WIRELESS ENGINEER

MARCH 1947

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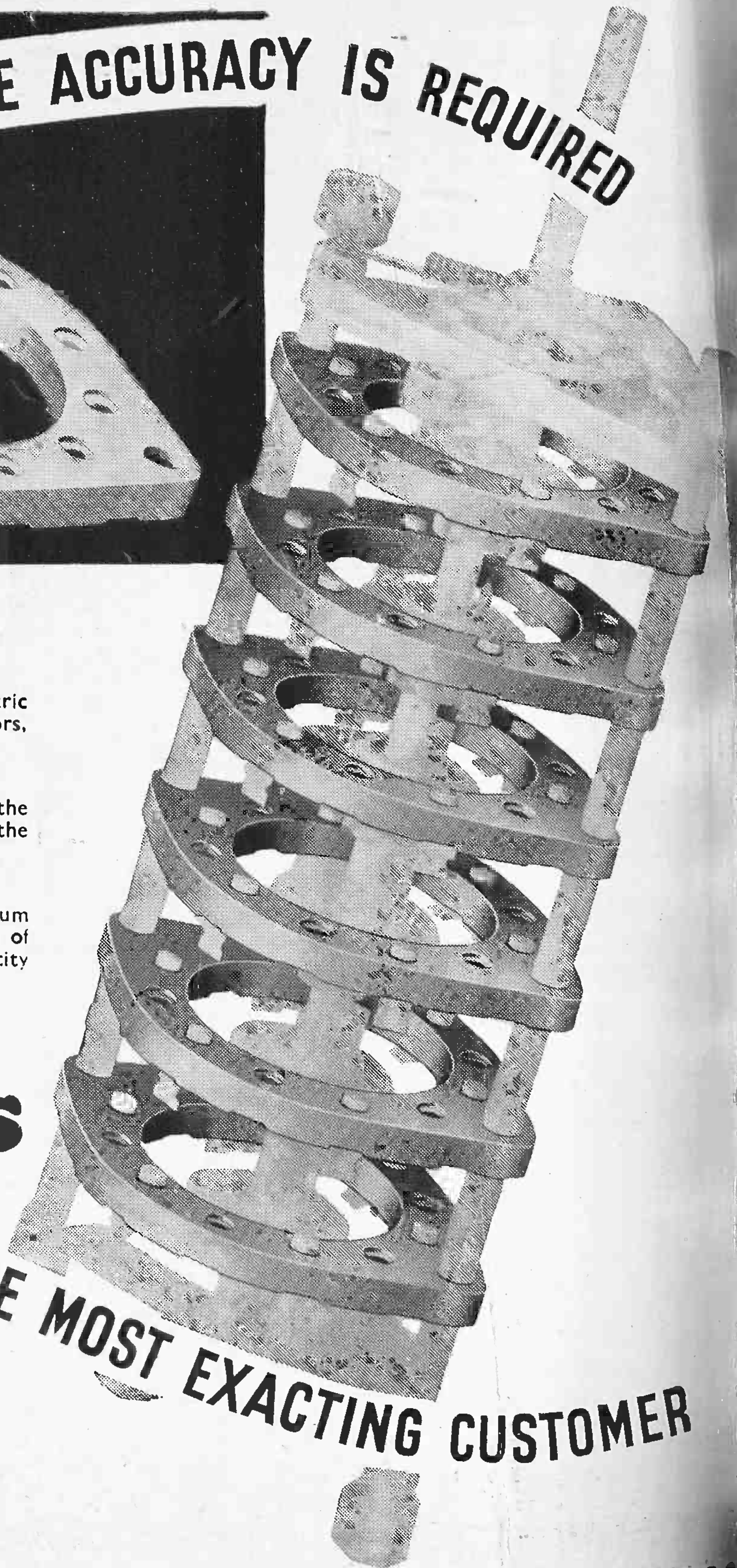

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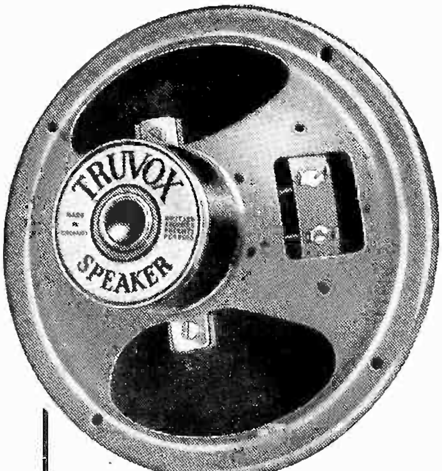

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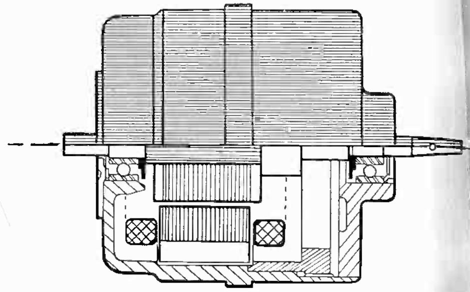

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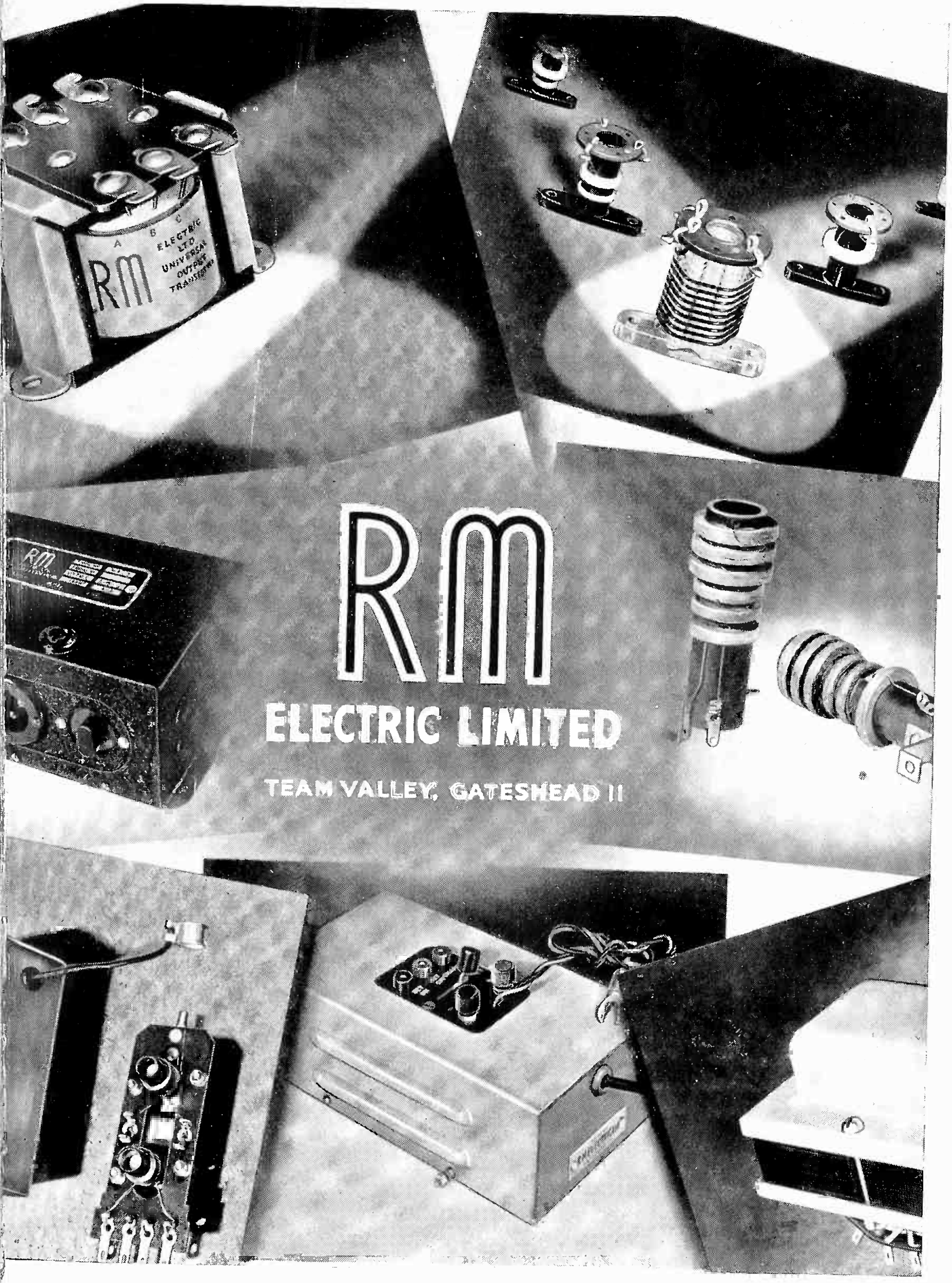
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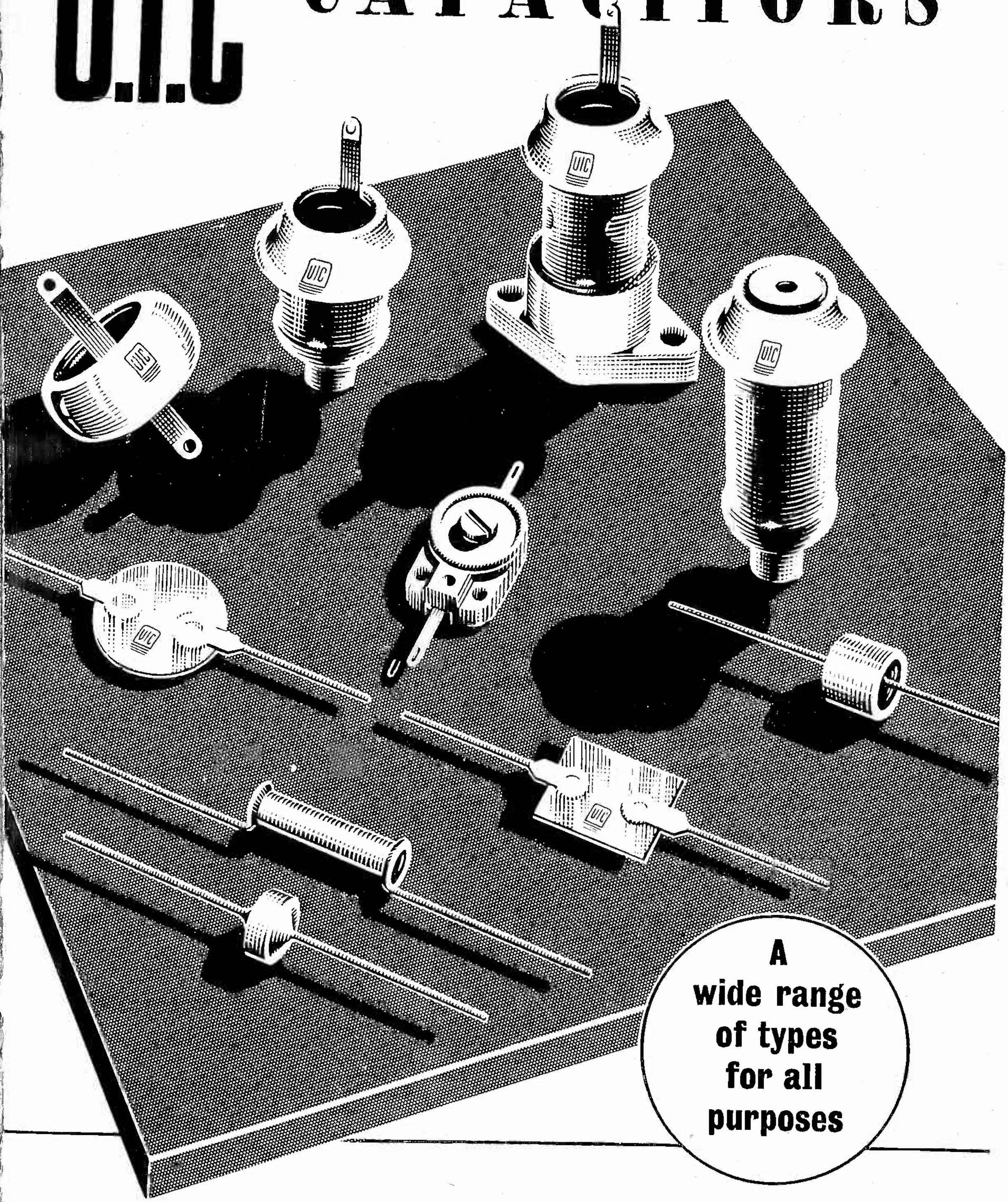

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MARCH 1947

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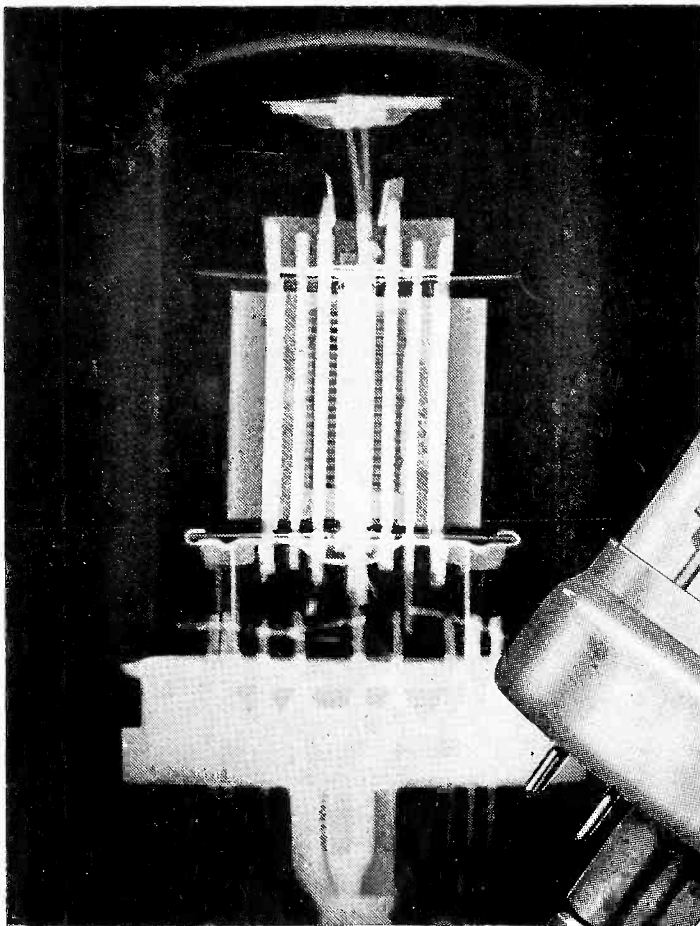

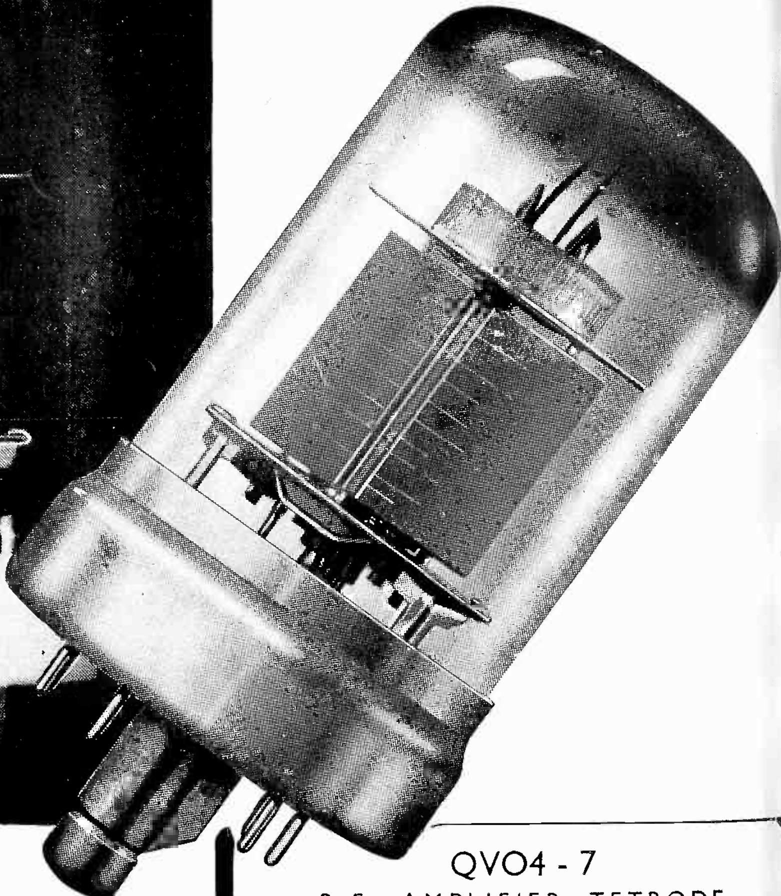

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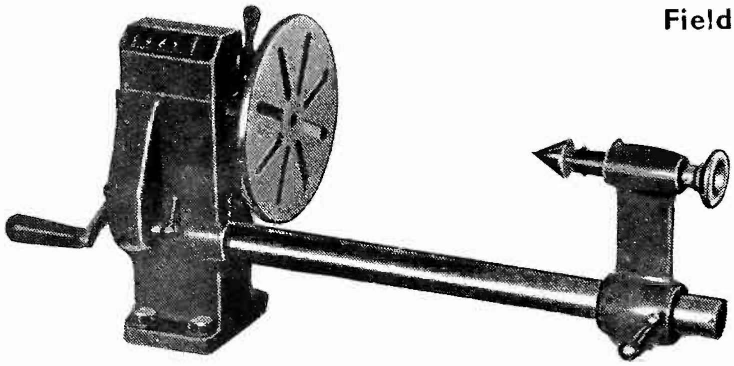

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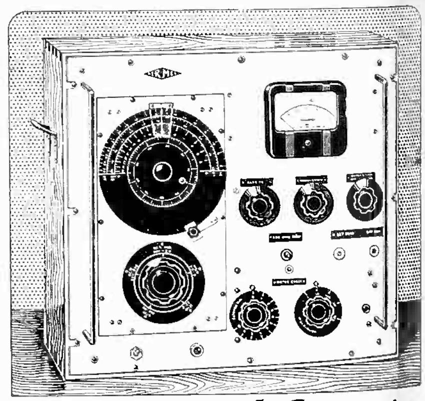

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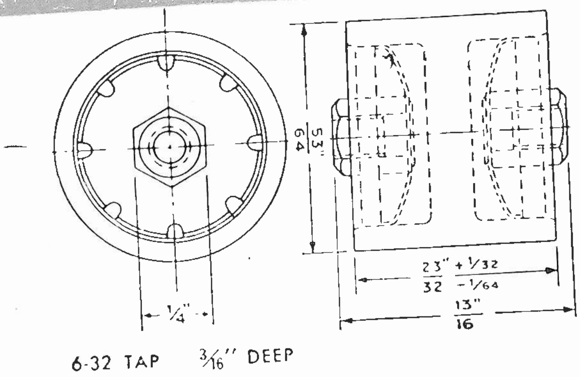

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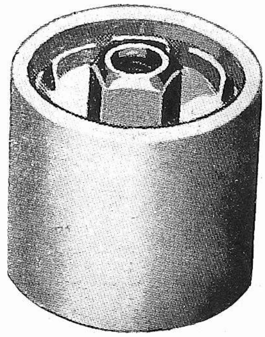

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WIRELESS ENGINEER

Vol. XXIV. MARCH 1947 No. 282

EDITORIAL

Alexander Graham Bell, born 3rd March, 1847—died 2nd August, 1922

ALEXANDER GRAHAM BELL was born in Edinburgh on 3rd March, 1847, the son of Alexander Melville Bell, who was a lecturer in elocution at New College, Edinburgh from 1843 to 1865, and whose father was also a prominent teacher of elocution in London and the author of several text-books on the subject. On the death of his father in 1865, Alex. Melville Bell moved from Edinburgh to London and became lecturer in elocution at University College. He was a noted authority on speech and published a great deal on vocal physiology, phonetics and visible speech; i.e., a method of teaching people who were born deaf to speak. He visited Boston, Mass., in 1868, 1870 and 1871 to give courses of lectures.

His son Alexander Graham was eighteen when the family removed to London and he being then a resident teacher of elocution and music at Elgin, followed later and became a student at University College where his father was a lecturer. There had been three sons but the other two had died, and in 1870, as Alexander Graham's health was causing anxiety, the family removed to Canada and Alexander Melville Bell was appointed Professor of Elocution at Queen's College, Kingston, Ontario. After three years Alex. Graham's health was so improved that he accepted a position at the Boston School of Oratory. This was in 1873 and he was 26 years of age. He was an elocutionist of the third generation and his whole upbringing had been in an atmosphere of vocal physiology and phonetics. He had tried to determine the pitch of the tones that constitute the different vowels, and the resonant pitches of the mouth cavities when formed to utter the different vowels. When he wrote to a friend about this he was told that Helmholtz had already done this much more thoroughly. He then obtained a copy of Helmholtz's "Theory of Tone" and tried to repeat his experiments, but he confessed that at that time he was too slightly acquainted with the laws of electricity fully to understand the explanations given. He thought of the possibilities of producing music by electrically maintained tuning forks and of using a number of forks of different pitch for the simultaneous transmission of a number of messages over a single line by means of Morse Code. He studied the various systems of telegraphy then in use and became familiar with Morse keys, sounders, etc. He replaced the tuning forks by simple vibrating reeds which closed and opened the circuit, each reed at the receiving end only responding to the transmitting reed to which it was tuned; at least, that was the intention.

One must not be misled by the use of the word telephone in accounts of these early experiments; the transmission of a single tone by means of an electric current was sometimes referred to as electric telephony and when speech transmission was attained it was sometimes referred to as articulate telephony.

Although Bell devoted himself whole-heartedly to the development of this harmonic telegraph, he was nursing the idea of the transmission of speech and proposed to his instrument maker and assistant, Watson, that he should make some instruments to try out the idea, but his future father-in-law, who was helping him financially, persuaded him to concentrate on the harmonic telegraph and not build such castles in the air. On June 2, 1875 a slight accident occurred that altered the whole course of events. Watson was in one room attending to the transmitting reeds while Bell in an adjacent room put each receiving reed in turn against his ear and adjusted the screw until it was properly tuned, Then the accident occurred, for the make-and-break points of one reed became welded together and Watson kept on plucking it to get it to restart. Bell rushed in to see what was happening, and as Watson said "the speaking telephone was born at that moment," for Bell saw that the peculiar sound that he had heard was not due to any intermittent current but to the undulatory current produced by the vibration of the steel spring over the pole of the magnet.

He told Watson to make a small drumhead of gold-beater's skin, with the centre joined to the free end of the steel spring and a mouth-piece over the drumhead. This was made at once and tested the next day with very little success. Although Watson could hear Bell's voice and almost catch the words, it required nine months of research before Watson heard a complete and intelligible sentence; that was in March 1876, and during the summer such progress was made that, to use Watson's own words, "one didn't have to ask the other man to say it over again more than three or four times before one could understand quite well, if the sentences were simple." Bell seems to have done little more with the harmonic telegraph, which was perfected later by his rival Elisha Gray, who was also working on the transmission of speech and lodged a caveat for a patent on the same day that Bell applied for his patent, but an hour or two later.

By October 1876 the telephone was being tested between Boston and Cambridge a distance of two miles. The present type of receiver emerged as the result of hundreds of experiments with diaphragms varying from several feet in diameter to representations of the human ear, with electro-magnets and permanent magnets of all sizes and shapes. Bell used the same instrument as transmitter and receiver, but his patent application included a transmitter consisting of a diaphragm carrying a wire dipping into a cup of acidulated water or salt solution, thus varying the resistance as the diaphragm vibrated. This he exhibited together with the electromagnetic transmitter and receiver at the Centennial Exhibition at Philadelphia in 1876. One of the judges at this exhibition was Sir William Thomson, afterwards Lord Kelvin, and on his return he said "In the Canadian department I heard 'To be or not to be—there's the rub' through an electric telegraph wire, but scorning monosyllables, the electric articulation rose to higher flights, and gave me messages taken at random from the New York newspapers. All this my own ears heard. This, the greatest by far of all the marvels of the electric telegraph, is due to a young countryman of my own, Mr. Graham Bell. Who can but admire the hardihood of invention which devised such very slight means to realize the mathematical conception that, if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of the current must vary continuously and as nearly as may be in simple proportion to the velocity of a particle of the air constituting the sound." This was in 1876 when the instruments were in a very crude stage of development; it shows that Kelvin fully appreciated the importance of Bell's insistence on an uninterrupted current made to vary in accordance with the particle velocity of the sound wave. It is interesting to note that the exhibit was in the Canadian department.

The first outdoor telephone line was installed in Boston in 1877, and at that time Bell gave a number of lectures in New York and in most of the large cities in New England, at which demonstrations were given of telephonic reproduction of distant singers and speakers. In August 1877 Bell married and made a trip to England; on 31st October a special meeting of the Society of Telegraph Engineers was held in London at which Bell gave an address on "Researches in Electric Telephony." He concluded by saying that conversations had been carried on between New York and Boston, and that Mr. Preece, the Engineer-in-Chief to the Post Office, had informed him that conversations had been successfully carried on through a submarine cable between Dartmouth and Guernsey. As an indication of the rapid appreciation of the value of Bell's work and of the development of the telephone on the commercial side, the Western Union Telegraph Co., declined the offer of Bell's father-in-law to sell them all the Bell patents for 100,000 dollars; this was early in 1876. Two years later, it was said that they would gladly have given 25,000,000 dollars for them.

Bell resigned his Professorship of Vocal Physiology at Boston and removed to Washington and it was at his house in Washington that his father Alex. Melville Bell died in 1905. Alexander Graham Bell died in Nova Scotia on 2nd August 1922.

G.W.O.H.

HIGH-SPEED WAVEGUIDE SWITCH*

By D. K. Bishop, B.Sc.

(Formerly, Radio Department, Royal Aircraft Establishment)

SUMMARY.—The high-speed switch described was developed to switch alternate pulses of r.f. power into the two aerials of a radar installation. This involves 500 switching operations per second. The device consists of a T-junction in a waveguide transmitting the H_{10} mode, the side arms being closed alternately by vanes on two discs rotated in synchronism with the pulses. It has been shown to operate satisfactorily between wavelengths of 9.8 cm and 10.2 cm and to handle a peak power of 500 kW.

1. Introduction

THE switch described was developed to fill a requirement in connection with a radar installation transmitting r.f. power in pulses of length 0.6 or 1.9 microseconds with a pulse recurrence frequency of 500 pulses per second at a wavelength within the band 9.8 cm to 10.2 cm. It was desired to switch alternate pulses to two aerial systems which were fed by a standard 3-inch by 1-inch rectangular waveguide, operating in the usual H_{10} mode. It was essential that the switch should remain open to a given aerial for a sufficient time to allow both transmission of a pulse and the reception of the reflected pulse from a target up to the maximum range of the equipment, since a common receiving-transmitting aerial was used. Also the switch must not present a voltage standing-wave ratio of more than about 1.3 to the transmitter, but since the pulse length was short (less than 2 microseconds) compared with the time between pulses (2,000 microseconds), the changeover, during which high standing-wave ratios may be produced, could be made to occur during the period between pulses when the transmitter was not working, by synchronizing the switch with the transmitter.

* MS. accepted by the Editor, June 1946.

2. Electrical Design

(a) Junction

Fig. 1 *(a)* represents an E-plane T-junction in a rectangular waveguide, with a conducting piston placed in one side arm at a distance x from the centre of the junction. It is found experimentally that if x and the dimensions of the junction are chosen suitably transmission of power into the other arm can take place without appreciable loss or mismatch.

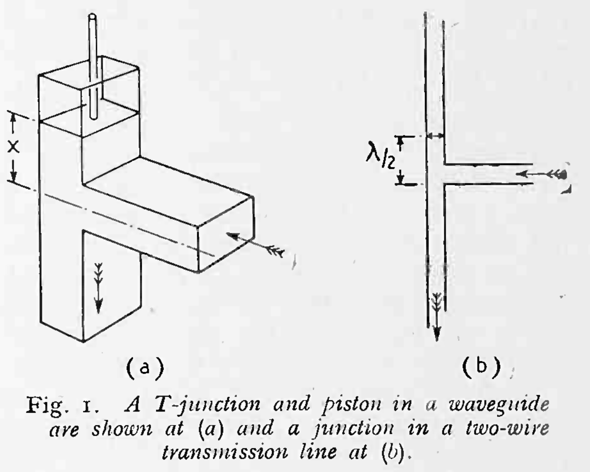


Fig. 1. *A T-junction and piston in a waveguide are shown at (a) and a junction in a two-wire transmission line at (b).*

Fig. 1 *(b)* shows an analogous arrangement in a two-wire transmission line, optimum power transfer round the angle occurs when the series stub is short circuited at one half-wavelength from the junction, since this effectively replaces the stub by a short circuit at the junction. The line is then virtually continuous round the angle. In a

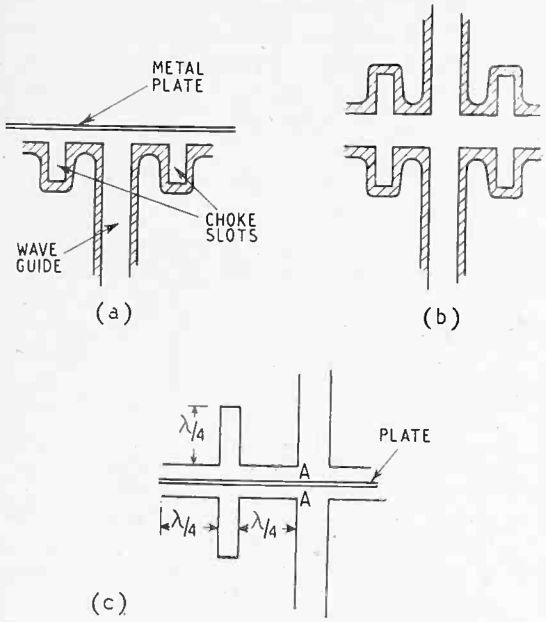


Fig. 2. *A waveguide can be blocked by fitting its open end with a flange having choke slots, and placing a conducting plate near it as at* (a). *With a double system* (b) *power is transmitted across the gap, but with the arrangement* (c) *the gap is blocked or open according to whether or not the plate is present.*

rectangular waveguide an exact analogy is approached as the narrow dimension of the guide approaches zero. In this case a narrow waveguide (3 in by ½ in) is used for mechanical reasons, and the correspondence between the stub length required (found experimentally to be 6.60 cm) and one-half of the guide wavelength (6.63 cm) is close.

(*b*) *Choke Flanges*

If now the side arms of the T-junction can be blocked alternately at the correct points by a piston or its equivalent, power will be fed alternately to either branch. The guide can be effectively blocked, or short circuited, by fitting its open end with a flange provided with choke slots [see Figs. 2(*a*) and 3(*a*) and (*b*)] opposite which a metal plate is fixed at a small distance as in Fig. 2(*a*). With this distance as large as 0.4 cm it is found that an effective short circuit occurs at the flange and very little radiation takes place.

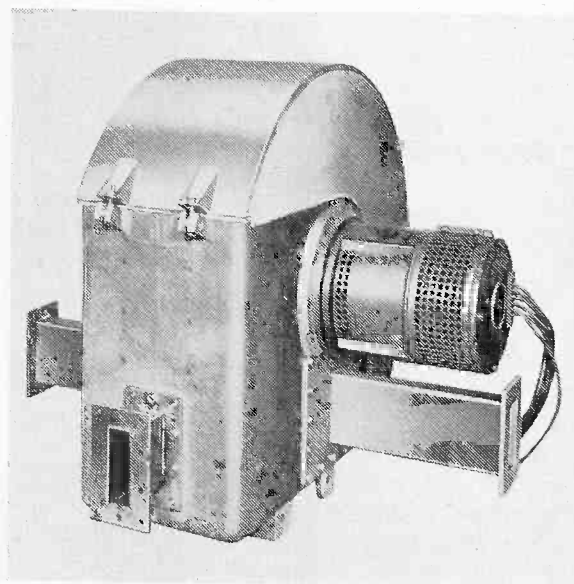
If a similar flange and waveguide are fixed opposite to it and the plate removed, Fig. 2(*b*), power is transmitted across the gap. When the dimensions are chosen, as in Fig. 2(*c*), the quarter-wavelength lines shown effectively produce a short circuit at A in each case, and the guide is either blocked or transmits power across the gap, depending on whether the plate is present or removed.

3. Switching

Switching can now be carried out by placing a metal plate in one gap while leaving the other open; this is done by two duralumin discs mounted on one spindle and rotating in the gaps between the choke flanges as in Fig. 3(*a*). The discs have alternate 36° sectors cut away, Fig. 3(*c*), so that when one end of the T-junction is closed by a metal sector the other disc presents a gap to the other end of the junction. Power is then transmitted into the open branch. The gap between the choke flanges is 0.60 cm and the discs approximately 0.3-cm thick, placed centrally so as to allow a gap of about 0.15 cm between each flange and the disc. Details of the choke flanges appear in Fig. 3(*b*).

4. Performance

The dimensions of the T-junction were determined experimentally by measuring the input standing-wave ratio of a T-junction having one side arm terminated by a choke flange and short-circuiting plate and the other by a matched load. Fig. 4 shows a curve of standing-wave ratio and wavelength for the final junction, having the dimensions given in Fig. 3.



General view of high-speed waveguide switch

Curves showing voltage-transmission coefficient and input standing-wave ratio (feeding matched loads) over a typical switching cycle at wavelengths of 9.8 cm, 10.0 cm, and 10.2 cm, are shown in Fig. 5.

diameter down to 17 inches. The switch is connected to the rest of the system by linearly tapered waveguides 8-in long, which are found to introduce no appreciable mismatch.

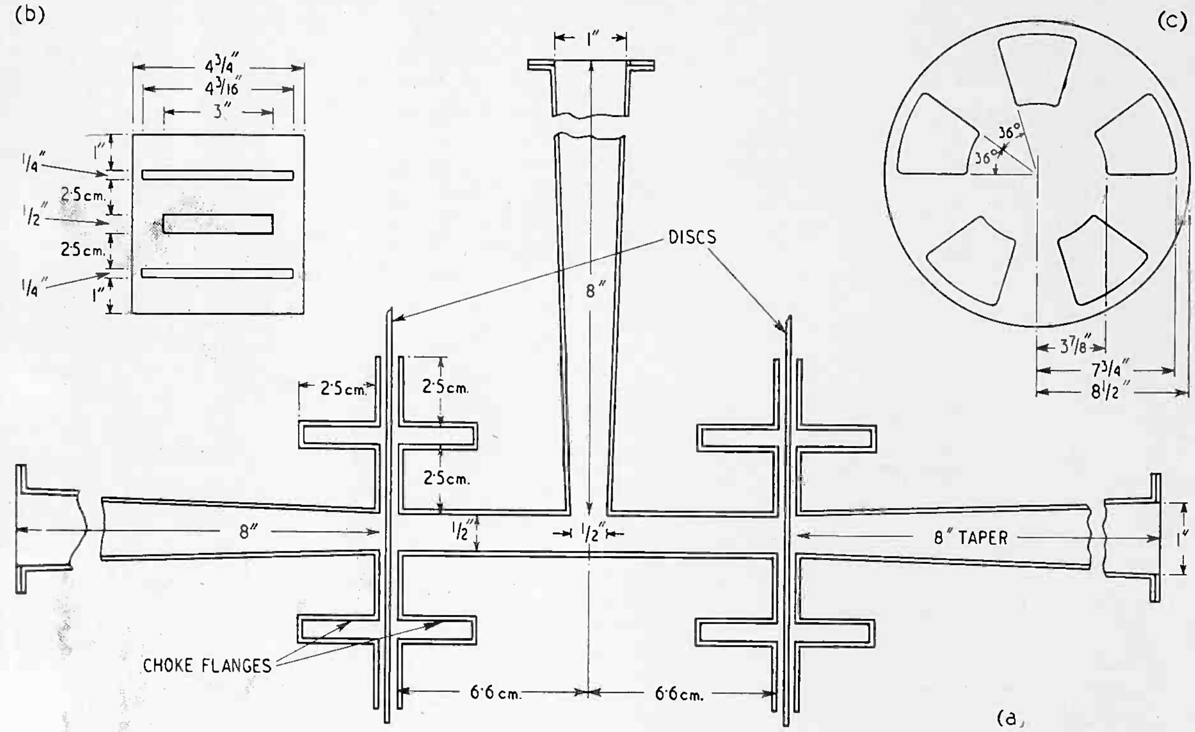


Fig. 3. *The general arrangement of the T-junction is shown at (a) with the details of the choke flanges and rotating discs at (b) and (c) respectively. Resonant dimension of waveguide 3" throughout.*

The difference in behaviour at the two switchings in each case is probably due to a misalignment in the prototype model, in which the vanes of one disc were not exactly opposite the gaps in the other.

Since the discs are rotated at a speed of 3,000 r.p.m., the 36° angle between switchings occupies 2,000 microseconds, of which about 1,550 microseconds are available as working time during which the standing-wave ratio remains below 1.25 and the transmission coefficient above 0.95. This time would enable a range of 150 miles to be obtained. Since the switching period, when the switch feeds both outputs and the standing-wave ratio is bad, occurs when the edges of the vanes cross the ends of the waveguides, and it is important to keep this time short, the angle subtended at the disc-centre by the width of the waveguide must be minimized. This can be done either by increasing the size of the discs or reducing the width of the guide. By using 3 in by ½ in waveguide it is possible to keep the disc

The dimensions of the junctions and choke flanges are given in Fig. 3.

5. Drive and Phasing

The discs are directly coupled to a 180-volt 500-c/s synchronous motor having a speed of 3,000 r.p.m. corresponding to 500 switch throws per second. Since the 500-c/s supply is also used to trigger the transmitter pulse the switch can be phased to deliver a pulse alternately into each aerial.

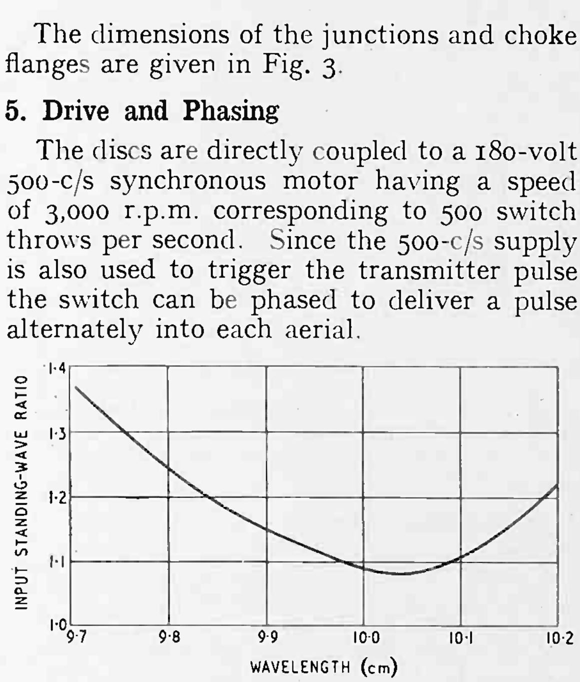


Fig. 4. *Measured standing-wave ratios for the junction of Fig. 3.*

Phasing is effected by rotating the motor relative to the switch housing, and the correct position is found by a stroboscopic device. A neon lamp is fitted inside the casing, where there is sufficient electric field to cause it to glow on each pulse. The edges of the vanes can then be seen as apparently stationary radial lines, and it is only necessary to adjust the motor until an edge comes in line with the lamp and a line marked on a Perspex window fitted to the housing.

The switch is adjusted so that after setting the motor the pulse comes on when the leading edge of a vane has passed the centre line of the waveguide by only 9°, the width of the vane being 36°. This allows time for the reception of the pulse reflected from a target.

