed elsewhere in the circuit. The positive supply is 150 V which is an economically low value and conveniently



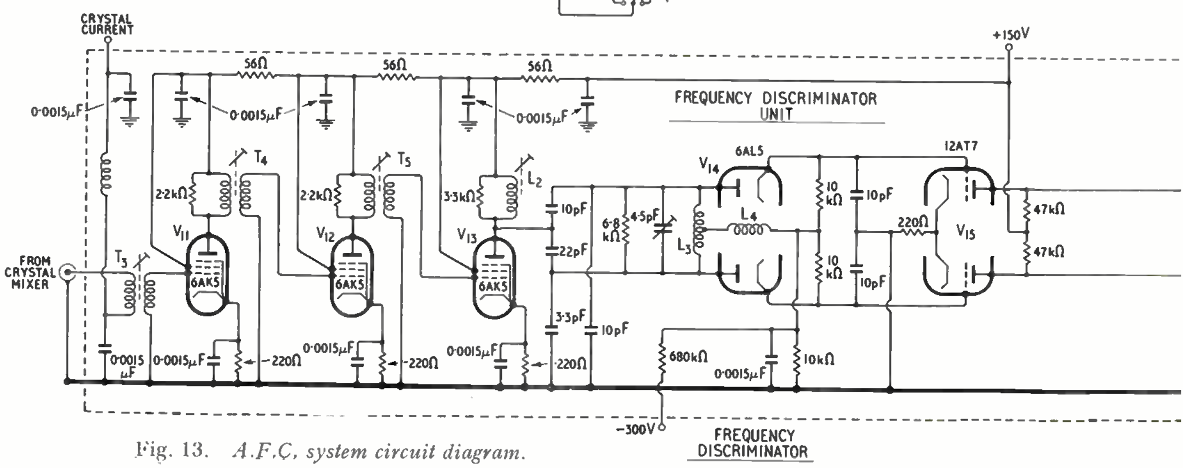
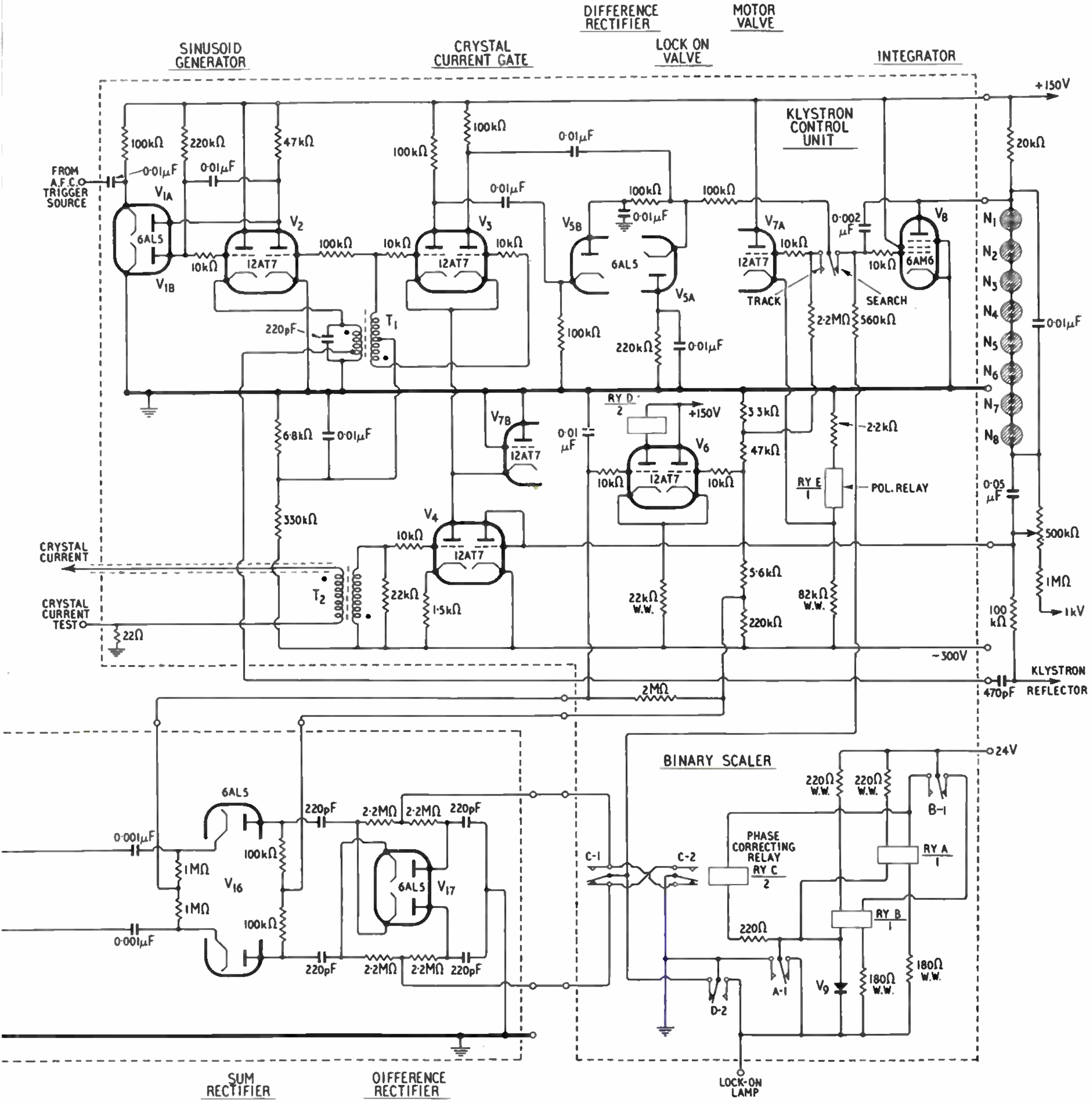




Fig. 13. *A.F.C. system circuit diagram.*

limits the anode base of the Miller valve $V_8$. A twenty-four volt line is introduced to operate the relays of the binary scaler, and the potentiometer to the klystron reflector is returned to a —1 kV source which is normally available in a transmitter for the 'keep alive' electrodes of the t.r. cells. It has been suggested that an r.f. oscillator and detector be used as a link between the Miller anode and the klystron reflector in order to obviate the need for this high voltage supply, and it would certainly be an attractive possibility if the −1-kV line were not already available. However, the present system incorporating a chain of miniature neons has the useful property of almost completely relieving the control system of the onus of dealing with errors due to supply-voltage drifts for, by holding the appropriate fraction of the reflector potential constant, the residual variations appearing on all the electrodes of the klystron combine to have approximately zero effect on the frequency being generated. For this reason the neon chain is to be preferred to other methods.

In the following sections the individual circuit functions are discussed in detail and certain aspects of the system are analysed.



## The Sinusoid Generator

Fig. 15 is the section of the circuit which produces one cycle of a sine wave when triggered by a negative pulse. One winding of a tuned transformer $T_1$ carries the current of the triode $V_{2B}$, and the energy stored causes the tuned circuit to ring when the valve is shut off. Neglecting losses, the peak amplitude of the ring is:

$$V = I\sqrt{L/C} \text{ volts} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where $I$ is the anode current of the valve when conducting, and $C$ is the capacitance which tunes the current-carrying inductance $L$.

Initially the shut-off is achieved by a trigger pulse passing through the diode $V_{1A}$ and the a.c. coupling to the ringing-valve grid, but the condition is sustained by coupling the ringing waveform itself back to this grid through the saturating amplifier $V_{2A}$. Being fully conductive, this valve holds $V_{2B}$ cut-off during the first half cycle of the sinusoid. In the next half cycle $V_{2A}$ is switched off and $V_{2B}$ grid recovers towards a positive potential until it is caught at earth by the diode $V_{1B}$. There is still no current in the ringing valve, however, because its cathode has run positive with the resonant circuit, and it remains shut off until the end of the second half cycle, when the cathode swings into the grid base. Then the valve abruptly damps out the oscillation.

Because the sinusoid itself performs the switching functions, the shut-off time is bound to correspond precisely to one ringing cycle and there is little that is critical about this circuit. The waveform that appears on the grid of $V_{2B}$ is shown in relation to the cathode swing in the oscillogram of Fig. 16. The slow recovery of the grid waveform is necessary to effect the transition from the first to the second half cycles of the ring.

The circuit is prevented from free running by a definite delay bias on $V_{2A}$ grid.

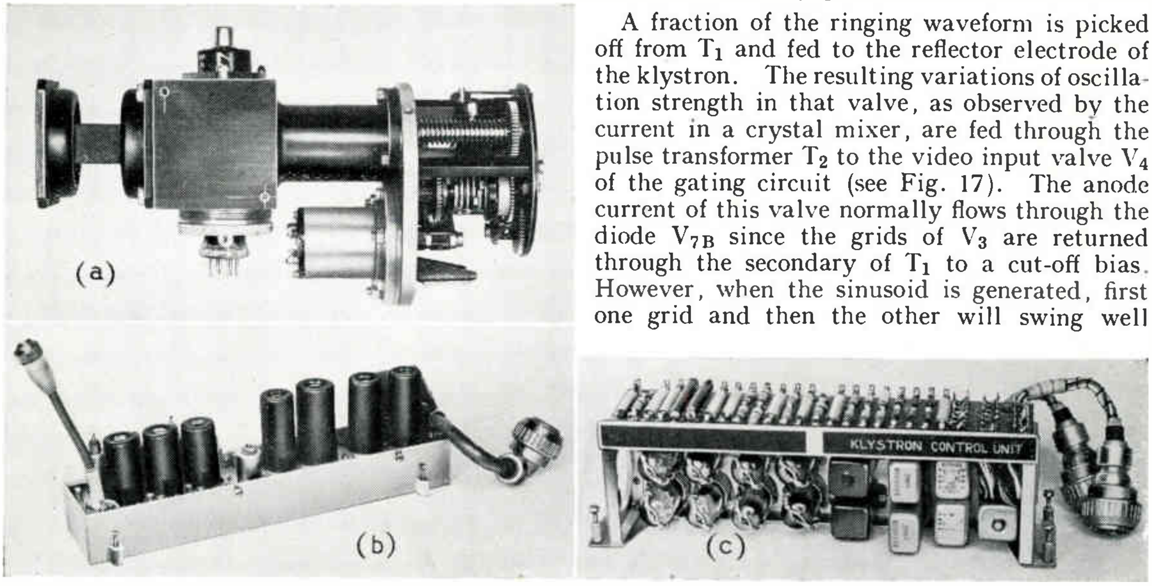



Fig. 14. *Component units; (a) Tuning mechanism; (b) Frequency discriminator unit; (c) Klystron control unit.*

## Time Discriminator

A fraction of the ringing waveform is picked off from $T_1$ and fed to the reflector electrode of the klystron. The resulting variations of oscillation strength in that valve, as observed by the current in a crystal mixer, are fed through the pulse transformer $T_2$ to the video input valve $V_4$ of the gating circuit (see Fig. 17). The anode current of this valve normally flows through the diode $V_{7B}$ since the grids of $V_3$ are returned through the secondary of $T_1$ to a cut-off bias. However, when the sinusoid is generated, first one grid and then the other will swing well

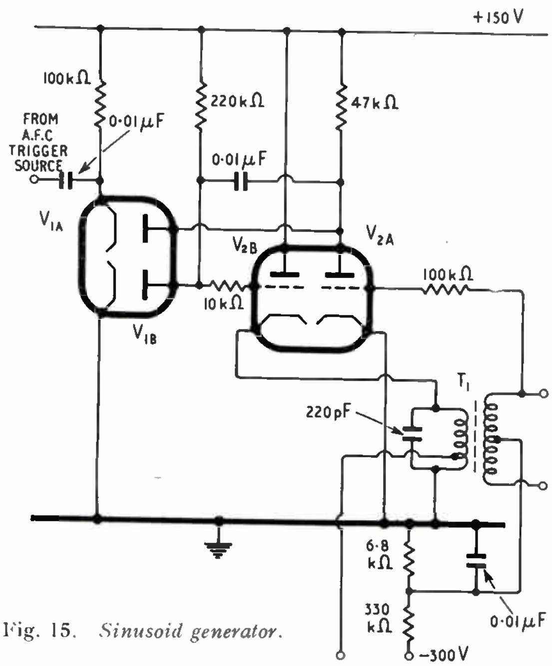



Fig. 15. *Sinusoid generator.*

positive with respect to earth and divert the anode current to the valve with the positive grid. In this way the modulated crystal current is separated into two channels which can be identified either as the 'early and late' or the 'negative and positive' channels, since they are associated with the first and second half periods of the sinusoid. The current pulses that pass through the gate valves are integrated in capacitors, and the

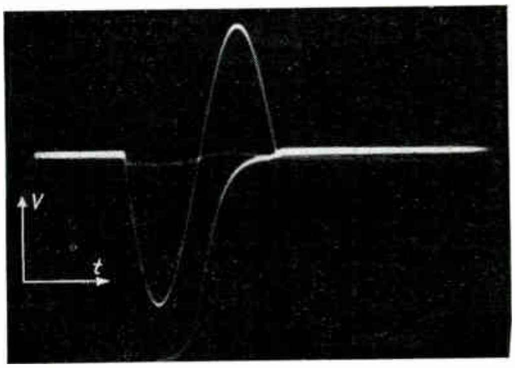



Fig. 16. *Grid and cathode waveforms of ringing valve.*

charge differences build up an error potential (see next section).

The features of this circuit to notice are, first, that the gate current is largely independent of the gate amplitude, being defined by the video input to the 'tail' valve $V_4$, and secondly, the gate generator is not loaded since the cathodes of $V_3$ follow the positive grid. Good switching action is obtained if the sinusoid amplitude at the transformer secondary is large compared with the standing bias.

of popular hypothesis, but are inseparable from either a time constant or a true integration effect. The error output circuits of both the discriminators are derived from that of Fig. 18. At the sampling times a current pulse is passed by the early and late gate valves and it is the difference in the area under these two pulses that constitutes the error signal. Only a small fraction of the input current is required to develop sufficient voltage across the resistors to switch on the diodes and, when these are conducting, the impedance in each gate-valve anode is just that of $C_1$ and $C_2$ in series. A charge then accumulates on these capacitors with a polarity which will hold off the diodes when the charging current ends. Until the next charging time there are therefore two independent but identical meshes comprising $C_1$, $R_1$, $C_2$, $R_2$ in series, and the capacitors in a common mesh are able to discharge into each other towards a final potential representing the charge difference. It may be demonstrated that if the $CR$ product is the same each side of the pick-off junction then the relaxation waveform is absent at this point and the final potential is available immediately the charging interval is over.

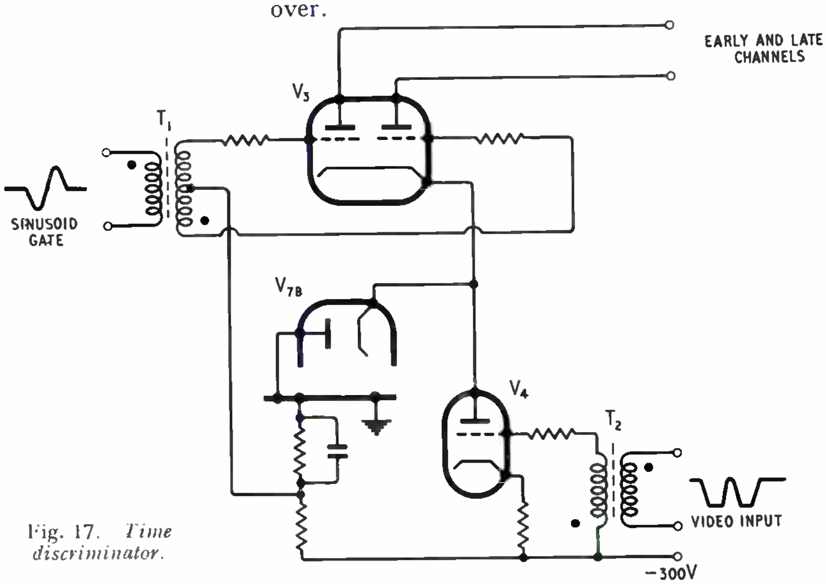



Fig. 17. *Time discriminator.*

## The Difference Rectifiers

The function of both the time and frequency discriminators is to produce a steady or 'clamped' error signal with magnitude and sign related to that of the misalignment measured at the sampling instants. This task is simplified if a measure of integration is permissible; that is to say, if the error output may be built up from not just the last sample but all previous samples as a weighted aggregate. The discriminators are not then the traditional error-clamp generators

In the circuit of Fig. 18 this output is available in balanced form from the two meshes, but this configuration is severely limited in the magnitude of error signal it can support when the diodes are biased entirely by the relaxation waveform on their anodes. A practical form of the circuit is shown in Fig. 19 in which no attempt is made to accumulate an error signal in both relaxation meshes but only in the upper one. The lower mesh is split into separate parts by an earth junction and the relaxation potentials on nodes

(5) and (6) [with that of node (3)], serve to bias the diodes without mutual interference. In fact, the components of the lower mesh are not related to the output circuit and the biasing waveforms can be freely designed to support a substantial error signal at node (2). This configuration is the one employed for the mode-centre discriminator.

In the pulsed frequency discriminator there is a special requirement that the output shall be available in either polarity (although not both simultaneously) and for this reason a symmetric

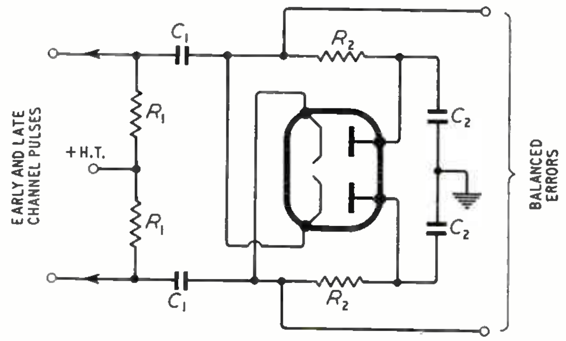
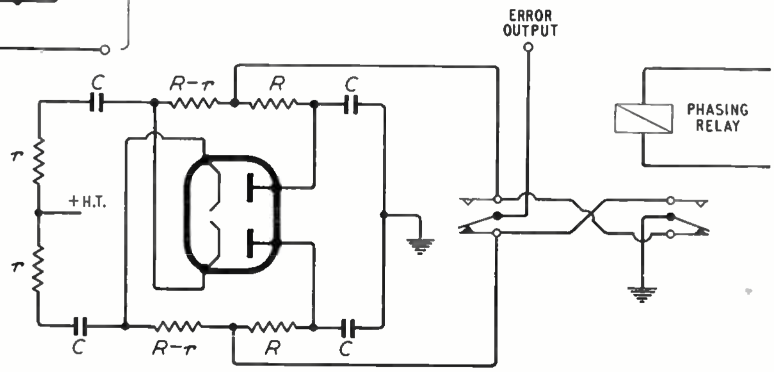
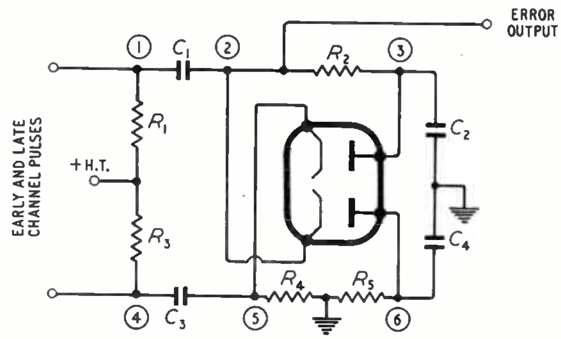



Fig. 18 (above). *Basic difference rectifier circuit.*

Fig. 19 (below). *Practical form of difference circuit.*

Fig. 20 (right). *Balanced form of difference circuit.*




form is reverted to (see Fig. 20). The upper and lower meshes are identical, with pick-off junctions at the balance point of each.

These junctions are not coincident with the diode cathodes and so either may be used as an earth point without interfering with the charging paths. By using a two-pole change-over relay which selects one junction and earths the other an error signal of either polarity may be extracted.

## Transfer Function of the Difference Rectifiers

The transfer function of the frequency discriminator is of fundamental importance when investigating the limitation of the complete a.f.c. system, whereas that of the time discriminator is of secondary interest. It is informative, however, to examine the behaviour of the most elementary difference rectifier circuits, such as the one employed in the time discriminator.

The upper relaxation network is drawn in Fig. 21 and by inspection its nodal determinant is:

$$\Delta = \begin{vmatrix} \frac{1}{R_1} + C_1 p & -C_1 p & . \\ -C_1 p & \frac{1}{R_2} + C_1 p & -\frac{1}{R_2} \\ . & -\frac{1}{R_2} & \frac{1}{R_2} + C_2 p \end{vmatrix} \qquad (2)$$

The voltage on node (2) is given by:

$$\frac{(\Delta_{22} + \Delta_{12})I_A + \Delta_{32} I_B}{\Delta}$$

which gives:

$$E_2 = \frac{(1 + C_2 R_2 p) I_A - (1 + C_1 R_1 p) I_B}{(1 + C_2 R_2 p) C_1 p + (1 + C_1 R_1 p) C_2 p} \quad \ldots \quad \ldots \quad (3)$$

It will be observed that by putting $C_1 R_1 = C_2 R_2$ this reduces to

$$E_2 = \frac{I_A - I_B}{(C_1 + C_2)p} \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

That is to say, the voltage on node (2) is the integral of the current difference, so that immediately after simultaneous current impulses of magnitude $Q_A$ and $Q_B$ there is a potential difference

$$e_2 = \frac{Q_A - Q_B}{C_1 + C_2} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

without extraneous relaxation waveforms. (There will be found unwanted impulses at the charging instants but these are more easily filtered off).

This simple configuration can therefore be considered to be a high-speed error clamp which integrates the input—provided it is not loaded. If it is loaded with resistance, there will be a relaxation waveform and a weighted memory, whereas if there is capacitance loading there will only be a relaxation waveform. The circuit of the frequency discriminator is of this type and will be examined in more detail.

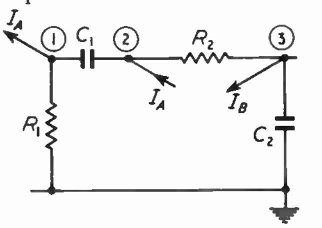


Fig. 21. *Output mesh of Fig. 19.*

Fig. 22 represents the relaxation mesh of a difference rectifier loaded with a Miller integrator, which corresponds to the output circuit of our frequency discriminator. The symbol $S$ denotes the mutual conductance of $V_8$.

The nodal determinant of the circuit is

$$\Delta = \begin{vmatrix} Cp+\frac{1}{r} & -Cp & \cdot & \cdot & \cdot \\ -Cp & Cp+\frac{1}{R-r} & -\frac{1}{R-r} & \cdot & \cdot \\ \cdot & -\frac{1}{R-r} & kCp+\frac{1}{R}+\frac{1}{R-r} & -\frac{1}{R} & -kCp \\ \cdot & \cdot & -\frac{1}{R} & Cp+\frac{1}{R} & \cdot \\ \cdot & \cdot & S-kCp & \cdot & kCp \end{vmatrix} \quad (6)$$

and the output voltage is given by:

$$E_5 = -\frac{(\Delta_{15}+\Delta_{25})}{\Delta} I_A + \frac{\Delta_{45}}{\Delta} I_B$$

$$= \frac{(S-kCp)(I_B-I_A)}{kCp[2Cp+S(CRp+1)]}$$

$$\approx \frac{(S-kCp)(I_B-I_A)}{kCpS(CRp+1)} \quad (\text{since } SR \gg 2)$$

$$= \frac{1}{kCp}(I_B-I_A) - \left(\frac{1}{SR}+\frac{1}{k}\right)\frac{1}{C}\frac{I_B-I_A}{\left(p+\frac{1}{CR}\right)} \quad \ldots \quad \ldots \quad (7)$$

$$\therefore e_5(t) = \int \frac{I_B-I_A}{kC}\,dt - \left(\frac{1}{SR}+\frac{1}{k}\right)\frac{(I_B-I_A)}{C}\,\epsilon^{-t/CR} \quad \ldots \quad \ldots \quad (8)$$

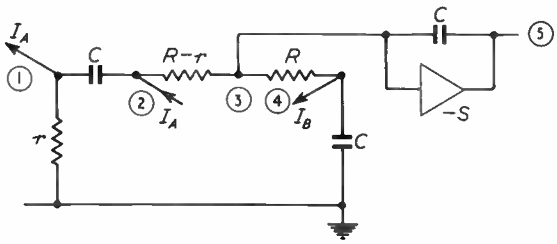


Fig. 22. *Output mesh of Fig. 20 with Miller load.*

The response to impulses of magnitude $Q_A$ and $Q_B$ is shown in Fig. 23. The final voltage is determined by the Miller capacitance $kC$ and the time taken to reach it is governed by the product $CR$. The initial reverse output voltage is due to the forward coupling through the Miller capacitance but is small enough to be ignored. Then the transform of the output simplifies to:

$$E_5 = -\frac{I_A - I_B}{kCp(CRp+1)} \quad \ldots \quad \ldots \quad (9)$$

Ideally, the degenerative action of the Miller valve would keep the pick-off junction node (3) stationary at all times so that any slight bias on the diode electrodes [nodes (2) and (4)] would be sufficient to keep these valves shut off in the relaxation period and ensure that the two relaxation meshes remained independent. In practice, several volts of error signal have to be supported at node (3) in order to provide an appreciable drive to the Miller valve and to accumulate the steady bias that this valve requires. Fortunately, the charging impulses themselves produce relaxation waveforms on the diodes which serve to hold them off, provided the repetition period is not too long compared with the time constant $CR$. The minimum bias provided by the relaxation waveforms is quite simply estimated by considering the effect of a current impulse $Q$ on a parallel $CR$ combination. After a time $\tau$ the voltage across the capacity is given by:

$$e = \frac{Q}{C}\,\epsilon^{-\tau/CR} \quad \ldots \quad \ldots \quad (10)$$

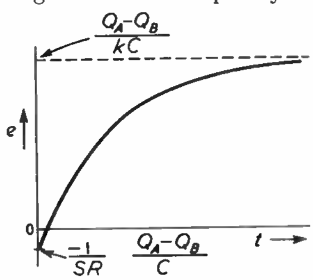


Fig. 23. *Impulse response of Fig. 22.*

If then the impulse is repeated again and again with uniform interval, the minimum voltage approaches the value

$$\frac{Q}{C} \cdot \frac{\epsilon^{-\tau/CR}}{1-\epsilon^{-\tau/CR}} \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

If for example $\tau = CR$ then the minimum voltage in the steady state is $0{\cdot}581Q/C$ and, in the configuration of Fig. 20, this bias appears on the diode anodes and also, if $r \ll R$, on the cathodes. In the circuit of Fig. 13 the product $CR$ is equal to the repetition period (500 $\mu$secs) and, when signals are received through the i.f. amplifier, current impulses of the order of 5 mA and $\frac{1}{2}$ $\mu$sec duration are produced by $V_{15}$, which charge the 220-pF capacitors and increase the potential across them by about 10 V.

(*To be concluded*)

# PARALLEL-T RC NETWORK

*Simplified Analysis*

By G. V. Buckley, A.M.I.E.E.

(*Designs Department, British Broadcasting Corporation*)

## Introduction

THE parallel-T or twin-T resistance capacitance network in recent years has attained considerable popularity, mainly due to the fact that an attenuation characteristic similar to that of an *LC* network can be obtained without the use of an inductance. This advantage can be very important, particularly at very low frequencies. The network has been used for many years[1] and there is a comprehensive literature on its uses and properties[2,3,4,5,6]. There are many ways of analysing this network and one of the more recent papers, by L. G. Cowles[5], presents a most interesting and complete solution. However, it is felt that a more simple analysis which avoids the usual laborious mathematical solution would help design procedure and give some mental picture of its mode of operation which is essential when the effect of a variable element is to be considered.

The method adopted is to find an equivalent network of a more familiar pattern which is also more amenable to mathematical treatment. There are many ways of finding an equivalent network, one being the use of Bartlett's Bisection Theorem which leads to the familiar Wheatstone type of bridge.

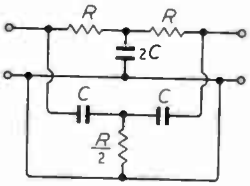



Fig. 1. *Basic parallel-T circuit; there is a null in the response when* $R = 1/\omega_0 C$.

## 1. Equivalent Network

The familiar parallel-T network is shown in Fig. 1, and the values of the components are chosen to give a null at a desired frequency ($f_0$) for the conditions shown. It is generally assumed that the network should work from a source of zero impedance into one of infinite impedance; these conditions simplify the mathematical analysis and give symmetrical characteristics. If the source and load impedances are finite, then the increased mathematical labours are seen from studying Fig. 2. Fig. 2(a) is fairly simply analysed by using 3-mesh equations but 4-mesh equations are necessary for the solution of Fig. 2(b). Having solved the equations, very little light is thrown on the principle of operation of the network.

However, an equivalent network can be found by making use of Bartlett's Bisection Theorem. The process, step by step, is shown in Fig. 3.

Step 1 shows Fig. 1.

Step 2 shows Fig. 1 bisected.

The Step 3 lattice network is obtained as follows:—The series arms of the lattice network consist of the input impedance of the network of Step 2 with all the bisected ends short-circuited; while the cross-arms of the lattice consist of the input impedance of Step 2 with all the bisected ends open-circuited. The process could readily stop at this point, as the lattice is a familiar network but Step 4 is more familiar and more easily understood.

Thus Step 4 is the final equivalent network which satisfies the conditions of simplified mathematical analysis and ease of understanding of its mode of operation.

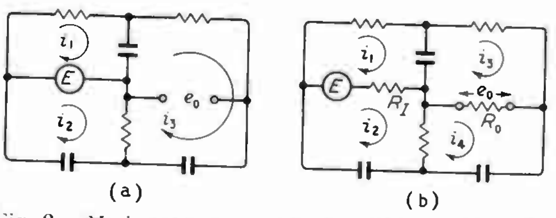



Fig. 2. *Mesh currents of parallel-T circuit when source is of zero impedance and load is infinite (a) and when both source and load are finite (b).*

## 2. Analysis

Examination of Fig. 3, Step 4 shows that if the network works from a zero-impedance source into one of infinite impedance, only two equations are necessary for its analysis. If the source and load impedance have finite values then three equations are necessary. This is seen from Fig. 4 where the impedances have been generalized. Although the source and load impedances have been shown as resistors they could also be of the form $R \pm jX$.

From Fig. 4 the mesh equations are:—

$$E = i_1 (R_I + Z_1 + Z_2) - i_2 Z_1 - i_3 Z_2 \quad \ldots \quad \ldots \quad (1)$$

$$0 = i_1 Z_1 + i_2 (R_0 + Z_1 + Z_2) - i_3 R_0 \quad \ldots \quad \ldots \quad (2)$$

$$0 = - i_1 Z_2 - i_2 R_0 + i_3 (R_0 + Z_1 + Z_2) \quad \ldots \quad \ldots \quad (3)$$

MS accepted by the Editor, June 1955

From these equations the determinant is found which is:—

$$\Delta = (Z_1+Z_2)[2R_IR_0+(R_I+R_0)(Z_1+Z_2)+2Z_1Z_2] \quad \ldots \quad (4)$$

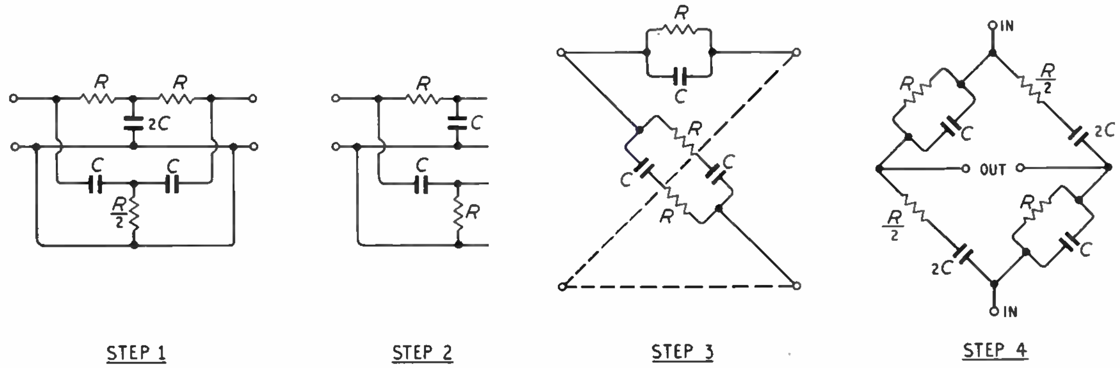



Fig. 3. *These diagrams illustrate the transformation of a parallel-T circuit through a lattice to a true bridge.*

The output voltage is

$$e_0 = (i_2 - i_3)R_0 \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

where

$$i_2 = \frac{E[R_0Z_2 + Z_1(R_0 + Z_1 + Z_2)]}{\Delta} \quad \ldots \quad (6)$$

and

$$i_3 = \frac{E[R_0Z_1 + Z_2(R_0 + Z_1 + Z_2)]}{\Delta} \quad \ldots \quad (7)$$

Substituting (6) and (7) into (5) gives

$$e_0 = ER_0\frac{Z_1 - Z_2}{2R_IR_0+(R_I+R_0)(Z_1+Z_2)+2Z_1Z_2} \quad (8)$$

Equation (8) completely defines the network, from which the attenuation and phase characteristics for any set of parameters can be plotted.

