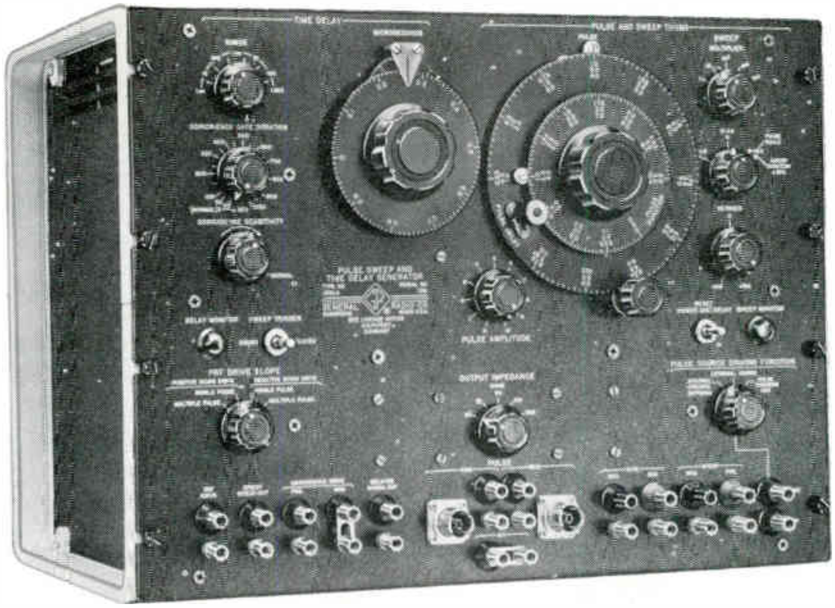
WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

OCTOBER 1956

Vol. 33 No. 10 · THREE SHILLINGS AND SIXPENCE

An extremely versatile generator for time-domain measurements



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DESCRIPTION The Pulse, Sweep and Time-Delay Generator consists of the following major circuit groups: (1) input synchronizing circuits, (2) delay and coincidence circuits, (3) sweep circuits, and (4) pulse-timing and pulse-forming circuits.

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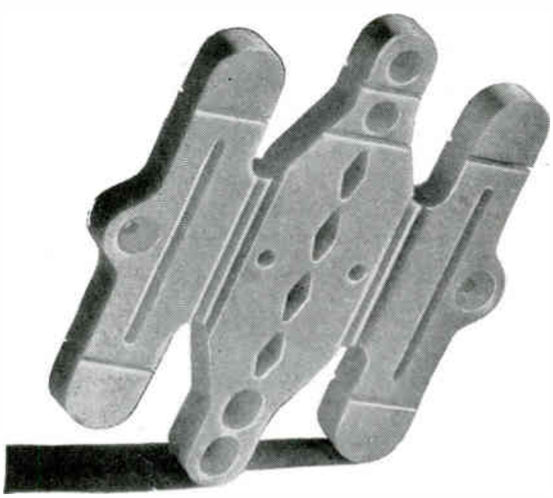

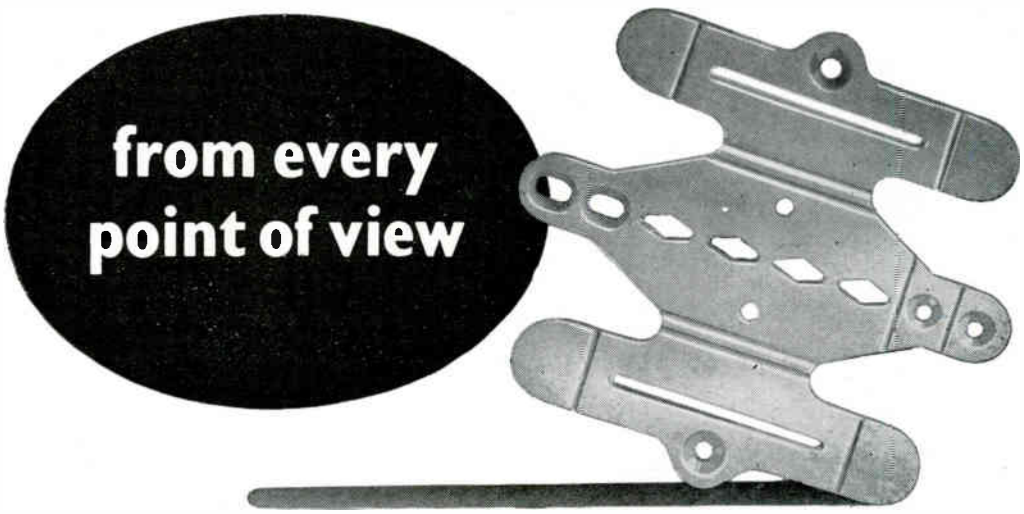

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V_{a4}	4.0kV
V_{a3}	2.0kV
V_{a2} (focus)	330 approx. V.
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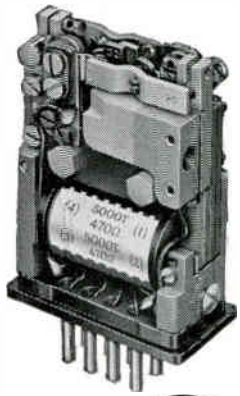

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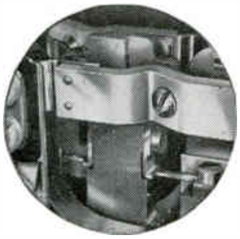

To learn more about this relay send for Leaflet F.3526.

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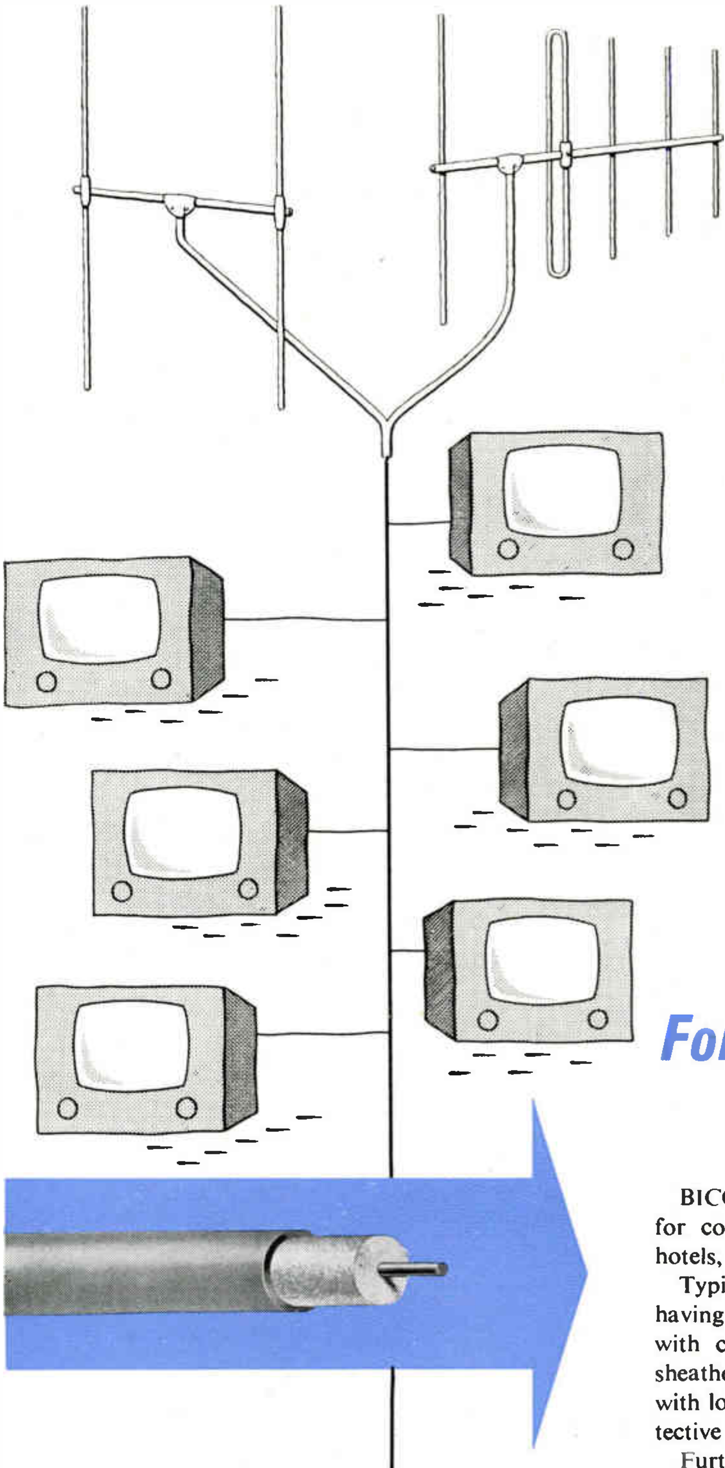

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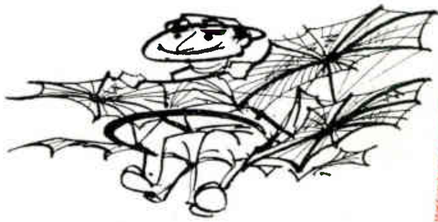

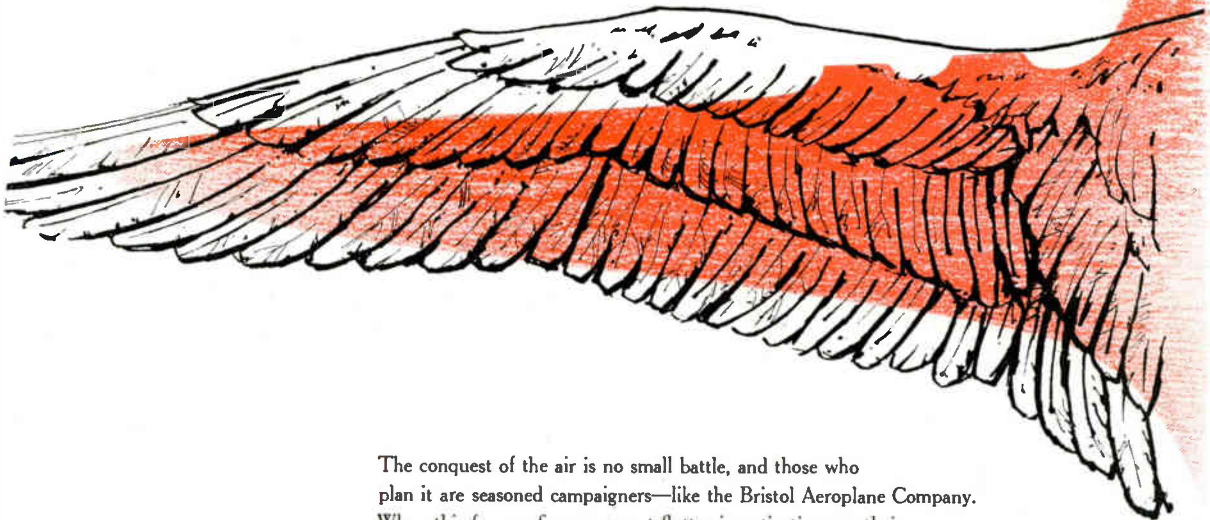

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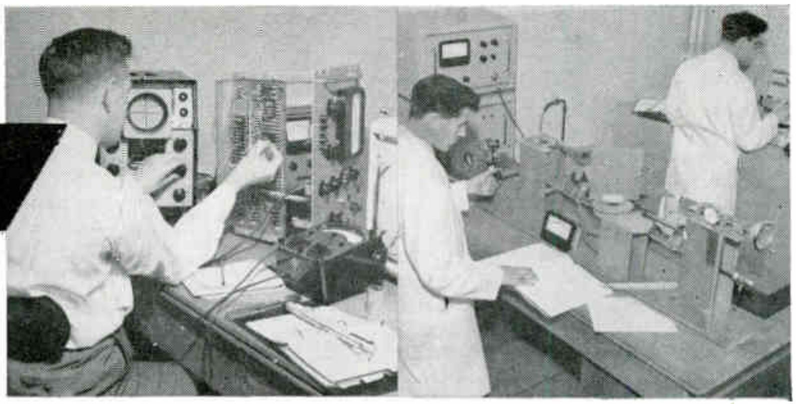

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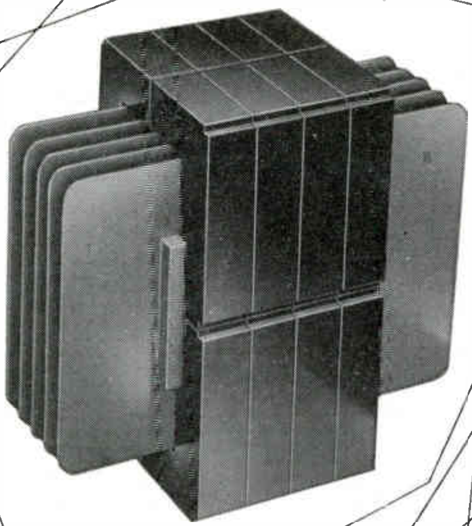

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WIRELESS ENGINEER

Vol. 33 OCTOBER 1956 No. 10

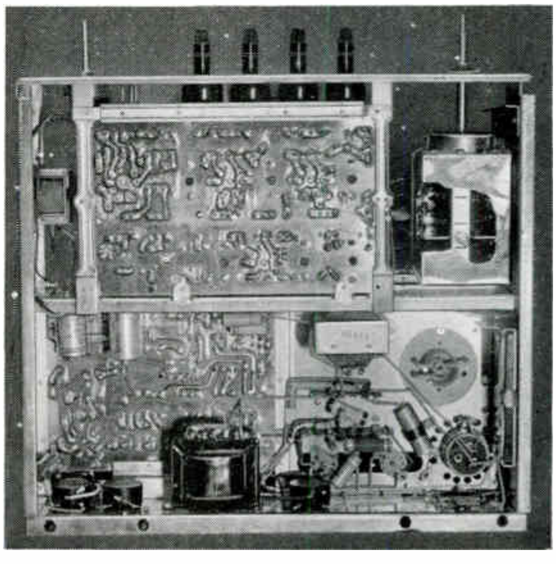
National Radio Exhibition

HELD at Earls Court from 22nd August to 1st September, the National Radio Exhibition was, as usual, confined chiefly to a display of domestic receiving equipment. Television was naturally the most obvious feature of the exhibition, but sound receivers were very prominent, and among them sets for v.h.f. reception of f.m. broadcasting were common. There were, of course, other exhibits. A few component manufacturers were showing, some test equipment was displayed and there were quite a number of electronic items. In none of these fields, however, were the displays as representative of the industry as they were in broadcast apparatus.

It is, perhaps, natural that since the exhibition is one for the public there should be no great show of technicalities. The stress is on appearance and performance and it was more difficult even than usual to see what the inside of a set looks like. There were a few exceptions, of course, and for example, Pam were making a feature of the chassis of one of their television sets, because it embodies a great amount of printed circuitry. Two such assemblies are used and together they cover the greater part of the i.f. amplifiers and the timebases. The tuner is a separate unit which, together with the two printed panels, is carried by the main chassis framework; this also holds the main power-supply components, variable resistors and the larger transformers.

Generally speaking, however, chassis were exhibited but rarely and the general visitor could see little but the cabinet styling and the picture. The use of 21-inch tubes has become general and few firms did not show at least one model of this size. The 17-inch tube, however, is probably the most popular and the 14-inch is very common. Tubes smaller than this are now almost completely obsolete for domestic television, save in one particular application. This is the portable set. Ekco have one, which was first shown last year, with a 9-inch tube and provision for Band II f.m. reception, which can be operated from a car battery. Spencer-West also have a 9-inch model for a.c. supplies which is intended perhaps less as a true portable than as an occasional receiver for the nursery or the sick room. Murphy showed last year a set of this character having a 12-inch tube and this model is being retained. The Pye version has a 14-inch tube and an aerial plugging into the top of the case.

In all these portable sets the cabinet styling is of a simple functional type which is perhaps more properly described by the word case than cabinet. Everywhere else, however, the polished wood



Under view of chassis of Pam 'printed circuit' television receiver.

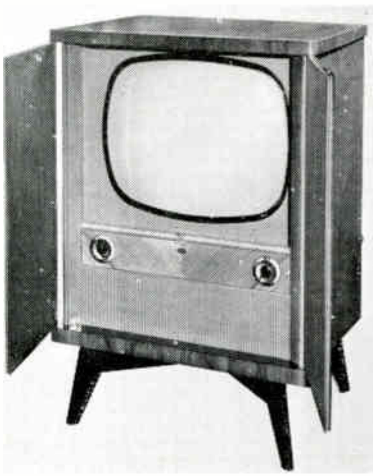
cabinet holds pride of place. Bush have a 14-inch model with a moulded bakelite case, but the same chassis is available at a higher price in the more conventional wooden cabinet. This firm has for a good many years favoured the bakelite case, and in the past has produced both 9-inch and 12-inch tube models.

There is a definite tendency this year to place the occasional controls in a more accessible position. Instead of being tucked away at the back, they are now often placed at the side and sometimes, even, on the front. The main controls, station selector, fine tuner, brightness and volume, are usually on the front. However, the introduction of table models with a 21-inch tube has resulted in these controls being quite commonly moved to the side of the cabinet, so that the frontal area can be reduced.

Remote control has appeared in a few cases. Ekco have a small unit containing brightness and volume controls which is connected to the set by a cable; it can be plugged in at will without circuit alterations. Philco have a more elaborate system which permits remote station selection; in this a pecking motor is used to control the turret tuner.

Television Circuits

In the general form of circuitry, television sets are exhibiting a marked tendency towards standardization. This is, of course, only in broad outline for there are many detailed differences between the products of different manufacturers. The tuner is invariably a sub-unit with a double-triode cascode r.f. amplifier and a triode-pentode frequency-changer. A single tuned circuit is used for the aerial-feeder-to-first-grid connection and a coupled pair of circuits between the r.f. stage and the mixer. The oscillator is based upon the Colpitts circuit and there are thus four tuned circuits which require alteration for station selection.



G.E.C. console with 21-inch tube.

Philco receiver with 21-inch tube, remote control and Band II f.m.

The turret tuner is the favourite. Each coil assembly forms a separate 'biscuit' mounted in a rotating framework so that the required biscuit can be brought round to a set of spring connectors. An advantage of the turret is its great flexibility, for the biscuits are readily changed. Some twelve can normally be fitted, but as only a few are necessary for British television, there are sufficient blanks to enable Band II coils to be fitted. The television set lends itself to v.h.f. sound broadcast reception and quite a few are arranged for it. Five Band I coils may be fitted with two or three Band III and three for Band II.

An alternative to the turret is the incremental-inductance tuner. In this some twelve coils are connected in series and the appropriate ones are short-circuited by a multi-way switch. Most of the coils are of very small inductance, merely enough for their insertion to shift the tuning by one channel. This scheme finds a number of supporters, including H.M.V. and Pye. Still another method is adopted by Bush. Virtually continuous tuning with ganged dust-iron cores is adopted; there are two sets of coils, one for each band, with a change-over switch. The control, however, is by a cam with a clicker mechanism. So far as the user is concerned, therefore, all three methods result in his having a control knob with some twelve definite positions for the various channels.

All these tuning methods were adopted last year, if not before, and there is no obvious change in any of them this year. Detail refinement has taken place, however, mainly in improving signal-noise ratio and uniformity in production.

Nearly everyone has now adopted the standard intermediate frequencies of 34·65 Mc/s for vision and 38·15 Mc/s for sound. The general practice is to use coupled pairs of circuits in both amplifiers with trap circuits for rejecting the sound signal. Three i.f. stages for the vision channel and two for the sound are quite common, but some makers adopt a stage less. There is, perhaps, a tendency for the greater number to be used by those makers who do not market special fringe-area models.

Detectors are invariably diodes, either valve or crystal, and the sound-channel ignition-interference suppressor is also a diode. The vision-channel suppressor may also be a diode but there is quite a tendency to include a triode arranged as a black spotter. It is usually fed with the video signal at its cathode and so biased that it is non-conductive until the signal level exceeds peak white. It then conducts on interference to produce an output signal at its anode in the same phase as the interference in the video output and, because of the amplification, at a somewhat greater level. The signal proper is applied to the cathode of the c.r. tube and the triode output to the grid; the net result is that the triode output tends to predominate in its effect on the tube and the interference tends to produce a black spot rather than a white one, hence the name black-spotter.

Pye V 17 RG with 17-inch tube. The sound receiver covers medium and long waves as well as Band II and gramophone equipment is housed behind the doors on the right.

The video amplifier is invariably a pentode. It is becoming increasingly common to add to it a cathode-follower, however. This is done partly to obtain a lower output impedance, and partly because it results in an increase of amplification. This comes about because the input capacitance of the cathode-follower is much less than that of the c.r. tube plus sync separator plus wiring. Consequently, the coupling resistance of the pentode stage can be increased to such a degree that the higher gain there more than offsets the loss in the cathode-follower itself.

On the sound side a pentode output stage is usual, but in some of the larger sets more attention is being paid to sound quality. A Pye radio cum television cum gramophone set has no less than four loudspeakers. An H.M.V. model has two and is very unusual in that provision is made for the bass speaker to be mounted on either side of the cabinet so that the side which best suits the room acoustics can be chosen.

Bush VHF 61, covering medium and long waves and Band II.

For the line timebase the so-called economy circuit with boost diode is universal. A few makers adopt the direct-drive system, but most include an auto-transformer for feeding the deflector coils. The pentode output valve is driven either by a blocking oscillator or a multivibrator. It appeared last year that there was a strong tendency towards the general adoption of flywheel sync. This year's practice hardly supports this, however; most, if not all, of those manufacturers who adopted it last year have retained it this, but few others have changed over to it.

The fact is that flywheel sync is a necessity in British television only under fringe-area conditions, and many people consider that the simpler direct-locking method is preferable when interference is not serious. It is, of course, also cheaper. Some firms, therefore, consider it desirable to market two models, one of moderate sensitivity with direct-locking for service-area use and another of high sensitivity with flywheel sync for fringe areas.

Other firms think it better to have only a single model and so find it necessary to include flywheel sync to cater for difficult receiving conditions, although it is not necessary for the easier ones.

Murphy is one example of a firm which follows the two-model policy. The normal sets have only two i.f. stages in the vision channel and direct-locking of the line timebase. The fringe-area models have three stages and flywheel sync.

B

For the frame timebase a blocking-oscillator or multivibrator sawtooth-generator is invariably used and is followed by a pentode output stage feeding the deflector coils through a transformer, or sometimes an auto-transformer. The well-known *RC* feedback circuit is still a favourite for securing linearity of scan. Synchronizing methods vary considerably but there is certainly a tendency to favour ones which embody some measure of integration of the frame sync pulses. The simple integrator, however, is hardly ever used.

Power supplies are usually simple and straightforward, a.c./d.c. technique being general. Valve heaters are connected in series and a half-wave rectifier supplies the h.t. through a simple smoothing circuit involving very large capacitances and a single choke, or even resistance. The e.h.t. supply is invariably taken from the flyback of the line timebase and supplies of up to some 17 kV are obtained for large tubes. Some firms, for example Ekco, connect a Metrosil unit across the e.h.t. supply to obtain a degree of voltage stabilization, but this is not the general practice.

There is a tendency for the focus magnet to disappear. Some of the larger tubes are being made with partial or complete electrostatic focusing. In some cases the control is pre-set or non-existent, but it can be a conveniently-placed potentiometer instead of the rather inaccessible lever which adjusts the permanent magnet of the more conventional set.

Ekco A 274 Band II f.m. receiver.

F.M. Reception

It was said earlier that the television set lends itself well to f.m. reception of Band II broadcasting. In part this is because the sound i.f. amplifier is normally of about the right bandwidth for f.m. Provision for f.m. reception requires merely the addition of a discriminator and a pair of diodes to act as a ratio detector. There is, of course, some switching complication. Basically, this is merely a changeover switch to connect the a.f. amplifier to the appropriate detector. However, it is usually desirable to put the purely vision side of the apparatus out of action when only Band II reception is needed, and some power-supply switching is thus included. All these switches are mechanically linked with the turret tuner so that operating the station-selector control automatically makes all the required circuit changes.

Cossor 543 portable, using a printed circuit.

Apart altogether from television, receivers equipped for Band II reception are growing in numbers. The basic arrangement is unchanged from last year. This is a standard medium- and long-wave receiver having a triode-heptode frequency-changer, one i.f. stage at around 465 kc/s, diode detector and one or two audio stages. For Band II, 10·7-Mc/s i.f. transformers are added and a ratio detector. The oscillator is put out of action, and the heptode section of the valve turned into an extra i.f. stage. All this is preceded by a Band II tuner comprising a double-triode of which one section functions as a mixer-oscillator and the other as a cathode-input r.f. amplifier. There are, of course, various detail differences between sets, but almost all use this basic arrangement. A few sets, rather more than last year, give Band II reception only, notably Ekco, who have three such models.

Aerials

Broadcast sets do now generally include internal aerials. The use of a ferrite-rod aerial for the medium and long wavebands is very common and either a compressed dipole or a capacitance plate for Band II. Provision for the connection of an external aerial is made, for the internal ones can naturally be wholly satisfactory only in areas of high field strength.

For television, internal aerials are not common, although some of the portable types have rod or similar aerials attached to them. In one form or another, however, the loft or outdoor dipole reigns supreme and is generally combined with a reflector and, possibly, one or more directors to form a Yagi.

Most of the complications arise from the need for an aerial to operate on both Bands I and III.

A favourite arrangement of the simpler type is a Band I dipole fitted with stub elements which, in effect, make it resonant in both bands. To this are added a Band III reflector and one or two directors, so that the assembly functions as a simple dipole on Band I and as a Yagi on Band III.

An alternative is adopted by J.B. Aerials, for in this there is a square frame with sides of a length resonant in Band III. This is mounted vertically and broadside on to the transmitter, and it is fed at the middle of the top and bottom elements through V arms, also resonant in Band III. At these junctions of the square and V vertical Band I rods are fitted.

A disadvantage of the conventional form of aerial is that the average loft is not large enough to contain a Band I array. Commonly some form of compression, such as by bending the ends, is used, but this naturally reduces the efficiency somewhat. A new form is the Labgear Bi-Square. There are two rods spaced a quarter-wave apart each bent to form a square one wavelength in periphery. One square is mounted broadside on to the transmitter and the other is behind it to act as a reflector. The driven element is fed at the centre of one of the vertical sides (for vertical polarization), and the reflector has a stub connected in series with each of its vertical sides at their centres in order to provide proper phasing.

For Channel I the dimensions are roughly 5 ft square and 4 ft back to front, the impedance is 75 Ω and it is claimed that the gain is 12 dB over a plain dipole.

Coaxial cables are probably the commonest form of feeder, but 75-Ω and 300-Ω twin-wire feeders are sometimes used. Two new, and rather specialized, types have been introduced by Aerialite. One is a normal 75-Ω coaxial cable, but with a galvanized-steel wire embedded in the outer p.v.c. covering to act as a mechanical support on a long run. The other is again a more or less normal coaxial cable, but with polyethylene over the outer conductor and a second outer outside this. It is thus a double-screened coaxial cable and is intended for use where exceptionally good screening is needed.

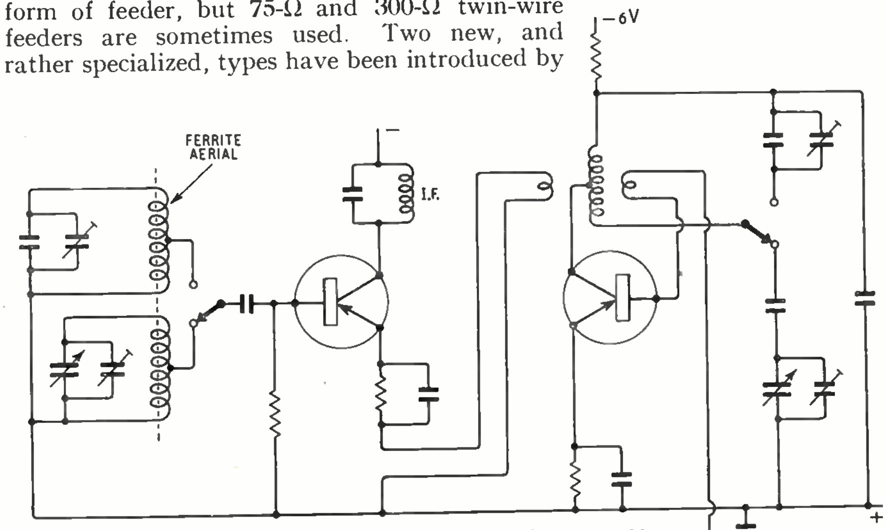
H.M.V. 1360 transportable for a.c./d.c. operation, covering long, medium and short waves.

Transistor Applications

To return to receivers, several portables have made their appearance in which the transistor has completely replaced the valve. Printed-circuit technique has also been introduced for them. The Pam 710 has in all eight transistors. There are a separate oscillator and mixer, two i.f. stages at 315 kc/s, a detector, an a.f. stage and a push-pull output stage. The i.f. stages are neutralized. Transformer coupling is used to the output stages but not from it, for the loudspeaker has a centre-tapped speech coil of some 120-Ω impedance. The battery supply is at 6 V.

The Cossor transistor set is somewhat different and has six transistors, the first functioning as a mixer-oscillator. There is only one i.f. stage, at 460 kc/s, and there is an a.f. stage followed by a pair of drivers for the push-pull output stage.

The transistor is also being widely used in portable record reproducers. A 6-V dry battery not only provides power for the amplifier but operates the motor-driven turntable for 45-r.p.m.



Circuit of frequency-changer used in the Pam transistor portable. It is a transistor equivalent of the one-time common two-valve arrangement with cathode injection of the oscillator voltage.

records. Cossor, Philco, Philips, Pye and Vidor all showed examples of this type of equipment.

Mullard demonstrated some of the things to come in possible future applications of the transistor, the apparatus shown including types of transistor not yet on the market. One was a class A push-pull amplifier with an output of 4 W at less than 0·4% distortion and a power supply of 12 V. Another was a Band II f.m. receiver utilizing an avalanche transistor as an r.f. oscillator, its tenth harmonic being picked out for frequency-changing purposes.

Ferguson 377 RG radio-gramophone with three loudspeakers.

Much more in accord with the present, and a thing which is more practicable as a production possibility of today was a car-radio receiver using push-pull transistors for the output stage and a 12-V power supply. The early stages were all valves, but valves developed to operate with a 12-V h.t. supply. This arrangement thus combines the power efficiency of the transistor for the output stage with the efficiency of the valve at high frequencies, and has the merit of making any h.t. supply equipment unnecessary. It is a line of attack of particular interest.

MICROWAVE AERIAL TESTING AT REDUCED RANGES

By David K. Cheng

(Electrical Engineering Department, Syracuse University, Syracuse, New York)

SUMMARY.—The far-zone distance needed for taking radiation patterns of microwave aerials with large aperture dimensions at very high operating frequencies is often not available on an average test site. It is a general practice in such cases to defocus the primary source along the principal axis of the reflector by a small distance so that Fraunhofer patterns may be simulated in the Fresnel zone. This paper presents three different approaches with which the proper amount of defocus may be determined. The results are plotted and compared.

Introduction

In testing microwave aerials, it is essential that radiation-pattern measurements be made in the far zone (Fraunhofer region) of the aerial assembly. While there is no clear-cut boundary line between the far zone and the quasi-near zone (Fresnel region), the usual rule-of-thumb criterion is that $2D^2/\lambda$ represents a safe far-zone distance, where D is the maximum dimension of the aerial aperture and λ is the operating wavelength. At a distance of $2D^2/\lambda$ the maximum path-length difference between the contribution from the edge of the aperture and that from the centre corresponds to $\pi/8$ or 22·5°. In practice, an unobstructed open space with a dimension of $2D^2/\lambda$ is often not available for testing high-gain aerials operating at microwave frequencies. For example, the $2D^2/\lambda$ distance for a 10-foot aerial at 3 cm would be about 2,030 feet. Higher gain requirements would demand even larger test sites. The need for the technique of testing microwave aerials at a closer distance with acceptable accuracy is therefore both real and urgent.

MS accepted by the Editor, October 1955

This paper begins with a résumé of the method used in contemporary practice of defocusing the primary feed in order to make radiation-pattern measurements at reduced ranges. Two new approaches, one from the consideration of the aperture phase and the other from the consideration of an ellipsoidal reflector, are then presented. Formulae relating the proper amount of defocus and the distance of measurement are given and the results obtained by the three different methods are critically compared.

