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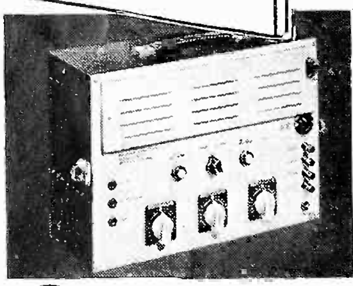

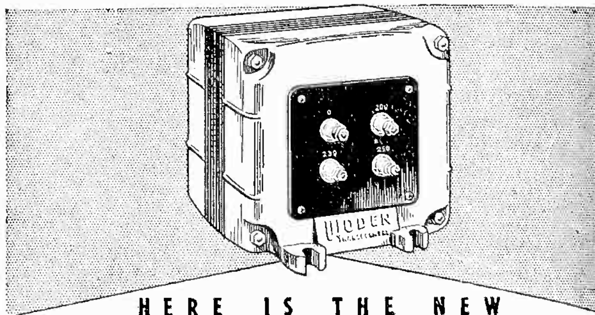

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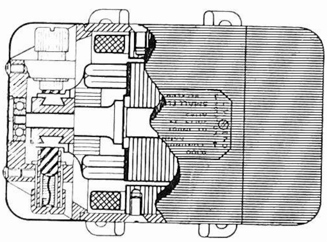

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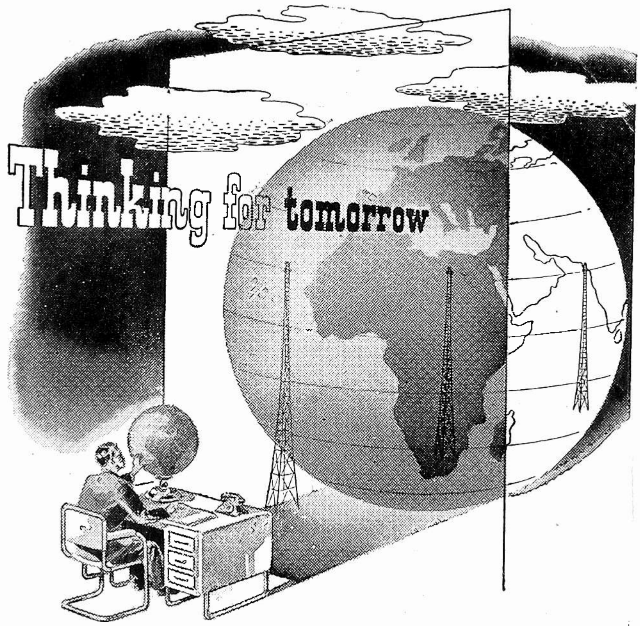

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WIRELESS ENGINEER

MAY 1946

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EDITORIAL

The Radiolocation Convention

THE Convention which was held at the Institution of Electrical Engineers in London from 26th to 29th March must be regarded as one of the milestones in the history of radio. The attendance at the inaugural meeting showed that the theatre of the Institution is too small for such occasions; overflow meetings had to be held in two other rooms. It will be recalled that when Sir Edward Appleton gave the Kelvin Lecture last year on "The Scientific Principles of Radiolocation" a large number of people failed to get into the theatre and the lecture had to be repeated. We note that the forthcoming Kelvin Lecture by Professor Oliphant on Nuclear Physics has been transferred from the Institution to the Kingsway Hall—a wise step. As a result of the war the number of people interested in the scientific development of radio and other branches of applied science has greatly increased and there is a very wide-spread desire to learn the details of the various developments that have taken place during the war, but which have necessarily been kept secret. On 8th April the Physical Society and the Royal Meteorological Society held a joint conference from 2.15 to 7.30 when nine papers were read on various aspects of "Meteorological Factors in Radio Wave Propagation." A convention was held in New York on 23rd to 26th January by the American Institute of Radio Engineers when 87 papers were read. Very brief summaries—sometimes merely the titles—of these are given in the February number of the Proc. I.R.E. with the tantalizing statement that "no papers are available in preprint or reprint form, nor is there any assurance that any of them will be published in the Proceedings, although it is hoped that many of them will appear in their pages." It was interesting to note that Dr. F. B. Llewellyn, the President of the American I.R.E., was able to be present at the London Convention and gave an address at the opening meeting. Speaking of the close co-operation between the two countries, he said that it was possible that radar was the best example of co-operative technical effort that the world had ever known. The other two speakers at the inaugural meeting were Mr. Wilmot, the Minister of Supply and Aircraft Production, who opened the proceedings, and Sir Robert Watson-Watt who gave a general survey of the evolution of radiolocation, a task for which he was eminently suited as he has been engaged in it, in some form or other, for over twenty years.