It is also very desirable to know the input impedance of the network.

Let $Z_{in}$ = input impedance

From Fig. 4

$$Z_{in} = \frac{E}{i_1} - R_I \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

where from equations (1), (2) and (3)

$$i_1 = \frac{E[(Z_1 + Z_2)(Z_1 + Z_2 + 2R_0)]}{\Delta} \quad \ldots \quad (10)$$

Therefore from (9) and (10)

$$Z_{in} = \frac{R_0(Z_1 + Z_2) + 2Z_1Z_2}{Z_1 + Z_2 + 2R_0} \quad \ldots \quad \ldots \quad (11)$$

### 3. Examination of Equation (8)

Rewrite equation (8) as:

$$\frac{E}{e_0} = \frac{2R_IR_0 + (R_I + R_0)(Z_1 + Z_2) + 2Z_1Z_2}{R_0(Z_1 - Z_2)} \quad \ldots \quad \ldots \quad (8a)$$

This equation can now be examined for various conditions.

3.1. Let $R_I = 0$ and $R_0 = \infty$. This is the normally-accepted working condition of this circuit.

$$\text{Then } \frac{E}{e_0} = \frac{Z_1 + Z_2}{Z_1 - Z_2} \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

It is immediately apparent that a null will be obtained when $Z_1 = Z_2$. Some further properties will become apparent if the parameters of Fig. 3, Step 4 are substituted into equation (12).

$$\text{Here } Z_1 = \frac{-jR}{\omega CR - j} \text{ and } Z_2 = \frac{\omega CR - j}{2\omega C}$$

$$\text{Therefore } \frac{E}{e_0} = \frac{(\omega CR)^2 - 1 - j4\omega CR}{1 - (\omega CR)^2}$$

Let $R = 1/\omega_0 C$

$$\text{Then } \frac{E}{e_0} = \frac{(\omega/\omega_0)^2 - 1 - j4(\omega/\omega_0)}{1 - (\omega/\omega_0)^2} \quad \ldots \quad (13)$$

$$= \frac{\sqrt{\left[\{(\omega/\omega_0)^2 - 1\}^2 + \{4\omega/\omega_0\}^2\right]}}{1 - (\omega/\omega_0)^2}$$

with phase angle

$$-\tan^{-1}\frac{4\omega/\omega_0}{(\omega/\omega_0)^2 - 1} \quad \ldots \quad \ldots \quad (13a)$$

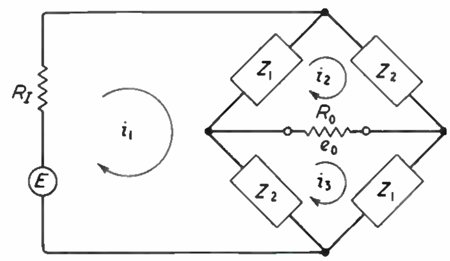



Fig. 4. *General bridge network.*

From (13a) the attenuation characteristic can be plotted against the parameter $\omega/\omega_0$, which is, in effect, against frequency ($f$) because $f_0$ is a constant. This method of presentation has many obvious advantages, one of the more important being compactness. From (13a) it can be seen that a null occurs when $\omega/\omega_0 = 1$ and also that the attenuation and phase characteristics are symmetrical about $\omega/\omega_0 = 1$. This last point can be checked by substituting $\omega_0/\omega$ for $\omega/\omega_0$ and equating the two equations; if they are identical, the characteristics are symmetrical.

3.2. Now let $R_I = R_I$ and $R_0 = \infty$

$$\text{Then } \frac{E}{e_0} = \frac{2R_I + Z_1 + Z_2}{Z_1 - Z_2} \quad \ldots \quad \ldots \quad (14)$$

Give values to $Z_1$ and $Z_2$ as in (3.1)

Then

$$\frac{E}{e_0} = \frac{(\omega CR)^2 - 1 + 4R_IR(\omega C)^2 - j(4\omega CR + 4\omega CR_I)}{1 - (\omega CR)^2}$$

Let $R = 1/\omega_0 C$

$$\frac{E}{e_0} = \frac{(\omega/\omega_0)^2(1 + 4R_I/R) - 1 - j4(\omega/\omega_0)(1 + R_I/R)}{1 - (\omega/\omega_0)^2} \quad \ldots \quad \ldots \quad (15)$$

Examination of (15) shows that a null occurs at $\omega/\omega_0 = 1$, but that the characteristics are not symmetrical. A rough shape of the attenuation characteristic can be found as follows:

$$\text{As } \frac{\omega}{\omega_0} \to \infty \quad \frac{E}{e_0} \to 1 + \frac{4R_I}{R} \quad \ldots \quad (16)$$

and as $\frac{\omega}{\omega_0} \to 0$

$$\frac{E}{e_0} \to -1 - j4\frac{\omega}{\omega_0}\left(1 + \frac{R_I}{R}\right) \to 1 \quad \ldots \quad (17)$$

Equation (17) compares with $(-1 - j4\omega/\omega_0)$ for the case when $R_I = 0$ (Section 3.1); both curves ultimately having the same value.

The attenuation and phase characteristics given by equations (13) and (15) are shown in Fig. 5(a) and (b) respectively. For equation (15) $R_I$ has been given the value of $R$.

3.3. Let $R_I = 0$ and $R_0 = R_0$

$$\text{Then } \frac{E}{e_0} = \frac{R_0(Z_1 + Z_2) + 2Z_1Z_2}{R_0(Z_1 - Z_2)} \quad \ldots \quad (18)$$

$$\text{or } \frac{E}{e_0} = \frac{Z_1 + Z_2 + 2Z_1Z_2/R_0}{Z_1 - Z_2} \quad \ldots \quad (18a)$$

Assume the same values for $Z_1$ and $Z_2$ as used in (3.2).

The resulting expression is given by:

$$\frac{E}{e_0} = \frac{\{(\omega/\omega_0)^2 - 1 - 2R/R_0\} - j(\omega/\omega_0)\ (4 + 2R/R_0)}{1 - (\omega/\omega_0)^2} \quad \ldots \quad \ldots \quad (19)$$

Let us examine the general shape of the attenuation characteristic as follows:

At $f = \infty$, $Z_1 = 0$ and $Z_2 = R/2$

Therefore $E/e_0 = 1 \quad \ldots \quad \ldots \quad \ldots \quad (20)$

At $f = 0$, $Z_1 = R$ and $Z_2 = \infty$

$$\text{Therefore } \frac{E}{e_0} = \frac{R_0 + 2R}{R_0} \quad \ldots \quad \ldots \quad \ldots \quad (21)$$

Compare equations (20) and (21) with (16) and (17) respectively. They appear to be inverse or mirror image curves and would be under certain conditions.

Equate (16) and (21):

$$1 + \frac{4R_I}{R} = \frac{R_0 + 2R}{R_0}$$

Therefore $R = \sqrt{2R_IR_0} \quad \ldots \quad \ldots \quad \ldots \quad (22)$

Now in (15) let $R_I = R$

$$\text{Therefore } \frac{E}{e_0} = \frac{5(\omega/\omega_0)^2 - 1 - j8\omega/\omega_0}{1 - (\omega/\omega_0)^2} \quad (23)$$

From (22) if $R_I = R$ then $R_0 = R/2$. Substitute this value into equation (19):

$$\frac{E}{e_0} = \frac{(\omega/\omega_0)^2 - 5 - j8\omega/\omega_0}{1 - (\omega/\omega_0)^2} \quad \ldots \quad \ldots \quad (24)$$

If expressions (23) and (24) give mirror image characteristics, then by substituting $\omega_0/\omega$ for $\omega/\omega_0$ in (24), the resulting expression should be equivalent to (23). This has been done below and the equivalence shown. The differences in sign indicate phase lag or lead.

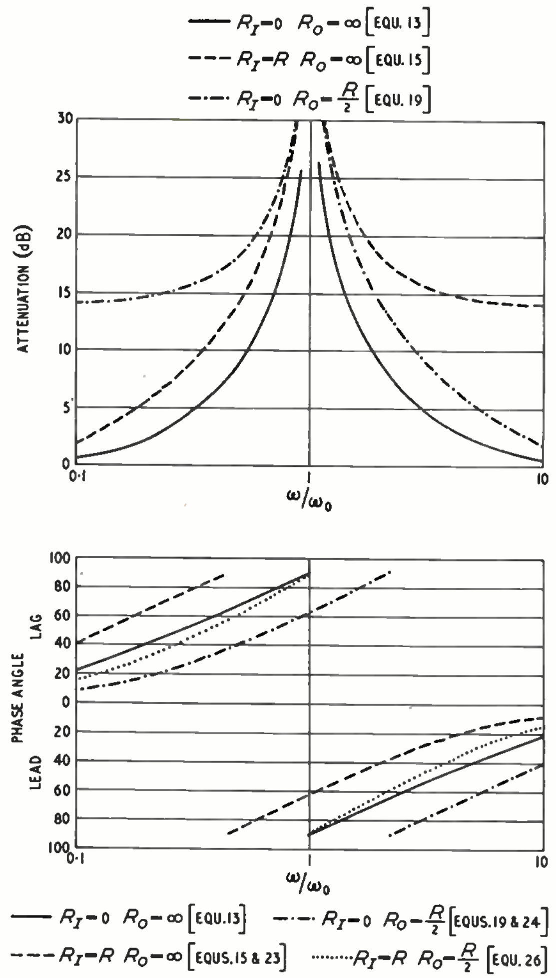



Fig. 5. *Normalized attenuation (a) and phase (b) characteristics of parallel-T network.*

Then

$$\frac{(\omega/\omega_0)^2-5-j8\omega/\omega_0}{1-(\omega/\omega_0)^2} \rightarrow \frac{(\omega_0/\omega)^2-5-j8\omega_0/\omega}{1-(\omega_0/\omega)^2}$$

$$= \frac{1-5(\omega/\omega_0)^2-j8\omega/\omega_0}{(\omega/\omega_0)^2-1}$$

which shows that the expressions give mirror image characteristics. These results are shown in Fig. 5.

It should now be possible to obtain a symmetrical characteristic with finite values of $R_I$ and $R_0$.

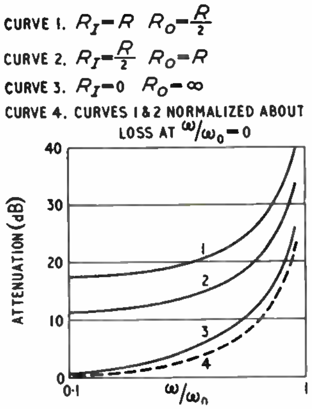



Fig. 6. *Attenuation characteristics symmetrical about* $\omega/\omega_0=1$ *for the condition* $2R_IR_0=R^2$.

3.4. Let $R_I = R_I$ and $R_0 = R_0$.
This expression was derived in Section 2 and is given by equation (8a) as

$$\frac{E}{e_0} = \frac{2R_IR_0+(R_I+R_0)\ (Z_1+Z_2)+2Z_1Z_2}{R_0(Z_1-Z_2)} \qquad \ldots \quad \ldots \quad (8a)$$

Substitute values of $Z_1$ and $Z_2$ as in Section 3.1:
Therefore

$$\frac{E}{e_0} = \left[\left(\frac{\omega}{\omega_0}\right)^2\left(\frac{4R_I}{R}+\frac{R_I}{R_0}+1\right)-\left(\frac{R_I}{R_0}+\frac{2R}{R_0}+1\right) - j\frac{\omega}{\omega_0}\left\{\frac{4R_I}{R}+4\left(\frac{R_I}{R_0}+1\right)+\frac{2R}{R_0}\right\}\right]\Bigg/\left[1-\left(\frac{\omega}{\omega_0}\right)^2\right] \qquad \ldots \quad (25)$$

For this curve to be symmetrical the condition of equation (22) must hold.
Substitute $R = \sqrt{2R_IR_0}$ into (25).
Then

$$\frac{E}{e_0} = \left[\left\{\left(\frac{\omega}{\omega_0}\right)^2-1\right\}\left\{\frac{R_I}{R_0}+2\sqrt{\left(\frac{2R_I}{R_0}\right)}+1\right\} - j4\left\{\frac{R_I}{R_0}+\sqrt{\left(\frac{2R_I}{R_0}\right)}+1\right\}\frac{\omega}{\omega_0}\right]\Bigg/\left[1-(\omega/\omega_0)^2\right] \qquad \ldots \quad (26)$$

It is apparent that this expression will give a symmetrical characteristic as it is of a similar form to equation (13). The basic loss will always be greater than that of equation (13), the degree depending on the values of $R_I$ and $R_0$, but when normalized it will be seen that a sharper characteristic is obtained. This is shown in Fig. 6 where curve 3 shows the response for $R_I = 0, R_0 = \infty$; curve 2 for $R_I = R/2, R_0 = R$; curve 1 for $R_I = R, R_0 = R/2$ and curve 4 is the normalized result of curves 1 and 2. It is seen that the conditions chosen for curves 1 and 2 give normalized curves that are coincident. If equation (26) is normalized, then

$$\frac{E}{e_0} = \frac{(\omega/\omega_0)^2-1-j4(\omega/\omega_0)(A/B)}{1-(\omega/\omega_0)^2} \qquad \ldots \quad (27)$$

where $A = \dfrac{R_I}{R_0} + \sqrt{\left(\dfrac{2R_I}{R_0}\right)} + 1$

and $B = \dfrac{R_I}{R_0} + 2\sqrt{\left(\dfrac{2R_I}{R_0}\right)} + 1$

and it can be shown that the ratio $A/B$ has a minimum value when $R_I/R_0 = 1$ and further is symmetrical about this point. Therefore, the sharpest characteristic will occur at $R_I/R_0 = 1$ and this is the reason for the coincidence of curves 1 and 2 when normalized.

## 4. General Circuit

The foregoing analysis has been based on Fig. 3 where, as shown in Step 2, the components in the two T-arms have similar values. A more general circuit would be of the form shown in Fig. 7 where "$n$" is any number. The null condition is given by $Z_1 = Z_2$ and, if the values of Fig. 7 are used, it is found that a null occurs when

$$R = 1/\omega_0 C\sqrt{n} \qquad \ldots \quad \ldots \quad \ldots \quad (28)$$

By inserting the values of $Z_1$ and $Z_2$ into the appropriate formulae given in previous sections any desired result can be obtained. The main properties of this circuit can be examined if it is compared with the case of $n = 1$, $R_I = 0$, $R_0 = \infty$ (Section 3.1).

By introducing the values of $Z_1$ and $Z_2$ of Fig. 7 into equation (12) the following result is obtained:

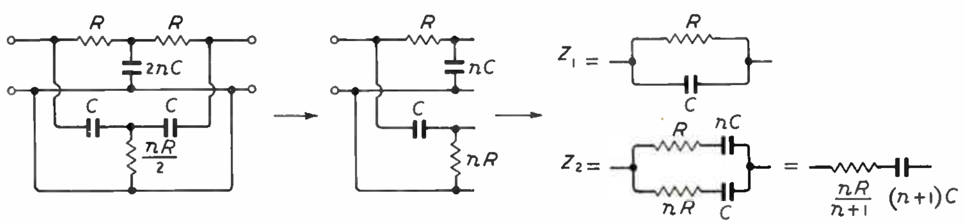



Fig. 7. *Derivation of bridge arms when the shunt arms of the parallel-T circuit are n times as great as in Fig. 1.*

$$\frac{E}{e_0} = \frac{\left(\frac{\omega}{\omega_0}\right)^2 - 1 - j\frac{2}{\sqrt{n}}(n+1)\frac{\omega}{\omega_0}}{1 - (\omega/\omega_0)^2} \quad \ldots \quad (29)$$

By examining the constant of the $j$ term it is seen that it is a minimum when $n = 1$ and that values are symmetrical about $n = 1$ (that is, at $n = 0{\cdot}25$ and $4{\cdot}0$, etc.), so that the sharpest attenuation characteristic is obtained when $n = 1$.

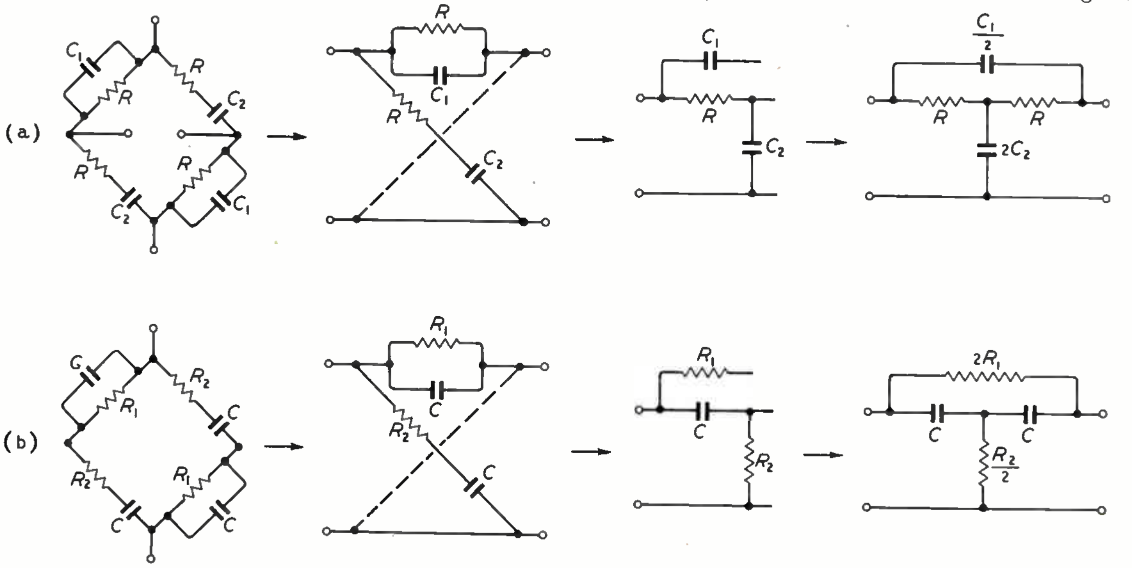



Fig. 8 (above). *This diagram illustrates how the bridge form of the circuit can be transformed to the bridged-T.*

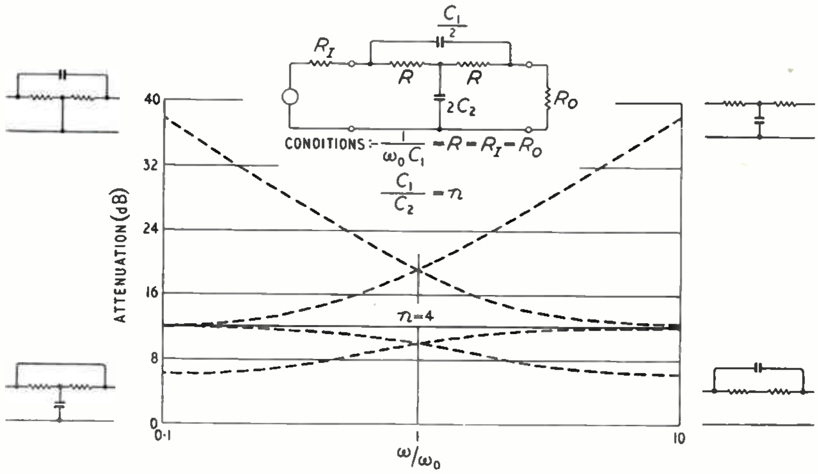



Fig. 9 (right). *Amplitude characteristics of Fig. 8 (a) for $R = R_0 = R_I = 1/\omega_0 C_1$.*

When $R_I$ and $R_0$ have finite values, an expression of a similar form to equation (25) can be obtained and, for the attenuation characteristic to be symmetrical, it is found that

$$R_I R_0 = R^2 \frac{n}{n+1} \quad \ldots \quad \ldots \quad \ldots \quad (30)$$

**5. Circuit Variations**

From a study of Fig. 3 it is apparent that starting with any other configuration of Step 4, the procedure can be reversed, ending at Step 1 with a circuit that may be appreciably different from that of the normal parallel-T. Such a procedure is shown in Fig. 8; the resulting circuits being of the bridged-T variety. These circuits have some very useful properties which can be easily examined by introducing the appropriate values of $Z_1$ and $Z_2$ into equation (8). An example of this is shown in Fig. 9 which shows the variations of amplitude characteristic obtainable for the circuit of Fig. 8(a) for the condition $1/\omega_0 C_1 = R = R_0 = R_I$. If in Fig. 9, $n = 4$, a characteristic is obtained independent of attenuation; so that this circuit could be used for eliminating the effects of an unwanted capacitance on an attenuation characteristic.

**6. Conclusions**

It has been shown that the design of a parallel-T network can be simplified considerably by this method of equivalence. A desired characteristic can be obtained by either varying the source and load impedance or by varying the ratio of the parallel-T components (that is, the value of $n$). Finally, it is seen that variations of the parallel-T or bridged-T can be simply analysed and hence designed precisely.

**Acknowledgment**

The author wishes to thank the Chief Engineer of the B.B.C. for permission to publish this paper.

**REFERENCES**

1 H. H. Scott, "A New Type of Selective Circuit and some Applications", *Proc. Inst. Radio Engrs*, February 1938.
2 L. Stanton, "Theory and Applications of Parallel-T Resistance-Capacitance Selective Networks", *Proc. Inst. Radio Engrs*, July 1946.
3 A. Wolf, "Note on a Parallel-T Resistance-Capacitance Network", *Proc. Inst. Radio Engrs*, September 1946.
4 A. B. Hillian, "The Parallel-T Bridge Amplifier", *J. Instn. Elect. Engrs*, Part III, No. 27, January 1947.
5 L. G. Cowles, "The Parallel-T Resistance-Capacitance Network", *Proc. Inst. Radio Engrs*, December 1952.
6 D. A. H. Brown, "The Equivalent Q of Resistance-Capacitance Networks", *Electronic Engineering*, July 1953.

# D.F. PLOTTING AID

**By H. G. Hopkins, B.Sc., Ph.D., M.I.E.E.**

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

**SUMMARY.**—A simple plotting aid is described for use in determining the contour enclosing the area within which the transmitter lies with a given probability. It is in the form of a transparent graticule which is placed on the map over the most probable point and is designed to facilitate the calculations. The aid is flexible in application and suitable for use where speed is required rather than the highest accuracy.

## 1. Introduction

WHEN a network of direction finders is used to determine the position of a distant transmitter, each instrument provides a best estimate of bearing, due allowance having been made for known systematic errors. The residual random error associated with the bearing provided by the $j$th direction finder may be represented by the standard deviation $\sigma_j$; the standard deviations can be separately estimated. Stansfield[1] has shown how to determine the most probable position (m.p.p.) of the transmitter from these data and that, granted certain assumptions of a geometrical nature, the contour enclosing the *minimum* area on the earth's surface within which the transmitter lies with a given probability is elliptical in shape and centred on the m.p.p. His analysis enables the direction and magnitudes of the ellipse axes to be computed. The computation is rather lengthy and Barfield[2] has suggested a plotting procedure which is speedier and avoids some of the complications involved; the aid described in the present note has a similar objective. A balance of the conflicting factors of precision and time will determine which method of determining the probability contours is best for any particular purpose. Limited experience of the technique to be described suggests that it is quicker than that proposed by Barfield, at any rate for those not fully experienced in his method. The accuracies of the two methods appear to be comparable.

## 2. Basis of the Method

It is assumed that the most probable position, F, of the transmitter has already been determined and marked on a gnomonic plotting chart showing the positions of the direction finders. Let orthogonal axes be set up at F; to fix ideas let the $Y$ axis be along the meridian at F and let angles be measured clockwise from north. Suppose $\theta_j$ to be the angle between the meridian at F and the bearing-string from the $j$th direction finder when the string is positioned over F. Following Stansfield let

$$\lambda = \sum \frac{\sin^2\theta_j}{d_j^2\sigma_j^2},$$

$$\mu = \sum \frac{\cos^2\theta_j}{d_j^2\sigma_j^2}, \text{ and}$$

$$\nu = \sum \frac{\sin\theta_j \cos\theta_j}{d_j^2\sigma_j^2}$$

where $d_j$ is the length of the string between the $j$th direction finder and F, and where the summations are carried out over all the direction finders. Then the constants for the ellipse

$$\frac{x^2}{b_p^2} + \frac{y^2}{a_p^2} = 1$$

centred on F and enclosing the area on the chart associated with a given probability, $p$, are approximately given by:

$$\tan 2\phi = -\frac{2\nu}{\lambda - \mu} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

and, taking the root $-\frac{\pi}{4} < \phi < \frac{\pi}{4}$,

$$-\frac{2\log_e(1-p)}{a_p^2} = \lambda - \nu\tan\phi \quad \ldots \quad (2)$$

$$\text{and } -\frac{2\log_e(1-p)}{b_p^2} = \mu + \nu\tan\phi \quad \ldots \quad (3)$$

MS accepted by the Editor, July 1955

In these equations $a_p$ and $b_p$ are the (orthogonal) semi-axes of the ellipse measured in the same units as $d_j$, and $\phi$ is the angle between the $a_p$ axis and the meridian at F. Note that $a_p$ is not necessarily the major semi-axis.

These equations correspond to (12), (15) and (16) of Stansfield, corrected in the case of (15) and (16) to allow for erroneous factors of 2 in the $\lambda$ and $\mu$ terms which appear to have arisen in the step following equation (14).

The difficulty in quickly applying the above equations lies in the determination of $\lambda$, $\mu$ and $\nu$. This may be facilitated as follows.

Let the string centred on the $j$th direction finder be rotated clockwise by an angle $\sigma_j$ from the position it occupies when aligned on F, the angle $\sigma_j$ being as indicated on the bearing rose for that direction finder. If $y_j$ is the intercept of the deflected string on the $Y$ axis, it will be noted that $y_j^{-2}$ is approximately equal to the contribution to $\lambda$ of the $j$th direction finder, namely, $\frac{\sin^2 \theta_j}{d_j^2 \sigma_j^2}$; similarly the contribution to $\mu$ is $x_j^{-2}$ where $x_j$ is the intercept on the $X$ axis.

Thus, if the process described above is carried out for each string in turn and the $x_j$ and $y_j$ noted, then $\lambda$ and $\mu$ can be derived by summation. The $j$th contribution to $\nu$ is given by $x_j^{-1}y_j^{-1}$ and, taking due note of signs, $\nu$ itself is found by summation.*

These relationships are applied in the construction of the simple plotting aid described below.

## 3. Description of the Plotting Aid

The plotting aid is shown in Fig. 1. It comprises orthogonal axes each graduated so as to read directly the reciprocal of the square of the distance from the origin. The graticule is engraved on the upper surface of a flat, rigid sheet of polished transparent material having chamfered edges to reduce friction with the strings. The region near the intersection of the axes is of little value because the scale is very crowded; the central portion of the upper surface is accordingly left blank, but a cross is engraved, as shown immediately below the centre of the graticule. This cross enables the aid to be set over the m.p.p. without parallax. The positive and negative signs in the four quadrants are used, as described later.

* Mr. E. M. L. Beale has kindly indicated to the author that $\nu$ can also be found by using an auxiliary set of orthogonal axes $(X_a, Y_a)$ rotated clockwise by $\pi/4$ from the $(X, Y)$ set. If $x_{aj}$ and $y_{aj}$ are the intercepts of the deflected $j$th string on $X_a$ and $Y_a$, then $2\nu = \Sigma(x_{aj}^{-2}) - \Sigma(y_{aj}^{-2})$. The relation $\Sigma(x_j^{-2}) + \Sigma(y_j^{-2}) = \Sigma(x_{aj}^{-2}) + \Sigma(y_{aj}^{-2})$ also provides a useful computational check.

A convenient size for the transparent sheet has been found to be about 25 cm square; this enables the scales along the axes to cover the range 0·01 to 2 cm$^{-2}$ where the centimetre is used as the unit for measuring the axial dimensions of the ellipses. The unit of length used in Fig. 1 has been chosen arbitrarily. To incorporate Mr. Beale's suggestion (mentioned in the footnote) would involve engraving on the sheet the second set of axes, similarly graduated. Since no experience has been gained of the aid so modified, it is not considered further.

In use, the aid is centred on the m.p.p. (assumed to be already known) and adjusted so that the $s^2$ (or $Y$ axis) is along the meridian at this point. The choice of the meridian as reference direction is mainly for convenience of description in this account; in practice, it may sometimes be found desirable to orient the graticule differently, for example, as a means of improving reading accuracy. Each string is taken in turn and aligned on the m.p.p.; the

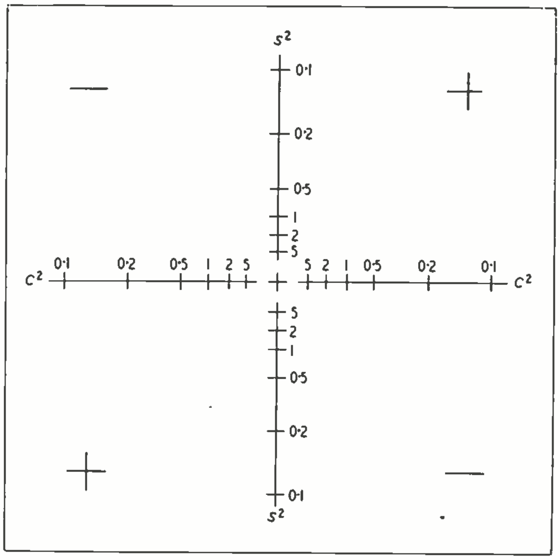


Fig. 1. *Diagram of plotting aid; a few graduations are shown to illustrate the scale.*

bearing of the m.p.p. is read off on the appropriate bearing rose and the string is rotated clockwise by its $\sigma_j$. The co-ordinates $l_j$, $m_j$ of the points where the string crosses the $s^2$ and $c^2$ axes are read off from the scale graduations and the sign of the quadrant across which the string cuts between the intercepts is noted. The results are set out in the $s^2$, $c^2$ and Sign columns as shown in the Table.

The entries in the $s^2$ and $c^2$ columns are all essentially positive; the scale readings are directly entered as positive values independently of how the deflected strings cut the axes. The sign read off as mentioned above applies to the entries to be made in the *sc* column; these may be conveniently read off from a nomogram giving the geometric mean of $l_j$ and $m_j$ or may be calculated from these values. The former process is quicker and avoids mistakes involving $\sqrt{10}$ which can easily occur in the latter.

The constants of the ellipse enclosing the area associated with probability $p$ are then given by:

$$\tan 2\phi = \frac{2N}{L - M} \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

and, taking the root $-\frac{\pi}{4} < \phi < \frac{\pi}{4}$

$$-\frac{2 \log_e (1 - p)}{a^2_p} = L + N \tan \phi \ldots \quad (5)$$

and $$-\frac{2 \log_e (1 - p)}{b^2_p} = M - N \tan \phi \quad (6)$$

It will be recalled that $\phi$ (the direction of the $a_p$ axis) is measured clockwise from the $s^2$ axis and that $a_p$ and $b_p$ are in the units used in constructing the graticule: $a_p$ is not necessarily greater than $b_p$. The discrepancies in sign between these three working equations and (1), (2) and (3) are a result of the signs allotted to the quadrants of the plotting aid. The scheme adopted (Fig. 1) appears more natural than the alternative, implicit in the earlier equations, in which the quadrants would have the opposite signs. It must be stressed that equations (4), (5) and (6) must be used if the quadrants are labelled as shown in the figure.