Geometrical Approach

It is a well-known fact that, for a given primary source of excitation, a best radiation pattern will be obtained from a paraboloidal reflector at a field point in the far zone when the source is located at the focal point of the reflector. Geometrically this may be explained by equal path-length from the source to all points in an aperture plane by virtue of the inherent property of a focused paraboloid. If the field point is far enough away from the reflector, the path-lengths from the aperture points to the field point will again be approximately equal, resulting in an optimum additive effect. When the field point lies in the quasi-near zone, the path-length differences from the points in an aperture plane to the field point must be compensated in some way in order that the measured radiation pattern may approach the true far-zone pattern. This is done by slightly defocusing the source along the reflector axis in the direction away from the reflector. Since the amount of on-axis defocus is the only adjustable variable here, one cannot expect to achieve equal path-lengths for all points in the aperture plane. For simplicity, the conventional approach is to make the path-length from the source to the field point by way of the apex of the paraboloid equal to that by way of the points on the edge of the reflector.

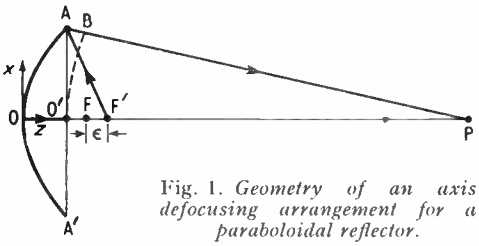


Fig. 1. *Geometry of an axis defocusing arrangement for a paraboloidal reflector.*

In Fig. 1, a cross section of a symmetrical paraboloidal reflector, AOA′, is shown along with the focal point F and a field point P. Let

$$A O' = O' A' = D/2$$
$$O' P = B P = R$$

The path-length difference from points A and O′ in the aperture plane to the field point P is then AB, which can be determined as follows:

$$A O'^2 + O' P^2 = A P^2 = (AB + BP)^2$$

or

$$(D/2)^2 + R^2 = (AB + R)^2 \quad .. \quad .. \quad (1)$$

When AB^2 is neglected in comparison with R^2, which is a very good approximation, (1) gives

$$AB = D^2/8R \quad .. \quad .. \quad (2)$$

The requirement of equal total path-length from the source point to the field point by way of the points A and O′ then can be satisfied by moving the source point to F′ such that

$$(F' O + O O') = F' A + A B \quad .. \quad (3)$$

Let the focal length OF $= f$ and the amount of defocus FF′ $= \epsilon$, then

$$O O' = D^2/16 f$$

$$F' A = \sqrt{\left[\epsilon + \left(f - \frac{D^2}{16f}\right)\right]^2 + \left(\frac{D}{2}\right)^2}$$

and substitution in (3) yields

$$\epsilon = \frac{f^2}{R}\left[\left(\frac{R}{R-f}\right) + \left(\frac{D}{4f}\right)\right] \quad .. \quad (4)$$

When $(f/R)^2 << 1$, it is accurate enough to write (4) as

$$\epsilon = \frac{f^2}{R}\left[1 + \frac{f}{R} + \left(\frac{D}{4f}\right)^2\right] \quad .. \quad (5)$$

Normalizing all quantities with respect to the focal length and introducing new notations $\epsilon' = \epsilon/f$, $R' = R/f$, and $D' = D/f$, one can rewrite (5) as

$$\epsilon' = \frac{1}{R'}\left[1 + \frac{1}{R'} + \left(\frac{D'}{4}\right)^2\right] .. \quad .. \quad (6)$$

The normalized amount of defocus needed is seen to increase when R' decreases and when D' increases. As R' approaches infinity, ϵ' correctly goes to zero.

Aperture-Phase Approach

Relation (6) was derived solely from the laws of geometrical optics; it does not impose any restriction on R other than $(f/R)^2 << 1$. The problem can also be approached from the consideration of the phase distribution in an aperture plane of the reflector together with the diffraction integral for the field at a point in space.

When the point under consideration is in the quasi-near zone (Fresnel region) of a paraboloidal reflector, the normalized diffraction integral which gives the field pattern in a horizontal plane can be approximated as[1]

$$I(u) = \int_0^1 F(r)\, e^{[-jk D^2 r^2/8R]}\, r\, J_0(ur)\, dr \quad (7)$$

In (7), r is the radial dimension of the aperture plane normalized with respect to $D/2$; $u = (\pi D/\lambda) \sin\theta$, θ being the azimuth angle; $k = 2\pi/\lambda$; and $F(r)$ is the circularly symmetrical amplitude illumination function over the aperture. The explicit exponential term is the Fresnel-zone contribution; terms above the second order are neglected. When R is very large, (7) reduces to the far-zone pattern function

$$I_0(u) = \int_0^1 F(r)\, r\, J_0(ur)\, dr \quad .. \quad (8)$$

With $R = 2D^2/\lambda$, the exponent $-jk\, D^2 r^2/8R$ equals $-j\,\pi r^2/8$ which yields the expected maximum phase difference $\pi/8$ at the edge ($r = 1$).

When the primary source is displaced from the focus of a paraboloidal reflector along the reflector axis in the direction away from the reflector with a view to simulating far-zone patterns in the quasi-near zone, there will be a relative phase

[1] S. Silver, "Microwave Antenna Theory and Design", M.I.T. Radiation Laboratory Series, Vol. 12, Chapter 6, 1949, McGraw-Hill Book Co., Inc., New York, N.Y.

variation over the aperture. This phase variation referred to the centre point is found with good approximation to be[1]

$$\delta = -\frac{2\epsilon}{1+\left(\frac{D}{4f}\right)^2 r^2} = -2\epsilon\left\{1 - \frac{r^2}{\left(\frac{4f}{D}\right)^2 + r^2}\right\} \quad \cdots \quad (9)$$

The diffraction integral now becomes

$$I(u) = \int_0^1 F(r)\, e^{jk[\delta - D^2r^2/8R]}\, r\, J_0(ur)dr \quad \cdots \quad (10)$$

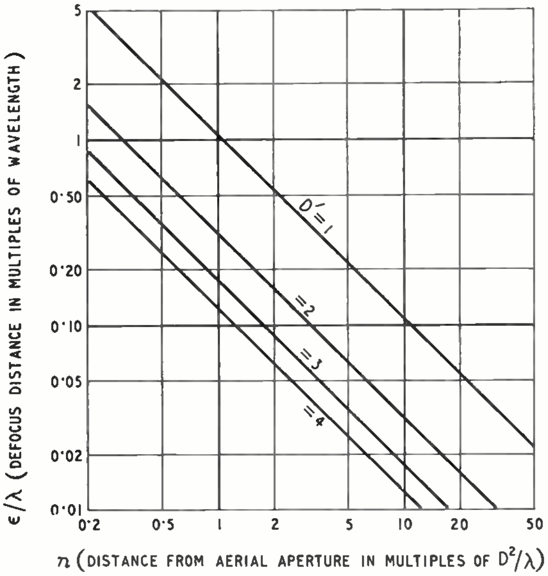


Fig. 2. *Defocus chart from aperture-phase viewpoint.*

The integration in (10) is difficult to carry out. However, comparison with the far-zone integral (8) reveals that ϵ should be chosen to make the exponent in (10) vanish or equal to a constant. Unfortunately this cannot be done exactly for all values of r because of the manner in which the exponent varies with r. A simple way of effecting this is to approximate δ in (9) with a function of the type $(a + br^2)$ where both a and b may involve ϵ. a, being independent of the variable of integration r, does not affect the normalized radiation pattern; the required amount of defocus can then be determined from the equation

$$b = \frac{D^2}{8R} \quad \cdots \quad \cdots \quad \cdots \quad \cdots \quad (11)$$

It has been found[1] that an acceptable and convenient approximation for δ is

$$\delta \approx -2\epsilon\left\{1 - \frac{r^2}{\left(\frac{4f}{D}\right)^2 + 1}\right\} \quad \cdots \quad (12)$$

[1] S. T. Moseley, "On Axis Defocus Characteristics of the Paraboloidal Reflector", Final Report for Contract No. AF 30(602)-925, Syracuse University Research Institute, August 1954.

(12) is exact for $r = 0$ (centre) and $r = 1$ (edge of aperture). For other values of r, the δ given by (12) is slightly larger than that given by (9); the error decreases when the (f/D) ratio of the reflector increases. (12), in conjunction with (11), gives

$$\frac{\epsilon}{f} = \frac{f}{R}\left[1 + \left(\frac{D}{4f}\right)^2\right]$$

or

$$\epsilon' = \frac{1}{R'}\left[1 + \left(\frac{D'}{4}\right)^2\right] \quad \cdots \quad \cdots \quad (13)$$

which checks with (6) when $R' = R/f >> 2$. If it is desirable to write

$$R' = nD'^2/\lambda' \quad \cdots \quad \cdots \quad \cdots \quad (14)$$

with $\lambda' = \lambda/f$, n a numeric, then (13) reduces to

$$\frac{\epsilon'}{\lambda'} = \frac{\epsilon}{\lambda} = \frac{1}{n}\left[\left(\frac{1}{D'}\right)^2 + \left(\frac{1}{4}\right)^2\right] \quad \cdots \quad (15)$$

It is obvious from (15) that for a given value of D', (ϵ/λ) plotted versus n gives a hyperbola in linear scales, and a straight line in log-log scales. Fig. 2 shows a set of parallel straight lines in log-log scales corresponding to several different values of D'. For a given reflector, the required amount of defocus to simulate far-zone patterns at a given distance is readily determined from these lines. It is noted that for $n = 2$ ($R = 2\,D^2/\lambda$), appreciable defocus is still necessary, the required amount being larger for smaller D'.

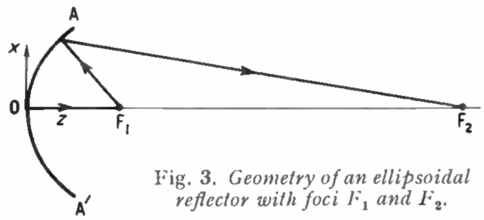


Fig. 3. *Geometry of an ellipsoidal reflector with foci F_1 and F_2.*

Ellipsoidal-Reflector Approach

The purpose of defocusing the primary source in the case of a paraboloidal reflector is to simulate far-zone radiation patterns at points in the quasi-near zone. In terms of geometrical optics, it is quite easy to see that this could be achieved by means of an ellipsoidal reflector. If the primary source is placed at one of the two foci of the ellipsoid, the reflected rays will converge at the other.

Let the reflector AOA′ in Fig. 3 be a cross section of an ellipsoid with focal lengths $OF_1 = f_1$ and $OF_2 = f_2$. Its equation in the xz-plane is then

$$z = \frac{f_1 + f_2}{2}\left\{1 - \sqrt{1 - \frac{x^2}{f_1 f_2}}\right\} \quad \cdots \quad (16)$$

Subject to the condition

$$\sqrt{1-\frac{x^2}{f_1 f_2}} \approx 1-\frac{x^2}{2 f_1 f_2} \quad \cdots \quad \cdots \quad (17)$$

(16) can be approximated as

$$z=\frac{f_1+f_2}{4 f_1 f_2} x^2 \quad \cdots \quad \cdots \quad \cdots \quad (18)$$

which is the equation for a parabola of focal length

$$f=\frac{f_1 f_2}{f_1+f_2} \quad \cdots \quad \cdots \quad \cdots \quad \cdots \quad (19)$$

or

$$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2} \quad \cdots \quad \cdots \quad \cdots \quad \cdots \quad (20)$$

Hence, for reflected rays to converge at $R=f_2$, the primary source should be placed at $z=f_1$, and

$$\epsilon=f_1-f=\frac{f_1^2}{f_1+f_2} \quad \cdots \quad \cdots \quad (21)$$

Solving (19) or (20) for f_1 and substituting the result in (21), one obtains

$$\epsilon=\frac{f^2}{f_2-f}=\frac{f^2}{R-f} \quad \cdots \quad \cdots \quad (22)$$

or, in normalized form,

$$\epsilon'=\frac{1}{R'-1}=\frac{1}{R'}\left[1+\frac{1}{R'}+\frac{1}{R'^2}+\ldots\right] \quad (23)$$

(23) should be compared with both (6) and (13).

An examination of (17) shows that it implies the condition $(1/8)\left(\frac{x^2}{f_1 f_2}\right)^2 << 1$. Now the maximum value of x is $D/2 \leqslant 2 f_1$. This reduces the condition to

$$\frac{f_2}{f_1} >> \sqrt{2} \quad \cdots \quad \cdots \quad \cdots \quad \cdots \quad (24)$$

which is undoubtedly true in practice. An ellipsoidal reflector with focal lengths f_1 and f_2 has its semi-major and semi-minor axes equal to $(f_1+f_2)/2$ (arithmetical mean) and $\sqrt{f_1 f_2}$ (geometrical mean) respectively; it approaches very closely a paraboloidal reflector when (24) is satisfied. As an example, with $f_2=R=10 f_1$, the maximum error introduced by (17) is about 3% and with $f_2=R=50 f_1$, the maximum error is less than 0·09%.

Comparison of Defocusing Methods

Curves plotting ϵ' versus R' based upon equations (6), (13), and (23) from the three different approaches discussed above are shown in Fig. 4. It is seen that except for small values of R', the required ϵ' from the geometrical approach is nearly the same as that from the aperture-phase approach, both of which increase with increasing D'. The required ϵ' from the ellipsoidal-reflector approach is the smallest of the three methods and is independent of D'.

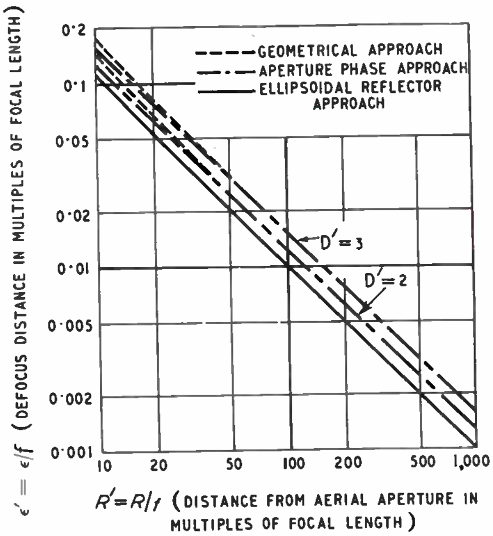


Fig. 4. *Comparison of defocusing methods.*

A review of the geometrical approach reveals that there is really no plausible justification for requiring equal path-length from the source to the field point by way of the apex and by way of the points on the edge of the paraboloidal reflector only; the path-lengths by way of the intermediate points on the reflector would then all be longer. The approximation (12) used in the aperture-phase approach is exact also for $r=0$ and $r=1$ only. For $0<r<1$, δ given by (12) is numerically too large, resulting in an ϵ' which is also too large. Although these two approaches yield approximately the same results, the aperture-phase approach makes it clear that this method would not be useful when R is too small because it would then be necessary to include terms higher than the second order in the exponent of (7); the geometrical approach gives no indication of this restriction. It is believed that ϵ' in (23) derived from the ellipsoidal-reflector approach gives the most nearly correct results because the approximation implied by (17) is very good; it does not restrict its correctness only to the edge of the reflector.

It should be noted that in all three methods the required amount of defocus is not a function of the operating wavelength and that diffraction phenomena are neglected.

BY-PASS FILTERS

By R. O. Rowlands, M.Sc., A.M.I.E.E.

(B.B.C. Engineering Training Department)

SUMMARY.—By-pass filters are described having three pairs of terminals and in which all frequencies are passed, without distortion, between two of the pairs but only a limited band of frequencies is transmitted between either of these pairs and the third pair of terminals.

Introduction

WHEN two terminal stations are connected by telephone line carrying voice frequencies and carrier channels, it sometimes occurs that there are, on the route, a number of wayside substations who wish to have facilities for communicating with either of the terminal stations or with each other. The problem arises of how to connect them to the line cheaply and with the minimum of interference to the carrier circuit. In the past, the solution has been to provide a filter consisting of two complementary high- and low-pass filters connected back to back, and to connect the substation to the junction of the two low-pass filters.

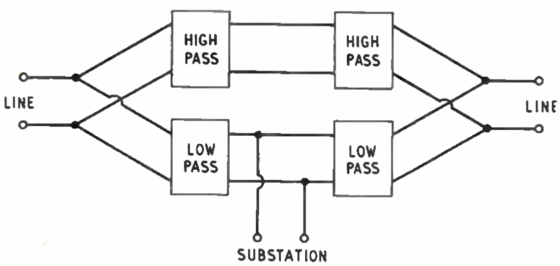


Fig. 1. *Usual by-pass filter arrangement.*

A typical arrangement is shown in Fig. 1. The input impedance of the substation telephones is high in the rest position but is otherwise equal to that of the line. Consequently the signals pass straight through the filters except when a substation comes on, in which case part of the low-frequency power is absorbed. A disadvantage of this method is that filters designed on the image-parameter basis have an appreciable amount of attenuation at the cross-over point and, when a large number of these filters are connected in tandem, the degree of sideband cutting may be excessive. Again, since the function of the high-pass filter is not to provide attenuation but merely to match the impedance of the unit to that of the line, the number of components involved is somewhat excessive. Analysis shows that a better solution may be obtained by designing the filter on a different basis.

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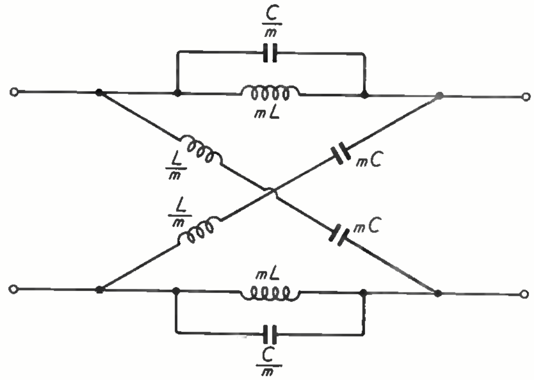

Fig. 2. *All-pass lattice network.*

The All-Pass Network

Type 1

The lattice shown in Fig. 2 is an all-pass network as the antiresonant frequency of the series arms coincides with the resonant frequency of the shunt arms. If the capacitors in the series arms are regarded as bridging the network, the remainder has the configuration of a low-pass filter and may be expanded into the form of a ladder. The circuit will now be as shown in Fig. 3 and fulfils the requirements of a by-pass filter, namely that it has a constant resistive impedance at all frequencies and passes all frequencies without attenuation, the low frequencies going through the low-pass filter portion and the high frequencies being by-passed by the series capacitors. The

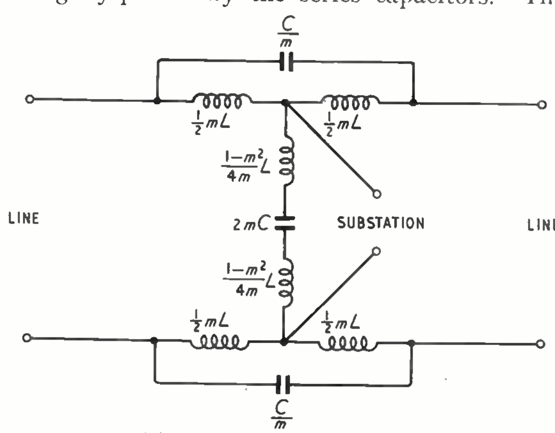

Fig. 3. *By-pass filter type* 1.

substation may be connected to the middle of the low-pass section and so will receive just under half the power available at this point. The carrier circuit will not be affected. The high-pass section of the filter, consisting of two capacitors, is of the simplest form possible. A typical performance curve for a filter with m equal to 0·6 is shown in Fig. 4.

The design formulae are,

$$L = \frac{R}{2\pi f} \qquad C = \frac{1}{2\pi f R} \qquad m = \sqrt{1 - \frac{f^2}{f_\infty^2}}$$

Where R = the impedance of the line

f = the cut-off frequency of the low-pass filter

f_∞ = the frequency of peak attenuation

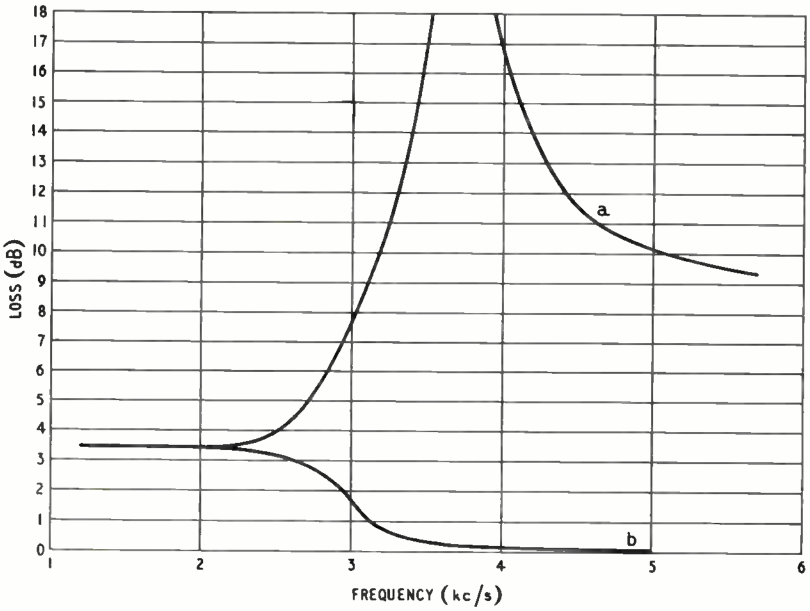

Fig. 4. *Performance of network type 1; curve (a) line to substation, curve (b), line to line with substation connected. The line-to-line loss with no substation in circuit is negligible at all frequencies.*

If, in a particular application, the high-frequency loss between the line and substation terminals of the network is insufficient, resulting in the carrier sideband breaking through at an intolerable level, an improvement may be obtained by connecting an extra low-pass filter section in the substation circuit provided, of course, that this filter may be disconnected when the substation is not in use, otherwise it will alter the all-pass characteristic of the network in this condition.

If it is not possible to have a filter in the substation circuit, which may be disconnected at will, then a network type 2 may be used instead of type 1 to give the extra protection required.

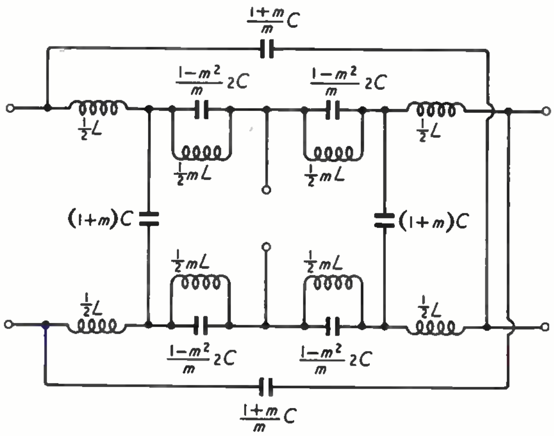

Fig. 5. *By-pass filter type* 2.1.

Type 2

If, in a particular application, the low-pass section does not attenuate the carrier-circuit frequencies to a sufficient degree, a more complex filter may be derived from the all-pass network having three elements in each lattice arm. This may be developed into a by-pass filter in either of the two ways shown in Figs. 5 and 6. It will be seen that, in order to expand the low-pass section into a ladder, the bridging capacitor must appear across the lattice arm of the filter. The design formulae are the same as for type 1 except that,

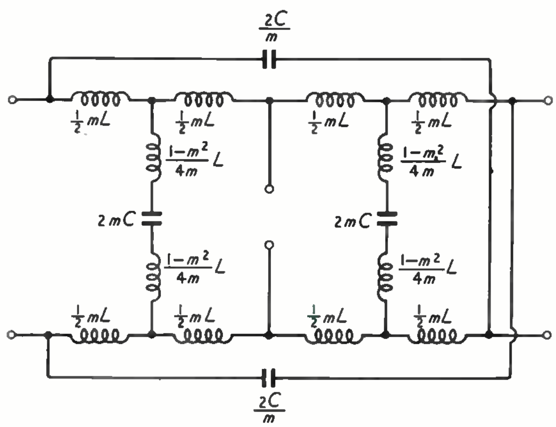

Fig. 6. *By-pass filter type* 2.2.

in this case, the impedance of the low-pass section is different from that of the complete all-pass section. If R is the impedance of the low-pass filter section, the line impedance is $\frac{m}{1+m} \cdot R$ for the filter of Fig. 5 and $\frac{m}{1+m^2} \cdot R$ for the filter of Fig. 6. As m is less than unity, the line impedance is less than the filter impedance at the T-off point. This may be an advantage as the substation will then absorb more of the available power.

Dual Circuits

To each of the networks described there exists a dual network in which the high frequencies appear at the third pair of terminals, instead of the low frequencies, as in the networks so far described. An example of the dual of the all-pass network type 1 is given in Fig. 7. These dual networks might find possible use in communication and signalling circuits on power lines.

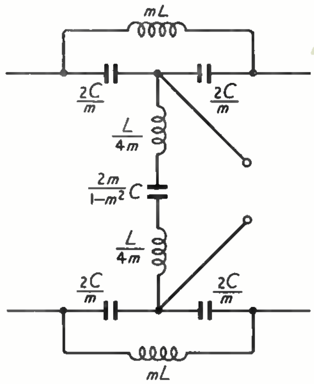

Fig. 7. *Dual of by-pass filter type* 1.

Acknowledgment

Acknowledgment is made to the Chief Engineer of the B.B.C. for permission to publish this article.

AERIAL PATTERN SYNTHESIS

Use of Poisson's Formula

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(This work was done while the author was employed at the Diamond Ordnance Fuze Laboratories, Washington, U.S.A.)

SUMMARY.—In the employment of linear arrays in aerial design, one of the important problems of pattern synthesis is to obtain feeding coefficients which will produce very sharp beams. Although optimum patterns are obtained from the Dolph-Tschebyscheff distributions, the numerical work in determining the feeding coefficients mounts as the number of sources increases. This article indicates an entirely independent method of finding feeding coefficients, which uses only one very special case of a general formula due to Poisson, to obtain extremely sharp patterns for broadside arrays. Although the resulting formulae are not as flexible as the Dolph-Tschebyscheff formulae and require a comparatively large number of sources, the amplitudes of the feeding coefficients are given at once by an extremely simple explicit expression, which is just as easy to calculate for a formula with over a hundred terms as for a formula having just a few terms (and these amplitudes of the feeding coefficients for broadside arrays are invariably positive).

In the employment of linear arrays in aerial design, one of the important problems of pattern synthesis is to obtain feeding coefficients which will produce very sharp beams. Although optimum patterns are obtained from the Dolph-Tschebyscheff distributions, the numerical work in determining the feeding coefficients increases with the number of sources. The purpose of this article is to indicate an entirely independent method of finding feeding coefficients, which uses only one special case of a general formula due to Poisson, to obtain extremely sharp patterns for broadside arrays.

The reader is warned that this present paper furnishes only a mathematical solution to the problem of finding a close approximation to a very sharp curve by a cosine series, and its results may need still further consideration before practical use in aerial design.

The resulting formulae have the following three possible disadvantages when compared with the Dolph-Tschebyscheff formulae:

(1) They are not optimum.

(2) Unlike the Tschebyscheff polynomials, where for a prescribed number of sources a single polynomial serves as the basis for calculating feeding coefficients for all variations in the ratio between d and λ, where $d =$ distance between sources and $\lambda =$ wavelength (e.g., for n odd, $d < \lambda/2$, by Riblet's method), here each expression obtained is used for a fixed ratio of d to λ.

(3) They require the use of a comparatively large number of sources, and so may have restricted applicability at the present time.

But these new formulae have the following four important advantages:

(1) The amplitudes of the feeding coefficients are given at once by an extremely simple explicit expression which is just as easy to calculate for a formula with over a hundred terms as for a formula having only a few terms.

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(2) Formulae which compare favourably with optimum ones can be constructed.

(3) The amplitudes of the feeding coefficients for broadside arrays are invariably positive.

(4) After one has developed the knack of choosing the required constants, even though Poisson's formula is not as adaptable as the Tschebyscheff polynomials for use with pre-assigned d and λ, considerable variations are possible which cover a wide range of the d to λ ratio.

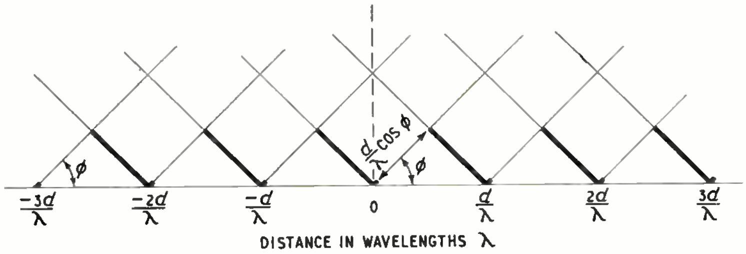

Fig. 1 (left). *System of reference for an array.*

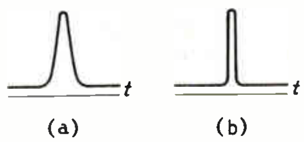

Fig. 2 (below). *Forms of aerial beam.*

Poisson's general formula[1] is expressed by

$$\sqrt{\beta}\left\{\tfrac{1}{2}F_c(0)+\sum_{n=1}^{\infty}F_c(n\beta)\right\}$$

$$=\sqrt{\alpha}\left\{\tfrac{1}{2}f(0)+\sum_{n=1}^{\infty}f(n\alpha)\right\} \quad \ldots \quad \ldots \quad (1)$$

where

$$\alpha\beta=2\pi,\ \alpha>0,\ \text{and } F_c(u)=\sqrt{\frac{2}{\pi}}\int_0^{\infty}f(t)\cos ut\,dt$$

is known as the *Fourier cosine transform* of $f(t)$. If in (1) we let $f(t)=e^{-t^2/2}\cos kt$, then $F_c(u)$ becomes exp. $[-(k^2+u^2)/2]$ cosh ku. This last relation follows immediately from the definite integral formula

$$\int_0^{\infty}\text{exp.}\,[-a^2x^2]\cos bx\,dx$$

$$=\frac{\sqrt{\pi}\ \text{exp.}\,[-b^2/4a^2]}{2a},\ a>0 \ \ldots \quad \ldots \quad (2)$$

by letting $a^2=1/2$ and $b=k+u$ or $k-u$. Then from (1), we get

$$\sqrt{\beta}\,\text{exp.}\,[-k^2/2]\left(\tfrac{1}{2}+\sum_{n=1}^{\infty}\text{exp.}\,[-\beta^2n^2/2]\cosh k\beta n\right)$$

$$=\sqrt{\alpha}\left(\tfrac{1}{2}+\sum_{n=1}^{\infty}\text{exp.}\,[-\alpha^2n^2/2]\cos k\alpha n\right) \quad \ldots \quad (3)$$

Formula (3) is essentially Jacobi's familiar imaginary transformation[2,3,4] which is also used to calculate the error function of a complex variable[5].

The purpose of the discussion in this paper is to show how by judicious choice of the quantities k and β in (3) (the α is determined from β by $\alpha=2\pi/\beta$), the left member of (3) may be closely approximated by a reasonable number of terms of the right member, in which, if considered as a series of the form $\Sigma a_n \cos nc$, the a_n, $n\neq 0$, corresponds to twice the amplitude of the feeding coefficient of a single point source which is one of a pair of symmetrically situated point sources corresponding to the cos nc term, for a linear broadside array. Furthermore, the choice of the k and β will be such as to yield a very sharp pattern for the sum of that number of cosine terms.

In all this discussion it is most convenient to work with only pure numbers, to which any problem in finding feeding coefficients, can be reduced. But Fig. 1 will recall to the reader the system of reference of the angle ϕ which denotes the beam angle when there is an odd number of symmetrically situated point sources for a linear broadside array, and the sources are at a distance d apart.

To illustrate this method we work through an example taking an extreme case, where over a 180° range of the angle ϕ, say from 0° to 180°, we desire to produce a very sharp beam at $\phi=90°$. The total width of the beam is to be only 2·5° and the plotted height is to be completely negligible (i.e., only around 1% or so of the maximum height) everywhere else between 0° and 180°. This is much sharper than the commonly used beams which, when plotted as functions of $t=\cos\phi$, are allowed to widen out away from the t-axis, something like Fig. 2 (a) in shape, whereas here we seek something more like Fig. 2 (b). In the approximate sum Σa_n cos nc, the quantity $c=C\cos\phi$, and if we denote cos ϕ by t, the range of t is from -1 to $+1$. Now the array problem here considered is to find a series of reasonable length, of the form Σa_n cos Cnt* which shall be close to 0 for nearly all values of t between -1 and 1, but which shall increase to 1 within a small range of t corresponding to the 2·5° range in ϕ. The broadside position of the lobe, or the occurrence of the sharp peak at $\phi=90°$, and the total width of 2·5° for the lobe, correspond to a total width of 0·04 in the argument t, at $t=0$

*$C=2\pi d/\lambda$ (See Fig. 1)

or, in other words, since $\Sigma a_n \cos Cnt$ is an even function of t, in the range $t = 0$ to $0{\cdot}02$ (i.e., $1{\cdot}25°$ in ϕ), we want $\Sigma a_n \cos Cnt$ to drop from 1 down to around 0·01 and to stay no larger than around 0·01 in the entire range of $t = 0{\cdot}02$ to 1.