The first session of the Convention proper was devoted to Aerials and Waveguides. Each session opened with one or two introductory, survey, or integrating papers, and at this first session one on aerials was read by J. A. Ratcliffe and another on waveguides by Dr. Pryce. Then followed seven papers as follows:—Ground Radiolocation Aerials, by D. Taylor; Slot Aerials, by H. G. Booker; Slotted Linear Arrays, by D. W.

Fry; Cheese Aerials, by O. Böhm; Waveguide Matching Technique, by E. Wild; Phase Correction of Horn Radiators, by N. M. Rust; and Production Testing of Waveguides, by L. W. Brown. Dr. Pryce's paper has a useful bibliography of 17 forthcoming papers on waveguides based on service reports and an indication in each case as to where they are likely to be published. Ratcliffe's paper has reference numbers up to 31, but unfortunately the bibliography is missing from the paper; it will doubtless appear later. Perhaps the most novel of all the subjects dealt with in the above papers was the replacement of the ordinary aerial by a slot of the same size cut in a metal sheet. This is an application to radio of Babinet's principle in optics which deals with the equivalence of an illuminated slit in an opaque screen and an opaque rod in a beam of light. If the slot is energized by connecting a generator between the two midpoints of the opposite sides of the vertical slot, the electric field will obviously be horizontally polarized, while the magnetic field will lie in vertical planes. Compared with a vertical dipole the directions of the electric and magnetic fields are thus interchanged.

Propagation

For the second session one had to choose between Propagation and Cathode Ray Tubes as these two sessions were held simultaneously. In the Propagation section there were two preliminary survey papers, one by Dr. Booker on Elements of Radio Meteorology and the other by E. C. S. Megaw on Experimental Studies of the Propagation of Very Short Radio Waves. Here, again, there were seven contributions, viz., Measurements of Refractive Index Gradient by F. L. Westwater; Attenuation of Centimetre Waves and Echoes Resulting from Atmospheric Phenomena, by J. W. Ryde; Transmission Conditions over Land and Sea, by Dr. Smith-Rose; Microwave Propagation, by B. S. Starnecki; Theoretical Estimation of Field Strength, by J. M. C. Scott; the Importance of Theory, by T. L. Eckersley, and finally, after a discussion of the foregoing, a paper on Extra-tropospheric Influences on U.S.W. Communication, by Sir Edward Appleton.

Perhaps the outstanding feature of this session was the stress laid on the propagation of microwaves over distances far beyond the visible range by radio ducts or atmospheric waveguides close to the surface of the sea. In this connection it is interesting to note that one of the papers read at the American convention was entitled "Three and Nine Centimetre Propagation Measurements in Low-level Ocean Ducts." Another interesting phenomenon was the echo from moderate rain some tens of kilometres distant, which might be comparable with that from an aircraft at the same distance. Such effects increase rapidly with increasing frequency.

In the cathode-ray tube session two survey papers were read giving a general survey of the wartime developments, one by J. G. Bartlett, D. S. Watson and G. Bradfield, and the other by L. C. Jesty, H. Moss and R. Puleston. These were followed by three papers on screens, the first by G. S. J. Garlick, S. T. Henderson and R. Puleston, the second by R. G. Hopkinson and the third, which dealt with the Skiatron or dark trace tube, by P. G. R. King. In the evening a lecture on "Precision Radar" was delivered by W. A. S. Butement who gave a very complete account of the development of the subject, and of the various alternative methods with their advantages and disadvantages.