With but little practice any chosen probability contour can be determined in less than ten minutes when four direction finders are in use. Limited experience suggests that the directions of the axes are usually accurate to one or two degrees and the axial lengths to within about 20% except when long thin ellipses are involved. In this case the errors in the long axis may be very large but may be somewhat reduced by orienting the $s^2$ axis roughly along the expected direction of the long axis rather than along the meridian. A useful practical way of improving accuracy when the intercepts on the axes are small is to multiply *all* $\sigma_j$ by a convenient factor $k$ (exceeding unity) thus removing the deflected strings from the crowded region of the scale near the origin; $\phi$ is unaffected but the derived values of $a_p$ and $b_p$ should be divided by $k$.

**TABLE**

| Direction Finder | Scale Reading | | Sign | Derived |
|---|---|---|---|---|
| | $s^2$ | $c^2$ | | $sc$ |
| 1 | $l_1$ | $m_1$ | | $\sqrt{(l_1m_1)}$ |
| 2 | $l_2$ | $m_2$ | | $\sqrt{(l_2m_2)}$ |
| 3 | $l_3$ | $m_3$ | | $\sqrt{(l_3m_3)}$ |
| ... | ... | ... | | ... |
| ... | ... | ... | | ... |
| | Sum = $L$ | Sum = $M$ | | Sum = $N$ (algebraic) |

## 4. Conclusion

The aid described is put forward as a practical and simple means of rapidly, if roughly, determining the elliptical area about the most probable point within which the transmitter lies with a chosen probability. It is useful on a map of any scale since the axial lengths are in units determined by the graduations on the aid itself and not by the scale of the map.

It is opportune to consider simple plotting aids of this general character since the rather complicated and lengthy computations inherent in statistical plotting techniques appear to have constituted one of the stumbling blocks in the way of the widespread adoption of these objective methods.


### Acknowledgment

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


### REFERENCES


1 R. G. Stansfield, "Statistical Theory of D.F. Fixing", *J. Instn elect. Engrs*, Part IIIA, 1947, Vol. 94, p. 762.

2 R. H. Barfield, "Statistical Plotting Methods for Radio Direction Finding", loc. cit., p. 673.


# 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.*

### New Rejector Circuit

SIR,—The April Editorial sets out to explain the behaviour of the so-called "bifilar-T rejector" by deriving an equivalent ladder circuit, free from mutual inductance. The equivalent, which appears in Fig. 4 of the Editorial, contains a tuned circuit with negative components, and it is to this feature that the special properties of the circuit are ascribed. The alternative treatment given below shows that these negative components are simply an incidental characteristic of the particular equivalent chosen and have no connection with the essential properties of the rejector.

The left-hand side of Fig. 1 shows the rejector circuit in question with the trivial modification of having a resistor of $4R$ placed across the whole of the tightly-coupled coil rather than a resistor of $R$ across one half it; this modification is perfectly legitimate in view of the assumed perfect coupling and it probably represents a better arrangement for the practical case of slightly imperfect coupling. On the right-hand side of Fig. 1 appears the lattice network which is equivalent to the rejector. This lattice equivalent may be found from purely topological considerations using the methods described by Bode[1].

If we postulate $R = R_1$ then resistances of $2R_1$ may be removed in shunt from both lattice arms and placed in parallel with the input and output terminals as in Fig. 2. At this stage we can see the true significance of the bifilar rejector—it allows us to remove all the dissipation from the network and place it across the source and load impedances. What is left is a network of dissipationless reactances which can consequently exhibit sharp discrimination and have true infinite-loss points at real frequencies. This technique has been used in conventional filters for many years and has been described by Mason[2]. networks. Although the circuit is potentially non-minimum-phase, as used it has minimum-phase properties as Fig. 3 indicates, and the phase characteristic is precisely the same as that of any other minimum-phase network with the same loss characteristic.

The problem of providing a band-pass response with

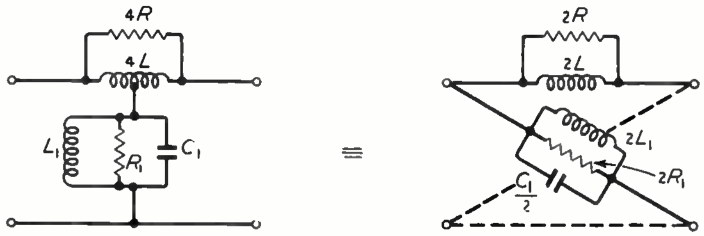



Fig. 1

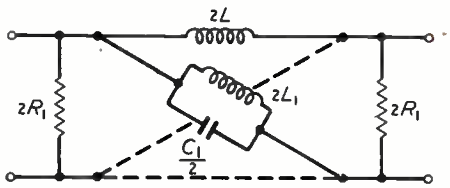



Fig. 2

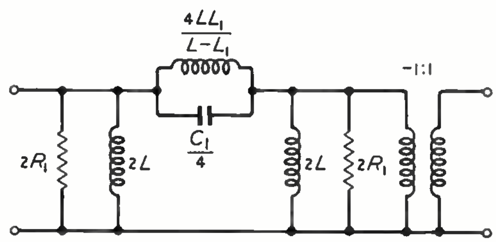



Fig. 3

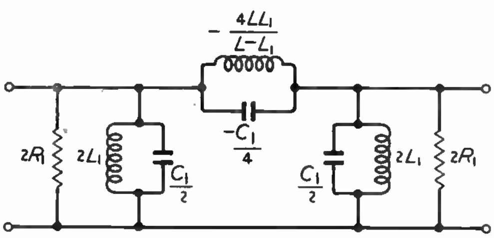



Fig. 4

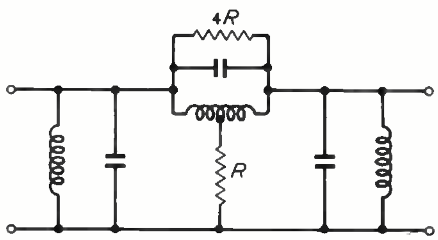



Fig. 5

In this particular case, the lattice reactance network is easily recognized as a simple high-pass filter of which the ladder equivalent is given in Fig. 3. The phase inversion which the original circuit provides at very high frequencies is produced in the equivalent by means of the tandem-connected ideal transformer. If, for some reason, one wishes to avoid the presence of transformers in *any* form in the unbalanced equivalent it is of course possible, but one is then forced to use negative elements in order to obtain the phase inversion. Such an equivalent is shown in Fig. 4, and is the circuit derived in the Editorial. By comparison with Fig. 3 it is more complicated and it is almost impossible to see clearly how the circuit works. Evidently the negative components have nothing to do with the sharp discrimination which the rejector may give.

There are many other circuits which can have their dissipation effects removed in the same way as the "bifilar-T". A band-pass example is given in Fig. 5. In the article[3] where the "bifilar-T" circuit was described by Fairhurst it was stated to be a non-minimum-phase network and this fact was said to be responsible for its superior phase characteristic compared with those of other equally-selective but otherwise minimum-phase sharp rejection near one edge of the pass-band, as needed for a vision i.f. channel, has been solved by conventional filter theory many years ago. Designing a simple band-pass filter so that its effective pass-band coincides with the wanted vision channel and with a peak of loss at the sound-channel frequency gives a circuit as shown in Fig. 5 in which all the dissipation has been thrown across the terminating resistors by using the resistance-compensation trick described by Mason. This circuit has the advantage of giving capacitances across input and output terminals, which can be used to absorb the valve capacitances, and also across the bifilar-wound inductor to absorb its self-capacitance.


H. J. ORCHARD

Post Office Research Station,
Dollis Hill,
London, N.W.2.


21st May 1956.

## REFERENCES


[1] H. W. Bode, "Network Analysis and Feedback Amplifier Design", pp. 266–270, D. Van Nostrand, New York, 1945.

[2] W. P. Mason, "Resistance Compensated Band-Pass Crystal Filters for use in Unbalanced Circuits", *Bell Syst. Tech. J.*, Vol. 16, p. 423, 1937.

[3] H. A. Fairhurst, "Experimental Color Receiver", *Wireless World*, March 1956, p. 112.

## Bifilar-T Trap

SIR,—I have been very interested to read your leaders in *Wireless Engineer* (April and May) on the "bifilar-T trap". I should like, however, to suggest to you that the equivalent network of the device can be obtained with great simplicity by recourse to two known theorems due respectively to Cauer and Bode. Both of these are most readily derived by matrix theory.

Cauer showed, in about 1930, that the lattice network, Fig. 1, is equivalent to the network of Fig. 2, in which T is an ideal transformer.

to the lattice network of Fig. 7, for which the conditions of maximum (or infinite) attenuation and overall transmission band can be calculated from the usual lattice-network relations.

The above lattice equivalents, it is interesting to note, have no "negative elements" and are therefore realizable physically.

W. PROCTOR WILSON
The British Broadcasting Corporation,
Kingswood Warren, Surrey.
14th June 1956.

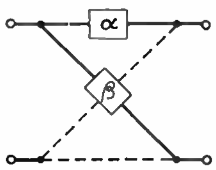



Fig. 1

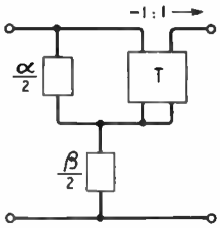



Fig. 2

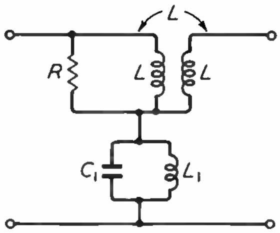



Fig. 3

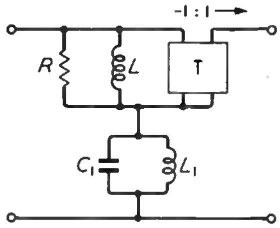



Fig. 4

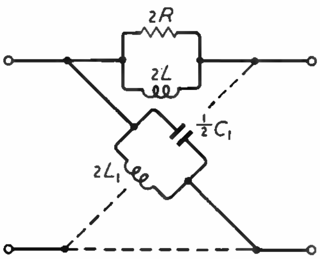



Fig. 5

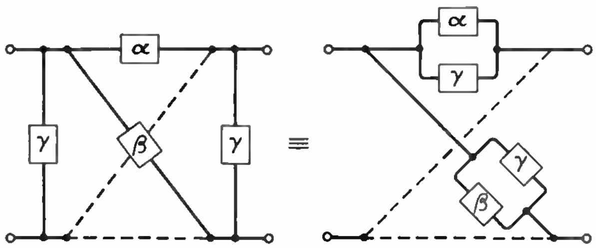



Fig. 6

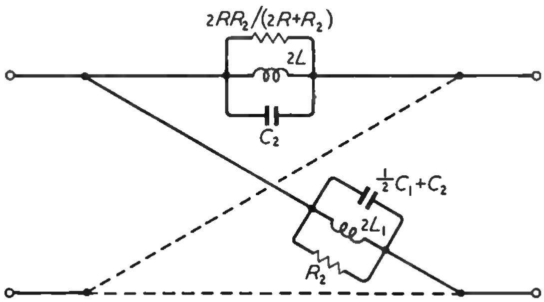



Fig. 7

Now the bifilar-T trap, as shown in your Fig. 1(a), p. 105, May, and here re-drawn in the form of Fig. 3, is obviously equivalent to Fig. 4 when T again is an ideal transformer of ratio $-1:1$.

It follows that this network is then equivalent at all frequencies to the lattice (bridge) network of Fig. 5.

Coming now to the effect of bilateral shunting of the network by leaking capacitors, we can make use of the equivalence (shown by Bode* in 1934) illustrated in Fig. 6. From this it follows immediately that the bifilar-T trap, terminated as in your Fig. 3, p. 106, with, say, $C_2$ in parallel with $R_2$, is identically equivalent

* "General Theory of Electric Wave Filters", *Journal of Mathematics and Physics*, Vol. 13, No. 3, November 1934, p. 341.

## INTERNATIONAL SCIENTIFIC RADIO UNION

The Proceedings of the 11th General Assembly of U.R.S.I. which was held on 23rd August–2nd September 1954 can be obtained from the General Secretariat of the U.R.S.I., 42 Rue des Minimes, Brussels, Belgium, as follows: Vol. 10, Part 2. Commission 2 on Radio and Troposphere, price 14s. 6d.; Part 7. Commission 7 on Radioelectronics, price 31s. 6d.

### "Phase-Angle Measurement"

The author, C. H. Vincent, of this article in the May issue, is with the Engineering Department of the University of Edinburgh.

# MSF STANDARD FREQUENCIES EXPRESSED IN TERMS OF THE CAESIUM RESONANCE

By L. Essen, D.Sc., Ph.D., A.M.I.E.E.

*(Communication from the National Physical Laboratory)*

As reported earlier[1] the MSF transmissions have been measured in terms of the caesium resonator since June 1955. No values have yet been published because the caesium frequency had been determined[2] only in terms of the unit of provisional uniform time for June of that year. It has been found[3], however, that this value differs very little from the value expressed in the unit of provisional uniform time averaged over the year June 1955–June 1956; and it has therefore been decided at the National Physical Laboratory to use this value 9 192 631 830 c/s as a provisional standard of frequency. Expressed in terms of this unit the mid-monthly deviations of the MSF 60-kc/s transmissions received at Teddington are as follows:—

| Date | Deviation parts in $10^9$ | Date | Deviation parts in $10^9$ |
|---|---|---|---|
| *June 1955 | −5 | Dec. 1955 | +1 |
| July | −2 | Jan. 1956 | −1 |
| Aug. | −1 | Feb. | −1 |
| Sept. | 0 | March | +1 |
| Oct. | +1 | April | +1 |
| Nov. | +1 | May | +3 |

* Value for 20th June. Small variation on 18th June.

In order to help those users who require the highest precision, for the testing of the drift rates of quartz standards for example, the values of MSF published in *Wireless Engineer* will, in future, be expressed in terms of this atomic standard of frequency with a precision of ± 1 part in $10^9$. The transmission frequency itself will be controlled to within ± 5 parts in $10^9$ of this frequency, being adjusted as before by steps of probably ± 5 parts in $10^9$ when necessary. (No adjustment has been made since 6th May 1953.)

This first practical application of an atomic frequency standard is particularly significant, because other atomic standards are likely to come into operation soon and these transmissions, with the help of the 16-kc/s GBR transmission which is controlled by the same quartz oscillator, will enable them to be measured directly in terms of the N.P.L. caesium resonator, wherever they are situated.[4]

The speech announcement made during the transmissions has been modified and is now as follows:—

This is MSF Rugby transmitting carrier and modulation frequencies within 5 parts in $10^9$ of the nominal values on 2 500, 5 000 and 10 000 kc/s, as determined by an atomic standard. A transmission of one hour duration is also radiated on 60 kc/s at 14·29 GMT. Carriers are modulated with 1 000 c/s for the first five minutes and with 1 c/s pulses for the second five minutes of each quarter hour. At 15 minutes past each hour all transmissions are interrupted for five minutes. Enquiries should be directed to the National Physical Laboratory, Teddington, Middlesex, England. This is MSF, Rugby, England.

Reception reports are no longer requested because it is considered that the coverage of the service is now well established. The reports sent in the past have been most useful for this purpose. Any suggestions or comments about the service are, however, still welcomed and should be addressed to the Director, National Physical Laboratory, Teddington, Middlesex, England.

This note is published by permission of the Director of the National Physical Laboratory.

## REFERENCES


1 L. Essen, *Wireless Engineer*, Vol. 32, p. 312, 1955.
2 L. Essen and J. V. L. Parry, *Nature*, Vol. 176, p. 280, 1955.
3 L. Essen and J. V. L. Parry, *Nature*, Vol. 177, p. 744, 1956.
4 J. A. Pierce, H. T. Mitchell and L. Essen, *Nature*, Vol. 174, p. 922, 1954.


## STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

*Values for May 1956*

| Date 1956 May | Frequency deviation from nominal: parts in $10^8$ — MSF 60 kc/s 1429-1530 G.M.T. | Frequency deviation from nominal: parts in $10^8$ — Droitwich 200 kc/s 1030 G.M.T. |
|---|---|---|
| 1 | +0·4 | −1 |
| 2 | +0·5 | +4 |
| 3 | +0·5 | −1 |
| 4 | +0·5 | +3 |
| 5 | N.M. | −1 |
| 6 | N.M. | N.M. |
| 7 | +0·5 | −2 |
| 8 | +0·4 | −1 |
| 9 | +0·5 | −1 |
| 10 | +0·4 | 0 |
| 11 | +0·5 | −1 |
| 12 | +0·5 | −1 |
| 13 | +0·5 | 0 |
| 14 | +0·5 | +3 |
| 15 | +0·5 | −1 |
| 16 | N.T. | +4 |
| 17 | N.T. | −1 |
| 18 | +0·5 | +5 |
| 19 | +0·5 | N.M. |
| 20 | +0·5 | N.M. |
| 21 | +0·6 | −3 |
| 22 | +0·6 | −1 |
| 23 | +0·6 | −2 |
| 24 | +0·6 | −1 |
| 25 | +0·6 | −1 |
| 26 | +0·6 | −1 |
| 27 | +0·6 | −2 |
| 28 | +0·5 | −1 |
| 29 | +0·5 | −2 |
| 30 | +0·5 | −1 |
| 31 | +0·6 | −2 |

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

The transmitter employed for the 60-kc/s signal is sometimes required for another service.

N.M. = Not Measured N.T. = No Transmission

# 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.*


| | PAGE A |
|---|---|
| **Acoustics and Audio Frequencies** | 143 |
| **Aerials and Transmission Lines** | 144 |
| **Automatic Computers** | 146 |
| **Circuits and Circuit Elements** | 146 |
| **General Physics** | 148 |
| **Geophysical and Extraterrestrial Phenomena** | 150 |
| **Location and Aids to Navigation** | 153 |
| **Materials and Subsidiary Techniques** | 153 |
| **Mathematics** | 158 |
| **Measurements and Test Gear** | 159 |
| **Other Applications of Radio and Electronics** | 160 |
| **Propagation of Waves** | 161 |
| **Reception** | 162 |
| **Stations and Communication Systems** | 163 |
| **Subsidiary Apparatus** | 164 |
| **Television and Phototelegraphy** | 164 |
| **Valves and Thermionics** | 165 |
| **Miscellaneous** | 166 |


## ACOUSTICS AND AUDIO FREQUENCIES

534.121 1928

**Forced Vibrations of a Rigid Circular Plate on a Semi-infinite Elastic Space and on an Elastic Stratum.**—G. N. Bycroft. (*Phil. Trans. A*, 5th Jan. 1956, Vol. 248, No. 948, pp. 327–368.) An analytical paper.

534.2-14-8 1929

**Measurement of Attenuation of [ultrasonic] Sound in the Isothermal Surface-Layer of Water.**—A. N. Barkhatov. (*Akust. Zh.*, Oct.–Dec. 1955, Vol. 1, No. 4, pp. 315–320.) Results obtained experimentally using a tank of water with a vertical temperature gradient are in reasonable agreement with the theory given by Brekhovskikh & Ivanov (3132 of 1955).

534.21-8 1930

**Acoustic and Other Physical Properties of Shallow-Water Sediments off San Diego.**—E. L. Hamilton, G. Shumway, H. W. Menard & C. J. Shipek. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 1–15.) The investigation reported covers in situ measurements of sound velocity on various sediments at 100 kc/s and laboratory measurements of velocity and attenuation at 23–41 kc/s on samples. In some cases the velocity in the sediment was less than the velocity in the bottom water; this result is discussed in a separate paper [*ibid.*, pp. 16–19 (Hamilton)].

534.213 1931

**Propagation of Sound Pulses in a Dispersive Medium.**—J. M. Proud, P. Tamarkin & E. T. Kornhauser. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 80–85.) Experiments are described in which rectangular pulses comprising many sound-wave cycles were propagated in a long rectangular channel containing water. The velocity of the main signal is different from that of the initial and final transients. Comparison of the observed beats between the initial transient and the main signal with results predicted from analysis shows good agreement, hence the technique can be used to predict the effect on more complex pulses after the system has been calibrated with rectangular pulses.

534.22: 551.510.53 1932

**Introductory Theory for Upper Atmosphere Wind and Sonic Velocity Determination by Sound Propagation.**—Groves. (See 2046.)

534.231 1933

**On the Dependence of Directivity Patterns on the Distance from the Emitter.**—J. Pachner. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 86–90.) A method is presented for the numerical computation of the directivity pattern at any distance from the source based on the expansion of a diverging wave into a series of spherical wave functions. In a separate paper (*ibid.*, pp. 90–92) the method of analysis is extended to cover the investigation of standing-wave as well as travelling-wave field components.

534.231: 519.24 1934

**Propagation of Correlation Functions in Continuous Media.**—R. H. Lyon. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 76–79.) The properties of noise fields produced by the random superposition of elementary sources are derived, using the method of analysis developed by Rice in connection with shot noise (2169 of 1945 and back references). A calculation is made of the correlation properties of the response of a continuous linear system exposed to a noise field, from a knowledge of the system impulse response and the correlation function of the source; the latter may be determined experimentally or by calculation.

534.232 1935

**Sound Radiation from the Acoustic Boundary Layer.**—U. Ingard & D. Pridmore-Brown. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 128–129.) "The sound radiated from a finite rectangular plate in an infinite wall oscillating in shear motion is calculated. The order of magnitude of the intensity of this sound field is compared with that which is produced when the plane oscillates with the same amplitude in a direction normal to its surface."

534.232: 546.431.824-31 **1936**

**On the Resonant Vibrations of Thick Barium Titanate Disks.**—E. A. G. Shaw. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 38–50.) Optical interference technique has been used to study the surface motion of $BaTiO_3$ disks with radius/semi-thickness ratios ranging from 1·14 to 6·63. Vibration patterns, resonance frequency and electromechanical coupling coefficients are given for 12 modes. There is no single mode that can be uniquely identified as the fundamental dilatational thickness resonance, but there is some evidence suggesting an optimum value of the ratio for transducer design.

534.232: 546.431.824-31 **1937**

**Radial Vibrations in Short, Hollow Cylinders of Barium Titanate.**—C. V. Stephenson. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 51–56.) A formula is developed, based on electrostriction equations, for determining the coupling coefficient of annular elements vibrating in the radial mode from the resonance and antiresonance frequencies. Many harmonics are found to be forbidden in this mode. Experimental evidence supports the theory presented.

534.24-14 **1938**

**Underwater Sound Reflection from a Corrugated Surface.**—E. O. LaCasce, Jr, & P. Tamarkin. (*J. appl. Phys.*, Feb. 1956, Vol. 27, No. 2, pp. 138–148.) Experimental results are compared with results predicted by three different published theories. Good agreement is obtained in respect of direction of reflection and cut-off frequencies. The closeness of the agreement in respect of intensity depends on the surface slope; the theories appear to be valid only for small slope.

534.52 **1939**

**Problem of Interaction of Sound Waves.**—A. G. Gorelik & V. A. Zverev. (*Akust. Zh.*, Oct.–Dec. 1955, Vol. 1, No. 4, pp. 339–342.) Report of an experimental investigation of the interaction of two sound waves traversing a liquid in mutually perpendicular directions.

534.6-8 **1940**

**Experimental Determination of Ultrasonic Wave Pressure on Obstacles.**—B. Ozdogan. (*J. Phys. Radium*, Dec. 1955, Vol. 16, No. 12, pp. 902–907.) Experiments using waves of frequency 1·5 Mc/s in water show that the coefficients of absorption for paraffin-wax and stearin surfaces increase with the angle of incidence. Curves show the variations of reflection and absorption coefficients with angle of incidence and with thickness of the absorbing layer.

534.61-8: 535.314 **1941**

**Investigation of Stationary Ultrasonic Waves by Light Refraction.**—A. P. Loeber & E. A. Hiedemann. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 27–35.) Continuation of work reported previously [2288 of 1954 (Kolb & Loeber)].

534.64 **1942**

**Method of measuring Acoustic Impedance based on Measurement of the Geometrical Difference of Sound Pressures.**—V. N. Fedorovich. (*Akust. Zh.*, Oct.–Dec. 1955, Vol. 1, No. 4, pp. 360–367.)

534.75 **1943**

**Sensitivity to Changes in the Interruption Rate of White Noise.**—G. H. Mowbray, J. W. Gebhard & C. L. Byham. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 106–110.)

534.78 **1944**

**Automatic Extraction of Formant Frequencies from Continuous Speech.**—J. L. Flanagan. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 110–118.) Two electronic devices are described for deriving direct voltages corresponding to the first three formant frequencies. The performance of the devices is evaluated in a separate paper (*ibid.*, pp. 118–125).

534.845 **1945**

**Absorption Characteristics of Upholstered Theater Chairs and Carpet as measured in Two Auditoriums.**—R. N. Lane. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 101–105.) Measurements on a 496-seat and on a 738-seat auditorium are reported. The value found for the absorption per seat over the a.f. band is much lower than reported in various previous publications [e.g. 2198 of 1953 (Parkin et al.)].

534.85/.86: 534.76 **1946**

**Two-Channel Stereophonic Sound Systems.**—F. H. Brittain & D. M. Leakey. (*Wireless World*, May 1956, Vol. 62, No. 5, pp. 206–210.) The basic requirements for sound location are discussed and the effects of the directional characteristics of the microphones and loudspeakers and of the position of the listener on the sound image are described. Experimental results show that differences of sound intensity from the two loudspeakers afford better guidance in positioning the sound image than do the time differences.

534.861: 621.396.66 **1947**

**Monitoring Sound Broadcast Programmes.**—Somerville. (See 2221.)

621.395.623.7 **1948**

**Loudspeakers with Spherical Radiation.**—H. Schiesser. (*Rev. Son*, Jan. 1956, No. 33, pp. 4–10.) A discussion is presented of the departure from linearity of the frequency response of a cone loudspeaker as a function of the polar coordinates of the auditor's position. Improvements are possible by use of a spherical loudspeaker system. Practical approximations involving a number of loudspeakers mounted in the faces of a polyhedron are described, with an indication of suitable feed amplifier circuits. For practical purposes a hemispherical arrangement may be satisfactory. Systems for domestic receivers giving stereophonic reproduction are discussed.

534.839 **1949**

**Notes on Applied Science No. 10. Noise Measurements Techniques.** [Book Review]—Publishers: H.M. Stationery Office, London, 1955, 40 pp., 2s. (*Brit. J. appl. Phys.*, Jan. 1956, Vol. 7, No. 1, p. 41.) ". . . a guide to the choice of methods and techniques for determining the physical characteristics of noise, based on the experience of the National Physical Laboratory."

## AERIALS AND TRANSMISSION LINES

621.315.212: 621.3.013.78: 621.317.3 **1950**

**Measurement of Coupling Impedance and its Application to the Study of Cable Screens.**—J. Bourseau & H. Sandjivy. (*Câbles & Transm.*, Jan. 1956, Vol. 10, No. 1, pp. 11–30.) Various definitions of coupling (transfer) impedance are discussed, together with known methods for measuring it. A new direct method of measurement is described, using a bridge. An account is given of an application of the method to an investigation of screens for reducing crosstalk between coaxial pairs. Helical as well as cylindrical screens are discussed.

621.315.212.011.21 1951

**Influence of Standard Splicing on the Uniformity of Impedance of a 2·6/9·4 Coaxial-Pair Cable.**—R. Roch & J. Bouzitat. (*Câbles & Transm.*, Jan. 1956, Vol. 10, No. 1, pp. 3–10.) Formulae are derived from the components and the modulus of the impedance deviation at the splices, which are assumed to comply with French Post Office standards. The frequency range considered is 2·45–4·1 Mc/s. A numerical example is included.

621.372.029.6 + 621.385.029.6 1952

**Report of Advances in Microwave Theory and Techniques—1954.**—D. D. King. (*Trans. Inst. Radio Engrs*, April 1955, Vol. MTT-3, No. 3, pp. 4–7.) A review of guided-wave transmission and the circuit aspects of microwave generators and amplifiers, comprising a classified bibliography of 167 items.

621.372.43 1953

**The Optimum Tapered Transmission-Line Matching Section.**—R. E. Collin. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 539–548.) The matching section is analysed as for a high-pass filter. The results obtained previously for the $n$-section $\lambda/4$ transformer (1250 of 1955) are adapted by allowing $n$ to become infinite; theory developed in relation to aerial design [984 of April (Taylor)] is used. The optimum taper determined yields a matching section 13·9% shorter than the exponential taper and 27% shorter than the Gaussian taper for the same cut-off frequency and pass-band tolerance.

621.372.8 1954

**A New Annular Waveguide Rotary Joint.**—K. Tomiyasu. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 548–553.) A description is given of a joint designed to permit multiple stacking on a common axis. The joint will carry high power and permit operation with low s.w.r. and low insertion loss throughout the full rotation. Theory and performance characteristics are included.

621.372.8: 512.3 1955

**Paired Systems of Infinite Linear Algebraic Equations, linked with Infinite Periodic Structures.**—Ya. N. Fel'd. (*C. R. Acad. Sci. U.R.S.S.*, 11th Jan. 1956, Vol. 106, No. 2, pp. 215–218. In Russian.) The method developed is applied to determine the currents in a rectangular waveguide containing an infinite array of transverse rods.

621.372.8: 621.318.134 1956

**Propagation in a Ferrite-Filled Waveguide.**—L. G. Chambers. (*Quart. J. Mech. appl. Math.*, Dec. 1955, Vol. 8, Part 4, pp. 435–447.) "Perturbation methods are used for the solution of the fields in a waveguide filled with ferrite material which is subjected to a static magnetic field in the direction of its axis. It is shown that quasi TE and quasi TM modes exist and the first terms in the expansion are calculated for the case of a waveguide of rectangular cross-section."

621.372.8: 621.318.134 1957

**Some Applications and Characteristics of Ferrite at Wavelengths of 0·87 cm and 1·9 cm.**—C. Stewart. (*Trans. Inst. Radio Engrs*, April 1955, Vol. MTT-3, No. 3, pp. 27–31.) The use of ferrites to produce Faraday rotation in waveguides is discussed and experimental results are presented, with details of the construction of a unidirectional waveguide for $\lambda$ 0·87 cm. The improvement of the Dicke-type radiometer by use of devices based on this principle is described.

621.396.674.3 1958

**Radiation Resistance of Dipoles in an Interface Between two Dielectrics.**—J. R. Wait. (*Canad. J. Phys.*, Jan. 1956, Vol. 34, No. 1, pp. 24–26.) Exact expressions are derived for electric and magnetic dipoles located in a plane interface.

621.396.674.3: 621.396.11 1959

**Transient Fields of a Vertical Dipole over a Homogeneous Curved Ground.**—J. R. Wait. (*Canad. J. Phys.*, Jan. 1956, Vol. 34, No. 1, pp. 27–35.) Analysis is given first for the flat-earth case; the earth's curvature is then taken into account by means of appropriate modifications. When the aerial current is a linear function of time, the radiation field on a flat perfectly conducting earth is of step-function form; departures from this form are caused by the finite conductivity and dielectric constant of the ground, the induction and static fields of the aerial, and the earth's curvature, the last-named factor becoming effective at distances > 50 km.

621.396.677.3 1960

**The Optimum Current and Field Distribution for Broadside and End-Fire Radiators with Continuous Illumination.**—A. Heilmann. (*Nachrichtentech. Z.*, Jan. 1956, Vol. 9, No. 1, pp. 1–9.) A method is presented for calculating the distribution of illumination to obtain maximum side-lobe attenuation for given beam width. The distribution function is built up from a limited number of terms of a Fourier series. The required number of terms and the beam width increase as the requirements for side-lobe attenuation become greater. With three terms, an attenuation > 70 dB can be attained with a broadside array and > 80 dB with an end-fire array.

621.396.677.3.029.62 1961

***LONG* Long Yagis.**—J. A. Kmosko & H. G. Johnson. (*QST*, Jan. 1956, Vol. 40, No. 1, pp. 19–24.) An experimental investigation of the characteristics of Yagi arrays for 2 m $\lambda$ is reported; results for arrays comprising up to 68 elements are presented graphically. Constructional details are also given.