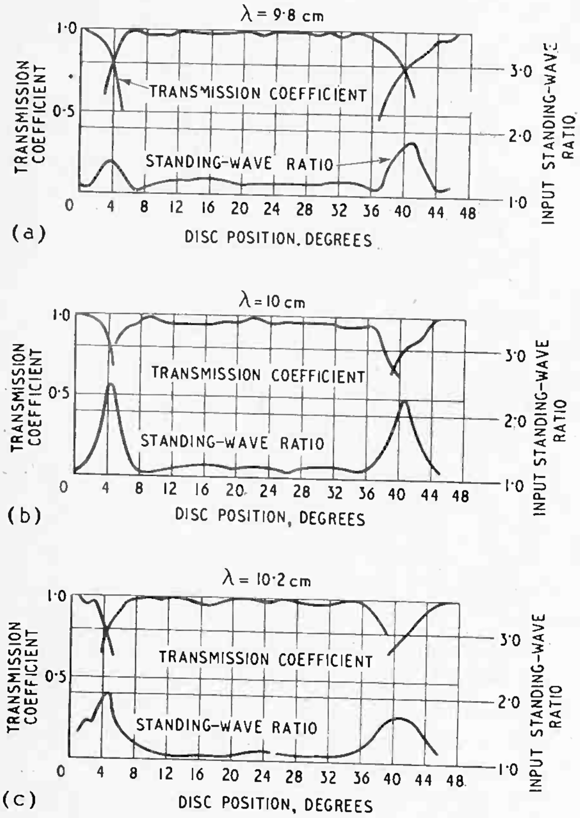
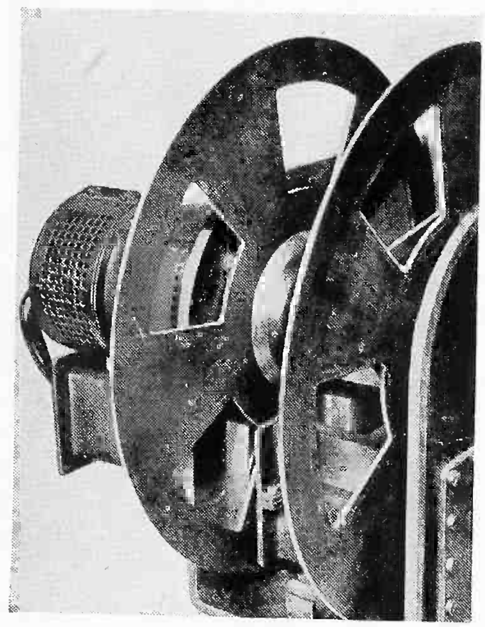


Fig. 5. *Standing-wave ratios and voltage-transmission coefficients over a switching cycle for three different wavelengths.*

6. Mechanical Details

The mechanical design of the switch is due to Mr. B. H. J. Rhodes of Radio Dept., R.A.E. The discs are of duralumin sheet (B.S.S. specn. L3) approximately $\frac{1}{8}$-in thick, and cut out as indicated in Fig. 3(*c*). The discs were planished, fitted with aluminium plates forming bosses, and mounted on a splined spindle. They were statically balanced after the bosses had been assembled. The disc spindle is carried on two ball bearings (B.S.S. spec. BR.L. 5/8) lubricated with a high melting-point grease. The clearance between discs and choke flanges is approximately 0.15 cm, the discs being central in the gap. This clearance has proved adequate in practice.



High-speed waveguide switch discs.

7. Power-handling Capacity

In radar technique, employing short pulses of power at comparatively long intervals, heating of waveguide components is of little importance as the mean power delivered is small, but during the pulse very high electric-field gradients are produced, which are liable to lead to breakdown and sparking; e.g., between the discs and the edges of the waveguide at the choke flanges. With the square-finished edges of flanges and vanes in the experimental model some trouble due to this effect was found, but was avoided by smoothing these edges to a small radius. The switch will handle a peak power of 500 kilowatts feeding a reasonably matched load and running synchronously.

Acknowledgments

The author wishes to acknowledge much valuable help and encouragement from Mr. J. L. Michiels and Mr. A. L. Cullen.

CAVITY RESONATORS AND ELECTRON BEAMS*

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1. Introduction

DURING the past few years it became necessary, for the development of certain microwave valves, to analyse the conditions governing the transfer of energy from an electron beam into a resonant cavity, and from thence to a load, and to investigate the design of resonant cavities themselves. This paper describes the theoretical basis of the relationships involved, and the methods of measurement which were used.

An incidental, but important, result of the theoretical part of the programme is that a short-wave limit to present-day radio valve technique is shown to exist. It is at about 1-cm wavelength.

It is generally agreed nowadays that it is best to think and write about microwave technique in terms of classic electromagnetic field theory (Bib. 1), and not in terms of "lumped" or "distributed" circuit constants. This means using a set of mental concepts which are new to most radio engineers. It follows that papers on microwave phenomena should be presented in ways which assist the development of such concepts. Moreover, it always seems desirable to the author to write the principal equations in any engineering treatise in the most explanatory manner rather than—as seems fashionable nowadays—in their briefest forms; indeed, in this respect, one finds oneself following an illustrious precedent.†

The question arises as to what system of units it is best to employ. The metre/kilogram/second, or Giorgi, system has been adopted in this paper. Current and field integrals are measured respectively in coulombs/second (amperes) and volts/metre. The unit of resistance is the ohm. Distances and wavelengths are in metres. Wavelengths measured in metres are, perhaps, clumsy at the extreme microwave end of the radio gamut; but there is no reason why they should not be converted to centimetres in the final stages of computation.

Consider the problem of transferring energy from a modulated electron beam to an electromagnetic field in a resonant cavity, and, from this field, to a load. In this paper the words "electron beam" are not intended to mean only a narrow pencil of electrons; but will refer to any electron stream of definite shape, all the electrons in which have sensibly the same velocities at a given time and position along the beam path.

The beam must be caused to enter the cavity and must be modulated so that it will produce a rate of change of charge within the cavity. If the frequency of the modulation corresponds to a mode of resonance of the cavity, then an electromagnetic field consisting of "standing" waves will appear within it. A part of this field will extend into the conducting walls of the cavity, and will therefore dissipate energy in these walls. Another part of the field may be guided out of the cavity, and its energy may be either dissipated in other conductors, or radiated into space in the form of travelling electromagnetic waves. The electron beam may be modulated by apparatus external to the cavity resonator, or, alternatively, by energy withdrawn from the electromagnetic field within the cavity so that the device as a whole operates as a generator of oscillations.

2. Power Output Conditions

The phenomenon may be expressed quantitatively as follows:—

The electron beam may be looked upon as a rate of flow of charge—that is, as a current I_0 which enters the field inside the resonant cavity at an entrance velocity

$$v_0 = 5.95 \times 10^5 V_B^{\frac{1}{2}} \text{ metres/sec.} \quad . . \quad (1)$$

V_B may be looked upon as the entrance energy of each electron measured in volts,

* MS. accepted by the Editor, June 1946.

† Clerk Maxwell, (Bib. 1, Vol. II, Chap. IX, Art. 615).

LIST OF SYMBOLS

v_0 = the velocity at which an electron enters the resonant cavity in metres/sec.

V_B = the entrance energy of the electrons measured in electron-volts ($v_0 = 5.95 \times 10^5 V_B^{\frac{1}{2}}$ m/sec.)

I_0 = the electron beam current in amperes.

v = the volume of the resonator in metres².

E′ = the maximum instantaneous value of the electric field in volts/metre.

H′ = the maximum instantaneous value of the magnetic field in amperes/metre.

ϵ_0 = the specific inductive capacity of free space.

μ_0 = the permeability of free space.

W_F = the maximum instantaneous energy stored in a space in joules.

S = the energy loss per second in joules per unit area of a conducting surface.

μ_1 = the permeability of that surface.

σ_1 = the conductivity of that surface in mhos per metre.

H'_{tan} = the maximum instantaneous absolute value of the tangential component of **H** at that surface.

$\omega = 2\pi f$.

δ = the "skin depth" in metres.

λ = the wavelength in metres.

c = the velocity of light in metres/sec.

s = the internal surface area of the resonant cavity in metres.

P_R = the power loss in the walls of the resonator in watts/metre².

Q = the selectivity factor of an unloaded resonator.

Q_L = the selectivity factor of a loaded resonator.

P_0 = the power delivered from an electron beam to the resonator field in watts.

P_L = the power delivered to a load in watts.

η_c = the efficiency of the combination of a resonator and a load.

A = the cross-sectional area of the beam of electrons in metres.

i = the current density of the beam in amperes.

l_1 = the distance in metres along the length of the beam within the resonator field.

$E'l_1$ = the voltage along l_1.

V'_R = the electric field integral along l_1 in volts.

$M = \frac{V'_R}{V_B}$.

ϕ = the "small signal" transit angle along l_1.

η_0 = the efficiency of transfer of power from the beam of electrons to the field of the resonator.

M_0 = the optimum value of M.

η = the overall efficiency of the electron beam-resonator-system.

ξ = the "voltage coefficient" of the resonator.

V_{OB} = the "characteristic voltage" of the resonator.

$a = \frac{l_1}{\lambda}$

A_0 = the area in metres² of the resonator which is utilized as the path of the beam of electrons along l_1.

Δ = the ratio between V_B and the current density i in the beam.

$R_B = \frac{V_{OB}}{I_0}$

ψ = the "resonator-beam ratio."

ζ = the "electronic coupling factor."

$k = A_0/\lambda^2$

λ_0 = a reference wavelength in metres (Q_0, R_{BO}, ψ_0, ξ_0 are the values of Q, R_B, ψ, and ξ at λ_0).

n, m, l = suffixes indicating the mode of resonance.

$r\ \phi, z$ = the co-ordinates of a cylindrical resonator.

r_0, z_0 = distances along these co-ordinates.

x, y, z = the co-ordinates of a rectangular box resonator.

x_0, y_0, z_0 = the distances in metres along these co-ordinates.

y_1, y_2 = distances in metres in the y-direction in a stepped rectangular box resonator.

J_0 = a Bessel function of the first kind and zero order.

r'_{nm} = the first (mth) root of $J_0(z) = 0$.

E'_z = the maximum value of electric field in the z-direction in a cylindrical resonator.

R = an integral due to Hansen & Richtmeyer.

$\Delta\lambda$ = the width of the resonance curve at 0.707 times the peak reading in the case of a linear indicator; or at 0.5 times the peak reading in the case of a square-law indicator.

$\left.\begin{matrix} Q_A \\ Q_B \\ Q_C \end{matrix}\right\}$ = successive readings of Q.

E_1, E_2 = electric field values at different points in a resonator.

A_1, A_2 = the entrance and terminating areas of a tube of force.

and is approximately equal to the high tension voltage of the valve of which the resonant cavity is part. This current I_0 is modulated so that it possesses a characteristic wave-form. The fields produced by the resulting rate of change of charge inside the cavity will depend upon certain characteristics of the resonator.

The maximum instantaneous energy in an electromagnetic field inside the resonator is equal to both the maximum energy found in the magnetic field and to the maximum energy found in the electric field. When the energy in the electric field is at a maximum, that in the magnetic field is zero, and vice versa—as is always the case with " standing " waves. That is to say, the energy may be looked upon as existing in space and to have a maximum instantaneous value of

$$W_F = \frac{\epsilon_0}{2}\int \mathbf{E}'^2 . d\mathbf{v} = \frac{\mu_0}{2}\int \mathbf{H}'^2 . d\mathbf{v} \text{ (joules)} \quad (2)$$

where

$\mathbf{v}$ = the volume of the resonator.

$\mathbf{E}'$ = the maximum instantaneous value of the electric field, in volts/metre.

$\mathbf{H}'$ = the maximum instantaneous value of the magnetic field, in amperes/metre.

ϵ_0 = the specific inductive capacity of free space. This is equal to $10^{-9}/36\pi \approx 8.854 \times 10^{-12}$ farad/meter.

μ_0 = the permeability of free space. This is equal to 1.247×10^{-6} henry-meter.

The electromagnetic field will extend into the conducting walls of the cavity, and energy will therefore be dissipated in those walls. It may be shown (for instance, Bib. 2, p. 141) that the energy loss in joules per unit area (in metres²) per second of a conducting surface may be found from the Poynting vector to be

$$S = \frac{1}{2}\sqrt{\frac{\mu_1\omega}{2\sigma_1}}\, H'^2_{tan} \quad \ldots \quad (3)$$

where

μ_1 = the permeability of the surface (for copper this may be taken as equal to μ_0).

σ' = the conductivity of the surface (for copper this may be taken as 5.8×10^7 mhos/metre).

H'_{tan} = maximum instantaneous absolute value of the tangential component of the magnetic field at the surface of the resonator.

$\omega = 2\pi f$.

The power loss per period will then be S/f, or

$$\frac{2\pi}{\omega} . \frac{1}{2}\sqrt{\frac{\mu_1\omega}{2\sigma_1}}\, H'^2_{tan} = \pi\sqrt{\frac{2}{\mu_1\omega\sigma_1}}\,\frac{1}{2}\mu_1 H'^2_{tan}$$

It can also be shown that the field may be looked upon as penetrating into the conducting surface for a distance

$$\delta = \sqrt{\frac{2}{\mu_1\omega\sigma_1}} \text{ (metres)} \quad \ldots \quad (4)$$

This is usually referred to as the " skin-depth," and for copper

$$\delta = 3.8 \times 10^{-6}\lambda^{\frac{1}{2}} \text{ (metres)} \quad \ldots \quad (4.1)$$

where

λ = the wavelength in metres,

δ is plotted for copper in Fig. 1.

Thus, the power loss per metre² of the walls of a resonator will be equal at each point on its surface to

$$\frac{\pi c\delta}{2\lambda}\mu_1 H'^2_{tan} \text{ watts/metre}^2$$

where

c = the velocity of light = 3×10^8 metres/sec.

The power loss in the surface $\mathbf{s}$ of the resonator will be

$$P_R = \frac{\pi c\delta\mu_1}{2\lambda}\int H'^2_{tan} . d\mathbf{s} \text{ (watts)} \quad \ldots \quad (5)$$

We are led to the postulation of a quantity which expresses the energy and power relations in an unloaded cavity. We may utilize the familiar relationship :—

$$Q = \frac{2\pi \text{ (maximum instantaneous energy present in the } \left\{\begin{matrix}\text{electric}\\ \text{or}\\ \text{magnetic}\end{matrix}\right\} \text{ field)}}{\text{(energy loss in one period)}}$$

(Bib. 3, p. 377.)

Moreover, $\frac{c}{\lambda}$ × (energy loss per period = P_R, and therefore, from equation (2), we have

$$Q = \frac{\omega W_F}{P_R} \quad \ldots \quad (6)$$

Energy flowing from a modulated electron beam into the electromagnetic field inside an unloaded resonator will appear as a flow of an equal amount of energy into the walls of the resonator, and (since the rate of flow of energy is equal to power), we have, for the power delivered from the electron beam to the resonator.

$$P_0 = P_R \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

The object of a resonator-type valve will be, however, to deliver electromagnetic energy to a load. A part of the electromagnetic field is therefore to be used to transfer some useful power into the load. This transfer may take place either by the direct penetration of a part of the field into a conductor or semi-conductor, or by the radiation of the energy into space. P_R should be as small as possible, because it is merely waste.

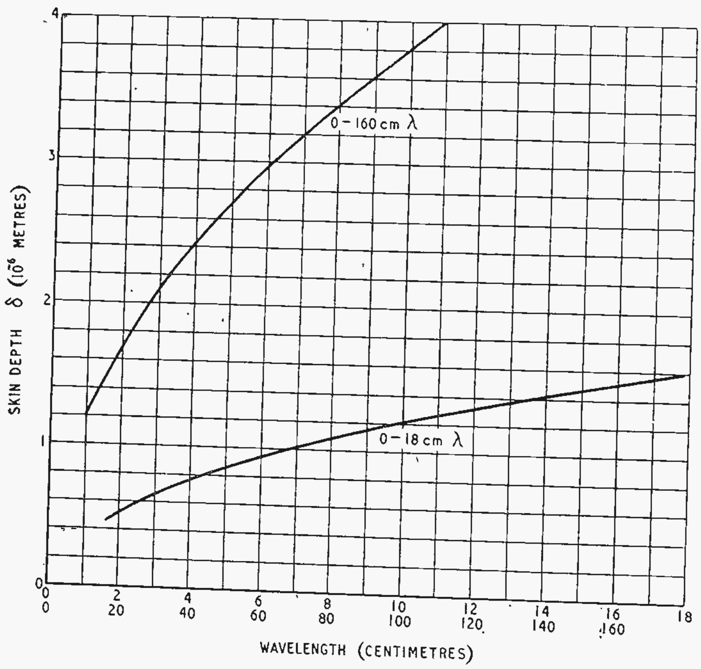

Fig. 1. *The depth of penetration of an electromagnetic wave into a copper surface (skin depth).*

Imagine, then, that a load is coupled to the resonator field (by, for instance, a coupling loop), and, therefore, that,

$$P_0 = P_R + P_L \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

where P_L = the power delivered to the load.

It is to be assumed that no energy escapes from the resonator other than to the load, and that the energy from the electron beam reaches the load and the copper walls of the resonator only through the field.

A further necessary assumption is that the addition of the load, and the existence of the copper losses, do not cause the fields to depart appreciably from the shape assumed when copper losses are negligible and the load does not exist.

We may then write down an expression for the energy and power relations in a loaded resonator which will correspond with that of equation (6) for an unloaded one, namely

$$Q_L \doteq \frac{\omega W_F}{P_R + P_L} \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

It will also be found desirable to establish a quantity which may be looked upon as the efficiency of the resonator and load in combination, namely :—

$$\eta_c = \frac{P_L}{P_L + P_R} \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

Then we have

$$\frac{1}{1 - \eta_c} = \frac{P_L + P_R}{P_R}$$

and it follows that

$$P_L + P_R = \frac{P_R}{1 - \eta_c}$$

Substituting the above in (9), we have

$$Q_L = \frac{\omega W_F}{P_R}(1 - \eta_c)$$

and from (6) we get

$$Q_L = Q(1 - \eta_c) \quad \ldots \quad (11)$$

3. Energy Transfer from a Modulated Electron Beam to an Electric Field

Turning next to the evaluation of the power P_0 delivered by the beam of electrons into the resonator, it is necessary to establish the conditions determining its magnitude. This involves a study of the energy relationships of electrons injected into an electric field. Whilst the principles of this mechanism are well known, quantitative relationships appear to have been set out only in the sketchiest forms in the literature. Recently, however, T. S. Popham has computed much of the necessary information.* In his work, an electron beam current is assumed to travel in an electric field between two parallel infinite plane electrodes, and has a value

$$I_0 = Ai \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

* See a paper to be published in due course.

where

A = the cross-sectional area of the beam,

and i = the current density of the beam.

The electric field **E** between the electrodes is assumed to be wholly normal to their surfaces, parallel to the entrance directions of the electrons, and to be a linear function of the distance l_1 between the electrodes. Curl **E** = zero, and consequently an alternating potential may be considered to exist between the electrodes which has a maximum instantaneous value

$$V'_R = \int_{l=0}^{l=l_1} E'_l dl = E'_l l_1 \text{ (volts)} \quad .. \quad (13)$$

where

E'_l is the field strength between the electrodes.

The electrons are assumed to enter this space at a steady initial energy V_B as defined by equation (1), and, throughout this paper, the velocity v_0 is assumed not to be large enough for relativity effects to be appreciable.

In this electron-beam — electric-field system there will exist a ratio

$$M = \frac{V'_R}{V_B} \quad .. \quad .. \quad .. \quad .. \quad (14)$$

Another parameter is the transit angle ϕ of an electron which is assumed to travel between the electrodes when $M \to 0$. This may be referred to as the d.c.- or "small signal"-transit angle. It is equal to

$$\phi = \frac{10^3 l_1}{\lambda V_B^{\frac{1}{2}}} \pi \text{ (radians)} \quad .. \quad .. \quad (15)$$

We may specify the efficiency of transfer of power from the beam to the resonator-load system by the factor

$$\eta_0 = \frac{P_0}{I_0 V_B} = \frac{P_0}{P_B} \quad .. \quad .. \quad .. \quad (16)$$

where

P_B = the d.c. power in the beam.

For any given values of ϕ and M, and of the waveform of the modulation of the beam current, there exists a value of η_0.

Throughout this paper it will be assumed that the resonator is operating at a mode such that it is tuned to the frequency of the fundamental component of the electron-beam modulation. Note that it is possible to provide a resonator that possesses a number of resonant modes which are simultaneously equal to a corresponding number of component frequencies of the electron-beam modulation shape.

In T. S. Popham's analysis, it has been shown that for any given value of the "small signal"- transit angle ϕ there exists an optimum value of $M = M_0$. This relationship, of course, is itself a "large signal" condition (i.e., when $V_B \approx V'_R$), but it is a matter of mathematical and practical convenience to relate it to the "small signal" parameter ϕ [(eqn. (15)] which may be readily evaluated.

Fig. 2 is obtained from T. S. Popham's work, and shows η_0 and M_0 as a function of ϕ for two typical waveforms.

M_0 varies with the beam current waveform at any given value of ϕ; but not very greatly. In what follows it will be assumed that the variation of M_0 with ϕ is that indicated in Fig. 2, and is the same for all beam current waveforms. In practical microwave valves, moreover, the difficulties of obtaining special waveforms are such that there seems no point in specifying in greater detail the comparatively minor effects of waveform upon M_0.

When ϕ is appreciable in magnitude (e.g., under microwave conditions), it is not perhaps obvious that the efficiency will fall if $M > M_0$. In fact, T. S. Popham's analysis is then no longer rigorous. It does not include the "proximity effects" of electrons, and when $M > M_0$ it indicates that different electrons may be in the same place at the same time. This, of course, is absurd; but an analysis which takes into account what really happens—that is, an analysis

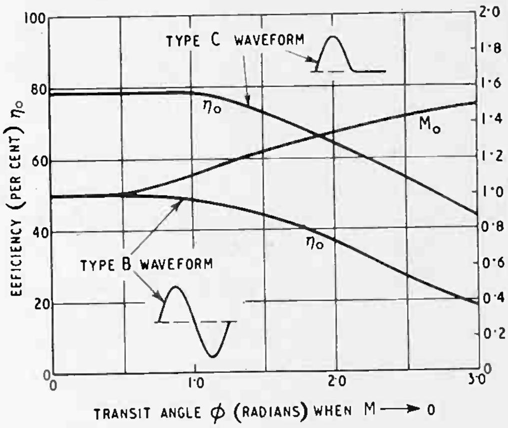

Fig. 2. *The efficiency η_0 of transfer of power from an electron beam into an electric field as a function of the d.c.-transit angle ϕ. The ratio M of the peak voltage to the entrance energy in volts is also shown, (after T. S. Popham).*

allowing for proximity effects—does not yet appear to exist in the art. In the present paper it will be assumed, as a result of approximate computations, that when M exceeds M_0, the efficiency will be reduced.

To apply these results to resonant cavities it will be assumed (as is in fact justified in the resonator shapes to be used) that curl **E** = 0 along the path of the beam in the resonator, though not necessarily so elsewhere. The line integral of the field along the path of the beam may then be looked upon as a potential difference and measured in volts.

It will be shown later in this paper that the technique of beam production and modulation is such that it is desirable for the field integral V'_R to be as great as possible in a given resonator, and (because E'_l is assumed to vary directly as l) we have the requirement (from 13) that ϕ should be as great as possible. But ϕ is proportional to l_1, and therefore should be as large as possible also. By reference to Fig. 2, it will be seen that η_0 commences to fall appreciably when ϕ exceeds $\frac{\pi}{2}$. These factors are found to result, on microwaves, in a choice of ϕ such that it must be theoretically in the neighbourhood of an optimum $\phi_0 = \frac{\pi}{2}$.

We have, also, the requirement that M should equal M_0. From Fig. 2, when $\phi = \frac{\pi}{2} = \phi_0$, then $M_0 = 1.24$. These two numerical values will be used for M_0 and ϕ_0 throughout this paper. Neither of these optima are at all critical from the point of view of manufacturing tolerances.

For the purposes of this paper, we may therefore restrict η_0 in equation (16) as expressing the efficiency of transfer of power from the beam to the resonator-load system in the conditions when $\phi = \phi_0$ and $M = M_0$.

4. Power Transfer from a Modulated Electron Beam to a Resonator

The problem with which the present paper deals is the transfer of this power P_0, first from the beam into a resonator, and secondly to a load. It is therefore necessary to establish a relationship between the power conditions of the resonator-load system itself and the electron beam relationships of equations (1), and (12) to (16).

If the integral in equation (13) is along a path of an electron beam which is injected into a resonator, we have a means of transferring power from the electron beam to the electromagnetic field in the resonator. A load may then be coupled to the field and fed with power P_L. The overall efficiency of the whole system will be, from equations (10) and (16),

$$\eta = \eta_0\eta_c = \frac{P_L}{P_B} \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

In any resonator which is to be set into oscillation at a given mode, there exists theoretically an infinite number of different paths along which the electron beam can travel. It will be assumed that V'_R is substantially the same over a cross-sectional area A_0 of the beam along the path chosen, and, as previously mentioned, that curl **E** = 0 along l_1. For the reasons already mentioned, the beam path is chosen, out of those available, to be that along which the integral in (13) is at its maximum at the operating mode of the resonator.

We can then specify an important relationship which expresses the properties of the resonator field shape and working mode with respect to the injection of energy by means of an electron beam, namely what may be termed the "voltage coefficient" of the resonator:—

$$\xi = \frac{V_R'^2}{4\pi f W_F} \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

From the foregoing (if the beam efficiency η_0 is to be at its maximum), $M = M_0$, and $\phi = \phi_0$; and therefore, from (14), we get

$$V_B = \frac{V'_R}{M_0} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (19)$$

For any given resonator and transit angle, we have then, from (15),

$$V_B^{\frac{1}{2}} = \frac{10^3 l_1}{\phi_0 \lambda}\pi$$

l_1/λ will not, of course, vary with λ in a resonator of given shape.

We have then the requirement that the small signal transit angle $\phi_0 = \frac{\pi}{2}$; therefore we have a value of V_B (to be designated by V_{OB}), which does not vary with wavelength, and which is a fixed property of any given resonator shape, mode and position of the beam path through the resonator. It may be called the "characteristic voltage" of the resonator.

Therefore, from (15), we may write

$$\frac{l_1}{\lambda} = a = 5 \times 10^{-4} V_{OB}^{\frac{1}{2}} \quad \ldots \quad \ldots \quad (20)$$

and

$$V_{OB} = 4 \times 10^6 a^2 \text{ (volts)} \quad .. \quad (20.1)$$

Equation (20.1) is plotted in Fig. 3.

We are now in a position to link together the beam and resonator equations. We have, from (9),

$$P_R + P_L = \frac{\omega W_F}{Q_L}$$

From (8), and by substituting from equation (11), we have

$$P_0 = P_L + P_R = \frac{\omega W_F}{Q(1 - \eta_c)} \quad .. \quad (21)$$

Substituting from (19) in (18), we have, for the resonator voltage coefficient (since $V_B = V_{OB}$)

$$\xi = \frac{M_0{}^2 V_{OB}{}^2}{2\omega W_F} \quad .. \quad .. \quad .. \quad (22)$$

Combining (21) and (22) gives the fundamental electron-beam—resonator-load relationship we require, namely,

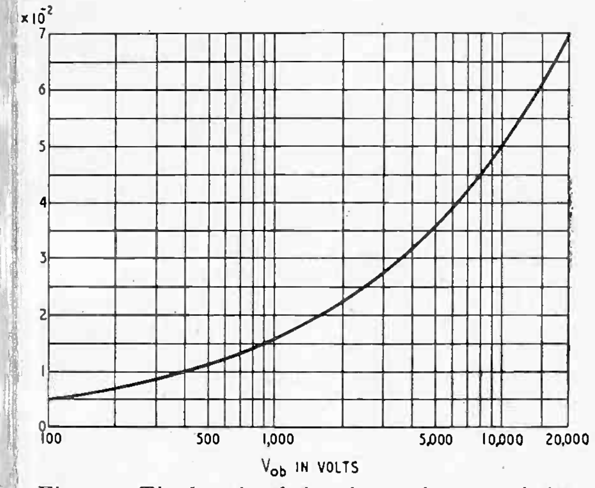

Fig. 3. *The length of the electron-beam path in terms of wavelength as a function of resonator "characteristic voltage."*

$$P_0 = P_R + P_L = \frac{M_0{}^2 V_{OB}{}^2}{2\xi Q(1 - \eta_c)}$$

$$= \frac{1.54\, V_{OB}{}^2}{2\xi Q\, (1 - \eta_c)} \quad .. \quad .. \quad (23)$$

We have, then, for any given shape of resonator and mode of oscillation, the following parameters :—

The "voltage coefficient" ξ

The "characteristic voltage" V_{OB}.

The "selectivity factor" Q.

It follows that, when equation (23) holds, $M = M_0$, and the small signal transit angle $\phi = \phi_0$, and the efficiency of transfer of power from the beam to the resonator-load system is η_0. The beam path is also chosen so that V'_R is at its maximum.

By substituting for P_0 in (23) from (16), and remembering that $V_B = V_{OB}$, we have

$$V_{OB} I_0 \eta_0 = \frac{1.54\, V^2{}_{OB}}{2\xi Q(1 - \eta_c)}$$

and

$$\eta_0 = \frac{1.54\, V_{OB}}{2\xi Q I_0 (1 - \eta_c)} \quad .. \quad .. \quad (24)$$

Note that an important factor in this equation is the ratio V_{OB}/I_0, which is plainly a characteristic of the particular beam-forming and modulating devices used, and of the area A_0 of the resonator over which V'_R is sufficiently uniform to be utilized as the path of the beam of electrons. We may then define a parameter, which will be typical of the particular electron-beam producing and modulating device used; namely, a ratio between the electron beam voltage and the current density,

$$\Delta = \frac{V_B}{i} = \frac{V_{OB}}{i} \quad .. \quad .. \quad .. \quad (25)$$

Thus, we have,

$$V_{OB}/I_0 = \frac{V_{OB}}{iA_0} = \frac{\Delta}{A_0} = R_B \quad .. \quad (26)$$

and equation (24) becomes

$$\eta_0 = \frac{1.54\Delta}{2\xi Q A_0 (1 - \eta_c)} \quad .. \quad .. \quad (27)$$

Δ is determined partly by theoretical considerations, which are set out in the Appendix, and in Fig. 4, for "focused"-beam valves, where $V = V_{OB}$; but to a great extent by considerations of valve engineering which, in the case of a given kind of valve (e.g., according to whether it is a klystron or a magnetron) will be affected by definite limitations. These limitations will be referred to again later.

Solving (27) for the resonator—load efficiency, we have

$$n_c = 1 - \frac{0.77\Delta}{\xi Q A_0 \eta_0} \quad .. \quad .. \quad (28.1)$$

or $$\eta_c = 1 - \frac{0.77 R_B}{\xi Q \eta_0} \quad .. \quad .. \quad (28.2)$$

Clearly, η_c should be as nearly unity as possible. Since $\frac{0.77}{\eta_0}$ is a constant for any given beam-current-modulation shape, the important engineering quantity is a ratio which may be referred to as the "resonator-beam ratio," namely,

$$\Psi = \frac{\xi Q}{R_B} \quad .. \quad .. \quad .. \quad .. \quad (29)$$

η_c is plotted as a function of Ψ in Fig. 5.

It will be seen from this that η_c does not approach a reasonable value unless Ψ is at least as large as 10. It should be as great as possible, and from (18) this means that the integral V'_R must also be as great as possible.

R_B is, from (26), in the nature of a ratio between a voltage and a current; but, because it varies with voltage, this ratio must not be looked upon as a "resistance." Similarly, we may define a parameter of major importance, which may be called the "electronic coupling factor" namely

$$\zeta = \xi Q = \left(\frac{V'^2_R}{2\omega W_F}\right)\left(\frac{\omega W_F}{P_R}\right) = \frac{V_R'^2}{2P_R} \qquad (30)$$

There is perhaps a temptation to look upon ζ as an "impedance" by analogy with lumped-constant low-frequency valve circuits; but, in fact, the analogy is not valid because its use infers the various special conditions already set out (for example $V'_R = V_{OB}M_0$, $\phi = \phi_0$, and $M = M_0$), and the parameter is not limited by "lumped constant" approximations.

Another useful relationship can be deduced. From (17) we have

$$P_L = V_{OB}I_0\eta_0\eta_c \quad \ldots \quad \ldots \quad \ldots \quad (31)$$

Substituting (28.1) in (31)

$$P_L = I_0V_{OB}\eta_0\left\{1 - \frac{0.77\Delta}{\xi QA_0\eta_0}\right\} \quad \ldots \quad (32)$$

From (26) this may also be written

$$P_L = \frac{V_{OB}^2\eta_0A_0}{\Delta}\left\{1 - \frac{0.77\Delta}{\xi QA_0\eta_0}\right\} \quad \ldots \quad (33.1)$$

or, from (26) and (29),

$$P_L = \frac{V_{OB}^2\eta_0}{R_B}\left\{1 - \frac{0.7}{\Psi\eta_0}\right\} \quad \ldots \quad \ldots \quad (33.2)$$

5. Notes on the Basic Relationships

Before proceeding further, the following general comments should be noted:—

The requirement that the overall efficiency η should be at a maximum applies to both power oscillators and to those electron-beam valves which may be employed for other purposes—such as to drive other valves. Both the maximum possible power output, and the maximum possible resonator field strength, require that η should be as large as possible.

During operation, changes in the effective value of I_0 may be utilized. The waveform of the modulation may be changed, or its depth, or the average current may be reduced. Then, over the range of $M < M_0$, M will vary with the amplitude of the a.c. component I_{ac} of I_0 to which the resonator is tuned. P_L and η_0 will vary as the square of I_{ac}. As previously-mentioned, when $M > M_0$, a relationship holds which is indeterminate, and, in general, theoretically undesirable.

It will be observed that ξ varies as $V_R'^2$. If, for any special purpose, it is required to vary ξ in a given resonator, and to reduce

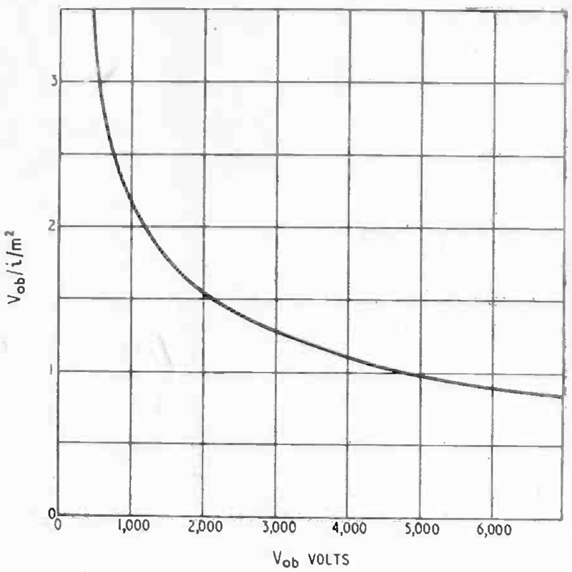

Fig. 4. *The approximate theoretical limits for the ratio of voltage to current density in a "focused" beam of electrons (see Appendix),* $V = V_{OB}$.

it from the maximum possible, it is generally possible to choose a path of integration l_1 so that the reduction is obtained. This procedure must always reduce the resonator-load efficiency η_c.

It will be clear, therefore, that, in order to meet the various requirements of microwave electron-beam technique, many different resonator shapes and sizes will be needed, and these shapes must have "characteristic voltages" which vary over a wide range. The square root of the resonator "characteristic voltage" $V_{OB}^{1/2}$ may well be required to have values which vary from the order of 10 to the order of 140 or more.

There is, theoretically, a limitation to P_L due to the heat loss P_R; but, in fact, with a properly designed system, this loss is generally negligible. In any case the temperature of the resonator is a function of the general mechanical design of the tube as regards cooling, and the heat loss P_R is generally completely swamped by the cooling requirements of the cathode and of the waste part of the beam power $P_B - P_o$. It will not be considered further in this analysis.

6. The Integral Forms of Ψ

It is now necessary to examine the parameter Ψ in greater detail, particularly with reference to its dependence upon wavelength.

From equations (29) and (30), we may write for this resonator-beam coefficient

$$\Psi = \frac{\xi Q}{R_B} = \left\{ \frac{V_R'^2}{2\omega W_F} \cdot \frac{\omega W_F}{P_R} \cdot \frac{A_0}{\Delta} \right\}$$

$$= \left\{ \frac{\left[\int_{l=o}^{l=l_1} E_l' dl \right]^2}{\frac{4\pi c}{\lambda} \frac{\epsilon_0}{2} \int \mathbf{E}^2 d\mathbf{v}} \right\} \left\{ \frac{\frac{2\pi c}{\lambda} \cdot \frac{\mu_0}{2} \int \mathbf{H}^2 d\mathbf{v}}{\frac{\pi c \delta \mu_1}{2\lambda} \int H'_{tan} d\mathbf{s}} \right\} \frac{A_0}{\Delta} \qquad \text{.. .. .. (34)}$$

Since the denominator of ξ is twice the numerator of Q, this reduces to

$$\Psi = \frac{\left[\int_{l=o}^{l=l_1} E'_l \cdot dl \right]^2}{\frac{\pi c \delta \mu_1}{\lambda} \int H'_{tan} d\mathbf{s}} \left(\frac{A_0}{\Delta} \right) = \frac{V'^2_R}{2 P_R} \cdot \frac{1}{R_B} \qquad \text{.. .. .. (35)}$$

For a discussion of the integrals which specify the losses and fields in resonators, see Sarbacher and Edson's text-book, (Bib. 3).

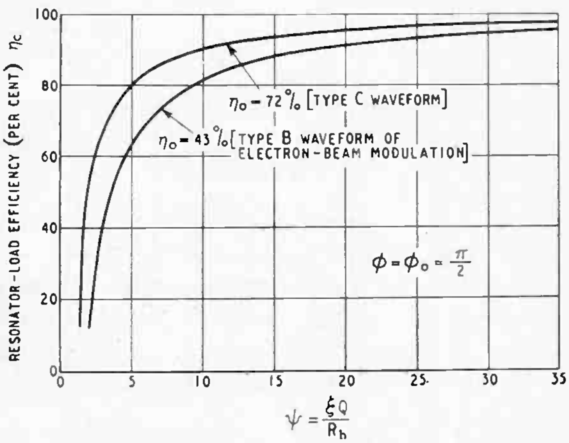

Fig. 5. *The efficiency η_c of transfer of power from a resonator to a load as a function of the ratio between the resonator "electron-coupling coefficient" $\xi Q = \zeta$ and the working voltage/current ratio R_B of the electron stream.*

7. The Effect of Wavelength Variations

It will be found that $\zeta = \xi Q$ varies as $\lambda^{\frac{1}{2}}$. It may be shown also that the effective beam cross-sectional area A_0 usually varies as the square of the wavelength, although it is sometimes possible to utilize over a limited range of wavelengths, as one dimension of A_0, a dimension of the resonator which does not vary with wavelength. With this latter reservation, then, we have

$$A_0 = k\lambda^2 \text{ (metres}^2\text{)} \qquad \text{.. .. (36)}$$

Then, it follows from this, and from (34), that Ψ varies as $\lambda^{5/2}$ which suggests (as indeed will be shown to be the case later) that the efficiency will fall very sharply indeed when λ becomes less than some quite definite value.

8. Uses of a "Reference Wavelength"

Unfortunately, R_B is not determined exclusively by the theoretical considerations of, for instance, the Appendix, but by the quite arbitrary sizes in which it is practicable to make vacuum apparatus, and, in fact, by the general constructional requirements of vacuum engineering. It is necessary for many reasons to use different techniques at different parts of the wavelength spectrum. There is no general voltage/current function of wavelength to insert in the equations. For this reason a practical difficulty arises in expressing analytically the general performance that may be expected from resonators and beams in combination.