The morning of the 28th March was devoted to valves, the survey paper on which was by Dr. J. H. E. Griffiths. This was followed by seven papers as follows: Early Work on the Cavity Magnetron by J. T. Randall and H. A. H. Boot; High Power Pulsed Magnetron, by W. B. Willshaw and L. Rushforth; Velocity Modulation Valves, by L. F. Broadway; The Crystal Valve, by B. Bleaney; Gas Discharge Switches, by A. H. Cooke; Triodes for Very Short Waves, by J. Bell; and Gas-filled Triodes for Radar Modulator Service, by H. de B. Knight. The papers on the magnetron will probably be regarded by most people as the high-water mark of the Convention and detailed papers dealing with the subject will be eagerly awaited; as Griffiths says, "This work was outstandingly successful, and resulted in what was probably the greatest single contribution to radar." It is a matter of great satisfaction that this idea, which originated with Randall and Boot at Birmingham University, was developed and brought to such outstanding fruition by the joint efforts of the University, the G.E. Co., the M.O. Co. and the B.T.H. Co. The paper by Bleaney is interesting because it describes how the old crystal detector with its cat's-whisker has been re-instated and it is interesting to read that "no vacuum tube which can rival its sensitivity has been developed for centimetre wavelengths". Radio measurements was the subject of the following session, and a survey paper was read by C. W. Oatley entitled "Ultra High Frequency Measurements," which was followed by seven papers as follows: Some Monitors of Transmitted Power at Centimetre Wavelengths, by L. B. Turner; Gold Leaf Electroscope and Enthrakometer by J. Collard; Signal Generators and Noise Measurement, by B. Bleaney; Cable Measurements, by L. Essen; Resonance Methods of Dielectric Measurement at Centimetre Wavelengths, by Willis Jackson; Radiation Patterns from Directive Antennae, by J. Dyson and B. A. C. Tucker, and the Study of Centimetre Wave Propagation, by H. Archer-Thomson and E. M. Hickin. The paper by Prof. Willis Jackson has exactly the same title as one published by him and a number of associates in the January number of Part III of the Institution Journal, and presumably covers much the same ground. Measurements at these extremely high frequencies bristle with difficulties and, when published, these papers will give a very good review of the methods developed to overcome these difficulties in a very wide range of measurements.

An evening lecture on "Shipborne Radar," by A. W. Ross described the difficulties due to the large accumulation of radio gear on board ship. It was surprising to learn that some ships have more than 30 radar sets in addition to an equally large number of other sets for radio communication. The complexity of the problems involved in avoiding interference, in frequency allocation and screening can easily be imagined. These matters were discussed in the lecture. It was stated that the 3-metre transmitter first fitted in 1940, which had a peak pulse power of 1,000 kilowatts, was the most powerful radar transmitter in service during the war. Another speaker mentioned peak powers of 3,000 kilowatts. Even although such a pulse may only last a few microseconds it can easily prove a very disagreeable neighbour unless special precautions are taken.

The morning session on 29th March was devoted to Transmitters and Receivers, with survey papers by O. L. Ratsey on the former and W. B. Lewis on the latter. Four papers on the development of various types of transmitter were read by R. V. Whelpton and J. M. Dodds, T. S. England, K. J. R. Wilkinson, D. F. Gibbs and B. W. Lythall, and four on receivers by H. Dahl, W. L. Watton, F. L. Humber, R. S. Paulden and M. K. Taylor, G. G. Macfarlane and J. R. Whitehead. The transmitters described cover a very wide field of research and development and a list is given of thirteen papers which are being prepared with a view to publication in the Journal of the I.E.E. The paper on the super-regenerative receiver takes one's mind back twenty years or more when such receivers were very much discussed.

Pulse Circuits

The subject for the afternoon session was "Circuit Techniques and Radiolocation" with an introductory paper by F. C. Williams, followed by seven papers as follows: Blocking Oscillators, by R. Benjamin; Low Power Pulse Transformers by N. F. Moody; Delay Networks in Pulse Formation, by E. L. C. White; Very Short Pulses, by D. C. Espley; Light Weight Radar, by H. R. Whitfield; The Velodyne, by F. C. Williams and A. M. Uttley; and Automatic Strobes, by F. C. Williams and F. J. U. Ritson. The introductory paper of 21 pages discusses many circuit problems in a very interesting manner and gives a bibliography of 38 references, several of which are described as I.E.E. convention papers and lectures, although they do not appear on the programme of this convention.

This session was followed by a lecture on "Radar Navigation" given by R. A. Smith.

An additional meeting was held on 3rd April when five papers on naval gunnery radar were read by J. F. Coales, J. C. Calpine and D. S. Watson, R. V. Alred, C. A. Laws, H. W. Pout and H. A. Prime.