621.396.677.7 1962

**The Phase Centre of Aperture Radiators.**—K. Baur. (*Arch. elekt. Übertragung*, Dec. 1955, Vol. 9, No. 12, pp. 541–546.) Calculations are based on Kirchhoff's aperture field method. Simplifications are introduced enabling the problem to be dealt with by means of tabulated functions. An approximate formula useful in practice is given. Results are compared with values obtained by measurements on horn radiators.

621.396.677.7 1963

**Two New Modifications for Microwave Aerials.**—G. von Trentini. (*Rev. telegr. Electronica, Buenos Aires*, Dec. 1955, Vol. 44, No. 519, pp. 715–718.) Constructional details and performance figures are presented for simple designs of (*a*) pyramidal horns with good directivity and gain, using trolitul masks for the counter-phase Fresnel zones in the aperture, and (*b*) wide-band aerials for circular polarization, using dielectric rods in circular waveguides.

621.396.677.8 1964

**Passive Reflectors for Radio Beams (Experimental Investigation).**—G. Andrieux. (*Onde élect.*, Jan. 1956, Vol. 36, No. 346, pp. 57–72.) Experiments based on theoretical work by Jakes (1243 of 1953) were carried out on a wavelength of 1·25 cm. Auxiliary tests proved that the results were applicable to an installation for 8·75 cm $\lambda$. The performance of a given radio link is not appreciably affected by the use of a reflector system; risk of increased coupling between neighbouring aerials does exist, but can be overcome.

621.396.677.859 **1965**
**Design of Radomes.**—L. Thourel & S. Herscovici. (*Ann. Radioélect.*, April 1955, Vol. 10, No. 40, pp. 163–173.) Formulae developed previously [651 of 1950 (Cady et al.)] are extended to deal with multiple sandwich constructions. Simple methods of calculation are presented, together with experimental results.

## AUTOMATIC COMPUTERS

681.142 **1966**
**A Mechanical Binary-Decimal Converter.**—M. Setterwall. (*J. sci. Instrum.*, Jan. 1956, Vol. 33, No. 1, pp. 18–19.)

681.142 **1967**
**An Electronic Generator for Functions of Two Independent Variables.** — V. Wentzel. (*Ericsson Tech.*, 1955, Vol. 11, No. 2, pp. 183–225.) A unit built at the Chalmers University of Technology is described. The function is recorded on a photographic plate in the form of variable-width columns; these are scanned by a c.r. tube. The output is either in the form of width-modulated pulses or in the form of a voltage proportional to the function.

681.142: 519.272: 534.6 **1968**
**Measurement of Correlation Coefficient.**—S. G. Gershman & E. L. Feinberg. (*Akust. Zh.*, Oct.–Dec. 1955, Vol. 1, No. 4, pp. 326–338.) The determination of the correlation coefficient of a.f. noise is based on the measurement of the coincidences of sign of rectangular pulses triggered by the incoming signals. The instrument is described in detail and the theory of operation is given. See also 2542 of 1955 (Goff).

681.142: 621.3: 620.16 **1969**
**Shock Spectrum Computer for Frequencies up to 2 000 c/s.**—C. T. Morrow & D. E. Riesen. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 93–101.) An arrangement for investigating the effects of mechanical shock on electronic equipment installed e.g. in guided missiles comprises an analogue computer which operates on an accelerometer signal, either direct or recorded, and solves the differential equation for the part involved, the result being displayed on a c.r.o. screen. The computer can be tuned up to 2 kc/s, thus covering the range within which the fundamental resonance of any delicate structure is likely to occur.

681.142: 621.314.7 **1970**
**Transistor Digital Computers.**—(*Wireless World*, May 1956, Vol. 62, No. 5, pp. 210–212.) A brief account is given of circuit techniques involving the use of transistors and ferrite two-state storage devices described at the I.E.E. convention on digital computers held in London in April 1956.

681.142: 621.318.5: 537.312.62 **1971**
**The Cryotron—a Superconductive Computer Component.**—Buck. (See 1980.)

681.142: 621.387 **1972**
**The Gas-Filled Diode as a Digital Storage Element.**—B. R. Taylor & R. Bird. (*Electronic Engng*, April 1956, Vol. 28, No. 338, pp. 151–155.)

681.142 **1973**
**Proceedings of the Eastern Joint Computer Conference.** [Book Review]—Publishers: The American Institute of Electrical Engineers, New York, 92 pp., $3.00. (*Brit. J. appl. Phys.*, Jan. 1956, Vol. 7, No. 1, p. 41.)

## CIRCUITS AND CIRCUIT ELEMENTS

621.3.011.2 **1974**
**Parallel-Connected Nonlinear Impedances.**—S. Mayr. (*Elecktrotech. u. Maschinenb.*, 15th Jan. 1956, Vol. 73, No. 2, pp. 31–38.) Analysis based on a matrix method of representing complex vectors (847 of March) and locus diagrams are used to determine the equivalent single impedance for an arbitrary system of parallel impedances; values of voltage resulting from given current loads and of current resulting from given applied voltages are hence derived. The methods are illustrated by a numerical example taking two nonlinear impedances with ohmic resistance components. The complete working diagram of the parallel system is obtained by combining the locus diagram with the $I/V$ characteristic.

621.314.2 + 621.318.43 **1975**
**Subminiature Transformers and Transductors.**—E. F. Dunkin & D. L. Johnston. (*Electronic Engng*, April 1956, Vol. 28, No. 338, pp. 144–150.) Limitations associated with subminiature design are discussed in relation to audio and control-frequency transformers and transductors. Below a certain size, a toroidal-shell construction has given results comparing favourably with laminated assemblies; the signal-power level of the transformers is sufficient for junction-transistor circuits. When this construction is applied to transductors, the excitation and control field are orthogonally related. A paper covering much of the same ground appears in *Trans. Inst. Radio Engrs*, April 1955, No. PGCP-3, pp. 30–44.

621.314.213 **1976**
**Transformer 'Miniaturization' using Fluorochemical Liquids and Conduction Techniques.**—L. F. Kilham, Jr, & R. R. Ursch. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 515–520.)

621.316.825 **1977**
**The Stability of Thermistors.**—A. Beck. (*J. sci. Instrum.*, Jan. 1956, Vol. 33, No. 1, pp. 16–18.) Experimental results indicate that though the constants of two thermistors tested undergo changes over a period of months, the changes are slow enough for temperature measurements to be made to an accuracy within 0·02°C over a range of 10°C in experiments lasting up to 24 h.

621.318.4.002.2 **1978**
**Design of Modern Winding Machines.**—(*TSF et TV*, Jan. 1956, Vol. 32, No. 327, pp. 10, 15.) A short review in which U.S. and European methods are contrasted.

621.318.5 **1979**
**Transfer Function of Relays with Inactive Zone and Hysteresis.**—R. Setton. (*C. R. Acad. Sci., Paris*, 27th Feb. 1956, Vol. 242, No. 9, pp. 1138–1140.) The equation of transfer for the relay is calculated by the Laplace-transform method.

621.318.5: 537.312.62: 681.142 **1980**
**The Cryotron—a Superconductive Computer Component.**—D. A. Buck. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 482–493.) "The study of nonlinearities in nature suitable for computer use has led to the cryotron, a device based on the destruction

of superconductivity by a magnetic field. The cryotron, in its simplest form, consists of a straight piece of wire about one inch long with a single-layer control winding wound over it. Current in the control winding creates a magnetic field which causes the central wire to change from its superconducting state to its normal state. The device has current gain, that is, a small current can control a larger current; it has power gain so that cryotrons can be interconnected in logical networks as active elements. The device is also small, light, easily fabricated, and dissipates very little power."

621.318.57: 621.374.3: 621.387 **1981**

**Batching and Counting using Gas-Filled Decade Tubes.**—W. Grimmond & W. H. P. Leslie. (*Electronic Engng*, April 1956, Vol. 28, No. 338, pp. 138–143.) A range of units is described from which a variety of frequency meters, batching counters, etc. can be quickly assembled; circuit diagrams are given.

621.319.4 **1982**

**The Impedance of Shorted-Edge Wound Capacitors.**—H. Heywang. (*Arch. elekt. Übertragung*, Jan. 1956, Vol. 10, No. 1, pp. 29–44.) Results on the frequency variation of the impedance of this type of capacitor, obtained by Leiterer (449 of 1944), are discussed, using simple mathematics. The analysis is given first neglecting losses and is then extended to take account of losses in the dielectric and in the thin metal films. Eddy currents in the projecting contact layer and in thicker metal foils are also taken into account. The method is used to determine the transfer impedance of lead-through capacitors.

621.319.45 **1983**

**The Forming of the Negative Electrode of Electrolytic Capacitors.**—T. Bohlin & Å. Lagercrantz. (*Ericsson Tech.*, 1955, Vol. 11, No. 2, pp. 263–278.) An examination is made of the conditions under which undesired forming occurs; formulae are presented for the decrease of the capacitance on repeated discharging; these enable load behaviour to be predicted and optimum design to be attained. The theory is supported by experimental results.

621.372: 621.314.7 **1984**

**Principles of Transistor Circuits.**—J. P. Vasseur. (*Ann. Radioélect.*, April 1955, Vol. 10, No. 40, pp. 99–162.) A comprehensive review covering amplifiers, oscillators and flip-flops. Over 70 references.

621.372.012 **1985**

**Tolerance Limits in Matching.**—W. Alexander. (*Electronic Engng*, April 1956, Vol. 28, No. 338, pp. 162–164.) Curves are given showing the level of power transfer from source to load for various degrees of mismatch.

621.372.029.6 + 621.385.029.6 **1986**

**Report of Advances in Microwave Theory and Techniques—1954.**—King. (See 1952.)

621.372.5 **1987**

**Impedance Synthesis without Minimization.**—A. Fialkow & I. Gerst. (*J. Math. Phys.* Oct. 1955, Vol. 34, No. 3, pp. 160–168.) The synthesis procedure described for realizing $Z(p)$, a rational positive real function of the complex-frequency variable $p$, by means of a network containing no mutual inductances, is performed in three steps in which the computationally difficult minimization process is avoided.

621.372.5 **1988**

**The Geometrical Representation of Combined Linear Quadripoles.**—J. de Buhr. (*Arch. elekt. Übertragung*, Dec. 1955, Vol. 9, No. 12, pp. 561–570.) Concepts of non-Euclidean geometry are used. The representation of reactance quadripoles by a rigid system of two straight transformation lines and the determination of impedance transformations from geometrical reflections afford useful methods for treating composite quadripoles.

621.372.5 **1989**

**The Geometrical Quadripole Representation of the Double Transformer.**—J. de Buhr. (*Arch. elekt. Übertragung*, Jan. 1956, Vol. 10, No. 1, pp. 45–49.) The representation is effected by adapting the technique described previously (1643 of June).

621.372.5.011.1 **1990**

**The Operating-Parameter Cascade Matrix of Quadripoles.**—F. L. Bauer. (*Arch. elekt. Übertragung*, Dec. 1955, Vol. 9, No. 12, pp. 559–560.)

621.372.54: 621.372.8: 537.226 **1991**

**Waveguide Filters.**—M. H. N. Potok. (*Wireless Engr*, April 1956, Vol. 33, No. 4, pp. 79–82.) Filters having high $Q$ and low insertion loss are produced by arranging inside a waveguide a number of suitably spaced dielectric sections constituting $\lambda/4$ transformers.

621.372.543.2 **1992**

**Band-Pass Characteristics of Low Asymmetry.**—B. Easter. (*Electronic Engng*, April 1956, Vol. 28, No. 338, pp. 156–158.) An empirical design procedure is formulated, leading to filter networks which compare favourably with conventional designs.

621.372.543.3: 621.397.62: 535.623 **1993**

**New Rejector Circuit.**—W. T. Cocking. (*Wireless Engr*, April 1956, Vol. 33, No. 4, pp. 77–79.) A circuit used in some colour television receivers [1882 of June (Fairhurst)] is described. It uses a conventional parallel-*LC* trap connected into circuit via a centre-tapped bifilar-wound coil with a resistance across one half; it is characterized by negative inductance and capacitance. The circuit is discussed further in *ibid.*, May 1956, Vol. 33, No. 5, pp. 105–107.

621.372.56.029.6: 621.372.8: 621.318.134 **1994**

**A Double-Slab Ferrite Field Displacement Isolator at 11 kMc/s.**—S. Weisbaum & H. Boyet. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 554–555.) Brief description, with performance figures, of an isolator comprising a waveguide with two slabs of ferrite arranged with transverse symmetry and subjected to equal but oppositely directed magnetic fields; the forward loss is $< 1$ dB over most of the range from 10·7 to 11·7 kMc/s, and varies by $< 0{\cdot}1$ dB over any 20-Mc/s channel, while the reverse loss is 64–70 dB. See also 972 of 1955 (Lax et al.).

621.372.6 **1995**

**Impedance Transformation of Linear 2*n*-Terminal Networks.**—H. Kleinwächter. (*Arch. elekt. Übertragung*, Jan. 1956, Vol. 10, No. 1, pp. 26–28.) If $(n-2)$ outlets of a $2n$-terminal network are terminated by variable reactances, the resulting quadripole represents a variable transformer. As the value of these reactances varies between $-\mathrm{j}\infty$ and $+\mathrm{j}\infty$, the input impedance assumes all values of the transforming range. This range does not include the entire right-hand half of the complex impedance plane, but only circular areas thereof. An equation is derived for determining these circles. The method is demonstrated in relation to a waveguide hybrid-T.

621.373 1996

**Fluctuations in Self-Oscillating Systems of Thomson Type.**—S. M. Rytov. (*Zh. eksp. teor. Fiz.*, Sept. 1955, Vol. 29, No. 3(9), pp. 304–328.) Amplitude and phase fluctuations in weakly nonlinear self-oscillating systems are considered, using a symbolic differential equation describing the fluctuations of the random functions and the methods of the correlation theory. A system with one degree of freedom is considered first and the general theory is applied to the case of a valve generator operating in the 'soft' state. The theory is then applied to passive systems with one and two degrees of freedom. The effect of stabilizing the frequency of an oscillator by means of a high-*Q* circuit is discussed. The method of taking into account thermal fluctuations is shown.

621.373.4.029.6: 621.396.822 1997

**Fluctuation of Oscillations of Klystron Generator.**—I. L. Pershtein. (*C. R. Acad. Sci. U.R.S.S.*, 21st Jan. 1956, Vol. 106, No. 3, pp. 453–456. In Russian.) A theoretical investigation of noise in a reflex klystron is presented. In a typical case the natural bandwidth of the oscillations is 0·1 c/s; the results obtained by Shimoda (2943 of 1953) are believed to be in error.

621.373.42 1998

**Frequency of the Three-Phase *RC* Coupled Oscillator: Part 1—Non-reactive Anode Load Resistance.**—H. Rakshit & M. C. Mallik. (*Indian J. Phys.*, Nov. 1955, Vol. 29, No. 11, pp. 534–547.) Report of an investigation of the effect of different types of cathode impedance on the oscillation frequency.

621.373.43: 621.314.7 1999

**Application of Junction Transistors to the Generation of Linear Sawtooth Waveforms.**—(*Mullard tech. Commun.*, Dec. 1955, Vol. 2, No. 16, pp. 134–139.)

621.373.44 2000

**Two Trigger Circuits Useful as Sources of Rectangular Pulses.**—G. G. E. Low. (*Electronic Engng*, April 1956, Vol. 28, No. 338, pp. 158–159.) A modified Eccles-Jordan circuit having low output impedance and a development of Schmitt's cathode-coupled trigger circuit are presented.

621.375: 621.314.7 + 621.385 2001

**Comparison of Junction Transistor and Amplifier Valve.**—G. Ledig. (*Arch. elekt. Übertragung*, Jan. 1956, Vol. 10, No. 1, pp. 1–9.) The quadripole equations are developed for the commonly used circuits; important parameters and relations are tabulated. For linear operation the valve can be regarded from the network point of view as a simplified limiting case of the class containing both valves and transistors.

621.375.221.2 2002

**Analysis of a Regenerative Amplifier with Distributed Amplification.**—B. S. Golosman. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 533–534.) Analysis indicates that the application of distributed amplification in regenerative circuits, such as the monostable multivibrator, is limited by its inherent time delay.

621.375.23 2003

**Component Tolerance Effects in Feedback I.F. Amplifiers.**—H. S. Jewitt. (*Electronic Engng*, April 1956, Vol. 28, No. 338, pp. 165–167.) Analysis relating to T and Π feedback networks is given. Resistor variation produces no asymmetry of the response curve; in this respect the feedback i.f. amplifier (1009 of 1954) is superior to the stagger-tuned amplifier.

621.375.232.3.024 2004

**A Direct-Current Amplifier Stage with Asymmetrically Earthed Input.**—E. G. Schlosser & S. Götze. (*Frequenz*, Jan. 1956, Vol. 10, No. 1, pp. 19–24.) A push-pull cathode-follower circuit is used, with two valves having dissimilar characteristics and a special resistance coupling, the usual phase-reversing stage being omitted. Analysis is presented on the basis of a parabolic approximation to the characteristics. Design procedures for ensuring the requisite quiescent-current and linearity conditions are indicated. A numerical determination is made of the operating point for a circuit using one Type-EL90 and one Type-EL32 valve.

621.376.22: 621.318.134 2005

**A Note on Sidebands produced by Ferrite Modulators.**—P. A. Rizzi & D. J. Rich. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, p. 556.)

621.376.23: 621.385.029.6 2006

**Microwave Detector.**—Mendel. (See 2259.)

621.376.332.029.6: 621.372.413 2007

**A Simple Microwave Discriminator.**—C. Colani. (*Frequenz*, Jan. 1956, Vol. 10, No. 1, pp. 25–26.) A cylindrical resonator with slightly disturbed symmetry has two closely spaced resonance frequencies for the $H_{11}$ mode, corresponding to two waves with slightly different propagation velocities. These can be detected separately, by means of rectifiers. A discriminator characteristic is given by the difference of the rectified currents as a function of frequency. The dimensions of the resonator for a given frequency can be reduced by capacitive loading. Discriminators of this type are suitable for measurement and control purposes rather than for demodulating f.m.

621.39.03 2008

**Miniaturization and Quality Improvement of Circuit Parts.**—T. Nijo. (*Rep. elect. Commun. Lab., Japan*, Aug. 1955, Vol. 3, No. 8, pp. 22–28.) Coils, transformers, resistors, capacitors, quartz-crystal units and filters developed by the Nippon Telegraph and Telephone Public Corporation are described and illustrated.

621.397.6.001.4 2009

**Circuit Technique for Generation of Electrical Test Patterns in Television.**—Pilz. (See 2231.)

## GENERAL PHYSICS

53.05 2010

**A Method of analysing Periodicity.**—F. Mosetti. (*Ann. Geofis.*, July 1955, Vol. 8, No. 3, pp. 331–349.) A method of analysing an empirical function such as that corresponding to the record of an oscillation process is based on asymmetrical rather than symmetrical linear combinations of ordinates; it permits detection of variations of phase as well as amplitude.

530.145: 535.14 2011

**Theory of Radiation.**—J. C. Gunn. (*Rep. Progr. Phys.*, 1955, Vol. 18, pp. 127–183.) A survey of the application of quantum field theory to the interaction between charged particles and the electromagnetic field; within this domain it is now possible to calculate any process with a precision only limited by the labour of the calculations. About 60 references.

534.01 2012

**Intensity of Harmonic and Combination Components in the Nonlinear Distortions of Complex Oscillations.**—V. M. Vol'f. (*Akust. Zh.*, Oct.–Dec.

1955, Vol. 1, No. 4, pp. 321–325.) The effect of linear, quadratic and cubic response characteristics on triangular, saw-tooth and rectangular signals is considered; results are tabulated.

535.34 : 537.56 : 546.17 **2013**

**Ultraviolet Absorption of Atomic Nitrogen in its Ionization Continuum.**—A. W. Ehler & G. L. Weissler. (*J. opt. Soc. Amer.*, Dec. 1955, Vol. 45, No. 12, pp. 1035–1043.) The absorption of radiation of 400–800 Å λ by the plasma of a discharge in an ionization gauge was measured by passing the transmitted radiation into a spectrograph. Various considerations indicate that the absorption is due to atomic nitrogen, the absorption cross-section of which is hence deduced.

537.1 **2014**

**The Physical Interpretation of the Self-Acceleration of Electrons.**—K. Wildermuth. (*Z. Naturf.*, June 1955, Vol. 10a, No. 6, pp. 450–459.) The forces governing the motion of electrons are most easily understood if the point electron is considered as the limiting case of the finite-size electron. For self-acceleration to occur, it is not essential that the e.m. field energy be infinite, but it is important that the mechanical mass of the electron be negative.

537.122 **2015**

**Measurement of the Specific Charge of Conduction Electrons.**—V. M. Yuzhakov. (*Zh. eksp. teor. Fiz.*, Sept. 1955, Vol. 29, No. 3(9), pp. 388–390.) The theory of a method of determining $e/m$ by means of a special dynamo is given. The device comprises a pair of concentric coils which together rotate with angular velocity $o$, about an axis parallel to the applied magnetic field. The rectangular inner coil can also rotate about its own axis, which is perpendicular to the magnetic field. The two resulting e.m.fs in the inner coil are due to (*a*) induction and (*b*) Coriolis force acting on the conduction electrons. If these e.m.fs are equal then $e/m = 2co/H$, where $c$ is the velocity of light and $H$ the magnetic-field strength. The estimated experimental errors are not greater than 1%.

537.2 **2016**

**Potential due to a Uniformly Charged Disk.**—É. Durand. (*C. R. Acad. Sci., Paris*, 13th Feb. 1956, Vol. 242, No. 7, pp. 887–889.) Formulae are derived applicable to any point.

537.311 **2017**

**The Effect of Free Electrons on Lattice Conduction.**—J. M. Ziman. (*Phil. Mag.*, Feb. 1956, Vol. 1, No. 2, pp. 191–198.) "The scattering of phonons by electrons is calculated, assuming the usual electron-phonon interaction, for a parabolic band whose degeneracy temperature is comparable with the temperature of the lattice. The contribution to the thermal resistance is given by an exact formula, subject only to justifiable assumptions concerning phonon-phonon interactions. With rising temperature the apparent mean free path of the phonons at first decreases as $1/T$ (or, if there are very few electrons, as exp $a/T$), but reaches a minimum and then increases as $T^2$. Energy and momentum conservation then allow only the tail of the electron distribution to contribute to the scattering. The model is thought to apply to certain observations on $p$-type germanium, irradiated sapphire and conducting diamond."

537.5 **2018**

**Ionization by Relativistic Particles.**—B. T. Price. (*Rep. Progr. Phys.*, 1955, Vol. 18, pp. 52–82.) A summary is given of theories of the relativistic increase of energy loss by ionization and of the density effect. The experimental evidence, as obtained with various types of counter, is discussed and compared with theoretical predictions. Over 100 references.

537.5 **2019**

**The Ionization and Dissociation of Complex Molecules by Electron Impact.**—J. D. Craggs & C. A. McDowell. (*Rep. Progr. Phys.*, 1955, Vol. 18, pp. 374–422.) A review covering theoretical and experimental aspects of collision processes in polyatomic molecular gases. Over 100 references.

537.525 : 537.534 **2020**

**Ion Oscillations in a Cathode Potential Minimum.**—K. G. Emeléus & N. R. Daly. (*Proc. phys. Soc.*, 1st Jan. 1956, Vol. 69, No. 433B, pp. 114–115.) A brief theoretical note.

537.525 : 538.569.029.6 : 538.6 **2021**

**The Rotation of Plasmoids in a Magnetic Field.**—H. Pupke & H. G. Thom. (*Naturwissenschaften*, Jan. 1956, Vol. 43, No. 2, p. 32.) The motion of a luminous low-pressure gas discharge in Ne in the presence of a magnetic field and a superposed r.f. field of frequency about 75 Mc/s was found to be a function of the anode voltage of the output valve of the 1-kW r.f. generator used.

537.528 **2022**

**Formative Time Lags in the Electric Breakdown of Liquid Hydrocarbons.**—R. W. Crowe. (*J. appl. Phys.*, Feb. 1956, Vol. 27, No. 2, pp. 156–160.)

537.533 **2023**

**The Work Function and Patch Field of an Irregular Metal Surface.**—M. J. Morant & H. House. (*Proc. phys. Soc.*, 1st Jan. 1956, Vol. 69, No. 433B, pp. 14–20.) Calculations show that the lowering of the work function due to irregularities of the surface is entirely compensated by a patch field.

537.56 : 538.569.029.4/.6 **2024**

**The Breakdown of Gases subject to Crossed Electric Fields.**—W. A. Prowse & P. E. Lane. (*Proc. phys. Soc.*, 1st Jan. 1956, Vol. 69, No. 433B, pp. 33–46.) The effect of an auxiliary electric field, acting at right angles to a 10-kMc/s field, on the breakdown stress of various gases is investigated experimentally. When the auxiliary field is unidirectional or of relatively low frequency (0·86 Mc/s) its application raises the breakdown stress, but when its frequency reaches 9·7 Mc/s the two fields appear to act independently. A partial explanation is advanced. The gases studied include air, oxygen, nitrogen, hydrogen and neon.

538.114 **2025**

**Spin-Deviation Theory of Ferromagnetism: Part 2—The Non-ideal Spin-Deviation Gas.**—J. Van Kranendonk. (*Physica*, Dec. 1955, Vol. 21, No. 12, pp. 925–945.) Part 1: 1368 of May.

538.114 **2026**

**Application of the Bethe-Weiss Method to Ferrimagnetism.**—J. S. Smart. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, pp. 585–591.)

538.3 **2027**

**Classical Electrodynamics as a Distribution Theory.**—J. G. Taylor. (*Proc. Camb. phil. Soc.*, Jan. 1956, Vol. 52, Part 1, pp. 119–134.)

538.3 : 535.13 **2028**

**A Derivation of Generalized Microscopic Electrodynamic Equations: Part 1—Non-relativistic.**—B. Podolsky & H. Denman. (*J. Math. Phys.*, Oct. 1955, Vol. 34, No. 3, pp. 198–207.) Maxwell's equations and the constitutive relations are derived from the classical microscopic theory, without making use of extensive assumptions, so that the effects of the higher-order electric and magnetic moments are retained in the equations.

538.56: 537.56 **2029**

**On the Theory of Stationary Waves in Plasmas.**—N. G. Van Kampen. (*Physica*, Dec. 1955, Vol. 21, No. 12, pp. 949–963.) A mathematical treatment is presented appropriate to the case of a continuous non-vanishing distribution of particle velocities. A complete set of stationary-plane-wave solutions can be constructed. There is no dispersion equation because for a given wave vector a continuous range of values of frequency is possible.

538.566: 537.56 **2030**

**Growing Electromagnetic Waves.**—J. H. Piddington. (*Phys. Rev.*, 1st Jan. 1956, Vol. 101, No. 1, pp. 9–14.) The growth of e.m. waves is considered in terms of Bailey's electromagneto-ionic theory (see e.g. 105 of 1952). Of the 12 different wave modes predicted by this theory, four are unreal; the remainder comprise two pairs of hydromagnetic waves which become pure e.m. waves at a sufficiently high frequency, one pair of modified sound waves, and one pair of modified electron-sound waves. The growth of the e.m. waves may result from the trappings of ions between potential troughs of the space-charge wave and the subsequent surrender of energy by the ions. Ion drifts may introduce important effects not indicated by the wave equations.

538.566: 538.221: 538.6 **2031**

**Theory of Wave Propagation in a Gyromagnetic Medium.**—P. S. Epstein. (*Rev. mod. Phys.*, Jan. 1956, Vol. 28, No. 1, pp. 3–17.) The theory presented is relevant to propagation in ferrites, but the physical nature of ferrites is not discussed.

538.569.4 **2032**

**On the Absorption of 3·18-cm Microwaves in some Substituted Phenols in the Liquid State.**—D. K. Ghosh. (*Indian J. Phys.*, Dec. 1955, Vol. 29, No. 12, pp. 581–586.)

538.569.4: 538.221 **2033**

**Possible Source of Line Width in Ferromagnetic Resonance.**—A. M. Clogston, H. Suhl, L. R. Walker & P. W. Anderson. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, pp. 903–905.) Brief theoretical discussion indicating the effect of the finite size of a sample on the dispersion of relaxation times.

539.1: [537.311.31 + 537.311.33 **2034**

**The Displacement of Atoms in Solids by Radiation.**—G. H. Kinchin & R. S. Pease. (*Rep. Progr. Phys.*, 1955, Vol. 18, pp. 1–51.) A survey covering theoretical and experimental aspects of the irradiation of solids by particles or $\gamma$ rays; effects produced in metals and semiconductors are described. Nearly 200 references.

## GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.16 **2035**

**Halo of Radio Emission and the Origin of Cosmic Rays.**—G. R. Burbridge. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, pp. 906–907.) Observations of r.f. radiation from nebulae [e.g. 104 of 1955 (Baldwin)] indicate that a large fraction of the radiation comes from roughly spherical regions centred on the galactic centre and having radii of about 15 kiloparsecs. The particle density and energy conditions in these regions are considered in relation to the acceleration of cosmic rays.

523.16: 523.45 **2036**

**A Search for Radiation from Jupiter at 38 Mc/s and at 81·5 Mc/s.**—F. G. Smith. (*Observatory*, Dec. 1955, Vol. 75, No. 889, pp. 252–254.) Following the observation of radiation from Jupiter at 22 Mc/s [2933 of 1955 (Burke & Franklin)], records obtained at Cambridge, England, of radiation received at 38 Mc/s and 81·5 Mc/s were searched for evidence of radiation from Jupiter at these frequencies; results were negative. Inferences are drawn regarding the source of radiation on Jupiter.

523.5: 621.396.96 **2037**

**Characteristics of Radio Echoes from Meteor Trails: Part 2—The Distribution of Meteor Magnitudes and Masses.**—I. C. Browne, K. Bullough, S. Evans & T. R. Kaiser. (*Proc. phys. Soc.*, 1st Jan. 1956, Vol. 69, No. 433B, pp. 83–97.) The distributions are deduced from observations of sporadic meteors and various showers. Part 1: 2782 of 1948 (Lovell & Clegg).

523.5: 621.396.96 **2038**

**Characteristics of Radio Echoes from Meteor Trails: Part 4—Polarization Effects.**—E. R. Billam & I. C. Browne. (*Proc. phys. Soc.*, 1st Jan. 1956, Vol. 69, No. 433B, pp. 98–113.) The theoretical estimates of plasma resonance effects by Kaiser & Closs (2208 of 1952) were tested at a frequency of 55·3 Mc/s. The polarization effects observed are in good agreement with the predictions for both short- and long-duration echoes, but some unexpected results were obtained for meteor trails with line densities in the transition region of $10^{12}$ electrons/cm. The echo amplitude $A$ was found to be proportional to $T^{0.3}$ instead of the predicted $T^{3/16}$, where $T$ is the duration of the echo. The discrepancy may be the result of diffusion by turbulence in the atmosphere. Part 3: 2493 of 1952 (Greenhow).

523.5: 621.396.96 **2039**

**Meteor Echo Durations and Visual Magnitudes.**—P. M. Millman & D. W. R. McKinley. (*Canad. J. Phys.*, Jan. 1956, Vol. 34, No. 1, pp. 50–61.) The statistical relation between the radio-echo duration and the visual magnitudes was analysed using observations obtained during the years 1948–1950 on about 3300 meteors. Over a range of magnitudes the relation is linear or nearly linear. It is inferred that a meteor of absolute magnitude + 5 produces $2 \times 10^{10}$ electrons per cm of path length.

523.5: 621.396.96 **2040**

**Radar-Echo Duration and Height of a Perseid Meteor.**—D. W. R. McKinley. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 76–82.) Triangulation data for a meteor echo lasting 549 sec, observed on 12th August 1948, are discussed.

523.7 **2041**

**Daily Maps of the Sun.**—P. A. Wayman. (*Nature, Lond.*, 17th March 1956, Vol. 177, No. 4507, pp. 518–519.) A brief note announcing the inauguration of a service in which a number of observatories are co-operating to produce comprehensive records of solar phenomena.