This difficulty will be overcome if we use an idea of splitting up the wavelength spectrum into arbitrary, and if necessary, overlapping bands of wavelengths. Then, for a given resonator used over a given range of wavelengths, and for a given sort of electron-beam modulating and producing device, a value of the beam area A_0 at a given wavelength (to be referred to as the "reference wavelength" λ_0) may readily be specified.

In accordance with this idea, the resonator and beam parameters which vary with wavelength in equations (34), (35), and (36) will all be evaluated at a reference wavelength λ_0, and these special values will be designated by a suffix indicating the wavelength in centimetres. Thus, Q_{100} will indicate the value of Q at a wavelength of 1 metre. Using o to represent this suffix, we may re-write equations (28), (29) and (30) as follows, noting that it is not necessary to specify the minimum wavelength of each band, because this will automatically be set by the point at which the fall of Ψ (with $\lambda^{5/2}$) indicates that the particular resonator—beam combination is no longer useful. Thus

$$\Psi = \frac{\zeta_0}{R_{B0}} \left(\frac{\lambda}{\lambda_0} \right)^{5/2} = \Psi_0 \left(\frac{\lambda}{\lambda_0} \right)^{5/2} \qquad \text{.. (37)}$$

and (28.2) and (33.2) may be written respectively as

$$\eta_c = 1 - \frac{0.77}{\eta_0} \frac{1}{\Psi_0} \left(\frac{\lambda_0}{\lambda}\right)^{5/2} \quad \ldots \quad \ldots \quad (38)$$

and, from (36),

$$P_L = \frac{V_{OB}^2 \eta_0}{R_{BO}} \left(\frac{\lambda}{\lambda_0}\right)^2 \left[1 - \frac{0.77}{\eta_0} \frac{1}{\Psi_0} \left(\frac{\lambda_0}{\lambda}\right)^{5/2}\right] \quad \ldots \quad \ldots \quad \ldots \quad (39)$$

The foregoing analysis is the general case for the transfer of energy from an electron stream to a field and then to a load, and includes the more familiar "lumped circuit" concepts as special approximate cases.

(To be continued)

(Bibliography will be included at end of Part III of the article.)

H.F. RESISTANCE AND SELF-CAPACITANCE OF SINGLE-LAYER SOLENOIDS

By R. G. Medhurst, B.Sc.

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

(Concluded from page 43 of the February issue.)

9. Self-capacitance of Single-layer Coils.

9.1. The self-capacitance of each coil, including capacitance due to leads, has to be added to the parallel capacitance reading of the twin-T. It is a small correction, usually less than 1 per cent. The original intention was to use Palermo's formula for self-capacitance[14], this being available in abac form[18] and hence readily made use of. However, for the closely-spaced coils, a noticeable variation with frequency started to appear in the calculated values of inductance (which should be consistent to better than ½ per cent), so it was decided that an attempt should be made to find out whether Palermo's formula did in fact agree with experiment, and, if there was a substantial disagreement, whether an empirical formula could be substituted.

What was required was a set of formulae, or, preferably, a set of curves from which the self-capacitance of a particular coil could be quickly and easily read off, say to 20 per cent or better. Since the capacitance of the leads is of the same order of magnitude as that of the coil, it was first necessary to find out whether the lead capacitance could be specified by some quantity which would be additive algebraically to the self-capacitance of the coil.

The simplest hypothesis is that the "live" lead can be treated as an isolated straight vertical wire; that is to say, that (1) the fact of its being bent, and (2) the proximity of the coil to the upper end have a negligible effect on its capacitance. This we shall show to be correct, to the degree of approximation we require.

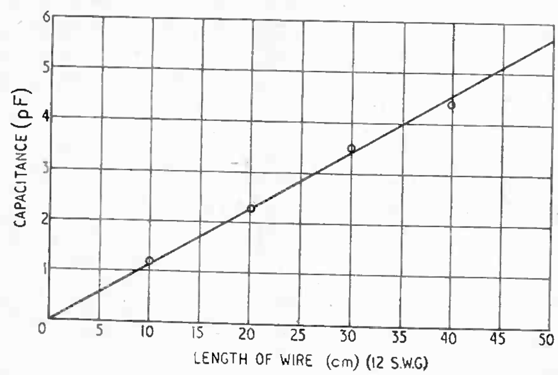

Fig. 4. *Variation with length of capacitance of vertical 12 gauge copper wire.*

9.2. The capacitances of a number of copper wires of various lengths and diameters, from 10 to 40 cm in length and from 12 S.W.G. to 44 S.W.G., were measured at 200 kc/s, the wires standing vertically upright with their lower ends in the live terminal of a Cambridge Capacity Meter. Over this range of length, the capacitances of each wire gauge were quite closely proportional to their lengths (see, for example, Fig. 4).

The capacitances, measured in this way, of 25-cm lengths of wire of various gauges are plotted against the wire diameter in Fig. 5. In Fig. 6 capacitance is plotted against length for a number of wire gauges.*

We may readily show that bending of the wire and alteration of its position relative to earth make no large difference to the measured capacitance. A 25-cm length of No. 12 S.W.G. copper wire was measured in a vertical position, as before. Its capacitance was 2.9 pF. Now, a piece of brass sheet, 35 cm × 15 cm, was attached to the earth terminal of the capacitance meter, so that it formed a horizontal earth adjacent to the wire in the live terminal. The wire was bent over so that about 2/3 of its length was horizontal and about 6 cm above the brass sheet. The capacitance was now 3.0 pF. Even when the wire was brought to within about 2 cm of the earth plate, the capacitance reading only rose to 3.6 pF. Finally, the wire was screwed into the meter terminal at its centre, the two ends being bent up to about 45° to the horizontal. The capacitance reading was now 3.1 pF.

Some of these measurements were repeated on the twin-T, at frequencies up to 20 Mc/s, and close agreement was obtained. In addition, some observations were made on the effect of the proximity of an adjacent vertical earth lead, screwed into the earth terminal of the twin-T. It was found that there was no measurable increase in capacitance until the earth lead was brought to within one or two centimetres of the live lead.

9.3. Before we discuss the effect of the proximity of the coil on the capacitance of the "live" lead, we have to describe the method used for measuring the capacitance of the whole coil-lead assembly.

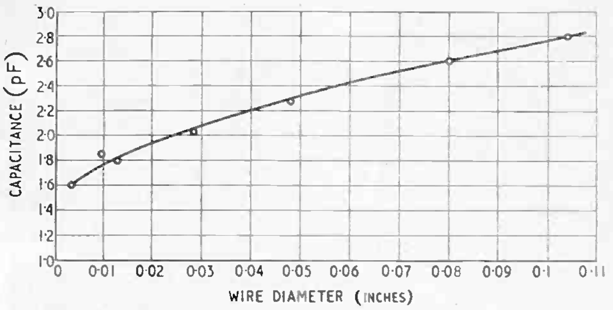

Fig. 5. *Capacitance of 25-cm lengths of vertical copper wire of various diameters.*

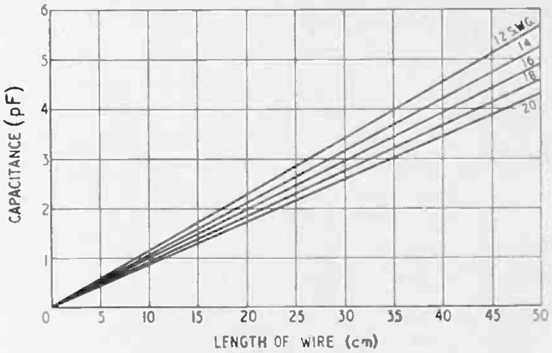

Fig. 6. *Variation of capacitance with wire length for vertical copper wires of various gauges.*

The standard technique for making self-capacitance measurements on coils was originally suggested by G. W. O. Howe[17]. The square of the wavelength is plotted against the added parallel capacitance necessary to resonate the coil. The points so obtained should lie on a straight line, which is produced to meet the capacitance axis, making a negative intercept which is numerically equal to the self-capacitance. The present method is a modification of this, making use of the large range (1,000 pF) of the main tuning capacitor of the twin-T and its fine graduation (0.2 pF per division). A measurement is carried out at the frequency at which the coil resonates with about 1,000 pF. About half a dozen additional measurements are now required, the first at about four times this frequency and the remainder at frequencies increasing in steps of 2 or 3 Mc/s.

Now, if we know the self-capacitance (including lead capacitance), we can calculate the inductance from any one of these measurements, since the coil is resonating with its self-capacitance plus the added capacitance. To obtain a given accuracy of inductance

* It is interesting to note that, over these ranges of length and diameter, the theoretical expression, given originally by G. W. O. Howe (see ref. 19: also ref. 12 p. 116), for capacitance of a straight vertical wire above a plane earth is very roughly linear with respect to the length of wire. Our experimental points, however, fit more closely to a straight line than to this theoretical curve. The theoretical curve for 12-gauge wire intersects the experimental straight line at the 45-cm length point and is about 0.4 pF above at a length of 10-cm. In the 20-gauge case, the theoretical curve falls above the experimental line throughout the range, the maximum deviation being about 0.3 pF.

we need to know the self-capacitance less accurately as the added capacitance becomes higher. In particular, if we make use of the measurement involving an added capacitance of about 1,000 pF, quite a rough value of the self-capacitance (which is not usually greater than 5 pF) will yield an inductance value of very high accuracy. The rough value is derived from the 1,000-pF measurement and the measurement involving the lowest added capacitance. In practice, we do not actually work out this self-capacitance correction, the inductance being obtained directly from the formula

$$L = \frac{0.02533}{C_2 - C_1} \left[\frac{1}{f_2^2} - \frac{1}{f_1^2}\right]$$

C_1 and C_2 (pF) being the added capacitances at frequencies f_1 and f_2 Mc/s) respectively.

Finally, using this value of inductance we can calculate the self-capacitance, at each of the frequencies of measurement after the first, from the formula

$$C_0 = \frac{0.02533}{Lf^2} - C$$

where C is the added capacitance at frequency f.

As an example of this method, coil No. 32 had 38 turns of 20 S.W.G. copper wire, mean diameter being 5.10 cm, overall length 4.79 cm, spacing ratio 0.720. Self-capacitance measurements took the form shown in Table IV.

The live lead consisted of 10 cm of 14 S.W.G. copper wire. Thus, a lead capacitance of 1.03 pF (independent of frequency) has to be subtracted from each of the readings in Table IV, to give the actual self-capacitance of the coil (see below, Sections 9.4 and 9.6). The mean self-capacitance now becomes 2.30 pF.

It appears, from these results, that the reactance of this coil can be represented closely, over quite a wide frequency range up to and beyond the self-resonant frequency, by a fixed inductance in parallel with a fixed capacitance. This is true for all the coils measured, no evidence being found for the suggestion sometimes made (e.g., ref. 12, p. 84, footnote) that self-capacitance is lower at the self-resonant frequency of the coil than at frequencies much less than this.

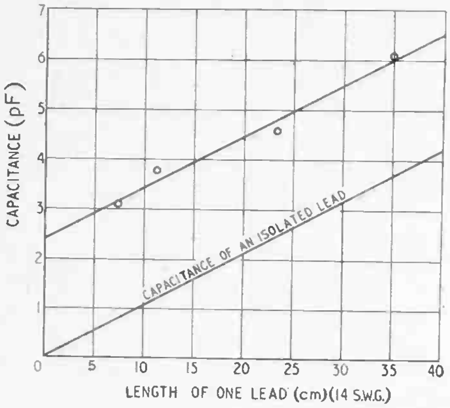

Fig. 7. *Apparent self-capacitance of a coil with various lengths of leads.*

TABLE IV.

Frequency Mc/s	C_1 (pF)	C_2 (pF)	C $C_2 - C_1$ (pF)	L Inductance (μH)	$\frac{0.02533}{Lf^2}$ (pF)	C_0 $\frac{0.02533}{Lf^2} - C$ (pF)
0.72	100	1076.0	976.0	49.89		
3.0	100	153.2	53.2		56.4	3.2
6.0	200	210.7	10.7		14.1	3.4
8.0	150	154.6	4.6		7.9	3.3
12.0	200	200.15	0.15		3.52	3.4
15.0	300	298.95	−1.05		2.25	3.3
18.0	200	198.2	−1.8		1.57	3.4
					Mean.	3.33

9.4 Now we can return to the question of the effect of the lead capacitance on the total measured capacitance.

A coil was constructed (39 turns of 20 gauge wire, mean diameter 5.08 cm, overall length 4.70 cm) having 14 gauge leads each 35 cm in length, inclusive of the portion bent over near the twin-T terminals. The parallel capacitance of coil plus leads was measured as just described, and the measurements repeated when the leads were shortened to 23.5, 11.5 and 7.5 cm.

The results are plotted, in Fig. 7, against the length of the live lead. If the lead capacitance adds algebraically, without modification, on to the coil self-capacitance, these points should lie on a straight line

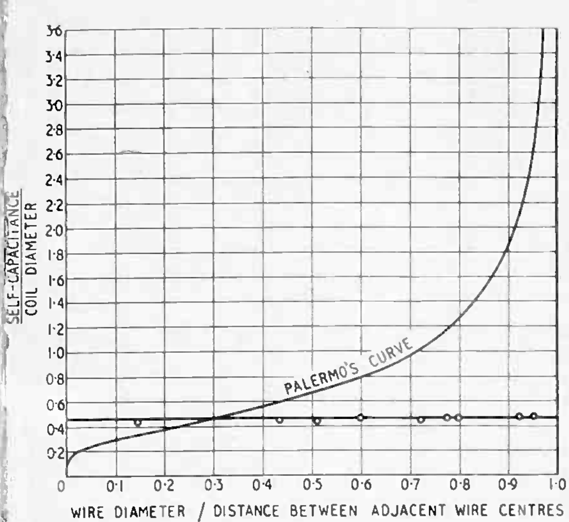

Fig. 8. *Comparison between Palermo's formula and measured self-capacitances of coils having length/diameter = 1 approximately.*

parallel to the 14 S.W.G. line of Fig. 6. By the method of least squares, the best fitting straight line has been drawn among these points, which deviate from it by not more than 5%. This line, it will be seen, is very closely parallel to the 14 S.W.G. line.

9.5. We are now in a position to deal with Palermo's self-capacitance formula. Previous work [14–17, 20] has established that the self-capacitance of a single-layer coil (C_0) is directly proportional to the coil diameter. It is also independent of the number of turns, provided this number is not too small. The remaining quantities upon which C_0 might depend are the ratio of coil length to diameter, the wire diameter (d) and the spacing of the turns (s). Investigators before Palermo had assumed that C_0 was independent of d and s. Palermo asserted that C_0 varied with d and s according to the following relation :

$$C_0 = \frac{\pi D}{3.6 \cosh^{-1} s/d}$$

where D is the coil diameter (cm).

This result, independent of the length of the coil, was supposed to hold for coils whose length/diameter ratio was equal to or less than 1.

Fig. 8 shows measured values of the ratio C_0/D for nine coils having diameters ranging from 2.6 to 6.4 cm and spacing ratios (d/s) from 0.15 to 0.95. Wire gauges used range from 18 to 30 S.W.G. All the coils were wound with bare wire on grooved Distrene formers except two, with values of d/s equal to 0.947 and 0.919, which were wound respectively with single-silk-covered and double-silk-covered wire on ungrooved Distrene rod, the turns being as close together as possible. Values of length/diameter were all about 1, ranging from 0.94 to 1.49. Each coil was measured as described above (see Table IV), lead capacitances being subtracted. In Fig. 8, Palermo's theoretical expression for C_0/D is plotted against d/s, and the experimental values are plotted on the same scale. To better than 5%, the measured values fit the expression

$$C_0 = 0.46\, D,$$

being independent of the spacing ratio. These observed values show a tendency to increase slightly with increasing proximity of turns, but this increase was of the order of magnitude of the experimental error anticipated, and it was not thought than any useful conclusions could be drawn.

It has to be pointed out that this experi-

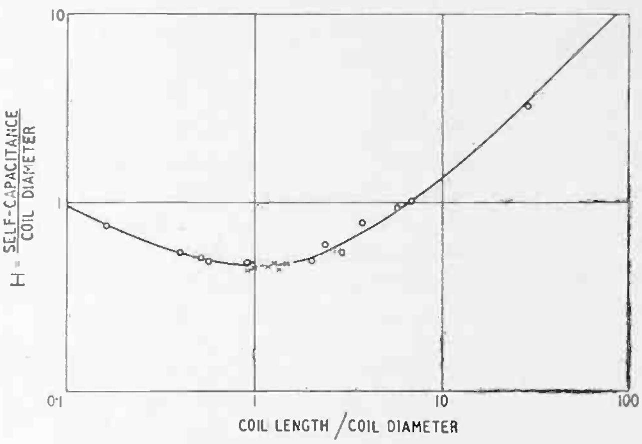

Fig. 9. *Variation of self-capacitance with coil length (one end of coil earthed).*

mental demonstration of the lack of dependence of self-capacitance on the spacing of turns contradicts not only Palermo's theory but also some experimental confirmation which he brought forward (see Section 9.7 below.) Consequently, it seems advisable to remark that no investigators other than Palermo have found a measurable variation with turn spacing. J. C. Hubbard [16], for example, says :

"There is no evidence that the variation of ratio of pitch to diameter of wire has a measurable effect on the distributed capacity in the region studied, though some effect is to be expected for coils of a smaller number of turns than those studied here." Hubbard's minimum number of turns was 35, and he worked down to a length/diameter of about 0.2; i.e., his coils are "short" enough for Palermo's formula to be applicable.

9.6. C_0 having been shown to be substantially independent of d/s, the final step is to find the variation of C_0 with the length/diameter ratio. Fig. 9 shows the results of a series of measurements on coils whose length/diameter ranged from 29.2 to 0.163. Diameters ranged from 0.675 to 6.36 cm, and numbers of turns from 10 to about 636. All the coils were those which had been used for h.f. resistance measurements, except the two with the greatest and smallest ratios of length/diameter. The former was wound with about 636 turns of 34 gauge wire, double-silk-covered, on a ¼-in Distrene former, and the latter with 10 turns of 20 gauge wire, double-silk-covered, on a 2½-in Distrene former.

It appears that, in the commonly occurring case when one end of the coil is at earth potential, we can write down the self-capacitance in the form

$C_0 = HD$ picofarads, where D is in centimetres.

H depends on the length/diameter ratio only. The table of values of H which follows is based on the curve of Fig. 9. The use of these values, with the appropriate lead correction, should give results accurate to 5% or better.

TABLE V.

Length/Diameter	H	Length/Diameter	H	Length/Diameter	H
50	5.8	5.0	0.81	0.70	0.47
40	4.6	4.5	0.77	0.60	0.48
30	3.4	4.0	0.72	0.50	0.50
25	2.9	3.5	0.67	0.45	0.52
20	2.36	3.0	0.61	0.40	0.54
15	1.86	2.5	0.56	0.35	0.57
10	1.32	2.0	0.50	0.30	0.60
9.0	1.22	1.5	0.47	0.25	0.64
8.0	1.12	1.0	0.46	0.20	0.70
7.0	1.01	0.90	0.46	0.15	0.79
6.0	0.92	0.80	0.46	0.10	0.96

J. C. Hubbard[16] remarked: "... we apparently have two quite independent factors" (determining the self-capacitance of coils), "one predominating greatly in very short coils, the other, in very long coils." It is an interesting confirmation of this suggestion that the experimental results of Fig. 9 and Table V can be fitted quite closely (to 2 or 3%) by an expression of the form

$$H = 0.1126 \frac{l}{D} + 0.08 + \frac{0.27}{\sqrt{l/D}}$$

The first numerical factor follows from Nagaoka's inductance formula for long coils and the experimental fact that the self-resonant wavelength for long coils equals twice the length of winding (see below). The other two factors are empirical.

A few additional measurements were made on some two-turn and single-turn coils. A coil of two turns of closely-spaced 18 S.W.G. double-silk-covered wire, diameter 6.47 cm, length/diameter 0.042 gave an H value of 1.53, which is quite close to the value, 1.40, calculated from the expression above. Another two-turn coil, of closely-spaced double-silk-covered 40 gauge wire, diameter 4.46 cm, length/diameter 0.0067, gave the low H value of 0.96. The lead correction is uncertain in both these cases, the assumptions about the live and the earth leads needing modification when the length of the lead becomes comparable with the winding length. It seems from these results that the curve of Fig. 9 can be extrapolated to a length/diameter of about 0.05, even when the number of turns is only two, but that there is a considerable falling off thereafter. A one-turn coil (14 S.W.G., mean diameter 23.9 cm, length/diameter 0.0084) departed even more from the trend of the curve in Fig. 9, the H value being only 0.23.

As an example of the use of Fig. 6 and 9, we may take the coil dealt with in Table III. Ratio of length to diameter was 1.375, and mean diameter was 5.10 cm. Hence, from Fig. 9,

$$\text{self-capacitance of coil} = 5.10 \times 0.47 = 2.4 \text{ pF}.$$

The leads were of 14 S.W.G., the length of each was 9.5 cm. Hence, from Fig. 6,

$$\text{capacitance of live lead} = 1.0 \text{ pF}$$

Thus, total capacitance $= 2.4 + 1.0$ pF $= 3.4$ pF.

9.7 The wide discrepancy between

Palermo's results and the present work make it desirable to say something about the theoretical basis of the expression put forward by Palermo.

What is called the "self-capacitance" of a coil will actually be a composite quantity, and the components will not necessarily be mutually dependent. It is convenient, to begin with, to divide coil self-capacitance into two parts, the "internal" and the "external" capacitances. When a current flows through the coil, each turn is at a different mean potential from every other turn. Consequently, there will be capacitances between each pair of turns (modified by the presence of the other turns between or on either side of the particular pair.). We shall call the effective parallel capacitance, across the whole coil inductance, the "internal" capacitance; it is formed by summing all these capacitances between turns, each taken across the appropriate part of the inductance.

Furthermore, each turn will be at a mean potential different from that of the earth, so that each turn will show a capacitance to earth. The effective parallel capacitance formed by summing these capacitances to earth we shall call the "external" capacitance.

It will be apparent that if the external and internal capacitances are comparable in magnitude, the apparent self-capacitance will be different when neither end of the coil is earthed, since the external capacitance will then not appear directly across the terminals of the coil. Hence, the present results, which are all for coils earthed at one end, may not be applicable to coils both ends of which are above earth potential.

Palermo further divides the internal capacitance into two portions, the capacitance between adjacent turns and the capacitance between turns which are not adjacent. He assumes that almost the whole of the self-capacitance is made up of the portion of the internal capacitance between adjacent turns: that is to say, he asserts that the capacitance between non-adjacent turns will be negligible, and he fails to mention the external capacitance.

Now, in spite of having neglected what may be a large part of the total self-capacitance, he predicts values which, for closely spaced coils, are very much larger than the values we have measured. The reason for this over-estimate is not too difficult to see.

Palermo derives his capacitance between adjacent turns from the formula for the capacitance between long parallel cylinders, diameter d and separation of centres s, which he quotes in the form

$$C = \frac{1}{3.6 \cosh^{-1} s/d} \text{ picofarads/cm.}$$

When s/d approaches 1, that is to say, when the cylinders are very close, this expression approaches infinity. However, when the turns of a coil are very close the self-capacitance does not approach infinity, and the reason for the discrepancy appears to be that what we have to concern ourselves with is the effective current-carrying path and not the whole of the cross section of each turn.

When high-frequency current flows through an isolated wire, the current tends to be concentrated near the surface. When the wire is bent into the form of a coil, the current tends, further, to flow round the inner surface of the coil. Finally, the effect of the adjacent turns is to cause the current to withdraw from the portions of the wire nearest to these turns. Thus, even when the turns are very close the effective current-carrying paths are still comparatively remote from each other.

Thus, the capacitance between adjacent turns will be less than that predicted by Palermo. The fact that self-capacitance is substantially independent of spacing of turns suggests that the part of the self-capacitance considered by Palermo is actually negligible.

The question of the validity, or otherwise, of Palermo's formula is complicated by the existence of some measurements (on coils earthed at one end) which he brings forward in support of his theory. It is difficult to say much about these measurements, except that they are closely in agreement with Palermo's formula, and consequently, when the turns are closely spaced, they are very different from other published results on similar coils. The discrepancy is drastically illustrated by Palermo's coil No. 9, which had a diameter of 10.40 cm and a length of 9.65. The number of turns was 28, the wire diameter 0.326 cm and the spacing ratio 0.94. The coil was measured at a "high frequency"; i.e., at something below, but of the order of magnitude of the self-resonant frequency. From the curve of Fig. 9 we would predict a self-capacitance of

4.8 pF. Palermo's formula gives 20.5 pF. The measured value he gives as 20.0 pF.

Palermo's measured coils fall into two groups. Seven of them, with spacing ratios between 0.3 and 0.8 were measured by the Bureau of Standards. Over this region of spacing ratio, Palermo's "proximity effect" is not too pronounced. The measured values were all between 1 and 3 picofarads larger than the values that would be predicted from our present work. Palermo makes no mention of a correction for leads and terminals, and possibly this accounts for the discrepancy. The remaining twelve coils were measured by Palermo himself, and it is among these that we find the capacitances (such as the one already quoted) which are so greatly different in magnitude from our results.

9.8. We have seen that, so far as self-capacitance is concerned, a single-layer coil behaves very closely like a cylindrical current sheet. It is well known that this is also true of the inductive part of its reactance. If we combine these two current-sheet formulae we might expect to deduce some simple expression, depending on the coil geometry, for the self-resonant frequency.

Our measurements have given a self-capacitance expression in the form

$C_0 = HD$, where H is a quantity dependent on the length/diameter only.

The Nagaoka expression for the inductance, L_0, may be written in the form

$L_0 = Kn^2D$, where K is dependent on the length/diameter only.

Now, if we call λ (cm) the self-resonant wavelength, we have

$\lambda = 2\pi c\sqrt{L_0C_0}$ where c (cm/sec) is the velocity of electro-magnetic radiation,

$= 2\pi c\sqrt{HKn^2D^2}$

$= 2\pi c\, nD\sqrt{HK}$

$= Nl$ where N is dependent on the length/diameter only and l is the total length of wire.

Values of N, worked out from the inductances and self-capacitances of the coils previously measured, are plotted against length/diameter in Fig. 10. Table VI gives values of N and has been worked out from Table V and Nagaoka's values of K.

TABLE VI.

Length/Diameter	N	Length/Diameter	N	Length/Diameter	N
50	2.0	5.0	2.3	0.70	3.8
40	2.0	4.5	2.4	0.60	4.0
30	2.0	4.0	2.4	0.50	4.3
25	2.0	3.5	2.5	0.45	4.5
20	2.0	3.0	2.5	0.40	4.8
15	2.1	2.5	2.6	0.35	5.0
10	2.1	2.0	2.7	0.30	5.4
9.0	2.1	1.5	2.9	0.25	5.8
8.0	2.2	1.0	3.4	0.20	6.3
7.0	2.2	0.90	3.5	0.15	7.1
6.0	2.3	0.80	3.6	0.10	8.3

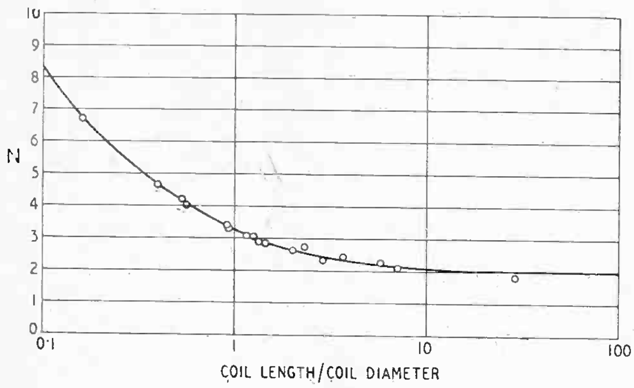

Fig. 10. *Wavelength at self-resonant frequency equals N × total length of wire.*

10. Frequency Correction.

The measured values of ϕ (ratio of the h.f. resistance of the coil to the resistance of the straightened wire at the same frequency) are mostly for frequencies such that z (see list of symbols) has values between 8 and 20. Though these frequencies are to be regarded as "high" according to our previous definition of "high frequency," (i.e., frequency for which $z>7$), ϕ will still, to some small extent, be frequency dependent. So that the measured values shall be comparable among themselves, it will be advantageous to apply a frequency correction such that the corrected ϕs correspond to the same value of z. If we choose infinity as this standard z value the corrected ϕs can be compared directly with Butterworth's "high-frequency" table, which is supposed to apply at infinitely large z. Since, as we shall see, the frequency correction is small, we may still use the corrected ϕ values at the orders of frequency commonly encountered.

It is unfortunate that exact measurements on coil resistance are almost as scarce at low as at high frequencies. Consequently, it has not been found possible to deduce from previous work an experimental frequency correction to convert the present measurements from "high" to "infinite" frequency. Tentatively, a correction formula was used based on Butterworth's theoretical considerations, modified in the light of the present results. The formula in question is

$$\Delta\phi = \frac{1}{8G}(\phi_{exp} - 2\alpha)$$

ϕ_{exp} being the measured value of ϕ, and G and α being quantities due to Butterworth (see, e.g., ref. 12, pp. 78 and 79).

The correction did not usually exceed 2%. It may be either positive or negative. In deriving $\Delta\phi$, the general form of Butterworth's resistance formula is assumed; i.e.,

$$\frac{\text{a.c. resistance}}{\text{d.c. resistance}} = \alpha H + kG$$

where the first term represents the losses due to the currents in the wires, and the second the losses due to the field of the whole coil. H and G are functions of z only, being given for large z by $\frac{\sqrt{2}\,z + 1}{4}$ and $\frac{\sqrt{2}z - 1}{8}$ respectively (the value of z chosen for each coil being that corresponding to the mean working frequency). α depends on the spacing ratio of the turns, and k on the spacing ratio and the dimensions of the coil.

Now, we have seen previously (Section 3.2) that the Butterworth theory is most open to suspicion in that part of it which deals with losses due to the "mean transverse field." The effect of these losses, in the theory, is to cause k, at infinitely high frequency, to have very high values, especially for close spacing. This is the effect that is not confirmed by the present measurements. So, to derive a frequency-correction formula, we shall assume that k has some value which does not vary with frequency (z being sufficiently high) and, eliminate k between the expressions for ϕ at the frequency of measurement and at infinite frequency. α we may take, according to the theory, as being also very nearly invariable with frequency.

When z approaches infinity, we have

$$\phi = \alpha + \frac{k}{2}$$

Also,
$$\phi_{exp} = \frac{\text{a.c. resistance}}{\text{d.c. resistance}} \cdot \frac{1}{\sqrt{2}z/4} = 4\,\frac{\alpha H + kG}{(8G + 1)}$$

and hence, eliminating k from the expressions for ϕ and ϕ_{exp} and using the relation $2H = 1 + 4G$, we obtain the required expression for ϕ; i.e.,

$$\phi = \phi_{exp} + \frac{1}{8G}(\phi_{exp} - 2\alpha)$$

We shall see later that the argument for assuming k to be substantially independent of frequency, when z is high enough, is not complete, because we have only given reasons for rejecting that part of Butterworth's theory which applies to *high*-frequency coil resistance. We shall consider the low-frequency case in Section 14.

11. Effect of the Proximity of the Twin-T Top.

It was thought that an additional correction might be necessary for losses due to the proximity of the metal top of the twin-T. To ascertain the order of magnitude of this effect, a coil (48 turns of 20 gauge d.s.c. wire, mean diameter 2.70 cm, length/diameter 1.82, d/s 0.89) was measured a number of times, the leads being progressively shortened until the distance of the coil from the twin-T terminals was about its own diameter. The coil was then about 2 diameters above the twin-T top.

There was no significant variation in the

TABLE VII.

Length of each lead cm	Total Resistance ohms	Temperature °C	Total Resistance at 20° C ohms	Resistance of leads (20° C) ohms	Resistance of coil (20° C) ohms
40	$1219 \times 10^{-6}\sqrt{f}$	24	$1210 \times 10^{-6}\sqrt{f}$	$25 \times 10^{-6}\sqrt{f}$	$1185 \times 10^{-6}\sqrt{f}$
15.5	1204 ,,	24	1195 ,,	10 ,,	1185 ,,
8	1212 ,,	25	1200 ,,	5 ,,	1195 ,,
8	1218 ,,	26.5	1203 ,,	5 ,,	1198 ,,
4.5	1211 ,,	27	1195 ,,	3 ,,	1192 ,,

4.8 pF. Palermo's formula gives 20.5 pF. The measured value he gives as 20.0 pF.

Palermo's measured coils fall into two groups. Seven of them, with spacing ratios between 0.3 and 0.8 were measured by the Bureau of Standards. Over this region of spacing ratio, Palermo's " proximity effect " is not too pronounced. The measured values were all between 1 and 3 picofarads larger than the values that would be predicted from our present work. Palermo makes no mention of a correction for leads and terminals, and possibly this accounts for the discrepancy. The remaining twelve coils were measured by Palermo himself, and it is among these that we find the capacitances (such as the one already quoted) which are so greatly different in magnitude from our results.

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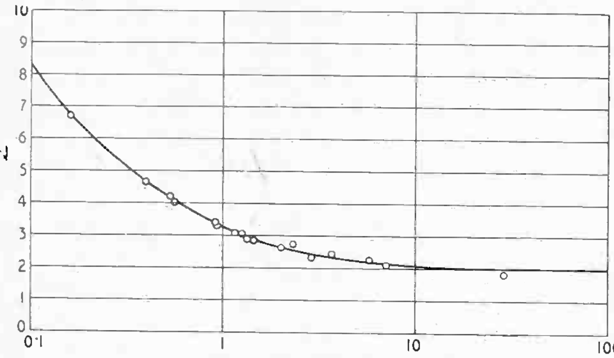

Fig. 10. *Wavelength at self-resonant frequency equals $N \times$ total length of wire.*

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Length / Diameter	N	Length / Diameter	N	Length / Diameter	N
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30	2.0	4.0	2.4	0.50	4.3
25	2.0	3.5	2.5	0.45	4.5
20	2.0	3.0	2.5	0.40	4.8
15	2.1	2.5	2.6	0.35	5.0
10	2.1	2.0	2.7	0.30	5.4
9.0	2.1	1.5	2.9	0.25	5.8
8.0	2.2	1.0	3.4	0.20	6.3
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TABLE VII.

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15.5	1204 ,,	24	1195 ,,	10 ,,	1185 ,,
8	1212 ,,	25	1200 ,,	5 ,,	1195 ,,
8	1218 ,,	26.5	1203 ,,	5 ,,	1198 ,,
4.5	1211 ,,	27	1195 ,,	3 ,,	1192 ,,

measured resistances, their spread being about 1 per cent. The results are given in Table VII.

The two 8-cm measurements were carried out on successive days. The length of each lead includes the right-angle bend at the twin-T terminal, so that in the case of the last measurement the coil was about 2.5 to 3 cm above the terminal.

12. Results of Measurements.

After all these corrections have been applied, we are left with a set of experimental values of ϕ for various non-integral values of coil length/diameter and d/s. These have to be reduced to a table with the same intervals as those of Table I.

We are assisted in this process by remembering that the error in Butterworth's values has been assumed to be due to excessive weight being given to the transverse field losses. If we work out Butterworth's formula again neglecting the transverse field we obtain another table whose entries are all less than those in the Butterworth table, except for the column corresponding to infinite length/diameter. In this case, the transverse field has disappeared.

Our experimental values all lie between these two sets of values. Consequently, we shall take the case where these two sets of values are equal, i.e. the extreme right-hand column, as the limiting case of our empirical table. This is convenient, because it is not possible to measure coils whose length/diameter is infinite.

Further, measurements on a few coils whose length/diameter ratio was about 8, showed that the experimental values of ϕ were within 1 or 2 per cent. of the Butterworth values when the transverse field is neglected. Since transverse-field effects are less appreciable as the length/diameter ratio increases, we may use this result to fill in the 8 and 10 length/diameter columns.

Measurements on several coils having values of $d/s = 0.2$ and 0.3, with length/diameter ranging from 0.5 to 4, showed that Butterworth's values for these two rows are confirmed by the experimental results. This was used to fill in the three lowest rows, it being assumed that the bottom row, the values in which are close to those for a straight wire, could safely be taken as following Butterworth.

It may be pointed out that this agreement with Butterworth's figures, over the region in which Butterworth's theory might be expected to hold, constitutes indirect evidence of the reliability of the measurements.

There remains the most important portion of the table, that is, the top left-hand quadrant. In general, due to difficulties in accurate grooving, the spacing ratios were not exact multiples of 0.1. However, the spacing ratios of the coils which had been constructed to have $d/s = 0.6$, turned out to be very close to the value aimed at. A smooth curve could thus be drawn through their ϕ values, giving the sixth row from the bottom. By extrapolating the values of coils having d/s about 0.5 and 0.7, using this $d/s = 0.6$ row and then drawing smooth curves, the adjacent rows were obtained, and similarly for the rest of the table.

The final result is Table VIII. The values for $d/s = 1$ are obtained by extrapolation. So are the values for the two left-hand columns.

In general, the experimental points deviate

TABLE VIII.

d/s	Coil Length/Coil Diameter											
	0	0.2	0.4	0.6	0.8	1.0	2	4	6	8	10	∞
1.0	5.31	5.45	5.65	5.80	5.80	5.55	4.10	3.54	3.31	3.20	3.23	3.41
0.9	3.73	3.84	3.99	4.11	4.17	4.10	3.36	3.05	2.92	2.90	2.93	3.11
0.8	2.74	2.83	2.97	3.10	3.20	3.17	2.74	2.60	2.60	2.62	2.65	2.81
0.7	2.12	2.20	2.28	2.38	2.44	2.47	2.32	2.27	2.29	2.34	2.37	2.51
0.6	1.74	1.77	1.83	1.89	1.92	1.94	1.98	2.01	2.03	2.08	2.10	2.22
0.5	1.44	1.48	1.54	1.60	1.64	1.67	1.74	1.78	1.80	1.81	1.83	1.93
0.4	1.26	1.29	1.33	1.38	1.42	1.45	1.50	1.54	1.56	1.57	1.58	1.65
0.3	1.16	1.19	1.21	1.22	1.23	1.24	1.28	1.32	1.34	1.34	1.35	1.40
0.2	1.07	1.08	1.08	1.10	1.10	1.10	1.13	1.15	1.16	1.16	1.17	1.19
0.1	1.02	1.02	1.03	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.04	1.05

Experimental values of the ratio of the high-frequency coil resistance to the resistance at the same frequency of the same length of straight wire.

from the smoothed curves by 1 or 2 per cent. In three cases the deviation is as high as 3 per cent.

It has already been pointed out (Section 5) that, from physical considerations, it becomes increasingly difficult to construct coils fulfilling the various criteria of Butterworth's h.f. resistance table as one approaches the extreme left-hand side of the table. The difficulty becomes acute in the bottom left-hand quadrant. To cover this region, it was necessary to sacrifice the condition that z should be high. Thus, coil No. 41, which had a mean diameter of 6.24 cm, length/diameter of 0.542, and d/s of 0.266, had to be wound with 30 gauge wire, and z was only 2.79. The correction for frequency was now about 17 per cent. This, however, is not too alarming because in this region Butterworth's formulae predict values of α and k (in the Butterworth expression for ϕ, given above) which are almost independent of frequency for large z.

The entries of Table VIII are shown graphically in Fig. 11. For closely spaced wires, there is a critical value when the length/diameter ratio is about 1. This may have some connection with the parallel phenomenon observable in the case of the self-capacitance (see Fig. 9).