The publication of the papers read at the Convention and of the many other papers referred to as being prepared for publication will be eagerly awaited; it will fortunately take a considerable time even with all the resources of the Institution journal and the technical press to publish such a great number of papers, many of which are of considerable length. A steady output spread over many months will facilitate the processes of digestion. The Institution of Electrical Engineers and all concerned in the organization of the Convention are to be congratulated on the highly efficient way in which it was carried out.

G. W. O. H.

CAVITY-RESONATOR WAVEMETERS*

Simple Types of Wide Frequency-Range

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

(*Communication from the National Physical Laboratory*)

SUMMARY.—The description is given of four simply constructed cavity-resonator wavemeters covering the frequency ranges 10,000 Mc/s–4,000 Mc/s, 5,600 Mc/s–2,000 Mc/s, 2,700 Mc/s–1,000 Mc/s and 1,000 Mc/s–200 Mc/s. The mode of resonance employed is the hybrid between the cylindrical TM_{010} mode and the coaxial TM_{00p} mode, and the frequency variation is effected by the axial movement of a plunger attached to a micrometer head. For the first three wavemeters the plunger is of a non-contact design, thus obviating the necessity for a good electrical contact which has hitherto caused considerable manufacturing difficulties. The setting accuracy of the instruments is shown to be better than 1 part in 10^4 of frequency throughout the greater part of the range.

Introduction

THE increasing application of electromagnetic oscillations of centimetric and decimetric wavelengths in recent years has created a need, particularly in laboratory work, for simple portable wavemeters to cover the complete frequency range between 200 Mc/s and 10,000 Mc/s. For most applications an accuracy of 1 part in 10^4 is adequate, and the range covered by each instrument should be as large as is consistent with this accuracy.

It is well known that electromagnetic waves are freely transmitted along hollow metal tubes, or waveguides, the dimensions of which exceed certain critical values depending on the wavelength of the oscillations. If a length of waveguide is closed by metal plates at each end, reflections of the wave occur and a system of standing waves is established. The closed waveguide constitutes an electrical resonator which, if coupled to a source of oscillations and provided with a means of detecting the oscillations, forms a very simple and convenient wavemeter. It can, however, resonate in many different modes having different frequencies, and for wavemeter applications it must be designed to have the greatest possible frequency separation between neighbouring resonances. Such cavity-resonator wavemeters have been widely used during the last few years.

For the purpose of designation, the modes are divided into two main types, the transverse electric (TE or H) modes, in which there is a component of magnetic field, but not of electric field, in the direction of propagation and the transverse magnetic (TM or E) modes in which the reverse is true. In the case of a circular guide the modes are uniquely defined by the addition of three suffixes which give the number of periodic variations of electric field in the angular, radial, and axial directions respectively. The value of the first suffix corresponds to the number of full period variations of electric field in a rotation of 360°, the value of the second to the number of half-period variations across a diameter and the value of the third to the number of half-period variations in the length of the guide. The configurations of the fields in the different modes are shown diagrammatically in a number of text-books.

The coaxial resonator, in which there is an inner conductor in the tube, may be regarded as a special case, its mode designation being TM_{00p} or TE_{00p} since there is no component of magnetic or electric field in the direction of propagation. The value of p is the number of half-waves along the coaxial line.

Barrow and Mieher† described a form of cylindrical waveguide resonator with which a frequency range of more than 2 to 1 could be covered by the axial movement of a plunger, the mode of resonance being the hybrid between the cylindrical mode TM_{010} and the coaxial mode TM_{00p}. A wavemeter using this mode was designed by Dr. Sayers at Birmingham University, but difficulty was experienced in obtaining a sufficiently reliable electrical contact between the plunger and the wall of the resonator. Moreover, in order to reduce the wear of the plunger, it was heavily chromium-plated. This resulted in a relatively high electrical resistance with

* MS. accepted by the Editor, October 1945.

† W. L. Barrow and W. W. Mieher. "Natural Oscillations of Electrical Cavity Resonators," *Proc. Instn Radio Engn*, 1940, Vol. 28, pp. 184–191.

the result that the Q-factor (π/Log. Decrement) of the wavemeter was reduced as the plunger was inserted. These difficulties have been overcome by the use of a non-contact plunger in three of the wavemeters described in this paper. These cover between them the frequency range 1,000 Mc/s to 10,000 Mc/s. In the wavemeter of the lowest frequency range, 200 Mc/s to 1,000 Mc/s, it was found that a contact type plunger was necessary to preserve a convenient physical design of instrument.