523.75: 550.385 **2042**

**Solar Corona and Geomagnetism.**—M. Notuki, Y. Nakagomi & M. Fukatsu. (*Rep. Ionosphere Res. Japan*, Dec. 1955, Vol. 9, No. 4, pp. 215–221.) Both coronal activity and geomagnetic disturbance vary directly with general solar activity except at the period of sunspot minimum, when correlation between the two is negative. Geomagnetic disturbance is greatest when the earth is in the radial line of an active coronal centre. An active centre appears to have a shielding effect on the outflow of corpuscles from the undisturbed solar areas.

523.78: 523.72.029.6 **2043**

**A Model for the Solar Enhanced Region at Centimeter Range derived from Partial Eclipse Observations.**—T. Hatanaka, K. Akabane, F. Moriyama, H. Tanaka & T. Kakinuma. (*Rep. Ionosphere Res. Japan*, Dec. 1955, Vol. 9, No. 4, pp. 195–204.) Records taken at three Japanese observatories on frequencies between 3 and 4 kMc/s during the partial eclipse of the sun on 20th June 1955 show a marked decrease on the observed flux during the period when a large sunspot group was eclipsed; the location, size and brightness distribution of the enhanced-radiation region are derived. A model for the quiet sun, having a bright region near the limb on the equator is also suggested.

550.385 **2044**

**$S_q$-Field in the Polar Region on Absolutely Quiet Days.**—T. Nagata & H. Mizuno. (*J. Geomag. Geoelect.*, Sept. 1955, Vol. 7, No. 3, pp. 69–74.) Analysis of data for the Second Polar Year indicates that the $S_q$ field, which is recognized as applying to the region between latitudes 60°N and 60°S, also represents the daily variation in the geomagnetic field over the rest of the earth for absolutely quiet days.

550.358: 523.78 **2045**

**Report of Observations of Geomagnetic Variations at Aso and Naze (Amami-Oshima), during the Solar Eclipse of June 20th, 1955.**—M. Ota, H. Maeda, H. Yasuhara & S. Hashizume. (*J. Geomag. Geoelect.*, Sept. 1955, Vol. 7, No. 3, pp. 86–90.)

551.510.53: 534.22 **2046**

**Introductory Theory for Upper Atmosphere Wind and Sonic Velocity Determination by Sound Propagation.**—G. V. Groves. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 24–38.) Theory applicable to a rocket-grenade experiment is developed.

551.510.534 **2047**

**The Atmospheric Ozone as Indicator of Air Streams in the Stratosphere: Part 1—The Photochemical Bases.**—H. U. Dütsch. (*Arch. Met. A, Wien*, 1st Dec. 1955, Vol. 9, No. 1, pp. 87–119.)

551.510.535 **2048**

**A Method of determining the Relative Amounts of D- and E-Region Absorptions of Medium and Short Radio Waves.**—A. P. Mitra. (*Indian J. Phys.*, Nov. 1955, Vol. 29, No. 11, pp. 518–521.) The method is based on the concept of 'relaxation time' [3289 of 1953 (Appleton)], the value of which for the D layer is appreciably different from that for the E layer.

551.510.535 **2049**

**Region E and the $S_q$ Current System.**—W. J. G. Beynon & G. M. Brown. (*Nature, Lond.*, 24th March 1956, Vol. 177, No. 4508, pp. 583–584.) The complete equilibrium equation for the electron density in a solar-controlled ionospheric region includes a term which depends on vertical drift and is usually neglected; the E-layer critical frequency $f_E$ is then related to the zenith angle $\chi$ by the equation $(f_E)^n = K \cos \chi$, where $K$ is a constant and, for an isothermal region, $n$ has the value 4 for recombination and 2 for attachment. Values of $n$ deduced from actual observations lie between 2 and 4; these findings are discussed on the assumption that the variation of $n$ results from neglect of the vertical-drift term. The theory is supported by observations of singularities in the noon curves of $n$/latitude for several longitudes; these singularities, corresponding to 'normal' values of $f_E$, coincide approximately with the position of the foci of the $S_q$ current system.

551.510.535 **2050**

**A New Method of analysing Ionospheric Movement Records.**—G. L. Rogers. (*Nature, Lond.*, 31st March 1956, Vol. 177, No. 4509, pp. 613–614.) Technique based on optical diffraction systems is outlined. The ionosphere is provisionally assumed to be a plane reflector, and the image of a ground transmitter in it is regarded as a source of coherent radiation giving rise to a diffraction pattern on the ground corresponding to an inhomogeneity moving in or below the ionosphere. From the geometry of the system a focal length is deduced, and when the record of the diffraction pattern is converted into a variable-density photographic record a corresponding visual focal length is obtained, from which the velocity of the moving inhomogeneity can be determined. The method has been tried at the New Zealand Dominion Physical Laboratory, using aerials arranged at the corners of a triangle as suggested by Mitra (96 of 1950). Holograms showing some results are reproduced; from these it is clear that moving objects far below the ionosphere can affect the records significantly.

551.510.535 **2051**

**Movements of Irregularities in the E Region: Part 2.**—T. Obayashi. (*J. Radio Res. Labs, Japan*, Oct. 1955, Vol. 2, No. 10, pp. 413–417.) Continuing the work referred to in 418 of February, results for the period July 1954–March 1955 show that an east wind with an average velocity of 80 m/sec predominates in the evening, continuing throughout the night in winter; towards sunrise winds in the reverse direction are frequent. Irregularities are estimated to be 100–200 km in extent.

551.510.535 **2052**

**Sequential $E_s$ and Lunar Effects on the Equatorial $E_s$.**—S. Matsushita. (*J. Geomag. Geoelect.*, Sept. 1955, Vol. 7, No. 3, pp. 91–95.) Among the various types of $E_s$ which have been observed, one shows apparent vertical movement on the ionogram, and has been termed 'sequential $E_s$' by investigators at the National Bureau of Standards. A study is made of this phenomenon using records from a number of stations; the subtype investigated is that involving an $E_s$ region which first appears at a height of about 200 km in winter and 180 km in summer and then drops to normal E level, where it persists for some hours. The latitude and time distributions of the phenomenon are briefly discussed.

551.510.535 **2053**

**On Anomalous Variations of Critical Frequencies and Virtual Heights of the $F_1$ and E regions of the Ionosphere.**—T. Sato. (*Rep. Ionosphere Res. Japan*, Dec. 1955, Vol. 9, No. 4, pp. 205–214.) Latitudinal and seasonal variations of critical frequencies and virtual heights of the $F_1$ and E layers, for years of high and low sunspot activity, are investigated. Anomalous variations are found, analogous to those in the $F_2$ layer (3254 of 1955); similar explanations are suggested.

551.510.535 **2054**

**The Diurnal and Annual Variations of $F_1$ Ionization. An Interpretation.**—O. Burkard. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 83–90. In German.) Values of $x$ and log $C$ in the formula $(f_0F_1)^2 = C^2 (\cos \chi)^x$, calculated from C.R.P.L. records for 1934–1954, are tabulated. The variation of these values is discussed and a model is derived for $F_1$-layer conditions in which the temperature gradient is smaller in summer than in winter.

551.510.535 **2055**

**A Study of the Total Electron Content of the F-Region of the Ionosphere over Ahmedabad (23°N, 72°38′E), India.**—R. M. Sheriff. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 91–97.) The total number of electrons in a column of unit cross-section in the $F_1$ and $F_2$ regions up to the height $h_p$ of maximum electron density has been calculated for three magnetically quiet and three disturbed days in each month from February 1953 to January 1954. The method of analysis is that suggested by Ratcliffe (1292 of 1952) assuming parabolic electron density distribution. The relation between the semi-thickness $y_m$ and $h_p$ for the $F_2$ layer shows that thick layers are associated with higher values of $h_p$ and that the parabolic-distribution law does not hold for very thick layers.

551.510.535 **2056**

**Determination of the F-Region Collisional Frequency (over Calcutta).**—M. Ghosh. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 116–118.) The collision frequency $\nu$ reaches its maximum ($\sim 5 \times 10^3$/sec) at about noon, and its minimum ($\sim 10^2$/sec) at about midnight. The rate of rise of $\nu$ increases with cos $\chi$.

551.510.535 **2057**

**A Possible Explanation of the Drop in F-Region Critical Densities accompanying Major Ionospheric Storms.**—M. J. Seaton. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 122–124.) An explanation in terms of increased recombination rates is suggested, based on evidence that the abundance of $O_2$ at great heights is governed by vertical transport [*Rocket Exploration of the Upper Atmosphere*, 1954, pp. 361–365 (Nicolet)].

551.510.535: 523.16 **2058**

**The Spectrum of Radio-Star Scintillations and the Nature of Irregularities in the Ionosphere.**—J. P. Wild & J. A. Roberts. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 55–75.) Simultaneous observations of the intense source in Cygnus were made with (*a*) a frequency-sweep spectroscope, (*b*) a frequency-sweep interferometer, and (*c*) a triangular spaced-aerial receiving system. Most fluctuations are due to focusing by single lens-like irregularities. The fluctuation amplitude shows two maxima: one near midnight (winter); the other near midday (summer). For day-time conditions at least, the elongation of the pattern at the ground indicates marked anisotropy in the ionosphere irregularities.

551.510.535: 523.746 **2059**

**Correlation between Noon $f_0F_2$ and Sunspot Number.**—J. M. Roy. (*J. Instn Telecommun. Engrs, India*, Dec. 1955, Vol. 2, No. 1, pp. 45–47.) Analysis of data from four Indian stations shows a linear relation between the running means of the sunspot number R and the noon value of $f_0F_2$, up to a limiting value of R.

551.510.535: 523.78 **2060**

**Tilts in the Ionosphere during the Solar Eclipse of 30 June 1954.**—E. N. Bramley. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 98–104.) "Directional measurements at nearly vertical incidence on the F layer during the eclipse showed the existence of a tilt whose direction agreed with that expected from the geometry of the eclipse. The magnitude of the tilt was also of the same order as that calculated from observed changes in the height of reflection. Oblique-incidence bearing measurements on signals reflected from the normal E layer failed to reveal any eclipse effect, and theoretical calculation showed that no detectably large effect would have been expected in this case."

551.510.535: 523.78 **2061**

**Preliminary Results of the Ionospheric Solar Eclipse of 25 December 1954.**—M. E. Szendrei & M. W. McElhinny. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 108–114.) An analysis of critical-frequency data obtained in Grahamstown during this annular eclipse. The effects may be explained to a first approximation by assuming that the radiation responsible for the ionosphere structure is distributed uniformly over the sun's disk. Values of recombination coefficient for the $E_1$, $F_1$ and $F_2$ layers are in good agreement with values obtained recently by independent methods.

551.510.535: 523.78 **2062**

**Observations of the Lower Ionosphere during the Solar Eclipse on 30th June 1954.**—K. Sprenger & E. A. Lauter. (*Gerl. Beitr. Geophys.*, 1955, Vol. 64, No. 4, pp. 284–312.) Propagation tests were made at Kühlungsborn on frequencies of 185 kc/s–1·223 Mc/s during the eclipse. The expected increase of reflection coefficient in the lower ionosphere was considerably delayed after first contact, and normal attenuation values were restored before the end of the eclipse. The magnitude of the effect (about 40 dB) and the delay of the maximum (about 4 min) agreed with predictions from normal diurnal and seasonal variations based on a single-layer model of the D layer, but the limited duration of the effect was consistent with a multilayer model. Observations of complex variations of very-long-wave atmospherics are also reported.

551.510.535: 550.38 **2063**

**The Influence of the Geomagnetic Field on Turbulence in the Ionosphere.**—J. W. Dungey. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 39–42.) E.m. damping of turbulent motion of neutral particles is negligible for the smaller eddies. In the higher regions electrons are constrained to move nearly parallel to the magnetic field; this results in variations of electron density, even when the density of neutral molecules does not vary. These variations may be appreciable above 100 km, e.g. $\sim$ 5% at 110 km.

551.510.535: 550.385 **2064**

**On the Disturbance Daily Variations and the Lunar Daily Variations in the $F_2$ Region of the Ionosphere on the Magnetic Equator.**—H. Maeda. (*J. Geomag. Geoelect.*, Sept. 1955, Vol. 7, No. 3, pp. 75–85.) Continuation of work reported previously [e.g. 425 of February (Maeda et al.)] on the effects of vertical electron drift due to the electrical fields associated with the currents responsible for the diurnal geomagnetic variations.

551.510.535: 621.396.11 **2065**

**D-E Layer Electron Model reduced from Considerations of M.F. and H.F. Wave Absorption.**—Kobayashi. (See 2194.)

551.510.535: 621.396.11 **2066**

**The Z Propagation Hole in the Ionosphere.**—Ellis. (See 2195.)

551.510.535: 621.396.11 **2067**

**The Interpretation of Measurements of Radio-Wave Interaction.**—Huxley. (See 2197.)

551.543 **2068**

**A Comparison of the Annual Mean Solar and Lunar Atmospheric Tides in Barometric Pressure, as regards their Worldwide Distribution of Amplitude and Phase.**—S. Chapman & K. C. Westfold. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 1–23.)

551.594.221 : 551.508.94 **2069**

**The Influence of Individual Variations in the Field Changes due to Lightning Discharges upon the Design and Performance of Lightning Flash Counters.**—E. T. Pierce. (*Arch. Met. A, Wien*, 1st Dec. 1955, Vol. 9, No. 1, pp. 78–86. In English.) Flash counters responding only to the e.s. component of the field change are likely to be least subject to error; this implies a preferential selection of very low frequencies. Examples are given indicating the extent of the inaccuracies encountered. From statistics of rates of flashing and duration of discharges it is concluded that counters should have an insensitive period of about 1 sec. The design of counters is discussed and a simple circuit is presented.

551.594.6 **2070**

**Low Audio-Frequency Electromagnetic Signals of Natural Origin.**—R. E. Holzer & O. E. Deal. (*Nature, Lond.*, 17th March 1956, Vol. 177, No. 4507, pp. 536–537.) Signals in the frequency range 25–130 c/s have been recorded in California over long periods. The diurnal variation of signal amplitude closely resembles the diurnal variation of atmospheric potential gradients measured at sea; it is inferred that these low-frequency signals are atmospherics and that their mean amplitude is roughly proportional to the number of storms in progress over the whole world.

523.746 + 550.385 **2071**

**Sunspot and Geomagnetic-Storm Data derived from Greenwich Observations 1874–1954.** [Book Review]—Publishers: H. M. Stationery Office, London, 1955, 106 pp. 25s. (*Nature, Lond.*, 17th March 1956, Vol. 177, No. 4507, p. 499.) Includes explanatory notes and literature references and some diagrams.

## LOCATION AND AIDS TO NAVIGATION

527.6 : 531.383 **2072**

**Inertial Air Navigation Systems.**—(*Tele-Tech & Electronic Ind.*, Jan. 1956, Vol. 15, No. 1, pp. 61 . . 122.) Systems are discussed in which the velocity and position of an aircraft at any time are determined by integrating the outputs of three accelerometers; a two-axis gyro device is used. No information is required from outside sources, and no detectable signal is radiated.

621.396.933 + 621.396.969 **2073**

**Communication and Navigational Aids for the Bristol Britannia.**—N. G. Anslow. (*Brit. Commun. Electronics*, Jan. 1956, Vol. 3, No. 1, pp. 6–9.) A brief description of the radio and radar installation in a modern long-range airliner is given.

621.396.96 **2074**

**Radar Operation and Data Collection desired during Tornadoes and Other Severe Weather Conditions.**—(*Bull. Amer. met. Soc.*, June 1955, Vol. 36, No. 6, pp. 289–291.) Procedures recommended by the Committee on Radar Meteorology of the American Meteorological Society are indicated.

621.396.96 : 621.396.662 **2075**

**Radar A.F.C. System uses Mechanical Tuning.**—J. L. Confalone & W. R. Rambo. (*Electronics*, April 1956, Vol. 29, No. 4, pp. 138–141.) For searching, the radar receiver local oscillator is tuned to within a few Mc/s by a motor-driven system controlled by signals from the i.f. amplifier; the system then switches to a.f.c. action, effected by means of a discriminator controlling a two-phase motor. A bistable trigger circuit provides automatic switching between the two states. The complete circuit is shown.

621.396.963 **2076**

**Clutter on Radar Displays.**—J. Croney. (*Wireless Engr*, April 1956, Vol. 33, No. 4, pp. 83–96.) "An analysis is developed of the action of an idealized logarithmic receiver followed by a differentiating circuit (high-pass filter), upon inherent receiver noise, sea-clutter and rain-clutter echoes. The analysis is extended to estimate the extent to which the performance of the practical logarithmic receiver may depart from that of the idealized receiver. Results are given of experiments with logarithmic receivers on both S and X band radars. The loss which occurs when a differentiating circuit follows a logarithmic receiver is stated, the cause examined and a method of minimizing the loss suggested. The important design parameters of a logarithmic receiver for clutter reduction are dealt with." See also 2953 of 1954.

621.396.963 : 621.385.832 **2077**

**Storage-Tube Device simulates Radar Net.**—S. Shenfield & M. Finkle. (*Electronics*, April 1956, Vol. 29. No. 4, pp. 181–183.) Signals in the form in which they would be received from two or more geographically separated stations are applied on a time-sharing basis to a storage-type cathode-ray tube provided with means for off-centring the beam in the X and Y directions. On reading out, the signals are separated and directed to individual indicator tubes corresponding to the individual stations.

## MATERIALS AND SUBSIDIARY TECHNIQUES

533.5 + 544.4 **2078**

**The Analysis of Gases at Low Pressures.**—M. A. Cayless. (*Brit. J. appl. Phys.*, Jan. 1956, Vol. 7, No. 1, pp. 13–16.) Apparatus for handling gas in measured quantities of $10^{-6}$ cm$^3$ and over at pressures down to $10^{-6}$ mm Hg, and for effecting analysis at pressures between $10^{-3}$ and 1 mm Hg is described.

535.37 : 546.41.33.185-85 **2079**

**Modified Calcium Pyrophosphate Phosphors.**—D. E. Kinney. (*J. electrochem. Soc.*, Dec. 1955, Vol. 102, No. 12, pp. 676–681.) The partial substitution of Na for Ca increases the luminescence efficiency.

535.37 : 546.472.21 **2080**

**Some Optical Properties of New Zinc-Sulphide Phosphors activated with Rare-Earth Elements.**—Z. A. Trapeznikova & V. V. Shchaenko. (*C. R. Acad. Sci. U.R.S.S.*, 11th Jan. 1956, Vol. 106, No. 2, pp. 230–232. In Russian.)

535.376 **2081**

**The Enhancement Effect of Electric Fields on some X-Ray-Excited Phosphors.**—G. Destriau, J. Mattler, M. Destriau & H. E. Gumlich. (*J. electrochem. Soc.*, Dec. 1955, Vol. 102, No. 12, pp. 682–684.) Experimental study of the influence of the strength and frequency of the applied field, the X-ray beam intensity and the temperature on the 'permanent' enhancement effect. See also 2959 of 1954 (Destriau).

535.376 : 546.472.21 **2082**

**Frequency Dependence of Electroluminescent Brightness.**—W. Lehmann: C. H. Haake. (*Phys. Rev.*, 1st Jan. 1956, Vol. 101, No. 1, pp. 489–491.)

ZnS phosphors activated with Cu and containing small quantities of Fe, Co or Ni are discussed; two different theories are advanced regarding the frequency variation of the electroluminescence.

537.226/.228.1 : 546.431.824-31 **2083**

**Electromechanical Properties of Barium Titanate Ceramics.**—G. Mesnard & L. Eyraud. (*J. Phys. Radium*, Dec. 1955, Vol. 16, No. 12, pp. 926–938.) The elastic, electrostrictive and dielectric properties of $BaTiO_3$ ceramics have been investigated by a resonance method, using disk specimens with their faces silvered to form capacitors; the equivalent circuit is derived, also the $Q$ factor and the coefficient of electromechanical coupling for static fields up to 20 V/cm and for the temperature range from − 150° to + 150°C.

537.226/.227 : 546.41/.431].824-31 **2084**

**Structural Behaviour in the System (Ba, Ca, Sr) $TiO_3$ and its Relation to Certain Dielectric Characteristics.**—M. McQuarrie. (*J. Amer. ceram. Soc.*, Dec. 1955, Vol. 38, No. 12, pp. 444–449.) For compositions near the solubility limits in the ternary system (Ba, Ca, Sr) $TiO_3$ firing temperature has a marked effect on dielectric properties. No evidence of ferroelectric properties was discovered in $CaTiO_3$–$SrTiO_3$ systems.

537.226/.227 : 546.431.824-31 **2085**

**Twinning in Barium Titanate Crystals.**—E. A. D. White. (*Acta cryst.*, 10th Dec. 1955, Vol. 8, Part 12, p. 845.)

537.226/.227 : 546.431.824-31 **2086**

**Dependence of the Coercive Force and Permittivity of Ceramic Barium Titanate on Mechanical Strains.**—N. A. Roi. (*Akust. Zh.*, Oct.–Dec. 1955, Vol. 1, No. 4, pp. 352–355.) Experimental results indicate that the coercivity can be increased by means of mechanical tension. The form of the permittivity/temperature curves cannot be explained on the basis of a simple thermodynamic theory neglecting the effects of changes in the domain structure.

537.226/.227 : [546.48 + 546.33].882.5 **2087**

**Solid-Solution Effects, Structural Transitions and Ferroelectricity in Sodium-Cadmium Niobates.**—B. Lewis & E. A. D. White. (*Acta cryst.*, 10th Dec. 1955, Vol. 8, Part 12, p. 849.) Results of a detailed experimental investigation of $NaNbO_3$-$Cd_2Nb_2O_7$ ceramics indicate that at any temperature the local Cd concentration within each crystallite determines whether the structure is ferroelectric or antiferroelectric. Microscopically, the ratio of the two modifications depends on the overall Cd concentration and on the temperature.

537.227/.228 **2088**

**Electrostriction.**—H. F. Kay. (*Rep. Progr. Phys.*, 1955, Vol. 18, pp. 230–250.) A survey paper. Ferroelectric materials are discussed with particular emphasis on the ceramic-oxide group, in which striction coefficients can be obtained which are high compared with those of true piezoelectric materials having irreversible polarity. There is still considerable doubt as to the exact mechanisms involved. About 50 references.

537.228.1 : 547.476.3 **2089**

**Low-Temperature Infrared Absorption Spectrum of Crystallized Rochelle Salt (4 400–7 100 $cm^{-3}$).**—M. P. Bernard. (*C. R. Acad. Sci., Paris*, 20th Feb. 1956, Vol. 242, No. 8, pp. 1012–1013.)

537.311.1/.31 **2090**

**Relaxation Fluctuations in Condensed Systems.**—P. S. Zyryanov. (*Zh. eksp. teor. Fiz.*, Sept. 1955, Vol. 29, No. 3(9), pp. 334–338.) The classification of fluctuations into small-scale (relaxation-type) and large-scale (vibration-type) is considered. The role of relaxation fluctuations in the electrical conductivity of metals is discussed.

537.311.33 **2091**

**New Semiconducting Compounds.**—E. Mooser & W. B. Pearson. (*Phys. Rev.*, 1st Jan. 1956, Vol. 101, No. 1, pp. 492–493.) Experiments have shown that a large number of compounds of the metalloids Se and Te, which are designated particularly, exhibit typical semiconductor properties.

537.311.33 **2092**

**Conductivity and Hall Effect in Semiconductors.**—G. Della Pergola. (*Ricerca sci.*, Dec. 1955, Vol. 25, No. 12, pp. 3269–3314.) Theoretical and experimental methods of investigating semiconductors are reviewed. Ionization energies of Ge and Si with various impurities are tabulated. 56 references.

537.311.33 **2093**

**Electronic Properties of Aromatic Hydrocarbons.**—D. C. Northrop & O. Simpson. (*Proc. roy. Soc. A*, 24th Jan. 1956, Vol. 234, No. 1196, pp. 124–149.) Report of an experimental investigation of electrical conductivity and fluorescence transfer in solid solutions of these substances.

537.311.33 **2094**

**Theory of High-Conductivity Semiconductors.**—L. L. Korenblit & T. Ya. Shraifel'd. (*Zh. tekh. Fiz.*, June & July 1955, Vol. 25, Nos. 6 & 7, pp. 1019–1025 & 1182–1189.) The electrical properties of some semiconductors over certain ranges of temperature and impurity concentration are quasi-metallic. A detailed mathematical analysis is presented for equilibrium conditions of the current carriers. Formulae are derived for the temperature dependence of conductivity, thermo-e.m.f. and Hall effect for both degenerate and non-degenerate semiconductors.

537.311.33 **2095**

**Formation of Mixed Crystals of $A^{III}$ $B^{V}$ Compounds.**—O. G. Folberth. (*Z. Naturf.*, June 1955, Vol. 10a, No. 6, pp. 502–503.) Investigations on InAs-InP and GaAs-GaP compounds are briefly reported. Crystals with any composition in these systems can be formed, the width of the energy gap ranging from 0·33 to 1·25 eV and from 1·45 to 2·25 eV respectively.

537.311.33 **2096**

**Isomorphism of Compounds of Type $A^{III}B^{V}$.**—N. A. Goryunova & N. N. Fedorova. (*Zh. tekh. Fiz.*, July 1955, Vol. 25, No. 7, pp. 1339–1341.) A property important for many technical applications, viz., high mobility of current carriers, has been observed in inorganic semiconductors with a covalent type of bond. In order to be able to vary the properties of such substances, use can be made of the phenomenon of isomorphism, i.e. the ability of the substances to form substitution solid solutions. A report is presented on a radiographic investigation into this property for a wide range of concentrations of the arsenides and antimonides of Ga and In.

537.311.33 **2097**

**Bipolar Diffusion of Charge Carriers in Semiconductors in the case of Spherical Symmetry in the Presence of an External Field (Linear Approximation).**—M. F. Deigen. (*Zh. tekh. Fiz.*, July 1955, Vol. 25, No. 7, pp. 1175–1181.)

537.311.33 **2098**

**The Dependence of the Lifetime of Excess Current Carriers on the Concentration of Equilibrium Charge Carriers.**—R. Paramonova & A. Rzhanov. (*Zh. tekh. Fiz.*, July 1955, Vol. 25, No. 7, pp. 1342–1344.) In connection with an experimental verification of a formula for the lifetime of holes [420 of 1953 (Shockley & Read)], specimens were prepared from a single crystal of Ge. It is not possible to check directly whether the concentration of recombination centres remains constant along the crystal when the concentration of impurities is varied. Indirect arguments support this view, as does also the experimentally obtained linear variation of the lifetime with the inverse value of the concentration of equilibrium charge carriers.

537.311.33: 535.33/.34 **2099**

**Study of Absorption and Reflection Spectra in the Visible and Near-Ultraviolet Regions, for some Semiconductors in the form of Thin Plates, at the Temperature of Liquid Nitrogen.**—S. Nikitine & R. Reiss. (*C. R. Acad. Sci., Paris*, 20th Feb. 1956, Vol. 242, No. 8, pp. 1003–1005.) Spectral lines attributable to excitons were observed with Cu and Tl halides.

537.311.33: 538.63 **2100**

**Theory of the Magnetic Blocking Layer in Semiconductors.**—O. Madelung, L. Tewordt & H. Welker. (*Z. Naturf.*, June 1955, Vol. 10a, No. 6, pp. 476–488.) Previous work [3590 of 1954 (Weisshaar & Welker)] is extended, with particular attention to the distribution of the electron-hole pairs under the influence of the crossed fields, and to the current/voltage characteristic and its relation to surface recombination and specimen dimensions. Photoeffects, frequency variation, and the growth and decay of the blocking layer in response to the field variations are also discussed.

537.311.33: [546.23 + 546.28 + 546.289 **2101**

**The Measurement of the Energy Gap of Semiconductors from their Diffuse Reflection Spectra.**—P. D. Fochs. (*Proc. phys. Soc.*, 1st Jan. 1956, Vol. 69, No. 433B, pp. 70–75.) The values deduced by this method for the energy gaps at room temperature are: amorphous Se 1·86 eV, metallic Se 1·74 eV, Si 1·20 eV and Ge 0·69 eV.

537.311.33: 546.23 **2102**

**Electron-Optical Investigations of Selenium.**—W. Theis. (*Z. Naturf.*, June 1955, Vol. 10a, No. 6, pp. 503–504, 464b.) Crystal structures observed by electron-diffraction technique in Se films deposited on preheated base plates are illustrated and discussed.

537.311.33: [546.289 + 546.682.86 **2103**

**Impurity Scattering in Semiconductors.**—R. Mansfield. (*Proc. phys. Soc.*, 1st Jan. 1956, Vol. 69, No. 433B, pp. 76–82.) Theory is developed and the combination of impurity and lattice scattering is considered for the general case of any degree of degeneracy of charge carriers. Theoretical and experimental results are compared for Ge and InSb.

537.311.33: 546.289 **2104**

**The Effect of Heat Treatment on the Concentration and Mobility of Charge Carriers in Germanium.**—V. V. Ostroborodova & S. G. Kalashnikov. (*Zh. tekh. Fiz.*, July 1955, Vol. 25, No. 7, pp. 1163–1167.) A report is presented on experiments in which Ge specimens were heated to a temperature of 500°C or higher, and then quenched in oil at room temperature. Measurements indicate that the mobility of majority and minority carriers decreases with the approach to the transformation temperature; this may be due to an increase in the volume heterogeneities in the crystal. The concentration of thermal acceptors varies linearly with the reciprocal of temperature in passing from the *p* into the *n* region.

537.311.33: 546.289 **2105**

**The Recombination of Non-equilibrium Charge Carriers at Thermal Acceptors in Germanium.**—V. V. Ostroborodova & S. G. Kalashnikov. (*Zh. tekh. Fiz.*, July 1955, Vol. 25, No. 7, pp. 1168–1174.) The effect of heat treatment on the rate of the volume recombination of non-equilibrium electrons and holes in Ge was investigated experimentally; the life-time varies in inverse proportion to the concentration of thermal acceptors. The effective recombination cross-section of the thermal acceptors was $2{\cdot}5 \times 10^{-17}$ cm². An estimate of the upper limit of the recombination cross-section for donors shows that its order cannot exceed $10^{-19}$ cm².

537.311.33: 546.289 **2106**

**Action of Etchants on Germanium Single Crystals.**—G. Della Pergola & D. Sette. (*Alta Frequenza*, Dec. 1955, Vol. 24, No. 6, pp. 499–518.) Four different etchants were applied to the (100) and (111) faces of the crystals for various periods; microscope examinations and resistivity measurements were made after each treatment. The action of the etchants is discussed in terms of energy released, and is illustrated by photomicrograms.

537.311.33: 546.289 **2107**

**Magnetic Susceptibility of Low-Resistivity *n*-Type Germanium.**—F. T. Hedgcock. (*Canad. J. Phys.*, Jan. 1956, Vol. 34, No. 1, pp. 43–49.) Measurements on polycrystalline specimens over a range of temperatures below room temperature are reported. From the experimental results, the contributions of the free and bound charge carriers to the susceptibility are determined; these appear to vary inversely with temperature. The value deduced for the effective mass of the carriers is 0·16 times that of the free electron mass.

537.311.33: 546.289 **2108**

**Review of Germanium Surface Phenomena.**—R. H. Kingston. (*J. appl. Phys.*, Feb. 1956, Vol. 27, No. 2, pp. 101–114.) "In general the surface may be treated as an assemblage of allowed electron states occurring in the normally forbidden energy range. A review of the measurements of the electrical properties suggests that there are two distinct types of state. The 'fast' state has a hole or electron capture time not greater than a microsecond and is chiefly involved in the recombination process. The 'slow' state has capture times from a millisecond to several minutes and determines the density and type of carrier at the surface. 'Fast' states are believed to occur at the interface between the germanium and the oxide layer, and their density of about $10^{11}$ cm$^{-2}$ is determined by the initial surface treatment. 'Slow' states are associated with the structure of the oxide layer and the gaseous ambient, and have a density greater than $10^{13}$ cm$^{-2}$. Since these states determine the conductivity type at the surface, they contribute to surface 'leakage' in diodes and transistors and, because of their long equilibrium times, to low-frequency noise. The absorption of gases such as water vapor, not only controls the density and energy of the 'slow' states but also leads to possible electrolytic conduction along the surface, in addition to the normal electron flow in the bulk semiconductor."