The appearance of equation (3) suggests that we can obtain such a curve from a series of the form $\Sigma a_n \cos Cnt$. We first write down (3) again after multiplying through by $2/\sqrt{\beta}$ for convenience sake:

$$\exp.[-k^2/2]\left(1 + 2\sum_{n=1}^{\infty} \exp.[-\beta^2 n^2/2] \cosh k\beta n\right)$$

$$= \left(\frac{\alpha}{\beta}\right)^{1/2}\left(1 + 2\sum_{n=1}^{\infty} \exp.[-\alpha^2 n^2/2] \cos k\alpha n\right) \quad (3')$$

Now the simplest type of function that is 1 at $t = 0$ and then falls down to 0 and remains small is e^{-t}. But, in order to decrease for negative as well as positive values of t, we should need something like $\exp.[-t^2]$. But $\exp.[-t^2]$ itself does not become small until t is considerably larger than 1, whereas we want a function that becomes and remains small even when $t = 0{\cdot}02$. Thus instead of $\exp.[-t^2]$ we need something like $\exp.[-At^2]$ where A is a large positive constant. This suggests the identification of this $\exp.[-At^2]$ with $\exp.[-k^2/2]$ in the left member of (3′). The question arises as to whether for a certain judicious choice of β, the combination of k and β will cause all the terms inside the summation on the left side, of the form $2\exp.[-(k^2 + \beta^2 n^2)/2] \cosh k\beta n$, to be negligible by comparison with the $\exp.[-k^2/2]$ term, so that the left side is essentially the solitary exponential $\exp.[-k^2/2]$ to within 1% accuracy. Of course, by making the β as large as one wishes, for every n the quadratic part of the exponent in each term, namely the $-\beta^2 n^2/2$ can be made arbitrarily larger in absolute value than the linear part of the exponent, namely $+k\beta n$ or $-k\beta n$ in the $\cosh k\beta n$, so that

$$2\sum_{n=1}^{\infty} \exp.[-\beta^2 n^2/2] \cosh k\beta n$$

becomes as small as one wishes. However, in practice we do not have such an unrestricted choice of β because too large a choice of β gives rise to such a small value of $\alpha = 2\pi/\beta$ that too many terms will be needed in the right member of (3′) before the factor $\exp.[-\alpha^2 n^2/2]$ becomes sufficiently small. In other words, we want an n_0 that is not too large so that all terms for

$$n > n_0 \left(\text{i.e., } 2\left(\frac{\alpha}{\beta}\right)^{1/2} \sum_{n=n_0+1}^{\infty} \exp.[-\alpha^2 n^2/2] \cos k\alpha n\right)$$

may be neglected. Finally, the choice of k and β must yield a product $k\alpha$ that falls within an attainable ratio of d to λ.

It turns out that we can meet all of the above-mentioned conditions by taking $k = 50\sqrt{10}t$ and $\beta = 320$. The choice of $k = 50\sqrt{10}t$ makes the first term in the left member of (3′) equal to $\exp.[-12{,}500t^2]$, which is equal to 1 for $t = 0$ and drops down to $e^{-5} < 0{\cdot}01$ even before $t = 0{\cdot}02$ and, of course, remains very close to 0. To show next that the choice of $\beta = 320$ enables us to neglect all the remaining terms of the left member of (3′), we note first that for $\beta = 320$, $n = 1$ gives the dominant term in

$$\sum_{n=1}^{\infty} \exp.[-\beta^2 n^2/2] \cosh k\beta n,$$

which is

$$\exp.[-(320)^2/2]\left\{\frac{\exp.[50\sqrt{10}\,t \times 320] + \exp.[-50\sqrt{10}\,t \times 320]}{2}\right\}$$

Disregarding the negative exponential within the brackets and noting that $t = 1$ gives the largest value, we have essentially

$$\tfrac{1}{2}\exp.[-(320)^2/2 + 50\sqrt{10} \times 320]$$
$$= \tfrac{1}{2}\exp.[-51{,}200 + 16{,}000\sqrt{10}]$$

or around $\frac{1}{2}e^{-604}$ which is negligible. That we cannot improve appreciably upon this choice of β is apparent if one tries out even $\beta = 310$ instead of $\beta = 320$, in which case the inequality $-\frac{1}{2}\beta^2 + k\beta < 0$ in the first exponential term (when $t = 1$) is far from satisfied and instead one obtains a huge positive exponential $\frac{1}{2}e^{965}$ instead of $\frac{1}{2}e^{-604}$. Now having fixed the β, from which $\alpha = \pi/160$, we examine the right member to see how many terms should be retained. The factor $\exp.[-\pi^2 n^2/51{,}200]$ becomes around 1/7 for $n = 100$ and that is multiplied by an outside factor of $2\sqrt{\alpha}/\sqrt{\beta} = \sqrt{2\pi}/160 < 1/60$. However, since for $t = 0$ all the oscillatory cosine factors become 1, beyond $n = 100$ we should be adding a number of decreasing exponentials (series is convergent) beginning with a term $< 1/420$. Owing to the slowness of the convergence, even though it is probable that the total error at $t = 0$ will be around 0·01, it is safest to choose an n_0 sufficiently large so that one can prove rigorously that

$$2\left(\frac{\alpha}{\beta}\right)^{1/2} \sum_{n=n_0+1}^{\infty} \exp.[-\alpha^2 n^2/2] \cos k\alpha n < 0{\cdot}01.$$

This last remainder is

$$< (1/60) \sum_{n=n_0+1}^{\infty} \exp.[-\pi^2 n^2/51{,}200]$$

in absolute value, which is around

$$(1/60)\sum_{n=n_0+1}^{\infty} \exp. [-0{\cdot}0002n^2].$$

The sum $\sum_{n=n_0+1}^{\infty} \exp. [-0{\cdot}0002n^2]$ may be pictured as a number of rectangles of unit width and decreasing height, and if placed beneath the curve of the integrand in $\int_{n_0}^{\infty} \exp. [-0{\cdot}0002x^2]\,dx$ it is seen to be less than the integral in absolute value. Of course, the first rectangle, corresponding to $n = n_0 + 1$ in the sum, is under the section of the curve of the integrand between $x = n_0$ and $x = n_0 + 1$. In the integral, set $u = \sqrt{2}x/100$, to obtain

$$\frac{100}{\sqrt{2}}\int_{\frac{\sqrt{2}\,n_0}{100}}^{\infty} \exp. [-u^2]\,du,$$

so that we seek an n_0 which will make (1/60)th of that integral or

$$\frac{5}{3\sqrt{2}}\int_{\frac{\sqrt{2}n_0}{100}}^{\infty} \exp. [-u^2]du < 0{\cdot}01.$$

From tabulated values of the error function,

$$\text{erf. } v = \frac{2}{\sqrt{\pi}}\int_0^v \exp. [-u^2]du,$$ we seek a

$$v = \sqrt{2}\,n_0/100$$

that will make

$$\frac{5}{3\sqrt{2}}\cdot\frac{\sqrt{\pi}}{2}\left\{\frac{2}{\sqrt{\pi}}\int_v^{\infty} \exp. [-u^2]du\right\},$$

or

$$\frac{5}{3\sqrt{2}}\cdot\frac{\sqrt{\pi}}{2}\left\{1-\frac{2}{\sqrt{\pi}}\int_0^v \exp. [-u^2]du\right\}$$
$$= 1{\cdot}044\,(1 - \text{erf. } v) < 0{\cdot}01,$$

or erf. $v > 0{\cdot}9904$, from which $v > 1{\cdot}84$. Now $\sqrt{2}n_0/100 > 1{\cdot}84$ for $n_0 = 131$, showing that we are perfectly safe in expecting a truncating error $<0{\cdot}01$ in retaining 131 terms of the summation in the right member of (3′). This upper limit for the truncating error, in conjunction with the fact that exp. $[-12{,}500\,t^2]$ is $< 0{\cdot}01$ for $t > 0{\cdot}02$, guarantees that for t between 0 and 0·02, the sum on the right-hand side will approximate exp. $[-12{,}500\,t^2]$ to within an error of 0·01, and between $t = 0{\cdot}02$ and $t = 1$ that sum will surely be less than 0·02 (in fact, for values of t only slightly greater than $t = 0{\cdot}02$ that sum will be less than 0·01). Finally the cos $k\alpha n$, or $\cos\left(\frac{5\sqrt{10}}{16}n\pi t\right)$, which corresponds to the term $\cos\left(\frac{2\pi nd}{\lambda}\cos\phi\right)$ where $t = \cos\phi$, shows that $d = 5\sqrt{10}\,\lambda/32 = 0{\cdot}494\,\lambda$, which is very close to spacing of one-half wavelength and certainly within the limits of practical design.

Thus, (3′) for this special choice of k and β assumes the form

$$\exp. [-12{,}500\,t^2] \approx \frac{\sqrt{2\pi}}{320}\left\{1 + 2\sum_{n=1}^{131} \exp. [-n^2\pi^2/51{,}200]\cos\left[\frac{5\sqrt{10}}{16}n\pi t\right]\right\} \quad \ldots \quad (4)$$

Glancing back at (2), one sees a suggestive analogy between (4) and (2) if we let x correspond to n, and replace the integrand in (2) by rectangles, letting a correspond to $\pi/160\sqrt{2}$ and b correspond to $5\sqrt{10}\,\pi t/16$. This analogy appears at first sight to break down only for the first rectangle which would have to be made equal to ½ instead of 1; but that is also plausible if we think of (2) as being doubled to go from $-\infty$ to ∞ instead of from 0 to ∞, and the rectangles centred at $x = n$ instead of beginning at $x = n$, so that there would be only a single rectangle of unit height between $x = -\frac{1}{2}$ and $x = \frac{1}{2}$. However, despite the closeness of the analogy between (2) and (4) we cannot circumvent the use of the deeper Poisson formula and all the considerations leading up to the derivation of a formula like (4), by merely assigning values to a and b in (2) and replacing the integral by a sum. The fact that that analogy holds is, in a sense, an amazing coincidence because, given an arbitrary integral of the form $\int_0^{\infty} \exp. [-a^2x^2]\cos bx\,dx$ where the damping factor exp.$[-a^2x^2]$ is so small that numerical integration would have to extend to around $x = 131$, and for b around $3t$, as in the above illustration, where t itself varies between 0 and 1, we should normally require many thousands of rectangles instead of merely 131 to approximate that integral to within 1% for all values of t. We could make arbitrary guesses for a and b in (2) and hit accidentally upon a combination that can be justified by studying (3) or (3′). The best indication of the fortuitousness of the analogy between a rectangular approximation to the integral in (2) and formula (4) where the 'rectangles' are really oscillatory functions of t is that if one attempts to alter (4) or reduce the number of terms necessary for 1% accuracy by any offhand slight changes in the constants, the approximation fails completely for some range of t. The reason for indicating this analogy is to convince the reader of the depth in the use of Poisson's formula which cannot be attained by merely protracted groping around in (2) for a lucky choice of a and b.

All the preceding discussion is perfectly general in its application so that the user can vary the k and β in (3′) and try for other descending exponential patterns that are more or less sharp, and which may require more or less than 131 terms.

Because of the possible utility of the coefficients of $\cos\left(\frac{5\sqrt{10}}{16}n\pi t\right)$ in (4) when considered as a series of the form

$$\exp.\left[-12{,}500\,t^2\right] \approx a_0 + \sum_{n=1}^{131} a_n \cos(3{\cdot}1045588nt) \qquad \ldots \quad \ldots \quad (4')$$

there are given in Table 1 the coefficients a_n, for values of n from 0 to 131 recalling that a_n, $n \neq 0$, is twice the amplitude of the feeding coefficient of a single-point source. They are accurate to within a unit in the last (fifth) decimal place, so that in using them, after the multiplication and summation operations in (4′), an upper bound for the contribution to the error which is due to the use of inexact coefficients will be around 0·001, and in all probability the actual contribution to the error will be very much smaller than 0·001. Formula (4′) was tested and verified for its accuracy to within 1% for eight different values of t, namely $t = 0$, 0·001, 0·005, 0·01, 0·05, 0·1, 0·5, and 1. The coefficients a_n which are tabulated were calculated and checked by Miss Isabelle Arsham, who also did all the computations verifying the accuracy of (4′) for the above mentioned values of t.

TABLE I

n	a_n	n	a_n	n	a_n	n	a_n	n	a_n
0	0·00783	30	0·01317	60	0·00783	90	0·00329	120	0·00098
1	0·01566	31	0·01302	61	0·00765	91	0·00317	121	0·00093
2	0·01565	32	0·01286	62	0·00747	92	0·00306	122	0·00089
3	0·01564	33	0·01270	63	0·00729	93	0·00296	123	0·00085
4	0·01562	34	0·01254	64	0·00711	94	0·00285	124	0·00081
5	0·01559	35	0·01237	65	0·00694	95	0·00275	125	0·00077
6	0·01556	36	0·01220	66	0·00677	96	0·00265	126	0·00073
7	0·01552	37	0·01203	67	0·00659	97	0·00255	127	0·00070
8	0·01547	38	0·01186	68	0·00642	98	0·00246	128	0·00067
9	0·01542	39	0·01169	69	0·00626	99	0·00237	129	0·00063
10	0·01537	40	0·01151	70	0·00609	100	0·00228	130	0·00060
11	0·01531	41	0·01133	71	0·00593	101	0·00220	131	0·00057
12	0·01524	42	0·01115	72	0·00577	102	0·00211		
13	0·01516	43	0·01097	73	0·00561	103	0·00203		
14	0·01509	44	0·01079	74	0·00545	104	0·00195		
15	0·01500	45	0·01060	75	0·00530	105	0·00187		
16	0·01491	46	0·01042	76	0·00515	106	0·00180		
17	0·01482	47	0·01023	77	0·00500	107	0·00172		
18	0·01472	48	0·01005	78	0·00485	108	0·00165		
19	0·01461	49	0·00986	79	0·00470	109	0·00159		
20	0·01450	50	0·00968	80	0·00456	110	0·00152		
21	0·01439	51	0·00949	81	0·00442	111	0·00146		
22	0·01427	52	0·00930	82	0·00429	112	0·00140		
23	0·01415	53	0·00912	83	0·00415	113	0·00134		
24	0·01402	54	0·00893	84	0·00402	114	0·00128		
25	0·01389	55	0·00874	85	0·00389	115	0·00122		
26	0·01375	56	0·00856	86	0·00377	116	0·00117		
27	0·01361	57	0·00837	87	0·00364	117	0·00112		
28	0·01347	58	0·00819	88	0·00352	118	0·00107		
29	0·01332	59	0·00801	89	0·00340	119	0·00102		

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LOW-FREQUENCY GROUND WAVES

Equipment for the Measurement of the Phase Change with Distance

By G. E. Ashwell, B.Sc. and C. S. Fowler, A.M.Brit.I.R.E.

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

SUMMARY.—The equipment described was developed to investigate the phase change with distance of a low-frequency wave passing over ground of finite conductivity and, in particular, the changes that occur near a boundary between grounds of different conductivities or across a coastline. The method employs a u.h.f. link between a fixed monitor station and a mobile measuring station to provide a reference signal against which the phase of the low-frequency signal is compared at the measuring station. The equipment is capable of operating over distances of up to 50 km and measures the phase to an accuracy of 2° at a frequency of 127·5 kc/s.

1. Introduction

In general, when a low-frequency wave travels across ground of finite conductivity, its phase velocity is less than that in air. That is, it suffers a phase retardation which is a function of the frequency of the wave, the distance from the transmitter and the conductivity of the ground. The equipment described below was developed to measure, at a frequency of 127·5 kc/s, these changes in phase over various types of ground and over sea in particular.

Equipment employed in previous experiments described by Pressey, Ashwell and Fowler[1] measured the sum of the phase changes that occur along a section of an inhomogeneous path when waves are propagated in both directions along that path. It was not possible to obtain from the observed results a unique solution for propagation in one direction only and the measurements were limited by the availability of transmitters to two land paths, one between Lewes and Warwick and the other between Lewes and Norwich. The present equipment was developed in order to obtain the phase changes for propagation in one direction only and to give greater freedom in the choice of paths by permitting measurements to be made along any radial path from a particular transmitter.

In particular, the detailed phase changes that occur when the wave crosses a boundary between grounds of different conductivity, or across a coastline, could be investigated more easily.

The previous method also required that the position of the measuring station be known to better than one metre, a requirement which entailed the making of an accurate survey at each site. With the system described below, a much lower order of positional accuracy is sufficient, a feature which considerably simplifies its use for measurements at sea.

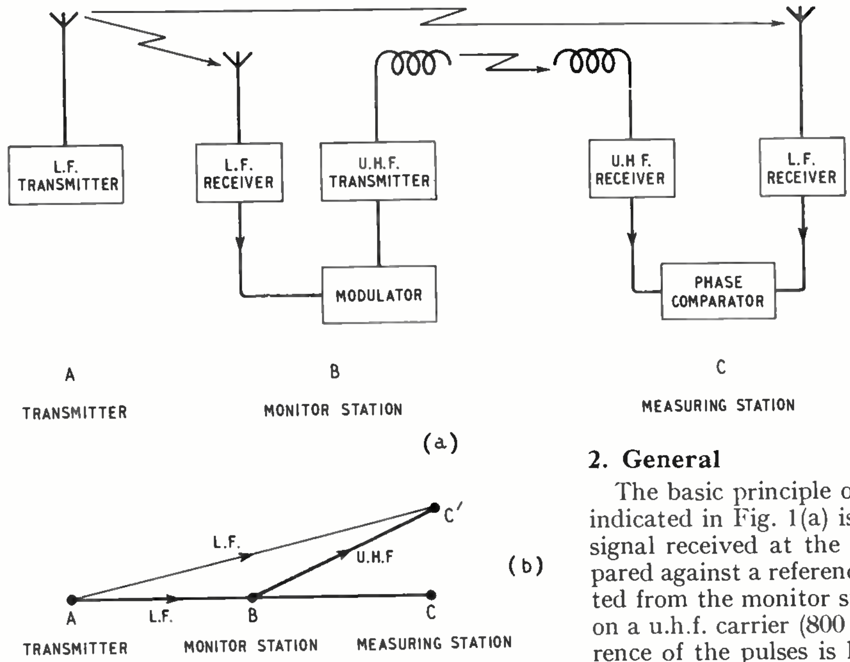

Fig. 1. *Basic system of measurement (a) and layout of stations (b).*

MS accepted by the Editor, December 1955

2. General

The basic principle of operation of the system, indicated in Fig. 1(a) is that the phase of the l.f. signal received at the measuring station is compared against a reference signal which is transmitted from the monitor station as pulse modulation on a u.h.f. carrier (800 Mc/s). The time of occurrence of the pulses is locked to the phase of the l.f. signal received at the monitor station.

The u.h.f. signal travels with a known velocity which is nearly constant and can be assumed to be equal to the phase velocity of the l.f. signal in air. Thus, the measured phase difference between the direct l.f. signal and that relayed from the monitor gives (allowing for any constant instrumental phase shift) the increase in the phase lag of the direct l.f. signal due to the presence of the ground between the monitor and the measuring station, provided the transmitter, monitor and measuring stations are collinear.

The disposition of the stations is shown in Fig. 1(b). It is desirable that the transmitter A, the monitor B and the measuring station C should lie on a straight line but, in order to obtain adequate range with the u.h.f. signal or to take observations along a line transverse to the radial, it was often necessary to site the monitor and receiver in positions which were not collinear with the transmitter. In this case it is necessary to make allowance for the excess distance AB + BC′ over AC′. The accuracy with which the positions of the points A, B and C′ must be known depends on the angle CBC′ and the phase accuracy required. In practice it was found that on land, using Ordnance Survey maps to a scale of 6 in. to the mile, it was possible to work with values up to 25° for the angle CBC′ and still obtain an accuracy of about 1° in the measured phase. For the measurements over the sea it was possible, using sextant fixing on objects on the coast, to keep the angle CBC′ to less than 1°, under which condition the correction for the excess distance is negligible.

3. Factors affecting Design and Performance

The design of the low-frequency sections of the equipment entails no specific problems. Conventional circuits are employed and, apart from care to maintain good stability, no unusual precautions had to be taken.

The design of the link to carry the reference signal, however, involves a number of problems. A primary requirement is that the velocity of the reference wave shall not be affected by the conductivity of the ground and that adequate range can be obtained without employing an excessively high-powered transmitter or complicated aerial systems. Since pulse modulation is employed (see below) it was desirable to use a carrier frequency that could be modulated with short pulses, and to employ valves that could be modulated precisely, and preferably, in a conventional manner. These conditions, together with others discussed below, led to the choice of a value in the region of 800 Mc/s for the carrier frequency.

At this frequency the propagation is entirely by space wave and the only parameters affecting the velocity are the atmospheric conditions. The normal variations in these conditions in England, however, do not cause the velocity to depart beyond the limits of 299670 and 299700 km/s. This velocity range results in a phase variation of less than 0·8° in the total phase change over a path of 50 km length; an amount that can be ignored when compared with the actual phase changes at the low frequency encountered over such a path.

To obtain the accuracy required with the system of measurement, a minimum signal-to-peak-noise ratio of about 6 dB was necessary. This was obtained on an optical path at a maximum distance of 60 km or at shorter distances depending upon the degree of screening by trees and small hills. It was found that for positions of the two stations, such that there was an optical path between them, the u.h.f. field strengths of the received signal obeyed an inverse distance law.

Another problem is that of secondary signals that arrive at the receiver after reflection from fixed objects and, because they are delayed with respect to the main signal, are liable to cause an error in the phase of the reference signal. This was overcome by using pulse modulation in conjunction with a strobing arrangement in the receiver which rejected any pulses that were delayed with respect to the leading edge of the main pulse. It could not deal, however, with secondary pulses which arrived during the rise of the main pulse and which, by distorting the leading edge of the pulse, caused an error in the phase of the reference signal. Had sinusoidal modulation been used there would have been no method of resolving signals arriving by different paths and the phase of the resultant reference signal would have depended upon all the signals received.

The effect of secondary signals is further reduced by the directivity and polarization characteristic of the helical aerials used. The aerials produce and receive circularly-polarized waves and, since the sense of rotation of circularly-polarized signals is reversed when they are reflected from a surface at any angle of incidence less than the Brewster angle, the receiving aerials will tend to reject such reflected signals.

4. Equipment: General

The monitor and measuring equipments each occupy two standard 19-in. racks 6 ft high. For measurements on land each is mounted in a five-ton van together with a petrol electric generator to supply 230 volts a.c. This supply is stabilized as also are the d.c. outputs from the various power units driven by it. A frequency-modulated radio telephone operating in the 20–30-Mc/s band is used for communication between the two vehicles.

When operated at sea the receiving equipment was installed in the cabin of a 75-ft motor-launch.

The aerial for receiving the 127·5-kc/s signal is a vertical rod 12 ft long mounted at the centre of the roof, immediately above the receiver. The aerial for the 800-Mc/s reference signal is a 16-turn helix mounted on the top of a 20-ft demountable mast at one corner of the van. The mast can be rotated through 360° so that the aerial can be set in the direction of arrival of the signal. The gain of the aerial is 17 dB and the beamwidth (3 dB) is 28°. The input impedance of the aerial is approximately 130 ohms resistive and is matched to the concentric feeder of 70 ohms characteristic impedance by a simple quarter-wave transformer.

modulate the anode current of a planar electrode triode (CV273) operating in a concentric-line circuit at a frequency of 800 Mc/s. The valve is allowed to oscillate at a low level during the periods between pulses, the anode potential being about 100 volts, and, under this condition, variations in the delay of the build-up of the oscillations on the application of the modulating pulse are less than 0·01 microsecond, corresponding to 0·5° at 127·5 kc/s.

If the oscillator were completely suppressed between the modulating pulses, it was found that there was a variation in the time of commencement of the oscillations of the order of 0·05 microsecond, which corresponds to a variation of

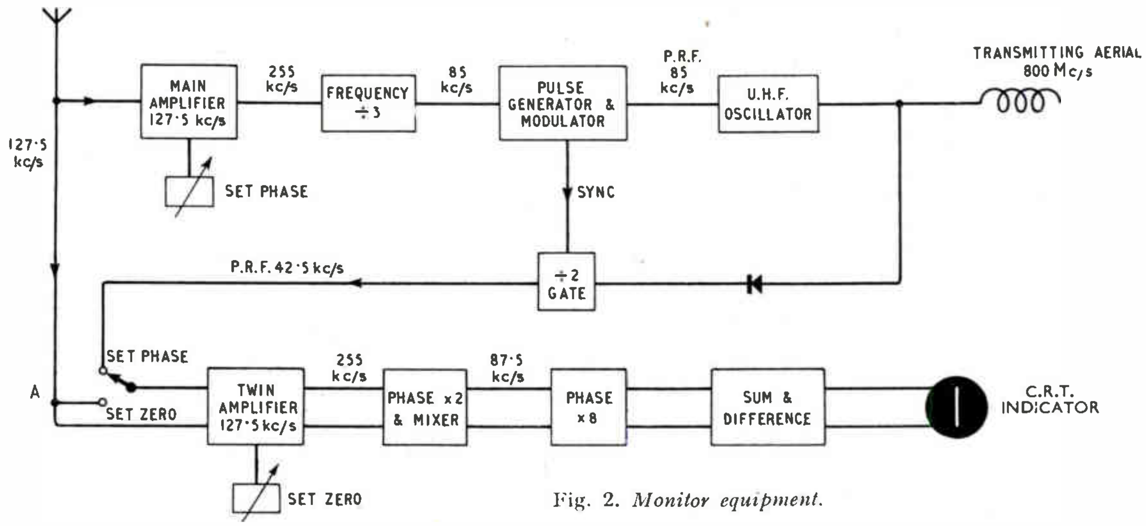

Fig. 2. *Monitor equipment.*

5. Monitor Equipment

The block diagram of the monitor station is given in Fig. 2. The l.f. signal from the vertical aerial is fed to a high-gain amplifier which has a crystal filter circuit with a pass band of 40 c/s. The output frequency is doubled to reduce overall feedback trouble. An automatic gain-control circuit is provided, and a variable capacitor across one of the tuned circuits permits the phase change through the amplifier to be adjusted.

The output frequency is divided by three in a regenerative modulator divider circuit[2] and the resultant 85-kc/s signal used to trigger a pulse generator circuit which feeds the modulator stages. This change of frequency is necessary to prevent radiation from the modulation stages of the u.h.f. transmitter causing interference with the received l.f. signal.

The pulse generator employs a triggered regenerative valve circuit (multiar)[3] which has a delay line in the anode circuit. This produces a pulse of about 0·3 microsecond duration which, after amplification to 800 volts peak, is used to

about 2° at 127·5 kc/s, a value too great for accurate measurements.

The peak power output of the oscillator is 12 watts and the pulse has a duration of 0·3 microsecond with equal rise and fall times of 0·1 microsecond measured between 10% and 90% amplitude.

The remainder of the equipment shown in the lower half of Fig. 2 is required to ensure the constant phasing of the transmitted pulse with respect to the received 127·5-kc/s signal. A fraction of the output of the oscillator is fed into a crystal-diode rectifier circuit to produce pulses with a recurrence frequency of 85 kc/s. These are passed through a gating valve which allows only alternate pulses to pass, thus reducing the pulse-recurrence frequency to 42·5 kc/s. The third harmonic of these pulses is then compared with the 127·5-kc/s signal received by the aerial.

The first stages of the phase comparison equipment comprise twin amplifiers with frequency-doubling stages providing an output at 255 kc/s similar to the main amplifier described above.

C

These are followed by a second pair of frequency-doubler stages and two frequency changers fed from a common oscillator which converts the signals to the intermediate frequency of 87·5 kc/s. These two signals are fed to an eight-times phase multiplier unit[4] which can be switched out of circuit when not required. This is followed by a sum and difference phase-indicator unit[5]. In the sum and difference unit the two signals whose phases are to be compared are combined so as to produce a trace on a compass-type cathode-ray tube. The angular rotation of the trace indicates the relative phase of the two signals and a rotation of 180° on the tube corresponds to a change of phase of 360° at the input of the sum and difference unit.

Since there is an overall phase multiplication of 32 times in the equipment, there is an ambiguity of 11¼° or multiples of it in the determination of the changes in phase angle. This ambiguity is reduced to 90° by reference to a reading taken with the eight-times multiplier stage removed from the circuit. This resultant ambiguity is far greater than any phase change that can occur in low-frequency propagation over the distances involved.

To check the phase adjustment of the equipment, the inputs to the twin amplifiers are joined in parallel by switch A so that there is a common signal input from the aerial. The phase of one amplifier is then adjusted so that the trace on the phase indicator has an arbitrary reading, usually zero. The switch is then changed so that the output pulses from the u.h.f. transmitter are applied to one channel and the phase control in the receiver feeding the transmitter is adjusted so that the same arbitrary reading is obtained. This ensures that the outgoing pulses have a fixed phase relationship to the incoming low-frequency signal. The stability of the equipment is such that, after an initial warming-up period of 45 minutes, only occasional checking of the phase is needed and in practice it can easily be held to within ¼° of phase at 127·5 kc/s.

6. Measuring Equipment

A block diagram of the measuring equipment is shown in Fig. 3.

The low-frequency signal is received on an aerial similar to that employed in the monitoring equipment and is fed to a variable-gain head amplifier whose phase shift is substantially independent of the gain. The phase shift can, however, be varied within limits by a variable capacitor across one of the tuned circuits. It was necessary to provide such a means of maintaining the input to the main receiver at constant level, as the automatic gain-control circuits in the latter caused a change of phase of about 1° for a 10-dB change in the signal level at its input.

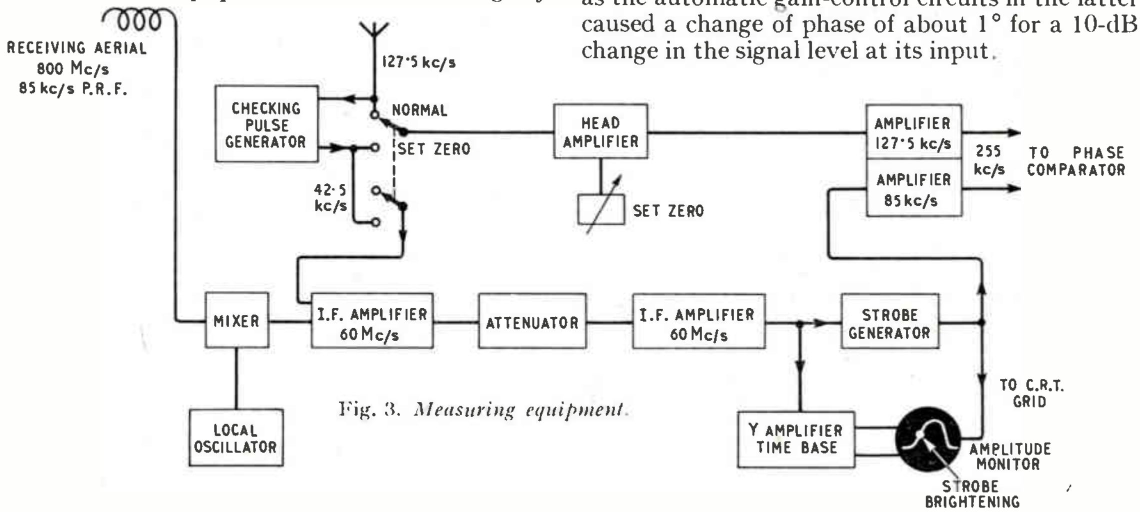

Fig. 3. *Measuring equipment.*

The output of the receiver at 255 kc/s is taken to one input of a phase-comparison unit which is identical with that used in the monitoring equipment.

The u.h.f. signal is received on a helical aerial similar to that at the transmitter and is fed to a crystal-diode frequency changer. The seven-stage intermediate frequency amplifier, operating at 60 Mc/s, has a bandwidth of 6·0 Mc/s. Bandpass coupling is used between all stages except the second and third where there is a π-network attenuator operating between heavily-damped single-tuned circuits. This attenuator has a range of 70 dB in 1-dB steps and permits the output of the amplifier to be kept at a constant level. An automatic gain-control stage having a range of about 20 dB may be inserted in series with the attenuator in order to keep the output constant under conditions of rapidly changing signal, as were encountered at sea when the movement of the boat changed the alignment of the u.h.f. aerial.

The bandpass-coupled stages have a coupling factor of 0·7 of the critical value. Under this condition, the phase characteristic is substantially linear over the pass band and, consequently, the delay of the pulses will not be affected seriously by frequency drift in the transmitter or in the receiver local oscillator.

Tests made on the stability of the u.h.f. receiver have shown that the change in phase is less than 0·06° for a change of 50 dB in the input level, the output level being kept constant by means of the attenuator.

The rectified output of the i.f. amplifier is fed to a strobe-generating circuit and also displayed on a cathode-ray tube indicator so that the output can be set to a standard amplitude. The strobing circuit employs a multiar to generate a pulse of 0·02-μsec duration and constant amplitude at a selected point on the leading edge of the received pulse.