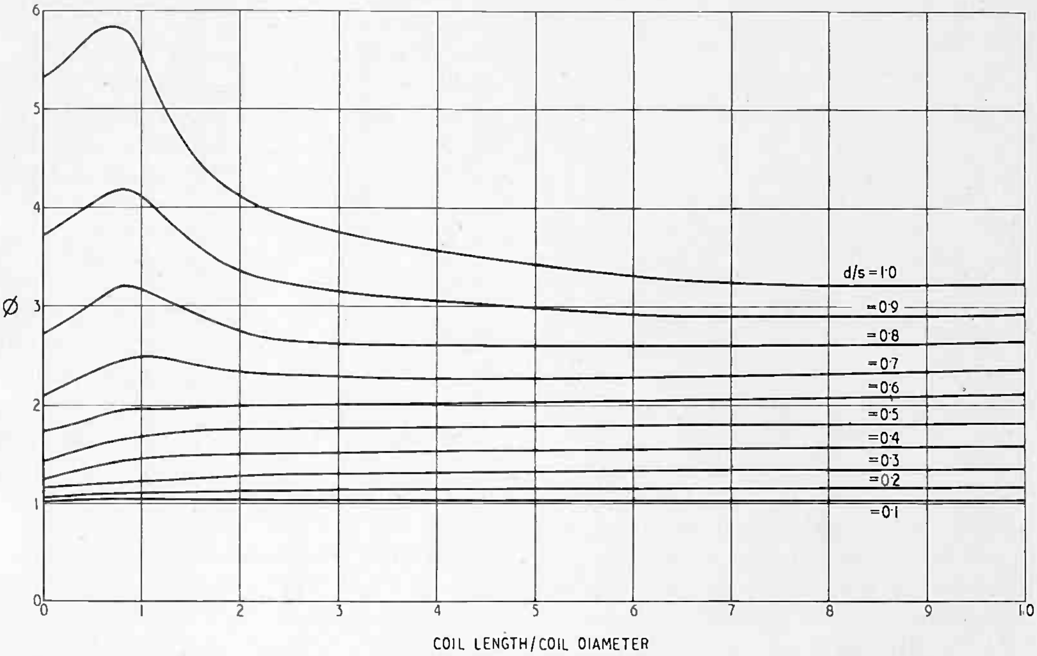

Fig. 11. *Variation of θ with spacing ratio and length/diameter ratio.*

$$\theta = \frac{h.f.\ resistance\ of\ coil}{h.f.\ resistance\ of\ same\ length\ of\ straight\ wire\ at\ same\ frequency}$$

13. Variation of Q with Coil Shape.

It is not very easy to judge coil performance from figures connected with the h.f. resistance. Normally, we are concerned with coil efficiency, which may best be defined by its Q value at a particular frequency.

It is well-known that Nagaoka's inductance formula may be used, with an error of not more than 5%, up to quite high frequencies. In fact, in the case of the coils used in the present series of measurements, if we assume a constant self-capacitance the inductive part of the reactance agrees closely with Nagaoka's value up to the self-resonant frequency. It breaks down most seriously when the wire diameter becomes comparable (of the order of 1/10th or more) with the coil diameter.

Nagaoka's inductance formula is usually written in the form

$$L_x = \frac{4\pi^2 R^2 n^2 K\ 10^{-9}}{l} \text{ henrys}$$

where R, l and n have the meanings previously defined, and K is a factor involving the ratio of length/diameter only.

Also, $R_x =$ (d.c. resist.). H . ϕ ohms.
where H has its high-frequency value (see Section 10) and ϕ is defined by Table VIII.

Hence,

$$R_x = \frac{2\pi Rn}{\pi(d/2)^2}\,\rho\,.\,\frac{1}{2\sqrt{2}}\,\pi d\sqrt{\frac{2f}{10^9\rho}}\,.\,\phi \text{ ohms.}$$

$$= \frac{\sqrt{2}\,Rn\,\rho}{\beta d}\,\phi \text{ ohms,}$$

where

$$\beta = \frac{1}{2\sqrt{2\pi}}\sqrt{\frac{10^9\rho}{f}}$$

Now,

$$Q = \frac{2\pi f\,L_x}{R_x}$$

$$= 2\pi f\,.\,\frac{4\pi^2 R^2 n^2}{l}\,K10^{-9}\,.\,\frac{\beta d}{Rn\rho\,\phi\sqrt{2}}$$

$$= \frac{\pi R}{\sqrt{2}\beta}\,.\,\frac{nd}{l}\,.\,\frac{K}{\phi}$$

$$= \frac{R}{\sqrt{2}\,\beta}\,\frac{\pi d}{s}\,.\,\frac{K}{\phi}$$

$$= \frac{R}{\sqrt{2}\beta}\,\psi$$ where ψ is a function of d/s and l/D.

For copper, taking $\rho = 1.7 \times 10^{-6}$ ohm-cm we find that

$$Q = 0.15R\,\psi\,\sqrt{f}$$

Table IX, which gives values of ψ for various values of coil length/diameter and spacing ratio, is derived from Table VIII and Nagaoka's table of K. The measured values of Q (uncorrected for leads) were checked against those predicted from this table. For coils falling within the body of the table, that is to say, to the left of the column length/diameter = 4, the difference was 5 per cent. or less, the values based on Table IX being usually higher than the experimental values. For coils with length/diameter = 5 or more, and d/s greater than 0.5, the measured values tended to be 10 per cent or more lower than the predicted values.

The discrepancy in the case of the long coils is due not to divergence of the measured resistances from the values corresponding to Table VIII but to inductance values different from those predicted by Nagaoka's formula. These coils all had small diameters, in order that a sufficiently large length/diameter ratio could be attained without excessive bulk of coil, and the wire diameter could no longer be regarded as small compared with the coil diameter. Now, Nagaoka's formula is a current-sheet formula and assumes that the thickness of this sheet

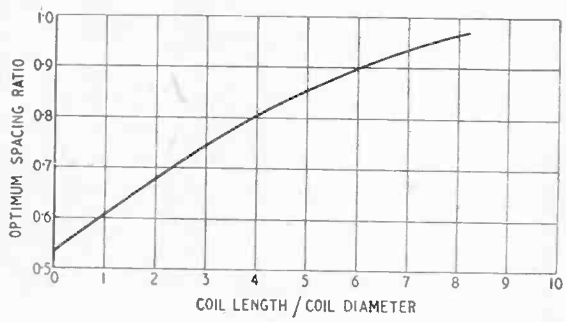

Fig. 12. *Variation of optimum spacing ratio with length/diameter.*

is negligible compared with the diameter. In using Nagaoka's formula, we have taken the mean diameter of our coil as the diameter of his equivalent current-sheet. However, the current in a coil, at high frequencies, tends to flow round the inner surface, so that the equivalent current-sheet should

TABLE IX.

d/s	Coil Length/Coil Diameter											
	0	0.2	0.4	0.6	0.8	1.0	2	4	6	8	10	∞
1.0	0.00	0.18	0.26	0.31	0.35	0.38	0.63	0.80	0.89	0.93	0.93	0.92
0.9	0.00	0.24	0.33	0.39	0.43	0.47	0.69	0.84	0.90	0.93	0.93	0.91
0.8	0.00	0.28	0.40	0.46	0.50	0.55	0.75	0.87	0.90	0.91	0.91	0.89
0.7	0.00	0.32	0.46	0.53	0.58	0.61	0.78	0.87	0.90	0.89	0.89	0.87
0.6	0.00	0.34	0.49	0.57	0.63	0.67	0.78	0.85	0.87	0.86	0.86	0.85
0.5	0.00	0.34	0.48	0.56	0.61	0.65	0.74	0.80	0.81	0.82	0.82	0.81
0.4	0.00	0.31	0.45	0.52	0.56	0.60	0.69	0.74	0.75	0.76	0.76	0.76
0.3	0.00	0.25	0.37	0.44	0.49	0.52	0.60	0.64	0.66	0.67	0.67	0.68
0.2	0.00	0.19	0.27	0.33	0.36	0.39	0.45	0.49	0.51	0.51	0.51	0.53
0.1	0.00	0.10	0.14	0.17	0.19	0.21	0.25	0.27	0.28	0.29	0.29	0.30

Values of ψ, from Table VIII and Nagaoka's inductance formula. High-frequency Q of a coil of copper wire or thick tubing is given by $Q = 0.15R\psi\sqrt{f}$.

have a diameter less than the mean diameter of the coil and greater than the inner diameter. That is to say, the measured inductance value should lie between the Nagaoka value obtained by using the mean diameter and that obtained by using the inner diameter. This is found to be the case.

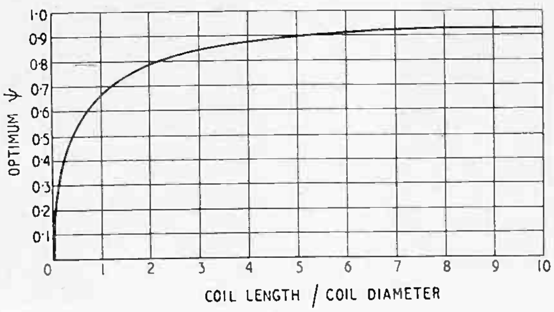

Fig. 13. *Variation of optimum ψ with length/diameter.*

Thus, for coil No. 54 (mean diameter 1.72 cm, wire diameter 0.12 cm), the two Nagaoka values corresponding to the inner and mean diameters respectively were 7.8 and 9.0 μH. The measured value was 8.15 μH., and, subtracting a (calculated) lead inductance of 0.13 μH., the coil inductance was 8.0 μH.

The entries in Table IX increase steadily with increasing length/diameter, except that when length/diameter approaches infinity, and $d/s > 0.4$, there is a small decline. This decline seems not to be readily explainable. The last three columns of the ϕ table, it will be remembered, are those resulting from Butterworth's theory when the transverse field term is neglected. The slight anomaly in the ψ table doubtless means that the effect of the transverse field is not quite negligible for length/diameter ratios of 8 and 10, when d/s is greater than 0.4.

The zero Q values for coils of zero length do not mean that the resistance is infinite, but that the inductance has disappeared.

For a given length/diameter, these entries show a rather flat optimum as the spacing ratio varies. In Fig. 12 the optimum spacing ratio is plotted against length/diameter. In Fig. 13 the value of ψ corresponding to the optimum spacing ratio is likewise plotted against length/diameter.

There is an interesting interpretation of ψ analogous to the interpretation of K in Nagaoka's formula. K may be defined as the ratio of the coil inductance to the inductance of an infinitely long cylindrical current sheet having a diameter equal to the mean diameter of the coil. K, in fact, is an end correction. Similarly, it can be shown from the results in reference 13 that ψ is the ratio of the coil Q to the Q at the same frequency of a certain idealized coil. This " coil " is an infinitely long cylinder, having its inner diameter equal to the mean diameter of the coil we are considering and a wall thickness large compared with the current penetration depth, the current being assumed to flow round the inner surface.

14. Low-frequency Resistance of Single-layer Coils.

When we derived a frequency correction to the measured h.f. resistance values, we assumed that the factor we have called k (in the version of Butterworth's formula given in Section 10) was independent of frequency if z was sufficiently high (of the order of 10 or more). This, it was pointed out, is not even approximately true in Butterworth's theory.

Another way of putting this is that, with close spacing of turns, in Butterworth's theory the h.f. resistance does not become proportional to the square root of the frequency until z is very high. When the turns are touching (physically, but not electrically), the h.f. resistance, in the theory, never becomes proportional to $\sqrt{f}$.

Butterworth gives values for his various quantities for z values up to 5, and for infinite z. Table I is based on these latter values. Interpolation for z values between 5 and ∞ is most conveniently done by plotting Butterworth's functions against the reciprocal of z. The values so obtained are, as one might expect, in closer agreement with the experimental results than those of Table I. Thus, when $z = 10$, for length/diameter = 1 we have the results of Table X.

TABLE X.

d/s	ϕ	% excess over experimental values
1.0	10.37	87%
0.9	5.57	36%
0.8	3.61	14%
0.7	2.61	6%

In the case of the single coil with $d/s = 0.95$, the theoretical value thus obtained was about 60 per cent. in excess of the measured value.

Thus, if Butterworth's low-frequency values can be relied upon, his predicted resistances are not so wildly in disagreement with experimental results as appears by comparison of Tables I and VIII, especially since in the top left-hand region of the Table, where the discrepancy will be largest, the coils, for physical reasons, had to be constructed with low z values, between 8 and 10.

We can easily show that these low-frequency Butterworth results are open to considerable suspicion. In fact, we shall see that, in consideration of the degree of approximation tolerated by Butterworth, any agreement with observation must, for closely spaced coils, be regarded as in the nature of an accident.

It was stated in Section 3 that Butterworth worked out each of his three types of loss by solving a set of an infinite number of linear equations, each containing an infinite number of unknowns. He used a method of successive approximations.

Now, when the frequency is low, that is to say, for $z = 5$ or less, the amount of arithmetic involved in proceeding beyond the first approximation becomes very large indeed. Consequently, for these values of z, Butterworth uses the first approximation only.

One can only guess at the error this introduces. For the case of touching wires, when z is infinite, there is an infinite error involved if we take only the first approximation for the transverse field losses. That is to say, the entries in the first row of Table I would be decreased from infinity to a series of not too large finite values.

Whether the converse is true, that is, whether if one proceeded to a sufficiently large number of approximations for the case of touching wires at low frequency an infinite result would be obtained, must be a matter of conjecture. On physical grounds, if a coplanar system of an infinite number of infinitely long touching wires offers infinite impedance to a transverse field of very high frequency, it seems not unreasonable to suppose that it will also offer an infinite impedance to a low-frequency transverse field.

Consequently, for different reasons, the applicability of the Butterworth low-frequency formula to specific coils is open to as much doubt as that of his high-frequency formula.

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Radiocommunication Convention

The Institution of Electrical Engineers is holding a convention, covering the wartime activities in the field of radiocommunications, from 25th to 28th March. The convention will be opened by the President of the Board of Trade, Sir Stafford Cripps, at 5.30 p.m. on Tuesday, 25th March, and he will introduce an address by Colonel Sir Stanley Angwin, on "Telecommunications in War."

On the following days there are to be morning, afternoon and evening sessions at which papers covering naval, military, short and long distance, and pulse communications will be read. Propagation, radio components and future trends will also be covered in the convention.

At a further meeting at 5.30 p.m. on 2nd April there will be a paper on C. W. Navigational Aids.

Physical Society's Exhibition

The 31st Exhibition of Scientific Instruments and Apparatus is being held by the Physical Society on 9th–12th April in the Physics and Chemistry Departments of Imperial College, South Kensington, London, S.W.7.

Admission is by ticket only and is restricted to members of the Society from 10 a.m. to 1 p.m., but it is open to non-members from 2 p.m. to 9 p.m.

CORRESPONDENCE

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

Television in France

To the Editor, "Wireless Engineer"

MONSIEUR,—Je viens de lire, dans "Abstracts and References," *Wireless Engineer*, Janvier 1947, une analyse (270) sur la Télévision en France.

Un passage m'a particulièrement frappé et mérite une rectification. Votre revue indique en effet que : "La Radiodiffusion Française a un grand studio de télévision construit sur l'ordre des Allemands, dans lequel tout l'equipement est allemand et construit par A. G. Fernseh."

Sur le premier point, je dois vous indiquer que les travaux ont été effectués sur nos plans, et évidemment sous le contrôle allemand ; des constructions de cette importance ne pouvaient être entreprises, comme vous devez le savoir, sans une telle surveillance dans un pays occupé.

D'autre part, l'équipement de tout ordre, technique ou artistique, a été construit uniquement et totalement par les constructeurs français. (ainsi, le matériel technique provient de la Compagnie Française de Télévision.

L'erreur qui s'est glissée dans l'article dans *The Journal of the Television Society** est dûe sans doute au fait que les Allemands, pendant leur occupation, ont utilisé leur matériel, qu'ils ont déménagé au moment de leur retraite.

J'espère que vous voudrez bien faire dans votre revue les rectifications nécessaires afin que vos lecteurs aient une vue exacte des efforts réalisés, malgré les difficultés, par l'Industrie française de la Télévision.

Veuillez agréer, Monsieur, l'assurance de ma considération distinguée.

A. ORY,
Le Chef du Service de la Télévision.
Radiodiffusion Française, Paris.

Transient Response of Filters

To the Editor "Wireless Engineer"

SIR,—In the January issue, p. 27, E. T. Emms states that when a voltage $\cos \omega_0 t$ is suddenly applied to a band-pass-filter of any bandwidth, the envelope of the output transient is the same as the output voltage produced by a unit-step in the equivalent low-pass filter. In this note it will be shown that this statement is generally incorrect and that the assumption of a narrow band is essential to validate the transient band-pass/low-pass analogy.

First, the simplest possible case will be discussed. The most rudimentary low-pass filter is a single coil L working between two resistances R. The transients are found by solving the symbolic equation $Lp + 2R = 0$ which gives the single root $p_1 = -\dfrac{2R}{L}$ corresponding to a transient $\exp(p_1 t)$. The low-pass is transformed into a band-pass by adding a series capacitor $C = \dfrac{1}{\omega_0^2 L}$ and the new new symbolic equation has two roots $\frac{1}{2}(p_1 \pm \sqrt{p_1^2 - 4/\omega_0^2})$. If p_1 can be neglected with respect to $2\omega_0$, the roots are approximately $\frac{1}{2}p_1 \pm j\omega_0$ and the corresponding two terms are combined into $\exp(\frac{1}{2}p_1 t)\cos \omega_0 t$, thus having an envelope identical to the low-pass transient. On the contrary, for small values of ω_0, both roots are real and the result bears no resemblance to the first case ; no envelope can even be defined since the transient has no oscillatory character. Obviously the condition $2\omega_0 \gg |p_1|$ corresponds to a high Q for the series resonant circuit $L, C, 2R$; i.e., to a narrow band.

Similar considerations hold for the general case. Let us suppose that the steady-state characteristic of a low-pass is defined by giving the output voltage $\dfrac{1}{S(p)} \exp(pt)$ corresponding to a generator $\exp(pt)$ at the input. The response to a unit-step will be given by Heaviside's Expansion Theorem

$$V(t) = \frac{1}{2\pi j}\int_{c-j\infty}^{c+j\infty} \frac{e^{pt}\,dp}{p\,S(p)} = \frac{1}{S(0)} + \sum_n \frac{e^{p_n t}}{p_n S'(p_n)} \quad (1)$$

where the sum extends to all the roots of $S(p)$. Since a low-pass has usually zero-loss and phase at zero-frequency, the result will take the form

$$V(t) = \tfrac{1}{2} + \sum_n A_n e^{p_n t} \quad \ldots \quad (2)$$

the p_n and the A_n being real or occurring in complex conjugate pairs.

Suppose now that a band-pass is obtained from the low-pass by the classical frequency transformation as described by Emms. The steady-state characteristic of the band-pass will be

$$T(p) = S\left(\frac{p^2 + \omega_0^2}{p}\right)$$

and the response to the voltage $\cos \omega_0 t \,.\, 1$ is calculated by using its Laplace transform as correctly given by Emms. The response is

$$V(t) = \frac{1}{2\pi j}\int_{c-j\infty}^{c+j\infty} \frac{e^{pt}\,p\,dp}{(p^2 + \omega_0^2)\,T(p)} \quad \ldots \quad (4)$$

Thus (4) is deduced from (1) by applying the same change of variable to the factor p and in the function $S(p)$ [see (3)], but this does not correspond to any simple transformation from U to V, because the factor $e^{pt}dp$ and the path of integration are preserved.

The expansion formula will now be applied to (4). First the poles $\pm|j\omega_0|$ of the integrand give the steady-state term. The remaining poles are zeros $\hat{p}_n$ of $T(p)$ and are deduced from the zeros p_n of $S(p)$ by solving the transformation equation

$$\frac{\hat{p}_n^2 + \omega_0^2}{\hat{p}_n} = p_n$$

This gives two roots $\hat{p}_n = \frac{1}{2}[p_n \pm \sqrt{p_n^2 - 4\omega_0^2}]$ of T corresponding to each root p_n of S. The residues of T are

$$T'(\hat{p}_n) = S'(p_n)\frac{\hat{p}_n^2 - \omega_0^2}{\hat{p}_n^2}$$

the last factor being the derivative $d\hat{p}_n/dp_n$. Combining the two terms corresponding to each term of the low-pass, one obtains the result

* This article is itself an abstract of a report issued by Combined Intelligence Objectives Sub-Committee.—ED.

$$V(t) = \tfrac{1}{2}\cos\omega_0 t + \sum A_n \exp(\tfrac{1}{2}p_n t)$$
$$\left[\tfrac{1}{2}\left(1 + \frac{p_n}{\sqrt{p_n^2 - 4\omega_0^2}}\right)\exp\left[\tfrac{1}{2}t\sqrt{p_n^2 - 4\omega_0^2}\right]\right.$$
$$+ \tfrac{1}{2}\left(1 - \frac{p_n}{\sqrt{p_n^2 - 4\omega_0^2}}\right)$$
$$\left.\exp\left[-\tfrac{1}{2}t\sqrt{p_n^2 - 4\omega_0^2}\right]\right] \quad \ldots \quad (5)$$

Thus, if the low-pass transient is given by (2) the band-pass transient can immediately be calculated by (5). But, since in the general case the p_n's are complex, the separation of the real and the imaginary parts of the square roots, necessary to write (5) in a manageable form, will involve double radicals. Even for the single-section filter considered by Tucker, the final formulae are prohibitively cumbersome.

If all the zeros p_n of the low-pass function can be neglected as compared with $2\omega_0$, the expression between brackets is reduced to $\tfrac{1}{2}(e^{j\omega_0 t} + e^{-j\omega_0 t}) = \cos\omega_0 t$ and (5) becomes

$$V(t) = \cos\omega_0 t\left(\tfrac{1}{2} + \sum_n A_n e^{\frac{1}{2}p_n t}\right) = \cos\omega_0 t\, U\left(\frac{t}{2}\right) \quad \ldots \quad (6)$$

In this case the envelope of $V(t)$ is actually the low-pass transient as given by (2). Since the roots p_n of the low-pass are proportional to its cut-off frequency ω_1 and usually such that the values of p_n are not very different from ω_1 [for instance in the case of a single section filter $p_1 = -\omega_1/m$; $p_{2,3} = \tfrac{1}{2}\omega_1(-m \pm j\sqrt{4 - m^2})$]; the validity of (6) requires $\omega_0 \gg \omega_1$. Since the transformation (3) preserves the absolute bandwidth, this is equivalent to the condition of a narrow band.

Attention should be paid to the replacement of t by $\tfrac{1}{2}t$ in the envelope. This shows that the time of subsidence of the transients is twice as large in a narrow band-pass as in a low-pass having the same absolute bandwidth.

Referring to C. C. Eaglesfield's remark[1] on the discrepancy between his correct theoretical result and the experiments of D. G. Tucker[2], it should be pointed out that "physical instinct" can be deceptive for narrow band-pass filters. A band-filter with $n = 0.037$ and $Q = 100$ is the analogue of a low-pass having a Q of $\tfrac{1}{2}\,100 \times 0.037 = 1.85$.

V. BELEVITCH, Dr.-Ing.

Brussels.

[1] *Wireless Engineer*, November, 1946, p. 306.
[2] *Wireless Engineer*, March, 1946, p. 84.

To the Editor, "Wireless Engineer"

SIR,—The letter of E. T. Emms in the January issue seems to clear up an interesting problem. It only needs the working out from first principles of a simple example, however, to show that the statement "if the wave $\cos\omega_0 t$. **1** is put into a band-pass network then the envelope of the output wave is exactly the same as the output wave obtained when unit step is placed into the low-pass analogue" is not true.

Take for example a low-pass system of bandwidth ω_1, whose unit-step response is $1 - e^{-\omega_1 t}$. The corresponding Laplace transform is $\omega_1/(p + \omega_1)$. Hence the Laplace transform of the band-pass analogue, with applied function $\cos\omega_0 t$. **1**, is:

$$\frac{\omega_1 p}{p^2 + \omega_1 p + \omega_0^2} \cdot \frac{p^2}{p^2 + \omega_0^2}.$$

This may be interpreted by routine methods to give the corresponding unit-step response:

$$\cos\omega_0 t - \frac{e^{-\frac{1}{2}\omega_1 t}}{\sqrt{(1 - \omega_1^2/4\omega_0^2)}} \times \cos\left[\omega_0 t\sqrt{(1 - \omega_1^2/4\omega_0^2)} + \tan^{-1}[\omega/\{2\omega_0\sqrt{(1 - \omega_1^2/4\omega_0^2)}\}]\right].$$

There are two remarks to be made about this expression: first, and mainly, it does not represent a wave whose envelope is $1 - e^{-\omega_1 t}$; if $\omega_1^2/4\omega_0^2$ can be neglected, then we do get a simple envelope, namely $1 - e^{-\frac{1}{2}\omega_1 t}$. This brings us to the second point; in order to get the band-pass analogue from the transient point of view, of a low-pass system, we must not only replace ω by $\omega(1 - \omega_0^2/\omega^2)$ but we must also double the bandwidth. There is of course nothing new in this; an example will be found in "Communication Networks, Vol. II Chap. XI, by E. A. Guillemin. In this connection, I disagree with E. T. Emms' result for the unit-step response of the low-pass filter. In his expression, $\tfrac{1}{2}\omega_1$ should be replaced by ω_1.

Now look at the matter from the Fourier Integral point of view. If $g(\omega)$ is the amplitude spectrum of a time-function $f(t)$, then the amplitude spectrum of $f(t)\cos\omega_0 t$ is, as is well known,

$$\tfrac{1}{2}\{g(\omega - \omega_0) + g(\omega + \omega_0)\}.$$

Emms' statement is thus equivalent to the statement that

$$g(\omega - \omega_0^2/\omega) = \tfrac{1}{2}\{g(\omega - \omega_0) + g(\omega + \omega_0)\},$$

which, if true, is certainly not obvious. It is not, in fact, true in general; it is not true, in particular, for the function $\omega_1/2\pi j\omega(j\omega + \omega_1)$ which is the appropriate function in the example above. E. T. Emms has in effect shown that it is true for the function $1/2\pi j\omega$. But to draw from this fact the conclusion that it is true for all functions is not justified.

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Wembley, Middx.

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Use of Analogies

To the Editor, "Wireless Engineer"

SIR,—With reference to Dr. Howe's Editorial on the use of analogies (Jan., 1947), it is evident that this practice has previously come under suspicion.

Over a hundred years ago, Gay-Lussac was prompted to make use of strained analogies between hydrogen compounds and alkalis.

Criticising these, Humphry Davy remarked:—

"The substitution of analogy for fact is the bane of chemical philosophy; the legitimate use of analogy is to connect facts together, and to guide to new experiments."

These words are as true to-day as they were a century ago.

F. BUTLER.

Putney, S.W.15.

WIRELESS PATENTS

A Summary of Recently Accepted Specifications

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

DIRECTIONAL AND NAVIGATIONAL SYSTEMS

578 094.—Blind-landing system in which spaced receivers on the ground analyse signals sent from the aircraft; or in which a receiver on the craft indicates the phase-difference between two ground transmitters.

The General Electric Co. Ltd. and D. C. Espley. Application date 26th May, 1943.

578 275.—Radiolocation equipment, carried by an aircraft, and utilized either to locate and pursue an enemy craft, or to home on to a landing ground.

Standard Telephones and Cables, Ltd. (communicated by International Standard Electric Corporation). Application date 4th June, 1943.

578 301.—D.F. installation for indicating simultaneously the location of all transmitters operating within a wide band of frequencies, and for selecting a particular station on which to take bearings.

Standard Telephones and Cables, Ltd. (communicated by International Standard Electric Corporation). Application date 31st July, 1942.

578 302.—The use of a superposed frequency-modulation to prevent distortion, due to undesired reflection, in a course-indicator of the overlapping-beam type.

Standard Telephones and Cables, Ltd., and H. P. Williams. Application date 31st July, 1942.

578 406.—Method of modulation-control, particularly applicable to altimeters and radiolocation equipment using a frequency-modulated carrier.

H. F. Rost, K. H. Thunell, S. D. Vigren and P. H. E. Claesson. Application date 24th November, 1942.

RECEIVING CIRCUITS AND APPARATUS

577 817.—D.C. generator, fitted with an auxiliary a.c. slip-ring and rectifier circuit, for supplying all the required operating-voltages to a cathode-ray tube.

A. D. Blumlein and E. A. Nind. Application date 13th October, 1939.

578 013.—Preparation of the silicon element in a low-capacitance catswhisker combination for rectifying very high frequencies.

The General Electric Co. Ltd. and C. E. Ransley. Application date 22nd March, 1943.

578 114.—Application of a phase-shifting or time-delay device to eliminate residual noise in a receiver fitted with certain known types of a.v.c. or a.t.c.

Standard Telephones and Cables, Ltd. (assignees of C. B. H. Feldman). Convention date (U.S.A.) 28th December, 1939.

578 116.—Composition and processing of the silicon element in a catswhisker combination for rectifying very short waves.

The General Electric Co. Ltd., D. E. Jones, C. E. Ransley, J. W. Ryde and S. V. Williams. Application date 18th July, 1941.

578 201.—Device for limiting the power consumed by a police-car or like receiver which is normally kept for long periods under "stand-by" conditions.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.) 22nd January, 1943.

TELEVISION CIRCUITS AND APPARATUS
For Transmission and Reception

578 092.—Coloured-television system in which the colour filter for the photo-sensitive screen is vibrated in synchronism with the frame-scanning voltage.

Farnsworth Television and Radio Corporation. Convention date (U.S.A.) 14th April, 1942.

578 108.—Colour-filter designed to facilitate the viewing of monochromatic television pictures in daylight, or under bright artificial lighting.

J. L. Baird. Application date 25th April, 1944.

578 423.—Colour-television system of the kind in which the transparency of a sensitive surface is controlled by a modulated beam of electrons, and in which the picture is projected on to an external viewing-screen.

Scophony Ltd. and G. Wikkenhauser. Application date 1st May, 1944.

TRANSMITTING CIRCUITS AND APPARATUS
See also under Television

577 842.—Wave-guide comprising a circular section, with rectangular input and output sections, for securing polarization effects.

Western Electric Co. Inc. Convention date (U.S.A.) 23rd December, 1942.

577 942.—Delay-network for generating substantially flat-topped pulses, which do not cause modulation-drift, when fed to a magnetron oscillator.

D. Blumlein (legal representative of A. D. Blumlein) Application date 28th October, 1941.

578 088.—Push-pull short-wave oscillator coupled to a hollow resonator or tank circuit through a link which automatically inhibits undesired or parasitic frequencies.

The General Electric Co. Ltd. and D. C. Espley. Application date 20th May, 1943.

578 151.—Oscillation-generator, with a two-stage crystal-control and heterodyne circuits, for transmitting signals on any selected one of a number of carrier-frequencies.

Hazeltine Corporation (assignees of D. E. Harnett). Convention date (U.S.A.) 30th September, 1940.

578 416.—Scanning and synchronizing system for transmitting and receiving pictures and messages in facsimile.

Creed & Co. Ltd. (assignees of S. Khalil). Convention date (U.S.A.) 29th January, 1943.

578 419.—Frequency-stabilizing device, particularly for a short-wave transmitter, in which the control voltage is developed by two velocity-modulating tubes arranged in opposition (divided from 578 406).

H. F. Rost, K. H. Thunell, S. D. Vigren and P. H. E. Claesson. Application date 24th November, 1942.

578 432.—Metering device for monitoring the performance of a valve-oscillator for generating frequency-modulated signals.

Marconi Instruments Ltd. and C. F. Brocklesby. Application date 27th July, 1944.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

578 117.—Arrangement and mounting of the "gun" structure of a short-wave oscillator wherein the electron stream is projected through a resonator.

E. K. Cole Ltd. and F. W. O. Kennedy. Application date 5th November, 1941.

578 270.—Velocity-modulating tube, comprising two or more resonators, arranged in series and tuned to harmonic frequencies, for use as a frequency-doubler.

Standard Telephones and Cables, Ltd. (communicated by International Telephone Development Co. Inc.). Application date 10th April, 1942.

578 271.—Oscillation-generator in which an electron beam is first "bunched" and is then "multiplied" by passing through a series of secondary-emission electrodes.

Standard Telephones and Cables, Ltd. (assignees of R. V. L. Hartley and C. V. Parker). Application date 30th April, 1942.

578 582.—C. R. tube fitted with a fluorescent screen having two superposed coatings, one giving a quick response, the other a more lasting after-glow.

A. C. Cossor Ltd., F. M. Walker and E. E. Shelton. Application date 13th July, 1939.

578 586.—Velocity-modulating tube in which the electron-stream is fed to the resonator through an open-ended length of a waveguide of restricted cross-section.

Standard Telephones and Cables Ltd. (Assignees of W. Shockley). Convention date (U.S.A.) 11th July, 1941.

578 587.—Velocity-modulating tube in which the final collector or anode is coated and designed to minimize undesirable secondary-emission.

Westinghouse Electrical International Co. Convention date (U.S.A.) 13th August, 1941.

578 588.—Velocity-modulating tube wherein the electron-stream is forced to pass from the "buncher" to the "catcher" resonator in a curved path so as to minimize space-charge effects.

Westinghouse Electric International Co. Convention date (U.S.A.) 20th August, 1941.

578 618.—Method of welding the resonator electrodes to the main walls of an electron-discharge tube of the velocity-modulating type.

The M-O Valve Co. Ltd., N. L. Harris and J. W. Ryde. Application dates 18th April and 31st May, 1940.

578 619.—Welding the resonators to the walls of a velocity-modulating tube in which the spacing or tuning of the elements can be adjusted (divided out of 578 618).

The M-O Valve Co. Ltd., N. L. Harris and J. W. Ryde. Application date 18th April, 1940.

578 620.—Velocity-modulating tube which is designed (a) to be free from critical spacings affecting the frequency, and (b) to employ secondary emission to increase the gain.

Standard Telephones and Cables Ltd., (assignees of W. McH. Goodall) Convention date (U.S.A.) 7th January, 1941.

SUBSIDIARY APPARATUS AND MATERIALS

577 953.—Variable control-network for stabilizing the operation of a high-frequency oscillator when used, say, for diathermy, or for spot-welding plywood.

The General Electric Co. Ltd. and L. C. Stenning. Application date 23rd October, 1942.

578 113.—Photo-electric cell in which secondary emission from the anode is utilized to ensure a predetermined voltage-response to a sudden small change of illumination.

J. D. McGee, L. Klatzow and R. E. Spencer. Application date 8th August, 1940.

578 129.—Multivibrator circuit arranged to generate short pulses (a) without the use of a delay circuit, or (b) independently of the duration of a saw-toothed triggering-voltage.

F. W. Cutts. Application date 31st January, 1944.

578 135.—Saw-tooth oscillation-generator wherein a point in the anode circuit, say of a pentode, is connected through a differentiating network to a point of fixed potential, the input voltage being derived from the said network.

A. C. Cossor Ltd. and B. C. Fleming-Williams. Application date 19th April, 1944.

578 290.—Stabilizing the operation of a crystal-oscillator when carried by V-shaped wire mountings.

The General Electric Co. Ltd., L. A. Thomas and A. H. Morser. Application date 20th October, 1944.

578 407.—Inverter circuit, comprising a saturated inductance for generating a.c. of constant magnitude from a variable source of d.c.

Electronic Laboratories Inc. Convention date (U.S.A.) 8th May, 1942.

578 456.—Valveholder comprising means for supporting a screening-can.

Carr Fastener Co. Ltd. and G. Wagstaff. Application date 27th April, 1944.

578 461.—Valve installation for generating a readily-adjustable polyphase supply, suitable for testing and research purposes, each oscillator-stage being coupled to a power-stage of the cathode-follower type.

Westinghouse Brake and Signal Co. Ltd. and A. H. B. Walker. Application date 23rd May, 1944.

578 487.—Construction and terminal connections for an electrolytic capacitor comprising interleaved sheets of metal-foil.

P. A. Sporing and The Telegraph Condenser Co. Ltd. Application date 27th March, 1944.

578 729.—Sound-ranging equipment comprising phase and amplitude control networks feeding a cathode-ray tube which gives a direct indication of the direction of the source of sound.

G. E. Condliffe and H. A. M. Clark. Application dates 3rd and 15th June, 19th July, and 10th September, 1938.

ABSTRACTS AND REFERENCES

Compiled by the Radio Research Board and published by arrangement with the Department of Scientific and Industrial Research

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. The abbreviations of the titles of journals are taken from the World List of Scientific Periodicals. Titles that do not appear in this List are abbreviated in a style conforming to the World List practice.

ACOUSTICS AND AUDIO FREQUENCIES

534.222.1 : 538.566.2 **611**

Propagation of Radiation in a Medium with Random Inhomogeneities.—Bergmann. (*See* 847.)

534.32 : 621.396.722 **612**

Tonal-Range and Sound-Intensity Preferences of Broadcast Listeners.—H. A. Chinn & P. Eisenberg. (*Proc. Inst. Radio Engrs, W. & E.*, Oct. 1946, Vol. 34, No. 10, pp. 757–761.) Discussion of 3567 of 1945.

534.43 : 621.395.613.32 **613**

Phonograph Pickup using Strain Gage.—K. J. Germeshausen & R. S. John. (*Electronic Industr.*, Nov. 1946, Vol. 5, No. 11, pp. 78–79 . . 120.) This uses the change in resistance of a carbon layer, which is elongated or compressed by the moving stylus. It is a simple, rugged device giving good performance.

534.75 **614**

The Threshold of Audition for Short Periods of Stimulation.—J. W. Hughes. (*Proc. roy. Soc. B*, Dec. 1946, Vol. 133, No. 873, pp. 486–490.) The threshold of audition rises as the period of stimulation is decreased. The relationship between these two quantities is similar to that found for other sensory mechanisms.

534.851.001.4 **615**

Disc Recording.—H. A. Chinn. (*Electronic Industr.*, Nov. 1946, Vol. 5, No. 11, pp. 64, 66.) Stresses the need for standard groove shape and for far wider co-operation between the makers of records and of reproducers.

534.851.6 **616**

Recording Styli.—I. L. Capps. (*Electronic Industr.*, Nov. 1946, Vol. 5, No. 11, pp. 65, 67 . . 110.) Discusses the effect of stylus contour, cutting edge and burnishing facet in lacquer-disk recording.

621.395.623.73 : 534.415 **617**

Stroboscopic Study of Loud-Speaker Membranes.—J. Fasal. (*Toute la Radio*, July/Aug. 1946, Vol. 13, No. 107, pp. 178–181.) An account of basic principles of the stroboscope and their special application to the study of the vibrations of loudspeaker membranes.

621.395.625 : 621.395.645 **618**

40-Watt Beam-Power Amplifier for Disc Recording.—J. K. Hilliard. (*Communications*, Nov. 1946, Vol. 26, No. 11, pp. 22–24.) The response of the input is pre-equalized so that the highest frequencies recorded are emphasized greatly, and the amplifier is designed to maintain rated output up to these frequencies.

621.395.625.3 **619**

Signal and Noise Levels in Magnetic Tape Recording.—D. E. Wooldridge. (*Trans. Amer. Inst. elect. Engrs*, June Supplement 1946, Vol. 65, p. 495.) Discussion of 2804 of 1946.

621.395.625.3 **620**

A New Wire Recorder Head Design.—T. H. Long. (*Trans. Amer. Inst. elect. Engrs*, June Supplement 1946, Vol. 65, pp. 495–497.) Discussion of 2127 of 1946.

621.395.667 **621**

Wide Range Tone Control.—J. M. Hill. (*Wireless World*, Dec. 1946, Vol. 52, No. 12, pp. 422–423.) Description and diagram of a circuit suitable for tone correction at low volume levels.

621.396.615.029.3 **622**

Low Cost Audio Oscillator.—R. W. Ehrlich. (*Radio News*, Nov. 1946, Vol. 36, No. 5, pp. 50–51 . . 110.) Resistance-tuned. 100 to 25 000 c/s.