537.311.33: 546.289 **2109**

**Use of Infrared Absorption to determine Carrier Distribution in Germanium and Surface Recombination Velocity.**—N. J. Harrick. (*Phys. Rev.*, 1st Jan. 1956, Vol. 101, No. 1, pp. 491–492.) Experiments are briefly described which indicate that surface recombination velocity can be directly evaluated from measurements of infrared absorption. In a particular case, values of 250 cm/s and 1 900 cm/s were obtained for surfaces which had been etched and ground respectively.

537.311.33: 546.289 **2110**

**Infrared Absorption in *n*-Type Germanium.**—H. Y. Fan, W. Spitzer & R. J. Collins. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, pp. 566–572.) Measurements were made at wavelengths from 5 to 38 $\mu$, at temperatures from 78° to 450°K. At the higher temperatures the absorption is proportional to carrier concentration, lattice scattering being the dominant effect. At 78° the absorption per unit carrier concentration comprises a constant term together with a term proportional to the impurity concentration. The absorption increases with wavelength more rapidly at the lower temperatures. The results are in quantitative agreement with theory if the effective carrier mass is assumed to be about 0·1 $m$.

537.311.33: 546.289 **2111**

**Deformation Potential Theory for *n*-Type Ge.**—W. P. Dumke. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, pp. 531–536.) A calculation is made of the mobility of electrons in Ge using the deformation potential theory of Bardeen & Shockley (3032 of 1950) and taking into account the effect of shear-wave scattering. Values obtained range between 4 550 and 6 700 cm/s per V/cm at 300°K, with a temperature-variation index of $-3/2$. Discrepancies between these results and experimental values are discussed.

537.311.33: 546.289 **2112**

**Hall Effect in Oriented Single Crystals of *n*-Type Germanium.**—W. M. Bullis & W. E. Krag. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, pp. 580–584.) Experimental evidence confirms the variations of Hall coefficient with direction and magnitude of the magnetic field and with direction of current which are predicted by the eight-ellipsoid energy-surface model. The observations can be explained by assuming an energy-independent scattering time. This type of measurement could be used to determine symmetry properties of energy surfaces near a band edge.

537.311.33: 546.289: 535.215: 538.6 **2113**

**Saturation of the Photomagnetoelectric Effect in Germanium as a Function of the Magnetic Field.**—A. A. Pires de Carvalho. (*C. R. Acad. Sci., Paris*, 6th Feb. 1956, Vol. 242, No. 6, pp. 745–747.) Measurements on small plates of Ge subjected to illumination and to magnetic induction flux densities $B$ up to about 2·7 Wb/m² indicate that the short-circuit current becomes saturated at values of $B$ consistent with the formula $V = CB/[1 + (\mu B)^2]$, where $\mu$ is the charge-carrier mobility, $C$ is a constant depending on the wavelength and intensity of the illumination, and $V$ is the photomagnetoelectric voltage.

537.311.33: 546.289: 538.63 **2114**

**Magnetic Blocking Layers in Germanium: Part 2.**—E. Weisshaar. (*Z. Naturf.*, June 1955, Vol. 10a, No. 6, pp. 488–495.) Experimentally determined $I/V$ characteristics of symmetrical and asymmetrical blocking layers developed in magnetic fields [3590 of 1954 (Weisshaar & Welker)] and their deviations from the theoretically predicted curves are discussed. The absence of a saturation effect is attributed to the impurity concentration of the Ge specimen used. Measurements of the growth and decay of the layers and of the frequency variation of the current at constant voltage are in good agreement with values calculated from theory for small values of the applied field.

537.311.33: 546.46-31: 535.215 **2115**

**Photo-induced Hall Effect in MgO.**—E. Yamaka & K. Sawamoto. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, pp. 565–566.) Short report of an investigation of the sign of the charge carriers produced by light in the various absorption bands. A hole mobility of about 2 cm/s per V/cm was found.

537.311.33: [546.472.21 + 546.682.86]: 537.228.1 **2116**

**Mobility in Zinc Blende and Indium Antimonide.**—W. A. Harrison. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, p. 903.) The relations between the piezoelectric properties and the charge-carrier mobility of these materials are discussed.

537.311.33: 546.561-31 **2117**

**Surface Conductivity of Copper Oxide.**—V. E. Lashkarev & V. I. Lyashenko. (*C. R. Acad. Sci. U.R.S.S.*, 11th Jan. 1956, Vol. 106, No. 2, pp. 243–245. In Russian.) Results of experimental determinations of conductivity and carrier mobility in specimens placed in vacuum and in ethylene alcohol vapour at various pressures are discussed.

537.311.33: 546.682.86 **2118**

**Optical Properties of Indium Antimonide in the Region from 20 to 200 Microns.**—H. Yoshinaga & R. A. Oetjen. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, pp. 526–531.) Reflectivity and transmission curves were obtained for large $n$-type single crystals. The curves indicate a strong lattice vibration at 54·6 $\mu$; absorption and transmission in this spectral region are not greatly affected by the presence of free electrons.

537.311.33: 546.682.86 **2119**

**Infrared Absorption of Indium Antimonide.**—E. Blount, J. Callaway, M. Cohen, W. Dumke & J. Phillips. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, pp. 563–564.) Observations are interpreted in terms of transition between valence and conduction bands.

537.311.33: 546.682.86: 538.6 **2120**

**Thermomagnetoelectric Effects in Indium Antimonide.**—P. Aigrain, C. Rigaux & J. M. Thuillier. (*C. R. Acad. Sci., Paris*, 27th Feb. 1956, Vol. 242, No. 9, pp. 1145–1148.) Observations of Seebeck and Nernst effects were in good agreement with theoretical predictions; these techniques are useful for determining the ratio of the effective masses and the mobilities of the carriers.

537.311.33: [546.817.231 + 546.817.241 + 546.817.221 **2121**

**Photon-Radiative Recombination in PbSe, PbTe and PbS.**—I. M. Mackintosh. (*Proc. phys. Soc.*, 1st Jan. 1956, Vol. 69, No. 433B, pp. 115–118.) Analysis indicates that in the absence of traps the maximum attainable lifetimes corresponding to direct electron-hole recombination in PbSe, PbTe and PbS are 0·6, 0·8 and 40 $\mu$s, to within factors of 2, 3 and 5 respectively.

537.311.33: 621.314.63 **2122**

**The Static Reverse-Voltage/Current Characteristic of the Barrier Layer formed at the Boundary between an *n*-type Semiconductor and a *p*-Type Semiconductor.**—E. I. Rashba & K. B. Tolpygo. (*Zh. tekh. Fiz.*, July 1955, Vol. 25, No. 7, pp. 1335–1338.) In existing theories of rectification at $p$-$n$ junctions, recombination and generation of carriers in the space-charge region are not taken into account, and therefore the universal formula (1) for the current through the semiconductor is not sufficient for determining the properties of *p-n* junctions from the observed *V/I* characteristic. These effects are now considered and an examination is made of the extent to which Shockley's theories (379 of 1950) regarding the variation of quasi-Fermi levels are justifiable.

537.311.33 : 621.396.822 **2123**

**High-Frequency Shot Noise in *P-N* Junctions.**—A. Uhlir, Jr. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 557–558.) A quantitative relation is derived between the frequency variation of the junction conductance and the frequency variation of the shot-noise current. The result obtained is valid for nonplanar as well as planar junctions, and in cases where drift is important.

537.311.4 **2124**

**New Low-Contact-Resistance Electrode.**—S. S. Flaschen & L. G. Van Uitert. (*J. appl. Phys.*, Feb. 1956, Vol. 27, No. 2, p. 190.) The contact resistance of various electrodes was investigated by measuring the resistance of Ni-ferrite specimens to which the contacts were applied. A contact made by rubbing an indium pencil moistened with mercury on to the surface gave both a minimum and a constant resistance over the voltage range 0·01–140 V. Liquid gallium may be substituted for the mercury in some cases.

537.311.4 : 537.226 **2125**

**Mechanism of Forming of Anode** [-interface] **Layers in Formed Dielectrics.**—Ya. N. Pershits. (*Zh. eksp. teor. Fiz.*, Sept. 1955, Vol. 29, No. 3(9), pp. 362–368.) Continuation of earlier experiments (448 of February) is reported. The current/time characteristics of the electrode/dielectric contacts were found to be similar for glass, rock salt, skin, and other dielectrics; the curves cannot be explained by assuming motion of cations only; motion of anions must be assumed. No evidence was found of electron conduction.

537.323 : 546.3-1-86-24 **2126**

**The Thermoelectric Properties of Alloys of the Antimony-Tellurium System.**—F. I. Vasenin. (*Zh. tekh. Fiz.*, July 1955, Vol. 25, No. 7, pp. 1190–1197.) An experimental investigation was carried out, the main results of which are as follows: (*a*) in the region of the binary system Te-$Sb_2S_3$ a slow decline of the thermo-e.m.f. curve is observed; this decline becomes a sharp fall when the stoichiometric composition is approached; (*b*) using powder-metallurgy technique it is possible to obtain homogeneous Sb-Te alloys with increased thermo-e.m.f. and electrical conductivity; (*c*) heating of the alloys to 400°C increases the thermo-e.m.f., while the corresponding decrease in electrical conductivity is relatively small; (*d*) addition of Pb decreases the thermo-e.m.f. of Sb and Sb-Te alloys and increases their conductivity.

538.22 : 546.711 **2127**

**Antiferromagnetic Structure of α-Manganese and a Magnetic Structure Study of β-Manganese.**—J. S. Kasper & B. W. Roberts. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, pp. 537–544.)

538.22 : 621.318.134 **2128**

**Comparative Study of the Crystalline Structures of Lanthanum, Praseodymium and Samarium Ferrites.**—G. Guiot-Guillain. (*C. R. Acad. Sci., Paris*, 6th Feb. 1956, Vol. 242, No. 6, pp. 793–795.)

538.221 **2129**

**Law of Approach to Saturation for a Single Crystal of Fe-Si along the Three Principal Crystallographic Directions.**—H. Danan. (*C. R. Acad. Sci., Paris*, 6th Feb. 1956, Vol. 242, No. 6, pp. 748–750.) Measurements are reported which indicate that magnetic hardness is greatest for magnetization along the direction of greatest anisotropy energy.

538.221 **2130**

**Demagnetization of Magnetite and of Sesquioxide of α Iron by the Action of Alternating Magnetic Fields.**—F. Rimbert. (*C. R. Acad. Sci., Paris*, 13th Feb. 1956, Vol. 242, No. 7, pp. 890–893.)

538.221 **2131**

**Influence of Method of Demagnetization of Specimen on Temperature Dependence of Magnetization of Nickel in Weak Fields.**—A. I. Drokin & V. L. Il'yushenko. (*Zh. eksp. teor. Fiz.*, Sept. 1955, Vol. 29, No. 3(9), pp. 339–344.) The effect of demagnetization by (*a*) heating to a temperature above the Curie point and (*b*) applying an alternating magnetic field, on the subsequent magnetization in a field of strength 0·39 oersted at temperatures between − 183°C and + 360°C is investigated experimentally. The magnetization curves obtained are not identical, probably because in (*a*) the alignment of the domains is random, in (*b*) the domains are antiparallel. The number and magnitude of jumps in the curves are also different.

538.221 : 538.569.4.029.6 **2132**

**Resonance in α $Fe_2O_3$.**—Y. Kojima. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. A*, Dec. 1955, Vol. 7, No. 6, pp. 591–594.) Microwave magnetic resonance in natural single crystals of α$Fe_2O_3$ was observed at several frequencies ranging from 16·5 kMc/s to 48·3 kMc/s. The anisotropic energy was studied as a function of crystal orientation. The *g* factor was also obtained from the resonance data.

538.221 : 538.63 **2133**

**The Problem of Galvanomagnetic Effects in Ferromagnetic Materials.**—K. M. Koch. (*Z. Naturf.*, June 1955, Vol. 10a, No. 6, pp. 496–498.) The tensor nature of the resistance of a ferromagnetic conductor in a magnetic field is discussed. Experiments are reported on strips of Fe, Ni and alloys arranged rotatably in the field of an electromagnet; pseudo Hall effects were observed confirming the theory presented.

538.221 : 621.317.411.029.6 **2134**

**Measurement of the Magnetic Permeability of Metals by means of Cavity Resonators, and the Permeability of Iron in the Region of Ferromagnetic Resonance.**—K. H. Reich. (*Frequenz*, Sept. & Dec. 1955, Vol. 9, Nos. 9 & 12, pp. 299–305 & 414–422 & Jan. 1956, Vol. 10, No. 1, pp. 11–19.) Various theoretical explanations of the fall of initial permeability with increasing frequency are examined; experiments with ferrites have made it clear that ferromagnetic resonance is an important factor. A method of measurement at cm wavelengths is described in which part of the boundary wall of a cavity resonator is replaced by the ferromagnetic test specimen and the resulting variation of the damping is observed. The effects of pseudo-damping due to the associated circuit arrangements are corrected for. Measurements are reported on iron specimens of various degrees of purity, at room temperature and at 200°C, using direct field strengths up to 11 000 A/cm and a radio frequency of 24·5 kMc/s; the reversible permeability is independent of purity, temperature and crystal orientation relative to the magnetic field. Variation of the permeability with surface roughness and low permeability of unordered specimens are attributed to scatter of the resonance frequencies. For related work, see 829 of March (Standley & Reich). 126 references.

538.221 : 621.318.122 **2135**

**Improved Permanent Magnet Materials.**—(*Electronic Engng*, April 1956, Vol. 28, No. 338, p. 171.) New types of alcomax with desired anisotropic properties are obtained by making suitable modifications in the composition and applying heat treatment in a magnetic field.

538.221 : 621.318.134 **2136**

**Initial Permeabilities of Sintered Ferrites.**—G. W. Rathenau & J. F. Fast. (*Physica*, Dec. 1955, Vol. 21, No. 12, pp. 964–970.) Measurements on Ni-Zn ferrites at low frequencies are reported. The results support the conclusion previously reached by Wijn & Went (1633 of 1952) that after demagnetization in an alternating field of decreasing amplitude the magnetization of these materials is almost exclusively caused by simultaneous rotation of the spins.

538.221 : 621.318.134 **2137**

**Complex Susceptibility of Magnesium Ferrites.**—B. Chiron & P. M. Prache. (*Câbles & Transm.*, Jan. 1956, Vol. 10, No. 1, pp. 73–74.) Experimental results are presented in a curve using frequency as parameter and choosing the coordinates so as to bring out significant properties of the material. Loops in this curve are attributed to causes other than gyromagnetic resonance.

538.221 : 621.318.134 : 538.6 **2138**

**Frequency Doubling in Ferrites.**—W. P. Ayres, P. H. Vartanian & J. L. Melchor. (*J. appl. Phys.*, Feb. 1956, Vol. 27, No. 2, pp. 188–189.) "A high intensity microwave magnetic field and an orthogonal d.c. magnetic field were applied to a ferrite body. Double frequency magnetic fields were generated in the same direction as the d.c. magnetizing field. A primary frequency of 3 175 Mc/s was used with peak powers up to 200 watts. The peak output power at 6 350 Mc/s was found to increase linearly with the square of the peak input power over a range of 42 dB. Reasonable agreement was found between theory and experiment."

538.222 : 538.569.4 **2139**

**Paramagnetic Resonance II.**—K. D. Bowers & J. Owen. (*Rep. Progr. Phys.*, 1955, Vol. 18, pp. 304–373.) A report complementary to that of Bleaney & Stevens (452 of 1954). Paramagnetic-resonance data on salts containing transition-group ions are collected and are discussed in the light of theory presented in simple form. Various physical properties of crystals comprising such ions are elucidated. Over 100 references.

538.569.4 : 546.87 **2140**

**Cyclotron Resonance in Bismuth.**—M. Tinkham. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, p. 902.) Results obtained by previous workers are discussed in relation to the energy-band structure for Bi first proposed by Jones (*Proc. roy. Soc. A*, 15th Nov. 1934, Vol. 147, No. 861, pp. 396–417).

538.63 : 546.87 **2141**

**Galvanomagnetic Effects in Bismuth.**—B. Abeles & S. Meiboom. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, pp. 544–550.) "Conductivity, Hall effect, and magnetoresistance in single crystals of pure and tin-doped bismuth have been measured as functions of temperature between 80 and 300°K and as functions of magnetic field up to 2 000 oersted. A simple many-valley model for the band structure of bismuth is proposed, and explicit expressions for the galvanomagnetic effects are derived. Numerical values are obtained for the number of conduction electrons and holes, their mobilities, and the overlap of valence and conduction bands."

538.65 **2142**

**Magnetostriction and Magnetomechanical Effects.**—E. W. Lee. (*Rep. Progr. Phys.*, 1955, Vol. 18, pp. 184–229.) A review with about 100 references.

538.652 : 546.74 **2143**

**Theory of Magnetostriction of Single Crystals of Ni.**—N. S. Akulov. (*C. R. Acad. Sci. U.R.S.S.*, 1st Jan. 1956, Vol. 106, No. 1, pp. 31–34. In Russian.)

546.841.05 **2144**

**Preparation of High-Purity Thorium by the Iodide Process.**—N. D. Veigel, E. M. Sherwood & I. E. Campbell. (*J. electrochem. Soc.*, Dec. 1955, Vol. 102, No. 12, pp. 687–689.)

548.5 : 546.482.21 **2145**

**New Method of Preparation of Single Crystals of Cadium Sulphide.**—E. Grillot. (*C. R. Acad. Sci.*, *Paris*, 6th Feb. 1956, Vol. 242, No. 6, pp. 779–781.) By sublimation in a tubular furnace heated to above 1 000°, tablets of CdS have been obtained in a few hours having thicknesses of several mm and surface areas of several cm², constituted by a mosaic of crystals joined at their lateral faces.

669 **2146**

**The Effect of Growth Conditions upon the Solidification of a Binary Alloy.**—W. A. Tiller & J. W. Rutter. (*Canad. J. Phys.*, Jan. 1956, Vol. 34, No. 1, pp. 96–121.) A theoretical and experimental analysis is reported of the influence of (*a*) the concentration of solute in the melt, (*b*) the rate of solidification and (*c*) the temperature gradient in the melt at the solid/liquid interface.

669.046.5 : 546.289 + 546.74 **2147**

**Floating Zone Melting of Solids by Electron Bombardment.**—M. Davis, A. Calverley & R. F. Lever. (*J. appl. Phys.*, Feb. 1956, Vol. 27, No. 2, pp. 195–196.) A rod of the solid material, held upright in chucks in a continuously evacuated enclosure, and maintained at a positive potential of a few kV, is encircled at the level chosen for melting by a heated tungsten filament cathode; a focusing shield is provided to control the length of the zone bombarded. The method is useful for dealing with Si and Ni as well as more refractory materials.

## MATHEMATICS

512.37 **2148**

**On the Calculation of the Roots of Equations.**—E. Frank. (*J. Math. Phys.*, Oct. 1955, Vol. 34, No. 3, pp. 187–197.) The method described, which is an extension of Newton's method of successive approximations, is particularly useful for accurate computations with an ordinary calculating machine.

517 **2149**

**Transformations of the Fourier and Laplace Types by means of Solutions of Second-Order Differential Equations.**—B. Levin. (*C. R. Acad. Sci. U.R.S.S.*, 11th Jan. 1956, Vol. 106, No. 2, pp. 187–190. In Russian.)

517 **2150**

**Determination of the Family of Orthogonal Polynomials whose Derivatives are Orthogonal.**—R. Campbell. (*C. R. Acad. Sci.*, *Paris*, 27th Feb. 1956, Vol. 242, No. 9, pp. 1110–1111.)

517: 534.01 2151

**The Initial-Value Problem for the Wave Equation in the Distributions of Schwartz.**—J. O'Keeffe. (*Quart. J. Mech. appl. Math.*, Dec. 1955, Vol. 8, Part 4, pp. 422–434.) "The classic formulae for the solution of initial value problems for the wave equation are found in the case of distributions by a Fourier transform method."

517.942.922 2152

**Tables of $\int_0^x J_0(t)dt$ for Large [values of] $x$.**—P. W. Schmidt. (*J. Math. Phys.*, Oct. 1955, Vol. 34, No. 3, pp. 169–192.) The Bessel function is tabulated in steps of 0·2 for the range $10 < x < 40$.

517.942.932 2153

**On Periodic Solutions of Duffing's Equation with Damping.**—W. S. Loud. (*J. Math. Phys.*, Oct. 1955, Vol. 34, No. 3, pp. 173–178.) Special cases are considered of the equation $\ddot{x} + f(x)\,\dot{x} + g(x) = p(t)$, where $f(x)$ is an even function, $g(x)$ is an odd function, and $p(t)$ is periodic and odd-harmonic.

518.2 2154

**Formulas for Inverse Osculatory Interpolation.**—H. E. Salzer. (*J. Res. nat. Bur. Stand.*, Jan. 1956, Vol. 56, No. 1, pp. 51–54.) The formulae presented provide an improved means for inverse interpolation in tables where the first derivative is either tabulated alongside the function, as in Bessel functions of the first and second kind, or where it is easily obtained, as in the elementary trigonometrical functions and their integrals.

## MEASUREMENTS AND TEST GEAR

531.789.1: 538.22 2155

**Torsion Balance for a Single Microscopic Magnetic Particle.**—S. P. Yu & A. H. Morrish. (*Rev. sci. Instrum.*, Jan. 1956, Vol. 27, No. 1, pp. 9–11.) The balance described may be used for measurements on individual magnetic particles of diameters down to about $1\,\mu$ (mass $\sim 10^{-13}$ g).

538.569.4.029.6:535.33 2156

**Millimeter and Submillimeter Wave Spectroscopy.**—C. A. Burrus & W. Gordy. (*Phys. Rev.*, 15th Jan. 1956, Vol. 101, No. 2, pp. 599–602.) Apparatus and results are described. The energy source is a Si-crystal frequency multiplier driven by a cm-$\lambda$ klystron. An evacuated bolometer is used as detector at wavelengths down to 2 mm. A Si-crystal detector is also used.

621.317.3: 621.315.212: 621.3.013.78 2157

**Measurement of Coupling Impedance and its Application to the Study of Cable Screens.**—Bourseau & Sandjivy. (See 1950.)

621.317.33: 621.372.413: 537.311.33 2158

**A Microwave Resonant Cavity Method for measuring the Resistivity of Semiconducting Materials.**—J. G. Linhart, I. M. Templeton & R. Dunsmuir. (*Brit. J. appl. Phys.*, Jan. 1956, Vol. 7, No. 1, pp. 36–38.) "A small spherical or cubic specimen is placed in a cavity resonating in the $H_{011}$ mode, and the reduction in $Q$ due to eddy-current loss in the specimen is measured. The theory given enables the resistivity of the material to be calculated. It is shown that resistivities in the range 0·005 to 10 Ω.cm can be determined."

621.317.335.3 2159

**Dielectric Constant of Water from 0° to 100°C.**—C. G. Malmberg & A. A. Maryott. (*J. Res. nat. Bur. Stand.*, Jan. 1956, Vol. 56, No. 1, pp. 1–8.) Measurements made using a low-frequency bridge with a Wagner earth are reported. The accuracy was within 0·1%. The value found at 25°C was 78·30, about 0·3% less than that usually accepted. A formula is derived for the temperature variation of the dielectric constant. Sources of error in the experimental method are considered in detail.

621.317.335.3.029.6 2160

**A Method for determining Complex Dielectric Constants of Very Small Amounts of Material (0.1 cm³) at Decimetre Wavelengths.**—H. Lueg & H. K. Ruppersberg. (*Arch. elekt. Übertragung*, Dec. 1955, Vol. 9, No. 12, pp. 533–540). A coaxial-line method is described in which the line stands vertical and the inner conductor is adjustable axially. When the inner conductor is pulled down a few tenths of a millimetre, a cavity is formed into which the test material can be inserted. In this position the field strength is a maximum, so that the specimen/air interface is nearly free from induction and field currents. With liquid specimens, two drops suffice; with solid specimens, thin disks are used.

621.317.411.029.6: 538.221 2161

**Measurement of the Magnetic Permeability of Metals by means of Cavity Resonators, and the Permeability of Iron in the Region of Ferromagnetic Resonance.**—Reich. (See 2134.)

621.317.42 2162

**Methods of measuring Strong Magnetic Fields.**—J. L. Symonds. (*Rep. Progr. Phys.*, 1955, Vol. 18, pp. 83–126.) A survey covering methods based on magnetic resonance, magnetoresistance, the Hall effect, peaking strips, the generator principle, the fluxmeter, and forces on current-carrying conductors. The technique of determining the magnetic median plane is discussed, and several less used methods of measurement are mentioned. About 150 references.

621.317.42: 621.383 2163

**The Photoelectric Fluxmeter.**—S. P. Kapitsa. (*Zh. tekh. Fiz.*, July 1955, Vol. 25, No. 7, pp. 1307–1315.) A detailed description and analysis of operation of the 'photoelectric hysteresisgraph' [*Elect. Engng, N.Y.*, July 1937, Vol. 56, No. 7, pp. 805–809 (Edgar)]. The frequency characteristics are considered. Conditions for distortion correction are established and the advantages of using negative feedback are indicated. The theoretical results are illustrated by oscillograms of transient processes.

621.317.44 2164

**Improved Method for observing Hysteresis Cycles with the Iliovici Permeameter.**—R. Dehors & L. Garde. (*C. R. Acad. Sci., Paris*, 6th Feb. 1956, Vol. 242, No. 6, pp. 751–753.)

621.317.7: 621.372.8 2165

**Bibliography on Directional Couplers.**—R. F. Schwartz. (*Trans. Inst. Radio Engrs*, April 1955, Vol. MTT-3, No. 3, pp. 42–43.) Addendum to 208 of 1955.

621.317.7: 621.396.81 2166

**New Apparatus for determining the Statistical Distribution of Random Electrical Processes.**—J. Grosskopf, K. H. Kappelhoff & G. Kopte. (*Nachrichtentech. Z.*, Jan. 1956, Vol. 9, No. 1, pp. 34–39.)

Automatic recording apparatus for studying radio signal-strength variations is described. The time-distribution curve is displayed every half-hour; accuracy of measurements is adequate for fading frequencies up to 10 kc/s. The evaluation of the 18-hour daily records is performed by one operator in about half-an-hour, using templates.

621.317.7: 621.396.822.1: 621.396.41 **2167**

**Equipment for Measurement of Interchannel Crosstalk and Noise on Broad-Band Multichannel Telephone Systems.**—R. W. White & J. S. Whyte. (*P.O. elect. Engrs' J.*, Oct. 1955, Vol. 48, Part 3, pp. 127–132.) A band of noise covering the frequency range of a multichannel system is passed through a narrow-band-stop filter, giving the equivalent of a fully loaded system with one quiet channel. Intermodulation measurements may be made in the quiet channel. The method may be used to investigate coaxial-cable systems as well as microwave radio links.

621.317.71: 620.193 **2168**

**An Electronic Self-Balancing Zero-Resistance Ammeter.**—D. R. Makar & H. T. Francis. (*J. electrochem. Soc.*, Dec. 1955, Vol. 102, No. 12, pp. 669–670.) Description of an instrument for continuous observation of the short-circuit current flowing in a galvanic corrosion cell. It comprises a 60-c/s chopper circuit, amplifier, phase-detector, relay and balancing circuit. The sensitivity is 50 $\mu$V with current range 20 mA.

621.317.729.029.6 **2169**

**Measurement of Time-Quadrature Components of Microwave Signals.**—J. H. Richmond. (*Trans. Inst. Radio Engrs*, April 1955, Vol. MTT-3, No. 3, pp. 13–15.) Equipment for measuring the real and imaginary components of a signal is described; it uses two barretters as detectors and is less elaborate than would be required for separate measurement of amplitude and phase.

621.317.729.029.6 **2170**

**Probes for Microwave Near-Field Measurements.**—J. H. Richmond & T. E. Tice. (*Trans. Inst. Radio Engrs*, April 1955, Vol. MTT-3, No. 3, pp. 32–34.) Details are given of the construction of waveguide probes which permit the calculation of far-field signal strengths in good agreement with measured values.

621.317.733 **2171**

**Compensating Recording Bridge for Measurement of Capacitance and Loss Factor.**—H. Poleck. (*Elektrotech. Z.*, *Edn A*, 1st Dec. 1955, Vol. 76, No. 23, pp. 822–826.) A modified Schering bridge is described.

621.317.733 **2172**

**A Simple Auxiliary Bridge for Accurate Measurements of Loss Factor with the Schering Bridge.**—A. Keller. (*Elektrotech. Z.*, *Edn A*, 1st Dec. 1955, Vol. 76, No. 23, pp. 826–827.)

621.317.755 **2173**

**Signal-Triggered Sweep magnifies Pulse Widths.**—R. L. Kuehn. (*Electronics*, April 1956, Vol. 29, No. 4, pp. 146–147.) A c.r.o. circuit is described which incorporates an automatic change-over from recurrent-sweep to triggered-sweep operation; the display corresponding to a signal pulse can be expanded as desired by increasing the recurrent-sweep frequency.

621.317.755.029.3 **2174**

**Audio-Frequency Spectrometer.**—W. Kaule & A. Johne. (*NachrTech.*, Jan. 1956, Vol. 6, No. 1, pp. 35–39.) The operation of a new c.r.o. instrument using only six filters is described. Over the frequency range 0–1 kc/s the analyser bandwidth is 50 c/s; over the range 0–20·5 kc/s it is 500 c/s.

621.317.76: 621.396.61 **2175**

**The Frequency-Band Recorder.**—H. Fleischer & H. Widdra. (*Nachrichtentech. Z.*, Jan. 1956, Vol. 9, No. 1, pp. 21–28.) An automatic instrument for measuring and recording the principal features of radio signals in accordance with the international monitoring system is described. The features covered are frequency, field strength, bandwidth, duration, type of modulation, and transmitter frequency deviation. The instrument can be used in conjunction with different receivers to suit the frequency and sensitivity requirements; the construction permits not more than three frequency sweeps of the receiver to be recorded per min. The receiver feeds an amplifier which modulates a variable-delay thyratron driving the recording pen. Typical records are reproduced.

621.317.761 **2176**

**Phase-Bridge Frequency Meters.**—C. Févrot. (*Rev. gén. Élect.*, Jan. 1956, Vol. 65, No. 1, pp. 34–38.) In this type of instrument, frequency variations are converted into phase variations which in turn are converted into variations of a direct voltage by means of the phase bridge. The design of circuits to give an indication independent of signal amplitude and harmonic content is discussed, and the merits of some known arrangements for converting from frequency to phase variations are compared.

## OTHER APPLICATIONS OF RADIO AND ELECTRONICS

534.2-8: 539.32 **2177**

**Apparatus for the Measurement of Physical Constants by the Elastic-Vibrations Method.**—A. V. J. Martin (*J. Brit. Instn Radio Engrs*, March 1956, Vol. 16, No. 3, pp. 167–183.) Ultrasonic techniques for determining elastic constants are surveyed. Equipment is described suitable for testing gaseous, liquid and solid specimens. The frequency range is 0·5–50 Mc/s, the temperature range 0°–100°C, and the pressure range up to 10 000 kg/cm². 40 references.

534.2-8: 61 **2178**

**Ultrasonic Irradiation of the Central Nervous System at High Sound Levels.**—W. J. Fry & F. Dunn. (*J. acoust. Soc. Amer.*, Jan. 1956, Vol. 28, No. 1, pp. 129–131.)

534.2-8: 61 **2179**

**High-Intensity Ultrasonic Oscillations for Treatment of Malignant Tumours in Animals and in Man.**—A. K. Burov. (*C. R. Acad. Sci. U.R.S.S.*, 11th Jan. 1956, Vol. 106, No. 2, pp. 239–241. In Russian.) Experimental results indicate that some tumours on the surface of the skin may successfully be treated using 1·5-Mc/s ultrasonic beams of intensities up to 350 W/cm² (continuous) or 600 W/cm² (pulsed). Quartz-plate transducers with surface areas up to 50 cm² were used. No constructional details are given. For experimental results, see also *ibid.*, 21st Jan. 1956, Vol. 106, No. 3, pp. 445–448 (Burov & Andreevskaya).