The circuit does not operate for signals having amplitudes less than 1/3rd of the main pulse and so discriminates against secondary pulses.

In order to observe and set the point of operation of the strobe generator, the pulse is made to brighten the trace of the received pulse displayed by the c.r.t. amplitude monitor.

The 0·02-μsec pulse is applied to a 85-kc/s amplifier similar in design to the main 127·5-kc/s circuits. The output frequency is trebled so that it is the same as the output frequency of the l.f. receiver (255 kc/s) and fed to the other channel of the phase comparison unit.

The phase alignment of the equipment is checked by injecting into the main receiver and into the first i.f. circuit of the u.h.f. receiver pulses of about 0·01 μsec duration with a p.r.f. of 42·5 kc/s. These pulses are locked to the received 127·5 kc/s. The third harmonic is selected by the main receiver while harmonics in the 60-Mc/s region are selected by the u.h.f. receiver i.f. circuits. The harmonics can be considered as co-phasal so that any differential phase shifts in the two channels of the equipment can be seen on the c.r.t. phase indicator and compensated for by the phase shifter in the head amplifier circuit.

It is not necessary to inject the alignment signals into the front of the u.h.f. frequency-changer stage, as this has a very broad pass band and tuning the unit has negligible effect on the phase shift. As with the monitoring equipment, readings were taken with and without the phase multiplier in circuit in order to resolve ambiguities. Measurements are made by observing the phase change on the indicator when the equipment is switched from the alignment to the normal operating condition. This change is divided by the appropriate phase multiplication factor employed.

On land, a number of readings were taken at each site over a period of 5–15 minutes, while at sea readings were taken at minute intervals, the position of the boat being fixed at the same time by sextant observations.

The readings obtained are corrected for any deviation from co-linearity of the transmitter, monitor and receiver and show the variation of the l.f. phase from point to point.

7. Performance

The equipment has been operated under various conditions for two years and has shown no major defects. This includes operation under adverse conditions at sea when, with the automatic gain control operating in the u.h.f. receiver, stable and repeatable results have been obtained.

Experience in the alignment and reading of the equipment has shown that the observing accuracy is of the order of $\pm$ 0·2° and is small in comparison with errors due to other causes.

One source of error in the equipment is the change in feedback conditions in the pulse transmitter which gives rise to changes of pulse shape. After a warming-up period of 45 minutes, during which the major changes occur, measurements taken at a fixed site over periods up to seven hours duration showed a standard deviation of only 0·3°.

The manner of earthing the receiving van was found to have a marked effect on the phase reading obtained; an effective earth resistance of 400 ohms gave a phase reading of 4° greater than that obtained with either a very good or no earth connection at all. The reason for this is that the capacitance of the van to earth is in parallel with its resistance to earth through the earthing pins and the resultant impedance is effectively in series with the capacitive impedance of the aerial. Thus, changes in the resistance of the pins to earth will affect the phase of the current flowing in the aerial circuit. However, consideration of the equivalent circuit shows that, if the earth resistance is either very high or very low, the whole circuit impedance is substantially capacitive and the phase of the voltage across the terminals of the receiver, which also has a substantially capacitive input impedance, will be the same in both cases. At the monitor van a good earth consisting of a number of rods driven into the ground was employed but, at the receiving van, the sites were often such that a good earth could not be obtained, so the majority of the measurements were made with no earth connection.

The overall repeatability of the results was such that for points at which observations were made at different times and on different days the standard deviation was 1·8°. Had more care been taken in the precise locating of the vehicles and in the degree of earthing, it is considered that this figure could have been reduced to 1°.

Tests to detect the effect of secondary signals from reflecting objects on the u.h.f. signal were made by moving the van over distances of up to 100 metres and by rotating the receiving aerial so as to reduce the main signal and enhance any reflections that may have been present. In no case were there observed any reflections which would have been of sufficient magnitude to give rise to errors of any consequence when the aerial was correctly aligned; and the strobing circuit was operating correctly.

8. Practical Results

A comprehensive series of measurements over land to sea boundaries and over various grounds of different conductivities has been made with the equipment and full details have been published elsewhere[6]. In order to illustrate the type of results obtained two typical phase/distance curves are shown in Figs. 4 and 5.

Fig. 4 illustrates the phase variation over the sea that occurs when a low-frequency wave passes from low conductivity ground to high conductivity sea water. About 100 observations were made on this path which was traversed several times. The variations about the mean line have a standard deviation of 0·5° and were due partly to experimental error and partly to local irregularities in the phase pattern, the existence of which has been amply confirmed by measurements on other paths.

Fig. 5 shows the very rapid phase variations that were measured over land near to a geological boundary between chalk and alluvium.

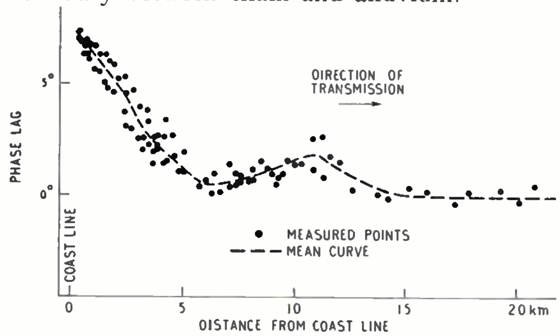

Fig. 4. *Phase change over sea near a coast line* (127·5 *kc/s*).

9. Conclusions

An equipment for the investigation of the phase variation with distance of low-frequency waves propagated along the surface of the ground has been described and its use under a variety of operational conditions has shown it to be very satisfactory. Although designed primarily for measurements over the sea, it has proved equally useful over land paths up to 60 km long. It has the advantage over previous equipment of providing directly the phase changes due to the finite conductivity and inhomogeneities of the ground. The instrumental accuracy is about ± 0·3° and is mainly determined by the shape of the reference pulse and the response of the associated u.h.f. equipment. The useful accuracy of measurement is, however, less than this value, being about ± 0·5° at sea and ± 2° on land. The difference between the land and sea figures is mainly due to the changes in the earthing resistance of the receiving van from one land site to another.

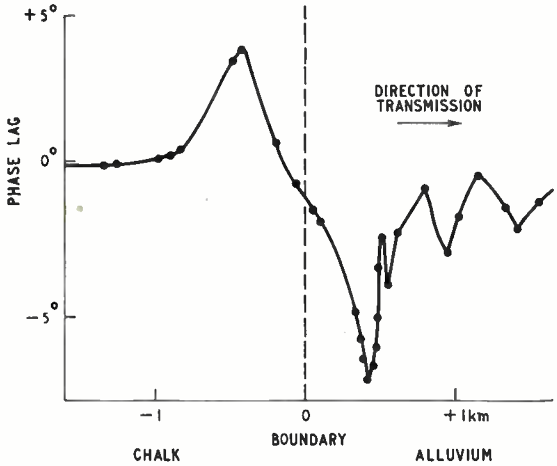

Fig. 5. *Phase change across a boundary on land* (127·5 *kc/s*).

Acknowledgments

The authors wish to acknowledge the contribution made by Dr. B. G. Pressey to the general design of the system and also to his helpful advice during the development of the equipment and in the preparation of this paper. The authors also desire to acknowledge the assistance of Mr. H. E. Brown in the construction and operation of the equipment, and to thank the Decca Navigator Company for the loan of components used in the low-frequency receivers.

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CORRESPONDENCE

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

Dual of Kirchhoff's Branch-Current Rule

SIR,—A rule for determining the magnitude of the steady-state current in any branch of a network of resistors and impressed electromotive forces was given by Kirchhoff[1] in 1847 when, for the second time, he published his famous laws of electrical network theory. In 1925, Franklin[2] gave an alternative proof of Kirchhoff's result and expressed the rule in the language of algebraic topology. In the light of recent developments in pure network theory, Franklin's version of the rule may be stated as follows:

> If the ith branch of a network with cyclomatic index c consists of a resistance R_i in series with a constant electromotive force source E_i, the steady-state current in branch j is given by a fraction whose denominator is the sum of all possible products of cR_is such that the corresponding branches constitute a co-tree[3]; and whose numerator is the sum of all products of $c - 1$ R_is such that the corresponding branches if open-circuited will leave a single tie-set[4] containing the jth branch, each such product being multiplied by the impressed electromotive forces in this tie-set with plus or minus signs according as they are or are not in the direction of the tie-set determined by the jth branch.

By exchanging every electrical and topological term in this statement for its dual, a second rule is obtained which, to the best of my knowledge, has not previously appeared in the literature. It is as follows:

> If the ith branch of a network with nodalic index p consists of a conductance G_i in parallel with a constant current source I_i, the steady-state potential difference across branch j is given by a fraction whose denominator is the sum of all possible products of pG_is such that the corresponding branches constitute a tree[5]; and whose numerator is the sum of all products of $p - 1$ G_is such that the corresponding branches if short-circuited will leave a single cut-set[5] containing the jth branch, each such product being multiplied by the impressed currents in this cut-set with plus or minus signs according as they are or are not in the direction of the cut-set determined by the jth branch.

The terms cyclomatic index and nodalic index are adopted in preference to Whitney's[6] corresponding terms nullity and rank because the rank of the node-branch incidence matrix of the network is also the column-nullity of the loop-branch incidence matrix and vice versa. The term cyclomatic index is due to Listing[7]; I take the liberty of coining the term nodalic index to indicate its dual.

If the nodalic index of a network is less than its cyclomatic index, the second rule given above requires less effort in application than the first.

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27th August 1956.

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By M. G. ANDREASEN. Pp. 149 + ix. In Danish with Summary and Bibliography in English. Laboratoriet for Elektromagnetisk Feltteori, Danmarks Tekniske Højskole, København, Denmark.

Standard Capacitors
National Physical Laboratory Notes on Applied Science No. 13. Published for Department of Scientific and Industrial Research by H.M.S.O., York House, Kingsway, London, W.C.2. Price 1s. 3d.

OBITUARY

We regret to record the death of G. M. Wright, C.B.E., B.Eng., M.I.E.E. Born in September 1890, he joined Marconi's Wireless Telegraph Company Ltd. in 1912 and on his retirement in 1954 he was Engineer-in-Chief. During both wars, he was attached to the Admiralty.

I.E.E. CONVENTION ON FERRITES

Opening on 29th October under the chairmanship of Sir Gordon Radley, K.C.B., C.B.E., Ph.D.(Eng.), M.I.E.E., at 2.30 p.m., with an introductory lecture by Willis Jackson, D.Sc., D.Phil., Dr.Sc.Tech., F.R.S., M.I.E.E., this convention is divided into fifteen sessions, as follows:—

A.1. "Chemical and Physical Properties and Preparation", 5.30 p.m., 29th October.
A.2. "Magnetic Spectra", 10 a.m., 30th October.
A.3. "Molecular Interaction", 2.30 p.m., 30th October.
A.4. "D.C. and L.F. Properties", 10 a.m., 31st October.
D. "Radio and Television Applications", 10 a.m., 31st October.
A.5. "New Materials", 2.30 p.m., 31st October.
C.1. "Square-Loop Materials", 5.30 p.m., 31st October.
B.1. "Microwave Introductory Session", 10 a.m., 1st November.
B.2. "Microwave Theory and Measurements", 2.30 p.m., 1st November.
C.2. "Square-Loop Applications I", 2.30 p.m., 1st November.
B.3. "Microwave Measurements and Properties", 5.30 p.m., 1st November.
C.3. "Square-Loop Applications II", 5.30 p.m., 1st November.
B.4. "Microwave Apparatus I", 10 a.m., 2nd November.
E. "Carrier Frequency Applications", 10 a.m., 2nd November.
B.5. "Microwave Apparatus II", 2.30 p.m., 2nd November.

Each session comprises from one to five papers. An admission ticket is required, which is obtainable by completing a registration form. Non-members of the Institution are required to pay a registration fee of £1.

All sessions are being held at the Institution of Electrical Engineers at Savoy Place, Victoria Embankment, London, W.C.2.

MEETINGS

I.E.E.

17th October. "The Electronic Age", Chairman's address by R. C. G. Williams, Ph.D., B.Sc.(Eng.).

19th October. "Experiments for the Electronics Laboratory", discussion to be opened by V. H. Attree, B.Sc.(Eng.) at 6 o'clock.

22nd October. "The Use of Transistors in Radio and Television", by A. J. Biggs, Ph.D., B.Sc. and E. Wolfendale, B.Sc.(Eng.).

The above meetings will be held at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2 and will commence at 5.30, except where otherwise stated.

Brit.I.R.E.

31st October. Annual General Meeting at 6 o'clock followed at 7.15 by Presidential Address of G. A. Marriott, B.A.(Cantab.), at London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.

The Television Society

25th October. "A New Picture Tube", by Dr. D. Gabŏr, F.R.S., to be held at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2. at 7 o'clock.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Values for August 1956

Date 1956 August	MSF 60 kc/s Frequency deviation from nominal*: parts in 10^9
1	0
2	−1
3	−1
4	−1
5	−1
6	−1
7	0
8	−1
9	−1
10	0
11	0
12	0
13	0
14	0
15	0
16	+1
17	−1
18	+1
19	+1
20	+1
21	+2
22	+1
23	+1
24	+1
25	N.M.
26	N.M.
27	+1
28	0
29	+1
30	+1
31	+1

N.M. = Not Measured.
*Nominal frequency is defined to be that frequency corresponding to a value of 9 192 631 830 c/s for the N.P.L. caesium resonator.

ABSTRACTS and REFERENCES

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

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

ACOUSTICS AND AUDIO FREQUENCIES

534.112 **2929**

Investigation of the Dependence of the Number of Antinodes on a Linear Elastic Body on the Tension of the Individual Mass Elements, as demonstrated by Transverse Waves on Strings.—H. Fark. (*Frequenz*, March 1956, Vol. 10, No. 3, pp. 89–91.)

534.121.1 **2930**

Vibrations of a Rectangular Plate with Distributed Added Mass.—H. Cohen & G. Handelman. (*J. Franklin Inst.*, March 1956, Vol. 261, No. 3, pp. 319–329.)

534.2-14 **2931**

An Estimate of the Effect of Turbulence in the Ocean on the Propagation of Sound.—J. A. Knauss. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, pp. 443–446.)

534.2-8-14 **2932**

The Absorption of Ultrasonic Waves in Water and its Dependence on the Temperature and Air Content of the Water.—S. K. Mukhopadhyay. (*Acustica*, 1956, Vol. 6, No. 1, pp. 25–34. In German.)

534.21-16 : 549.514.5 **2933**

Propagation of Longitudinal Waves and Shear Waves in Cylindrical Rods at High Frequencies.—H. J. McSkimin. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, pp. 484–494.) General theory is presented, and experimental results are reported for propagation at 10–25 Mc/s in fused-silica rods of radius 1·13 cm.

534.22-14 : 546.212 **2934**

Temperature Coefficient of the Speed of Sound in Water near the Turning Point.—M. Greenspan, C. E. Tschiegg & F. Breckenridge. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, p. 500.) Results of measurements at a frequency of 15·3 kc/s and temperatures between 70° and 77·5°C are presented graphically. The temperature coefficient α_c is given by the formula $-25{\cdot}9\,(T - 73{\cdot}95) \times 10^{-6}$/°C and the calculated velocity is 1 555·5 m/s at the turning point 73·95°C.

534.22-14 : 546.212 **2935**

Effect of Dissolved Air on the Speed of Sound in Water.—M. Greenspan & C. E. Tschiegg. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, p. 501.) The effect of dissolved air does not exceed 1 part in 10^5 at temperatures of 31·8° and 0°C.

534.231 **2936**

The Radiation Force on a Spherical Obstacle in a Cylindrical Sound Field.—T. F. W. Embleton. (*Canad. J. Phys.*, March 1956, Vol. 34, No. 3, pp. 276–287.) A general expression is obtained for the radiation force in terms of the complex amplitudes of spherical harmonics required to synthesize the incident field. The results are qualitatively the same as for a spherical field (1636 of 1954), but the point at which the force changes from attraction to repulsion, for a given obstacle size and sound frequency, is nearer the source.

534.232 **2937**

Directional Circular Arrays of Point Sources.—W. Welkowitz. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, pp. 362–366.) The Fourier-series solution for the radiation field of a circular current sheet presented by LePage et al. (31 of 1951) is applied to the synthesis of a sound field expressed in the form of a Tchebycheff polynomial. This leads to an exact solution in closed form for the amplitude and phase of excitation of the transducer elements when the main lobe width of the radiation pattern, the side-lobe suppression and the array circle diameter are specified. Some numerical results are given.

534.24 + [538.566 : 535.42 **2938**

Fourier-Transform Method for the Treatment of the Problem of the Reflection of Radiation from Irregular Surfaces.—W. C. Meecham. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, pp. 370–377.)

534.52 **2939**

Scattering of Sound by Sound.—U. Ingard & D. C. Pridmore-Brown. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, pp. 367–369.) "Calculations and measurements are reported of the summation and difference frequency components which are scattered from the interaction region of two sound beams in air intersecting each other at right angles."

534.64 + 621.317.73 **2940**

An Impedance Measuring Set for Electrical, Acoustical and Mechanical Impedances.—Ayers, Aspinall & Morton. (See 3149.)

534.64 **2941**

Some Notes on the Measurement of Acoustic Impedance.—O. K. Mawardi. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, pp. 351–356.) The theory of a plane-wave method of measuring the acoustic impedance of a specimen in a tube is developed and the effect of surface irregularities is investigated.

534.75 **2942**

Intelligibility of Diphasic Speech.—G. E. Peterson, E. Sivertsen & D. L. Subrahmanyam. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, pp. 404–411.) The effect on intelligibility of the switching rate at which successive portions of the speech signal are reversed in phase was investigated; the intelligibility was high at switching frequencies up to 100 c/s.

534.78 : 621.39 **2943**

The Vobanc—a Two-to-One Speech Bandwidth Reduction System.—B. P. Bogert. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, pp. 399–404.) The Vobanc (voice band compression) system is described and the characteristics of experimental equipment are given. See also 2605 of September (Kock).

534.79 **2944**

The Significance of the 'Frequency Group' for the Loudness of Sounds.—H. Bauch. (*Acustica*, 1956, Vol. 6, No. 1, pp. 40–45. In German.) Report of an experimental investigation of the effect on the subjective loudness of a complex tone of the frequency separation of the component tones, for different absolute frequencies, intensity levels and relative phases. The 'frequency group' is the term applied to a critical bandwidth; for lower values of bandwidth the ear assesses the loudness as for a single tone. Intensity fluctuations can still be perceived at frequencies < 3 c/s.

534.833.4 : 538.569.2/.3].029.6 **2945**

Absorption Devices for Centimetre Electromagnetic Waves and their Acoustic Analogues.—Meyer & Severin. (See 3037.)

534.844/.845 **2946**

Determination of the Form of Reverberation Chambers for Measurements.—G. Venzke. (*Acustica*, 1956, Vol. 6, No. 1, pp. 2–11. In German.) The influence of the shape and size of the reverberation chamber on the measurement results obtained has been investigated experimentally; procedure recommended in German Standard DIN 52212 was used. For comparison, calculations were made of the curvature to be expected in the reverberation curves for rectangular rooms of different sizes. In addition, independent measurements were made of the absorption coefficient of a particular material in two separate sets of rooms, each set ranging in volume from 83 to 258 m³. The results indicate that the uncertainty of measurements increases with decrease of room size, especially for highly absorbent materials. Rooms with non-parallel plane walls are not necessarily better than rectangular rooms.

534.846.6 **2947**

Accuracy of Matching for Bounding Surfaces of Acoustic Models.—A. F. B. Nickson & R. W. Muncey. (*Acustica*, 1956, Vol. 6, No. 1, pp. 35–39.) A theoretical study is reported of the extent to which precise matching of the specific acoustic impedance of the surfaces of the model with those of the original space is possible or necessary.

534.861.1 : 621.376.223 **2948**

Sound Transformations in Broadcasting Studio Technique, particularly by Application of Frequency Conversion.—L. Heck & F. Bürck. (*Elektronische Rundschau*, Jan. 1956, Vol. 10, No. 1, pp. 1–7.) The production of special sound effects particularly by means of a ring modulator, is discussed.

621.395.616 **2949**

Air-Stiffness Controlled Condenser Microphone.—T. J. Schultz. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, pp. 337–342.) The construction and characteristics of small microphones using rubber hydrochloride (pliofilm), vinylidene chloride (saran), or polyethylene terephthalate (mylar) membranes, are described.

621.395.623.7.012 **2950**

A Method for the Measurement of the Directivity Factor [of loudspeakers].—G. Sacerdote & C. B. Sacerdote. (*Acustica*, 1956, Vol. 6, No. 1, pp. 45–48.)

2951

621.395.625.3 + 621.395.92 + 621.396.62] : 621.314.7

Transistor Circuitry in Japan.—(See 3204.)

621.395.625.3 : 534.86 **2952**

An Acoustic Time-Regulator for Sound Recordings.—A. M. Springer. (*Elektrotech. Z.*, *Edn B*, 21st March 1956, Vol. 8, No. 3, pp. 93–96.) The reproduction of a magnetic-tape recording may be expanded or compressed in time, without changing the pitch, by changing the speed of the tape and simultaneously moving the pick-up head so as to keep their relative speed constant. This is achieved by using a quadruple rotating pick-up head in conjunction with the mechanical coupling to the tape-drive motor described. For a short description, in English, see *Electronics*, June 1956, Vol. 29, No. 6, pp. 184–188.

AERIALS AND TRANSMISSION LINES

621.315.212.011.3 **2953**

The Mean Geometrical Distances of a Circle.—H. Schering. (*Elektrotech. Z.*, *Edn A*, 1st Jan. 1956, Vol. 77, No. 1, pp. 12–13.) Simple formulae are derived for the mean distances of a circle from itself and from a surface enclosed by it. The formulae involve power series whose convergence is such that they need not be taken beyond the quadratic term. Further formulae are derived for the inductance of coaxial lines with inner conductors of various cross-sections.

621.372.2 **2954**

Theory of Helical Lines.—S. Kh. Kogan. (*C. R. Acad. Sci. U.R.S.S.*, 1st April 1956, Vol. 107, No. 4, pp. 541–544. In Russian.) The dispersion characteristics of helical lines are derived, taking into account both of the orthogonal components of the current in the case of a thin helical strip or of the field in a helical slit cut in a thin metallic cylinder. Calculated characteristics for three different conductor-width/spacing ratios are presented graphically.

621.372.2 **2955**

The Propagation of Electromagnetic Waves along a Helical Strip in a Circular Waveguide.—E. V. Anisimov & N. M. Sovetov. (*Zh. tekh. Fiz.*, Oct. 1955, Vol. 25, No. 11, pp. 1965–1971.) Theory is developed for the case of an ideally conducting strip. The e.m. wave at certain frequencies is the sum of a number of components; these are given by equations (16). The results can be applied to more complex helical systems.

621.372.2 : 621.372.8 **2956**

Electromagnetic Surface Waves in Rectangular Channels.—M. A. Miller. (*Zh. tekh. Fiz.*, Oct. 1955, Vol. 25, No. 11, pp. 1972–1982.) The conditions necessary for a surface wave to be guided by a rectangular channel are discussed; no surface waves can be present in a channel with an ideally conducting bottom. Analysis is presented for two systems which would act as waveguides: (*a*) channels with longitudinal or transverse partitions on the bottom, and (*b*) channels with curved bottom. The optimum operating conditions are established for these two cases.

621.372.8 **2957**

Transitions from the TE_{01} Mode in a Rectangular Waveguide to the TE_{11} Mode in a Circular Waveguide.—F. Mayer. (*J. Phys. Radium*, March 1956, Vol. 17, Supplement to No. 3, *Phys. appl.*, pp. 52A–53A.) Brief descriptions are given of a graded-cross-section coupling of length about 12 cm, and of a $\lambda/4$ transformer giving satisfactory operation over a 500-Mc/s band centred on 9·35 kMc/s.

621.372.8 : 538.221 : 538.614 **2958**

Ferrites in Waveguides.—G. H. B. Thompson. (*J. Brit. Instn Radio Engrs*, June 1956, Vol. 16, No. 6, pp. 311–328.) A survey covering the theory of the gyromagnetic mechanism controlling the microwave permeability of a ferrite, and of wave propagation in circular or rectangular waveguides containing longitudinally or transversely magnetized ferrites. Devices based on resonance absorption or on nonreciprocal transmission are described, including gyrators, isolators and phase circulators; the different types are compared in respect of ease of construction and performance at a single frequency or over a band. Methods of measuring the components of the ferrite permeability tensor are discussed.

621.372.8 : 621.318.134 **2959**

Broad-Band Nonreciprocal Phase Shifts—Analysis of Two Ferrite Slabs in Rectangular Guide.—S. Weisbaum & H. Boyet. (*J. appl. Phys.*, May 1956, Vol. 27, No. 5, pp. 519–524.) A differential phase shift equalized over a wide frequency band can be produced by using two ferrite slabs of different thickness and magnetic properties but magnetized in the same direction. Analysis is given for the general case. Examination of a particular example indicates that a differential phase shift of π can be obtained constant to within $\pm 2{\cdot}5\%$ over the frequency range 5·925–6·425 kMc/s using ferrite slabs 5·4 in. long in a waveguide 1·59 in. wide.

621.396.674.3 **2960**

Radiation from an Electric Dipole in the Presence of a Corrugated Cylinder.—J. R. Wait. (*Appl. sci. Res.*, 1956, Vol. B6, Nos. 1/2, pp. 117–123.) "A solution is outlined for the problem of an electric dipole which is located outside and parallel to the axis of a circular cylinder of infinite length. The corrugated surface of the cylinder is assumed to be described by an anisotropic boundary impedance which specifies the ratios of the tangential electric and magnetic fields. It is shown that, in general, the radiated field is elliptically polarized."

621.396.674.3 : 621.396.11 **2961**

Radiation from a Vertical Antenna over a Curved Stratified Ground.—Wait. (See 3190.)

621.396.677.71 **2962**

Calculated Radiation Characteristics of Slots cut in Metal Sheets: Part 2.—J. R. Wait & R. E. Walpole. (*Canad. J. Technol.*, March 1956, Vol. 34, No. 2, pp. 60–70.) "Theoretical radiation patterns are presented for antennas consisting of a notch cut in the edge of a perfectly conducting half-plane and a vanishingly thin elliptic cylinder. The principal plane patterns for these two cases are found to be very similar. The conductance of the notch is also considered." Part 1: 3160 of 1955. See also 1309 of May (Frood & Wait).

621.396.677.833 **2963**

Aerial with Wide-Lobe Radiation Pattern.—L. Thourel. (*Ann. Radioélect.*, Oct. 1955, Vol. 10, No. 42, pp. 348–354.) The design of a parabolic-reflector aerial with a sector-shaped radiation pattern is discussed, such as is desirable for long-range surveillance radar installations. Analysis indicates that the optimum radiation pattern for the primary radiator consists of a principal lobe with two counter-phased side lobes; a suitable arrangement for producing such a pattern is a twin-horn radiator. Experimental results supporting the theory are presented.

621.396.677.85 **2964**

Designing Dielectric Microwave Lenses.—K. S. Kelleher. (*Electronics*, June 1956, Vol. 29, No. 6, pp. 138–142.) Design data for Maxwell, Luneberg, Eaton, Kelleher and modified types of variable-refractive-index lenses.

AUTOMATIC COMPUTERS

681.142 **2965**

The Logical Design of an Idealized General-Purpose Computer.—A. W. Burks & I. M. Copi. (*J. Franklin Inst.*, March & April 1956, Vol. 261, Nos. 3 & 4, pp. 299–314 & 421–436.) A detailed discussion emphasizing the distinction between the logic requirements and the particular physical form of a digital computer.

681.142 **2966**

Analog Computers for the Engineer.—J. M. Carroll. (*Electronics*, June 1956, Vol. 29, No. 6, pp. 122–129.) A review of computer techniques, with tabulated data for some 20 commercially available types.

681.142 **2967**

Electronic Methods of Analogue Multiplication.—Z. Czajkowski. (*Electronic Engng*, July & Aug. 1956, Vol. 28, Nos. 341 & 342, pp. 283–287 & 352–355.) A general survey of the principles used; different systems are compared as to accuracy, speed and complexity.

681.142 **2968**

High-Speed Electronic-Analogue Computing Techniques.—D. M. MacKay. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 558–559.) Discussion on 3499 of 1955.

681.142 **2969**

An Analog Computer for the Solution of Tangents.—F. S. Preston. (*Trans. Inst. Radio Engrs*, Sept. 1955, Vol. EC-4, No. 3, pp. 101–106.) A modified Wheatstone-bridge arrangement is described, permitting computation of the tangents of angles between 0° and 90°. Only linear elements are used. The accuracy achieved is within 1 part in 2 500. The design of plug-in units is discussed.

681.142 2970

Design of Diode Function Simulators.—A. D. Talantsev. (*Avtomatika i Telemekhanika*, Feb. 1956, Vol. 17, No. 2, pp. 129–139.)

681.142 : 061.3 2971

Digital Computer Techniques.—D. B. G. Edwards. (*Nature, Lond.*, 9th June 1956, Vol. 177, No. 4519, pp. 1069–1071.) Brief report of a convention held at the Institution of Electrical Engineers, London, in April 1956. 58 papers were presented; the full text, together with reports of the discussion, is to be published in three sections as a supplement to *Proc. Instn elect. Engrs*, Part B.

681.142 : 621.374.3 2972

A Variable Multiple Pulse-Stream Generator.—W. Woods-Hill. (*Electronic Engng*, July 1956, Vol. 28, No. 341, pp. 306–307.) Apparatus designed for checking the logic of electronic computer circuits which require numerous pulse streams for their operation is described. The electrostatic pickup described previously (1632 of June) is used.

681.142 : 621.384.612 2973

Analog Computer for the Differential Equation $y'' + f(x)y + g(x) = 0$.—E. Bodenstedt. (*Rev. sci. Instrum.*, April 1956, Vol. 27, No. 4, pp. 218–221.) A high-precision electromechanical system developed from that mentioned previously (830 of 1955) uses a torsion pendulum whose motion corresponds to the given expression; the solutions are obtained from photographic records of the motion.

681.142 : 621.385.132 2974

Binary Adder uses Gas-Discharge Triode.—Maynard. (See 3261.)

681.142.002.2 2975

Pulse Circuits fabricate Computer Code Disk.—E. M. Jones. (*Electronics*, June 1956, Vol. 29, No. 6, pp. 146–149.) "Frequency divider, counter, gate and wave-shaping circuits control optical circle-dividing machine to produce 16-bit pattern on photosensitive glass disk. Used for analog-to-digital conversion, the code disk has a pattern accuracy of ±0·0001 inch and can be made in about 2 hours." For another account, see *Proc. nat. Electronics Conf., Chicago*, 1955, Vol. 11, pp. 288–299 (Jones et al.).

681.142 2976

An Introduction to Electronic Analogue Computers. [Book Review]—C. A. A. Wass. Publishers: Pergamon Press, London, 1955, 237 pp., 40s. (*Brit. J. appl. Phys.*, April 1956, Vol. 7, No. 4, p. 157.)

CIRCUITS AND CIRCUIT ELEMENTS

621.3.018.3 2977

An Experimental Investigation of Subharmonic Oscillations in a Nonlinear System.—K. Göransson & L. Hansson. (*Kungl. tek. Högsk. Handl., Stockholm*, 1956, No. 97, 16 pp. In English.) Forced subharmonic oscillations in a circuit containing an iron core are studied. Damping is reduced by means of feedback, so that measurements can be effected at very low driving voltages and subharmonics up to the ninth. Results are in good agreement with theory developed by Lundquist (1269 of May) for low driving voltages.

621.316.8 : 621.372.44 : 621.314.26 2978

Frequency Conversion with Positive Nonlinear Resistors.—C. H. Page. (*J. Res. nat. Bur. Stand.*, April 1956, Vol. 56, No. 4, pp. 179–182.) Positive nonlinear resistors are defined as two-terminal devices through which the current I is a real finite single-valued nondecreasing function of the voltage V across the terminals, with the added condition that $I(0) = 0$. When subjected to an almost periodic voltage such a resistor will absorb power at some frequencies and supply power at other frequencies. Analysis indicates that modulation efficiency cannot exceed unity, that subharmonics are not produced, and that the efficiency of generating an nth harmonic cannot exceed $1/n^2$.

621.318.4 2979

Winding Focus Coils with Aluminium Foil.—(*Electronics*, July 1956, Vol. 29, No. 7, pp. 244..252.) Coils of Al foil with a thin coating of Al oxide are wound with no additional insulation.

621.319.4 : 621.315.615.9 2980

Polychloronaphthalene-Impregnated-Paper Capacitors.—J. Coquillion. (*Rev. gén. Élect.*, March 1956, Vol. 65, No. 3, pp. 185–193.) Polychloronaphthalene waxes are particularly suitable for use as impregnants in paper-dielectric capacitors, having stable characteristics at temperatures as high as 110°C or over. In certain cases an aging effect is avoided by allowing the wax to cool from the liquid to the solid state under the influence of an a.c. or d.c. field. This phenomenon is discussed in relation to the dipole nature of the waxes.