621.396.645.36.029.3 **623**

Class B Audio-Frequency Amplifiers.—F. Butler. (*Wireless Engr*, Jan. 1947, Vol. 24, No. 280, pp. 14–19.) The distortion introduced by the variable grid input impedance into a conventionally connected Class B amplifier is considered. By earthing the grid and injecting at the cathode, a very low but comparatively constant input impedance is achieved. Although considerable excitation power is required, " a large proportion of this appears as useful output." The design of a practical push-pull amplifier using cathode injection is outlined.

AERIALS AND TRANSMISSION LINES

621.314.214 **624**

A Tuned-Line Matching Transformer.—T. A. Gadwa. (*QST*, Jan. 1947, Vol. 31, No. 1, pp. 36–38.) Matching of an open-wire line to a close-spaced beam aerial, or other low impedance, is effected by means of an adjustable capacitor in combination with short parallel lines for the inductance elements. Adjustment procedure is described.

621.315.1.015.3 + 621.316.98 **625**

Study of Transient Voltages on Lines struck by Lightning. Protection by Lightning Arresters.—G. Bodier. (*Rev. gén. Élect.*, May 1946, Vol. 55, No. 5, pp. 199–215.)

621.315.2 : 621.317.372 **626**

End Leakage in Cable Power-Factor Measurement.—Rosen. (*See* 795.)

621.315.2.015.532 **627**

Detecting Corona in Cables.—W. J. King. (*Bell Lab. Rec.*, Nov. 1946, Vol. 24, No. 11, pp. 413–415.) As it forms, usually in air pockets between the conductor and its shield, corona produces an electrical disturbance which can be detected and amplified by the test equipment. Tests at reduced pressure are included for cables to be used at high altitudes in aircraft.

621.315.21 **628**

Propagation along a Cable having Resistance and Capacitance only, these Parameters being Functions of Position and satisfying Certain Relations.—M. Parodi. (*C.R. Acad. Sci., Paris*, 3rd Sept. 1945, Vol. 221, No. 10, pp. 257–259.) By means of the Laplace transformation an expression is derived for the voltage distribution along the line from which the current can be calculated. A similar method is applicable to a line having only inductance and capacitance.

621.315[.211.2 + .22 **629**

Mineral-Insulated Metal-Sheathed Conductors.—F. W. Tomlinson & H. M. Wright. (*J. Instn elect. Engrs*, Part I, Nov. 1946, Vol. 93, No. 71, pp. 561–562.) Summary of 12 of January.

621.319.7 : 621.392 **630**

Some Applications of Field Plotting.—E. O. Willoughby. (*J. Instn elect. Engrs*, Part I, Nov. 1946, Vol. 93, No. 71, pp. 543–545.) Summary of 2814 of 1946.

621.392 + 621.316.35.011.3 **631**

Formulas for the Inductance of Coaxial Busses comprised of Square Tubular Conductors.—H. P. Messinger & T. J. Higgins. (*Trans. Amer. Inst. elect. Engrs*, June Supplement 1946, Vol. 65, p. 501.) Discussion of 2815 of 1946.

621.392 : 621.317.784 **632**

A Wide-Band Wattmeter for Wave Guide.—Early. (*See* 813.)

621.392 : 621.397.62 **633**

The Choice of Transmission Lines for connecting Television Receiving Aerials to Receivers.—F. R. W. Strafford. (*Tech. Bull. Radio Component Mfrs' Fed.*, Nov. 1946, Vol. 1, No. 2, pp. 3–5.) Various possible types of transmission line are considered; the twin unscreened feeder with a pair of ' Fahnstock ' terminal plugs is likely to be the most satisfactory for simple domestic television aerial installations.

621.392.012.8 **634**

The Equivalent Circuit for a Plane Discontinuity in a Cylindrical Wave Guide.—J. W. Miles. (*Proc. Inst. Radio Engrs, W. & E.*, Oct. 1946, Vol. 34, No. 10, pp. 728–742.) Equivalent circuits representing a plane discontinuity consisting of a junction between two waveguides of arbitrary cross-section are given and the values of the equivalent impedances enumerated.

It is shown that in general the equivalent circuit takes the form of a T-network, but that in many cases it reduces to an ideal transformer plus a shunt element. For discontinuities such as slots in guide walls it is shown that an equivalent π-network is a better representation.

The theory is applied to a transverse wire, capacitive and inductive windows, and capacitive and inductive cross-sections in a rectangular guide, and approximate expressions for the impedances are deduced.

621.392.21 **635**

Propagation along any Line whose Parameters, Functions of Space, satisfy at All Points a Condition Analogous to that of Non-Distortion.—M. Parodi. (*Rev. gén. Élect.*, Oct. 1946, Vol. 55, No. 10, pp. 414–415.) Extends the results of 550 of 1946 (Colombo & Parodi).

621.396.67 **636**

A Folded Unipole Antenna for Emergency Communications.—J. S. Brown. (*Communications*, Nov. 1946, Vol. 26, No. 11, pp. 18–20.) A quarter-wave system using vertical polarization and having broad-band impedance characteristics with omni-directional horizontal radiation pattern. Graphs are given for standing-wave ratio and aerial impedance over the frequency range 30–44 Mc/s.

621.396.67 : 621.396.712 **637**

Postwar Broadcast Antenna Installation.—D. W. Jefferies. (*Communications*, Nov. 1946, Vol. 26, No. 11, pp. 11–13, 34.) Description of the construction and erection of a $\lambda/4$ self-supporting steel radiator for 1 450 kc/s using a 48 ft × 48 ft square mesh mat with 90 radial wires each $\lambda/4$ long. Arrangements are described for obstruction lighting; and for a.f. monitoring using germanium crystal rectifiers.

621.396.67.029.56/.58 **638**

A Unique Five-Band Antenna System.—J. A. McCullough. (*QST*, Dec. 1946, Vol. 30, No. 12, pp. 29–31 . . 136.) Describes a novel means of using combinations of the supporting tower and four parallel dipoles (rotary) to cover all bands from 3.5 to 28 Mc/s.

621.396.67.029.58 **639**

10-Meter Vertical Coaxial Antenna.—C. V. Hays. (*Radio News*, Nov. 1946, Vol. 36, No. 5, pp. 88 . . 92.) Constructional details.

621.396.67.029.58 **640**

A Simple Rotatable Antenna for Two Bands.—R. J. Long. (*QST*, Jan. 1947, Vol. 31, No. 1, pp. 22–24.) A two-element array for 14 and 28 Mc/s.

21.396.67.029.64 : 621.396.931 641
V.H.F. Antenna for Trains.—E. G. Hills. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 134–136.) A top-loaded, folded, vertically-polarized, monopole aerial (for 160 Mc/s) concentrates radiation close to the ground in an omni-directional pattern. The aerial is only five inches high, mechanically rugged, and has an input impedance of 50 Ω. Design techniques are described.

21.396.671 : 621.396.822 642
Study of the Thermal Equilibrium of Wireless Aerials.—G. Lehmann. (*Ann. Télécommun.*, May/June 1946, Vol. 1, Nos. 5/6, pp. 91–98.) The black-body radiation law is used to determine the intensity of the r.f. noise field in a uniform temperature enclosure. The noise e.m.f. induced in a dipole corresponds to the value given by applying Nyquist's formula to the radiation resistance. The identity of the polar diagrams of any aerial for reception and for transmission is established. In practice extraterrestrial noise (from the galaxy and the sun) leads to relatively high aerial noise temperatures at metre wavelengths. The relations between the aperture, the beam width and the gain of a directive aerial are deduced. The paper was first published in September 1942 in *Cahiers de Physique*. See also 2122 of 1941 and 2699 of 1946 (Burgess).

1.396.677 643
A High-Gain Two-Meter Rotary Beam.—J. A. Mosko. (*QST*, Nov. 1946, Vol. 30, No. 11, pp. 45–47.) A six-element broadside parasitic array with coaxial feed, which has a forward gain of 12 db, a front-to-back ratio of 36 db and a beam width of ± 10° for half power.

.396.677 644
Directional Patterns of Rhombic Antennae.—N. Christiansen. (*A.W.A. tech. Rev.*, Sept. 1946, Vol. 7, No. 1, pp. 33–51.) "Spatial directional patterns of typical rhombic antennae are given. It is shown that a design which involves the application of the simple 'alignment' relation at the geometric mean of the frequency range is much inferior at the higher frequencies to one in which a larger aperture has been used to obtain higher output at this mean frequency.

A comparison with the pattern of a large tuned array shows the inferiority of a single rhombic antenna. Many of the prominent minor lobes seen in the directional pattern of the latter may be suppressed by the use of several rhombics in the form of an array. Various simple designs are discussed and it is shown possible, particularly when the rhombics are arranged in an interlaced 'end-fire' array, to produce over the whole working range of the rhombic, a directional pattern which compares well with that of a large tuned array at its designed frequency."

396.677.2 645
Five are Better than Three. Some Experiences with a Five-Element Rotary.—W. W. Basden. (*QST*, Dec. 1946, Vol. 30, No. 12, pp. 32..138.) The five-element 28-Mc/s beam at W5CXS is different from the usual three-element beam in that director elements have been added 0.1 λ above and below the normal director. Delta-match feed is used and the line is tapped on the radiator inches each side of the centre.

621.396.679.4 646
Dipole with Unbalanced Feeder.—D. A. Bell. (*Wireless Engr*, Jan. 1947, Vol. 24, No. 280, pp. 3–5.) A short account of the effect of pick-up on the concentric downlead from a directly connected dipole receiving aerial. The equivalent circuit of such an aerial arrangement is discussed and the function of a quarter-wave balancing sleeve is considered. An example is given showing the distortion of the polar diagram of an array produced by feeder-lead pick-up.

621.396.931/.933].22.029.62 647
Radio Direction Finding at 1.67 Meter Wavelengths.—Yuan. (*See* 732.)

CIRCUITS AND CIRCUIT ELEMENTS

621.314.26 648
Mechanism of Frequency Changing.—L. Chrétien. (*Toute la Radio*, March/April & May 1946, Vol. 13, Nos. 104 & 105, pp. 76–78 & 104–106.) Criticizes existing theories of the behaviour of frequency changing circuits and puts forward a new theory based on the stroboscopic effect.

621.315.59 + 621.316.89 649
Properties and Uses of Thermistors — Thermally Sensitive Resistors.—Becker, Green & Pearson. (*See* 765.)

621.317.432 650
Energy dissipated by Eddy Currents in a Thin Ferromagnetic Disk Normal to the Field.—G. Ribaud. (*C. R. Acad. Sci., Paris*, 25th March 1946, Vol. 222, No. 13, pp. 726–727.) Formulae have previously been given (3811 of 1944) for the energy dissipated by eddy currents in a thin non-magnetic disk. The difference in the case of a magnetic material results essentially from magnetic charges on the faces of the disk which produce a uniform demagnetizing field, which is added to that due to the eddy currents. The ratio of the energy dissipated in a magnetic disk to that in a non-magnetic disk of the same resistivity, has a maximum value of $r/4\epsilon$ when $\mu = r^2/\epsilon^2$, μ being the permeability, ϵ the skin thickness and r the distance from the axis. The energy dissipation formulae given are only valid when the thickness of the disk is more than 2 or 3 times the skin thickness.

621.318.423.012.3 651
Mutual Inductance of Concentric Coils.—T. C. Blow. (*Electronics*, Nov. 1946, Vol. 19, No. 11, p. 138.) A nomogram for calculating mutual inductance between two concentric single-layer air-core solenoids with greater length than diameter.

621.318.7 652
Tchebycheff Polynomials and the Theory of Electric Filters.—A. Colombani. (*C. R. Acad. Sci., Paris*, 27th May 1946, Vol. 222, No. 22, pp. 1278–1280.) The successive intensities in a filter of n cells are shown to depend on polynomials which satisfy Tchebycheff's equation. The particular solution applicable to the filter enables a simple formula for the intensities to be derived.

621.319.4 653
Modern Capacitors.—R. Besson. (*Toute la Radio*, June 1946, Vol. 13, No. 106, pp. 139–142.) Discusses the temperature, loss and other characteristics of electrolytic capacitors, capacitors with

low but comparatively constant input impedance is achieved. Although considerable excitation power is required, "a large proportion of this appears as useful output." The design of a practical push-pull amplifier using cathode injection is outlined.

AERIALS AND TRANSMISSION LINES

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621.315.1.015.3 + 621.316.98 **625**

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621.315.2 : 621.317.372 **626**

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621.315.21 **628**

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621.315[.211.2 + .22 **629**

Mineral-Insulated Metal-Sheathed Conductors.—F. W. Tomlinson & H. M. Wright. (*J. Instn elect. Engrs*, Part I, Nov. 1946, Vol. 93, No. 71, pp. 561–562.) Summary of 12 of January.

621.319.7 : 621.392 **630**

Some Applications of Field Plotting.—E. O. Willoughby. (*J. Instn elect. Engrs*, Part I, Nov. 1946, Vol. 93, No. 71, pp. 543–545.) Summary of 2814 of 1946.

621.392 + 621.316.35.011.3 **631**

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621.392.012.8 **634**

The Equivalent Circuit for a Plane Discontinuity in a Cylindrical Wave Guide.—J. W. Miles. (*Proc. Inst. Radio Engrs, W. & E.*, Oct. 1946, Vol. 34, No. 10, pp. 728–742.) Equivalent circuits representing a plane discontinuity consisting of a junction between two waveguides of arbitrary cross-section are given and the values of the equivalent impedances enumerated.

It is shown that in general the equivalent circuit takes the form of a T-network, but that in many cases it reduces to an ideal transformer plus a shunt element. For discontinuities such as slots in guide walls it is shown that an equivalent π-network is a better representation.

The theory is applied to a transverse wire, capacitive and inductive windows, and capacitive and inductive cross-sections in a rectangular guide, and approximate expressions for the impedances are deduced.

621.392.21 **635**

Propagation along any Line whose Parameters, Functions of Space, satisfy at All Points a Condition Analogous to that of Non-Distortion.—M. Parodi. (*Rev. gén. Élect.*, Oct. 1946, Vol. 55, No. 10, pp. 414–415.) Extends the results of 550 of 1946 (Colombo & Parodi).

621.396.67 **636**

A Folded Unipole Antenna for Emergency Communications.—J. S. Brown. (*Communications*, Nov. 1946, Vol. 26, No. 11, pp. 18–20.) A quarter-wave system using vertical polarization and having broad-band impedance characteristics with omni-directional horizontal radiation pattern. Graphs are given for standing-wave ratio and aerial impedance over the frequency range 30–44 Mc/s.

621.396.67 : 621.396.712 **637**

Postwar Broadcast Antenna Installation.—D. W. Jefferies. (*Communications*, Nov. 1946, Vol. 26, No. 11, pp. 11–13, 34.) Description of the construction and erection of a $\lambda/4$ self-supporting steel radiator for 1 450 kc/s using a 48 ft × 48 ft square mesh mat with 90 radial wires each $\lambda/4$ long. Arrangements are described for obstruction lighting; and for a.f. monitoring using germanium crystal rectifiers.

621.396.67.029.56/.58 **638**

A Unique Five-Band Antenna System.—J. A. McCullough. (*QST*, Dec. 1946, Vol. 30, No. 12, pp. 29–31 . . 136.) Describes a novel means of using combinations of the supporting tower and four parallel dipoles (rotary) to cover all bands from 3.5 to 28 Mc/s.

621.396.67.029.58 **639**

10-Meter Vertical Coaxial Antenna.—C. V. Hays. (*Radio News*, Nov. 1946, Vol. 36, No. 5, pp. 88 . . 92.) Constructional details.

621.396.67.029.58 **640**

A Simple Rotatable Antenna for Two Bands.—R. J. Long. (*QST*, Jan. 1947, Vol. 31, No. 1, pp. 22–24.) A two-element array for 14 and 28 Mc/s.

21.396.67.029.64 : 621.396.931 641

V.H.F. Antenna for Trains.—E. G. Hills. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 134–136.) top-loaded, folded, vertically-polarized, monopole erial (for 160 Mc/s) concentrates radiation close the ground in an omni-directional pattern. The erial is only five inches high, mechanically rugged, nd has an input impedance of 50 Ω. Design chniques are described.

1.396.671 : 621.396.822 642

Study of the Thermal Equilibrium of Wireless erials.—G. Lehmann. (*Ann. Télécommun.*, May/ ne 1946, Vol. 1, Nos. 5/6, pp. 91–98.) The black- dy radiation law is used to determine the ensity of the r.f. noise field in a uniform tempera- re enclosure. The noise e.m.f. induced in a pole corresponds to the value given by applying yquist's formula to the radiation resistance. e identity of the polar diagrams of any aerial reception and for transmission is established. practice extraterrestrial noise (from the galaxy d the sun) leads to relatively high aerial noise nperatures at metre wavelengths. The relations ween the aperture, the beam width and the gain a directive aerial are deduced. The paper was t published in September 1942 in *Cahiers de ysique*. See also 2122 of 1941 and 2699 of 1946 argess).

.396.677 643

High-Gain Two-Meter Rotary Beam.—J. A. tosko. (*QST*, Nov. 1946, Vol. 30, No. 11, 45–47.) A six-element broadside parasitic ty with coaxial feed, which has a forward gain 2 db, a front-to-back ratio of 36 db and a beam th of ± 10° for half power.

.396.677 644

irectional Patterns of Rhombic Antennae.— N. Christiansen. (*A.W.A. tech. Rev.*, Sept. 6, Vol. 7, No. 1, pp. 33–51.) "Spatial directional erns of typical rhombic antennae are given. shown that a design which involves the appli- on of the simple 'alignment' relation at the metric mean of the frequency range is much rior at the higher frequencies to one in which a r aperture has been used to obtain higher out at this mean frequency.

A comparison with the pattern of a large tuned y shows the inferiority of a single rhombic nna. Many of the prominent minor lobes seen he directional pattern of the latter may be ressed by the use of several rhombics in the form n array. Various simple designs are discussed it is shown possible, particularly when the nbics are arranged in an interlaced 'end-fire' y, to produce over the whole working range of rhombic, a directional pattern which compares with that of a large tuned array at its designed uency."

96.677.2 645

e are Better than Three. Some Experiences a Five-Element Rotary.—W. W. Basden. , Dec. 1946, Vol. 30, No. 12, pp. 32..138.) five-element 28-Mc/s beam at W5CXS is ent from the usual three-element beam in director elements have been added 0.1 λ above below the normal director. Delta-match feed used and the line is tapped on the radiator ches each side of the centre.

621.396.679.4 646

Dipole with Unbalanced Feeder.—D. A. Bell. (*Wireless Engr*, Jan. 1947, Vol. 24, No. 280, pp. 3–5.) A short account of the effect of pick-up on the concentric downlead from a directly connected dipole receiving aerial. The equivalent circuit of such an aerial arrangement is discussed and the function of a quarter-wave balancing sleeve is considered. An example is given showing the distortion of the polar diagram of an array produced by feeder-lead pick-up.

621.396.931/.933].22.029.62 647

Radio Direction Finding at 1.67 Meter Wavelengths.—Yuan. (*See* 732.)

CIRCUITS AND CIRCUIT ELEMENTS

621.314.26 648

Mechanism of Frequency Changing.—L. Chrétien. (*Toute la Radio*, March/April & May 1946, Vol. 13, Nos. 104 & 105, pp. 76–78 & 104–106.) Criticizes existing theories of the behaviour of frequency changing circuits and puts forward a new theory based on the stroboscopic effect.

621.315.59 + 621.316.89 649

Properties and Uses of Thermistors — Thermally Sensitive Resistors.—Becker, Green & Pearson. (*See* 765.)

621.317.432 650

Energy dissipated by Eddy Currents in a Thin Ferromagnetic Disk Normal to the Field.—G. Ribaud. (*C. R. Acad. Sci., Paris*, 25th March 1946, Vol. 222, No. 13, pp. 726–727.) Formulae have previously been given (3811 of 1944) for the energy dissipated by eddy currents in a thin non-magnetic disk. The difference in the case of a magnetic material results essentially from magnetic charges on the faces of the disk which produce a uniform demagnetizing field, which is added to that due to the eddy currents. The ratio of the energy dissipated in a magnetic disk to that in a non-magnetic disk of the same resistivity, has a maximum value of $r/4\epsilon$ when $\mu = r^2/\epsilon^2$, μ being the permeability, ϵ the skin thickness and r the distance from the axis. The energy dissipation formulae given are only valid when the thickness of the disk is more than 2 or 3 times the skin thickness.

621.318.423.012.3 651

Mutual Inductance of Concentric Coils.—T. C. Blow. (*Electronics*, Nov. 1946, Vol. 19, No. 11, p. 138.) A nomogram for calculating mutual inductance between two concentric single-layer air-core solenoids with greater length than diameter.

621.318.7 652

Tchebycheff Polynomials and the Theory of Electric Filters.—A. Colombani. (*C. R. Acad. Sci., Paris*, 27th May 1946, Vol. 222, No. 22, pp. 1278–1280.) The successive intensities in a filter of n cells are shown to depend on polynomials which satisfy Tchebycheff's equation. The particular solution applicable to the filter enables a simple formula for the intensities to be derived.

621.319.4 653

Modern Capacitors.—R. Besson. (*Toute la Radio*, June 1946, Vol. 13, No. 106, pp. 139–142.) Discusses the temperature, loss and other characteristics of electrolytic capacitors, capacitors with

low but comparatively constant input impedance is achieved. Although considerable excitation power is required, "a large proportion of this appears as useful output." The design of a practical push-pull amplifier using cathode injection is outlined.

AERIALS AND TRANSMISSION LINES

621.314.214 **624**

A Tuned-Line Matching Transformer.—T. A. Gadwa. (*QST*, Jan. 1947, Vol. 31, No. 1, pp. 36–38.) Matching of an open-wire line to a close-spaced beam aerial, or other low impedance, is effected by means of an adjustable capacitor in combination with short parallel lines for the inductance elements. Adjustment procedure is described.

621.315.1.015.3 + 621.316.98 **625**

Study of Transient Voltages on Lines struck by Lightning. Protection by Lightning Arresters.—G. Bodier. (*Rev. gén. Élect.*, May 1946, Vol. 55, No. 5, pp. 199–215.)

621.315.2 : 621.317.372 **626**

End Leakage in Cable Power-Factor Measurement.—Rosen. (*See* 795.)

621.315.2.015.532 **627**

Detecting Corona in Cables.—W. J. King. (*Bell Lab. Rec.*, Nov. 1946, Vol. 24, No. 11, pp. 413–415.) As it forms, usually in air pockets between the conductor and its shield, corona produces an electrical disturbance which can be detected and amplified by the test equipment. Tests at reduced pressure are included for cables to be used at high altitudes in aircraft.

621.315.21 **628**

Propagation along a Cable having Resistance and Capacitance only, these Parameters being Functions of Position and satisfying Certain Relations.—M. Parodi. (*C.R. Acad. Sci., Paris*, 3rd Sept. 1945, Vol. 221, No. 10, pp. 257–259.) By means of the Laplace transformation an expression is derived for the voltage distribution along the line from which the current can be calculated. A similar method is applicable to a line having only inductance and capacitance.

621.315[.211.2 + .22 **629**

Mineral-Insulated Metal-Sheathed Conductors.—F. W. Tomlinson & H. M. Wright. (*J. Instn elect. Engrs*, Part I, Nov. 1946, Vol. 93, No. 71, pp. 561–562.) Summary of 12 of January.

621.319.7 : 621.392 **630**

Some Applications of Field Plotting.—E. O. Willoughby. (*J. Instn elect. Engrs*, Part I, Nov. 1946, Vol. 93, No. 71, pp. 543–545.) Summary of 2814 of 1946.

621.392 + 621.316.35.011.3 **631**

Formulas for the Inductance of Coaxial Busses comprised of Square Tubular Conductors.—H. P. Messinger & T. J. Higgins. (*Trans. Amer. Inst. elect. Engrs*, June Supplement 1946, Vol. 65, p. 501.) Discussion of 2815 of 1946.

621.392 : 621.317.784 **632**

A Wide-Band Wattmeter for Wave Guide.—Early. (*See* 813.)

621.392 : 621.397.62 **633**

The Choice of Transmission Lines for connecting Television Receiving Aerials to Receivers.—F. R. W. Strafford. (*Tech. Bull. Radio Component Mfrs' Fed.*, Nov. 1946, Vol. 1, No. 2, pp. 3–5.) Various possible types of transmission line are considered; the twin unscreened feeder with a pair of 'Fahnstock' terminal plugs is likely to be the most satisfactory for simple domestic television aerial installations.

621.392.012.8 **634**

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621.392.21 **635**

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621.396.67 **636**

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621.396.67 : 621.396.712 **637**

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621.396.67.029.56/.58 **638**

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621.396.67.029.58 **639**

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621.396.67.029.58 **640**

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21.396.67.029.64 : 621.396.931 **641**

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21.396.671 : 621.396.822 **642**

Study of the Thermal Equilibrium of Wireless Aerials.—G. Lehmann. (*Ann. Télécommun.*, May/June 1946, Vol. 1, Nos. 5/6, pp. 91–98.) The black-body radiation law is used to determine the intensity of the r.f. noise field in a uniform temperature enclosure. The noise e.m.f. induced in a dipole corresponds to the value given by applying Nyquist's formula to the radiation resistance. The identity of the polar diagrams of any aerial for reception and for transmission is established. In practice extraterrestrial noise (from the galaxy and the sun) leads to relatively high aerial noise temperatures at metre wavelengths. The relations between the aperture, the beam width and the gain of a directive aerial are deduced. The paper was first published in September 1942 in *Cahiers de Physique*. See also 2122 of 1941 and 2699 of 1946 (Burgess).

.396.677 **643**

A High-Gain Two-Meter Rotary Beam.—J. A. Kosko. (*QST*, Nov. 1946, Vol. 30, No. 11, 45–47.) A six-element broadside parasitic array with coaxial feed, which has a forward gain of 2 db, a front-to-back ratio of 36 db and a beam width of ± 10° for half power.

.396.677 **644**

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A comparison with the pattern of a large tuned array shows the inferiority of a single rhombic antenna. Many of the prominent minor lobes seen in the directional pattern of the latter may be suppressed by the use of several rhombics in the form of an array. Various simple designs are discussed and it is shown possible, particularly when the rhombics are arranged in an interlaced 'end-fire' array, to produce over the whole working range of a rhombic, a directional pattern which compares with that of a large tuned array at its designed frequency."

396.677.2 **645**

Five are Better than Three. Some Experiences with a Five-Element Rotary.—W. W. Basden. (*QST*, Dec. 1946, Vol. 30, No. 12, pp. 32..138.) The five-element 28-Mc/s beam at W5CXS is different from the usual three-element beam in that director elements have been added 0.1 λ above and below the normal director. Delta-match feed is used and the line is tapped on the radiator inches each side of the centre.

621.396.679.4 **646**

Dipole with Unbalanced Feeder.—D. A. Bell. (*Wireless Engr*, Jan. 1947, Vol. 24, No. 280, pp. 3–5.) A short account of the effect of pick-up on the concentric downlead from a directly connected dipole receiving aerial. The equivalent circuit of such an aerial arrangement is discussed and the function of a quarter-wave balancing sleeve is considered. An example is given showing the distortion of the polar diagram of an array produced by feeder-lead pick-up.

621.396.931/.933].22.029.62 **647**

Radio Direction Finding at 1.67 Meter Wavelengths.—Yuan. (*See* 732.)

CIRCUITS AND CIRCUIT ELEMENTS

621.314.26 **648**

Mechanism of Frequency Changing.—L. Chrétien. (*Toute la Radio*, March/April & May 1946, Vol. 13, Nos. 104 & 105, pp. 76–78 & 104–106.) Criticizes existing theories of the behaviour of frequency changing circuits and puts forward a new theory based on the stroboscopic effect.

621.315.59 + 621.316.89 **649**

Properties and Uses of Thermistors — Thermally Sensitive Resistors.—Becker, Green & Pearson. (*See* 765.)

621.317.432 **650**

Energy dissipated by Eddy Currents in a Thin Ferromagnetic Disk Normal to the Field.—G. Ribaud. (*C. R. Acad. Sci., Paris*, 25th March 1946, Vol. 222, No. 13, pp. 726–727.) Formulae have previously been given (3811 of 1944) for the energy dissipated by eddy currents in a thin non-magnetic disk. The difference in the case of a magnetic material results essentially from magnetic charges on the faces of the disk which produce a uniform demagnetizing field, which is added to that due to the eddy currents. The ratio of the energy dissipated in a magnetic disk to that in a non-magnetic disk of the same resistivity, has a maximum value of $r/4\epsilon$ when $\mu = r^2/\epsilon^2$, μ being the permeability, ϵ the skin thickness and r the distance from the axis. The energy dissipation formulae given are only valid when the thickness of the disk is more than 2 or 3 times the skin thickness.

621.318.423.012.3 **651**

Mutual Inductance of Concentric Coils.—T. C. Blow. (*Electronics*, Nov. 1946, Vol. 19, No. 11, p. 138.) A nomogram for calculating mutual inductance between two concentric single-layer air-core solenoids with greater length than diameter.

621.318.7 **652**

Tchebycheff Polynomials and the Theory of Electric Filters.—A. Colombani. (*C. R. Acad. Sci., Paris*, 27th May 1946, Vol. 222, No. 22, pp. 1278–1280.) The successive intensities in a filter of n cells are shown to depend on polynomials which satisfy Tchebycheff's equation. The particular solution applicable to the filter enables a simple formula for the intensities to be derived.

621.319.4 **653**

Modern Capacitors.—R. Besson. (*Toute la Radio*, June 1946, Vol. 13, No. 106, pp. 139–142.) Discusses the temperature, loss and other characteristics of electrolytic capacitors, capacitors with

paper dielectric and those using silvered mica or ceramic material.

621.319.4 : 621.315.614.6 **654**

Paper Capacitors containing Chlorinated Impregnants — Mechanism of Stabilization.—L. Egerton & D. A. McLean. (*Bell Syst. tech. J.*, Oct. 1946, Vol. 25, No. 4, pp. 652–653.) Barrier films formed on the electrodes reduce the catalytic decomposition of the chlorinated impregnant of the electrode metal, prevent attack of the electrodes by liberated hydrogen chloride and hinder electrolytic action. Abstracted from *Industr. Engng Chem.*, May 1946. For part 3 of this article see 655 below.

621.319.4 : 615.315.614.6 **655**

Paper Capacitors containing Chlorinated Impregnants : Part 3 — Effects of Sulfur.—D. A. McLean, L. Egerton & C. C. Houtz. (*Industr. Engng Chem.*, Nov. 1946, Vol. 38, No. 11, pp. 1110–1116.) Sulphur is an effective stabilizer with both tin and aluminium electrodes and improves the power factor especially with tin foil electrodes. Previous findings confirmed by the tests are : the importance of all parts of the capacitor, the superiorities of kraft paper over linen, and the widely different behaviours of capacitors with different electrode metals. For an earlier part in this series see 654 above.

621.392 **656**

Analysis of Linear Sweep Generator.—E. L. Langbergh. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 194..198.) A theoretical analysis of a timebase circuit consisting of a capacitor which charges in series with a valve having negative current feedback. The degree of nonlinearity depends on valve characteristics and on the charging rate of the capacitor. Details of a practical laboratory circuit are given using a high-μ pentode as the charging valve and a gasfilled triode as the discharging device.

621.392 **657**

The Transfer Impedance of Recurrent Π and T Networks.—J. B. Rudd. (*A.W.A. tech. Rev.*, Sept. 1946, Vol. 7, No. 1, pp. 79–87.) The transfer impedances are derived for chains of up to six sections of symmetrical Π and T networks terminated in equal resistances. Where the product of the impedance values of the arms of the Π and T sections is equal to the square of the terminating resistance, the circuits have identical transfer impedances.

621.392 : 621.385.832 **658**

Design of Cathode-Ray Tube Circuits.—W. Knoop. (*QST*, Dec. 1946, Vol. 30, No. 12, pp. 45–50..160.) The operation of a c.r.t., and methods of using it in designing power supply and control circuits, are explained.

621.392 : 621.396.615 **659**

The Design of Parallel-T Networks for RC Oscillators.—L. E. V. Lynch & D. S. Robertson. (*A.W.A. tech. Rev.*, Sept. 1946, Vol. 7, No. 1, pp. 7–25.) ". . . the theory of unbalanced parallel-T networks is developed and the application to resistance-capacitance oscillators is discussed. Curves are given to facilitate the design of such oscillators, together with a typical oscillator circuit showing a new method of applying automatic gain control to the associated amplifier."

621.392.5 **660**

Theory of the 'Enclosed' [encadré] Linear Quadripole.—P. Grassot. (*Rev. gén. Élect.*, Nov. 1946, Vol. 55, No. 11, pp. 443–448.) The term 'quadripôle encadré' is used for a quadripole interposed between a source and a dipole receiver. General considerations are applied to a discussion of the case of a non-dissipative enclosed quadripole consisting of pure resistances, leading to the formulation of three theorems. Examples are given of their application. The results may also be applied to telephone transformers, tuned transformers, filters, lines, etc.

621.392.52 **661**

Rigorous Formula for the Attenuation Constant of a Filter.—P. Marié. (*C. R. Acad. Sci., Paris*, 8th April 1946, Vol. 222, No. 15, pp. 869–870.) A rigorous formula is derived for the attenuation ratio produced by a filter made up of $(n-1)$ quadripoles, of iterative impedances Z_0 and Z_n, when the filter is terminated by an impedance z_n and the source presents an internal impedance z_0.

621.392.52.015.33 **662**

Transient Response of Filters.—E. T. Emms. (*Wireless Engr*, Jan. 1947, Vol. 24, No. 280, pp. 27–28.) Comment on 48 of January (Eaglesfield) and 1188 of 1946 (Tucker). It is shown "that if the wave $\cos\omega_0 t$. **1** is put into a band-pass network then the envelope of the output wave is exactly the same as the output wave obtained when unit step is placed into the low-pass analogue."

621.394/.397].645 **663**

Cathode Follower of Very Low Output Resistance.—(*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 206 . . 210.) Abstract of a report by C. M. Hammack, of the Radiation Laboratory of M.I.T. A two-stage cathode follower is described having the normal cathode load resistance of the first stage replaced by a second valve. The output conductance is shown to be increased by a factor μ over the conventional circuit. The response to pulses is also greatly improved.

621.395.667 **664**

Design of Constant Impedance Equalizers.—A. W. J. Edwards. (*Wireless Engr*, Jan. 1947, Vol. 24, No. 280, pp. 8–14.) "Some useful pr-perties of inverse networks (as used in line equalization) are deduced and applied to the development of simple practical design procedures involving no calculations when suitable test equipment is available."

621.396.61.015.33 **665**

Calculation of the Minimum Pass Band of a Pulse Transmission System.—J. Laplume. (*Ann. Radio-élect.*, April/July 1946, Vol. 1, Nos. 4/5, pp. 327–332.) The rate of rise of the output potential from a transmission system when a Heaviside pulse is applied to the input may be increased by improving the h.f. response of the system. The output then has an oscillatory form.

Transmission systems which distort the applied pulses in the same way have sensibly identical response curves and it is therefore possible to define mathematically an output signal type and deduce the response curve which produces this signal from the input pulse. The pass-band of such a system is worked out in terms of two characteristics f the output pulse, namely, amplitude of the first scillation and a quantity measured from the steeply ising part of the potential-time curve of the pulse.

21.396.611 666
Increment Features on Variable Oscillators.—. R. A. Rendall. (*Electronic Engng*, Nov. 1946, 'ol. 18, No. 225, p. 350.) The frequency of an scillator can be expressed in the form $f_0 = 1/2\pi RC$. y connecting in series with the main variable apacitor C a fixed capacitor C_1, the new frequency ill be $f_1 = (C + C_1)/2\pi RCC_1$, so that the increment f frequency is $1/2\pi RC_1$, which is independent of C.

1.396.611 667
Stability and Frequency Pulling of Loaded nstabilized Oscillators.—J. R. Ford & N. I. orman. (*Proc. Inst. Radio Engrs, W. & E.*, ct. 1946, Vol. 34, No. 10, pp. 794–799.) "Contions are established under which the frequency a loaded unstabilized oscillator will not jump scontinuously as the load susceptance is changed. requency-pulling equations and stability criteria e established for an oscillator coupled to a resistive d through a pair of coupled resonant circuits."

1.396.611 : 621.396.615.18 668
The Inductance-Capacitance Oscillator as a equency Divider.—Norrman. (*See* 817.)

.396.611.1 + 531.12 669
Calculation of the Natural Frequencies of Nonear Systems.—H. Jounin. (*C. R. Acad. Sci., ris*, 20th May 1946, Vol. 222, No. 21, pp. 1203–5.) The method of approximation for quasiear systems proposed by Kryloff and Bogolouboff their "Introduction to Nonlinear Mechanics", pplied to the case of a certain class of isochronous illators to obtain a simple formula.

.396.611.1 670
Constant Current Circuits.—O. T. Fundingsland . J. Wheeler. (*Electronics*, Nov. 1946, Vol. 19, 11, pp. 130–133.) "Exponential circuits can made to carry more nearly constant current longer times if corrective networks are used. ign equations and actions of these circuits are ved, and their advantages in magnetron pulse uits are illustrated by a numerical example."

.396.611.3.015.33 671
ransient Response of V.F. [video frequency] **plings.**—W. E. Thomson. (*Wireless Engr*, . 1947, Vol. 24, No. 280, pp. 20–27.) "Formulae curves are given for the response to the Heaviunit function of a single [frequency-compend] resistance-capacitance coupled stage . . . analysis of the low-frequency response deals nly with the compensation of grid coupling by le decoupling . . ." For h.f. compensation case in which a reactance is inserted in series the load resistor is analysed, critical damping g assumed.

396.615.11 672
Resistance-Capacitance Beat-Frequency Oscilla-—D. S. Robertson & L. C. Nye. (*A. W. A. Rev.*, Sept. 1946, Vol. 7, No. 1, pp. 27–31.) racies of ±2 c/s from 20–200 c/s and of 1% 200–5 000 c/s, and high stability with respect emperature and supply voltage variations are claimed. The unit is light and can be used in aircraft; it may be operated from a 120 or 240 V, 50–800 c/s, supply.

621.396.615.142 673
Reflex Oscillators.—J. R. Pierce. (*Electronic Engng*, Nov. 1946, Vol. 18, No. 225, pp. 345–346.) Summary of paper noted in 3530 of 1945.

621.396.615.17 : 621.396.96 674
Coil Pulsers for Radar.—E. Peterson. (*Bell Syst. tech. J.*, Oct. 1946, Vol. 25, No. 4, pp. 603–615.) A method of generating regularly spaced, sharply peaked pulses of high power for modulating h.f. generators by making use of the variation of reactance with current of molybdenum permalloy-cored coil. Pulse widths were obtained from 0.2 to over 1 μs, peak powers from 100 to 1 000 kW and pulsing rates from 400 to 3 600 pulses/sec.

The principles of operation of a low power coil pulser working from an a.c. input and of a high-power apparatus for d.c. operation are described.

621.396.619.23 675
A 15-Watt Modulator for Low-Power Work.—B. H. Geyer, Jr. (*QST*, Jan. 1947, Vol. 31, No. 1, pp. 28, 104.) Uses a cathode-follower type of driver with resistance coupling.

621.396.62.029.64 676
Components of U.H.F. Field [strength] **Meters.**—Karplus. (*See* 819.)

621.396.645 677
Oscillation Conditions in Single Tuned Amplifiers.—W. R. Faust & H. M. Beck. (*J. appl. Phys.*, Sept. 1946, Vol. 17, No. 9, pp. 749–756.) The gain of a tuned amplifier of n similar stages is calculated. A certain minimum grid-to-plate capacitance is required to cause oscillation. There also exists a region of stable gain, zero to $2^{1/n}$ (approx.) within which no oscillation will occur however large the grid-to-plate capacitance.