535.42: 548: 621.397.6 **2180**

**Apparatus for the Electronic Presentation of Optical Diffraction Patterns.**—A. W. Hanson & A. Menarry. (*J. sci. Instrum.*, Jan. 1956, Vol. 33, No. 1, pp. 24–27.) "An image of the diffraction pattern is focused on the photomosaic of a television camera tube capable of accumulating, for a period of about ten seconds, a corresponding charge pattern. This pattern is transferred to a storage device where it remains for a relatively long time during which it can be continuously presented on a television receiver.''

537.534.9 : 621.314.632 : 546.28 **2181**

**Solid-State Detector for Low-Energy Ions.**—O. Heinz, E. M. Gyorgy & R. S. Ohl. (*Rev. sci. Instrum.*, Jan. 1956, Vol. 27, No. 1, pp. 43–47.) Experimental results of bombardment of silicon by $He^+$ ions through a silver film deposited on the surface show that the rectifying properties are modified so as to increase the turnover voltage. Ion energies up to 30 keV and dosages up to 1 800 $\mu C/cm^2$ were used.

621.3 : 620.16 : 681.142 **2182**

**Shock Spectrum Computer for Frequencies up to 2 000 c/s.**—Morrow & Riesen. (See 1969.)

621.3 : 681.8 : 78 **2183**

**Electronic Music.**—H. Le Caine. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 457–478.) A comprehensive discussion dealing with fundamental aspects and particular instruments and techniques. Various means of achieving interpretative effects are indicated. Coded-performance devices are described, including those used by the Musique Concrète group in Paris and the Cologne studio for electronic music.

621.317.39 : 534.6 : 621.385.83 **2184**

**Electron-Acoustic Image Converter.**—P. K. Oshchepkov, L. D. Rozenberg & Yu. B. Semennikov. (*Akust. Zh.*, Oct.–Dec. 1955, Vol. 1, No. 4, pp. 348–351.) The tube described uses a $BaTiO_3$ screen at which an ultrasonic field is converted into an electric-charge distribution which is scanned by an electron beam. The response at frequencies of a few Mc/s is linear over the intensity range $3 \times 10^{-9} - 3 \times 10^{-3}$ W/cm². The sensitivity of the instrument is $2 \times 10^{-8}$ V/bar.

621.384.612 **2185**

**Scattering of Protons by Residual Gas in a Synchrotron: Part 1—Elastic Scattering.**—J. Seiden. (*J. Phys. Radium*, Dec. 1955, Vol. 16, No. 12, pp. 917–925.) The amplitude of oscillations set up by elastic collisions of the accelerated protons with gas molecules is directly proportional to the square root of the gas pressure and inversely proportional to the square roots of the energy of injection and of the energy gain per revolution. Direct losses of protons by single collisions vary in the same way; the calculated values for certain existing synchrotrons range between 2% and 14%.

621.384.612 **2186**

**Space Charge and Ionization Phenomena in Constant-Gradient Proton Synchrotrons.**—P. B. Moon. (*Proc. phys. Soc.*, 1st Feb. 1956, Vol. 69, No. 434A, pp. 153–156.) The calculation of space-charge effects for constant-gradient machines is simpler than for the alternating-gradient ones discussed by Barden (2485 of 1954).

621.385.833 **2187**

**Electron Optics of Cylindrical Systems having a Plane of Symmetry: Part 2—Aberrations.**—M. Laudet. (*J. Phys. Radium*, Dec. 1955, Vol. 16, No. 12, pp. 908–916.) Aberration formulae are derived following the method proposed by Durand (1756 of 1955). Part 1: 2391 of 1955.

621.389 : 535.833 **2188**

**Role of Saturation in the Limitation of [star] Magnitudes attained by Classical Photography and by Use of the Electron Telescope.**—P. Vernier. (*C. R. Acad. Sci., Paris*, 20th Feb. 1956, Vol. 242, No. 8, pp. 1006–1008.)

621.398 **2189**

**Telemetering—Electronic Data Transmission.**—A. A. McKenzie & H. A. Manoogian. (*Electronics*, April 1956, Vol. 29, No. 4, pp. 153–180.) A survey under the headings: systems development; input transducers; signalling methods; commutating devices; output indicators. An extensive bibliography is included.

655 : 621.37/.38] + 621.397 **2190**

**Electronic Methods of Pictorial Reproduction.**—(*J. Brit. Instn Radio Engrs*, March 1956, Vol. 16, No. 3.) The text is given of the following papers, presented at a symposium held in January 1956:—

Facsimile Transmission of Weather Charts and Other Material by Landline and Radio.—J. A. B. Davidson (pp. 115–124).

Facsimile Communication.—H. F. Woodman & P. H. J. Taylor (pp. 129–144).

Electronic Engraving.—S. W. Levine & A. B. Welch (pp. 145–152).

Tone Reproduction with Electronically Cut Stencils.—R. Lant (pp. 153–157).

Discussion on the above papers is given on pp. 158–161.

## PROPAGATION OF WAVES

621.396.11 **2191**

**Propagation of Electromagnetic Waves over the Spherical Earth across Boundaries separating Different Earth Media.**—K. Furutsu. (*J. Radio Res. Labs, Japan*, Oct. 1955, Vol. 2, No. 10, pp. 345–398.) Formulae for propagation over one or two boundaries agree with those for a homogeneous earth in special cases. A rigorous proof is given of a general formula for propagation over any number of boundaries, and methods of summation are discussed. For the case of a flat earth, see 541 of February and 1848 of June.

621.396.11 **2192**

**On the Multiple Scattering of Waves by an Irregular Medium.**—H. Hojo. (*J. Radio Res. Labs, Japan*, Oct. 1955, Vol. 2, No. 10, pp. 419–427.) Expressions are derived, assuming irregularities in one direction only, for the power distribution among the incident wave and singly, doubly and triply scattered waves in the forward and backward directions. Near the critical frequency in an ionized medium, intense and diffuse reflections may occur.

621.396.11 **2193**

**Forward Scatter of Radio Waves.**—(*Tech. News Bull. nat. Bur. Stand.*, Jan. & Feb. 1956, Vol. 40, Nos. 1 & 2, pp. 8–12 & 24–29.) A short survey of N.B.S. investigations of scatter propagation via the ionosphere and via the troposphere. For detailed papers, see *Proc. Inst. Radio Engrs*, Oct. 1955.

621.396.11 : 551.510.535 **2194**

**D-E Layer Electron Model reduced from Considerations of M.F. and H.F. Wave Absorption.**—T. Kobayashi. (*J. Radio Res. Labs, Japan*, Oct. 1955, Vol. 2, No. 10, pp. 399–412.) The model developed is used as a basis for calculating the field strength of waves transmitted over a 1 200-km path by a single E-layer reflection. The results are shown graphically; they differ markedly from corresponding curves derived from National Bureau of Standards charts published in 1948.

621.396.11 : 551.510.535 **2195**

**The Z Propagation Hole in the Ionosphere.**—G. R. Ellis. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 43–54.) The transformation of the ordinary wave to an extraordinary wave under certain conditions gives rise to a 'propagation hole' at the ordinary reflection level. Two methods of estimating the angular size of the 'hole' are based on: (*a*) measurement of *Z*-echo power; (*b*) analysis of the distribution of angle of arrival of *Z* echoes. Measurements at Hobart at a frequency of 4·65 Mc/s show the 'hole' to be approximately circular, with an angular width to half-power points of < 0·84°.

621.396.11 : 550.551.535 **2196**

**Interaction of Ordinary and Extraordinary Waves in the Ionosphere and the Effect of Multiplication of Reflected Waves.**—N. G. Denisov. (*Zh. eksp. teor. Fiz.*, Sept. 1955, Vol. 29, No. 3(9), pp. 380–381.) The propagation of e.m. waves in the ionosphere is considered for the case of a small angle between the direction of propagation and the magnetic field. Strong interaction between the ordinary and extraordinary waves takes place in the region where the refractive indices are nearly equal and, as a result, the ordinary wave becomes an extraordinary wave; this leads to multiple reflections. Application of the mathematical methods originally developed for inelastic collisions between atoms [*Helv. phys. Acta*, 1932, Vol. 5, No. 6, pp. 369–422 (Stueckelberg)] leads to simple expressions for the reflection and transmission coefficients in terms of the ordinary and extraordinary refractive indices.

621.396.11 : 551.510.535 **2197**

**The Interpretation of Measurements of Radio-Wave Interaction.**—L. G. H. Huxley. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 118–120.) The original formula relating the rate *R* at which electrons with energy *Q* lose energy in collisions with molecules is rewritten $R = B_n (Q - Q_0)$, where *B* is a function of *Q* and $Q_0$ that is effectively constant when $(Q/Q_0 - 1) \ll 1$, and *n* is the molecular concentration. Earlier results interpreted according to this formula give a range of *n* from $1{\cdot}2 \times 10^{14}$ to $3 \times 10^{14}$ per cm³ for height 83–90 km. These heights are consistent with values determined from the phase of cross-modulation.

621.396.11 : 551.510.535 **2198**

**On the Observation of Ionospheric Self-Interaction.**—F. H. Hibberd. (*J. atmos. terr. Phys.*, Feb. 1956, Vol. 8, Nos. 1/2, pp. 120–122.) "Essential precautions are described that must be taken in experimental studies of ionospheric self-interaction to avoid misleading results caused by interference between various rays and by the bandwidth of the receiver."

621.396.11 : 621.396.65 **2199**

**Physical Problems of Transmission over Radio Links.**—J. Fagot. (*Onde élect.*, Jan. 1956, Vol. 36, No. 346, pp. 7–22.) Basic problems discussed include the development of an adequate signal/noise ratio, the effect of different propagation paths, and distortion due to frequency variation of propagation velocity over the transmitted band.

621.396.11 : 621.396.65 **2200**

**The Radio Link under Conditions of Atmospheric Superrefraction.**—L. Sacco. (*Alta Frequenza*, Dec. 1955, Vol. 24, No. 6, pp. 436–469.) Superrefraction is commonly experienced in Italy at altitudes up to 500 m. An investigation is made of the geometrical features (reflection points, path differences and convergence coefficients) of the radio link under these conditions, and the value of the received field strength is calculated. Focusing and multiple-reflection effects are discussed.

621.396.11 : 621.396.674.3 **2201**

**Transient Fields of a Vertical Dipole over a Homogeneous Curved Ground.**—Wait. (See 1959.)

621.396.11.029.55 : 523.746 **2202**

**Oblique Incidence and Sunspots.**—R. Gea Sacasa. (*Rev. Telecomunicación, Madrid*, Dec. 1955, Vol. 9, No. 42, pp. 17–31. In Spanish and English.) Twenty-four charts of m.u.f. predictions by various national laboratories, based on the index of solar activity, are compared with predictions by Gea's method. For periods of high solar activity, in summer, the former predictions are too low and are in better agreement with the observations if displaced by six months. With the accuracy of prediction at present attained there is no experimental confirmation of the need to vary the predictions over the eleven-year cycle.

621.396.11.029.63 **2203**

**The Influence of Atmospheric Turbulence on Ultra-short-Wave Radio Links across the Mediterranean.**—F. du Castel. (*Onde élect.*, Jan. 1956, Vol. 36, No. 346, pp. 32–42.) Receiving stations working on wavelengths of 10, 22 and 70 cm were sited at various heights above and below the transmitter horizon. The signal-strength patterns caused by turbulence are described and probable values of the parameters involved are deduced. A mean 'scale of turbulence' of 17 m is indicated, as against measured values in the range 20–130 m obtained in the U.S.A. by Gordon (1136 of 1955).

621.396.81 : 621.317.7 **2204**

**New Apparatus for determining the Statistical Distribution of Random Electrical Processes.**—Grosskopf, Kappelhoff & Kopte. (See 2166.)

621.396.812.3.029.63 **2205**

**Diversity Tests and Study of Focusing Effects on Long Line-of-Sight Radio Links.**—Rivet. (See 2210.)

621.396.812.3.029.64 **2206**

**An Interpretation of the Statistics of Fading over Optical-Range Microwave Radio Paths.**—G. Kraus. (*Arch. elekt. Übertragung*, Jan. 1956, Vol. 10, No. 1, pp. 19–25.) Fading due to tropospheric ducts is investigated. It is assumed that the signal at the receiver comprises a principal ray together with a number of subsidiary rays with random phases. The degree of stratification is characterized by the fraction *q* contributed by the subsidiary rays; the higher the value of *q* the greater the fluctuations of signal power about the mean value associated with the main ray. When $q = 1$, the depth of fading is at least 20 dB for 1% of the time. The results are in fairly good agreement with published observations of fading.

621.396.812.3.029.64 **2207**

**Interference Fading caused by Frontal Discontinuities.**—P. Misme. (*Onde élect.*, Jan. 1956, Vol. 36, No. 346, pp. 43–47.) Microwave fading is produced due to varying convergence of rays in the horizontal plane by sharply defined fronts characterized by stationary or rising temperature and falling humidity. Field-strength records showing the effect of a normal cold front and the passage of a storm are presented.

## RECEPTION

621.376.232.2 : 621.396.62 : 621.396.822 **2208**

**Effect of Electrical Fluctuations on a Detector (Wave-Envelope Method).**—V. I. Tikhonov. (*Bull. Acad. Sci. U.R.S.S., tech. Sci.*, Oct. 1955, No. 10, pp. 3–13. In Russian.) The detection of a signal which is modulated in amplitude and phase by voltage fluctuations in the i.f. amplifier is considered theoretically for a diode detector with (*a*) a linear, (*b*) a quadratic, and (*c*) an exponential characteristic. Results are also given of an experimental investigation of the modification of the detected voltage probability distribution by the time constant of the detector *RC* circuit.

621.396.62 : 621.396.3 : 621.376.3 **2209**

**Automatic Frequency Control in Frequency-Shift Radiotelegraphy.**—A. Niutta & G. Bronzi. (*Alta Frequenza*, Dec. 1955, Vol. 24, No. 6, pp. 519–522.) Discussion on 253 of January and author's reply.

621.396.812.3.029.63 **2210**

**Diversity Tests and Study of Focusing Effects on Long Line-of-Sight Radio Links.**—P. Rivet. (*Onde élect.*, Jan. 1956, Vol. 36, No. 346, pp. 23–32.) Signal-strength records obtained with transmissions on $\lambda = 10$, 20 and 30 cm, over a distance of 230 km, are discussed. Both space and frequency diversity were employed. Fading phenomena affecting large areas and local interference fading effects were observed. The fine structure of the records cannot be satisfactorily explained without further theoretical and experimental investigation of focusing effects due to variations of atmospheric refraction.

621.396.82 : 621.397.62 **2211**

**Parasitic Radiations from Television Receivers.**—Egidi & Maggiore. (See 2237.)

621.396.823 : 621.316.13 **2212**

**Measurement of H.F. Interference by 380-kV Installations in Sweden.**—R. Bartenstein, A. Bergman & L. Menstell. (*Elektrotech. Z.*, *Edn A*, 11th Dec. 1955, Vol. 76, No. 24, pp. 857–859.) Field-strength measurements in the frequency range 150 kc/s to about 15 Mc/s and symmetrical line-interference-voltage measurements between 40 and 200 kc/s were made on two h.v. overhead lines of respective lengths 1·7 km and 207 km. The ratios of the interference voltages and of the field strengths are fairly well represented by the two formulae given. Results are presented graphically.

## STATIONS AND COMMUNICATION SYSTEMS

621.376.2 **2213**

**Tables of Bennett Functions for the Two-Frequency Modulation Product Problem for the Half-Wave Square-Law Rectifier.**—R. L. Sternberg, J. S. Shipman & H. Kaufman. (*Quart. J. Mech. appl. Math.*, Dec. 1955, Vol. 8, Part 4, pp. 457–467.) A companion set to the tables presented previously by Sternberg et al. (1779 of 1955).

621.376.55 : 621.397.5 **2214**

**Multiple-Pulse-Time Modulation.**—H. J. Griese. (*Arch. elekt. Übertragung*, Dec. 1955, Vol. 9, No. 12, pp. 571–572). Signal/noise ratio can be improved in a system in which a multiple pulse is phase modulated, because the width of the transmitted frequency band can be reduced. The phase shifts corresponding to the signal and simultaneous noise are integrated in an oscillating circuit whose output is rectified and smoothed to give a single phase-modulated pulse which is demodulated in the usual way. Individual communication channels can be selected by frequency separation instead of or combined with time separation. The system is suitable for television sound.

621.39(54) **2215**

**Research in Electrical Communications in India since 1865.**—S. P. Chakravarti. (*J. Instn Telecommun. Engrs, India*, Dec. 1955, Vol. 2, No. 1, pp. 7–18.) A short review with 157 references.

621.39.001.11 **2216**

**Prolongation [extrapolation] of Signals with Limited Spectrum.**—J. A. Ville. (*Câbles & Transm.*, Jan. 1956, Vol. 10, No. 1, pp. 44–52). Analysis based on operational methods indicates that extrapolation to instants corresponding to $t > 0$ cannot be effected in practice, though theoretically possible.

621.39.001.11 : 519 **2217**

**Theory of the Reliability of Operation of Systems comprising a Large Number of Elements.**—Sh. L. Bebiashvili. (*Bull. Acad. Sci. U.R.S.S.*, *tech. Sci.*, Oct. 1955, No. 10, pp. 29–39. In Russian.) The reliability of a system such as a radio-relay system is calculated as a function of the probable lifetime of its elements (e.g. valves) and the method of operating the groups and elements of the system.

621.395.44 + 621.396.41 **2218**

**Carrier-Frequency Installations for Cables, Overhead Lines and Radio Paths.**—H. Hannemann & H. Piechatzek. (*Nachrichtentech. Z.*, Jan. 1956, Vol. 9, No. 1, pp. 10–18.) Survey of methods used by a German company to standardize the equipment for carrier systems with different numbers of channels.

621.396.41 : 621.396.822.1 **2219**

**Nonlinear Cross-Talk in Multicarrier Multichannel Systems.**—P. Güttinger. (*Arch. elekt. Übertragung*, Dec. 1955, Vol. 9, No. 12, pp. 573–577.) Analysis is presented for a system in which the individual carriers are phase modulated and all lie within one octave. By suitable design and operation of the mixer, interference products can be kept low.

621.396.61 : 621.317.76 **2220**

**The Frequency-Band Recorder.**—Fleischer & Widdra. (See 2175.)

621.396.66 : 534.861 **2221**

**Monitoring Sound Broadcast Programmes.**—T. Somerville. (*Wireless World*, May 1956, Vol. 62, No. 5, pp. 228–231.) A brief review is given of the evolution of methods used by the B.B.C. in assessing the quality of the a.f. signal leaving the broadcasting studios. The selection of the loudspeaker and problems of studio and listening-room acoustics are briefly discussed.

621.396.8 **2222**

**Theoretical and Experimental Study of Signal Interference in Radiocommunication Systems.**—J. Villepelet. (*Ann. Télécommun.*, Dec. 1955, Vol. 10, No. 12, pp. 264–276 & Jan. 1956, Vol. 11, No. 1, pp. 8–24.) The protective effect of receiver selectivity in amplitude-keyed communication systems is analysed in detail. The required relation between the dynamic selectivity curve for the system and the static selectivity curves of the receiver filters is examined. If an interfering pulse signal is filtered through a circuit tuned to its carrier at an early stage in the receiver, the width of the dynamic selectivity curve is reduced appreciably. Experimental confirmation of the results is reported. The properties of the dynamic selectivity curve are determined for a.m., ph.m. and f.m. systems. It is possible to realize a system with a frequency occupancy as low as that of a system in which only static interference is present. To achieve this, the spectral curve of the transmitter must slope off at least as fast as the asymptotic slope of the receiver selectivity curve, which should be as great as possible.

## SUBSIDIARY APPARATUS

621.316.7: 621.387 **2223**

**A Magnetic Thyratron Grid Control Circuit.**—J. H. Burnett. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 529–532.) A circuit described previously (1983 of 1951) is modified by including an a.c. source and a rectifier in the secondary circuit of the grid transformer, changing the mode of operation to that of a reset magnetic amplifier. A 180° range of firing-voltage phase is available; the firing voltage builds up rapidly.

621.35 **2224**

**Chemical Generation and Storage of Electricity.**—A. M. Adams. (*J. Instn elect. Engrs*, Jan. 1956, Vol. 2, No. 13, pp. 7–13.) A review of recent work on fuel cells, whose operation is based on oxidation of carbon and hydrogen, and which give a low-voltage d.c. output; the particular importance of this type of cell is that it may give higher efficiency in the use of primary fuels.

621.352.32 **2225**

**Some Basic Scientific Problems relating to** [Leclanché-type] **Manganese Dioxide Electrochemical Cells.**—J. Brenet. (*Rev. gén. Élect.*, Jan. 1956, Vol. 65, No. 1, pp. 61–64.)

## TELEVISION AND PHOTOTELEGRAPHY

621.397 + [621.37/.38: 655 **2226**

**Electronic Methods of Pictorial Reproduction.**—(See 2189.)

621.397.24: 621.372.55 **2227**

**Phase-Correcting All-Pass Sections. Design of a Delay Equalizer for Television Transmission.**—H. Martin. (*Câbles & Transm.*, Jan. 1956, Vol. 10, No. 1, pp. 31–43.) Continuation of earlier work (1196 of 1954). Nomograms facilitating design calculations are presented. Calculations are made for equalizing a Paris-Soissons coaxial-pair circuit for television transmission.

621.397.26: 621.396.65.029.63 **2228**

**I.T.A.** [Independent Television Authority] **Midlands Relay.** (*Wireless World*, May 1956, Vol. 62, No. 5, pp. 223–226.) The Lichfield television station is connected by two radio links, using frequencies of 1·712 and 1·784 kMc/s, and one return link on 2·216 kMc/s, to the Telephone House in Birmingham, 12 miles distant. The three channels share a single aerial at each terminal, horizontal polarization being used for the one direction of transmission and vertical for the other. Frequency modulation is used; the bandwidth occupied by the signal at peak deviation is about 14 Mc/s. The equipment is briefly described.

621.397.5: 621.376.55 **2229**

**Multiple-Pulse-Time Modulation.**—Griese. (See 2214.)

621.397.5(46) **2230**

**National Plan for Television** [in Spain].—J. Sánchez-Cordovés, I. Miró & E. Gavilán. (*Rev. española Electrónica*, Dec. 1955, Vol. 2, No. 13, pp. 18–20.) The first stage of the plan envisages one transmitter at Madrid and another at Barcelona, with power initially 1·5 kW for image and 500 W for sound rising later to 15 kW for image and 5 kW for sound. Band-I frequencies of 55·25 Mc/s for image and 60·75 Mc/s for sound are to be used, with 625-line standards. Second- and third-stage plans are outlined.

621.397.6.001.4 **2231**

**Circuit Technique for Generation of Electrical Test Patterns in Television.**—F. Pilz. (*Arch. elekt. Übertragung*, Dec. 1955, Vol. 9, No. 12, pp. 547–558.) Discussion of methods for producing test patterns without using optical or electron-optical arrangements, i.e. using only combinations of pulse signals. A unit developed at the Nuremberg Rundfunk-Technisches Institut is described.

621.397.61: 535.623 **2232**

**Correction Circuits for Color TV Transmitters.**—K. E. Mullenger & R. H. McMann, Jr. (*Electronics*, April 1956, Vol. 29, No. 4, pp. 130–133.) Gamma and matrix correction circuits designed primarily for reproduction of colour films but useful also for live colour transmissions are described.

621.397.611.2: 621.383.27 **2233**

**Flying-Spot Scanning and the Transmission of Episcopic Pictures.**—H. Stier, P. Lindner & E. Kosche. (*NachrTech.*, Dec. 1955, Vol. 5, No. 12, pp. 537–541.) Description of an electron-optical epidiascope used at the East Berlin Television Centre.

621.397.62 **2234**

**Trends in 1955–56 TV Receivers** [in the U.S.A.].—R. F. Scott. (*Radio-Electronics*, Jan. 1956, Vol. 27, No. 1, pp. 36–39.)

621.397.62 **2235**

**Linear-Phase-Characteristic Television Receivers.**—A. van Weel. (*Onde élect.*, Jan. 1956, Vol. 36, No. 346, pp. 48–56.) Phase distortion is practically eliminated by provision of a linear-phase i.f. amplifier, using simple circuitry. Selectivity is normal and disadvantages of phase compensations at video frequency are avoided. See also 594 of February.

621.397.62: 621.372.632 **2236**

**Simplified Band-III Converter.**—O. E. Dzierzynski. (*Wireless World*, May 1956, Vol. 62, No. 5, pp. 221–223.) Constructional details are given of a fixed-tuned aerial filter used in conjunction with the converter described earlier (1564 of May).

621.397.62: 621.396.82 **2237**

**Parasitic Radiations from Television Receivers.**—C. Egidi & F. Maggiore. (*Alta Frequenza*, Dec. 1955, Vol. 24, No. 6, pp. 470–498.) The sources of the parasitic radiations are reviewed; the local oscillator is recognized as being the most troublesome. A field-measuring set developed at Turin is described and relevant formulae for the field close to a radiator are presented. The observed radiation patterns are classified according to whether they are produced by chassis radiation only or not. Methods of reducing the parasitic radiations by suitable design are discussed.

621.397.7: 621.325.5 **2238**

**Xenon Arc Discharge Lamps.**—H. W. Cumming. (*Elect. Times*, 19th Jan. 1956, Vol. 129, No. 3350, pp. 83–85.) Details are given of several types; their illumination characteristics are highly suitable for television studios, intensity being controllable without colour change.

621.397.7: 628.972 **2239**

**Television Studio Lighting.**—C. L. Faudell. (*Proc. Instn Radio Engrs, Aust.*, Jan. 1956, Vol. 17, No. 1, pp. 7–12.) Basic requirements are discussed and types of lamps and accessories available and the techniques of their use are indicated.

621.397.8: 621.372.553 2240

**Delay Equalization of a Television System.**—D. Bünemann. (*Arch. elekt. Übertragung*, Jan. 1956, Vol. 10, No. 1, pp. 10–18.) The problem is discussed on the basis of a given frequency variation of the envelope delay. A graphical method is used to design an all-pass circuit by combining elementary all-pass units in such a way that the sum of the delays of the transmission system and the all-pass units has a minimum deviation from a constant mean value.

## VALVES AND THERMIONICS

621.314.63.012 2241

**A Chart for the Evaluation of Crystal Rectifier Constants.**—I. M. Templeton. (*Electronic Engng*, April 1956, Vol. 28, No. 338, p. 172.)

621.314.7 2242

**Alloyed-Junction Transistor Development.**—J. J. Ebers. (*Bell Lab. Rec.*, Jan. 1956, Vol. 34, No. 1, pp. 8–12.) A description is given of the method of producing an *n-p-n* or *p-n-p* transistor by heating a pellet of the alloying material in contact with a wafer of the base material. The properties of this type of transistor are particularly suitable for switching applications.

621.314.7 2243

**Factors affecting Reliability of Alloy Junction Transistors.**—A. J. Wahl & J. J. Kleimack. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 494–502.) Report of an investigation of the effects on Ge *p-n-p* transistors alloyed with In and *n-p-n* transistors alloyed with As-doped Pb of exposure to oxygen, water vapour and other gases. Changes of the breakdown voltage, reverse current, and current gain are produced by oxygen and water vapour in opposite senses; no observable changes were produced by pure hydrogen, nitrogen or helium. The changes produced are reversible; the true characteristic can be restored by baking in vacuum at a suitable temperature. Very high stability of characteristics can be achieved if water vapour and oxygen are completely excluded in this way.

621.314.7 + 621.385 2244

**Transistors versus Vacuum Tubes.**—D. G. Fink. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 479–482.) The relative merits of these two types of device are compared with reference to particular applications; possible future developments are briefly indicated.

621.314.7 + 621.385]: 621.375 2245

**Comparison of Junction Transistor and Amplifier Valve.**—Ledig. (See 2001.)

621.383.001.4 2246

**Simplified Determination of the Spectral Sensitivity of Photocathodes.**—C. Dufour. (*Ann. Radio-élect.*, April 1955, Vol. 10, No. 40, pp. 174–181.) Methods using monochromatic filters, particularly Fabry-Pérot and multi-dielectric types, are preferred. Laboratory equipment is described and results obtained with a Ag-Cs photocathode are reported.

621.383.27 2247

**Transit-Time Spread in Electron Multipliers.**—T. D. S. Hamilton & G. T. Wright. (*J. sci. Instrum.*, Jan. 1956, Vol. 33, No. 1, p. 36.) Brief report of experiments on commercial multistage photomultipliers, demonstrating how the modulation of h.f. signals detected by the multiplier decreases as the transit-time spread increases with the reduction of overall operating voltage.

621.383.4: 546.482.21 2248

**Industrial CdS Photoresistors.**—P. Tarbes. (*Bull. Soc. franç. Élect.*, Jan. 1956, Vol. 6, No. 61, pp. 73–82.) Properties and applications of commercially available CdS photoconductive cells are described.

621.383.4: 546.817.221: 621.396.822 2249

**On the Specific Noise of Lead Sulfide Photo-detectors.**—B. Wolfe. (*Rev. sci. Instrum.*, Jan. 1956, Vol. 27, No. 1, pp. 60–61.) A brief note giving experimental results for several commercial PbS cells.

621.383.5: 537.311.33 2250

**GaAs Photo-element.**—R. Gremmelmaier. (*Z. Naturf.*, June 1955, Vol. 10a, No. 6, pp. 501–502.) According to Rittner's findings (1682 of 1955) GaAs, which has an energy gap of 1·38 eV, should be a highly efficient converter for solar energy. Some measurements on a *p-n* junction made of polycrystalline material are briefly reported; higher efficiency is to be expected if carefully prepared single-crystal material is used.

621.385: 621.318.57 2251

**Keep-Alive Instabilities in a TR Switch.**—T. J. Bridges, P. O. Hawkins & D. Walsh. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 535–538.) The risk of the keep-alive discharge being accidentally extinguished as a result of glow-to-arc transitions is lessened by providing two keep-alive electrodes. See also 2252 below.

621.385: 621.318.57.032.2 2252

**Electrode Deterioration in "Keep-Alive" Discharges in Transmit-Receive Switches.**—D. Walsh, A. W. Bright & T. J. Bridges. (*Brit. J. appl. Phys.*, Jan. 1956, Vol. 7, No. 1, pp. 31–35.) An investigation of the behaviour of electrode materials in a discharge in a medium containing water vapour is described. Most common stable metals and one semiconducting ceramic material were tried. Normal- and abnormal-glow conditions in t.r. switches are considered separately; the former lead to long life, while the latter give freedom from oscillations.

621.385.004 2253

**Sampling of Vacuum Valves for Acceptance Inspection.**—M. D. Indjoudjian & J. Oswald. (*Câbles & Transm.*, Jan. 1956, Vol. 10, No. 1, pp. 65–72.) Sampling methods adopted by the French Post Office are described; these have led to saving in testing time without loss of efficiency. The mathematical basis of the technique is given.

621.385.004 2254

**Utilization of Electronic Valves on [French] Long-Distance Underground Lines.**—P. Bassole & J. Eldin. (*Câbles & Transm.*, Jan. 1956, Vol. 10, No. 1, pp. 53–64.) A study of the methods used for accounting, inspection and analysing replacements.

621.385.029.6 + 621.372.029.6 2255

**Report of Advances in Microwave Theory and Techniques—1954.**—King. (See 1952.)

621.385.029.6 2256

**A Graphical Method for investigating Travelling-Wave Valves.**—V. M. Lopukhin & Yu. D. Samorodov. (*Zh. tekh. Fiz.*, July 1955, Vol. 25, No. 7, pp. 1265–1275.) A method is proposed, by means of which it is possible to investigate dispersion equations of any algebraic degree. The method is applied to a study of travelling-wave and two-beam amplifiers for a wide range of values of the parameters. Analysis of the interaction between the field and the space charge yields solutions including one corresponding to a wave travelling in the negative direction. Curves of the phase velocity of the waves are plotted for various operating conditions.