621.319.4 : 621.317.3 : 681.142 2981

Industrial Measurement of the Temperature Coefficient of Ceramic-Dielectric Capacitors.—Peyssou & Ladefroux. (See 3136.)

621.319.45 2982

Tantalum Solid Electrolytic Capacitors.—D. A. McLean & F. S. Power. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, pp. 872–878.) A capacitor with low volume/capacitance ratio is obtained by forming a layer of Ta_2O_5 on a porous Ta anode and then depositing a number of coatings of MnO_2 to form a solid electrolyte. The unit is further coated with graphite, and a layer of Pb-Sn alloy is sprayed on to form the cathode. Temperature, frequency and life characteristics are reported.

621.372 2983

Inter-reciprocity applied to Electrical Networks.—J. L. Bordewijk. (*Appl. sci. Res.*, 1956, Vol. B6, Nos. 1/2, pp. 1–74.) A new concept, 'inter-reciprocity', is introduced which is useful in the study of nonreciprocal networks. When a particular topological operation termed 'transposition' is performed on a given linear network, the initial network and the resulting transposed network are said to be inter-reciprocal. Application of the theory to a variety of general and special circuit problems is illustrated; the noise properties of gyrator, triode and transistor networks are discussed.

621.372 : 621.3.018.752 : 621.397.8 2984

The Effect upon Pulse Response of Delay Variation at Low and Middle Frequencies.—M. V. Callendar. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 475–478.) "Calculations are given for the magnitude and form of the distortion introduced into a square wave by a network or system which exhibits uniform transmission except for increasing (or decreasing) phase delay in the low-mid-frequency region. The fractional peak distortion is found to be equal to twice the area under the curve relating T_n to frequency, where T_n is the delay relative to that at high frequencies. The waveform of the distortion is given for several simple shapes of curve for T_n. This distortion is especially characteristic of vestigial-sideband systems, and occurs in television as a 'pre-shoot' before a transition and as a smear (in principle equal, but opposite, to the pre-shoot) after it."

621.372.012 2985

Feedback Theory—Further Properties of Signal Flow Graphs.—S. J. Mason. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, pp. 920–926.) Continuation of theory presented previously (3531 of 1953).

621.372.41 : 621.318.424 2986

Transient Behavior in a Ferroresonant Circuit.—J. G. Skalnik. (*J. appl. Phys.*, May 1956, Vol. 27, No. 5, pp. 508–513.) An analysis is made of the response to a sinusoidal voltage of a circuit including a nonlinear inductor. For certain frequency values of the applied voltage there are three possible values for the flux in the inductor, of which the middle value is unstable. The differential equation representing the circuit has been solved using an analogue computer. For the case when the system is released in the region of the lower stable state, the solution corresponds to two sinusoidal oscillations of different amplitude and frequency. If the system is released in the region of the upper stable state, the solution corresponds to an oscillation modulated in amplitude and phase, for certain values of the parameters.

621.372.413 : 621.317.337 2987

Measurement of the Q-Factor of Cavity Resonators, using a Straight Test Line.—Urbarz. (See 3141.)

621.372.44 : 621.372.6 2988

Some General Properties of Nonlinear Elements: Part 1—General Energy Relations.—J. M. Manley & H. E. Rowe. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, pp. 904–913.) An analysis is made of power relations in networks with reactive nonlinear elements. Two equations are derived relating the powers at different frequencies; the only assumption introduced is that the nonlinear characteristic is single-valued. The theory is relevant to the operation of modulators, demodulators and harmonic generators.

621.372.5(083.5) 2989

Tables of Phase of a Semi-infinite Unit Attenuation Slope.—D. E. Thomas. (*Bell Syst. tech. J.*, May 1956, Vol. 35, No. 3, pp. 747–749.) The five-figure tables published previously (968 of 1948) are to appear together with newly prepared seven-figure tables as *Bell System Monograph* 2550.

621.372.51 : 621.372.22 2990

Fundamentals in the Synthesis of Loss-Free Quadripoles from Lines with Continuous Nonuniformities.—H. Meinke. (*Nachrichtentech. Z.*, March 1956, Vol. 9, No. 3, pp. 99–106.) The synthesis is facilitated by appropriate choice of line coordinates and a polynomial representation of the characteristic impedance. Application to problems of wide-band transformation and matching are illustrated.

621.372.51 : 621.396.67 2991

Impedance Quadripoles for the Frequency Compensation of Aerial Input Impedance.—R. Herz. (*Nachrichtentech. Z.*, March 1956, Vol. 9, No. 3, pp. 128–133.) Networks with one or two frequency-independent resistances are discussed which are capable of effecting wide-band matching with lower losses than reactive circuits at frequencies up to 1 kMc/s or above. Composite coaxial-line sections are used; in an application to a dipole aerial for use with a parabolic-cylinder reflector, the compensating coaxial line serves as support for the dipole.

621.372.54 : 621.375.132 : 621.3.018.75 2992

Normalized Representation of Transients in Filter Amplifiers with Double-T Elements.—H. Dobesch. (*Hochfrequenztech. u. Elektroakust.*, Jan. 1956, Vol. 64, No. 4, pp. 102–107.) The response of amplifiers with frequency-dependent negative feedback is analysed for various pulse and step waveforms; the frequency spectrum corresponding to a train of square pulses is determined.

621.372.542.2 2993

A Solution to the Approximation Problem for *RC* Low-Pass Filters.—K. L. Su & B. J. Dasher. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, pp. 914–920.) A method of synthesizing filters is described in which elliptic functions are used to effect a transformation in the complex-frequency plane which results in a symmetrical arrangement of the zeros and poles. Some design charts are included.

621.372.57 : [621.385 + 621.314.7 2994

A Particular Case of the Application of the Matrix Method to Radio Engineering.—B. Ya. Yurkov. (*Zh. tekh. Fiz.*, Oct. 1955, Vol. 25, No. 11, pp. 1988–1993.) Use of the matrix method in analysis of the operation of quadripoles including thermionic valves or transistors is discussed. A simple method is proposed for carrying out the necessary transformations to the formulae on passing from the one case to the other.

621.373 + 621.375.9] : 538.561.029.6 2995

Application of Electron Spin Resonance in a Microwave Oscillator or Amplifier.—Combrisson, Honig & Townes. (See 3032.)

621.373.421 2996

Constant-Frequency Oscillators.—L. B. Lukaszewicz. (*Wireless Engr*, Aug. 1956, Vol. 33, No. 8, pp. 201–202.) Comment on 697 of March (Gladwin).

621.373.421 2997

Bridge-Stabilized Oscillators and their Derivatives.—E. J. Post & J. W. A. van der Scheer. (*J. Brit. Instn Radio Engrs*, June 1956, Vol. 16, No. 6, pp. 345–350.) Reprinted from *PTT-Bedrijf*, Sept. 1955, Vol. 6, No. 4. General analysis is presented for the operation of the bridge-stabilized feedback oscillator, and modifications obtained by interchanging bridge elements crosswise or by unbalancing the bridge are discussed.

621.373.421.13 : 621.372.412 : 621.316.726 2998

Frequency Stability and Quartz-Controlled Oscillators.—A. Erkens. (*Ann. Radioélect.*, Oct. 1955, Vol. 10, No. 42, pp. 399–405.) The operation of some commonly used types of crystal-controlled oscillator is reviewed. Frequency can be held constant to within a factor of 10^{-8} over a period of months by using a Y-bar crystal resonator.

621.373.431.1 2999

Bistable Circuits using Triode-Pentodes.—H. L. Armstrong. (*Electronics*, July 1956, Vol. 29, No. 7, pp. 210..214.) Note on the operation of multivibrator-type circuits in which one feedback path is provided by connecting triode anode to pentode screen, leaving one grid free for triggering, gating or modulation.

621.373.432 3000

Simple Method for producing H.F. Pulses of Short Duration and Large Amplitude.—A. V. J. Martin. (*J. Phys. Radium*, March 1956, Vol. 17, No. 3, p. 310.) Pulses of duration about 10 μs and peak-to-peak amplitude about 240 V are obtained from the tuned secondary of a transformer in the cathode circuit of a thyratron.

621.373.52 + 621.375.4] : 621.314.7 3001

Applications for Tandem Transistors.—H. E. Hollmann. (*Tele-Tech & Electronic Ind.*, Feb. 1956, Vol. 15, No. 2, pp. 58–59..114.) The tandem transistor, consisting of two transistors housed in a single container and cascaded so that one acts as the base leak for the next, may be used as an amplifier with high input impedance and in various applications in which single grounded-emitter stages are normally used.

621.373.52.029.3 3002

Superregenerative Transistor Oscillator.—R. J. Kircher & I. P. Kaminow. (*Electronics*, July 1956, Vol. 29, No. 7, pp. 166–167.) The circuit described generates pulses of 500-c/s tone at a rate of 7/sec. The performance with different values of quench capacitor, bias, feedback, etc. is shown graphically.

621.374 3003

Investigation of Special Frequency Dividers with Large Dividing Ratio.—E. O. Philipp. (*Z. angew. Phys.*, March 1956, Vol. 8, No. 3, pp. 119–126.) Two frequency dividers and one pulse counter are developed on the basis of Kroebel's work (383 of 1955). These give stable dividing ratios of 100 and 200 at input pulse frequencies of 4 Mc/s and 31·25 kc/s respectively. The counter can handle irregular pulses spaced at intervals of 1–50 ms.

621.374.3 : 621.385.5.032.24 3004

A New High-Slope Multigrid Valve and its Application in Pulse and Switching Circuits.—Gosslau & Guber. (See 3262.)

621.374.32 : 621.314.7 3005

A Point-Contact Transistor Scaling Circuit with 0·4-μs Resolution.—G. B. B. Chaplin. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 505–509. Discussion, pp. 516–518.) Simple circuits using normal point-contact transistors are described; features contributing to the short resolving time are the prevention of bottoming of collector potential and the absence of capacitors. A typical scale-of-ten circuit uses seven transistors, seven pulse transformers and 14 crystal diodes. Wide tolerances on the transistor parameters are permissible.

621.374.32 : 621.314.7 3006

A Junction-Transistor Scaling Circuit with 2-μs Resolution.—G. B. B. Chaplin & A. R. Owens. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 510–515. Discussion, pp. 516–518.) The basic circuit discussed is a binary scaler using a differentiating transformer instead of capacitors for coupling; the speed of operation thus depends only on the transistor characteristics. Scale-of-5 and scale-of-10 circuits built up from the basic circuit are described.

621.375.2 : 621.385.3.029.63 3007

Disc-Seal Triode Amplifiers.—G. Craven. (*Wireless Engr*, Aug. 1956, Vol. 33, No. 8, pp. 179–183.) "The design of a resonant π-type coupling network for disc-seal triodes operating in the earthed-grid connection at frequencies in the range 300–3 000 Mc/s is considered. A coaxial form of line is adopted. Tuning for a small range can be by a 'screw' or, for a larger range, by a built-in capacitance. Complete amplifiers can give 100-W output and 30-dB gain using three stages."

621.375.2 : 621.385.5 : 621.314.7 3008

Higher Pentode Gain.—L. Levy. (*Electronics*, July 1956, Vol. 29, No. 7, pp. 190..196.) Note on the use of a transistor as an anode load.

621.375.232.029.3 : 621.396.822 3009

Noise in an Amplifier Stage with Negative Voltage Feedback.—H. Nottebohm. (*Elektronische Rundschau*, March 1956, Vol. 10, No. 3, pp. 57–62.) The problem is considered with particular reference to the input circuit of an amplifier for a magnetic tape recorder. Analysis indicates that frequency distortion inherent in the system can be corrected by use of negative feedback at the input valve, and indicates the existence of an optimum ratio for the input transformer, from the point of view of signal/noise ratio.

621.375.232.3.029.3 3010

Triode Cathode-Followers for Impedance Matching to Transformers and Filters.—T. J. Schultz. (*Trans. Inst. Radio Engrs*, March/April 1955, Vol. AU-3, No. 2, pp. 28–37.) Design curves derived from measurements on five different types of triode are presented.

621.375.232.9 3011

An Improved Type of Differential Amplifier.—J. C. S. Richards. (*Electronic Engng*, July 1956, Vol. 28, No. 341, pp. 302–305.) "A differential amplifier stage capable of giving a high rejection ratio with unselected valves and components and without a balance control is analysed, and a particular amplifier is described in some detail. The stage is particularly suitable for converting balanced to unbalanced signals."

621.375.3 3012

Comparison of some Magnetic-Amplifier Circuits with Internal Feedback.—A. B. Gorodetski. (*Avtomatika i Telemekhanika*, Feb. 1956, Vol. 17, No. 2, pp. 147–159.)

621.375.3 3013

Push-Pull Magnetic Amplifier with Direct-Current Output.—R. Kh. Bal'yan. (*Avtomatika i Telemekhanika*, Feb. 1956, Vol. 17, No. 2, pp. 160–171.)

621.375.3 : 621-526 3014

Decicycle Magnetic-Amplifier Systems for Servos.—L. J. Johnson & S. E. Rauch. (*Elect. Engng, N.Y.*, March 1956, Vol. 75, No. 3, p. 243.) Digest of paper published in *Trans. Amer. Inst. elect. Engrs*, Part I, *Communication and Electronics*, 1955, Vol. 74, pp. 667–672. Improvements in circuitry and core materials, and the adoption of pulse techniques, make possible systems whose response times are one tenth to one hundredth of a cycle of the power-supply frequency.

621.376.22 : 621.318.134 3015

A Ferrite Microwave Modulator employing Feedback.—W. W. H. Clarke, W. M. Searle & F. T. Vail. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 485–490.) An amplitude modulator with good linearity is obtained by applying feedback to a gyrator comprising a ferrite rod in a circular waveguide section interposed between rectangular waveguide sections. The feedback circuit is based on linear detection of the amplitude modulation by means of a crystal. Limitations of the arrangement are discussed. Good results have been obtained with sinusoidal modulating signals of frequencies up to 20 kc/s.

621.37/.39(083.74) **3016**

Handbook Preferred Circuits, Navy Aeronautical Equipment, NAVAER 16-1-519. [Book Review]—J. C. Muncy. Publishers: Government Printing Office, Washington, $1.75. (*Tech. News Bull. nat. Bur. Stand.*, May 1956, Vol. 40, No. 5, pp. 66–67.) Gives design details and characteristics of the standardized circuits discussed previously (342 of February). Supplements are to be issued from time to time.

621.375.13 **3017**

Linear Feedback Analysis. [Book Review]—J. G. Thomason. Publishers: Pergamon Press, London, 365 pp., 55s. (*J. Instn elect. Engrs*, March 1956, Vol. 2, No. 15, p. 187). A useful introduction to the subject.

GENERAL PHYSICS

537 : 538.56 **3018**

Electron Plasma Oscillations in an External Electric Field.—A. I. Akhiezer & A. G. Sitenko. (*Zh. eksp. teor. Fiz.*, Jan. 1956, Vol. 30, No. 1, pp. 216–218.) The oscillation frequency is calculated, assuming that the electron distribution function satisfies a given kinetic equation.

537.2 **3019**

Fields and Stresses in Dielectric Media.—G. Power. (*Brit. J. appl. Phys.*, April 1956, Vol. 7, No. 4, pp. 137–144.) Expressions are obtained for the mechanical forces at the boundary of an isotropic dielectric, caused by an electric field. Results are verified in particular cases by electrolyte-tank experiments.

537.311.1 **3020**

On the Energy Dissipation of Conduction Electrons undergoing Elastic Scattering by Impurities.—T. Yamamoto, K. Tani & K. Okada. (*Progr. theor. Phys.*, Feb. 1956, Vol. 15, No. 2, pp. 184–185.) A brief theoretical note on the mechanism responsible for the energy dissipation in conduction in metals.

537.311.31 : 537.312.8 **3021**

Theory of Galvanomagnetic Phenomena in Metals.—I. M. Lifshits, M. Ya. Azbel' & M. I. Kaganov. (*Zh. eksp. teor. Fiz.*, Jan. 1956, Vol. 30, No. 1, pp. 220–222.) The theory is developed without making any special assumptions regarding the conduction-electron dispersion law and the form of the collision integral.

537.311.62 **3022**

Anomalous Skin Effect assuming Arbitrary Collision Integral.—M. Ya. Azbel' & E. A. Kaner. (*Zh. eksp. teor. Fiz.*, Dec. 1955, Vol. 29, No. 6(12), pp. 876–878.) Results of a calculation of the surface impedance $Z_\alpha = R_\alpha + iX_\alpha$, show that the ratio X_α/R_α equals $\sqrt{3}$ for an arbitrary electron-dispersion law and an arbitrary collision integral; Z_α is proportional to $\omega^{2/3}$ and is independent of temperature in the anomalous-skin-effect temperature range.

537.5 **3023**

Statistics of Electron Avalanches in a Uniform Field.—L. Frommhold. (*Z. Phys.*, 7th Feb. 1956, Vol. 144, No. 4, pp. 396–410.) The statistical distribution of the number of charge-carrier pairs about the mean was determined experimentally by measurements on discharges in ethyl alcohol. Results agree with theory.

537.523 **3024**

Surge Voltage Breakdown of Air in a Non-uniform Field.—J. H. Park & H. N. Cones. (*J. Res. nat. Bur. Stand.*, April 1956, Vol. 56, No. 4, pp. 201–224.) Experiments on discharges between a spherical and a plane electrode are described, and a tentative explanation of the breakdown mechanism is presented.

537.525 : 538.56.029.5 **3025**

Investigation of a Discharge in the Frequency Region between High Frequency and Audio Frequency at Low Gas Pressure.—N. A. Popov & N. A. Kaptsov. (*Zh. eksp. teor. Fiz.*, Jan. 1956, Vol. 30, No. 1, pp. 68–76. English summary, *ibid.*, Supplement, p. 5.)

537.525 : 538.56.029.6 **3026**

Investigation of the High-Frequency Discharge.—G. M. Pateyuk. (*Zh. eksp. teor. Fiz.*, Jan. 1956, Vol. 30, No. 1, pp. 12–17. English summary, *ibid.*, Supplement, p. 3.) The dependence of the ignition and operating potentials in Ar, Ne and H_2 on the gas pressure and the geometry of the discharge space was investigated in the frequency range 57–500 Mc/s. Results, presented graphically, are in agreement with the diffusion theory of Herlin & Brown (690 of 1949).

537.533 **3027**

Influence of an Adsorbed Film of Dipole Molecules on the Electron Work Function of a Metal.—N. D. Morgulis & V. M. Gavrilyuk. (*Zh. eksp. teor. Fiz.*, Jan. 1956, Vol. 30, No. 1, pp. 149–159. English summary, *ibid.*, Supplement, p. 7.) Experimental results indicate that films of CsCl molecules decrease the work function of W by up to 1·8 eV, as compared with a decrease of up to 3 eV produced by Cs, 3·5 eV by BaO and 2·9 eV by Ba.

537.533.8 **3028**

Auger Electron Emission in the Energy Spectra of Secondary Electrons from Mo and W.—G. A. Harrower. (*Phys. Rev.*, 15th April 1956, Vol. 102, No. 2, pp. 340–347.) Analysis of the observed energy distributions of the secondary electrons for a range of primary energies reveals subsidiary maxima at points along the energy axis characteristic of the target material but independent of the primary voltage; the positions of these points are consistent with an Auger-process origin for the electrons with these energies.

537.533.8 : 546.561-31 **3029**

Investigation of the Inelastic Reflection of Electrons by a Cuprous Oxide Surface.—N. B. Gornyi. (*Zh. eksp. teor. Fiz.*, Jan. 1956, Vol. 30, No. 1, pp. 160–170. English summary, *ibid.*, Supplement, pp. 7–8.) The energy losses of electrons on reflection at monocrystalline or polycrystalline Cu_2O surfaces are equal to the energy required to transfer electrons of the crystal lattice from filled to permitted zones. The mechanism involved is similar to that responsible for the appearance of discrete groups of true secondary electrons (685 of 1955).

538.311 **3030**

Production and Use of High Transient Magnetic Fields: Part 1.—H. P. Furth & R. W. Waniek. (*Rev. sci. Instrum.*, April 1956, Vol. 27, No. 4, pp. 195–203.) Technique for the production of pulsed magnetic fields of strength 5×10^5 G or over is discussed; capacitor-discharge arrangements are used, with impact-resistant solenoids comprising massive single-layer helices. Pulse durations range from 50 μs to 10 ms. Measurement of the magnetoresistance of Ge is one of the applications mentioned.

538.56 : 53 **3031**

Radio-Frequency Physics.—J. G. Powles. (*Nature, Lond.*, 2nd June 1956, Vol. 177, No. 4518, pp. 1022–1023.) Brief report of the 1956 annual conference, held at Geneva, of the organization A.M.P.É.R.E. (Atomes et Molécules par Études Radioélectriques), which is concerned with the use of radio frequencies in the various branches of physics. Some 50 papers were presented, the subjects including dielectric and magnetic properties, electron resonance of various types and associated effects, and microwave spectroscopy. See also *Onde élect.*, May 1955, Vol. 35, No. 338, pp. 437–505, which gives papers from the 1954 conference, held at Paris, covering a similar range of subjects and including also some material on atmospheric physics.

538.561.029.6 : [621.373 + 621.375.9 **3032**

Application of Electron Spin Resonance in a Microwave Oscillator or Amplifier.—J. Combrisson, A. Honig & C. H. Townes. (*C. R. Acad. Sci., Paris*, 14th May 1956, Vol. 242, No. 20, pp. 2451–2453.) A brief analysis indicates the condition for a paramagnetic substance located within a cavity resonator and subjected to a direct magnetic field to supply power instead of absorbing it from the field. Results of preliminary experiments indicate that it should be possible to produce oscillations using e.g. a small sample of Si containing a suitable impurity providing a concentration of about 10^{17} paramagnetic centres per cm^3.

538.566 : 535.337 **3033**

Radiation from Molecules in the Presence of a Strong High-Frequency Field.—V. M. Fain. (*Zh. eksp. teor. Fiz.*, Dec. 1955, Vol. 29, No. 6(12), pp. 878–880.) It is shown that in addition to an absorption of the h.f. energy at a frequency $\omega \simeq \omega_0 = (E_1 - E_2)/h$, where E_1 and E_2 are energy levels of the molecule, emission takes place at a frequency Ω_0 which is a function of the matrix element $\vec{\mu_{12}}$ of the dipole moment corresponding to the transition $E_1 \rightarrow E_2$ and the field strength of the h.f. field. In a typical case $|\vec{\mu_{12}}| \simeq 10^{-18}$ c.g.s.e. and the field strength is 1–10 c.g.s.e.; the value of Ω_0 is then approximately 10^9 sec^{-1} – 10^{10} sec^{-1}. The radiation is only present if the elements $\vec{\mu_{11}}$ and $\vec{\mu_{22}}$ are not equal to zero.

538.566 : 535.42] + 534.24 **3034**

Fourier Transform Method for the Treatment of the Problem of the Reflection of Radiation from Irregular Surfaces.—W. C. Meecham. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, pp. 370–377.)

538.566 : 537.533.9 **3035**

Incidence of an Electromagnetic Wave on a 'Čerenkov Electron Gas'.—M. A. Lampert. (*Phys. Rev.*, 15th April 1956, Vol. 102, No. 2, pp. 299–304.) Analysis is presented for the interaction of an e.m. wave in a retarding medium (e.g. a dielectric) with an electron gas moving through or near the medium at a velocity exceeding that of the wave in the medium. For electron densities exceeding a critical value, the gas acts as a mirror for the incident e.m. wave. Possible laboratory experiments for investigating the problem are outlined.

538.566.2 **3036**

Method of calculating Electromagnetic Fields excited by an Alternating Current in Stratified Media.—A. N. Tikhonov & D. N. Shakhsuvarov. (*Bull. Acad. Sci. U.R.S.S., sér. géophys.*, March 1956, No. 3, pp. 245–251. In Russian.) The expressions for the field due to a dipole in the boundary of a stratified half-space are developed in a form suitable for evaluation by a modern computer. The e.m. characteristics of the strata are assumed to be independent of time and of the field; the permeability is constant and the conductivities are arbitrary; the conductivity of the surface layer is finite.

538.569.2/.3].029.6 : 534.833.4 **3037**

Absorption Devices for Centimetre Electromagnetic Waves and their Acoustic Analogues.—E. Meyer & H. Severin. (*Z. angew. Phys.*, March 1956, Vol. 8, No. 3, pp. 105–114.) A survey of the operating mechanism of three types of absorbers: (*a*) homogeneous material, (*b*) wedges, and (*c*) resonance absorbers.

538.6 : 537.311.31 **3038**

Thermo- and Galvano-magnetic Effects in Strong Fields at Low Temperatures.—G. E. Zil'berman. (*Zh. eksp. teor. Fiz.*, Dec. 1955, Vol. 29, No. 6(12), pp. 762–769.) Thermoelectric force, resistance and Hall effect of a metal in a magnetic field at low temperatures are calculated using a two-zone model of the metal.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.16 **3039**

An Investigation of Monochromatic Radio Emission of Deuterium from the Galaxy.—G. J. Stanley & R. Price. (*Nature, Lond.*, 30th June 1956, Vol. 177, No. 4522, pp. 1221–1222.)

525.2 : 523.2 **3040**

Gravitational Influence of Jupiter on some Geophysical Phenomena.—D. Argentieri. (*Ann. Geofis.*, Oct. 1955, Vol. 8, No. 4, pp. 457–473.) Consideration of astronomical observations from ancient times onwards has indicated apparent variations in astronomical time. Attention is drawn particularly to a variation having a period of 83 years; this is also the period taken by the sun, the earth and Jupiter to return to the same alignment and relative distance. It is suggested that the combined gravitational action of the sun and Jupiter causes tidal motion in the earth's crust, the apparent variation of astronomical time corresponding to a real displacement of the meridian.

551.510.5 : 538.569.4.029.6 : 523.72 **3041**

Atmospheric Attenuation of Solar Millimeter-Wave Radiation.—H. H. Theissing & P. J. Caplan. (*J. appl. Phys.*, May 1956, Vol. 27, No. 5, pp. 538–543.) Measurements have been made of the absorption of solar radiation by atmospheric water vapour at wavelengths down to about 1 mm. The results are combined with theoretical formulae for the absorption spectrum of water vapour [see e.g. 3100 of 1947 (Van Vleck)].

551.510.53 : 551.593 **3042**

Origin of the Meinel Hydroxyl System in the Night Airglow.—D. R. Bates & B. L. Moiseiwitsch. (*J. atmos. terr. Phys.*, June 1956, Vol. 8, No. 6, pp. 305–308.)

551.510.53 : 551.593 + 551.594.5] : 535.241 **3043**

A Photometric Unit for the Airglow and Aurora.—D. M. Hunten, F. E. Roach & J. W. Chamberlain. (*J. atmos. terr. Phys.*, June 1956, Vol. 8, No. 6, pp. 345–346.)

551.510.534 **3044**

Note on the Variations of Atmospheric Ozone as a Function of Height.—E. S. Epstein, C. Osterberg & A. Adel. (*J. atmos. terr. Phys.*, June 1956, Vol. 8, No. 6, pp. 347–348.) Observations confirming those of Paetzold (748 of March) are reported.

551.510.535 **3045**

Symposium on Ionospheric Drifts.—(*J. sci. industr. Res.*, Oct. 1955, Vol. 14A, No. 10, pp. 482–485.) Brief report of symposium held at New Delhi in July 1955.

551.510.535 **3046**

Accurate Height Measurements using an Ionospheric Recorder.—A. J. Lyon & A. J. G. Moorat. (*J. atmos. terr. Phys.*, June 1956, Vol. 8, No. 6, pp. 309–317.) "A method for the calibration of an ionospheric recorder is described, which corrects errors in height measurement arising from the distortion of the echo-pulse in its passage through the receiver. The amount of this error depends on the echo amplitude, and is shown to vary in an approximately linear manner with the width of the recorded echo trace. Several methods of checking the calibration confirm that it is reliable to within ± 2 km. Using a calibrated recorder and an expanded timebase, it is possible to measure E-region equivalent heights to this order of accuracy. The systematic error due to pulse distortion will, in general, cause the heights recorded in routine ionospheric measurements to be from 5 to 15 km too high. Some consequences of this, e.g. for m.u.f. predictions, are mentioned."

551.510.535 **3047**

Monthly Mean Values of Ionospheric Characteristics at Rome in the Period March 1949–April 1953.—P. Dominici. (*Ann. Geofis.*, Oct. 1955, Vol. 8, No. 4, pp. 379–400.) Hourly values are tabulated for the critical frequency and virtual height of the F_2, F_1 and E layers and for the percentage of occurrences of the E_s layer. Brief particulars are given of the sounding schedule operated and the conventions adopted in the calculations.

551.510.535 **3048**

Sporadic Echoes from the E Region over Ahmedabad (23° 02′ N, 72° 38′ E).—K. M. Kotadia. (*J. atmos. terr. Phys.*, June 1956, Vol. 8, No. 6, pp. 331–337.) An analysis is made of *h′f* records for the sunspot-minimum period 1953–1954. The diurnal and seasonal variations of E_s as a whole are interpreted as variations in the relative contributions of three distinct types of E_s, namely (*a*) E_{sc}, a thin layer observed at 95–100 km, with a maximum frequency of occurrence at late evening, (*b*) E_{sn}, which is observed at 105–125 km with a minimum in the afternoon and maximum towards the end of the night, and (*c*) E_{ss}, at 115–125 km, developed by the vertical downward movement of the E_2 layer and observed only during the daytime.

551.510.535 **3049**

A New Theory of Formation of the F_2 Layer.—T. Yonezawa. (*J. Radio Res. Labs, Japan*, Jan. 1956, Vol. 3, No. 11, pp. 1–16.) Electron/ion pairs generated in the upper part of the F_2 region diffuse rapidly downwards under gravity, but at sufficiently low heights they are rapidly lost by the mechanism of charge transfer and dissociative recombination suggested by Bates & Massey (1944 of 1948), giving rise to a maximum ionization density at a greater height. This theory gives results in accordance with observations.

551.510.535 **3050**

The Structure of the F_2 Layer as deduced from its Daily Variations.—T. Shimazaki. (*J. Radio Res. Labs, Japan*, Jan. 1956, Vol. 3, No. 11, pp. 17–43.) Observed variations in the F_2 region may be accounted for by assuming that (*a*) in consequence of the decrease with height of the effective decay coefficient, the maximum electron density in the F_2 region is at a level above that of maximum electron production, and that (*b*) vertical semidiurnal tidal drift is nonuniform. At the level of maximum electron production the rate of production varies inversely as temperature. An attachment coefficient of $8{\cdot}3 \times 10^{-5}$/sec at 300 km is indicated, with a solar temperature of 6 000° K.

551.510.535 **3051**

Geomagnetic Control to the Diurnal Variation of the F_2 Layer on the Temperate Latitude.—Syun-ichi Akasofu. (*Sci. Rep. Tohoku Univ., 5th Ser., Geophys.*, Nov. 1955, Vol. 7, No. 2, pp. 45–50.) The 'longitude effect' demonstrated by Appleton (882 of 1951) is examined. The observed diurnal variation is consistent with geomagnetic control of the thermal vertical flow in the F_2 region. Seasonal variations are also observed.

551.510.535 : 523.746.5 **3052**

Comparison of f_0F_2 at Four Observatories in Japan.—I. Kasuya & K. Sawada. (*J. Radio Res. Labs, Japan*, Jan. 1956, Vol. 3, No. 11, pp. 45–53.) Observations over the solar-activity half-cycle 1947–1954 are correlated with sunspot numbers. On a long-term basis, the magnitude of the variation of f_0F_2 is a function of latitude.

551.510.535 : 537.56 **3053**

Negative Oxygen Ions in the Upper Atmosphere: the Affinity and Radiative Attachment Coefficient of Atomic Oxygen.—L. M. Branscomb & S. J. Smith. (*Trans. Amer. geophys. Union*, Oct. 1955, Vol. 36, No. 5, pp. 755–758.) "The influence of negative ions of atomic oxygen on the physics of the ionosphere and night airglow is re-examined in the light of new experimental determinations of the oxygen affinity ($1{\cdot}48 \pm 0{\cdot}10$ eV) and photodetachment cross section [396 of February (Smith & Branscomb)]. The radiative attachment coefficient is calculated from the photodetachment cross section. There is no evidence of a resonance at the threshold, where the attachment coefficient is approximately $1{\cdot}2 \times 10^{-15}$ cm³/sec."

551.510.535 : 621.396.11 **3054**

Observations of Ionospheric Absorption at the K.N.M.I. [Royal Netherlands Meteorological Institute]. —C. J. van Daatselaar. (*Tijdschr. ned. Radiogenoot.*, March 1956, Vol. 21, No. 2, pp. 49–63.) Theory of ionospheric absorption is outlined and measurement difficulties due to fading are discussed. The procedure at the Netherlands station is to determine the apparent reflection coefficient for vertically incident waves, using pulse transmissions with c.r.o. display of the echo amplitude; total absorption and absorption index are hence derived. The equipment is described and some results are reported.