621.396.645 678
Design of Broad Band I.F. Amplifier: Part 2.—R. F. Baum. (*J. appl. Phys.*, Sept. 1946, Vol. 17, No. 9, pp. 721–730.) The mathematical analysis for broad band amplifiers of the stagger-tuned type is given. The resonant frequencies of the tuned circuits are assumed to be arranged in pairs so that the geometric mean of each pair is the mid-band frequency, and the two circuits of each pair have equal Q. An exact solution is possible for either a monotonic or an oscillatory response but the latter is shown to be preferable because for a given response characteristic (*i.e.* a given gain tolerance within the pass band and given minimum attenuation outside it) the oscillatory type requires fewer stages. For part 1 see 3223 of 1946.

621.396.645.35 679
A D.C. Amplifier using a Modulated Carrier System.—R. A. Lampitt. (*Electronic Engng*, Nov. 1946, Vol. 18, No. 225, pp. 347–350.) Many of the difficulties which occur with a standard d.c. amplifier are overcome by using the signal to be amplified for modulation of a 20 kc/s amplifier in a linear mode. Any additional amplification may then be carried out by an ordinary a.c. amplifier at 20 kc/s. The

a.c. output is rectified so that the resulting d.c. component is a replica of the original input. The amplifier described has an overall gain of 100 000.

621.396.692.012.3 680
Parallel Standard Resistors.—A. K. W. (*Wireless World*, Dec. 1946, Vol. 52, No. 12, p. 396.) A table is given for finding the value of parallel combinations of standard resistors.

621.397.645 681
Video Amplifier H.F. Response : Part 3.—(*Wireless World*, Dec. 1946, Vol 52, No. 12, pp. 413–414.) For parts 1 and 2, see 61 and 62 of January. The circuits there described are combined to form a single coupling having two correcting inductances; this considerably improves performance.

621.398 682
Continuously Variable Radio Remote Control.—D. W. Moore, Jr. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 110–113.) "Phase-shifting properties of a resonant circuit provide automatic self-adjustment of a radio control system. Guided missiles, aircraft, satellite transmitters, and telemetering systems can be radio controlled by the stepless positioning provided."

621.3.011.3 683
Introduction au calcul des inductances. [Book Review]—M. Romanowski. Gauthier-Villars, Paris, 114 pp. (*Rev. gén. Élect.*, May 1946, Vol. 55, No. 5, p. 172.) The calculation falls into two stages: (1) application of Maxwell's equations and of the energy laws of linear circuits; (2) integration leading to energy formulae for the whole conductor. The second stage is more particularly concerned in this case. Mathematical difficulties preclude exact solutions except in the simplest cases.

621.319.4 : 621.396.69 (02) 684
Capacitors — Their Use in Electronic Circuits. [Book Review]—M. Brotherton. D. Van Nostrand, New York, 1946, 107 pp., $3.00. (*Gen. elect. Rev.*, Nov. 1946, Vol. 49, No. 11, pp. 66–67.)

GENERAL PHYSICS

530.13 : 530.12 685
Comments on "A Relativistic Misconception". M. E. Deutsch: V. P. Barton: A. J. O'Leary. (*Science*, 25th Oct. 1946, Vol. 104, No. 2704, pp. 400–401.) The original article was abstracted in 388 of February (Eddy).

530.145 686
New Developments in Relativistic Quantum Theory.—C. Møller. (*Nature, Lond.*, 21st Sept. 1946, Vol. 158, No. 4012, pp. 403–406.)

530.145 : 538.3 687
Quantum Mechanics of Fields : Part 3 — Electromagnetic Field and Electron Field in Interaction.—M. Born & H. W. Peng. (*Proc. roy. Soc. Edinb. A*, 1944/46, Vol. 62, Part 2, pp. 127–137.) For parts 1 and 2 see 236 of 1945.

534.1 + 535.13] Huyghens 688
On Huyghens' Principle.—Rocard. (*See* 845.)

535.1 689
Waves of Ordinary Light are propagated as if the Luminous Vector were Divergent ; Consequences for Physical Optics.—A. Foix. (*C. R. Acad. Sci., Paris*, 14th Jan. 1946, Vol. 222, No. 3, pp. 180–181.)

535.13 690
Mechanical Explanation of Maxwell's Equations.—D. Riabouchinsky. (*C. R. Acad. Sci., Paris*, 8th Oct. 1945, Vol. 221, No. 15, pp. 391–394.) Treatment of Maxwell's equations establishes a univocal and reciprocal correspondence between all the elements of gas-dynamic and electromagnetic fields.

535.13 691
Dynamics of the Ether.—D. Riabouchinsky. (*C. R. Acad. Sci., Paris*, 15th Oct. 1945, Vol. 221, No. 16, pp. 432–434.) A system of equations is derived for fluid motion analogous to Maxwell's equations. Continuation of 690 above.

535.312 692
Optical Properties of Thin Metallic [non-magnetic] **Laminae.**—F. Scandone & L. Ballerini. (*Nuovo Cim.*, 1st April 1946, Vol. 3, No. 2, pp. 81–115. In Italian with English summary.) Drude's method involving a complex refractive index is applied to derive the classical Fresnel relations and explicit formulae for the intensity and phase relations of the reflected and transmitted energy are obtained.

535.333 : [546.212 + 546.212.02 693
Water Spectrum near One-Centimeter Wave-Length.—C. H. Townes & F. R. Merritt. (*Phys. Rev.*, 1st/15th Oct. 1946, Vol. 70, Nos. 7/8, pp. 558–559.) The spectral lines of H_2O and of mixtures of H_2O and D_2O have been measured at pressures near 0.1 mm Hg using an oscillator whose frequency can be swept across the lines. The frequencies, intensities, and widths of the lines agree with previous measurements at atmospheric pressure within experimental error.

535.736.1 + 771.53 + 621.397.611.2 694
A Unified Approach to the Performance of Photographic Film, Television Pickup Tubes, and the Human Eye.—Rose. (*See* 918.)

536.73 695
Derivation, Interpretation and Application of the Second Law of Thermodynamics.—P. G. Nutting. (*Science*, 4th Oct. 1946, Vol. 104, No. 2701, pp. 317–318.) The second law is "here derived as a by-product of Gibbs's masterful general treatment, but apparently neither Gibbs nor any of his followers ever noted it."

537 + 538].081.5 696
Simplification of the Dimensional Equations of Electric and Magnetic Quantities.—M. Tarbouriech. (*Rev. gén. Élect.*, April 1946, Vol. 55, No. 4, pp. 151–155.) Tables are given showing the further simplification of the dimensional system of Brylinski (4023 of 1944) (*a*) when Q is replaced by IT and LT^{-1} by V in the equations involving I, L and T, and (*b*) when the quantities involved are R, I, T and L. The advantages of the latter system are enumerated.

537.291 **697**

Graphical Determination of Electron Trajectories n a Given Electric Field.—R. Musson-Genon. C. R. Acad. Sci., Paris, 8th April 1946, Vol. 222, No. 5, pp. 858–860.) The determination of planar lectron trajectories, when the potential is known, is ffected generally by a graphical construction analo-ous to Huyghens' method in optics. The accuracy ormally achieved by this method is discussed and method of correction indicated which increases it.

37.311.33 **698**

Relation between the Constant A and the Thermal ctivation Energy & in the Conductivity Law of emiconductors.—G. Busch. (*Helv. phys. Acta,* 1st May 1946, Vol. 19, No. 3, pp. 189–198.) Vilson's theory of excess semiconductors is extended ssuming that the location of the electron distribu-on centres in the energy scheme is not given by a screte value ΔB of the thermal activation energy but by a region of finite breadth. For the con-uctivity σ two temperature regions exist in which g σ is a linear function of the reciprocal of the bsolute temperature, the two slopes being different. pplication of the theory of lattice defects in crystals the semiconductor problem shows the empirical lation $\log A = \alpha + \beta\epsilon$ between the constant and the thermal activation energy ϵ to be exactly lid.

7.52 **699**

On the Mechanism of the Progress of a Discharge. A. Zingerman & N. Nikolaevskaya. (*Zh. eksp. t. Fiz.,* 1946, Vol. 16, No. 6, pp. 499–502. In ssian.) Photographs were taken of incomplete charges between two spheres separated by dis-nces of several hundred millimetres. Impulse ltages up to 3 MV were applied to the spheres. appears from these photographs that the dis-rge channel is not formed by the movement from cathode to the anode of a single 'electron alanche' but consists of several merging streams. e speed of the growth of the 'electron avalanche' discussed and two typical photographs are shown.

.523.4 **700**

Phenomena of Voltage Recovery in V.H.F. rks.—S. Teszner. (*C. R. Acad. Sci., Paris,* 1st . 1945, Vol. 221, No. 14, pp. 373–375.) The nomena are explained on the assumption that rmionic emission from the electrodes can be lected in practice.

.533.74 **701**

eaction of Radiation on Electron Scattering and tler's Theory of Radiation Damping.—H. A. he & J. R. Oppenheimer. (*Phys. Rev.,* 1st/15th . 1946, Vol. 70, Nos. 7/8, pp. 451–459.)

.565 **702**

he Mobility and Diffusion of Ions.—É. Montel. *R. Acad. Sci., Paris,* 8th April 1946, Vol. 222, 15, pp. 873–875.) If I is the current varying period T represented by identical ions, of bility k, introduced into a plane condenser at level of one of the plates, i the current collected he other plate when a constant p.d. $V = ha$ is ntained between the armatures, a being their nce apart, then neglecting diffusion and osing the space density is small enough to produce no deformation of the field, i has a zero minimum value every time the wavelength khT/m of the harmonic of order m is contained an integral number of times in a. When account is taken of ionic diffusion it is shown that the effect on the position of these minima is completely negligible and so cannot influence values of k determined from them.

538.23 + 538.541 **703**

Simple Relation between the Energies dissipated by Hysteresis and Eddy Currents in a Solid of Revolution.—G. Ribaud. (*C. R. Acad. Sci., Paris,* 1st April 1946, Vol. 222, No. 14, pp. 788–789.) Calculations of the energy dissipation made for different solids of revolution, assuming that the frequency is high enough for the skin thickness to be small and the field weak enough for the permeability to be considered constant. In all cases it is found that the ratio of hysteresis loss to that due to eddy currents is the same and equal to $1/\pi$ of the area of the B, H cycle for H=1.

538.3 **704**

The Interpretation of Maxwell's Equations.—L. Bouthillon. (*C.R. Acad. Sci., Paris,* 8th April 1946, Vol. 222, No. 15, pp. 871–873.) It is shown that Maxwell's equations can be written in the form :

$$-[\overline{\nabla}\overline{D}] = \frac{4\pi}{a_e}\,\overline{j} + \frac{\partial\overline{H}}{\partial t} \qquad [\overline{\nabla}\overline{B}] = \frac{4\pi}{a_m}\,\overline{i} + \frac{\partial\overline{E}}{\partial t},$$

$$(\overline{\nabla}\overline{E}) = \frac{4\pi}{k_e}\,\rho \qquad (\overline{\nabla}\overline{H}) = \frac{4\pi}{k_m}\,\mu.$$

Thus each term in the equations on the left has its counterpart in those on the right. $-\overline{B}$, the magnetic induction, corresponds to $\overline{D}$, the electric induction, and vice versa ; $\overline{H}$, the intensity of the magnetic field, to $\overline{E}$, the intensity of the electric field ; $\overline{j}$, the intensity of the magnetic current, to $\overline{i}$, that of the electric current, and μ, the magnetic charge, to ρ, the electric charge. Written in this way, Maxwell's equations have maximum symmetry.

538.566.2 + 534.222.1 **705**

Propagation of Radiation in a Medium with Random Inhomogeneities.—Bergmann. (*See* 847.)

538.691 : 513.738 **706**

Geometrical Characterizations of Some Families of Dynamical Trajectories.—L. A. MacColl. (*Bell Syst. tech. J.,* Oct. 1946, Vol. 25, No. 4, p. 653.) A solution of the problem of "obtaining a set of geometrical properties which shall completely characterize the 5-parameter family of trajectories of an electrified particle moving in an arbitrary static magnetic field." Abstracted from *Amer. math. Soc. Trans.,* July 1946.

539.133 **707**

A New Method of Measuring the Electric Dipole Moment and Moment of Inertia of Diatomic Polar Molecules.—H. K. Hughes. (*Phys. Rev.,* 1st/15th Oct. 1946, Vol. 70, Nos. 7/8, pp. 570–571.) Preliminary results of experiments on the behaviour of molecules subjected simultaneously to a steady homogeneous electric field and an oscillating electric field mutually at right angles.

539.15 **708**

Nuclear Magnetic Resonance and Spin Lattice Equilibrium.—B. V. Rollin. (*Nature, Lond.,* 9th Nov. 1946, Vol. 158, No. 4019, pp. 669–670.) Measurement of r.f. absorption of a material in a magnetic field gives the time for establishment of thermal equilibrium between the spin system and the lattice. Measurable absorptions have been observed so far only with substances containing protons or fluorine nuclei.

539.152.1 **709**
The Principles of Nuclear Physics.—L. Bloch. (*Rev. gén. Élect.*, Jan. 1946, Vol. 55, No. 1, pp. 31–35.)

539.16.08 **710**
An Arrangement with Small Solid Angle for Measurement of Beta Rays.—L. F. Curtiss & B. W. Brown. (*Bur. Stand. J. Res.*, Aug. 1946, Vol. 37, No. 2, pp. 91–94.)

539.23 **711**
[Optical] **Anti-Reflexion and High-Reflexion Films.**—S. Weintroub. (*Nature, Lond.*, 21st Sept. 1946, Vol. 158, No. 4012, p. 422.) Describes some of the properties of single-layer films of high refractive index and optical thickness $\frac{1}{4}$ of the mean wavelength of the incident light, and of multi-layer films of alternately low and high refractive index.

541.133 **712**
On the Conductivity of Strong Electrolytes.—S. G. Chaudhury. (*J. phys. Chem.*, Nov. 1946, Vol. 50, No. 6, pp. 477–485.) An equation relating conductivity and concentration, derived by Onsager and modified by Shedlovsky, neglects "the effect of the change in the concentrations of ions near the electrode surface (during the time the current is on) from those in the bulk on the conductivities or mobilities of ions". This effect is considered and an equation for the conductivity deduced.

541.135 **713**
Research on the Mechanism of Electrolysis. Study of the Energy Transfer Coefficients.—M. Bonnemay. (*C. R. Acad. Sci., Paris*, 1st April 1946, Vol. 222, No. 14, pp. 793–795.)

546.33-16 + 546.171.1-16] : 621.3.02 **714**
Persistent Currents in Frozen Metal-Ammonia Solutions.—J. W. Hodgins. (*Phys. Rev.*, 1st/15th Oct. 1946, Vol. 70, Nos. 7/8, p. 568.) Persistent currents up to 0.1 A lasting for as much as 30 sec have been detected in frozen rings of sodium solutions in liquid ammonia. Currents were detected by means of a search coil and ballistic galvanometer. The presence of persistent currents appeared to depend critically on the temperature cycle involved.

621.385.1.016.4.029.5 **715**
Production of High-Frequency Energy by an Ionized Gas.—P. C. Thonemann & R. B. King. (*Nature, Lond.*, 21st Sept. 1946, Vol. 158, No. 4012, p. 414.) By coupling a coaxial line into a discharge tube near the anode and suitably adjusting an external bar magnet, an output corresponding to 3 mV could be obtained at the output of a 1 000-Mc/s superheterodyne receiver of 4 Mc/s bandwidth. No input was observed in the cathode region or in the absence of the magnet.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.72.029.62 **716**
Temperature Radiation from the Quiet Sun in the Radio Spectrum.—D. F. Martyn. (*Nature, Lond.*, 2nd Nov. 1946, Vol. 158, No. 4018, pp. 632–633.) The undisturbed sun can be considered as a radiator having maximum effective temperature of the order of 10^6 degrees Kelvin at about $\lambda = 1$ m. For $\lambda < 1$ m the radiation emanates from the cooler chromosphere while for $\lambda > 1$ m the corona tends to behave as a reflector. The temperatures observed are consistent with Edlén's estimate of 10^6 degrees for the coronal temperature. It is predicted that for $\lambda > 1$ m there should be a progressive reduction of brightness as the limb is approached but at wavelengths below 60 cm there should be a limb brightening (Fig. 2). The effect of the solar magnetic field is illustrated in Fig. 1 where the estimated effective temperature/wavelength distribution for both ordinary and extraordinary radiation is shown.

523.72.029.62 **717**
Observation of Million Degree Thermal Radiation from the Sun at a Wavelength of 1.5 Metres.—J. L. Pawsey. (*Nature, Lond.*, 2nd Nov. 1946, Vol. 158, No. 4018, pp. 633–634.) Daily measurements of solar noise over a period of 6 months on λ 1.5 m confirm Martyn's predictions of thermal radiation at temperatures of the order of 10^6 degrees Kelvin (see 716). Histograms of the results show a sharp cut-off at a lower limit corresponding to 0.6 – 1.2 × 10^6 degrees; the skewness of the curve at high intensities may be explained by variable additional radiation associated with sunspots.

537.591 **718**
Momentum Spectrum of Mesons at Sea-Level.—J. G. Wilson. (*Nature, Lond.*, 21st Sept. 1946, Vol. 158, No. 4012, pp. 414–415.)

537.591 **719**
Observations of Protons of Great Energy in the Penetrating Part of Cosmic Radiation.—L. Leprince-Ringuet, M. Lhéritier & R. Richard-Foy. (*C.R. Acad. Sci., Paris*, 8th Oct. 1945, Vol. 221, No. 15, pp. 406–407.)

537.591 : [546.621 + 546.815 **720**
A Comparison of the Stopping Power of Lead and Aluminium for Cosmic-Ray Mesotrons.—E. Fein. (*Phys. Rev.*, 1st/15th Oct. 1946, Vol. 70, Nos. 7/8, p. 567.)

537.591 : 550.385 **721**
Changes in Cosmic Ray Intensity associated with Magnetic Storms.—H. Alfvén. (*Nature, Lond.*, 2nd Nov. 1946, Vol. 158, No. 4018, pp. 618–619.) These may be due to changes in the earth's electrostatic potential caused by differences in potential between the two sides of the ion stream emitted by the sun at the time of a storm. This potential difference may amount to 50 MV and is due to motion of the ion stream in the sun's magnetic field.

537.591.1 **722**
Observations of Remarkable Particles Other than Protons in the Penetrating Part of Cosmic Radiation.—L. Leprince-Ringuet, M. Lhéritier & R. Richard-Foy. (*C. R. Acad. Sci., Paris*, 22nd Oct. 1945, Vol. 221, No. 17, pp. 465–467.) Trajectories observed in a large Wilson chamber differ from those due

to protons or mesons. A particle intermediate between the two would explain satisfactorily the observed results, which are compatible with the emission of a neutral meson.

538.71.087 723
Monitor for Magnetic Storms.—A. Dauvillier. (*C. R. Acad. Sci., Paris*, 12th June 1946, Vol. 222, No. 24, pp. 1380–1381.) Describes apparatus installed at the Pic du Midi observatory to give audible warning of large variations of the horizontal component of the earth's magnetic field.

550.38(44) " 00/04 " 724
Intensity of the Terrestrial Magnetic Field in France in the Gallo-Roman Period.—É. Thellier & O. Thellier. (*C. R. Acad. Sci., Paris*, 8th April 1946, Vol. 222, No. 15, pp. 905–907.) Measurements on samples from the Fréjus amphitheatre and the Cluny thermal baths have given mean values of 0.66 and 0.71 gauss respectively for the earth's field in ancient times. These results are discussed.

550.385 " 1946.03.28 " 725
Exceptional Magnetic Disturbance of 28th March 1946.—G. Gibault. (*C. R. Acad. Sci., Paris*, 8th April 1946, Vol. 222, No. 15, pp. 907–908.)

551.510.535 726
High-Power Radio Soundings of the Ionosphere.—P. Lejay & R. Chezlemas. (*C.R. Acad. Sci., Paris*, 12th June 1946, Vol. 222, No. 24, pp. 1363–1366.) A report of results obtained, every two hours in the daytime, since April 1946, at the National Radio Laboratory, Bagneux (Seine). Rectangular pulses, of duration 20 μs, were transmitted 50 times per second from each of two self-oscillators giving about 20 kW aerial power, one covering 3.5–6.5 Mc/s and the other 6.5–11.5 Mc/s, the sweep being completed in about 15 min. The photographic records show that the critical frequencies for reflection from the F_2 layer are considerably higher than those expected on theoretical grounds and than those observed elsewhere. The mean values for April were about 2 Mc/s higher than those predicted by American forecasts. Slow changes were noted, low values for the critical frequencies on April 7 and 14 being followed by high values on April 9 and 16–17 respectively. Low values correspond in general to greater equivalent heights.

551.510.535 727
Nocturnal Variations of the Heights of the Layers of Maximum Ionisation of Regions *E* and *F*.—S. N. Ghosh. (*Sci. Culture*, Oct. 1946, Vol. 12, No. 4, pp. 201–202.) The height of the layer of maximum electron density in the E layer remains fairly constant during the night while the corresponding height for the F layer increases. This fact is explained theoretically as being due to the different laws of disappearance of free electrons in the two regions.

551.510.535 : 550.38 728
Geomagnetic Control of Region F_2 of the Ionosphere.—S. K. Mitra. (*Nature, Lond.*, 9th Nov. 1946, Vol. 158, No. 4019, pp. 668–669.) Discussion of Appleton's recent note (2898 of 1946). The geomagnetic effects may arise from bombardment of the upper atmosphere by charged particles but it is more likely that the particles are of terrestrial origin and ionized by solar ultra-violet rays. This hypothesis is consistent with Appleton's experimental data and with the geomagnetic control of the intensity of night-sky radiation.

551.510.535 : 550.384.4 729
Geomagnetic Time Variations and Their Relation to Ionospheric Conditions.—S. K. Chakrabarty. (*Curr. Sci.*, Sept. 1946, Vol. 15, No. 9, pp. 246–247.) The quiet day solar diurnal variation S_q of the geomagnetic field is believed to originate in the earth's outer atmosphere or the ionosphere. S_q curves of San Juan, Alibag, and Huancayo are given. For low latitude stations variations of S_q appear to depend on geomagnetic parameters, although for high latitude stations they depend more on geographical coordinates.

These results can be explained if the atmospheric conductivity K is supposed to vary with geomagnetic latitude, particularly for low latitudes, and if K is not dependent on the sun's zenith distance as has previously been assumed. The probable source of the S_q current system is the F_2 layer.

551.515.42 730
On the Development of Microcyclones below Thunder Clouds.—S. Mull & Y. P. Rao. (*Sci. Culture*, Aug. 1946, Vol. 12, No. 2, pp. 106–108.) An expression is derived for the pressure fall below a thunder cloud. This explains the existence of small kinks in the isobars, before the development of a major thunderstorm.

LOCATION AND AIDS TO NAVIGATION

621.396.9 : 523.2 : 621.396.1 731
Astronomical Radar.—In 106 of January please cancel the words 'using a parabolic aerial array'.

621.396.931/.933].22.029.62 732
Radio Direction Finding at 1.67-Meter Wavelengths.—L. C. L. Yuan. (*Proc. Inst. Radio Engrs, W. & E.*, Oct. 1946, Vol. 34, No. 10, pp. 752–756.) Describes 1.67 m tests on various aerial systems for measuring both the elevation and bearing of an incident wave. Measurements were made at ranges from 7 to 30 miles. With the aerial system 1.5 λ above ground, and with a dry surface free from reflecting objects, the results agree with the optical direction for the incident wave to within $\frac{1}{2}°$ in bearing, and to within $\pm\frac{1}{2}°$ in elevation. With wet ground the error in the elevation may be as great as $3\frac{3}{4}°$. A mathematical analysis of the reception by the two aerial systems used is given.

621.396.932.1 733
New Techniques in Modern Marine Navigation.—R. Leprêtre. (*Rev. gén. Élect.*, Nov. 1946, Vol. 55, No. 11, pp. 419–426.) A general account of the application of radar to marine navigation and a more detailed account of the operation of the Decca system.

621.396.933 734
The Radio Equipment used by the Pilot of an Aircraft and the Corresponding Ground Installations.—Gaillard. (*See* 887.)

621.396.933 735
An Introduction to Hyperbolic Navigation, with Particular Reference to Loran.—J. A. Pierce. (*J. Instn elect. Engrs*, Part I, Nov. 1946, Vol. 93, No. 71, pp. 546–547.) A longer abstract of the same paper was noted in 3287 of 1946.

621.396.933.1 **736**

Simple Radio Approach System.—R. Besson. (*Toute la Radio*, March/April 1946, Vol. 13, No. 104, pp. 84–85.) A coil is carried by the aircraft in a plane perpendicular to the axis of the fuselage, with a vertical aerial just behind the coil and a suitable receiver whose output feeds a bridge type rectifier associated with a centre-zero voltmeter. A motor driven commutator reverses the coil connexions every 1/12 sec and at the same time reverses the voltmeter connexions. With the aircraft on its proper course the voltmeter needle points to zero, deviations being indicated by movement of the needle to either side.

621.396.96 + 621.396.932 **737**

SJ Radar for Submarines.—C. L. Van Inwagen. (*Bell Lab. Rec.*, Nov. 1946, Vol. 24, No. 11, pp. 402–406.) A 3 000-Mc/s radar for location of ship target by submarines, with p.p.i. and A-scope displays. It can also be used as an aid to navigation.

621.396.96 **738**

Scanning Equipment for Ground Radar.—D. Taylor & W. H. Penley. (*Engineering, Lond.*, 11th Oct. 1946, Vol. 162, No. 4213, pp. 337–338.) The motions of two aerial systems may be synchronized by using (*a*) two identical three-phase induction motors with stators in parallel and wound rotors in parallel; (*b*) three selsyns as a differential mechanism to operate an oil pump and oil motor; and (*c*) two selsyns operating a Ward-Leonard control unit through a thermionic-valve torque amplifier. The last method gave the smoothest control and with 1-h.p. motors two arrays were synchronized within $\pm 1°$. A dipole-rocking mechanism is described in which the dipole is at the end of a pivoted arm which is rocked by means of a special arrangement of two crankshafts using weights to provide mechanical balance.

621.396.96 **739**

Radio v. U-Boat.—G. M. Bennett. (*Wireless World*, Dec. 1946, Vol. 52, No. 12, pp. 408–411.) An account of the development of radio detecting devices used by allied aircraft and ships in the Battle of the Atlantic and the countermeasures adopted by the enemy.

621.396.96 : 011.4 **740**

What is Radar?—"Cathode Ray". (*Wireless World*, Dec. 1946, Vol. 52, No. 12, pp. 415–416.) A discussion of the various definitions that have been given of radar, pointing out the techniques covered by each definition.

621.396.96 **741**

The Battle of the Atlantic. [Book Notice]—Central Office of Information, London, 104 pp., 1s. (*Govt Publ., Lond.*, Oct. 1946, p. 3.) The official account of the fight against the U-Boats, 1939–1945.

MATERIALS AND SUBSIDIARY TECHNIQUES

533.5 **742**

What is a Vacuum?—H. Piraux. (*Toute la Radio*, July/Aug. 1946, Vol. 13, No. 107, pp. 189–193.) A review of methods of obtaining and measuring high vacua.

535.377 **743**

The Thermoluminescence and Conductivity of Phosphors.—R. C. Herman & C. F. Meyer. (*J. appl. Phys.*, Sept. 1946, Vol. 17, No. 9, pp. 743–748.) Phosphors such as zinc sulphide irradiated by ultraviolet at low temperatures can be made to glow by raising the temperature, the electrical conductivity rising at the same time. A theoretical discussion of these phenomena is given.

537.13 : 621.385.1.032.216 **744**

Some Cases of Interaction between Positive Ions and Metallic Surfaces.—N. Morgulis. (*Zh. eksp. teor. Fiz.*, 1946, Vol. 16, No. 6, pp. 489–494. In Russian.) An experimental attempt to determine the contact potential differences of thoriated tungsten by observing the displacement of the ion current characteristics for different thorium coatings and different conditions of thermal ionization did not produce satisfactory results.

In experimental investigations of this kind the neutralization of the ions on the surface is often slowed down, but the electric field prevents the ions from leaving the surface. This phenomenon is discussed for the case of a pure tungsten filament in caesium vapour, and conditions of equilibrium are established.

537.311.33 : 546.281.26 **745**

Electric Conductivity of Silicon Carbide.—G. Busch. (*Helv. phys. Acta*, 31st May 1946, Vol. 19, No. 3, pp. 167–188.) Conductivity measurements on single crystals of silicon carbide for current densities between 10^{-5} A/sq. cm and about 1 A/sq. cm show Ohm's law to be valid. Curves are given showing the variation of conductivity with temperature from 80°K to 1 400°K.

537.533.8 **746**

Secondary Emission from Germanium, Boron, and Silicon.—L. R. Koller & J. S. Burgess. (*Phys. Rev.*, 1st/15th Oct. 1946, Vol. 70, Nos. 7/8, p. 571.) The experiments were carried out in an electron gun tube evacuated to between 10^{-6} and 10^{-7} mm Hg. The germanium and silicon were heated to dull red heat and the boron to 425°C before making measurements. Results are shown graphically.

538.221 **747**

Anomalous High-Frequency Resistance of Ferromagnetic Metals.—J. H. E. Griffiths. (*Nature, Lond.*, 9th Nov. 1946, Vol. 158, No. 4019, pp. 670–671.) At λ 1–3 cm the product $\mu\rho$ of the permeability and resistivity of ferromagnetic films shows a large increase at a certain value of external steady magnetic field H. If H^1 is the magnetic field inside the metal, the product $H^1\lambda$ tends to be constant and is of the order of $2\pi mc/e$ (= 10.7 × 10^3 gauss/cm.) This suggests that resonant absorption by magnetic dipoles is taking place.

538.221 **748**

Magnetic Dispersion of Iron Oxides at Centimetre Wave-Lengths.—J. B. Birks. (*Nature, Lond.*, 9th Nov. 1946, Vol. 158, No. 4019, pp. 671–672.) Measurements were made of the characteristic impedance and propagation constant of a coaxial line (at λ 9 and 6 cm) and of a waveguide (at λ 3 cm) filled with mixtures of ferroso-ferric or gamma-ferric oxide and paraffin wax. The complex permeability of each oxide was deduced; its magnitude decreases rapidly with the wavelength and a large absorption occurs.

538.221 749
Magnetic Properties of Feebly Magnetic Sesquioxide of Iron.—J. Roquet. (*C. R. Acad. Sci., Paris*, 25th March 1946, Vol. 222, No. 13, pp. 727–729.)

546.287 750
Silicone Oils: Part 1—Their Properties.—D. F. Wilcock. (*Gen. elect. Rev.*, Nov. 1946, Vol. 49, No. 11, pp. 14–18.) Description of chemical constitution, viscosity in relation to temperature, pour point, evaporation, miscibility, combustion, and some chemical properties.

546.841.78 : 621.385.032.21 : 539.16.08 751
A Geiger Counter for Determination of Thorium Content of Thoriated-Tungsten Wire.—R. E. Aitchison. (*A.W.A. tech. Rev.*, Sept. 1946, Vol. 7, No. 1, pp. 1–5.)

548.0 : 537 : 546.331.2 752
Elastic, Piezoelectric, and Dielectric Properties of Sodium Chlorate and Sodium Bromate.—W. P. Mason. (*Phys. Rev.*, 1st/15th Oct. 1946, Vol. 70, Nos. 7/8, pp. 529–537.) Determination over a wide temperature range by measuring the properties for three oriented cuts. Values of piezoelectric constant and Poisson's ratio obtained differ considerably from those of previous workers.

548.4 753
Imperfections in the Structure of Large Metal Crystals, revealed by Micrography and by X Rays.—P. Lacombe & L. Beaujard. (*C. R. Acad. Sci., Paris*, 8th Oct. 1945, Vol. 221, No. 15, pp. 414–416.)

[549.514.51 + 549.614] : 548.4 754
Surface Layers on Quartz and Topaz.—D. D'Eustachio. (*Phys. Rev.*, 1st/15th Oct. 1946, Vol. 70, Nos. 7/8, pp. 522–528.) An investigation, by X-ray photography, of the nature of the surface layers of single crystals of quartz and topaz.

621.314.632 755
Phenomena of Aging of Copper Oxide Rectifiers.—R. Douçot. (*Rev. gén. Élect.*, Nov. 1946, Vol. 55, No. 11, pp. 448–451.) Results of an experimental study are given graphically. Aging is rapid in the days immediately following manufacture and can be accelerated by special treatment. The d.c. characteristic has a point of maximum stability at about 0.3 V. This is of importance in carrier-current telephony, where the rectifier is used at a particular point of its characteristic.

621.315.33 756
The Inside of Electrical Machines [manufacture and insulation of copper wire and strip].—R. H. Robinson. (*Electrician*, 20th Sept. 1946, Vol. 137, No. 3564, pp. 787–791.) An account of the drawing and covering of copper wire with a short discussion of the dielectric strength of various coverings.

621.315.61 : 537.533.73 757
Study of Insulating Materials by Electron Diffraction.—J. Devaux. (*Ann. Radioélect.*, April/July 1946, Vol. 1, Nos. 4/5, pp. 324–326.) Charge which accumulates on the specimen can be dispelled by playing on it a secondary beam of electrons of low velocity. This is due to ionization by the slow electrons of the residual gas in the discharge tube. The value of using X-ray and electron diffraction methods in the study of crystals is outlined.

621.315.61 : 679.5 758
New Electrical Materials: Part 2.—A. E. L. Jervis. (*Electrician*, 20th Sept. 1946, Vol. 137, No. 3564, pp. 793–797.) Continuation of 2931 of 1946. Notes on silicones and their use in ceramics, resins, greases and enamels. An extensive bibliography is appended.

621.315.612 759
High Dielectric Constant Ceramics.—A. von Hippel, R. G. Breckenridge, F. G. Chesley & L. Tisza. (*Industr. Engng Chem.*, Nov. 1946, Vol. 38, No. 11, pp. 1097–1109.) Dielectric measurements over a wide range of frequencies, temperatures and voltages, and thermal expansion and X-ray studies, were undertaken for titanium dioxide and the alkaline earth titanates, including some mixtures and solid solutions of the barium and strontium compounds. Barium titanate and the barium-strontium titanate solid solutions exhibit peculiar dielectric behaviour which is connected with a lattice transition from pseudocubic to cubic.

621.315.614.72.011.5 760
Dielectric Strength Measurements on Varnished Cambric.—A. Rufolo & H. K. Graves. (*ASTM Bull.*, Oct. 1946, No. 142, pp. 34–37.) A study of the effect of humidity, electrodes, and breakdown media on dielectric strength.

621.315.615 : 679.5 761
Dielectric Constants of Dimethyl Siloxane Polymers.—E. B. Baker, A. J. Barry & M. J. Hunter. (*Industr. Engng Chem.*, Nov. 1946, Vol. 38, No. 11, pp. 1117–1120.) The dielectric constants of these silicones were measured as functions of temperature. The results, together with density/temperature and optical data, were used to calculate the dipole moments, the infra-red dispersion and the dipole, atomic and electronic polarizations by means of the Onsager-Kirkwood theory.

621.315.616 : 679.5 762
Plastic Compositions for Dielectric Applications.—W. C. Goggin & R. F. Boyer. (*Industr. Engng Chem.*, Nov. 1946, Vol. 38, No. 11, pp. 1090–1096.) Plastics are described for use as casting and laminating resins and for sealing components. For radar housings polystyrene fibres were used. A sandwich method using hard outer surfaces filled with polystyrene foam gave low loss at very high frequencies. The housings for proximity fuses and the materials used in cables present special problems. The characteristics of an experimental plastic having rigidity and ideal electrical properties are given.

621.315.616.029.5 : 679.5 763
Polystyrene Plastics as High Frequency Dielectrics.—A. von Hippel & L. G. Wesson. (*Industr. Engng Chem.*, Nov. 1946, Vol. 38, No. 11, pp. 1121–1129.) The dielectric loss in styrene monomer is analysed. Polymerization conditions are investigated and a high quality polystyrene is modified by cross-linking, copolymerization and hydrogen substitution. Special filters allow adjustment of the dielectric constant and the thermal expansion (for sealing to metal surfaces).

621.315.616.9.015.5 764

The Electric Strength of Paraffins and Some High Polymers.—A. E. W. Austen & H. Pelzer. (*J. Instn elect. Engrs*, Part I, Nov. 1946, Vol. 93, No. 71, pp. 525–532.) Attempts to measure the electric strength of paraffins were unsuccessful, except for material oriented by pressing. A value of 6.5 × 10^6 V/cm was obtained for polythene, with little change from room temperature to −190°C. The strength of polyvinyl chloride-acetate increased from 6.5 × 10^6 V/cm at room temperature to 12 × 10^6 V/cm at −190°C.

621.316.89 + 621.315.59 765

Properties and Uses of Thermistors — Thermally Sensitive Resistors.—J. A. Becker, C. B. Green & G. L. Pearson. (*Trans. Amer. Inst. elect. Engrs*, Nov. 1946, Vol. 65, No. 11, pp. 711–725.) A detailed discussion of the conduction mechanism in semiconductors, and the criteria for usefulness of circuit elements made from them. Methods of preparation, and numerous applications of thermistors using their high temperature coefficient of resistivity are given.

621.316.89.029.63 766

Thermistors at High Frequencies.—J. Walker. (*Wireless Engr*, Jan. 1947, Vol. 24, No. 280, pp. 28–29.) Measurements made on the resistance of a directly heated high resistance thermistor at 400 Mc/s are in agreement with values calculated from a knowledge of the d.c. resistance.

621.318.32 : 621.317.44 767

New Method for the Study of Ferromagnetic Materials in Weak A.C. Fields. Application to Some Alloys.—Épelboïm. (*See* 797.)

621.357.8 : 537.533.73 768

Diffraction of Electrons at Monocrystalline Surfaces of Electrolytically Polished Copper.—P. Renaud & H. Frisby. (*C. R. Acad. Sci., Paris*, 17th June 1946, Vol. 222, No. 25, pp. 1429–1430.) For the metallurgical or electrochemical study of metals it is very desirable to use well-defined and reproducible surfaces which, as far as possible, correspond to the true crystal lattice. Polished copper surfaces were prepared electrolytically. The bath must be protected from dust particles and it is desirable to calcine the anode and cathode before use. Excellent diffraction photographs were obtained with such surfaces after treatment with boiling water. The diagrams correspond to Cu_2O and suggest that the electrons penetrate a large number of layers; they cannot be explained in terms of diffraction by a few layers of atoms only. The electrolytically polished copper surfaces are attacked when cold by distilled water.

621.357.8 : 548.73 769

X-Ray Study of the Surface Hardening of Single Crystals of Aluminium and of Iron by Mechanical Polishing.—J. Bénard & P. Lacombe. (*C. R. Acad. Sci., Paris*, 14th Jan. 1946, Vol. 222, No. 3, pp. 182–183.) To determine the depth of the structural modification due to polishing with emery, electrolytic polishing of the successive layers was used and a study made of the changes in the X-ray reflection diagrams. Beyond a certain depth (5 to 10 μ for No. 2 emery) the original pattern of Laue spots and continuous Debye-Scherrer rings changed, the rings becoming sectors only and disappearing altogether, leaving only the Laue spots, at a depth of the order of 60 μ. The results for aluminium were similar, but the depth of modification was considerably less than for iron.

621.362 770

Characteristics of Thermocouples.—Weller. (*See* 815.)

621.385.832.087.5 771

A New Film for Photographing the Television Monitor Tube.—White & Boyer. (*See* 907.)

621.791.76 : 621.3.011.2 772

Measurement and Effect of Contact Resistance in Spot Welding.—R. A. Wyant. (*Trans. Amer. Inst. elect. Engrs*, June Supplement 1946, Vol. 65, p. 513.) Discussion of 1890 of 1946.

621.798 : 679.5 773

Polythene Plastics for Packaging.—Visking Corporation. (*Materials & Methods*, Nov. 1946, Vol. 24, No. 5, pp. 1188–1189.)