621.385.029.6 2257

**Using Travelling-Wave Tubes.**—R. E. White. (*Electronics*, April 1956, Vol. 29, No. 4, pp. 144–145.) The suitability of travelling-wave valves as amplitude modulators, limiters and mixers is indicated by reference to the valve characteristics.

621.385.029.6: 538.566: 537.56 2258

**Growing Electric Space-Charge Waves and Haeff's Electron-Wave Tube.**—J. H. Piddington. (*Phys. Rev.*, 1st Jan. 1956, Vol. 101, No. 1, pp. 14–16.) Analysis is presented indicating that the explanation of wave growth presented e.g. by Haeff (1825 of 1949) is not the true one; an alternative explanation based on trapping of electrons between potential troughs of a space-charge wave (2030 above) is considered more plausible.

621.385.029.6: 621.376.23 2259

**Microwave Detector.**—J. T. Mendel. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 503–508.) The detector described is based on the 'stop-band' velocity-discriminator properties of periodic magnetic focusing systems used in association with travelling-wave valves [2546 of 1954 (Mendel et al.)]. The focusing system surrounds a drift tube following the wave-slowing circuit, and the beam electrons are sorted according to their r.f. velocity modulation, thus the collector current is a function of the microwave power. A numerical calculation for an arrangement comprising 20 magnetic lenses indicates that a power level of 0·36 mW corresponds to a velocity change of 0·76%. Other possible applications of the device include a high-level mixer.

621.385.032.216.2: 621.37 2260

**Heater-Cathode Leakage.**—(*Tele-Tech & Electronic Ind.*, Jan. 1956, Vol. 15, No. 1, pp. 56–57 . . 110.) Various mechanisms by which current leakage takes place between an oxide cathode and its heater are described; observation and test methods are indicated. The effects on circuit performance are discussed with particular reference to a class-A amplifier, a multivibrator and a f.m. demodulator.

621.385.3 2261

**Some New Types of High-Voltage Low-Current Vacuum Triodes.**—R. Feinberg & K. C. Burn. (*Electronic Engng*, April 1956, Vol. 28, No. 338, pp. 160–162.) Characteristics are given of valves suitable for use as variable high-voltage resistors and in direct-voltage control and stabilization.

621.385.832 2262

**Deposition and Removal of Electric Charges on Insulators by Secondary Emission: Part 1.**—M. Barbier. (*Ann. Radioélect.*, April 1955, Vol. 10, No. 40, pp. 182–214.) A detailed theoretical study is presented of the processes involved in recording signals in the form of charges on insulator plates in cathode-ray tubes; the field distributions and secondary-electron paths are analysed for some simple configurations. Possible accumulations of space charge are taken into account, and estimates are made of the amount of charge that can be deposited, the limits of resolution to be expected, the accumulation factor, and the beam intensity required for writing or reading.

621.385.832 2263

**Permanent-Writing Cathode-Ray Recorder.**—L. N. Heynick, R. J. Wohl & D. H. Andrews. (*Electronics*, April 1956, Vol. 29, No. 4, pp. 148–149.) A special c.r. tube of rectangular cross-section has a linear array of styli projecting inwards and outwards through the end face. The beam is swept across the inner ends of the styli by a signal, and a suitable co-operating potential is applied to an external electrode which serves also to keep a moving sheet of recording paper pressed against the outer ends of the styli. Various applications of the device are mentioned.

621.385.832 (083.7) 2264

**I.R.E. Standards on Electron Devices: Definitions of Terms related to Storage Tubes, 1956.**—(*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 521–522.) Standard 56 I.R.E. 7. S1.

621.387 2265

**Thyratron R.M.S. Current Ratings.**—(*Mullard tech. Commun.*, Dec. 1955, Vol. 2, No. 16, pp. 152–156.) The increased ratings possible with delayed firing angles are shown.

## MISCELLANEOUS

621.3.002.2 2266

**New Developments in Automatic Production for Electronics.**—(*Elect. Mfg*, April 1955, Vol. 55, No. 4, pp. 126–131.) An illustrated report on progress, including descriptions of a machine for inserting 24 different components into a printed-circuit board, an automatically programmed punching machine and an adaptation of the Tinkertoy technique.

621.37/.38].004.5/.6 2267

**Increasing the Reliability of Electronic Equipment by the Use of Redundant Circuits.**—C. J. Creveling. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 509–515.) Conditions are considered for equipment comprising a large number of elements, such as that of bombers. Equations are derived relating reliability to the number of circuit elements in the redundant and nonredundant cases; examples indicate the degree of improvement attainable. The improvement effected in this way is increased by arranging for regular maintenance; attention is drawn to the fact that the redundancy obscures the faulty condition.

621.37/.38].004.5/.6 2268

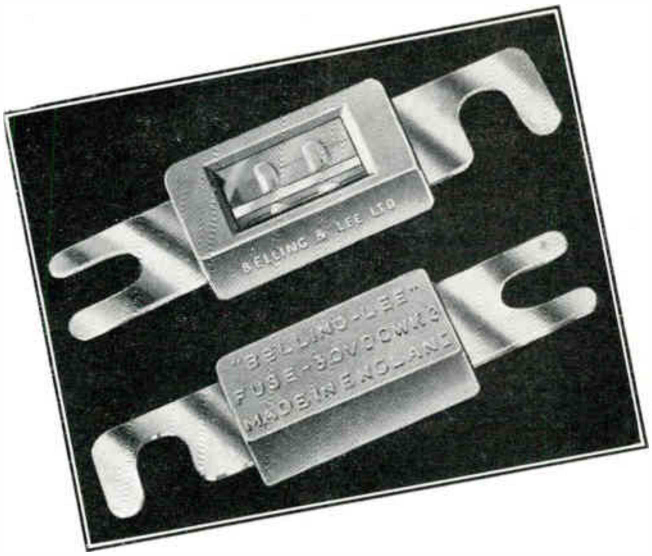
**A Systems Approach to Electronic Reliability.**—W. F. Luebbert. (*Proc. Inst. Radio Engrs*, April 1956, Vol. 44, No. 4, pp. 523–528.) A rationale for the development of reliable systems is presented in the form of a check-list.

621.39 2269

**Radiotechnical Literature [in the U.S.S.R.] in 1956.**—V. Shipov, A. Smirnov & P. Popov. (*Radio, Moscow*, Jan. 1956, No. 1, pp. 16–17.) Brief survey of the publishing programme of three leading publishing houses.

621.39 (083.7) 2270

**Symbols used in Electrical Communication Engineering.**—H. Meinke. (*Nachrichtentech. Z.*, Jan. 1956, Vol. 9, No. 1, pp. 39–46.) German draft standard DIN 1344, October 1955, is presented and discussed.




## AIRFUSE
## L.1330

### CONSTRUCTION:

The fusible element is of electro-tinned copper and is in one piece with end connections which are suitably shaped for direct bolting to bus-bars, etc. The body is of high grade ceramic and is fitted with a glass window so that the fusible part of the element is visible. The rating is stamped on the lugs and is also printed on the glass.

### SPECIFICATION:

The fuselink is to be capable of breaking currents of up to 3,000 amperes at 30V d.c. (2,500 amperes at 30V. d.c. for the 35A and 50A ratings) without shattering. The arcing time shall not exceed 0.003 seconds at 3,000 amperes.

The fuse is intended as a direct replacement for the American "Current Limiter" used on 28V. d.c. aircraft power supplies, and for this purpose has received the approval of the Air Registration Board under their reference No. E.3217.

It is also suitable for the protection of battery operated vehicles, heavy current rectifier output circuits, low voltage furnaces and other similar d.c. applications.

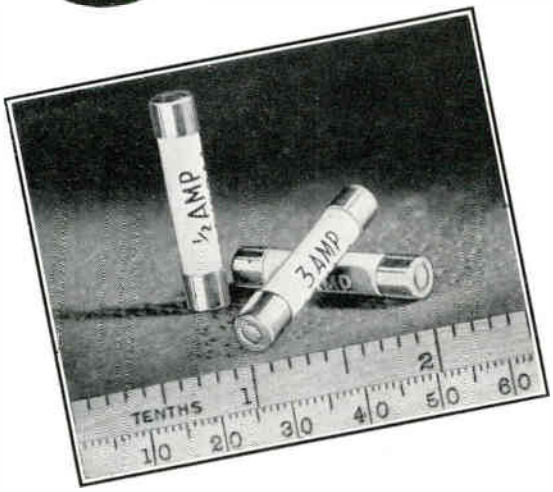
### RATINGS:

35A, 50A, 80A, 100A, 130A, 150A, 200A, 225A, and 275A. The range will be extended in four further steps to 500A maximum.

# HEAVY CURRENT, LOW VOLTAGE, FUSE-LINKS

*for use on D.C. supplies in*
*AIRCRAFT, RECTIFIER EQUIPMENT,*
*BATTERY DRIVEN VEHICLES,*
*BATTERY CHARGING PLANT, &c.*

# H.R.C. CERAMIC BODIED FUSE-LINKS




The high rupturing capacity fuse-links comply with the requirements of R.C.S. 261 and B.S. 88 — made in two sizes, and a range of seven ratings in each size, as follows:—

**L.693.** 1¼" x ¼". Ratings: 0.25, 0.5, 1, 2, 3, 5 & 7A. Category of duty: B.S. 88, a.c.4. 440V. a.c. at 55°C. It is expected that their d.c. category of duty will comply with B.S. 88, d.c.4. 230V.

**L.754.** ¾" x 3/16". Ratings: 0.025, 0.050, 0.100, 0.250, 0.500, 1 & 2A. Category of duty: B.S. 88, a.c.2. & d.c.2., 250V a.c. and 230V. d.c. at 55°C.

*Also available but not to the above specifications:*

**L.760.** 1¼" x ¼" Ceramic, unfilled, designed to blow within 10 secs. on 100% overload.

**BELLING & LEE LTD**
GREAT CAMBRIDGE ROAD, ENFIELD, MIDDX., ENGLAND

**Telephone: Enfield 3322 · Telegrams: Radiobel, Enfield**

# DC 10
# PRESSURE UNIT

SPECIFICATION

| | |
|---|---|
| Power Handling Capacity | 10 watts peak |
| Voice Coil Impedance | 15 ohms |
| Frequency Response | 120–9000 c.p.s. |
| Flux Density | 12,000 gauss |
| Pole Piece | 1·5″ diameter |

***Price £6 10s. 0d.***

Specially designed and developed to meet the need of the P.A. Engineer requiring a compact, efficient unit combining good tone with average handling capacity, at a price that will make the "small" installation a profitable proposition.

***High Sensitivity*** Heavy cross-sectioned cup with latest anisotropic alloy CP magnet.

***Phase Equalizing Throat*** One-piece zinc based alloy die-casting.

***Self-Centring Diaphragm Assembly*** Can be changed in the field without special tools or soldering iron in 1½ mins.

***Spring Loaded Terminals*** Ensure quick and positive line termination.

***Weatherproof*** Totally enclosed, ensuring protection when in exposed position, watertight gland cable entry.

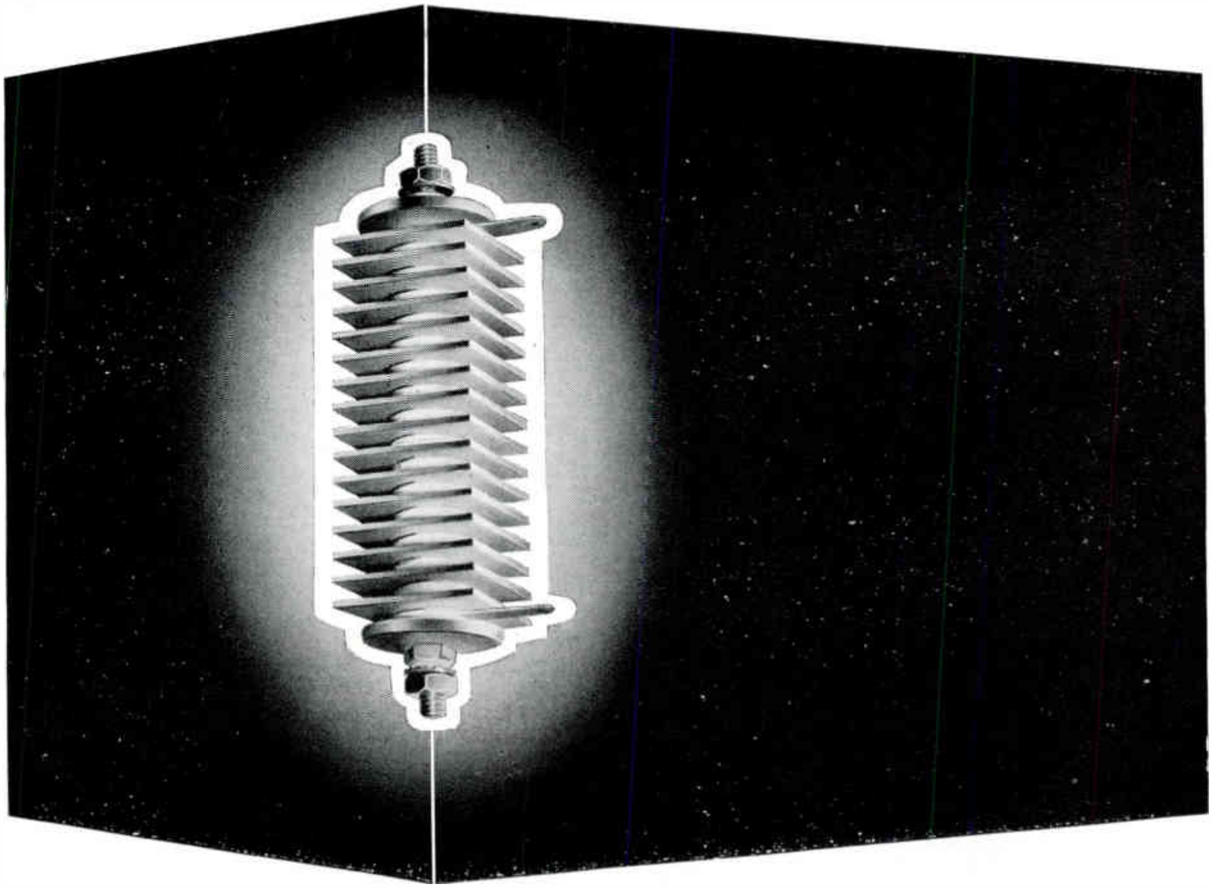
DIMENSIONS

| | DC 10 (without line trs.) | DC 12 (with line trs.) |
|---|---|---|
| Diameter | 4⅛″ | 4⅛″ |
| Length | 4¼″ | 6⅝″ |
| Weight | 4¾ lb. | 5½ lb. |

DC 12 PRESSURE UNIT (WITH TRANSFORMER)
As DC 10 but fitted with totally enclosed 100v line transformer tapped 2·5, 5, 8 and 12 watts.
**PRICE £7 10s. 0d.**

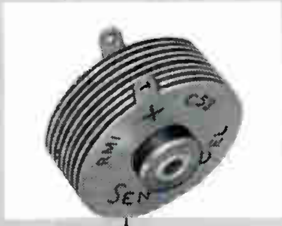
*Manufactured in Gt. Britain by*

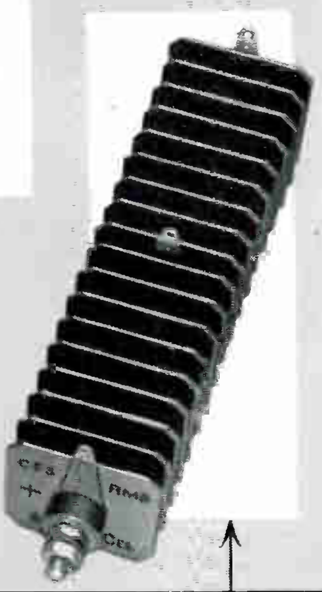
**Rola Celestion Ltd.**
FERRY WORKS THAMES DITTON, SURREY
Telephone: EMBerbrook 3402



# SenTerCel H.T. RECTIFIERS

## from 125V 30mA to 250V 300mA



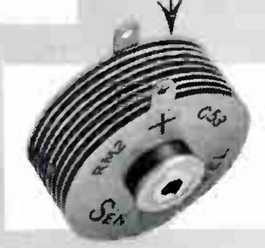


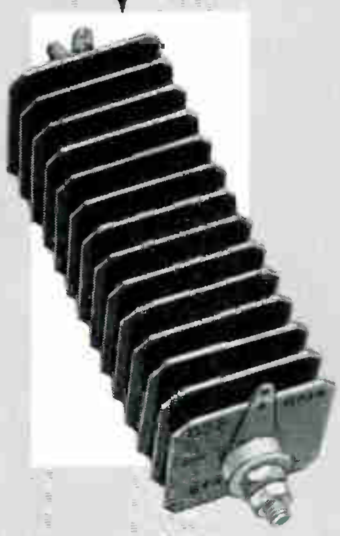
Specially designed for use in domestic Radio & Television receivers, these miniature rectifier stacks have an established position with manufacturers to whom reliability, small dimensions and low costs are important.

| TYPE | RM0 | RM1 | RM2 | RM3 | RM4 | *RM5 |
|---|---|---|---|---|---|---|
| Maximum ambient temperature | 35°C 55°C | 35°C 55°C | 35°C 55°C | 35°C 55°C | 40°C 55°C | 40°C 55°C |
| Maximum output current (mean) | 30mA 15mA | 60mA 30mA | 100mA 60mA | 120mA 90mA | 250mA 125mA | 300mA 150mA |
| Maximum input voltage (r.m.s.) | 125V | 125V | 125V | 125V | 250V | 250V |
| Maximum peak inverse voltage | 350V | 350V | 350V | 350V | 700V | 700V |
| Max. instantaneous peak current | Unlimited | Unlimited | Unlimited | Unlimited | Unlimited | Unlimited |
| Weight ...... ... ... ... | 0.82 oz. | 1 oz. | 1.4 oz. | 2 oz. | 4.5 oz. | 4.75 oz. |

* For use in voltage doubler circuits the peak inverse and maximum input voltages are halved, current output being as for half wave operation.

- Instant starting—no warming-up period
- Unlimited instantaneous overload
- No limit to size of reservoir capacitor
- Simple mounting—no valve holder
- Withstand overloads such as charging current of de-formed electrolytic capacitors
- Low heat dissipation
- Practically indestructible in service
- Simple wiring—two connectors only
- Small size . . . low weight
- Low cost





SELENIUM SenTerCel RECTIFIERS

## Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

RECTIFIER DIVISION: EDINBURGH WAY · HARLOW · ESSEX

Telephone: Harlow 26811 Telegrams: SenTerCel, Harlow, Essex

Inspector of Workshops required for Broadcasting Department, Gold Coast Local Civil Service, for one tour of 18-24 months in first instance. Consolidated salary scale £990 rising to £1,230 a year with gratuity at rate £100/£150 a year. Outfit allowance £60. Free passages. Liberal leave on full salary. Candidates must have up-to-date knowledge broadcasting equipment. Should have at least ten years' experience workshops practice in radio, including five years in large broadcasting organization, preferably B.B.C., or five years in large manufacturing firm in radio industry. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/41020/WJ.

THE MITCHAM WORKS LIMITED

have a number of vacancies for young Draughtsmen to be trained as **Mechanical Designers.** These opportunities provide for interesting work, leading to recognition as qualified Designers in the Radio and Television field.

Starting salaries would be in accordance with age and experience. Applicants are invited to write to the Personnel Officer, The Mitcham Works Limited, New Road, Mitcham Junction, Surrey, quoting reference MD/1.

Radio Engineer required for Broadcasting Division, Social Development Department, Tanganyika, on contract for tour of 30–36 months in first instance. Salary scale (including inducement pay and present temporary allowance of 10 per cent of salary) £1,003 rising to £1,498 a year. Gratuity at rate of 13½ per cent of total substantive salary drawn. Outfit allowance £45. Free passages. Liberal leave on full salary. Candidates, preferably under 35, should have experience of high-power transmitting equipment and be able take charge of 20 kW, 1·25 kW and 250 watt R.C.A. transmitters at Broadcasting Station. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/41312/WJ.

ELGAR SILVER PRODUCTS

Full range of silver preparations for silvered condenser manufactures and other applications in electronics.

Elgar Laboratories (Elgar Trading Ltd.), 240 High Street, London, N.W.10.

Designer Draughtsmen required by firm engaged in radio and electronic instrument work. Experience in this field highly desirable. These are senior staff, pensionable appointments. Apply with details of experience and salary required to Personnel Officer, British Communications Corporation Ltd., Exhibition Grounds, Wembley.

**Development Engineer** required to work on tape recording applications. The successful applicant must have experience in developing tape recording machines from the mechanical, electrical and electronic points of view. This is a senior position and an appropriate salary will be paid. Apply to Box No. A45/12, Strand House, London, W.C.2.

Electronic Engineer required for small but expanding Division of Scientific Instrument Company in London. The work will involve taking charge of a number of projects in the industrial and scientific applications of electronic devices. Apply to Box No. 2539, c/o *Wireless Engineer.*

Atomic Energy Research Establishment, Harwell

has a vacancy in the Electronics Division Extension

at Bracknell, Berks

for an Assistant or Senior Assistant (Scientific) to assist in the design, construction and testing of electronic instruments for nuclear particle detecting equipments.

Minimum qualifications: G.C.E. Ordinary level in four subjects including (a) English language and (b) a scientific or mathematical subject, or equivalent.

The successful candidate will be expected to work at A.E.R.E., Harwell, until January 1957, when the Bracknell extension will be ready for occupation.

*Salary:* Senior Assistant (Scientific), £656–£895 per annum according to experience and qualifications. (The minimum age for Senior Assistants is normally 27.) Assistant (Scientific), £266 (at age 16)–£600 per annum (maximum starting salary £460).

Contributory Pension Scheme; five-day week; excellent working conditions and generous leave allowances.

Send POST CARD for application form, which must be returned by 25th July 1956 to Establishment Officer, A.E.R.E., Harwell, Didcot, Berks, quoting reference 587/46.

**First-class**

**DEVELOPMENT ENGINEER**

required by well-known manufacturers of T.V. aerials. The firm, which is progressive, ambitious and well financed, intends to pay adequately for good work and would consider profit participation after a six months probationary period. All negotiations in absolute confidence. Box No. 2713, c/o *Wireless Engineer.*

## UNIVERSITY OF BIRMINGHAM

**Department of Electrical Engineering**

Applications are invited for two lectureships in Electrical Engineering; qualifications should include a good university degree, preferably in Electrical Engineering, and a special interest in any branch of the subject. It is hoped that one of the posts can be filled by a man interested in acoustical engineering.

One post will be in Grade II with salary in the range £650–£1,350 (efficiency bar at £900) plus family allowance and membership of the F.S.S.U.; the other post is in Grade III with salary in the range £550–£650 plus family allowance and membership of the F.S.S.U. Commencing salary may be at any point in the ranges according to qualifications and experience.

Three copies of applications, together with the names of three referees, should reach the Registrar, The University, Birmingham 15, immediately. Further particulars may be obtained from the Registrar.

G. L. BARNES,
*Secretary.*

The University,
Birmingham, 15.

---

**Scientific Computer and Mathematician required.** This vacancy is for a woman who will be concerned with the design and development of (and some research into) electric networks for use in multi-channel carrier telephone systems. Minimum qualifications Inter B.Sc. (or equivalent) but a degree in Mathematics (or Telecoms or Physics) is preferred. Experience in electric network engineering or theory an advantage but not essential. Initiative and interest in the applications of the results of mathematical reasoning and computations to practical problems is important. Write giving full details age, qualifications and experience, if any, to **Personnel Manager, Telephone Manufacturing Co. Ltd., Sevenoaks Way, St. Mary Cray, Kent.**

---

**Engineer-in-Charge, Broadcasting Service, Nicosia,** required by **Government of Cyprus,** on contract for two years in first instance. Salary in scale (including overseas allowance and present temporary allowance of 11¼ per cent of salary) £1,480 rising to £1,789 a year. Gratuity at rate of £150 a year. Free passages. Liberal leave on full salary. Candidates, preferably between 25 and 35, should have sound theoretical knowledge and practical experience of operation and maintenance of MF broadcast transmitters and aerial systems and be able to control and supervise junior staff. Knowledge of studio engineering and recording desirable. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/41601/WJ.

---

## COMMONWEALTH OF AUSTRALIA

### Appointment of Member of Australian Broadcasting Control Board

The Commonwealth Government will shortly make an appointment of a full-time member of the Australian Broadcasting Control Board. Applications are invited from British subjects who are university graduates in Engineering or Physics, or possess corresponding qualifications, and who have had considerable experience in administration and in electronics and electrical engineering in connection with broadcasting and television. The appointment will be for a term not exceeding seven years at a salary of £A3,500 per annum in accordance with the provisions of the Broadcasting Act 1942-1954.

Applications, with full particulars of qualifications and experience, should be addressed to the undersigned at Parliament House, Canberra, A.C.T., Australia, and will close on 1st August 1956.

C. W. DAVIDSON,
*Postmaster-General of the Commonwealth.*

14*th June* 1956.

---

**Atomic Energy Research Establishment, Harwell**

has vacancies in the Electronics Division Extension at Bracknell, Berks

(i) **Experimental Officer** (Ref. 585/46) to assist in the design and development of electronic instruments for nuclear particle detecting equipments and to be responsible for development through to a production prototype.

Previous experience in the design of circuits for pulse and D.C. applications is required and some experience in the preparation of technical information for production is desirable.

(ii) **Experimental or Assistant Experimental Officer** (Ref. 584/46) to be responsible for the testing, calibration and inspection of electronic equipment. The duties will require ability to initiate design modifications for improved layout and reliability.

Previous experience in the use of electronic test equipment in pulse and D.C. applications is required. Some experience of the construction and maintenance of electronic equipment is desirable.

(iii) **Assistant Experimental Officer** (Ref. 586/46) to assist in the design and development of electronic instruments for nuclear particle detecting equipment.

Previous experience in the design of circuits for pulse and D.C. applications is desirable.

Minimum qualifications for all the above posts:
G.C.E. Advanced level in two science subjects (or equivalent) and good theoretical and practical circuit knowledge.

Successful candidates will be expected to work at A.E.R.E., Harwell, until the Bracknell extension is ready for occupation in January 1957.

*Salary:* Experimental Officer £846–£1,040 p.a. according to experience and qualifications. (Minimum age for Experimental Officers is normally 26.)

Assistant Experimental Officer £353 (at age 18)–£756 p.a. (maximum starting salary £605).

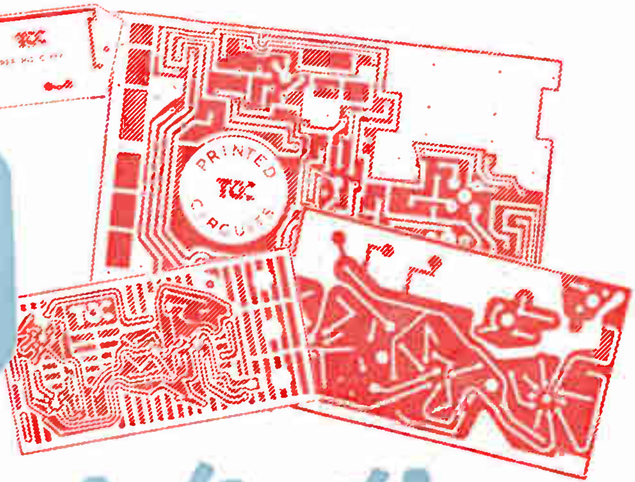
Contributory pension scheme; five-day week, excellent working conditions and good leave allowances.

Send POST CARD for application form, which must be returned by 23rd July 1956, to Establishment Officer, A.E.R.E., Harwell, Didcot, Berks, quoting appropriate reference.

## Index to Advertisers

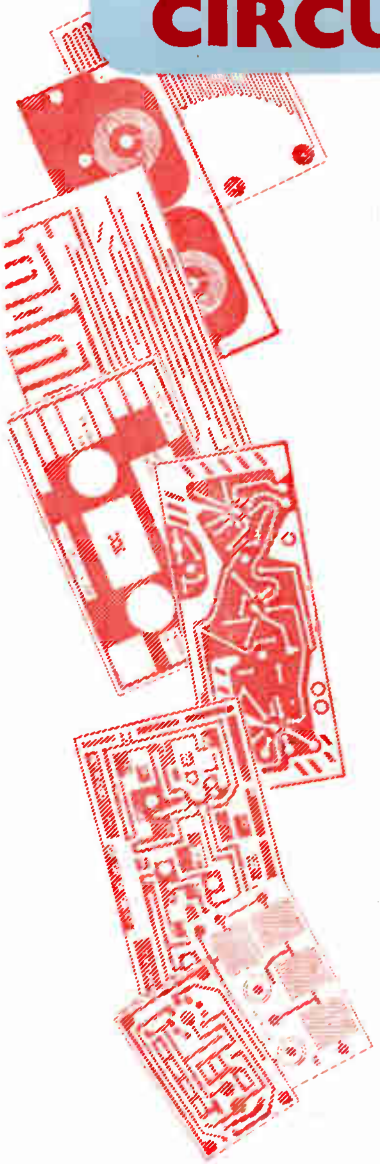

| | PAGE |
|---|---|
| Anderton Springs, Ltd. | 22 |
| Appointments Vacant | 19, 20, 21, 22 |
| Belling & Lee, Ltd. | 13 |
| British Insulated Callender's Cables, Ltd. | 7 |
| Brookes Crystals, Ltd. | 18 |
| Bullers, Ltd. | Cover ii |
| Electro-Methods, Ltd. | 5 |
| Electronic Components | 4 |
| Elgar Trading, Ltd. | 20 |
| Elliott Bros., Ltd. | 2 |
| English Electric Valve Co., Ltd. | 3 |
| Ferranti, Ltd. | 9 |
| Fortiphone, Ltd. | 18 |
| Foyle, W. & G., Ltd. | 22 |
| Girdlestone, Ltd. | 16 |
| Hunt, A. H. (Capacitors), Ltd. | Cover iv |
| Iliffe & Sons, Ltd. | 18, 19 |
| Light Soldering Developments, Ltd. | 22 |
| Lyons, Claude, Ltd. | 1 |
| Mullard, Ltd. | 12 |
| Nagard, Ltd. | 16, 19 |
| Oxley Developments Co., Ltd. | 22 |
| Rola Celestion, Ltd. | 14 |
| Salford Electrical Instruments, Ltd. | 15 |
| Standard Telephones & Cables, Ltd. | 17 |
| Sullivan, H. W., Ltd. | 10 |
| Telegraph Condenser Co., Ltd., The | Cover iii |
| Telegraph Construction & Maintenance Co., Ltd. | 16 |
| Telephone Mfg. Co., Ltd. | 4, 21 |
| Unbrako Socket Screw Co., Ltd. | 8 |
| Welwyn Laboratories, Ltd. | 6 |


Printed in Great Britain for the Publishers, Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1 by W. P. Griffith & Sons, Ltd., London and Bedford.



# PRINTED CIRCUITS

## *Specialisation*



To the equipment maker, the printed circuit is just one more component, but experience in the manufacture and marketing of this particular item has proved beyond doubt that it is a job for the specialist.

**The T.C.C. Organisation** with its enormous research, development and production facilities backed by half a century of specialisation, has been made available for printed circuitry. Special design and drawing office facilities are provided to enable equipment makers to take full advantage of the technique on new designs of radio and T.V. receivers, electronic and electrical equipment.

**Engineers specialising** in the design of electrical and electronic equipment on to printed circuits and a laboratory studying the physical and chemical problems, such as surface finishes, plating, dip soldering, etc., are also available. A special photographic department is also staffed by operators trained to work to the close dimensional limits required.

**The production of T.C.C. Printed Circuits** is the combined contribution of all these sections, and every stage is carried out in a completely self-contained works.

**As a technical service to the industry** T.C.C. offer these facilities. To manufacturers we say "Discuss your printed circuit problems with our engineers. Put yourself in our hands, with full confidence that T.C.C. printed circuits are backed by all the resources of an established specialist organisation".

1906 - 1956 GOLDEN JUBILEE

**THE TELEGRAPH CONDENSER CO. LTD**

*SPECIAL PRODUCTS DIVISION*

NORTH ACTON · LONDON · W.3 · Telephone: ACORN 0061