1. General Features of the Design using a Non-Contact Plunger

The general design of the wavemeters is illustrated in Fig. 1, and the photograph shows the three non-contact models. In the mode of oscillation used there is a flow of current between the plunger and the walls of the resonator, and there must therefore be a low impedance path between them. The input impedance at C, Fig. 1, is that of a coaxial line, including lengths of very different values of characteristic impedance.

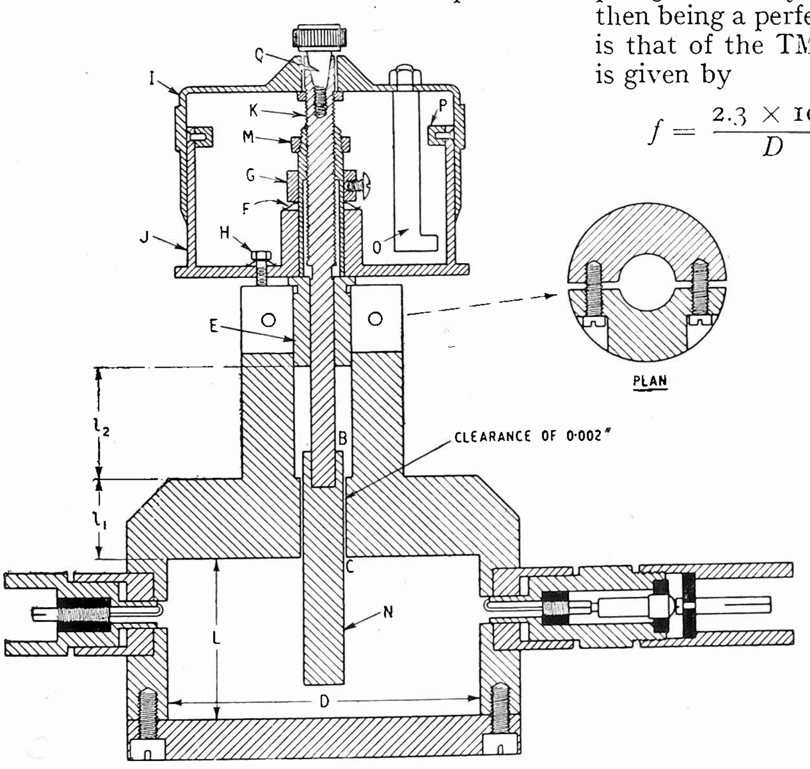


Fig. 1. *This section through a wavemeter shows the general design adopted for types A, B and C. A micrometer-head is used for the adjustment of the plunger N.*

Neglecting the smaller discontinuity at B caused by the different diameters of the plunger and the micrometer spindle and neglecting the resistance of the conductors, the input impedance is

$$Z = jZ_1 \frac{\frac{Z_2}{Z_1}\tan\beta l_2 + \tan\beta l_1}{1 - \frac{Z_2}{Z_1}\tan\beta l_2 + \tan\beta l_1} \quad (1)$$

in which Z_1 and Z_2 are the characteristic impedances of the lines of lengths l_1 and l_2, respectively, and $\beta = \frac{2\pi}{\lambda}$, λ being the wavelength of the oscillations. With the dimensions used, and a clearance of 0.002 in, the values of Z_1 and Z_2 are of the order of 1 ohm and 50 ohms respectively and the input impedance Z is small unless l_1 or l_2 approaches 0 or $\frac{n\lambda}{2}$. Values ranging between 0.06λ and 0.42λ have been used with satisfactory results. The dimensions of the resonating element of the wavemeter are governed by the upper frequency limit, and the need to avoid the excitation of other modes of oscillation within or near the frequency range of the instrument. The highest frequency is obtained when the plunger is fully withdrawn, the resonator then being a perfect cylinder. The frequency is that of the TM_{010} mode of resonance and is given by

$$f = \frac{2.3 \times 10^{10}}{D} \text{ c/s} \quad \ldots \quad \ldots \quad (2)$$

D being the diameter in centimetres.