621.9.038 774

Dies from Diamonds and Their Use : a Triumph of Technical Precision.—C. C. Paterson. (*Not. Proc. roy. Instn*, 1946, Vol. 33, No. 150, pp. 14–21.)

666.1.031.13 775

Physical Basis of the Electrical Fusion of Glass.—I. Peychès. (*Rev. gén. Élect.*, April 1946, Vol. 55, No. 4, pp. 143–150.) The difficulties encountered in the fusion of glass by the passage through it of electric currents are due to the wide variation of resistance with temperature, low heat conductivity and high viscosity. These are discussed from a practical standpoint.

666.115 : [532.13 + 536.4 776

Viscosity and the Extraordinary Heat Effects in Glass.—A. Q. Tool. (*Bur. Stand. J. Res.*, Aug. 1946, Vol. 37, No. 2, pp. 73–90.)

666.29.041 777

Automatic Glazing Machine.—R. Rulison. (*Bell Lab. Rec.*, Nov. 1946, Vol. 24, No. 11, pp. 400–401.) The rods to be glazed are mounted on a slowly rotating shaft placed inside an electrically heated furnace.

669.738 778

Cadmium Plate and Passivated Cadmium-Plate Coatings.—E. E. Halls. (*Metallurgia, Manchr*, Oct. 1946, Vol. 34, No. 204, pp. 295–297.)

669.738 779

Cadmium Plate and Passivated Cadmium-Plate Coatings.—F. Taylor : E. E. Halls. (*Metallurgia, Manchr*, Nov. 1946, Vol. 35, No. 205, pp. 28–31.) Comment on 778 above, and Halls' reply.

678 780

Comparison of Natural and Synthetic Hard Rubbers.—G. G. Winspear, D. B. Herrmann, F. S. Malm & A. R. Kemp. (*Bell Syst. tech. J.*, Oct. 1946, Vol. 25, No. 4, p. 654.) Abstracted from *Industr. Engng Chem.*, July 1946.

621.31 781

Electrical Contacts. [Book Review]—L. B. Hunt. Johnson & Matthey, London, 1946, 122 pp., 10s. 6d. (*Nature, Lond.*, 9th Nov. 1946, Vol. 158, No. 4019, p. 647.) A book of reference for the electrical engineer, written in collaboration with others. The subject is dealt with under three headings: design and selection of contacts, properties of contact materials and contact engineering.

666.1 (02) **782**
Techniques of Glass Manipulation in Scientific Research. [Book Review]—J. D. Heldman. Prentice-Hall, New York, 1946, 132 pp., $2.50. (*J. phys. Chem.*, Nov. 1946, Vol. 50, No. 6, p. 489.)

MATHEMATICS

517.432.1 **783**
On the Operator Formulae of the Symbolic Calculus.—P. Humbert. (*C. R. Acad. Sci., Paris*, 8th Oct. 1945, Vol. 221, No. 15, pp. 398–399.) Distinguishes three classes of operational formulae, of which the third has been very little studied. Examples are given.

517.512.2 **784**
Fourier Analysis of Frequency-Modulated Oscillations with Saw-Tooth Variation of the Instantaneous Frequency.—J. Rybner. (*Akad. tekn. Vidensk., Lydtekn. Lab.*, Publ. No. 2: Reprint from *Matemat. Tidskr. Afd. B*, 1946. In Danish with English summary.) The oscillation is $= A \sin (\omega t + f.\delta\omega.t^2)$] where t lies between $\pm 1/2f$. The carrier-frequency components can be expressed in terms of Fresnel integrals. The sideband components cannot be expressed in terms of fully tabulated functions, but values are given for the first four terms for a range of about 1–10 of modulation index.

517.942.9 **785**
The Numerical Solution of Laplace's Equation in Composite Rectangular Areas.—M. M. Frocht. (*J. appl. Phys.*, Sept. 1946, Vol. 17, No. 9, pp. 730–742.)

517.948.32 **786**
The Principal Methods of Solving Numerically the Integral Equations of Fredholm and Volterra.—J. Bernier. (*Ann. Radioélect.*, April/July 1946, Vol. 1, Nos. 4/5, pp. 311–318.) These equations occur in numerous boundary-condition problems.

518.5 **787**
The Automatic Sequence Controlled Calculator: Part 3.—H. H. Aiken & G. M. Hopper. (*Elect. Engng, N.Y.*, Nov. 1946, Vol. 65, No. 11, pp. 522–528.) For parts 1 and 2 see 461 of February.

518.5 **788**
A Punched-Card Technique for Computing Means, Standard Deviations, and the Product-Moment Correlation Coefficient and for Listing Scattergrams.—R. Bartlett. (*Science*, 18th Oct. 1946, Vol. 104, No. 2703, pp. 374–375.)

(075.8) **789**
Higher Mathematics for Students of Chemistry and Physics, with Special Reference to Practical Work.—[Book Review]—J. W. Mellor. Dover Publications, New York, 1946, 641 pp., $4.50. (*Rev. elect. Rev.*, Nov. 1946, Vol. 49, No. 11, p. 67.) The purpose is "to give a working knowledge of higher mathematics to students of physical and general chemistry". A special feature is the large number of examples based on actual measurements published in current scientific articles.

MEASUREMENTS AND TEST GEAR

621.316.89.029.63 **790**
Thermistors at High Frequencies.—Walker. (*See* 766.)

621.317.32 : 537.533.73 **791**
Measurement of High D.C. Voltages by Electron Diffraction.—J. J. Trillat. (*Rev. gén. Élect.*, Aug. 1946, Vol. 55, No. 8, pp. 307–310.) By means of electrons with uniform velocity, measurements are made of the radial distances of spots or rings in the diffraction diagrams of thin sheets of silver, aluminium, or gold of known thickness. An accuracy approaching 1% is possible.

621.317.32.087 **792**
Simultaneous Recording of Current, Voltage and Short-Period Voltage Fluctuations.—E. Schwabe. (*Arch. tech. Messen*, May 1940, No. 107, p. T49.) A triple recorder using current and voltage transformers and, for recording the voltage fluctuations, a lamp and photocell with compensation for normal voltage.

621.317.334 **793**
Adaptation of the Method of Maxwell-Wien to the Precise Comparison of Inductance Standards.—R. Hérou & M. Romanowski. (*C. R. Acad. Sci., Paris*, 1st April 1946, Vol. 222, No. 14, pp. 789–791.) If P and Q are the resistances of two opposite arms of a Maxwell-Wien bridge, a fixed capacitor being connected in parallel with the third arm and inductances L_1, L_2 inserted successively in the fourth arm, the bridge arms all being approximately equal and earth capacitances and residual inductances compensated, then $L_1/L_2 = P_1 Q_1/P_2 Q_2$. P and Q should be of the type used for high precision measurements, variable in 1-Ω steps. Final balance is achieved by means of a resistor of 100 Ω, shunted by a variable capacitor, in series with the inductance. Tests carried out with frequencies of 1 000 and 100 c/s show that with such an arrangement inductance comparisons can be effected with an accuracy of about 1 in 10^5 and this may be increased when the apparatus details are perfected.

621.317.35 : 578.088.7 **794**
A New Electronic [infrasonic frequency] **Analyser.**—G. R. Baldock & W. Grey Walter. (*Electronic Engng*, Nov. 1946, Vol. 18, No. 225, pp. 339–344.) The apparatus consists of a number of selective circuits which respond to frequencies between 1.5 and 30 c/s. These circuits are RC phase-shift positive feedback amplifiers with gains adjusted to values below that at which oscillation occurs. An epoch of an aperiodic waveform may be analysed be means of a switch which selects each of the selective circuits. An additional circuit, called an averager, records the analysis of the record over periods of one to two minutes. The analyser records the mean relative amplitudes throughout the period, but it will not distinguish between a large signal present for a

short time and a smaller one present for a long time. Its main use is for vibration studies and bioelectric effects.

621.317.372 : 621.315.2 795

End Leakage in Cable Power-Factor Measurement.—A. Rosen. (*J. Instn elect. Engrs*, Part I, Nov. 1946, Vol. 93, No. 71, p. 549.) Summary of 176 of January.

621.317.42 796

A B-H Curve Tracer for Magnetic-Recording Wire.—T. H. Long & G. D. McMullen. (*Trans. Amer. Inst. elect. Engrs*, June Supplement 1946, Vol. 65, pp. 494–495.) Discussion of 2247 of 1946.

621.317.44 : 621.318.32 797

New Method for the Study of Ferromagnetic Materials in Weak A.C. Fields. Application to Some Alloys.—I. Épelboïm. (*Rev. gén. Élect.*, July & Aug. 1946, Vol. 55, Nos. 7 & 8, pp. 271–281 & 310–324.) Theory and operational details are given of a bridge method. A specially designed demountable coil attachment permits accurate and reproducible results. The nickel alloys anhyster-D, mumetal and permalloy were studied after each had been subjected to two different heat treatments resulting in widely differing magnetic characteristics. In the case of the 76%-nickel alloys, the existence of a superstructure in annealed permalloy and of anistropy of the copper in tempered mumetal may account for the observed differences. Measurements were made at frequencies from 50 to 10 000 c/s. The effective resistance to eddy currents was found to be less than the d.c. resistance and the ratio of permeability to effective resistance was constant over a wide frequency range. Rayleigh's law is shown to be valid whatever the difference between the crystalline energy and that of the internal strains in a ferromagnetic material. The empirical law proposed by Sixtus is found inaccurate. The anomalous behaviour of the permeability characteristic as a function of the field can be explained by the effect of harmonics.

621.317.7 + 681.2].085.34 798

A Scanning Device for All Types of Luminous-Spot Measuring Apparatus.—F. Perrier. (*C. R. Acad. Sci., Paris*, 8th April 1946, Vol. 222, No. 15, pp. 868–869.) The beam reflected from a rotating mirror is given a motion at right angles to its usual path by interposing a suitable screen between the mirror and the source, the deflexion law being determined by the shape of the screen. Where one variable is the time, the screen may be semi-cylindrical, pierced with a helical slot and suspended from a torsion pendulum. This produces a sinusoidal sweep. Alternatively, a motor-driven disk has its edge cut to the shape of identical portions of Archimedean spirals. This gives a saw-tooth linear sweep.

621.317.7.029.64 799

Microwave Test and Measuring Equipment.—W. T. Jones. (*Electronic Industr.*, Nov. 1946, Vol. 5, No. 11, pp. 48–54 . . 136.) A review of the various types of instruments and methods developed for the measurement at u.h.f. of (*a*) frequency, using cavity and coaxial line type meters, (*b*) spectrum distribution, (*c*) power, using diodes, crystals, thermocouples, calorimeters or bolometers, (*d*) attenuation, and (*e*) standing-wave ratios, by insertion of a slotted section of transmission line between generator and load, with a pickup probe moved along the line and a meter to indicate the relative field strength at points under examination.

621.317.7.029.64 800

Microwave Measurements and Test Equipments.—F. J. Gaffney. (*Proc. Inst. Radio Engrs, W. & E.*, Oct, 1946, Vol. 34, No. 10, pp. 775–793.) A general summary is given of the methods of measuring such quantities as standing-wave ratios, impedance, power, attenuation and frequency. The electrical and mechanical considerations in the design of microwave measurement apparatus and the accuracies at present obtainable are discussed. The application of the methods to the measurement of the performance of radar systems is outlined.

621.317.71+.72].082.742 801

Moving-Coil Current and Voltage Multi-Range Meters.—J. Bubert. (*Arch. tech. Messen*, June 1940, No. 108, p. T68.) Design considerations.

621.317.714 + 621.317.725 802

Frequency Compensated A.C. Ammeters and Voltmeters.—J. M. Whittenton & C. A. Wilkinson. (*Trans. Amer. Inst. elect. Engrs*, Nov. 1946, Vol. 65, No. 11, pp. 761–764.) Impedance changes can cause frequency errors in moving-iron voltmeters, while eddy currents can cause them in both ammeters and voltmeters. By suitable choice of materials, eddy currents can be made negligible. Errors due to impedance changes can be corrected by shunting about 75% of the series resistance with a capacitor.

621.317[.72 + .784 803

A Precision A.C./D.C. Comparator for Power and Voltage Measurements.—G. F. Shotter & H. D. Hawkes. (*J. Instn. elect. Engrs*, Part I, Nov. 1946, Vol. 93, No. 71, pp. 549–550.) Summary of 183 of January.

621.317.73 804

Reactance Comparator.—(*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 142 . . 150.) The tuning of a circuit containing the test reactor is varied by a vibrating reed capacitor. A thyratron-controlled stroboscope lamp illuminates a pointer attached to the reed when the natural frequency of the test reactor equals that of the oscillator under test.

621.317.73 : 518.3 805

Capacity Nomogram for Use with Avometer Type D.—R. Terlecki & J. W. Whitehead. (*Electronic Engng*, Nov. 1946, Vol. 18, No. 225, p. 336.) The unknown capacitance is connected in series with the 230-V a.c. mains and the Avometer, set to the 300 V a.c. range. The nomogram shown can then be used for measuring capacitances from 200 to 100 000 pF.

621.317.733 806

An Equal-Ratio Impedance Bridge.—L. G. Alexander. (*A. W. A. tech. Rev.*, Sept. 1946, Vol. 7, No. 1, pp. 59–77.) A detailed description of a bridge which has an accuracy of 1%, or better, in measuring impedances at frequencies up to 3 Mc/s.

621.317.733 : 518.4 807

Universal Chart for Unbalanced Bridge.—R. C. Paine. (*Electronic Industr.*, Nov. 1946, Vol. 5, No. 11, pp. 72–74..110.) Gives graphical methods for determining the detector voltages of unbalanced bridges and derives a universal chart.

621.317.75 : 621.396.619 : 621.397.61 **808**

Test Oscilloscope for Television Stations.—A. H. Brolly & W. R. Brock. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 120–122.) For measurement of transmitter modulation. The r.f. signal is picked up from the transmitter feeder and is fed through a tuned transformer directly to the Y-deflexion plates of a cathode-ray tube; a timebase for the X deflexion operates at half the time frequency.

621.317.755 : 621.3.001.4 **809**

Routine Testing by Cathode Ray Oscillograph.—F. Haas. (*Toute la Radio*, June 1946, Vol. 13, No. 106, pp. 161–163.) Full circuit details are given for apparatus which gives a vertical trace on a c.r.o. corresponding to a particular frequency. For routine testing of capacitors or inductances connexions are made to an oscillator so that the trace on the c.r.o. is displaced from the central position by an amount proportional to the percentage error. The method is readily adaptable to routine testing of lengths, thicknesses, angles, etc.

621.317.757 **810**

A Non-Reactive [Déphaseuse] **Valve and a New Method of Harmonic Analysis.**—A. Colombani. (*C. R. Acad. Sci., Paris*, 8th Oct. 1945, Vol. 221, No. 15, pp. 399–401.) Across the anode resistance of a pentode is connected, through 1-μF capacitors, a bridge of two fixed resistors, one variable resistor R and a variable capacitor C. The voltage across one diagonal of the bridge can be varied both in magnitude and phase with respect to that across the other diagonal by suitably altering R and C. By coupling this circuit to a variable frequency oscillator, together with the source to be analysed, it is possible to measure the frequencies, amplitudes, and phase differences of the harmonics with reference to the fundamental.

621.317.76.029.64 **811**

U.H.F. Signal Generator [Mark SX-12].—(*Electronic Industr.*, Nov. 1946, Vol. 5, No. 11, pp. 76–77.) A set of five interchangeable klystrons supplies microwave energy at any frequency from 2 600 Mc/s to 10 300 Mc/s and can be matched to any load by means of a tunable double-stub transformer. It delivers at least 200 mW, and up to 750 mW in certain frequency ranges. The stable output can be modulated either in frequency or in amplitude. A built-in generator gives undistorted square-waves up to 100 V (peak) in the range 350–3 500 c/s, and may be externally synchronized. The electronically regulated power supply of the klystron delivers up to 1 250 V with better than $\pm$ 0.2 V regulation, and less than 0.2 V peak to peak ripple.

621.317.761 **812**

Precision Frequency Meter.—P. Bernard. (*Toute la Radio*, May 1946, Vol. 13, No. 105, pp. 121–124.) An account of a rack-mounted equipment of controlled multivibrators, selectors, mixers and filters designed originally for the precision measurement of quartz crystal frequencies by unskilled workmen. The unknown frequency is caused to beat successively with standard decade frequencies and can be read directly from the settings of the various selectors. An absolute precision to within 1 c/s is obtainable.

621.317.784 : 621.392 **813**

A Wide-Band Wattmeter for Wave Guide.—H. C. Early. (*Proc. Inst. Radio Engrs, W. & E.*, Oct. 1946, Vol. 34, No. 10, pp. 803–807.) Used to measure the power transmitted by a waveguide or coaxial transmission line, the wattmeter consists of a special section of 1½ inches by 3 inches waveguide containing a tapered ridge, with a directional coupler assembly connected to two lengths of cable, each with a thermojunction at the end and a low resistance microammeter. The cable lengths are so chosen that the variation of attenuation with frequency compensates for the variation of voltage pick-up in the coupler loop, giving a substantially constant calibration over the range 8–12 cm.

621.317.784.029.64 **814**

Microwave Wattmeter.—(*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 164..169.) The current flowing into a matched terminated transmission line is measured by a thermocouple. At low frequencies (20 Mc/s) the terminating resistance decides the input impedance while at high frequencies (1 500 Mc/s) the line has sufficient loss for the characteristic impedance to be the deciding factor.

621.362 **815**

Characteristics of Thermocouples.—C. T. Weller. (*Gen. elect. Rev.*, Nov. 1946, Vol. 49, No. 11, pp. 50–53.) Standard calibration points, operating ranges, and limits of departure from the average curve are tabulated for the five principal types of thermocouple, namely copper-copnic, iron-copnic, chromel-copnic, chromel-alumel, and platinum-platinum with 10% rhodium. The voltage is also shown graphically as a function of temperature difference between the two ends for these types of thermocouple, and is tabulated for copper-copnic thermocouples.

621.385 : 621.317.7 **816**

Simple Valve Tester.—R. E. Hartkopf. (*Wireless World*, Dec. 1946, Vol. 52, No. 12, pp. 386–390.) For measurement of insulation, mutual conductance and emission.

621.396.611 : 621.396.615.18 **817**

The Inductance-Capacitance Oscillator as a Frequency Divider.—E. Norrman. (*Proc. Inst. Radio Engrs, W. & E.*, Oct. 1946, Vol. 34, No. 10, pp. 799–803.) The basic circuit and the effects of changes in the values of the circuit components on the range of frequency control are discussed. Details are given of a four-stage frequency divider, with an output of 90 c/s, controlled by an 81 kc/s quartz crystal oscillator. The method of tuning the successive oscillator stages is described.

621.396.615.14.029.54/.62 **818**

Design of F. M. Signal Generator.—D. M. Hill & M. G. Crosby. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 96–101.) The means of obtaining constant frequency deviation with a reactance modulator are discussed for both heterodyne and the constant-deviation variable oscillator systems. In the latter, which is shown to be the more efficient, a modulation input potentiometer is ganged with the tuning dial. A satisfactory design is one in which the reactance-modulated oscillator operates from 27 to 54 Mc/s, and is balanced by a doubler stage and a second doubler output stage, providing frequency coverage from 54 to 216 Mc/s. Maximum stability and simplicity are achieved since oscillator and modulator operate at a low frequency and r.f. switching is simple. By means of a converter, the range 100 kc/s – 25 Mc/s can also be covered.

621.396.62.029.64 **819**
Components of U.H.F. Field [strength] **Meters.**—E. Karplus. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 124–129.) A description of the characteristics of the various units concerned. (*a*) The tuning limitations of butterfly circuits, which are described in detail in 3260 of 1945 (Karplus), are discussed in terms of circuit dimensions. Where low losses are more important than wide tuning range, cylinder or coaxial butterfly circuits are preferable. These are fully described in 1797 of 1946 (Gross). (*b*) A tunable resonator with a five-to-one frequency range is described, which uses a short, fixed waveguide and a long flexible conductor which is pushed through the guide as required to produce resonance. (*c*) For a cartridge type crystal detector the correction for frequency is examined, and necessary precautions in use are mentioned. (*d*) The output from a signal generator may be checked by measuring either the input to the attenuator or the output at a known attenuator setting. (*e*) A regulated power supply can be obtained by using a controlled saturable reactor in the power input circuit.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

539.16.08 : 546.841.78 : 621.385.032.21 **820**
A Geiger Counter for Determination of Thorium Content of Thoriated-Tungsten Wire.—R. E. Aitchison. (*A. W. A. tech. Rev.*, Sept. 1946, Vol. 7, No. 1, pp. 1–5.)

621.314.12 : 621.3.07 **821**
Industrial Applications of the Amplidyne.—F. Penin. (*Rev. gén. Élect.*, July 1946, Vol. 55, No. 7, pp. 266–270.) Essentially consisting of two generators in series, the amplidyne gives power amplification of the order of 10 000, with a low time constant, so that a power of a few microwatts from a radar receiving aerial can be applied through an electronic amplifier to operate apparatus requiring hundreds of kilowatts. Industrial applications are described, such as the control of h.f. alternators for induction furnaces, or of the voltage of a d.c. generator, with limitation of the current.

621.315.332.7. 001.4 **822**
Process Testing of Film Continuity on Formex Fine Wire.—B. Mulvey. (*Gen. elect. Rev.*, Nov. 1946, Vol. 49, No. 11, pp. 46–48.) An apparatus consisting essentially of mercury electrodes, an electronic relay, and a recorder is used to count the number of breaks in enamel film covering fine wire as soon as the wire is made. Constructional and operating details are given.

621.317.35 : 578.088.7 **823**
A New Electronic [infrasonic frequency] **Analyser.**—Baldock & Grey Walter. (*See* 794.)

621.317.39 : 531.7 **824**
Recent Electrical Devices for the Measurement of Forces, Acceleration and Displacements.—H. Gondet. (*Rev. gén. Élect.*, April 1946, Vol. 55, No. 4, pp. 123–135.) Many practical inventions are described, based on the properties of piezoelectric crystals, magnetostriction, variation of magnetic fields, capacitance, resistance and inductance changes. Devices using a photoelectric cell are also discussed. An indication is given of the accuracy to be expected.

621.317.39 : 633.1 **825**
Determination of the Moisture Content of Cereals by Measurement of Specific Inductive Capacity.—L. G. Groves & J. King. (*J. Soc. chem. Ind., Lond.*, Oct. 1946, Vol. 65, No. 10, pp. 320–324.)

621.317.725 : 621.385 : 536.52 **826**
Flame Radiation Measuring Instrument.—E. M. Yard. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 102–104.) A highly stable bridge-type battery-operated valve voltmeter connected to a radiation pyrometer, for checking performance of open-hearth steel furnaces.

621.318.572 : 531.76 **827**
High Speed Counter.—(*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 190, 192.) The apparatus, now being produced in quantity, can be used to measure velocities and accelerations for intervals up to 1 sec in steps of 1 μs.

621.365 **828**
High-Frequency Heating.—M. J. A. (*Toute la Radio*, July/Aug. 1946, Vol. 13, No. 107, pp. 168–173.) Practical methods and applications.

621.365.5 **829**
Duplex Operation of Induction Heaters.—W. C. Rudd. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 93–95.) Multiple connexion of identical units, for either two-phase or three-phase input, can provide twice the power of either unit operating alone.

621.383 : 535.24 **830**
Logarithmic Photometer.—M. H. Sweet. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 105–109.) A method for obtaining logarithmic response to light intensity from a photocell.

621.383 : 535.33.071 **831**
Observation of Spectral Lines with Electron Multiplier Tubes.—J. D. Craggs & W. Hopwood. (*Nature, Lond.*, 2nd Nov. 1946, Vol. 158, No. 4018, p. 618.)

621.384 **832**
A New Method for Displacing the Electron Beam in a Synchrotron.—J. S. Clark, I. A. Getting & J. E. Thomas, Jr. (*Phys. Rev.*, 1st/15th Oct. 1946, Vol. 70, Nos. 7/8, pp. 562–563.) Auxiliary coils are provided to induce radial oscillations of the beam, which can be swept across the target in a time of the order of 2 μs.

621.384.6 **833**
The Betatron.—A. Ghosh. (*Sci. Culture*, Aug. 1946, Vol. 12, No. 2, pp. 75–85.)

621.384.6 **834**
Experimental 8 MeV Synchrotron for Electron Acceleration.—F. K. Goward & D. E. Barnes. (*Nature, Lond.*, 21st Sept. 1946, Vol. 158, No. 4012, p. 413.) Results obtained indicate that the

nchrotron gives much greater energy and X-ray eld than the betatron without increase in magnet e.

1.385.833 **835**

Determination of the First Order Elements of mmetrical Electrostatic Lenses.—P. Chanson, Ertaud & C. Magnan. (*C. R. Acad. Sci., Paris*, th Aug. 1945, Vol. 221, No. 8, pp. 233–235.)

1.386 + 537.531] : 535.34 **836**

Absorption Measurements for Broad Beams of and 2-Million-Volt X-Rays.—G. Singer, C. B. aestrup & H. O. Wyckoff. (*Bur. Stand. J. Res.*, g. 1946, Vol. 37, No. 2, pp. 147–150.)

1.396 : 539.172.4 **837**

Electronics at Bikini.—D. G. Fink & C. L. Engle-n. (*Electronics*, Nov. 1946, Vol. 19, No. 11, . 84–89.) A description, with photographs, of equipment used at the atomic bomb tests for ording the geophysical phenomena and for amining the effects of blast and radiation on radio uipment.

.396.029.64 : 643.33 **838**

Radarange for Cooking.—(*Electronics*, Nov. 1946, . 19, No. 11, pp. 178, 180.) Microwave cooking ng a magnetron and a horn aerial to direct r.f. rgy into food. See also *Elect. Engng, N.Y.*, . 1946, Vol. 65, No. 12, p. 591.

.398 **839**

Continuously Variable Radio Remote Control.—ore. (*See* 682.)

398 : 621.6.031 **840**

arrier Supervisory Control of Pumping Station r Power Cable.—W. A. Derr, W. A. Keller & A. W. Hedke. (*Trans. Amer. Inst. elect. Engrs*, . 1946, Vol. 65, No. 11, pp. 699–710.)

.123 : 621.3.013.8 **841**

he Magnetic Field of a Ship and Its Neutralization Coil Degaussing.—W. C. Potts. (*J. Instn elect. rs*, Part I, Nov. 1946, Vol. 93, No. 71, pp. –495. Discussion, pp. 522–524.)

123 : 621.3.013.8 **842**

he Electrical Engineering Aspect of Degaussing. S. Fraser, A. A. Read & B. E. Vieyra. (*J. n elect. Engrs*, Part I, Nov. 1946, Vol. 93, No. 71, 496–507. Discussion, pp. 522–524.)

123 : 621.3.013.8 **843**

ocesses applied to a Ship to alter Its State of netization.—S. H. Ayliffe. (*J. Instn elect. rs*, Part I, Nov. 1946, Vol. 93, No. 71, pp. –517. Discussion, pp. 522–524.)

123 : 621.3.013.8 **844**

he Correction of Ships' Magnetic Compasses for Effects of Degaussing.—H. C. Wassell & D. A. ner. (*J. Instn elect. Engrs*, Part I, Nov. 1946, 93, No. 71, pp. 518–522. Discussion, pp. 524.)

PROPAGATION OF WAVES

1 + 535.13] Huyghens **845**

n Huyghens' Principle.—Y. Rocard. (*Onde* , July 1946, Vol. 26, No. 232, pp. 288–298.) esentation intended to be mathematically rigid and physically useful. The derivation of Kirchhoff's formula from Green's theorem is given and the formula is applied to the simple case of acoustical radiation from a monochromatic point source. The application to electromagnetic waves is considered, and the radiation from an elementary area dS situated in a normal plane wave is discussed in detail and the diffracted energy calculated. The case of larger obstacles is considered; in particular Darbord's method is applied to a doublet at the focus of a parabolic mirror.

538.566 : 551.4 **846**

The Diffraction of Radio Waves around the Surface of the Earth.—V. A. Fock. Published as a monograph by the Academy of Sciences of the U.S.S.R., Moscow, 1946, 80 pp. In Russian.

A theoretical treatment of the propagation of radio waves round the curved surface of the earth for distances short enough for ionospheric influences to be negligible. The finite conductivity of the earth is taken into account. Formulae appropriate to the region where the transmitter and the observation point are intervisible, and also to the diffraction zone, are derived, and particular attention is paid to the evaluation of the field in the region of the 'cut-off' point.

The work is in agreement with the earlier considerations of Weyl and van der Pol, but represents an extension of their analyses, particularly in so far as it permits the determination of the field produced by ultra-short waves just inside the diffraction zone.

538.566.2 + 534.222.1 **847**

Propagation of Radiation in a Medium with Random Inhomogeneities.—P. G. Bergmann. (*Phys. Rev.*, 1st/15th Oct. 1946, Vol. 70, Nos. 7/8, pp. 486–492.) An analysis is given of the propagation of radiation through a medium whose index of refraction varies from point to point or from time to time in a random manner. The methods of geometrical optics are used to correlate statistically the variations in optical path length and received signal level with the properties of the inhomogeneities. The dependence of signal fluctuation on range may be predicted without a detailed knowledge of the statistical properties of the medium. The results obtained may be applied to the propagation of either electromagnetic or sound waves of high frequency in the atmosphere.

551.510.535 **848**

High-Power Radio Soundings of the Ionosphere.—Lejay & Chezlemas. (*See* 726.)

621.396.11 **849**

Propagation of Electromagnetic Waves in a Medium with Non-Uniform Electrical Characteristics and with a Magnetic Field. [Thesis]—C. T. F. van der Wyck. Drukkerij Waltman (A. J. Mulder), Delft, 1946. In Dutch, with long English summary.

Theoretical analysis of the propagation of plane, cylindrical, and spherical waves, in a medium with an exponential variation of electrical characteristics in a vertical direction, under the influence of a uniform magnetic field.

621.396.81.029.64 : 629.13 **850**

Effect of Aircraft on Fading.—J. W. Whitehead. (*Wireless Engr*, Jan. 1947, Vol. 24, No. 280, p. 29.) The type of fading to be expected in v.h.f. ground-based communication systems due to reflection from an aircraft is briefly discussed and illustrations are given.

621.396.812.029.4/.5 : 539.172.4 **851**

A Note on " The Possible Effect of the Atomic Bomb Test at Bikini on Radio Reception ", at about 3.05 a.m. (I.S.T.) on 25th July 1946.—S. P. Chakravarti. (*Curr. Sci.*, Aug. 1946, Vol. 15, No. 8, pp. 226–227.) The results of some observations taken at Bangalore in the direction of Bikini during the test. Reception of atmospherics at λ 20 000 m was increased ; the field strength of an American station on λ 25.3 m decreased considerably.

621.396.812.029.64 **852**

Propagation of Microwaves.—A. de Gouvenain. (*Toute la Radio*, Feb. 1946, Vol. 13, No. 103, pp. 50–52.) A survey of general propagation characteristics, taking account of refraction, with application to u.s.w. link calculations.

621.396.812.3 : 551.510.535 **853**

Space-Diversity Reception and Fading of Short-Wave Signals.—S. S. Banerjee & G. C. Mukerjee. (*Nature, Lond.*, 21st Sept. 1946, Vol. 158, No. 4012, pp. 413–414.) An account of observations on the fading of signals of 16–41 m wavelength over a 700 km path. Occasionally the nature of the fading changes from random fluctuations to smooth and quasi-periodic variations, according as the signals suffer single or multiple reflection in the ionosphere.

621.396.96 : 523.53 " 1946.10.09 " **854**

Radar Observations during Meteor Showers 9 October 1946.—R. Bateman, A. G. McNish & V. C. Pineo. (*Science*, 8th Nov. 1946, Vol. 104, No. 2706, pp. 434–435.) A peak pulse power of about 100 kW on 107 Mc/s was used in tests carried out at the Sterling (Virginia) Laboratory of the National Bureau of Standards. Observations were both visual and photographic. On 9th Oct. 1946 the rate of occurrence of radar echoes rose from about 8 per hour at 7.30 p.m., 75°W mean time, to a peak of over 60 per hour between 10.30 and 11.30 p.m., the predicted time for the maximum intensity of the Draconid shower being 10.00 p.m. Cloud prevented visual observations.

RECEPTION

621.396.62 **855**

High Fidelity Receiver.—J. C. Hoadley. (*Radio News*, Nov. 1946, Vol. 36, No. 5, pp. 46–48.) Straight r.f. amplification ; infinite impedance detector.

621.396.62 : 621.317.79 **856**

A Signal Tracer.—F. Haas. (*Toute la Radio*, Feb. 1946, Vol. 13, No. 103, pp. 56–58.) A practical instrument for fault finding in receivers, which enables the signal to be followed from the aerial socket to the loudspeaker.

621.396.62 : 621.396.619.13].015.33 **857**

The Theory of Impulse Noise in Ideal Frequency-Modulation Receivers.—D. B. Smith & W. E. Bradley. (*Proc. Inst. Radio Engrs, W. & E.*, Oct. 1946, Vol. 34, No. 10, pp. 743–751.) An analysis is given of the effect of impulsive noise on an ideal f.m. receiver. It is shown that the amplitude and waveform of the generated noise are substantially independent of the amplitude and waveform of the initiating noise. One form of generated noise is determined largely by the characteristics of the audio amplifier and results from a perturbation of the phase of the detector signal, while another and more objectionable form is produced by the de-emphasis circuit when the phase of the detector signal is caused to slip one revolution.

" An operational formula for the ideal detection process is given from which both the steady-state and transient solutions of the detection process may be derived."

621.396.62.029.52/.62 **858**

Special-Purpose Receivers for the Range 50 kc/s to 50 Mc/s.—B. Sandel. (*A.W.A. tech. Rev.*, Sept. 1946, Vol. 7, No. 1, pp. 89–93.) A brief description of two directly-calibrated receivers, covering respectively the ranges 50 kc/s–5 Mc/s in six bands, and 5–50 Mc/s in eight bands. They were used for testing signal generators.

621.396.621 **859**

Murphy A104.—(*Wireless World*, Dec. 1946, Vol. 52, No. 12, pp. 394–395.) Test report on table model receiver for a.c. mains.

621.396.621 **860**

New Communication Receiver.—(*Wireless World*, Dec. 1946, Vol. 52, No. 12, p. 425.) A brief description of equipment B40/B41 made by Murphy Radio for the Admiralty, consisting of two receivers covering the ranges 640 kc/s–30.6 Mc/s and 14.7–720 kc/s.

621.396.621.029.5 **861**

Some Considerations in the Design of Communication Receivers.—I. F. Simpson. (*Electronic Engng*, Nov. 1946, Vol. 18, No. 225, pp. 332–336.) Desirable qualities of self-contained and semi-portable receivers in the frequency range 130 kc/s–30 Mc/s are considered, and the compromises which have been necessary in their development. An accurately calibrated oscillator, stable to within ±6 kc/s at 30 Mc/s, is the most important requirement. Sensitivity, a.v.c., noise, selectivity, ease of handling, flexibility, spurious response, and signal strength indication are also discussed.

621.396.621.029.54 **862**

A Home-Made Midget Receiver.—L. G. Woollett. (*Electronic Engng*, Nov. 1946, Vol. 18, No. 225, p. 352.) Employs an internal frame aerial, uses ordinary battery-type valves, and is internally powered. Frequency range is 588–1 230 kc/s, and dimensions are $4\frac{5}{8}$ inches × $4\frac{1}{8}$ inches × $3\frac{3}{4}$ inches.

621.397.82 **863**

Television Sound Rejection.—Cocking. (*See* 922.)

621.396.822 **864**

Noise Factor : Part 1.—L. A. Moxon. (*Wireless World*, Dec. 1946, Vol. 52, No. 12, pp. 391–393.) A discussion and definition of noise factor. It is defined as the number of times by which the ailable signal power must exceed KTB, where is Boltzmann's constant, T the absolute tempera-re and B the 'energy bandwidth', in order to give ity ratio of available signal-to-noise power at e input to the detector.

1.396.822 : 621.396.671 **865**
Study of the Thermal Equilibrium of Wireless rials.—Lehmann. (*See* 642.)

1.396.828 **866**
Noise Limiters.—H. B. Dent. (*Wireless World*, ec. 1946, Vol. 52, No. 12, pp. 397–398.) The ckert shunt-type noise limiter and improvements it are described. The noise is automatically ited to the strength of the carrier instead of a predetermined level. Circuit diagrams are ven.

1.396.828 + 621.396.665 **867**
Noise and Output Limiters : Part 1.—E. Toth. *lectronics*, Nov. 1946, Vol. 19, No. 11, pp. 114–119.) comprehensive survey, with circuit diagrams, eleven limiting circuits for a.m. communication eivers, including simple diode circuits, balanced ectors, self-adjusting circuits, and degenerative angements. Analysis of operation, and advan-es and disadvantages are stated for each type of uit.

ATIONS AND COMMUNICATION SYSTEMS

.315.66 **868**
New "Microwave Tower".—(*J. appl. Phys.*, t. 1946, Vol. 17, No. 9, p. 757.)

.395 : 654.05 **869**
ntensity Fluctuations in Telephone Traffic.—Palm. (*Ericsson Technics*, 1943, No. 44, pp. 89. In German.) Three principal sections : Telephone traffic considered as a stochastic , pertaining to conjecture) process. (2) Intensity tuations as a starting point for the treatment telephone traffic problems. (3) Measurement hods and results.

.396(675)" 1939/1945 " **870**
elecommunications in the Belgian Congo during War.—A. Huynen. (*Bull. sci. Ass. Inst. rotechn. Montefiore*, April/May 1946, Vol. 59, 4/5, pp. 247-262.) From Oct. 1940 short e transmissions from the Congo station at poldville were well received in Belgium, as the mans were unable to jam them to any extent. retransmission of the B.B.C. news bulletins French, a receiver was tuned to each of the .C. frequencies, thus giving a choice at any time etransmission under the best possible conditions. en the Germans jammed the B.B.C. frequency ise, simple switching arrangements gave an antaneous change to one not being jammed.

396.1 **871**
oscow [telecommunications conference]. — B. (*QST*, Jan. 1947, Vol. 31, No. 1, pp. 25–27.) ount of the discussions on amateur frequency ations.

396.1.029.62/.63 **872**
Plan for [improved frequency allocation in] **Ten-Meter Band.**—K.B.W. (*QST*, Dec. 1946, 30, No. 12 , pp. 26–27..130.)

621.396.324 **873**
High-Flying Teletype.—R. A. Vanderlippe. (*Bell Lab. Rec.*, Nov. 1946, Vol. 24, No. 11, pp. 396–399.) A lightweight teletype printer with an associated converter-control unit which makes it practicable to send teletype messages to and from aircraft in flight.

621.396.619[.13 + .16 **874**
Frequency Modulation : Pulse Modulation.—C. Dreyfus-Pascal. (*Toute la Radio*, May 1946, Vol. 13, No. 105, pp. 126–128.) A short account of an f.m. system of the Federal Telephone and Radio Corporation which enables 24 programmes to be transmitted on the same carrier wave, together with a synchronization signal. The system uses an electronic commutator with 24 elementary pentodes, each of which is linked with a particular studio. The electronic beam rotates at 24 000 c/s and the carrier frequency used is 1 300 Mc/s. See also 239 of January.

621.396.619.16 **875**
Pulse Time Modulation Circuits.—(*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 140, 142.) A preliminary description of this Federal Telecommunication Laboratories equipment was given in 2803 of 1945 (Deloraine & Labin). The transmitter will take eight audio channels with fidelity over the a.f. range 50–9 000 c/s. Its output is approximately 800–1 000 W (peak) and 40–50 W (average). This is fed to a vertically stacked omni-directional loop aerial having a gain of 9 db over a dipole. The directive receiving aerial has a parabolic reflector, with a gain of 17 db.