551.510.535 : 621.396.11 **3055**

On the Existence of a 'Q.L.'-'Q.T.' 'Transition-Level' in the Ionosphere and its Experimental Evidence and Effect.—D. Lepechinsky. (*J. atmos. terr. Phys.*, June 1956, Vol. 8, No. 6, pp. 297–304.) See 1767 of 1955 (Lepechinsky & Durand).

551.510.535 : 621.396.11.029.55 **3056**

Back-Scatter Ionospheric Sounder.—Shearman & Martin. (See 3197.)

551.510.535 : 621.396.812.3 **3057**

A Correlation Treatment of Fading Signals.—Barber. (See 3200.)

551.594.6 3058

On the Propagation of Whistling Atmospherics.—G. R. Ellis. (*J. atmos. terr. Phys.*, June 1956, Vol. 8, No. 6, pp. 338–344.) "It is shown that the dispersion of whistling atmospherics propagated along the lines of force of the earth's magnetic field should be greatly dependent on the geomagnetic latitude of the observing point. The change in the magnetic-field intensity along a line of force produces an upper-frequency limit for whistler propagation which, at latitudes greater than 62°, should fall within the usually observed frequency region of 1–10 kc/s. Dispersion curves showing this critical frequency are given for geomagnetic latitudes 55°, 60° and 65°."

551.594.6 : 523.75 3059

Sudden Decrease in Low-Frequency Atmospheric Noise during the Cosmic-Radiation Storm of February 23.—C. A. McKerrow. (*Nature, Lond.*, 30th June 1956, Vol. 177, No. 4522, pp. 1223–1224.) Note of observations on 100 kc/s at Churchill, Manitoba. The relation of the disturbance to solar-flare conditions and to the proximity of the station to the auroral zone is briefly discussed.

551.594.6 : 538.566.029.43 3060

Influence of the Horizontal Geomagnetic Field on Electric Waves between the Earth and the Ionosphere travelling Obliquely to the Meridian.—W. O. Schumann. (*Z. angew. Phys.*, March 1956, Vol. 8, No. 3, pp. 126–127.) A more general case than that noted earlier (232 of January) is considered briefly. Results indicate that the differences in the type of atmospherics waveform arriving from south-east and from south-west [2809 of 1952 (Caton & Pierce)] are due to differences not in the propagation but in the nature of the discharge, which may occur over the sea in one case, over land in the other.

551.594.6 : 550.385 3061

The Low-Frequency Noise of the Geomagnetic Field.—R. Benoit. (*C. R. Acad. Sci., Paris*, 23rd May 1956, Vol. 242, No. 21, pp. 2534–2535.) Grenet's investigations of the source of a.f. disturbances (1718 of June) are discussed. Observations made in the Sahara are reported; a telephone cable formed into a circular loop of diameter 300 m was used as aerial, in conjunction with a multistage amplifier and pen recorder; the total frequency band explorable was 10 c/s–50 kc/s. The results indicate that the low-frequency pulses received are almost entirely due to atmospherics; this confirms Grenet's theory.

551.594.6 : 550.385 3062

Electromagnetic Phenomena of Natural Origin in the 1·0–150-c/s Band.—P. A. Goldberg. (*Nature, Lond.*, 30th June 1956, Vol. 177, No. 4522, pp. 1219–1220.) A report is presented of observations made at an isolated region in Oregon in the summer of 1955. Air-core detector coils were used, one with an effective area of 12 800 m^2 for observing the vertical magnetic-field component, and another with an effective area of 5 500 m^2 for the horizontal north-south component. Voltage waveforms proportional to the field and to its time rate of change were studied by means of photographic records from c.r. oscillographs. The signals recorded are predominantly of burst type, the horizontal component being more intense than the vertical. The level of activity exhibits a systematic diurnal variation. Comparison with the incidence of r.f. atmospherics suggests that the low-frequency signals are associated with lightning, while the timing of the daytime maximum indicates that the propagation mechanism is different from that for the r.f. atmospherics.

551.594.6 : 621.396.11 3063

The Propagation of a Radio Atmospheric.—Srivastava. (See 3189.)

551.594.6 : 621.396.11.029.4 3064

Propagation of Audio-Frequency Radio Waves to Great Distances.—Chapman & Macairo. (See 3192.)

LOCATION AND AIDS TO NAVIGATION

621.396.93 3065

Fluctuations in Continuous-Wave Radio Bearings at High Frequencies.—W. C. Bain. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, p. 560.) The investigation reported previously (3265 of 1955), covering the frequency band 6–20 Mc/s, is extended to cover the band 3–4 Mc/s. The results differ from those obtained previously in that the standard deviation in a group of observations is not correlated significantly with the value of τ_0.

621.396.93 3066

The 'Wullenwever' Long-Base Direction-Finding Installation.—H. Rindfleisch. (*Nachrichtentech. Z.*, March 1956, Vol. 9, No. 3, pp. 119–123.) This system was developed during the war and is described in *Radio Research Special Report*, No. 21, 1951, *Radio Direction Finding and Navigational Aids; some Reports on German Work issued in* 1944–45.

621.396.96 : 519.21 : 621.396.822 3067

Connection between the Detectability of an Object and the Number of Illuminating Pulses.—G. N. Bystrov. (*Radiotekhnika, Moscow*, Feb. 1956, Vol. 11, No. 2, pp. 74–76.) The probability *P*, that a blip on the c.r. tube display is due to the object and not to the noise is $P = 1 - \exp.(-na_v^2/2a_0^2)$, where n is the number of radar pulses, a_v the amplitude of the blip, and a_0 the mean effective noise voltage. A Rayleigh-type noise-voltage amplitude distribution in the output of the second detector is assumed. The probability of detecting an object is then calculated in terms of the distance, transmitter power, aerial gain, wavelength, surface area of object and power input to receiver, as well as the absolute temperature, pass band and receiver noise factor.

621.396.96 : 621.316.726 : 621.385.029.6 3068

Klystron Control System.—R. J. D. Reeves. (*Wireless Engr*, June–Aug. 1956, Vol. 33, Nos. 6–8, pp. 135–143, 162–167 & 184–189.) Wide-range tuning of reflex klystrons is discussed with particular reference to an a.f.c. system for primary radar. The problem is complicated because the optimum reflector voltage is not independent of the resonator frequency. The concept of a 'control plane' is introduced to facilitate analysis of the klystron operation. Test equipment is described which presents the control plane on a c.r.o. and maps either klystron mode areas and frequency contours or servo-trajectories on to the plane. In the particular a.f.c. system described in detail, a sampling technique for mode centring is introduced which causes minimum disturbance of the controls and provides a slightly better error criterion than mode peak finding.

621.396.962.2 : 621.376.3 : 629.13 3069

A Frequency-Modulation Radio Altimeter.—G. Collette & R. Labrousse. (*Ann. Radioélect.*, Oct. 1955, Vol. 10, No. 42, pp. 387–398.) The Type-AM.210 altimeter is discussed; the range is 1 500 m and the frequency band 420–460 Mc/s; the modulating function is a symmetrical sawtooth repeated 4 050 or 810 times per min. The problem of coupling between the slotted-cavity aerials is examined, and suitable values of aerial spacing and feeder length are indicated.

621.396.963.001.4 : 534.21-8 **3070**

Variable Delay Line simulates Radar Targets.—S. A. Gitlin. (*Electronics*, June 1956, Vol. 29, No. 6, pp. 143–145.) "Two quartz transducers and movable corner reflector in 3½-ft water-filled copper tank give time delays ranging from 72 to 1 400 μs for simulating moving targets during tests of new radar."

621.396.963.33.001.4 **3071**

Three-Dimensional Radar Video Simulator.—P. Pielich. (*Electronics*, July 1956, Vol. 29, No. 7, pp. 131–133.) Terrain is represented on a test slide with six contour lines defining range and azimuth at six heights. The slide is scanned by a flying-spot system and x, y, z voltages from the simulator unit are combined to give appropriate X, Y deflection voltages for a c.r.o. Detailed circuit diagrams are given.

621.396.969 **3072**

Frequency-Modulation Radar for Use in the Mercantile Marine.—D. N. Keep. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 519–523. Discussion, pp. 523–526.) "The principles of f.m. radar are outlined and a comparison is made between pulse and f.m. techniques, particularly with respect to the requirements of the merchant service. It is concluded that multi-gate f.m. radars are too complex for this application and methods are outlined for overcoming the inherently low scanning rate of single sweeping-gate systems. Equipment is described which has an aerial beamwidth of 1·7° and a rotation rate of 10 r.p.m. with a fractional range resolution of 1/30. The future of f.m. radar for mercantile marine use is critically examined, the conclusion being that it will be most useful where very-short-range high-resolution pictures are required. Before such equipment is economically available further developments in transmitting valves must take place."

MATERIALS AND SUBSIDIARY TECHNIQUES

531.788.7 **3073**

Observations on the Characteristics of the Cold-Cathode Ionization Gauge.—J. H. Leck & A. Riddoch. (*Brit. J. appl. Phys.*, April 1956, Vol. 7, No. 4, pp. 153–155.) A gauge of the type described by Penning & Nienhuis (1423 of 1950) has been calibrated for the pressure range 10^{-5}–10^{-9} mm Hg. Anode-cathode-voltage/current and pressure/current characteristics are given; in the latter a sharp discontinuity occurs at a pressure of about 10^{-8} mm Hg. A marked change in sensitivity occurs during the first 200 hours of operation; this may account for conflicting characteristics obtained by various workers.

533.56 **3074**

The Ultimate Vacuum Obtainable in Vapour Pumps.—N. A. Florescu. (*Vacuum*, Jan. 1954, Vol. 4, No. 1, pp. 30–39.) Experiments with hydrogen are described; the results indicate that in a well designed vapour pump the ultimate vacuum is limited not by the pressure of the gas diffused from the fore-pressure side but by the lowest total pressure of all gases and vapours leaving the nozzle, apart from the partial pressure of the vapour of the working fluid.

533.56 **3075**

Theory of Molecular Pumps at Very Low Pressures.—C. Mercier. (*J. Phys. Radium*, March 1956, Vol. 17, Supplement to No. 3, *Phys. appl.*, pp. 1A–11A.)

535.215 + 535.37 **3076**

A Theoretical Property of Relaxation Curves of Luminescence and Photoconductivity.—N. A. Tolstoi & A. V. Shatilov. (*Zh. eksp. teor. Fiz.*, Jan. 1956, Vol. 30, No. 1, pp. 109–114. English summary, *ibid.*, Supplement, p. 6.) A note on the recombination mechanism of phosphors and photoconductors.

535.215 : 546.817.221 **3077**

A Photo-E.M.F. dependent on Direction of Illumination in Polycrystalline PbS Films.—G. Schwabe. (*Ann. Phys., Lpz.*, 29th Feb. 1956, Vol. 17, Nos. 4/5, pp. 249–262.) Fuller account of work described previously (3271 of 1955).

535.215 : [546.863.221 + 546.23 **3078**

Time-Lag in Photoconductors for Camera Tubes.—W. R. Daniels. (*J. Instn elect. Engrs*, March 1956, Vol. 2, No. 15, pp. 150–151.) A brief note on preliminary observations of the time lag in amorphous Se and Sb_2S_3.

535.37 : 546.472.21 **3079**

Reduction of the Luminous Output of Phosphors under Intense Excitation.—V. V. Antonov-Romanovski & L. A. Vinokurov. (*Zh. eksp. teor. Fiz.*, Dec. 1955, Vol. 29, No. 6(12), pp. 830–833.) Measurements on ZnS-Cu,Co, and comparison with earlier measurements on ZnS-Cu, indicate that the observed effect is due to an increase of the concentration of localized electrons and ionized luminescence centres resulting in an increase of the number of radiationless recombinations.

535.37 : 546.472.21 **3080**

Phosphorescence of ZnS-Cu Crystal Phosphor excited by an Electron Beam.—T. P. Belikova. (*Zh. eksp. teor. Fiz.*, Dec. 1955, Vol. 29, No. 6(12), pp. 905–906.) Luminescence decay curves of a ZnS-Cu specimen excited by radiation of wavelength 365 mμ and by an electron beam (2 000 V, up to 3 μA/cm²) are compared. The initial-intensity/temperature curves are also given.

535.376 **3081**

Electroluminescence from Boron Nitride.—S. Larach & R. E. Shrader. (*Phys. Rev.*, 15th April 1956, Vol. 102, No. 2, p. 582.) A preliminary note reporting observations of electroluminescence with alternating-field excitation, using an electrode isolated from the phosphor.

537.226 + 537.228.1] : 546.431.824-31 **3082**

Elastic, Piezoelectric, and Dielectric Constants of Polarized Barium Titanate Ceramics and some Applications of the Piezoelectric Equations.—R. Bechmann. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, pp. 347–350.) A complete set of the constants and the various electromechanical coupling factors is given and typical values are tabulated.

537.228.1 : 549.514.51 **3083**

Piezoelectric Structure of Quartz and of Minerals containing Quartz.—E. I. Parkhomenko. (*Bull. Acad. Sci. U.R.S.S., sér. géophys.*, March 1956, No. 3, pp. 297–306. In Russian.)

537.311.31 : 539.23 **3084**

The Electrical Conductivity of Anisotropic Thin Films.—R. Englman & E. H. Sondheimer. (*Proc. phys. Soc.*, 1st April 1956, Vol. 69, No. 436B, pp. 449–458.) "It is shown that, when the electron free path is large, the theoretical electrical conductivity of single crystal metal films exhibits anomalous anisotropic properties similar to, but even more pronounced than, those found in the anomalous skin effect in anisotropic metals."

537.311.31 : 621.316.842(083.74) **3085**

Nickel-Chromium-Aluminium-Copper Resistance Wire.—A. H. M. Arnold. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 439–447.) Report of an investigation made at the National Physical Laboratory on the suitability of alloys for resistance standards. The alloy 'evanohm', composed of Ni, Cr, Al and Cu, has a resistivity three times that of Mn, and its temperature coefficient can be adjusted to zero by heat treatment. A number of resistance standards made of this wire are undergoing long-term stability tests.

537.311.33 **3086**

Grain-Boundary Structure and Charge-Carrier Transport in Semiconductor Crystals.—H. F. Mataré. (*Z. Naturf.*, Aug. 1955, Vol. 10a, No. 8, pp. 640–652.) "The structural character of boundaries or interfaces between two perfect crystals of different orientation but equal chemical composition defines the behaviour of grain boundaries with respect to carrier transport. The amount of misfit in the grain boundary zone, as well as the amount of energy stored by elastic deformation, defines the electrical properties. The number of free carriers (electrons) in boundary states increases with the cross-potential applied, while positive space charge regions build up on both sides of the boundary. The boundary zone itself has *p*-type character and becomes more conductive when the number of electrons bound to the dangling bonds increases. Grain boundary zones may be as thick as a few tenths of a mm. Extremely small zones are formed by disturbed twins. Two- and three-probe measurements on such bicrystals have been made in order to study the carrier transport phenomena. High current multiplication due to carrier density misfit and gate action in the case of opposite polarization have been found. In addition, contacts were plated to boundary zones and modulation through the bulk material, as in a *n-p-n* junction, was studied. Here current multiplication can reach high values even in a base-to-ground connection. Since those electrons bound to a grain boundary interface by a cross potential may be present only in the form of excitons, in the field of their dangling bonds before adjustment, their time constants for recharging processes might be very short such that it is probable that high-frequency response is improved. Basic elements and consequences of the developed theory and the correlation between boundary stress field and carrier transport are outlined." Similar material is presented in a paper entitled 'Grain Boundaries and Transistor Action' in *Convention Record Inst. Radio Engrs*, 1955, Vol. 3, Part 3, pp. 113–124.

537.311.33 **3087**

***p-n* Junction Theory by the Method of δ Functions.**—H. Reiss. (*J. appl. Phys.*, May 1956, Vol. 27, No. 5, pp. 530–537.) A concise method is presented for calculating the current flow in one-dimensional semiconductor structures with any number of junctions and contacts. The method indicates the importance of the space derivatives of the hole currents in the neighbourhood of junctions.

537.311.33 **3088**

A Method for Measurement of Surface-Recombination Velocities in Semiconductors using the Photomagnetoelectric Effect in a Sinusoidal Regime.—J. Grosvalet. (*Ann. Radioélect.*, Oct. 1955, Vol. 10, No. 42, pp. 344–347.) The method is based on the phase difference between the photomagnetoelectric and photoresistive voltages discussed previously (1062 of 1955).

537.311.33 : 536.21 **3089**

Thermal Conductivity of Semiconductors.—J. M. Thuillier. (*C. R. Acad. Sci., Paris*, 28th May 1956, Vol. 242, No. 22, pp. 2633–2634.) Addendum to analysis presented previously (799 of March). An error in the calculation is corrected.

537.311.33 : 536.21 **3090**

Thermal Conductivity of Semiconductors.—A. V. Ioffe & A. F. Ioffe. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, Jan. 1956, Vol. 20, No. 1, pp. 65–75. In Russian.) A discussion of theoretical and experimental work.

537.311.33 : 537.533 **3091**

The Effect of Field Emission on the Behaviour of Semiconductor Contacts.—R. Stratton. (*Proc. Phys. Soc.*, 1st April 1956, Vol. 69, No. 436B, pp. 491–492.) Recent work by Sillars (1084 of April) is extended to include field emission across gaps of arbitrary width and fields varying with the distance from the centre of the contact, such as might arise if a variable work function exists at the gap surfaces.

537.311.33 : [546.28 + 546.289 **3092**

Chemical Interactions among Defects in Germanium and Silicon.—H. Reiss, C. S. Fuller & F. J. Morin. (*Bell Syst. tech. J.*, May 1956, Vol. 35, No. 3, pp. 535–636.) Chemical reaction mechanisms in semiconductor solid solutions are shown to be similar to those in aqueous solutions. A comprehensive report of experimental and theoretical investigations of these mechanisms is presented. The limits of validity of the mass-action principle are examined. 71 references.

537.311.33 : 546.28 **3093**

Theory of Electron Multiplication in Silicon.—J. Yamashita. (*Progr. theor. Phys.*, Feb. 1956, Vol. 15, No. 2, pp. 95–110.) General theory of the conductivity of nonpolar crystals in strong e.s. fields, developed previously [*ibid.*, Oct. 1954, Vol. 12, No. 4, pp. 443–453 (Yamashita & Watanabe)] on a kinetic-statistical basis, is extended to take account of the impact ionization process and is used to explain the electron multiplication in Si *p-n* junctions observed by McKay & McAfee (1079 of 1954).

537.311.33 : 546.28 **3094**

Measurement of Minority Carrier Lifetime in Silicon.—R. L. Watters & G. W. Ludwig. (*J. appl. Phys.*, May 1956, Vol. 27, No. 5, pp. 489–496.) A method of measurement based on the decay of photocurrent in a specimen exposed to pulsed illumination is used. Limitations on the injection level are discussed. Trapping, barrier and contact effects are taken into account in evaluating the results, which are checked by measurements using a drift technique. Lifetime values $> 1\,500\ \mu s$ for *p*-type crystals and $> 2\,500\ \mu s$ for *n*-type have been found. The temperature dependence of the lifetime was investigated. A value of about 3 500 cm/s at 300°K was determined for the surface recombination velocity of a *p*-type crystal.

537.311.33 : 546.28 **3095**

Diffusion of Donor and Acceptor Elements in Silicon.—C. S. Fuller & J. A. Ditzenberger. (*J. appl. Phys.*, May 1956, Vol. 27, No. 5, pp. 544–553.) The diffusion of Group-III and Group-V elements in Si has been measured over the temperature range 1 050°–1 350°C. Results are tabulated. In nearly all cases the acceptor elements diffuse more rapidly than the donor elements. Boron and phosphorus exhibit similar diffusional properties; they may form compounds with the Si under the conditions of diffusion.

537.311.33 : 546.28 : 535.37 **3096**

Photon Emission from Avalanche Breakdown in Silicon.—A. G. Chynoweth & K. G. McKay. (*Phys. Rev.*, 15th April 1956, Vol. 102, No. 2, pp. 369–376.) Results obtained by Newman (1088 of April) are discussed. Further experiments were made using a junction very close to a surface; the results indicate that light is emitted from breakdown regions distributed over the whole of the junction area, not only where the junction intercepts the surface. The emitted light has a continuous spectrum. Recombination between free electrons and holes is thought to be responsible for the shorter wavelengths, and intra-band transitions for the longer ones. The emission efficiency over the visible spectrum is tentatively estimated as 1 photon per 10^8 electrons crossing the junction.

537.311.33 : 546.289 **3097**

Effect of Water Vapor on Germanium Surface Potential.—A. R. Hutson. (*Phys. Rev.*, 15th April 1956, Vol. 102, No. 2, pp. 381–385.) A simple calculation based on the thickness and dielectric properties of the water film adsorbed on the Ge surface gives values of the surface potential in good agreement with the observed values for different degrees of humidity of the ambient atmosphere.

537.311.33 : 546.289 **3098**

Temperature-Dependent Factor in Carrier Lifetime.—R. L. Longini. (*Phys. Rev.*, 15th April 1956, Vol. 102, No. 2, pp. 584–585.) Results of measurements on carrier recombination in Ge made by various workers are discussed. It is suggested that rapid recombination believed to occur at dislocations may be due to relaxation of momentum selection rules. When recombination does take place predominantly at dislocations, the lifetime is not necessarily temperature dependent.

537.311.33 : 546.289 **3099**

Time-Dependent Changes of Surface Lifetime in Germanium in the Presence of Electric Fields.—J. D. Nixon & P. C. Banbury. (*Proc. phys. Soc.*, 1st April 1956, Vol. 69, No. 436B, pp. 487–488.) Extension of the work of Henisch & Reynolds (3652 of 1955); curves show the relation between surface-recombination velocity and applied field for both *n*- and *p*-type Ge, and the time variation of the conductance on applying and removing the field.

537.311.33 : 546.289 **3100**

The Absorption of 39-kMc/s (39-Gc/s) Radiation in Germanium.—A. F. Gibson. (*Proc. phys. Soc.*, 1st April 1956, Vol. 69, No. 436B, pp. 488–490.) Experimentally determined values of the absorption coefficient over the temperature range 15°–55°C are in excellent agreement with theory, assuming the effective mass of charge carriers to be of the same order as the electronic mass. The results are not in agreement with those of Klinger (1088 of 1954), which indicate an effective mass about ten times greater.

537.311.33 : 546.289 : 548.24 **3101**

Growth Twins in Germanium.—G. F. Bolling, W. A. Tiller & J. W. Rutter. (*Canad. J. Phys.*, March 1956, Vol. 34, No. 3, pp. 234–240.) The nucleation of twin crystals in Ge requires a certain degree of supercooling; the frequency of occurrence of twins increases with the degree of supercooling. The addition of Ga to the melt lowers the solid/liquid interface energy.

537.311.33 : 546.289 : 669.046.54 **3102**

Single Crystals of Exceptional Perfection and Uniformity by Zone Leveling.—D. C. Bennett & B. Sawyer. (*Bell Syst. tech. J.*, May 1956, Vol. 35, No. 3, pp. 637–660.) Technique for producing semiconductors with very low impurity content and with very uniform impurity distribution is based on traversing a single liquid zone through the crystal. Ge crystals have been produced with transverse variations of resistivity as low as ± 3% and longitudinal variations ± 7%.

537.311.33 : 546.3-1-28-289 **3103**

Preparation of Alloys of Germanium with Silicon and Other Metalloids by Fusion Electrolysis.—M. J. Barbier-Andrieux. (*C. R. Acad. Sci., Paris*, 7th May 1956, Vol. 242, No. 19, pp. 2352–2354.) A whole range of mixed Ge-Si crystals has been obtained by the technique described. Some experiments with Ge-Sn and Ge-As alloys are also mentioned.

537.311.33 : 546.561-31 **3104**

Excitation Spectrum of Excitons in a Solid.—E. F. Gross. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, Jan. 1956, Vol. 20, No. 1, pp. 89–104. In Russian.) A critical survey of literature with particular reference to Cu_2O. 45 references.

537.311.33 : 546.561-31 **3105**

Occlusions of Cupric Oxide in Cuprous Oxide Layers.—A. I. Andrievski & M. T. Mishchenko. (*Zh. tekh. Fiz.*, Oct. 1955, Vol. 25, No. 11, pp. 1893–1897.) Statements made by various authors to the effect that layers of Cu_2O contain crystals of CuO have been confirmed by a microscope investigation. A report is presented including a number of photomicrographs.

537.311.33 : 546.561-31 : 539.23 **3106**

Investigation of the Structure of the Surface of Films of Cuprous Oxide on Different Faces of a Single Crystal of Copper and Determination of the Contact Potential Difference between these Surfaces.—N. B. Gornyi. (*Zh. eksp. teor. Fiz.*, Dec. 1955, Vol. 29, No. 6(12), pp. 808–816.)

537.311.33 : [546.682.18 + 546.681.19 **3107**

Preparation and Electrical Properties of InP and GaAs.—O. G. Folberth & H. Weiss. (*Z. Naturf.*, Aug. 1955, Vol. 10a, No. 8, pp. 615–619.) Measurements were made of conductivity and Hall effect over the temperature range from −180° to +960°C. Polycrystalline rod specimens were used. Results are shown graphically. Values are deduced for the carrier mobilities and the widths of the energy gaps.

537.311.33 : 546.682.86 **3108**

Preparation of Indium Antimonide. Determination of the Effective Masses.—M. Rodot, P. Duclos, F. Kover & H. Rodot. (*C. R. Acad. Sci., Paris*, 23rd May 1956, Vol. 242, No. 21, pp. 2522–2525.) Specimens of various degrees of purity were prepared; impurity concentrations down to 10^{15} centres/cm³ were attained. Hall-effect and Seebeck-effect measurements indicate that the effective masses of electrons and holes depend greatly on temperature.

537.311.33 : 546.786-31 **3109**

The Preparation of Semiconducting Ceramics based on WO_3, and a Study of Some of their Electrical and Thermal Properties.—G. I. Skanavi & A. M. Kashtanova. (*Zh. tekh. Fiz.*, Oct. 1955, Vol. 25, No. 11, pp. 1883–1892.) The preparation of the specimens is described in detail and results are given of numerous experiments. The main properties of the material are as follows: the conductivity varies within relatively wide limits, from 7×10^{-3} to 4 $\Omega^{-1}.cm^{-1}$; the thermo-e.m.f. has negative sign, corresponding to *n*-type conductivity; the temperature coefficient of thermo-e.m.f. is relatively high (0·70–0·85 mV/deg). The material should find application in the production of thermocouples.

537.311.33 : 546.873-31 **3110**
The Electrical Conductivity of Bismuth Oxide.—V. M. Konovalov, V. I. Kulakov & A. K. Fidrya. (*Zh. tekh. Fiz.*, Oct. 1955, Vol. 25, No. 11, pp. 1864–1867.) Measurements are reported. In air, at room temperature, the resistivity varied from 10^8 to 10^{10} Ω.cm. When the specimens were heated up to 700°C, the resistivity fell to about 10^2 Ω.cm. The conductivity depends to a great extent on the preparation of the specimens and on their moisture content. The results indicate that within the range of temperatures investigated the conductivity is predominantly of *n*-type, which is contrary to previous conclusions. A considerable positive photoeffect was also observed.

537.32 : 546.562-31 **3111**
A Thermoelectric Effect exhibited by Cupric Oxide in Powder Form.—M. Perrot, G. Peri, J. Robert, J. Tortosa & A. Sauze. (*C. R. Acad. Sci., Paris*, 23rd May 1956, Vol. 242, No. 21, pp. 2519–2522.) Experiments have been made with elements comprising powdered CuO compressed between two Cu electrodes. Graphs show the temperature variation of resistance of an element as a whole, and the variation of the thermo-e.m.f. as a function of the temperature difference between the electrodes for several elements; in one case the useful power is 22 mW/cm². Elements using Cu_2O powder give a greater e.m.f. for the same temperature conditions, but their resistance is also greater.

537.533 : 546.815 **3112**
Work Function of Lead.—P. A. Anderson & A. L. Hunt. (*Phys. Rev.*, 15th April 1956, Vol. 102, No. 2, pp. 367–368.) The work function of Pb surfaces has been determined by measuring the contact difference of potential with respect to a Ba surface in a special tube. The value obtained is 4·00 ± 0·01 eV. The results indicate that the work function is unaffected when an initially clean Pb surface is exposed to the residual gas in a sealed-off Ba-gettered tube.

538.22 : 621.318.134 **3113**
Micrographic Study of the Order-Disorder Transformation in Lithium Ferrite.—I. Behar. (*C. R. Acad. Sci., Paris*, 14th May 1956, Vol. 242, No. 20, pp. 2465–2468.)

538.22 : 621.318.134 **3114**
Magnetic Properties of Garnet-Type Yttrium Ferrite $5Fe_2O_3 . 3Y_2O_3$.—R. Aléonard, J. C. Barbier & R. Pauthenet. (*C. R. Acad. Sci., Paris*, 23rd May 1956, Vol. 242, No. 21, pp. 2531–2533.)

538.221 **3115**
The Behavior of Ferromagnetics under Strong Compression.—F. D. Stacey. (*Canad. J. Phys.*, March 1956, Vol. 34, No. 3, pp. 304–311.) Magnetization curves are given for thin specimens of Ni and Ni-Cu alloys under non-hydrostatic pressures up to 10 000 atm. The saturation magnetizations increase markedly with pressure.

538.221 **3116**
Interpretation of Domain Patterns recently found in BiMn and SiFe Alloys.—J. B. Goodenough. (*Phys. Rev.*, 15th April 1956, Vol. 102, No. 2, pp. 356–365.)

538.221 : 538.632 **3117**
Theory of the Hall Effect in Ferromagnetic Alloys.—K. Meyer. (*Z. Naturf.*, Aug. 1955, Vol. 10a, No. 8, pp. 656–657.)

538.221 : 538.652 **3118**
Iron-Aluminium Alloys for Use in Magnetostrictive Transducers.—M. T. Pigott. (*J. acoust. Soc. Amer.*, May 1956, Vol. 28, No. 3, pp. 343–346.) A systematic determination of the electromechanical coupling coefficient *k* of Fe-Al alloys containing between 12% and 14% Al by weight and annealed at temperatures between 600° and 1 000°C is reported. For annealing temperatures near 1 000°C, k^2 is about 0·05 and is nearly independent of composition; k^2 has a maximum value of 0·12 for an alloy containing 12·3% Al annealed at 650°C. Eddy-current losses are smaller than for soft annealed 'A' nickel.

538.221 : 621.318.134 **3119**
Resonance Widths in Polycrystalline Nickel-Cobalt Ferrites.—M. H. Sirvetz & J. H. Saunders. (*Phys. Rev.*, 15th April 1956, Vol. 102, No. 2, pp. 366–367.) Brief report of measurements at a frequency of 10 kMc/s on ferrites of composition $Co_\alpha Ni_{1-\alpha}Fe_2O_4$. The variation of resonance-line width with variation of α up to 0·04 and with variation of temperature between 20° and 350°C is shown graphically and discussed in relation to the crystal properties.

538.221 : 621.318.134 **3120**
Investigation of the Magnetic Spectra of Solid Solutions of some NiZn Ferrites at Radio Frequencies.—L. A. Fomenko. (*Zh. eksp. teor. Fiz.*, Jan. 1956, Vol. 30, No. 1, pp. 18–29. English summary, *ibid.*, Supplement, p. 3.) Results of an experimental investigation of the frequency dependence in the range 0·2–60 Mc/s of the permittivity, permeability and loss angles of oxifer ferrites [*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1952, Vol. 16, p. 6 (Shol'ts & Piskarev)] with initial permeabilities of 200, 400 and 2 000 G/oersted are presented graphically. Specimens with various dimensions were used; dispersion effects are practically independent of the dimensions.

538.221 : 621.318.134 **3121**
Influence of Alkali and Alkaline-Earth Ions on the Initial Permeability of Manganese-Zinc Ferrites.—C. Guillaud, B. Zega & G. Villers. (*C. R. Acad. Sci., Paris*, 7th May 1956, Vol. 242, No. 19, pp. 2312–2315.) Results of measurements are presented as curves for μ_0/μ as a function of impurity content, where μ_0 is the initial permeability of the pure material and μ that of the impure material. The relation between the effectiveness of the impurity and its ionic radius is studied.

538.221 : 621.318.134 **3122**
Initial Permeability and Grain Size of Manganese-Zinc Ferrites.—C. Guillaud & M. Paulus. (*C. R. Acad. Sci., Paris*, 23rd May 1956, Vol. 242, No. 21, pp. 2525–2528.) A graph shows the relation between initial permeability and mean grain size, derived on the basis of a careful analysis of the distribution of grain size in 100 specimens. The results are consistent with a mechanism involving rotation of the direction of spontaneous magnetization for grains whose mean dimension is < 5·5 μ, and domain-wall displacements for larger grains.

538.23 **3123**
A Relation between Hysteresis Coefficient and Permeability: Part 3—Ferrite Cores with Rectangular Loop. Part 4—Influence of Coercive Force.—M. Kornetzki. (*Z. angew. Phys.*, March 1956, Vol. 8, No. 3, pp. 127–135.) Continuation of the investigation noted earlier (1714 of 1955). Anomalies

due to the large magnetic crystal energy of several materials are noted and experimental results obtained by various workers are discussed.

539.23 : 537/538 3124

International Colloquium on the Present State of Knowledge of the Electric and Magnetic Properties of Thin Metal Films in Relation to their Structure.—(*J. Phys. Radium*, March 1956, Vol. 17, No. 3, pp. 169–306.) French text and English abstracts are presented of 27 papers given at a colloquium held at Algiers in April 1955.

539.23 : 546.561-31 3125

Electron Interference at Electrolytically Polished Surfaces after Cathode Sputtering.—A. Ladage. (*Z. Phys.*, 7th Feb. 1956, Vol. 144, No. 4, pp. 354–372.) Apparatus is described by means of which thin Cu_2O films were detected on the surface of cleaned Cu exposed to air for 30 minutes.

549.514.5 : 534.21-16 3126

Propagation of Longitudinal Waves and Shear Waves in Cylindrical Rods at High Frequencies.—McSkimin. (See 2933.)

621.3.049.75 3127

Silver Migration in Electric Circuits.—O. A. Short. (*Tele-Tech & Electronic Ind.*, Feb. 1956, Vol. 15, No. 2, pp. 64–65..113.) Electrolytic migration of silver used in components and printed circuits may be reduced by covering the silver completely with solder, or by Cr plating. An organic coating is effective if soluble salts are first removed from the surface covered.

621.315.61 : 621.317.335.029.64 3128

Temperature Dependence of Loss Angle and Dielectric Constant of Solid Insulating Materials in the 4-kMc/s Range.—Gross. (See 3139.)

621.315.612.6 3129

Electrical Resistivity of Vitreous Ternary Lithium-Sodium Silicates.—S. W. Strauss. (*J. Res. nat. Bur. Stand.*, April 1956, Vol. 56, No. 4, pp. 183–185.) Glasses with compositions in the system $xLi_2O : (1 - x) Na_2O : 2SiO_2$ have been investigated over the temperature range 150°–230°C. Resistivity/composition characteristics are presented.

621.315.615.9 : 621.319.4 3130

Polychloronaphthalene-Impregnated-Paper Capacitors.—Coquillion. (See 2980.)

MATHEMATICS

517.9 3131

The Asymptotic Solution of Linear Differential Equations of the Second Order in a Domain containing One Transition Point.—F. W. J. Olver. (*Phil. Trans. A*, 19th April 1956, Vol. 249, No. 959, pp. 65–97.)

517.941.91 3132

The Interrelation between the Phase Planes of Rayleigh's Equation and van der Pol's Equation.—V. V. Kazakevich. (*C. R. Acad. Sci. U.R.S.S.*, 1st April 1956, Vol. 107, No. 4, pp. 521–523. In Russian.) The equations considered are: $\ddot{y} - \mu f(\dot{y}) + y = 0$ and $\ddot{y} - \mu F(y)\dot{y} + y = 0$.

517 3133

Spheroidal Wave Functions. [Book Review]—J. A. Stratton et al. Publishers: Technology Press of Massachusetts Institute of Technology, and John Wiley & Sons, New York, 1956, 611 pp., $12.50. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, pp. 951–952.) Contains numerical tables and an introduction, together with a reprint of a paper on elliptic and spheroidal wave functions [1594 of 1942 (Chu & Stratton)].

MEASUREMENTS AND TEST GEAR

621.3.011.3(083.74) : 621.318.42 3134

The Calibration of Inductance Standards at Radio Frequencies.—L. Hartshorn & J. J. Denton. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 429–438. Discussion, p. 438.) The practice adopted at the National Physical Laboratory for calibrating laboratory standards is described. An accuracy within about 1 part in 10^4 is obtained over a considerable range of inductance values. The accuracy associated with such standards is determined partly by the definition of inductance used; this aspect as well as the experimental technique is discussed.

621.317.3 : 551.594.6 3135

Measurement of the Amplitude Probability Distribution of Atmospheric Noise.—H. Yuhara, T. Ishida & M. Higashimura. (*J. Radio Res. Labs, Japan*, Jan. 1956, Vol. 3, No. 11, pp. 101–108.) Noise picked up on a 2-m vertical aerial is amplified at an i.f. of 100 kc/s, the output is sliced and the resulting groups of 100-kc/s pulses are counted. Results obtained during the summer of 1955, on a frequency of 3·5 Mc/s, using a bandwidth of 2·4 kc/s, show that the noise includes random and impulsive components.

621.317.3 : 621.319.4 : 681.142 3136

Industrial Measurement of the Temperature Coefficient of Ceramic-Dielectric Capacitors.—J. Peyssou & J. Ladefroux. (*Ann. Radioélect.*, Oct. 1955, Vol. 10, No. 42, pp. 355–371.) Known beat-frequency and self-synchronizing techniques are reviewed. The accuracy and speed of measurements is increased by using an automatic machine incorporating an analogue computer. The construction of a temperature-coefficient distribution curve for a batch of 4 000 capacitors is described. For a shorter version, in English, see *Tele-Tech & Electronic Ind.*, April 1956, Vol. 15, No. 4, pp. 70–71..166.

621.317.3 : 621.396.822 3137

New Method of measuring the Effective Value of Band-Limited Radio Noise Voltage.—K. Kawakami & H. Akima. (*J. Radio Res. Labs, Japan*, Jan. 1956, Vol. 3, No. 11, pp. 109–113.) The noise voltage is passed through a pentode frequency-doubling stage and the output is linearly rectified and smoothed. The resulting voltage is the mean square of the input voltage. Equipment is described for measurements on a centre frequency of 455 kc/s, giving accurate results for an input dynamic range of 30 dB.

621.317.33 : 546.28 3138

The Measurement of the Electrical Resistivity of Silicon.—R. H. Creamer. (*Brit. J. appl. Phys.*, April 1956, Vol. 7, No. 4, pp. 149–150.) The method described by Valdes (1502 of 1954) was modified by using probes made from wires containing a donor or acceptor impurity for measurements on *n*- or *p*-type Si respectively. Potentials were measured with a standard potentiometer, giving an accuracy within ± 7% for resistivities up to several hundred Ω.cm.

621.317.335.029.64 : 621.315.61 **3139**

Temperature Dependence of Loss Angle and Dielectric Constant of Solid Insulating Materials in the 4-kMc/s Range.—F. Gross. (*Nachrichtentech. Z.*, March 1956, Vol. 9, No. 3, pp. 124–128.) Measurements were made on rod specimens of ceramics, glass and plastics used in the manufacture of valves and other equipment, over the temperature range 20°–350°C, using an E_{010}-mode resonator. Theory based on that of Horner et al. (966 of 1946) is outlined; results are presented in tables and graphs.

621.317.335.3.029.64 : 621.315.614.6 **3140**

Birefringence and Rectilinear Dichroism of Paper at 9 350 Mc/s.—R. Servant & J. Gougeon. (*C. R. Acad. Sci., Paris*, 7th May 1956, Vol. 242, No. 19, pp. 2318–2320.) The complex dielectric constant of a pile of sheets of paper has been determined by a waveguide method using a s.w.r. meter within which the material under test is located. Measurement results are evaluated as absorption coefficients and refractive indices; very considerable differences are observed for the cases of the electric vector (*a*) parallel to and (*b*) perpendicular to the plane of the paper sheets. Some results obtained with kraft paper are shown graphically.

621.317.337 : 621.372.413 **3141**

Measurement of the Q-Factor of Cavity Resonators, using a Straight Test Line.—H. Urbarz. (*Nachrichtentech. Z.*, March 1956, Vol. 9, No. 3, pp. 112–118.) Methods appropriate for measurements on resonators with only one coupling point, such as those associated with klystrons, are based on determination of the s.w.r. and the shift of the minimum along a test line terminated by the resonator. The effect of loading on the *Q*-factor is discussed. Measurements are reported indicating the variation of the resonator input admittance with the area of the coupling loop.

621.317.34 : 621.3.018.7 **3142**

An Approximate Method for investigating Distortion of Test Pulses transmitted over Coaxial Cables.—H. Larsen & H. E. Martin. (*Frequenz*, March 1956, Vol. 10, No. 3, pp. 65–76.) In practice, the waveforms of pulses used for testing may deviate considerably from ideal forms such as rectangular or $\cos^2$. The Fourier components of the actual initial waveform can be determined with sufficient accuracy by analysing its oscillogram. The waveform of the transmitted pulse can then be determined as usual by multiplying together the pulse spectral function and the system transfer function and transforming the product. Application of the theory is described in relation to tests on wide-band cables several km long.

621.317.4 **3143**

A Rapid Method for measuring Coercive Force and other Ferromagnetic Properties of Very Small Samples.—G. W. van Oosterhout. (*Appl. sci. Res.*, 1956, Vol. B6, Nos. 1/2, pp. 101–104.) The method is based on measurement of the alternating e.m.f. generated when the sample is caused to vibrate within a search coil.

621.317.443 **3144**

Description of a Balance for the Measurement of Magnetization from 1·4°K to Room Temperature.—R. Conte. (*C. R. Acad. Sci., Paris*, 23rd May 1956, Vol. 242, No. 21, pp. 2528–2531.)

621.317.6 : 621.385.5 : 621.376.22 **3145**

Study of Amplitude Modulation applied via a Pentode Suppressor Grid.—Loeckx. (See 3237.)

621.317.7 : 537.54 : 621.396.822.029.6 **3146**

On the Effective Noise Temperature of Gas-Discharge Noise Generators.—W. D. White & J. G. Greene. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, p. 939.) A method of calculating the noise temperature is indicated.

621.317.7 : 537.54 : 621.396.822.029.6 **3147**

Wide-Band Noise Sources using Cylindrical Gas-Discharge Tubes in Two-Conductor Lines.—R. I. Skinner. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 491–496.) Noise sources for the dm-λ band are discussed. A noise output which is level over several octaves can be obtained by matching a cylindrical gas-discharge tube directly to a two-conductor line. The matching can be achieved by using conductors of various shapes. Practical design procedure is outlined.

621.317.72 + 621.317.772 **3148**

An A.C. Potentiometer for Measurement of Amplitude and Phase.—M. J. Somerville. (*Electronic Engng*, July 1956, Vol. 28, No. 341, pp. 308–309.) A simple circuit using a.c. coupled amplifiers permits generation of quadrature components whose phase relation remains unchanged when substantial phase shifts occur in the couplings.

621.317.73 + 534.64 **3149**

An Impedance Measuring Set for Electrical, Acoustical and Mechanical Impedances.—E. W. Ayers, E. Aspinall & J. Y. Morton. (*Acustica*, 1956, Vol. 6, No. 1, pp. 11–16.) "An impedance to be measured is compared with a reference impedance of similar nature by connecting each in turn to a source of adjustable strength. If the internal impedance of the source is constant, the vector ratio of the unknown and reference is the ratio of the changes in stimulus required to restore the source to short-circuit conditions, or the reciprocal of this ratio if the source is restored to open-circuit conditions."

621.317.733.029.4 : 621.375.2 **3150**

A Tuned Differential Amplifier for Low-Frequency Bridges.—W. K. Clothier & F. C. Hawes. (*Aust. J. appl. Sci.*, March 1956, Vol. 7, No. 1, pp. 38–44.) The amplifier described is suitable for use as a balance detector where there is high impedance between both detector points and ground. Rejection factors greater than 30 000 are obtained for in-phase input voltages up to 10 V. The amplifier is tunable over the frequency range 15–20 000 c/s by means of ladder-type feedback networks. The discrimination against third harmonics of the selected frequency is 130. Maximum gain is 150 000.

621.317.734 **3151**

Extending the Limits of Resistance Measurement using Electronic Techniques.—G. Hitchcox. (*J. Brit. Instn Radio Engrs*, June 1956, Vol. 16, No. 6, pp. 299–309.) Methods for measuring resistance are surveyed with special attention to those for very low and very high resistance. In one method for dealing with very low resistance, test currents with triangular waveform are used to reduce thermal dissipation. A commercial general-purpose megohmmeter is described in some detail.

621.317.734 **3152**

A Logarithmic Megohmmeter.—P. Hariharan & M. S. Bhalla. (*J. sci. Instrum.*, April 1956, Vol. 33, No. 4, pp. 158–159.) An ohmmeter based on the logarithmic grid-current/anode-current characteristic of a triode valve covers the range from 1 to 10^5 MΩ on a single approximately logarithmic scale.

621.317.75 : 621.396.3 3153
The Response of Radio Spectrometers.—J. Marique. (*Rev. HF, Brussels*, 1956, Vol. 3, No. 5, pp. 167–177.) The spectrum of repeated signals such as the pulses in on-off telegraphy systems is a function of two factors, one depending on the waveform of the individual signals and the other on the repetition process. The operation of a spectrometer comprising a cascaded-tuned-circuit filter (813 of 1955) is discussed, taking as criterion the time interval $T = 2/B_F$, where B_F is the filter bandwidth. See also 1900 of 1955.

621.317.755 : 531.76 3154
Four-Place Timer codes Oscillograph Recordings.—S. E. Dorsey. (*Electronics*, July 1956, Vol. 29, No. 7, pp. 154–156.) A 1-kc/s signal from a tuning-fork oscillator is fed through a trigger circuit into a chain of four decade counters which have additional 'staircase' outputs. Differentiation and combination of these outputs provides a c.r.o. trace indicating time in increments of 0·001 sec up to 9·999 sec, with markers for tenths, hundredths and thousandths of a second. A simple calibration method is described.

621.317.79 : 538.632 : 537.311.33 3155
A Simple Apparatus for recording the Variation of Hall Coefficient with Temperature.—E. H. Putley. (*J. sci. Instrum.*, April 1956, Vol. 33, No. 4, p. 164.)

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

536.52 : 621.385.029.6.032.21 3156
A New Method for the Measurement of Rapid Fluctuations of Temperature.—Dehn. (See 3258.)

550.837 3157
Geophysical Prospection of Underground Water in the Desert by means of Electromagnetic Interference Fringes.—G. L. Brown : M. A. H. El-Said. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, p. 940.) Comment on 1171 of April and author's reply.

620.179.1 : 621-52 3158
An Electronic Position-Tracking Instrument.—(*Tech. News Bull. nat. Bur. Stand.*, May 1956, Vol. 40, No. 5, pp. 68–69.) The motion of a metal object in a nonconducting medium is automatically followed by a mutual-inductance probe associated with a servo-mechanism.

621.317.39 : 531.71 3159
Mechanic-Electric Transducer.—K. S. Lion. (*Rev. sci. Instrum.*, April 1956, Vol. 27, No. 4, pp. 222–225.) A system for converting mechanical displacement into a voltage is based on the local variations of the voltage between a pair of electrodes in a luminous low-pressure discharge excited by a r.f. field.

621.317.39 : 621.383 3160
A Wide-Range Photoelectric Automatic Gain Control.—C. Riddle. (*Electronic Engng*, July 1956, Vol. 28, No. 341, pp. 288–292.) "A photocell and valve are arranged in such a way that the output voltage is proportional to the light modulation, and independent of the value of the steady light flux. The circuit is extremely simple, and the range over which the light flux may vary is very large (100 000 : 1)."

621.383 : 77 : 522.61 3161
Obtaining the Spectra of Faint Stars by Electronic Photography.—A. Lallemand & M. Duchesne. (*C. R. Acad. Sci., Paris*, 28th May 1956, Vol. 242, No. 22, pp. 2624–2626.)

621.383.5 : 531.745 : 621.396.934 3162
Photoelectric Angular-Error Sensors.—R. A. Nidey & D. S. Stacey. (*Rev. sci. Instrum.*, April 1956, Vol. 27, No. 4, pp. 216–218.) A device is described in which Ge-junction photocells are used to produce a voltage dependent on the orientation of a research rocket relative to the sun. See also 3182 below.

621.384.611 3163
Improving the Characteristics of the Cyclotron Beam.—W. B. Powell. (*Nature, Lond.*, 2nd June 1956, Vol. 177, No. 4518, p. 1045.) Brief preliminary note of a technique involving the use of beam-defining slits on the dee interface.

621.384.612 3164
Excitation of Synchrotron Oscillations due to Electron Radiation Fluctuations in a Strong-Focusing Accelerator.—A. A. Kolomenski. (*Zh. eksp. teor. Fiz.*, Jan. 1956, Vol. 30, No. 1, pp. 207–209.) Theoretical note. If $H_{max} \simeq 10^4$ oersted and $E \simeq 10$ kMeV, then the radial r.m.s. deviation of the orbit is of the order of a fraction of a centimetre.

621.384.612 3165
Influence of Radiation on Betatron Oscillations of Electrons in Synchrotrons with Strong [alternating-gradient] **Focusing.**—A. N. Matveev. (*C. R. Acad. Sci. U.R.S.S.*, 11th April 1956, Vol. 107, No. 5, pp. 671–674. In Russian.)

621.384.612 : 681.142 3166
Analog Computer for the Differential Equation $y' + f(x)y + g(x) = 0$.—Bodenstedt. (See 2973.)

621.385.833 3167
Electrostatic Fields permitting Rigorous Calculation of the Electron Paths.—H. Grümm. (*Ann. Phys., Lpz.*, 29th Feb. 1956, Vol. 17, Nos. 4/5, pp. 269–280.) Analysis is given separately for two-dimensional fields (pp. 269–274) and for rotationally symmetrical fields (pp. 275–280).

621.385.833 3168
Calculation of Electrostatic [electron] **Lenses.**—U. Timm. (*Z. Naturf.*, Aug. 1955, Vol. 10a, No. 8, pp. 593–602.) The use of matrix methods is described and illustrated.

621.385.833 3169
Construction of Magnetic Electron Lenses.—P. Durandeau. (*J. Phys. Radium*, March 1956, Vol. 17, Supplement to No. 3, *Phys. appl.*, pp. 18A–25A.) Design of short-focus lenses for very-high-velocity electrons is based on measurements of the field along the axis by the method described previously (1743 of 1953).

621.385.833 3170
Stereoscopic Reflection Electron Microscopy.—D. E. Bradley, J. S. Halliday & W. Hirst. (*Proc. phys. Soc.*, 1st April 1956, Vol. 69, No. 436B, pp. 484–485, plate.) The technique is briefly described, with some practical examples.

621.385.833 3171
Aperture Aberration of 5th Order in Spherically Corrected Electron Microscopes.—W. E. Meyer. (*Optik, Stuttgart*, 1956, Vol. 13, No. 2, pp. 86–91.)

621.385.833 3172
The Lower Limit of Aperture Aberration in Magnetic Electron Lenses.—H. Grümm. (*Optik, Stuttgart*, 1956, Vol. 13, No. 2, pp. 92–93.)

621.385.833 : 621.383.2 **3173**

Area Sources of Low-Energy Electrons for Electron-Optic Studies.—R. J. Schneeberger. (*Rev. sci. Instrum.*, April 1956, Vol. 27, No. 4, pp. 211–215.) If the final stages of the design of electron-optical systems for image tubes are carried out with a demountable tube containing a photocathode, the latter requires repeated cleaning and re-processing. Three sources suitable as substitutes for the photocathode are discussed, viz., (*a*) a thermionic source which sprays electrons through a perforated large-area electrode at about cathode potential, (*b*) a secondary-emission arrangement using a perforated plate with baffles associated with individual holes, and (*c*) a secondary-emission transmission arrangement.

621.386 : 621.383.2 **3174**

Cineroentgenography with Image Intensification.—F. J. Euler & P. A. Virbal. (*Elect. Engng, N.Y.*, March 1956, Vol. 75, No. 3, pp. 238–242.) Intensification of the X-ray image by means of a special form of image-intensifier tube permits shortening of exposure time and increase in thickness of material examined in studies of objects in motion.

621.387.4 : 621.314.7 **3175**

The Application of Transistors to the Trigger, Ratemeter and Power-Supply Circuits of Radiation Monitors.—E. Franklin & J. B. James. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 497–504. Discussion, pp. 516–518.) General requirements and conditions of use of radiation monitors for γ- and β-ray survey in connection with geological prospecting are outlined. Discussion indicates that junction transistors are preferable to either filament or cold-cathode valves or point-contact transistors for these applications.

621.389 **3176**

An Electronic Machine for Statistical Particle Analysis.—H. N. Coates. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 479–484.) "A system is described for associating and collecting the intercepts of individual particles in a particle scanning system, where the information is presented as a function of the scanning voltages. A series of stores is used to segregate the intercepts, each store having its own memory system and provision for re-use on completion of the scanning of the particle with which it is associated; the stores can thus be used many times during a single frame scan. A method of adding the intercepts of each particle to obtain a measure of the area of the particle is described, but this must be regarded as only one of the possibilities of extracting information from the series of intercepts collected."

621.396.934 **3177**

Missile Guidance by Three-Dimensional Proportional Navigation.—F. P. Adler. (*J. appl. Phys.*, May 1956, Vol. 27, No. 5, pp. 500–507.)

621.398 : 621.376 **3178**

Telemetering Demodulator for Wide-Band F.M. Data.—T. D. Warzecha. (*Electronics*, July 1956, Vol. 29, No. 7, pp. 157–159.) Demodulation of 12 subcarrier signals is effected by a pulse-averaging technique after recording the signals at a reduced tape speed and converting f.m. to p.f.m.

621.398 : 621.396.93 **3179**

Remote Radio Control of a Train.—(*Elect. J.*, 30th March 1956, Vol. 156, No. 4059, pp. 998–999.) Brief account of a system which has been successfully operated in the U.S.A.

621.398 : 621.396.934 **3180**

Shipboard Telemetering for Terrier Missiles.—W. S. Bell & C. W. Schultz. (*Electronics*, June 1956, Vol. 29, No. 6, pp. 134–137.) Description of equipment for a six-channel f.m./f.m. system providing magnetic-tape recordings of missile data.

621.398 : 621.396.934 **3181**

Transistor Modulator for Airborne Recording.—J. L. Upham, Jr, & A. I. Dranetz. (*Electronics*, June 1956, Vol. 29, No. 6, pp. 166–169.) Description of a p.p.m. telemetry system for indicating pressure or acceleration, based on the displacement of the core of a differential transformer.

621.398 : 621.396.934 **3182**

Transistors telemeter Small Missiles.—C. M. Kortman. (*Electronics*, July 1956, Vol. 29, No. 7, pp. 145–147.) Rate of spin of a missile 2 in. in diameter is determined from the cyclic frequency shift produced by the rotation of a Ge photocell exposed to the ambient light and connected across the coil of a junction-transistor Hartley oscillator. Curves showing oscillator frequency plotted against light intensity, temperature, etc. are given.

621.396.934 **3183**

Guidance. [Book Review]—A. S. Locke & collaborators. Publishers: Van Nostrand, Princeton, N.J., and Macmillan, London, 1955, 729 pp., $12.50 or 90s. (*Nature, Lond.*, 2nd June 1956, Vol. 177, No. 4518, pp. 1003–1004.) A general introduction and reference book, constituting the first of a projected series of five books on the principles of guided-missile design. The subjects involved include servomechanism theory, aerodynamics, radar, navigation, communications and the application of computers.

PROPAGATION OF WAVES

538.566.029.43 : 551.594.6 **3184**

Influence of the Horizontal Geomagnetic Field on Electric Waves between the Earth and the Ionosphere travelling Obliquely to the Meridian.—Schumann. (See 3060.)

621.396 **3185**

Symposium on Communications by Scatter Techniques.—(*Trans. Inst. Radio Engrs*, March 1956, Vol. CS-4, No. 1, pp. 1–122.) The text is given of papers presented at a symposium held in Washington in November 1955. These include the following:

Some Practical Aspects of Auroral Propagation.—H. G. Booker (p. 5).

Progress of Tropospheric Propagation Research related to Communications beyond the Horizon.—J. H. Chisholm (pp. 6–16).

Practical Considerations for Forward Scatter Applications.—J. R. McNitt (pp. 28–31).

Some Meteorological Effects on Scattered V.H.F. Radio Waves.—B. R. Bean (pp. 32–38).

Point-to-Point Radio Relaying via the Scatter Mode of Tropospheric Propagation.—K. A. Norton (pp. 39–49).

A Simplified Diversity Communication System for Beyond-the-Horizon Links.—F. J. Altman & W. Sichak (pp. 50–55).

V.H.F. Trans-horizon Communication System Design.—R. M. Ringoen (pp. 77–86).

System Parameters using Tropospheric Scatter Propagation.—H. H. Beverage, E. A. Laport & L. C. Simpson (pp. 87–96).

A Simple Picture of Tropospheric Radio Scattering.—W. E. Gordon (pp. 97–101).

Some Ionosphere Scatter Techniques.—D. A. Hedlund, L. C. Edwards & W. A. Whitcraft, Jr (pp. 112–117).

Signal Fluctuations in Long-Range Overwater Propagation.—W. S. Ament & M. Katzin (pp. 118–122).

Abstracts of some of these are given in *Proc. Inst. Radio Engrs*, June 1956, Vol. 44, No. 6, Part 1, p. 831.

621.396.11 **3186**

Field Strength in the Vicinity of the Line of Sight in Diffraction by a Spherical Surface.—K. Furutsu. (*J. Radio Res. Labs, Japan*, Jan. 1956, Vol. 3, No. 11, pp. 55–76.) The convergency of the formula for diffraction by a spherical earth is improved by using the expression for a flat earth, with an appropriate correction in the form of an integral.

621.396.11 : 551.510.535 **3187**

Observations of Ionospheric Absorption at the K.N.M.I. [Royal Netherlands Meteorological Institute].—van Daatselaar. (See 3054.)

621.396.11 : 551.510.535 **3188**

On the Existence of a 'Q.L.'-'Q.T.' 'Transition-Level' in the Ionosphere and its Experimental Evidence and Effect.—D. Lepechinsky. (*J. atmos. terr. Phys.*, June 1956, Vol. 8, No. 6, pp. 297–304.) See 1767 of 1955 (Lepechinsky & Durand).

621.396.11 : 551.594.6 **3189**

The Propagation of a Radio Atmospheric.—C. M. Srivastava. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 542–546.) Analysis is presented assuming that the original disturbance is a rectangular pulse of duration 100 μs and that propagation takes place by multiple reflections in the waveguide constituted by the earth and the ionosphere. The theory provides an explanation of the smooth oscillating waveform of atmospherics received from a distance.

621.396.11 : 621.396.674.3 **3190**

Radiation from a Vertical Antenna over a Curved Stratified Ground.—J. R. Wait. (*J. Res. nat. Bur. Stand.*, April 1956, Vol. 56, No. 4, pp. 237–244). Analysis is presented on the basis of a specified surface impedance at the earth's surface.

621.396.11.001.57 **3191**

Multipath Simulator tests Communications.—A. F. Deuth, H. C. Ressler, J. W. Smith & G. M. Stamps. (*Electronics*, July 1956, Vol. 29, No. 7, pp. 171–173.) A system designed for laboratory testing of long-range communication equipment is described. Two signal paths are provided by acoustic transducers operating at 150 kc/s in air which is disturbed by heat or fans to effect frequency-selective random fading.

621.396.11.029.4 : 551.594.6 **3192**

Propagation of Audio-Frequency Radio Waves to Great Distances.—F. W. Chapman & R. C. V. Macario. (*Nature, Lond.*, 19th May 1956, Vol. 177, No. 4516, pp. 930–933.) Observations of atmospherics waveforms have been supplemented by simultaneously recording the relative amplitudes of the frequency components in the waveform spectrum. Magnetic recording techniques were used to obtain permanent records of all disturbances reaching a vertical rod aerial. A second channel on the magnetic tape provided information as to the source of individual disturbances. The spectrometer was a modified form of that used previously [419 of 1954 (Chapman & Matthews)]. The results described were obtained from observations of cloud-to-ground discharges at known distances up to about 4 000 km. In all cases marked absorption was found at frequencies around 1–2 kc/s. An attenuation/frequency curve is presented linking the results with those obtained by Eckersley (*J. Instn elect. Engrs*, Sept. 1932, Vol. 71, No. 429, pp. 405–454) on long-distance radio transmissions at frequencies up to about 30 Mc/s. For a range of frequencies below 200 or 300 c/s the attenuation is no greater than for short waves.

621.396.11.029.45 **3193**

Long-Distance Propagation of 16-kc/s Waves.—N. M. Rust. (*Marconi Rev.*, 1st Quarter 1956, Vol. 19, No. 120, pp. 47–52.) Discussion of papers by Budden (2773 of 1953) and Pierce (2404 of 1955) suggests that the experimental results can be explained qualitatively in terms of simple ionosphere/ground-reflection propagation, taking into account up to four hops, without invoking more elaborate theories. The need for further experimental work is emphasized.

621.396.11.029.51 **3194**

Change of Phase with Distance of a Low-Frequency Ground Wave propagated across a Coast-Line.—B. G. Pressey, G. E. Ashwell & C. S. Fowler. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 527–534.) Continuation of work described previously (1782 of 1953). Observations were made on a frequency of 127·5 kc/s along a number of paths of lengths up to 22 km radiating from a transmitter near Lewes, England, and crossing the coast between Pevensey and Littlehampton; some paths tangential to the coast-line and some at right angles to the radials were also studied. The results confirm the existence of the phase-recovery effect on passing from low-conductivity ground to sea water. They also indicate systematic phase variations whose magnitudes decay from about 4° near the coast to a negligible amount at 6 λ out to sea. A very marked phase disturbance within λ/2 of the coast on the landward side is also evident; this is similar to that previously observed over geological boundaries on land.

621.396.11.029.51 **3195**

The Deviation of Low-Frequency Ground Waves at a Coast-Line.—B. G. Pressey & G. E. Ashwell. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 535–541.) "After consideration of the methods which have been suggested for computing the deviation of ground waves at a coast-line, the phenomenon is re-examined in the light of recent experimental and theoretical work on the phase disturbances at such a boundary. It is shown that the deviation may be calculated from the rate of change of phase with distance along the path of propagation. The changes in this rate which occur at the boundary give rise to a considerable increase in the magnitude of the deviation as the receiving point is brought within a few wavelengths of that boundary. This increase near the coast seems to provide an explanation of the unexpectedly large deviations previously observed at medium frequencies. A series of simultaneous measurements of the phase change and the deviation at 127·5 kc/s along a number of paths crossing the south coast of England are described. Although general agreement between the measured deviations and those derived from the phase curves was obtained on some paths, there were appreciable discrepancies on others. These discrepancies are attributed to the irregularities in the phase surface which were evident over the area and which the method of derivation did not take into account."

621.396.11.029.55 : 551.510.535 **3196**

The Prediction of Maximum Usable Frequencies for Radiocommunication over a Transequatorial Path.—G. McK. Allcock. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 547–552.) "Times of reception of 15 Mc/s radio waves over a transequatorial path of 7 500 km have been recorded throughout the recent period of declining solar activity (1950–54). The analysis of these times has shown that predictions of m.u.f. made by the usual control-point method were, in general, too high by about 4 Mc/s, and at times by as much as 7 Mc/s or more. This is contrary to the normal experience for long transmission paths lying within a single hemisphere. When a transmission mechanism involving multiple geometrical reflections is assumed instead of the forward-scattering mechanism implied by the control-point method, it is found that the path can be considered, for the purpose of predicting m.u.f.s, to consist of three reflections. The discrepancies between prediction and observation, which still remain after a 3-reflection mechanism has been invoked, are attributed mainly to reflections from the sporadic-E region at the southernmost reflection point, although it is possible that lateral deviation of the radio waves is also a contributing factor."

621.396.11.029.55 : 551.510.535 **3197**

Back-Scatter Ionospheric Sounder.—E. D. R. Shearman & L. T. J. Martin. (*Wireless Engr*, Aug. 1956, Vol. 33, No. 8, pp. 190–201.) Equipment is described for studying waves reflected from irregularities on the earth's surface and propagated back to the source via the ionosphere. The design of a suitable 150-kW pulse transmitter which can be simply tuned to any frequency in the band 10–27 Mc/s is discussed. The same 3-wire rhombic aerials are used for transmission and reception, with a tunable transmit-receive switch. A receiver of the type described by Piggott (2301 of 1955) provides an output suitable for presentation of the received echoes on a normal timebase display. A photographic record is made of this display, and continuous range/time ($p't$) records are also obtained. The same transmitter and receiver are also used with a continuously rotating Yagi aerial and p.p.i. By using speeded-up kinematography, the changes occurring over 24 h may be shown in a few minutes. See also 1854 and 1855 of June (Shearman).