621.396.65 **876**
Radio Relays for Telegraphy.—F. B. Bramhall. (*Elect. Engng, N.Y.*, Nov. 1946, Vol. 65, No. 11, pp. 516–520.) Relay towers 20 to 50 miles apart will be used in a Western Union triangular radio network, New York–Washington–Pittsburgh, operating at 4 000 Mc/s with an 'audio' width of 150 kc/s divided into 1 080 teleprinter operating circuits. The absence of noise in this band and the heavy traffic makes the project economical.

621.396.7.029.58 **877**
World List of Short-Wave Transmitters.—(*Toute la Radio*, May 1946, Vol. 13, No. 105, pp. 118–119.) A list of the frequencies, call signs and locations of transmitters with frequencies from 2.5–26.55 Mc/s.

621.396.712 **878**
Cooperative Two-Station Antenna System.—L. McManus. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 154..164.) A system of phasing units and filters permits the simultaneous use of two towers as radiators and driven reflectors for two broadcasting transmitters at Sherbrooke, Quebec.

621.396.712 : 621.316.9 **879**
Protecting against Carrier Failure.—H. G. Towlson. (*Electronic Industr.*, Nov. 1946, Vol. 5, No. 11, pp. 68–71..116.) "Practical methods of insuring against interruptions and loss of broadcasting time due to lightning and other causes."

621.396.712.3 **880**
New Station Techniques.—(*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 169..176.) A summary of recent developments in B.B.C. studio

organization, and of the results of extensive f.m. field trials, abstracted from the new journal *B.B.C. Quart.*

621.396.72 **881**

Army Broadcasting.—P.B.J. (*Wireless World*, Dec. 1946, Vol. 52, No. 12, p. 414.) Location and frequencies of stations used for broadcasting to the British and American Forces.

621.396.81.029.64 : 629.13 **882**

Effect of Aircraft on Fading.—Whitehead. (*See* 850.)

621.396.931 **883**

Two-Way Radio for Power Line Crews.—(*Electronics*, Nov. 1946, Vol. 19, No. 11, p. 123.) Photographs of a f.m. transmitter and a mobile receiver.

621.396.931 **884**

Inductive System for Train Communication.—P. N. Bossart. (*Telegr. Teleph. Age*, Nov. & Dec. 1946, Vol. 64, Nos. 11 & 12, pp. 8–10, 30 & 16–19.) For communication between vehicles of the same or different trains, or between vehicles and wayside stations. At frequencies below 10 kc/s the reliable range is of the order of a mile if only the rails are used, but can be increased up to 30 or 40 miles if adjacent line wires are available. Carrier frequencies up to 100 kc/s, preferably with f.m., are used. Break-in schemes, power requirements, receiver sensitivities, squelch systems and channel widths are discussed. A 'carrytone' portable telephone can be provided to enable individuals, not necessarily in any vehicle, to communicate within the system.

621.396.931 **885**

Railroad Radiotelephone Tests on the Nickel Plate Road.—R. G. Peters. (*Communications*, Nov. 1946, Vol. 26, No. 11, pp. 14–16..34.) See also 884 and 886.

621.396.931.029.62 **886**

Two-Way V.H.F. Radio in Potomac Yard improves Control of R.R. Operations.—(*Telegr. Teleph. Age*, Dec. 1946, Vol. 64, No. 12, pp. 5–6.) Description of tests of a comprehensive v.h.f. two-way radiotelephone installation as a means of improving managerial control in the operation of large railway yards. The f.m. system included a central station transmitter and receiver, five remote control units located at key points, a mobile transmitter and receiver on each of two steam locomotives, and remote control units on their forward platforms and in their cabs. See also 885.

621.396.933 **887**

The Radio Equipment used by the Pilot of an Aircraft and the Corresponding Ground Installations.—S. Gaillard. (*Ann. Radioélect.*, April/July 1946, Vol. 1, Nos. 4/5, pp. 333–342.) A description of airborne and ground apparatus developed by the Société Indépendante de T.S.F. for the communication of landing and take-off instructions between the aerodrome controller and the pilot. The airborne transmitter (frequency band 2 800–6 700 kc/s) works on telegraphy or telephony with 20 W aerial power; the receiver requires 10 μV input for 350 mW output with a signal-to-noise ratio of not less than 26 db. The ground apparatus is similar but is designed for a.c. mains power supply.

An airborne beacon receiver (200–428 kc/s) is also described.

621.396.97.029.62 **888**

Against V.H.F. Broadcasting.—"Radiophare". (*Wireless World*, Dec. 1946, Vol. 52, No. 12, p. 412.) The objection to broadcasting on frequencies as high as 90 Mc/s with a service range of only 50 miles is that broadcasting, if limited to such frequencies, would tend to lose its international character.

SUBSIDIARY APPARATUS

531.35 : 621.396.619.13 : 621–526 **889**

A Low Frequency Mechanical Modulator.—B. B. Underhill. (*Rev. sci. Instrum.*, July 1946, Vol. 17, No. 7, pp. 280–281.) A medium-speed motor drives a fly-wheel through a continuously variable reduction gear. The motion of the fly-wheel is converted to s.h.m. by a scotch yoke-rack and pinion assembly to which a linear potentiometer is directly coupled.

621–526 **890**

Linear Servo Theory.—R. E. Graham. (*Bell Syst. tech. J.*, Oct. 1946, Vol. 25, No. 4, pp. 616–651.) "This paper discusses a typical analogy between electrical and mechanical systems and describes, in frequency response language, the behavior of such common servo components as motors, synchro circuits, potentiometers, and tachometers. The elementary concepts of frequency analysis are reviewed briefly, and the familiar Nyquist stability criterion is applied to a typical motor-drive servo system. The factors to be considered in choosing stability margins are listed—system variability, noise enhancement, and transient response. The basic gain-phase interrelations shown by Bode are summarized, and some of their design implications discussed. In addition to the classical methods, simple approximate methods for calculating dynamic response of servo systems are presented and illustrated."

621–526 **891**

Electrical Analogy Methods applied to Servomechanism Problems.—G. D. McCann, S. W. Herwald & H. S. Kirschbaum. (*Trans. Amer. Inst. elect. Engrs*, June Supplement 1946, Vol. 65, p. 515.) Discussion of 1362 of 1946.

621.314 **892**

Operation of a Vibrator.—C. Dreyfus-Pascal. **Vibrator Applications.**—C. Dreyfus-Pascal. (*Toute la Radio*, March/April 1946, Vol. 13, No. 104, pp. 86–88 & 89–91.) A review of the principles of operation, including electromechanical rectification, and circuit diagrams for various practical applications.

621.314.2.04 **893**

Transformer Theory.—P. Bricout. (*C. R. Acad. Sci., Paris*, 2nd July 1945, Vol. 221, No. 1, pp. 21–22.) Theory is given which enables all necessary calculations to be made for transformer design, given the primary and secondary voltages, maximum power, the output and the hysteresis cycle for the laminations on full load.

621.314.63.001.8 **894**

Some Applications of Dry Rectifiers.—J. Girard. (*Rev. gén. Élect.*, May 1946, Vol. 55, No. 5, pp. 192–198.) An account of the application of dry rectifiers to obtain high voltages with low or very low currents, moderate voltages with moderate ırrents, and low voltages with high currents. xamples are given of equipment for central telehone exchanges. Selenium rectifiers have recently een designed to give 60 000 A at 6 V and currents high as 150 000 A are envisaged.

.1.314.634 **895**

Selenium Rectifiers.—J. Loebenstein. (*Communitions*, Nov. 1946, Vol. 26, No. 11, pp. 26–28.) etails of design, construction and characteristics. pplications in single- and 3-phase circuits are scribed.

1.316.98 **896**

Selective Attraction of Lightning: Role of ectrical Resistances.—S. Szpor. (*Rev. gén. Élect.*, n. 1946, Vol. 55, No. 1, pp. 25–31.) Quantitative ıdy of the part played by the electrical resistance projecting points in attracting lightning shows ıt it rarely has any effect.

1.317.755.087.5 **897**

An Automatic Oscillograph with a Memory.—M. Zarem. (*Trans. Amer. Inst. elect. Engrs*, June pplement 1946, Vol. 65, p. 514.) Discussion of 9 of 1946.

.318.5 **898**

A High-Voltage Vacuum-Sealed Relay.—K. R. e. (*A.W.A. tech. Rev.*, Sept. 1946, Vol. 7, 1, pp. 95–101.) The relay was designed to be d with aircraft transmitter aerials at voltages to 15 kV (peak) and at a keying speed of v.p.m.

.318.572 : 621.396.96 **899**

Spark Gap Switches for Radar.—F. S. Goucher, R. Haynes, W. A. Depp & E. J. Ryder. (*Bell . tech. J.*, Oct. 1946, Vol. 25, No. 4, pp. 563–602.) account of war-time development work on rotary fixed switches for use in radar modulators.

he irregular breakdown of rotary spark gaps used modulator switching voltages of less than V was overcome by irradiating the gap, prior reakdown, with corona produced by a sharp t on the cathode.

vestigations into the most suitable gas atmore, electrode material and gap design for use in d-off fixed gaps are fully described with parar reference to the methods adopted for cing the effects of sputtering of the electrode ıls on the gap spacing and insulation.

perating characteristics for various types of uction gaps are given.

25.53 : 535.61–15 **900**

odulated Arc Lamp.—(*Electronics*, Nov. 1946, 19, No. 11, pp. 150, 154.) A caesium vapour for modulated infra-red ray communication nvoy and troop landing operations.

52.4 **901**

ater Activated Cell.—(*Electronic Industr.*, Nov. Vol. 5, No. 11, p. 75.) A primary battery emergency services using silver chloride as arizer and thin magnesium sheet separated ighly absorbent paper. It is both light and , has indefinite shelf life in its sealed container s activated by immersion in either fresh or ater.

621.396.615.17 **902**

A Linear Sweep Generator.—W. J. Haywood. (*Radio News*, Nov. 1946, Vol. 36, No. 5, pp. 78..84.) Saw-tooth generator, 1 to 10^6 c/s.

621.396.622.71 **903**

An Unusual Rectifier Circuit.—E. E. Comstock. (*QST*, Nov. 1946, Vol. 30, No. 11, pp. 56–57.) A combination of the conventional bi-phase centre tap rectifier circuit with an inverted form of the same circuit makes four different output voltages available.

621.396.68 : 621.385.832 **904**

R.F. H.T. Power Supplies for Cathode-Ray Tubes.—R. D. Boadle. (*A.W.A. tech. Rev.*, Sept. 1946, Vol. 7, No. 1, pp. 53–57.) Description of a 2-kV unit for an electrostatic cathode-ray tube, and a 4-kV unit for a magnetically deflected and focused tube. The high voltage circuits are enclosed in oil-filled brass or copper tanks, with solder-seal glass insulators.

669 : 621.38/.39 **905**

Specialised Metallurgical Products in Industry.—(*Electronic Engng*, Nov. 1946, Vol. 18, No. 225, pp. 328–331.) An illustrated description of products now available, including cathode tubing, metal films on glass, silvered mica capacitor packs, and specialized contacts.

621.327.4 **906**

Electric Discharge Lamps. [Book Review]—H. Cotton. Chapman & Hall, London, 36s. (*Engineering, Lond.*, 11th Oct. 1946, Vol. 162, No. 4213, p. 339.)

TELEVISION AND PHOTOTELEGRAPHY

621.385.832.087.5 **907**

A New Film for Photographing the Television Monitor Tube.—C. F. White & M. R. Boyer. (*J. Soc. Mot. Pict. Engrs*, Aug. 1946, Vol. 47, No. 2, pp. 152–164.) "A film which is specially adapted for photographing images on the P-4 monitor tube surface has been prepared. Optical sensitization is adjusted to yield peaks of sensitivity with the blue to yellow spectral region corresponding to the emission of the P-4 screen. Resolving power of the film has been found of controlling importance when used in 16-mm size and this factor has affected the choice of emulsion for this purpose. The film may be employed either as a negative or reversed."

621.385.832.088 **908**

C. R. Tube Quality Test.—P. L. F. Jones. (*Electronic Engng*, Nov. 1946, Vol. 18, No. 225, p. 353.) Apparatus which injects into a television receiver a complete waveform consisting of dots of approximately element duration separated from the next in the line scan direction by an equal space.

621.396.97 : 535.88 **909**

Pre-Television.—P. Toulon. (*Toute la Radio*, July/Aug. 1946, Vol. 13, No. 107, pp. 194–195.) An apparatus resembling an epidiascope may be used with rolls of paper film giving broadcast programme pictures, the rolls being circulated each week for the following week's programmes. Changing of the pictures may be effected by special signals.

621.397.5 **910**
Fundamentals of Television.—(*Cah. toute la Radio*, July 1946, No. 5, pp. 16–19.) The basic features of television transmitting and receiving apparatus are described; interlacing is illustrated by an inset paragraph with interlaced text.

621.397.5 **911**
Colour Television.—J. Vergennes. (*Cah. toute la Radio*, July 1946, No. 5, pp. 22–25.) Fundamental problems are discussed and a short account is given of the main features of the C.B.S. system using a set of colour screens rotated mechanically, and of Baird's special 3-colour tube.

621.397.5 : 778.5 **912**
The Relation of Television to Motion Pictures.—A. B. Du Mont. (*J. Soc. Mot. Pict. Engrs*, Sept. 1946, Vol. 47, No. 3, pp. 238–247.) A broad discussion of the applications of film recording in the television field, on the basis of the equivalence ". . . film recordings are to television what the transcribed program is to broadcasting"; and of ways in which the two industries could collaborate.

621.397.5 : 778.5 **913**
Television Reproduction from Negative Films.—E. Meschter. (*J. Soc. Mot. Pict. Engrs*, Aug. 1946, Vol. 47, No. 2, pp. 165–181.) "The expected reproduction characteristics are examined for the cases where film is included as one step of the television process. Features of performance to be expected from both negatives and prints as image sources are predicted from average characteristics of elements of the television system. A dynamic test procedure for the investigation of the over-all reproduction curve involving film and television is described. Actual tests confirm the theoretical prediction that a negative film with a rising shoulder characteristic may provide superior television images."

621.397.6 **914**
Projection Television.—(*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 212..216.) A description of (*a*) a German lens system for projecting and enlarging phosphorescent images (U.S. Patent 2 229 302) and (*b*) a system with transmission screens of zinc blende as optical polarizing gates controlled by a scanning electron beam (U.S. Patents 2 277 008 and 2 297 443).

621.397.6 **915**
High-Definition Television Equipment.—R. R. Cahen. (*Cah. toute la Radio*, July 1946, No. 5, pp. 14–15.) The special features and general lay-out of an 829-line television equipment with an amplifier pass-band of 15 Mc/s; the equipment includes telecinema apparatus with an iconoscope.

621.397.61 : 621.317.75 : 621.396.619 **916**
Test Oscilloscope for Television Stations.—Brolly & Brock. (*See* 808.)

621.397.611 : 621.383 **917**
Theory of the Iconoscope.—R. Barthélemy. (*C.R. Acad. Sci., Paris*, 27th Aug. 1945, Vol. 221, No. 9, pp. 245–247.) Summarizes the results of a year's work with the object of reconciling theory and practice. It appears that the simultaneous existence of a state of equilibrium and an appreciable p.d. between the front and back of the moving beam can only be caused by the action of space charge.

621.397.611.2 + 771.53 + 535.736.1 **918**
A Unified Approach to the Performance of Photographic Film, Television Pickup Tubes, and the Human Eye.—A. Rose. (*J. Soc. Mot. Pict. Engrs*, Oct. 1946, Vol. 47, No. 4, pp. 273–294.) "The picture pickup devices—film, television pickup tube, and eye—are subject ultimately to the same limitations in performance imposed by the discrete nature of light flux. The literature built up around each of these devices does not reflect a similar unity of terminology. The present paper is exploratory and attempts a unified treatment of the three devices in terms of an ideal device." In this ideal device scene brightness is proportional to the square of the signal/noise ratio and inversely proportional to the picture element area and to quantum efficiency.

621.397.62 **919**
Pye Television Model B16T.—(*Wireless World*, Dec. 1946, Vol. 52, No. 12, pp. 403–407.) Test report and full circuit diagram.

621.397.62 : 621.392 **920**
The Choice of Transmission Lines for connecting Television Receiving Aerials to Receivers.—Strafford. (*See* 633.)

621.397.645 **921**
Video Amplifier H.F. Response: Part 3.—(*See* 681.)

621.397.82 **922**
Television Sound Rejection.—W. T. Cocking. (*Wireless World*, Dec. 1946, Vol. 52, No. 12, pp. 417–421.) The various forms of rejector and acceptor circuits used in avoiding interference between the sound and vision channels are fully analysed and their effect on the main inter-valve coupling is discussed.

621.397.82 **923**
Television Fading.—G. T. Clack. (*Electronic Engng*, Nov. 1946, Vol. 18, No. 225, p. 353.) Suggestions to reduce the effects of fading in television receivers due to reflections from aircraft by introducing a.c. coupling to the c.r. tube.

621.397.5 **924**
Television Simplified. [Book Review]—M. S. Kiver. D. Van Nostrand, New York, 1946, 369 pp. $4.75. (*Proc. Inst. Radio Engrs, W. & E.*, Oct., 1946, Vol. 34, No. 10, p. 772.)

TRANSMISSION

621.385 + 621.396.694 **925**
The VT-127-A in Amateur Transmitters.—G. E. Davies. (*QST*, Nov. 1946, Vol. 30, No. 11, pp. 33–37..132.) Operating data and constructional details for using these valves in a 144-Mc/s transmitter both as the doubler valve and in push-pull as the final amplifier. Operation at audio and low frequencies is also suggested.

621.396.61 + 538.561 926
Electric Signals with Rectangular Frequency Spectrum.—P. Boughon & P. Jacquinot. (*C.R. Acad. Sci., Paris*, 24th June 1946, Vol. 222, No. 26, pp. 1476–1478.) An experimental and theoretical study of the production of oscillations having a uniform distribution of energy over the band ΔN, and negligible energy outside this band. The theoretical form of such oscillations is $f(t) = E_0\cos 2\pi N_0 t\,[(\sin\pi\Delta Nt)/\pi\Delta Nt]$ where N_0 is the mid frequency. A modulation voltage proportional to $(\sin\pi\Delta Nt)/\pi\Delta Nt$ was obtained by rotation of a disk in front of a photoelectric cell with a window, so that the height of the window uncovered varied as $a + (\sin\pi\Delta Nt)/\pi\Delta Nt$. The voltage from the cell was applied to a symmetrical modulator, balanced so as to eliminate the constant term a. The bandwidth could be varied at will by altering the speed of the disk.

621.396.61 927
New Transmitter for Amateur Radio.—W. Bruene & N. Hale. (*Radio News*, Nov. 1946, Vol. 36, No. 5, pp. 39 . . 111.) A general account of the Collins 30K transmitter.

621.396.61.029.5 928
200 Watt All-Band Transmitter.—H. D. Hooton. (*Radio News*, Nov. 1946, Vol. 36, No. 5, pp. 40– . . 134.) An easily constructed unit, with either crystal or v.f.o. control for the 10, 20, 40 and 80 m bands.

621.396.61.029.56/.58 929
Single Control in the Bandswitching Transmitter.—J. H. Harms. (*QST*, Dec. 1946, Vol. 30, No. 12, pp. 19–25 . . 128.) "A 3.5–30 Mc/s exciter with broad-band driver circuits . . . well within the electrical and mechanical capabilities of the ordinary amateur."

621.396.61.029.56/.58 930
What about the BC-375-E?—R.M.S. (*QST*, Dec. 1946, Vol. 30, No. 12, pp. 38–42 . . 148.) A U.S. Army aircraft transmitter, using a MOPA circuit, producing 45–75 W output over a frequency range including the 3.5- and 7-Mc/s amateur bands. Considerable modifications for satisfactory amateur use would be necessary.

621.396.619.13/.14 931
A New Phase-Modulation Circuit for Narrow-Band F.M. Transmission.—J. J. Babkes. (*QST*, Jan. 1947, Vol. 31, No. 1, pp. 11–15.) The circuit described uses crystals in the 3 625–3 712 kc/s range and, after eight-fold multiplication, will produce a frequency swing of 10 to 12 kc/s at 29 Mc/s. The power output is about 3.5 W.

621.396.619.13 932
Narrow-Band F.M. with Crystal Control.—G. W. Hart. (*QST*, Nov. 1946, Vol. 30, No. 11, pp. 27– . .) Design and construction of a reactance modulator with crystal controlled oscillator, forming a narrow band f.m. system. With a 3.5-Mc/s AT-cut crystal there is a total frequency swing of 3 200 c/s at 28 Mc/s.

621.396.619.2 : 534.78 933
Don't Not Overmodulate — It isn't Necessary!—W. Smith & N. H. Hale. (*QST*, Nov. 1946, Vol. 30, No. 11, pp. 23–26.) Describes the use of speech clipping and filtering for more effective communication.

621.396.828.018.3 934
Keeping Your Harmonics at Home.—G. Grammer. (*QST*, Nov. 1946, Vol. 30, No. 11, pp. 13–19.) "A discussion of the factors in harmonic generation and radiation."

VALVES AND THERMIONICS

621.38 935
Flicker Effect.—A. Blanc-Lapierre. (*C. R. Acad. Sci., Paris*, 1st Oct. 1945, Vol. 221, No. 14, pp. 375–377.) Schottky attributes the effect to random modifications of the emissive property of the cathode due to fluctuations in the number of atoms adsorbed at its surface, but Surdin (3586 of 1939) has shown that the effect can also be explained by fluctuations of the number of free electrons in the metal, so that it is related to the Bernamont effect. The two points of view lead to equivalent mathematical hypotheses.

621.385 : 537.291 936
Deflected Beam Valves for Ultra High Frequencies.—M. R. Gavin & G. W. Warren. (*G.E.C. J.*, Aug. 1946, Vol. 14, No. 2, pp. 97–104.) The theory of transverse control of an electron beam is investigated, at frequencies where the electron transit times are comparable with the period of the alternating field. A general expression is derived for the high-frequency sensitivity of deflexion-control valves and from considerations of energy of the electrons the input resistance is deduced. In both these respects, deflexion-control valves compare favourably with grid-control valves, but high shot-noise level makes them inferior to modern high-frequency triodes as amplifiers of very small signals. A brief description is given of valves designed for frequencies up to 750 Mc/s.

621.385 : 621.396.645.029.5 937
Characteristics of Vacuum Tubes for Radar Intermediate Frequency Amplifiers.—G. T. Ford. (*Bell. Syst. tech. J.*, July 1946, Vol. 25, No. 3, pp. 385–407.) The important factors are merit bandwidth, noise figure, input conductance, constancy of capacitances, power consumption and physical size. The effect of valve geometry on transconductance and electrode capacitances is considered in detail for an idealized plane structure. The close spacing used ensures that any limitation due to input conductance is due to lead inductance rather than to transit time effects. The cathode emission and the valve geometry of the Western Electric 6AK5 (described in detail) are such that a noise figure of 2.8 may be obtained at 60 Mc/s with a bandwidth of 10 Mc/s.

621.385.029.63/.64 938
Wideband Microwave Amplifier Tube.—F.R. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 90–92.) For another account see 585 of February.

621.385.032.24 939
Certain Electrostatic Properties of Grid Electrodes.—V. S. Lukoshkoff. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, 1944, Vol. 8, No. 5, pp. 243–247. In Russian.) A conception of an ideal grid with an infinitely fine mesh is introduced, and a general theory applicable to grids of all shapes and struc-

tures in conjunction with neighbouring electrodes developed. The electrostatic field is regarded as made up of two fields, the 'far' field determined by the shape of the grid and of the neighbouring electrodes, and the 'near' field similar in its structure to that of the grid. Using these conceptions, and referring to his previous work (3394 of 1936), the author considers the triode to which all other multi-electrode types can be reduced. In all classical theories of the triode it is assumed that the field at the cathode is the same as it would be were the grid replaced by a whole electrode of the same shape and having a potential U_δ related to the grid potential U_g in accordance with formula (1). Thus the triode is reduced in effect to a diode in order to determine the cathode field. The main problem of this analysis becomes the question whether such a reduction can be used with any type of triode. It is concluded that such a reduction is justifiable only under the following two conditions: (*a*) the shape of the grid should be co-ordinated with that of the other two electrodes, and (*b*) the structure and shape of the grid should also be co-ordinated. Further possible developments of the analysis are also given.

An abstract in English was noted in 2397 of 1946.

621.385.1 + 621.396.694 **940**

Analysis of Intermittent Discharges in Valves.—J. Moussiegt. (*C. R. Acad. Sci., Paris*, 27th May 1946, Vol. 222, No. 22, pp. 1280–1282.) An explanation of the intermittent nature of the discharge in a valve, across which is connected a capacitance above a certain minimum value, is based on the fact that a portion of the voltage/current characteristic has a negative slope.

621.385.1 **941**

Current Maximum in Intermittent Functioning of Discharge Tubes.—J. Moussiegt. (*C. R. Acad. Sci., Paris*, 24th June 1946, Vol. 222, No. 26, pp. 1479–1480.) A systematic study of a commercial neon tube containing some argon. A linear relation is shown to exist between the reciprocals of the current maximum and the parallel capacitance. See also 940 above.

621.385.1.032.216 **942**

Oxide Coated Cathode Literature, 1940-1945.—J. P. Blewett. (*J. appl. Phys.*, Aug. 1946, Vol. 17, No. 8, pp. 643–647.) A brief survey with an annotated bibliography.

621.385.1.032.216 **943**

The Pulsed Properties of Oxide Cathodes.—E. A. Coomes. (*J. appl. Phys.*, Aug. 1946, Vol. 17, No. 8, pp. 647–654.) A survey of experimental results. Large electron currents are available in microsecond pulses. Sparking, which may be either current limited or voltage limited, and pulse temperature rise depend on cathode materials and life; pulse temperature rise also indicates the nature of cathode resistance. Pulsed data also provide evidence for a layer structure of the oxide cathode.

621.385.1.032.216 : 537.13 **944**

Some Cases of Interaction between Positive Ions and Metallic Surfaces.—Morgulis. (*See* 744.)

621.385.1.032.216 : 621.386.1 **945**

A Study of Oxide Cathodes by X-Ray Diffraction Methods: Part 2 — Oxide Coating Composition.—A. Eisenstein. (*J. appl. Phys.*, Aug. 1946, Vol. 17, No. 8, pp. 654–663.) An investigation of the time changes occurring in oxide cathode coating composition. Lattice constant measurements are used to detect changes in the bulk of the coating and a new method of diffraction pattern analysis gives variation of composition with depth below the surface. The effect on the thermionic emission of changes in BaO-SrO composition, which depends on the base metal used, is discussed. For part 1 see 3811 of 1946; see also 943 above and 946 below.

621.385.1.032.216 : 621.386.1 **946**

Studies of the Interface of Oxide Coated Cathodes.—A. Fineman & A. Eisenstein. (*J. appl. Phys.*, Aug. 1946, Vol. 17, No. 8, pp. 663–668.) X-ray diffraction patterns show the existence of a crystalline 'interface' compound between the base metal and the oxide coating of the cathode. This 'interface' has an anomalous resistance to microsecond pulse currents, whose value, measured with embedded probes, is shown as a function of peak current for various operating temperatures. See also 945 above.

621.385.16 **947**

The Donutron.—F. H. Crawford & M. D. Hare. (*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 200.. 204.) Abstract with drawings of an unpublished report by F. H. Crawford and M. D. Hare of Harvard University on a tunable squirrel cage magnetron having an output of 50 W at 45% efficiency operating in the re-entrant line mode over a frequency range of 1 to 1.5 at a single anode voltage.

621.385.16 **948**

The Internal Mechanism of the Magnetron.—J. Voge. (*Onde élect.*, Aug-Oct. 1946, Vol. 26, Nos. 233–235, pp. 345–354 & 374–386.) The steady state conditions in a non-oscillating magnetron are first considered: the importance of taking into account the initial velocity of the electrons is stressed. For voltages up to a value somewhat exceeding the critical potential, cardioid and spiral trajectories are possible. Reasons are advanced suggesting that the latter type occurs in practice. At higher potentials the cardioid type alone is obtained.

The processes involved in an oscillating magnetron are considered in part 2. Formulae are obtained for the frequencies of the possible modes of oscillation, in terms of the magnetic field and number of anode segments. The internal impedance of the magnetron is also calculated. Finally, theory and experiment are compared.

621.385.3 : 621.396.694.012.8 **949**

Theory of the Equivalent Diode.—G. B. Walker. (*Wireless Engr*, Jan. 1947, Vol. 24, No. 280, pp. 5–7.) A new method, based on electrostatic considerations, is suggested whereby the equivalent diode can be uniquely determined whatever the emission velocity may be.

621.385.38 **950**

The Parallel Operation of Gasfilled Triodes.—G. Windred. (*Electronic Engng*, Nov. 1946, Vol. 18, No. 225, pp. 337–338, 357.) By operating thyratrons in parallel, increased anode currents may be obtained. In some cases two small tubes can be more economical than one large one. Failure of one ɛube may cause overloading of the other. A tube replacement technique is suggested whereby a faulty tube may be replaced without interrupting the operation of the circuit. Possible methods of ensuring the simultaneous striking of both tubes are discussed.

521.385.38 **951**

Extending Thyratron Life.—(*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 210, 212.) Abstract of report by H. W. Gerlicher of Evans Signal Laboratory. The loss of hydrogen due to absorption by nickel parts of the tube is made good by placing within the envelope a heated capsule of titanium hydride powder.

21.385.4/.5 **952**

Tetrode *versus* Pentode.—L. Chrétien. (*Toute la Radio*, Dec. 1945, Vol. 12, No. 101, pp. 2–4..8.) he characteristics of both valves are reviewed, nd it is concluded that the tetrode gives better erformance for power amplification. Push-pull rrangement of tetrodes is advocated, in order to iminate harmonics of even order.

21.385.41 **953**

Spontaneous Fluctuations in a Double-Cathode alve.—D. K. C. MacDonald. (*Wireless Engr*, Jan. 47, Vol. 24, No. 280, p. 30.) At low temperatures 900–2 000°K) the ratio, β, of the ' fluctuation mperature ' to the true temperature approximates unity. The rapid rise of β at higher temperatures difficult to explain in terms of positive ion nission.

1.385.82.029.3 : 621.395.61 **954**

High Power Thermionic Cell using Positive Ion nission and operating in a Gaseous Medium.— Klein. (*C. R. Acad. Sci., Paris*, 27th May 1946, l. 222, No. 22, pp. 1282–1284.) Another account the cell described in 593 of February.

1.396.615.142 **955**

Lens Effect of Alternating Fields in Velocity odulated Valves.—P. Guénard. (*Ann. Radioélect.*, ril/July 1946, Vol. 1, Nos. 4/5, pp. 319–323.) a velocity-modulated valve, the electric field ross the gap in the modulating electrode (buncher) oduces a ' lens ' effect, so that an incident rallel beam of electrons is not only bunched e normal velocity-modulation effect) but benes alternately convergent and divergent. The ect is computed for the case of small applied ds.

1.396.615.142.2 **956**

The Theory of the Monotron.—S. Gvozdover & Lopukhin. (*Zh. eksp. teor. Fiz.*, 1946, Vol. 16, . 6, pp. 528–536. In Russian, with English nmary.) Resonant frequencies, the amplitude stationary vibrations, the efficiency, and the nimum current required for excitation are deterned for the monotron. The monotron is a single cuit klystron whose operation is based on the t that negative impedance can be produced by ssing an electron discharge between two rallel planes. The original theory of J. J. ller (406 and 1010 of 1942) and F. B. Llewellyn 55 of 1939) is elaborated.

621.396.69 : 389.6 **957**

Why New Valves ?—F. C. Connelly. (*Murphy News*, Dec. 1946, Vol. 21, No. 12, Supplement pp. 8–10.) A description of the new B8A standard type of valve base, and comparison with former types.

621.396.69 : 389.6 **958**

Valve Standardization.—(*See* 980.)

MISCELLANEOUS

001.3 **959**

The Cultural Understanding and Appreciation of the Scientific Approach.—R. H. Ojemann. (*Science*, 11th Oct. 1946, Vol. 104, No. 2702, pp. 335–338.) Information is presented which appears to show that the vast majority of the population grow up with little real understanding of scientific principles and methods, or of the function of research in a democratic society. Causes of this situation are suggested ; adequate support for research projects is unlikely unless it can be remedied.

001.4 **960**

μ is Overworked.—" Cathode Ray ". (*Wireless World*, Nov. 1946, Vol. 52, No. 11, pp. 364–365.) Many examples are quoted of different and inconsistent uses of μ. It is suggested that ' μ ' for ' micro- ' should be used with discretion especially in magnetic formulae, and that ' $\mu\mu$ ' should be replaced by ' p ' (' pico- ').

001.89 **961**

Recommendations of the Royal Society Empire Scientific Conference.—(*Sci. Culture*, Sept. 1946, Vol. 12, No. 3, pp. 117–124.) For another account see 3828 of 1946.

001.891 **962**

Research and the Smaller Firm in Britain.—(*Nature, Lond.*, 2nd Nov. 1946, Vol. 158, No. 4018, pp. 638–639.) Report of conference arranged by the Manchester Joint Research Council. Small firms were anxious to develop their own lines of research.

029 : 62 **963**

Documentation in Engineering.—M. Doucet. (*Tech. wet. Tijdschr.*, April/May 1946, Vol. 15, Nos. 4/5, pp. 27–31. In Flemish.) A Central Reference Service should be founded to provide research workers and practical engineers with all available information on any particular subject. Collaboration with existing institutions is emphasized.

029 : 778.142 **964**

Document Copying on Microfilm.—(*Nature, Lond.*, 26th Oct. 1946, Vol. 158, No. 4017, p. 579.) The importance of photographic copying is stressed, and attention is called to a new document-recording camera and microfilm reader made by W. Watson & Sons. See also 2409 of 1946 (Moholy).

5 + 6] " 1939/45 " **965**

The Scientist in War Time.—E. V. Appleton. (*Proc. Instn mech. Engrs*, 1946, Vol. 154, No. 3, pp. 303–316.) The thirty-second Thomas Hawksley lecture. For another account see 2420 of 1946.

519.283 **966**

Statistical Methods in Quality Control : Part 11 — Statistical Tests of Significant Differences.—A.I.E.E.

Subcommittee on Educational Activities. (*Elect. Engng, N.Y.*, Oct. 1946, Vol. 65, No. 10, pp. 466–468.) Discusses the statistical interpretation of limited experimental tests. For previous parts see 2422 and 2423 of 1946 and back references.

531.715.1 : 531.717.1 : 539.23 **967**
Measurement of Thickness of Thin Films.—A. F. Gunn & R. A. Scott. (*Nature, Lond.*, 2nd Nov. 1946, Vol. 158, No. 4018, p. 621.) The film is applied over a portion of a sheet glass plate so that it has an abrupt edge, and the whole surface is coated with a thin layer of silver; this is placed in contact with a similarly silvered glass plate. Interference fringes are formed by multiple reflection.

533.45 : 629.13.052 **968**
Barometric Measurement of Height in Aviation.—K. Ramsayer. (*Arch. tech. Messen*, June 1940, No. 108, pp. T61–62.) A brief account of aneroid barometers for height measurement in aircraft, with a detailed tabular analysis of causes of error.

538 + 531].081 : 621.39.012.8 **969**
Electrical and Mechanical Analogies.—E. B. Ferrell. (*Bell Lab. Rec.*, Oct. 1946, Vol. 24, No. 10, pp. 372–373.) A list is drawn up of quantities which play analogous parts in electrical, mechanical, and rotational problems respectively. The method of analysis by analogy has been successfully used to solve problems concerning recording and loud-speaking systems, relays, and servomechanisms.

538.3 : 001.5 **970**
The Use of Analogies.—G.W.O.H. (*Wireless Engr*, Jan. 1947, Vol. 24, No. 280, pp. 1–3.) A defence of the use of analogies in teaching the theory of electromagnetism. "The obvious way of explaining new and intangible concepts is by means of familiar and tangible concepts."

621.3.016.25 **971**
The Sign of Reactive Power.—A.I.E.E. Standards Committee. (*Elect. Engng, N.Y.*, Nov. 1946, Vol. 65, No. 11, pp. 512–516.) Some examples are quoted to support the contention that inductive reactive power should be considered positive.

621.365 **972**
Electronic Heating Conference.—(*Electronics*, Nov. 1946, Vol. 19, No. 11, pp. 184..190.) Held at San Francisco. The main subjects discussed were baking of foundry cores, and r.f. sterilization of food.

621.386.86 **973**
Invisible Industrial Hazard.—S. R. Warren, Jr. (*Elect. Engng, N.Y.*, Nov. 1946, Vol. 65, No. 11, pp. 499–507.) Excessive exposure to X rays and gamma rays can cause bodily harm months or even years later. As these rays are invisible, the urgent necessity is emphasized of warning workers of the danger, and providing adequate protection.

621.396 Bethenod **974**
The Radio Work of Joseph Bethenod.—L. Bouthillon. (*Ann. Radioélect.*, April/July 1946, Vol. 1, Nos. 4/5, pp. 279–292.) A lecture given to the Société des Radioélectriciens to commemorate the work of Joseph Bethenod, a former president of the society.

621.396.001.6 **975**
Research and Development in Radio Technology.—R. A. Collacott. (*Electronic Engng*, Sept. 1946, Vol. 18, No. 223, pp. 287–288.)

621.396/.397].6.004.67 **976**
Civic Radio Service.—(*Elect. Rev., Lond.*, 6th Dec. 1946, Vol. 139, No. 3602, p. 944.) Fulham Electricity Department will sell and service radio and television equipment, "a decision which has been followed by a number of other municipal undertakings."

621.396.615.14 **977**
The New Technique of Ultra-Short Waves.—A. V. J. Martin. (*Toute la Radio*, June 1946, Vol. 13, No. 106, pp. 153–156.) The evolution is traced from the Barkhausen-Kurz oscillator up to cavity magnetrons, klystrons and rhumbatrons.

621.396.69 : 389.6 **978**
Some Aspects of Standardisation in Radio.—T. R. W. Bushby. (*Proc. Instn Radio Engrs, Aust.*, Oct. 1946, Vol. 7, No. 10, pp. 15–20.) National and international organizations concerned with standardization are specified. The advantages are stressed of using only sizes of components belonging to a 'preferred numbers' series, and of specifying the standard deviation and the number of observations as well as the mean value when testing batches of similar components. The correct use of technical terms is important.

621.396.69 : 389.6 **979**
Commercial Standardisation.—(*Tech. Bull. Radio Component Mfrs' Fed.*, Aug. 1946, Vol. 1, No. 1, pp. 5–6.) A survey of the constitution and activities of the technical panels of the Federation, giving details of the draft recommendations for standardization of certain components.

621.396.69 : 389.6 **980**
Valve Standardization.—(*Wireless World*, Nov. 1946, Vol. 52, No. 11, p. 375.) Although discussion is still proceeding on standard valve types, tentative agreement has been reached that most valves will have a new small eight-pin base (type B8A) with a central spigot and a locating boss. For large-bulb valves, a base of type B8B will be used. Any further changes will be of a minor character. See also *Electronic Engng*, Nov. 1946, Vol. 18, No. 225, p. 327.

621.396.69 : 389.6 **981**
Why New Valves?—Connelly. (*See* 957.)

621.396.96 : 001.4 **982**
What is Radar?—"Cathode Ray". (*See* 740.)

5 + 6] : 41.3 = 00 **983**
Dictionary of Science and Technology. [Book Review]—M. Newmark. Pitman, London, 386 pp., 30s. (*J. sci. Instrum.*, Sept. 1946, Vol. 23, No. 9, p. 219.) Intended for use in the fields of chemistry, physics and engineering. The French, German and Spanish languages are covered.

51 **984**
The Mathematical Discoveries of Newton. [Book Review]—H. W. Turnbull. Blackie, London, 1945, 68 pp., 5s. (*Beama J.*, Sept. 1946, Vol. 53, No. 111, p. 330.)