621.396.11.029.6 : 551.510.52 **3198**

Some Considerations for the Field Strength of Ultra-short Waves at Night.—K. Tao. (*J. Radio Res. Labs, Japan*, Jan. 1956, Vol. 3, No. 11, pp. 77–99.) The high level of field strength found locally at night is caused by reflection at a tropospheric inversion layer. The formation of such layers is discussed and related to the prevailing meteorological conditions.

621.396.11.029.62 : 551.510.52 **3199**

Investigations of the Propagation of Ultra-short Waves.—R. Schünemann. (*Hochfrequenztech. u. Elektroakust.*, Jan. 1956, Vol. 64, No. 4, pp. 107–123.) Expressions are derived relating received field strength to atmospheric pressure, temperature and humidity and their height gradients, while taking account of diffraction at the earth's surface. Verifying experiments were made over a 76-km path, using a frequency of 68 Mc/s, with the transmitter aerial at a height of 90 m and the receiver aerial at a height of 30 m. The measured field strengths were correlated with meteorological observations; results are shown graphically for eight months, first for the main refracted and diffracted wave only, and then taking account of the reflected wave, which makes an effective contribution for 15%–30% of the time.

621.396.812.3 : 551.510.535 **3200**

A Correlation Treatment of Fading Signals.—N. F. Barber. (*J. atmos. terr. Phys.*, June 1956, Vol. 8, No. 6, pp. 318–330.) An examination in terms of the complete correlogram is made of the fading signals observed at three receivers located at the apices of a right-angled isosceles triangle with equal arms of length 91 m. Methods based on three different sets of assumptions are used to interpret the correlograms in relation to ionospheric drifts. Discussion indicates that a quadratic method of analysis is not affected by decay in the correlogram.

621.396.11.029.62 **3201**

Atlas of Ground-Wave Propagation Curves for Frequencies between 30 Mc/s and 300 Mc/s. [Book Review]—B. van der Pol. Publishers: International Telecommunication Union, Geneva, 1955, 35 pp. + 174 diagrams, $8.55. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, p. 952.) Information prepared at the request of the C.C.I.R. is presented regarding propagation over a spherical earth allowing for standard atmospheric refraction. The curves are preceded by an outline of the theory.

RECEPTION

621.376.23 : 621.396.822 **3202**

Interaction of Signal and Noise in an Inertial Detector.—L. S. Gutkin. (*Radiotekhnika, Moscow*, Feb. & March 1956, Vol. 11, Nos. 2 & 3, pp. 43–53 & 51–62.) The detection by a linear inertial detector of a signal in the presence of noise is analysed for the case when the signal is (*a*) unmodulated, and (*b*) amplitude modulated. The results are compared with the corresponding relations for a non-inertial detector. The detector arrangement considered is a diode with *RC* circuit.

621.376.33 : 621.396.82 **3203**

Fourier Representation of a Demodulated Beat Oscillation.—R. Leisterer. (*Elektronische Rundschau*, Jan. 1956, Vol. 10, No. 1, pp. 19–20.) The analysis presented shows that, if two sinusoidal signals, slightly differing in frequency, are applied via an ideal amplitude limiter to a linear wide-band f.m. discriminator, then the l.f. output voltage due to interference will increase with the signal frequency separation, and the waveform will depend on the amplitude ratio of the signals.

3204

621.396.62 + 621.395.625.3 + 621.395.92] : 621.314.7

Transistor Circuitry in Japan.—(*Electronics*, July 1956, Vol. 29, No. 7, pp. 120–124.) Circuits and characteristics of four types of broadcast receiver, a battery-operated tape recorder and a hearing aid are given.

621.396.621 + 621.397.62 **3205**

Preventing Fires from Electrical Causes in the Design and Manufacture of Radio and Television Receivers.—H. T. Heaton. (*Trans. Inst. Radio Engrs*, April 1955, Vol. BTR-1, No. 2, pp. 28–36.)

621.396.621 : 621.396.828 **3206**

The Compensation of Interference in Carrier-Frequency Receivers by means of an Opposing Receiver connected in Parallel.—H. Kaden. (*Frequenz*, March 1956, Vol. 10, No. 3, pp. 76–82.) Rigorous analysis is presented for the nonideal case, i.e. for circuits with arbitrary response characteristics over the pass band, assuming a sinusoidal signal of frequency within the pass band of the main receiver but outside that of the compensating receiver, and short interfering pulses. Rectifiers with square-law and broken-line characteristics are considered as demodulators; the broken-line characteristic leads to more effective elimination of the interference. For pulses occurring over a certain signal-phase range, the effect of the parallel receiver may be to increase the interference.

621.396.621.029.62 : 621.396.662 : 621.314.63 **3207**
Junction Diode A.F.C. Circuit.—G. G. Johnstone. (*Wireless World*, Aug. 1956, Vol. 62, No. 8, pp. 354–355.) A circuit intended primarily for a f.m. receiver uses a junction diode biased to cut-off; in this condition the diode capacitance varies with the applied voltage.

621.396.8 **3208**
Asymmetry in the Performance of High-Frequency Radiotelegraph Circuits.—A. M. Humby & C. M. Minnis. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 553–558.) A further study has been made of the systematic differences which have been observed previously in the performance of radiotelegraph circuits for transmission in the two opposite directions [3394 of 1955 (Humby et al.)]. Measurements on transequatorial circuits suggest that the asymmetry is due at least partly to the combined effects of using directive receiving aerials and the diurnal and seasonal changes in the sources of atmospheric noise.

621.396.82 : 621.327.43 **3209**
Evaluation of Radio Influence Voltages in Fluorescent Lighting Systems.—F. H. Wright & S. A. Zimmermann. (*Elect. Engng, N.Y.*, March 1956, Vol. 75, No. 3, pp. 272–274.) Interference with radio reception is caused mainly by supply-line radiation and by direct conduction. Elimination of interference by a low-impedance earth on the lighting system is unreliable; the connection of capacitors across individual lamps is most effective. In evaluating the efficiency of any filtering system a reference standard obtained by putting 0·01-μF capacitors across each lamp is recommended.

STATIONS AND COMMUNICATION SYSTEMS

621.376.56 **3210**
Coding of Signals by Damped-Oscillation Method.—B. Carniol. (*Slab. Obz., Prague*, March 1956, Vol. 17, No. 3, pp. 129–134.) A system of pulse coding which obviates the use of a coding tube is described. Voltage pulses of amplitudes proportional to the instantaneous amplitudes of the speech voltage, produced at intervals of 125 μs, excite an *LCR* circuit tuned to 500 kc/s. The resultant modulated voltage is passed through an amplitude limiter to a binary coder. Basic circuit diagrams of a simple coder and one with symmetrical logarithmic compression are given.

621.39 : 534.78 **3211**
The Vobanc—a Two-to-One Speech Bandwidth Reduction System.—Bogert. (See 2943.)

621.39.01 : 512.831 **3212**
Topological Properties of Telecommunication Networks.—Z. Prihar. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, pp. 927–933.) A method of matrix analysis developed in connection with sociological studies is applied to investigate problems relating to the connections between a number of points. Numerical examples are given.

621.396 **3213**
Symposium on Communications by Scatter Techniques.—(See 3185.)

621.396.41 + 621.395.43] : 621.376.3 **3214**
An Extended Analysis of Echo Distortion in the F.M. Transmission of Frequency Division Multiplex.—R. G. Medhurst & G. F. Small. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 447–448.) Discussion on 1867 of June.

621.396.41 : 621.376.3 **3215**
Multiprogram F.M. Broadcast System.—W. N. Hershfield. (*Electronics*, June 1956, Vol. 29, No. 6, pp. 130–133.) A system is described in which three additional programs with bandwidth 10 kc/s are transmitted by f.m. on subcarriers 28, 49 and 67 kc/s above the main broadcast carrier. Detailed circuit diagrams are given of the subcarrier generator with serrasoid modulator, the transmitter exciter stage, the main-channel receiver and a subcarrier demodulator unit.

621.396.41.029.6 : 621.376.3 : 621.396.82 **3216**
Nonlinear Distortion in Multichannel Communication Systems with Frequency Modulation.—V. A. Smirnov. (*Radiotekhnika, Moscow*, Feb. 1956, Vol. 11, No. 2, pp. 14–28.) Noise due to multipath propagation and waveguide mismatch is considered theoretically. The results are more general than those obtained by Borovich (*ibid.*, Oct. 1955, Vol. 10, No. 10, pp. 3–14) and by Bennett et al. (3089 of 1955).

621.396.5 : 621.396.4 **3217**
The Copenhagen-Thorshavn Radiotelephony Link.—S. Gregersen. (*Teleteknik, Copenhagen*, Feb. 1956, Vol. 7, No. 1, pp. 15–34.) Detailed description of this h.f. multichannel system.

621.396.65 **3218**
V.H.F. Radio Link in the West Indies.—R. McSweeny. (*Elect. Engng, N.Y.*, March 1956, Vol. 75, No. 3, p. 271.) Digest of paper published in *Trans. Amer. Inst. elect. Engrs*, Part I, *Communication and Electronics*, Jan. 1956, Vol. 74, pp. 781–785. Details are given of two radio links over 69 miles and 45 miles respectively, using f.m. transmissions on frequencies of 150–160 Mc/s.

621.396.7 + 621.397.7](47) **3219**
Broadcasting in the U.S.S.R.—(*Wireless World*, Aug. 1956, Vol. 62, No. 8, pp. 379–381.) Some technical details of the sound and vision services are given, with a note on the television standards.

621.396.7(492) : 621.376.3] + 621.397.7(492) **3220**
A Survey of the TV and F.M. Projects in the Netherlands.—J. L. Bordewijk. (*PTT-Bedrijf*, March 1956, Vol. 7, No. 1, pp. 1–12. In English.)

621.396.71(489) **3221**
Coast Stations in Denmark.—K. Svenningsen. (*Teleteknik, Copenhagen*, Feb. 1956, Vol. 7, No. 1, pp. 1–14.) The radio stations at Thorshavn, Skagen (The Skaw) and Rønne are described; telegraphy and telephony services are handled.

SUBSIDIARY APPARATUS

621-526 **3222**
An On-Off Servomechanism with Predicted Change-Over.—J. F. Coales & A. R. M. Noton. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 449–460. Discussion, pp. 460–462.) "A general method has been devised for achieving optimum switching with an on-off control system. The practicability of predicting the ideal switching time has been demonstrated with a model experiment for which responses to step, ramp, and parabolic input functions

have been found to compare favourably with those of an orthodox system."

621-526 **3223**

The Dual-Input Describing Function and its Use in the Analysis of Nonlinear Feedback Systems.—J. C. West, J. L. Douce & R. K. Livesley. (*Proc. Instn elect. Engrs*, Part B, July 1956, Vol. 103, No. 10, pp. 463–473. Discussion, pp. 473–474.)

621.3-71 : 537.32 : 537.311.33 **3224**

Thermoelectric Cooling.—L. S. Stil'bans, E. K. Iordanishvili & T. S. Stavitskaya. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, Jan. 1956, Vol. 20, No. 1, pp. 81–88.) A brief account is given of A. F. Ioffe's theory of thermoelectric cooling (*Energetical Bases of Semiconductor Thermo-Batteries*, published by the U.S.S.R. Academy of Sciences, Moscow, 1956) and of experimental results. Temperature differences up to 70°C have been obtained. Applications being investigated include cooling of components in radio and electronic equipment.

621.314.63 : 546.28 **3225**

Diffused *p-n* Junction Silicon Rectifiers.—M. B. Prince. (*Bell Syst. tech. J.*, May 1956, Vol. 35, No. 3, pp. 661–684.) Development types with current ratings up to 100 A for reverse peak voltages of 200 V or over are described. Operation is satisfactory at temperatures up to 200°C.

621.314.63 : 546.28 **3226**

The Forward Characteristic of the P-I-N Diode.—D. A. Kleinman. (*Bell Syst. tech. J.*, May 1956, Vol. 35, No. 3, pp. 685–706.) Theory for the *p-i-n* Si diffused-junction diode indicates that the forward characteristic should be similar to that of the simple *p-n* diode until the current density approaches 200 A/cm²; anomalies in the characteristic at low current densities are unrelated to the presence of the weakly *p* middle region. See also 3225 above.

621.362 : 537.311.33 : 537.32 **3227**

Thermoelectric Generators.—A. F. Ioffe. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, Jan. 1956, Vol. 20, No. 1, pp. 76–80. In Russian.) Basic design formulae are given and discussed. Using a semiconductor layer 0·5 cm thick, with thermoelectric coefficient 170×10^{-6} V/deg, a temperature difference of 300°C across it, and a heat input of 11·6 W/cm², and assuming a specific mass of 5 and an efficiency of 8%, an output of 0·2 kW/kg may be obtained.

TELEVISION AND PHOTOTELEGRAPHY

621.397.611.2 : 525.623 : 621.397.7 **3228**

The 'Vitascan'—New Color TV Scanner.—C. E. Spicer. (*Tele-Tech & Electronic Ind.*, Feb. 1956, Vol. 15, No. 2, pp. 60–61 . . 117.) A spot of white light, generated on the screen of a c.r. tube by a beam deflected at the standard television rate, is projected on the scene and the reflected light is picked up by fixed photo-multiplier tubes, associated with colour filters, which generate the video signal. General studio lighting is provided by pulsing xenon lamps to be on during the vertical retrace time of the television signal.

621.397.62 + 621.396.621 **3229**

Preventing Fires from Electrical Causes in the Design and Manufacture of Radio and Television Receivers.—H. T. Heaton. (*Trans. Inst. Radio Engrs*, April 1955, Vol. BTR-1, No. 2, pp. 28–36.)

621.397.62 **3230**

A Television Receiver Suitable for Four Standards.—H. L. Berkhout. (*Philips tech. Rev.*, Dec. 1955, Vol. 17, No. 6, pp. 161–170.) A model suitable for receiving the Belgian 625- and 819-line, the European 625-line, and the French 819-line standards is described. A common vision i.f. amplifier is used, the frequency being 38·9 Mc/s and the bandwidth 4 Mc/s. The video signal is applied to the picture-tube control grid for positive modulation and to the cathode for negative modulation. Different sound intermediate frequencies are again converted to a common second i.f. of 7 Mc/s. Flywheel synchronization is used for the horizontal deflection.

621.397.62 : 525.623 **3231**

Chrominance Circuits for Colour-Television Receivers.—B. W. Osborne. (*Electronic Engng*, June & July 1956, Vol. 28, Nos. 340 & 341, pp. 240–246 & 293–297.) "A survey of current practice and recent developments in phase synchronization, chrominance demodulator and matrix circuits for use in colour-television receivers."

621.397.621 : 535.623 : 621.385.832 **3232**

Television Receiver uses One-Gun Color C.R.T.—(*Electronics*, June 1956, Vol. 29, No. 6, pp. 150–153.) A description is given of the 'apple' tube. An electron beam sequentially strikes vertical phosphor stripes arranged in triplets of red, blue and green on an aluminized screen, with interstices filled with non-luminescent material. Applied behind each red stripe and covering about 40% of the triplet width is an 'indexing' stripe of MgO with high secondary-emission characteristic. An intensity-modulated pilot beam from the same electron gun is aligned so that it strikes the same colour stripe as the main beam, and the secondary-emission current is used to derive an indexing signal controlling the amplitude and phase modulation of the main signal to produce a colour display. Block diagrams and some details of the associated receiver circuit are given.

621.397.7 **3233**

Optical Multiplexing in Television Film Equipment.—A. H. Lind & B. F. Melchionni. (*J. Soc. Mot. Pict. Telev. Engrs*, March 1956, Vol. 65, No. 3, pp. 140–145. Discussion, p. 145.)

621.397.7 + 621.396.7](47) **3234**

Broadcasting in the U.S.S.R.—(See 3219.)

621.397.7(492) + [621.396.7(492) : 621.376.3 **3235**

A Survey of the TV and F.M. Projects in the Netherlands.—J. L. Bordewijk. (*PTT-Bedrijf*, March 1956, Vol. 7, No. 1, pp. 1–12. In English.)

621.397.8 : 621.372 : 621.3.018.752 **3236**

The Effect upon Pulse Response of Delay Variation at Low and Middle Frequencies.—Callendar. (See 2984.)

TRANSMISSION

621.376.22 : 621.317.6 : 621.385.5 **3237**

Study of Amplitude Modulation applied via a Pentode Suppressor Grid.—J. Loeckx. (*Rev. HF, Brussels*, 1956, Vol. 3, No. 5, pp. 183–190.) With this method of modulation, the pentode screen grid is maintained at fixed potential. The relation between the anode current and the grid and anode voltages is derived, and the equation of the modulation characteristic is hence determined explicitly. A measurement method particularly suitable for obtaining the characteristics of power valves is outlined.

621.396.61 : 621.396.662 3238

Automatic Tuning for High-Power Transmitter.—V. R. DeLong. (*Electronics*, July 1956, Vol. 29, No. 7, pp. 134–137.)

VALVES AND THERMIONICS

621.314.63(47) : 546.289 3239

Germanium Diodes.—A. N. Puzhai. (*Avtomatika i Telemekhanika*, Feb. 1956, Vol. 17, No. 2, pp. 140–146.) Discussion of the characteristics of point-contact and junction-type Ge diodes available in Russia.

621.314.632 : 546.289 3240

Effect of Vacuum Heating and Ion Bombardment of Germanium on Point Contact Rectification.—R. B. Allen & H. E. Farnsworth. (*J. appl. Phys.*, May 1956, Vol. 27, No. 5, pp. 525–529.) Measurements were made of the characteristics of diodes comprising a Ge crystal with a tungsten or columbium point contact, to determine whether an adsorbed gas layer on the Ge surface is a pre-requisite for rectification. Ge surfaces free from such layers are obtained by vacuum heating and argon-ion bombardment. The best rectification characteristics were obtained after the Ge had been subjected to a long anneal, argon-ion bombardment, and a short anneal, in that order. The diode activation potential does not appear to be dependent on the metallic work function.

621.314.7(083.7) 3241

I.R.E. Standards on Letter Symbols for Semiconductor Devices, 1956.—(*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, pp. 934–937.) Standard 56 I.R.E. 28. SI on transistors.

621.314.7.002.2 3242

Automatic Etching of Transistor Pellets.—(*Electronics*, July 1956, Vol. 29, No. 7, pp. 226..236.) A description of the etching, washing and indium plating of concentric holes in Ge or Si pellets for surface-barrier transistors. The precision electrochemical etching is controlled by a light beam and photocell.

621.314.7 : 537.311.33 3243

Propagation of a Short Pulse in a Semiconductor bounded by Two Electron-Hole Transitions.—E. I. Adirovich & V. G. Kolotilova. (*Zh. eksp. teor. Fiz.*, Dec. 1955, Vol. 29, No. 6(12), pp. 770–777.) The propagation of a short pulse in a *p-n-p* transistor is considered theoretically. Using the continuity equation for holes, an expression is derived for the concentration of non-equilibrium carriers at an arbitrary cross-section due to application of the pulse at the emitter. The collector current is calculated for various values of lifetime of the nonequilibrium carriers, and the effect of the boundary conditions on the electron processes in the body of the semiconductor is discussed.

621.314.7 : 621.318.57 3244

A Switching Transistor with Short Transition Times.—H. Salow & W. v. Münch. (*Z. angew. Phys.*, March 1956, Vol. 8, No. 3, pp. 114–119.) A characteristic with an unstable region is obtained by adding an auxiliary collector adjacent to the usual collector of a junction transistor. In an experimental *n-p-n* unit with base thickness of 50 μ, a change of emitter/base resistance from 1 MΩ to 20 Ω was achieved in 2×10^{-7} s. The theory and the characteristics are discussed.

621.314.7 : 621.387.4 3245

The Application of Transistors to the Trigger, Ratemeter and Power-Supply Circuits of Radiation Monitors.—Franklin & James. (See 3175.)

621.314.7 : 621.396.822 3246

Microphonism due to Transistor Leads.—C. W. Durieux & T. A. Prugh. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, pp. 938–939.) A brief note of observations of voltages generated by the vibrations of transistor leads in a magnetic field.

621.38.004.6 3247

Reliability as a Design and Maintenance Problem.—R. Matthews. (*Electronic Engng*, July 1956, Vol. 28, No. 341, pp. 310–312.) The subject is discussed particularly in relation to valve performance.

621.383.27 : 621.387.464 3248

Study of the First-Stage Focusing of a Photomultiplier Tube for Scintillation Counting.—G. Wendt. (*Ann. Radioélect.*, Oct. 1955, Vol. 10, No. 42, pp. 372–386.)

621.383.4 3249

The Photo-effect in Lead Sulphide and Related Materials.—R. Stein & B. Reuter. (*Z. Naturf.*, Aug. 1955, Vol. 10a, No. 8, pp. 655–656.) Discussion of photoelectric inertia effects which have been traced to the presence of excess sulphur. Experiments are reported which indicate that these effects are probably related to the sensitization of the PbS cell by the usual method involving oxidation.

621.383.4/5 : 546.817.221 3250

***p-n* Junctions in Photosensitive PbS Layers.**—J. Bloem. (*Appl. sci. Res.*, 1956, Vol. B6, Nos. 1/2, pp. 92–100.) PbS layers containing sharp *p-n* junctions can be produced by precipitation from an aqueous solution on to a glass plate partially coated with a thin layer of a trivalent metal; immediately after deposition, the whole of the PbS layer is of *n* type, but the portion on the uncoated glass is converted to *p* type soon after coming into contact with the air. Measurements of the photo-e.m.f. and resistance of such cells are reported; variations with storage time were investigated. The influence of oxygen in the ambient gas is discussed.

621.383.5 3251

The Photo-Electromotive Force of Lead Sulphide Photocells.—R. Ya. Berlaga, M. A. Rumsh & L. P. Strakhov. (*Zh. tekh. Fiz.*, Oct. 1955, Vol. 25, No. 11, pp. 1878–1882.) Layers of PbS were obtained in which an e.m.f. appeared during illumination, although no voltage was applied during their preparation. The photo-e.m.f. of freshly prepared specimens was of the order of a few mV. When the specimens were heated to temperatures between 500° and 600°C, the photo-e.m.f. increased to 3 V. The experimental investigation is described, electron-diffraction diagrams are reproduced, and a theoretical interpretation of the results is given.

621.385.029.6 3252

Theory of the Transverse-Current Traveling-Wave Tube.—D. A. Dunn, W. A. Harman, L. M. Field & G. S. Kino. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, pp. 879–887.) Valves are discussed in which an extended beam approaches the helix from the side, either normally or at an angle; each electron, instead of travelling the length of the helix, cuts across it and interacts with it for only a fraction of its length. Three forward waves are produced in such a system. Expressions are derived for the overall gain. The power output reaches saturation for a given value of input and stays at this value with further increase of input.

621.385.029.6 3253

An Experimental Transverse-Current Travelling-Wave Tube.—D. A. Dunn & W. A. Harman. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, pp. 888–896.) Details are given of the construction and performance of a valve of the class discussed by Dunn et al. (3252 above) using a flat helix and a skew beam. The valve operates as an amplifier over the frequency range 1–2 kMc/s with a power output of the order of 30 mW. The gain/voltage characteristic is markedly different from that of a conventional travelling-wave valve; high attenuation is observed over a wide range of current and voltage values. Gain/current, gain/frequency and saturation-power/frequency characteristics are as predicted by the theory. Experiments are described in which two input signals of different frequencies were applied simultaneously.

621.385.029.6 3254

Some Effects of Magnetic Field Strength on Space-Charge-Wave Propagation.—G. R. Brewer. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, pp. 896–903.) General analysis is presented for the propagation of space-charge waves in magnetically focused electron beams. The propagation characteristics for the fundamental radial mode are expressed in terms of the plasma-frequency reduction factor, graphs of which are shown. The case of a beam within a helix, as in the travelling-wave valve, is examined particularly.

621.385.029.6 3255

Study of the Oscillation Modes of the M-Type Carcinotron: Part 1.—M. de Bennetot. (*Ann. Radioélect.*, Oct. 1955, Vol. 10, No. 42, pp. 328–343.) The starting current and oscillation frequency are determined theoretically, taking account of space-charge effects. The field of the space harmonic interacting with the electron beam in this case is constituted by the sum of three travelling waves.

621.385.029.6 : 621.316.726 : 621.396.96 3256

Klystron Control System.—Reeves. (See 3068.)

621.385.029.6 : 621.396.822 3257

A Dip in the Minimum Noise Figure of Beam-Type Microwave Amplifiers.—P. K. Tien. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, p. 938.) A detailed computation has been made of the fluctuations of electron current and velocity at the potential minimum of a particular valve. The results indicate that the velocity fluctuation is not smoothed and the fluctuations of current and velocity are not correlated. A physical explanation is given of the resulting shape of the cumulative autocorrelation curve. The minimum noise figure for a typical travelling-wave valve as calculated from this autocorrelation curve shows a dip at about 2·5 kMc/s and a peak at about 4 kMc/s.

621.385.029.6.032.21 : 536.52 3258

A New Method for the Measurement of Rapid Fluctuations of Temperature.—R. Dehn. (*Brit. J. appl. Phys.*, April 1956, Vol. 7, No. 4, pp. 144–148.) Instantaneous changes in cathode surface temperature in an oscillating magnetron are displayed and measured as pulses on a c.r.o. screen by means of an infrared-image converter and photomultiplier. The instrument is calibrated against an optical pyrometer; changes of 2°C at 900°C have been detected.

621.385.032.21 : 537.58 3259

Thermionic Emission Properties of Thin Films of Thorium Oxide and Thorium on Metallic Bases.—A. R. Shul'man & A. P. Rumyantsev. (*Zh. tekh. Fiz.*, Oct. 1955, Vol. 25, No. 11, pp. 1898–1909.) Report on an experimental investigation of thin films of ThO_2 and Th deposited on Mo and Pt bases. The deposition of the films is described in detail and a large number of experimental curves are given. The results are discussed and various suggestions regarding the mechanism of thermionic emission are made.

621.385.032.216 3260

Radioactive Isotope Study of the Dissociation of Barium Oxide under Electron Bombardment.—S. Yoshida, N. Shibata, Y. Igarashi & H. Arata. (*J. appl. Phys.*, May 1956, Vol. 27, No. 5, pp. 497–500.) Measurements are reported of the rate of evolution of Ba; the number of Ba atoms produced per bombarding electron is plotted as a function of bombarding-electron voltage and of oxide temperature. The results are qualitatively similar to those for SrO (*J. phys. Soc. Japan*, July/Aug. 1954, Vol. 9, No. 4, pp. 640–641); discussion indicates that they can be reconciled with those of Leverton & Shepherd (3601 of 1952).

621.385.132 : 681.142 3261

Binary Adder uses Gas-Discharge Triode.—F. B. Maynard. (*Electronics*, June 1956, Vol. 29, No. 6, pp. 196..202.) The elementary triode cell has a large-area cathode and closely overlaid anode element of fine wire. A probe element in the upper part of the cathode glow, common to a number of cells, acquires a positive charge. The voltage excursion at the probe can be as much as 30 V without causing a discharge in cells other than that actuated. Experimental valves with a matrix of 30 of these cells have been tested.

621.385.5.032.24 : 621.374.3 3262

A New High-Slope Multigrid Valve and its Application in Pulse and Switching Circuits.—K. Gosslau & W. Guber. (*Frequenz*, March 1956, Vol. 10, No. 3, pp. 83–89.) An experimental heptode Type-V108 with three frame grids had slopes of 13 and 7·5 mA/V respectively at the two control grids, high pulse current intensity, and adequate loading capacity at the first screen grid. A pulse distributor using this valve is described.

621.385.832 : 621.397.621 : 535.623 3263

Television Receiver uses One-Gun Color C.R.T.—(See 3232.)

MISCELLANEOUS

061.6 : 621.396 3264

International Cooperation in Radio Research—U.R.S.I. and I.R.E.—J. H. Dellinger. (*Proc. Inst. Radio Engrs*, July 1956, Vol. 44, No. 7, pp. 866–872.) The internal structure of the International Scientific Radio Union is described, and its relations with the C.C.I.R. and the I.R.E. are explained.

621.3 : 537 3265

Advances in Electronics and Electron Physics, Vol. VII. [Book Review]—L. Marton (Ed.). Publishers: Academic Press, New York, 1956, 503 pp., $11.50. (*Proc. Inst. Radio Engrs*, June 1956, Vol. 44, No. 6, Part 1, pp. 828–829.) Review articles are presented on the physics of semiconductor materials, theory of electrical properties of Ge and Si, energy losses of electrons in solids, sputtering by ion bombardment, observational radio astronomy, analogue computers, and electrical discharge in gases and modern electronics.

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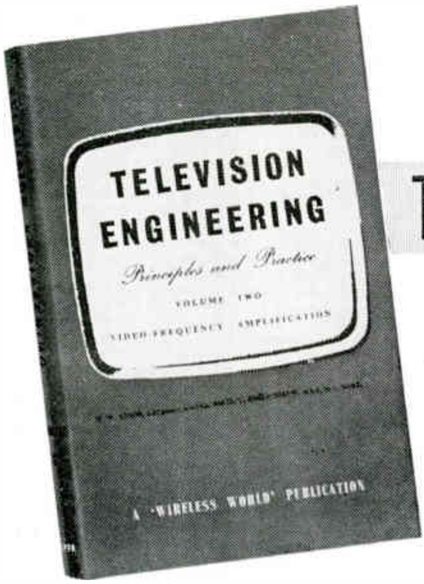

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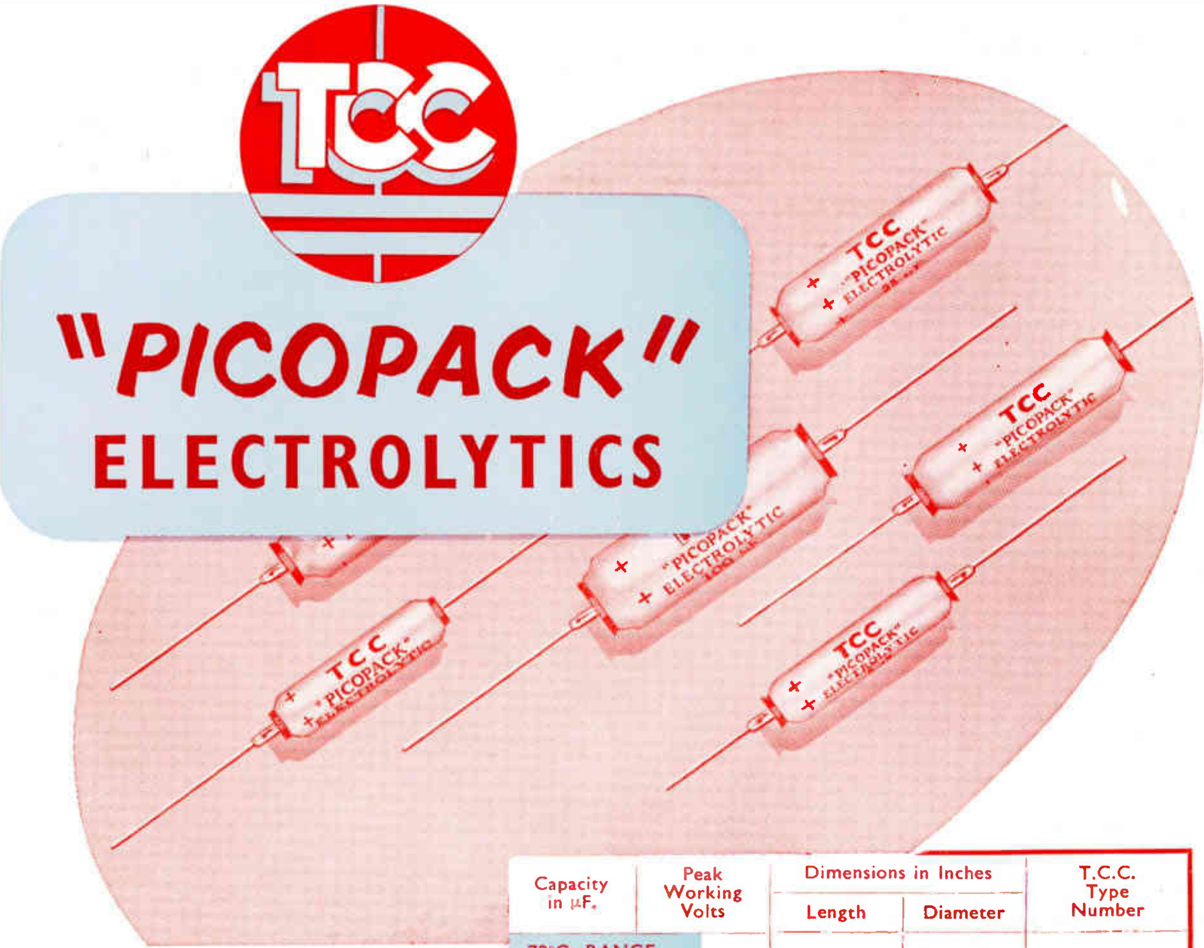

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