In order to avoid confusion with the TE_{111} mode of resonance the length of the resonator should be less than the diameter. The TE_{111} mode will then occur at a frequency higher than that of the TM_{010} mode, and there is no mode of resonance at a frequency lower than that of the TM_{010} mode. The frequency determined by the reading of the wavemeter is thus free from ambiguity.

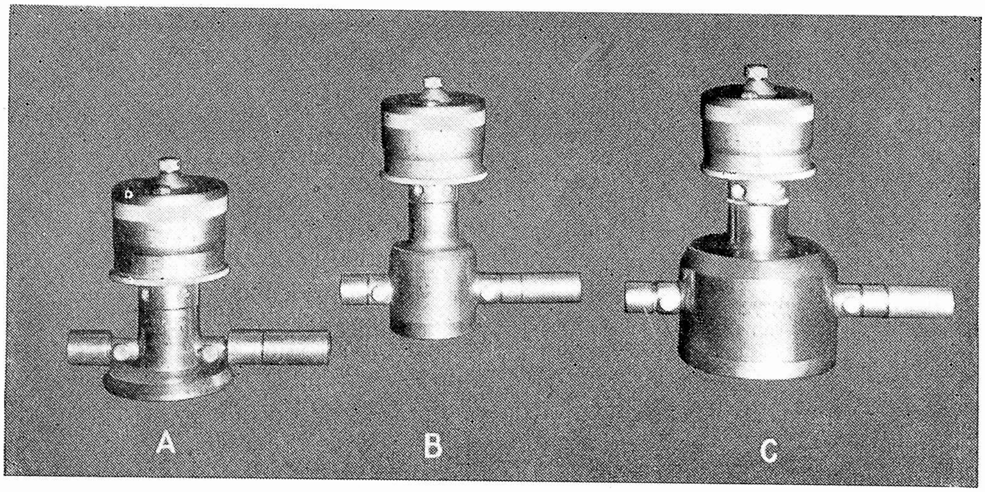
The movement of the plunger is effected by a micrometer head, a standard commercial model being used because of the difficulty of obtaining articles made to special requirements during wartime conditions. The movement is therefore restricted to 1 in, and for the wavemeters covering the lower frequency ranges it is moreover necessary to extend the spindle of the micrometer as shown in Fig. 1.

The body of the wavemeter is turned from a solid brass rod and the inside surface of the resonator is silver-plated and polished. The plunger is a silver-plated brass rod, except for the smallest wavemeter, for which the lower half of the micrometer spindle itself is silver-plated. Coupling loops are fitted through diametrically opposite holes in the cylindrical walls of the resonator, and are fixed in a suitable position by means of grub screws. The input loop is terminated in a socket to take a G.E.C. Type 3 plug, and the detector loop is in series with a totally enclosed fixed-contact crystal detector, the output from which is taken from a similar socket.

2. Details of the Design using a Non-Contact Plunger

The main electrical requirement is that the plunger should be circular and move coaxially in the hole through the end wall of the resonator. To achieve this, the hole to take the micrometer barrel and that through the wall of the resonator should be bored together without the wavemeter being taken from the lathe. It has been found also that although the clamping of the barrel, shown in Fig. 1, is designed to allow for the small differences in the diameters of the individual barrels, it tends to produce some tilt of the micrometer if the barrel or hole is non-circular or tapered. It is best to fit the micrometers individually, if the diameters of the micrometer barrels deviate from the nominal value by more than 0.0002 in. When a plunger is fitted to the micrometer spindle, care is needed to ensure that these are coaxial, and it may be necessary to turn the plunger true after it has been fitted. The plating also should be of a uniform thickness to avoid making the plunger non-circular.

For the reasons given in the preceding section a standard pattern of micrometer



Cavity-resonator wavemeters of frequency ranges:—A, 4,000–10,000 Mc/s; B, 2,000–5,600 Mc/s; and C, 1,000–2,700 Mc/s.

TABLE I

Designation of Wavemeter	Size of Resonator (cm)		Length of Coaxial Lines (cm)		Frequency Range (Mc/s)	Accuracy of Setting and Reading	Average Value of Q
	D	L	l_1	l_2			
A	1.6	1.47	0.9	1.04	4,000–10,000	1 in 10^4	1,000
B	3.8	2.54	1.9	2.23	2,000–5,600	0.5 in 10^4	1,500
C	7.6	3.80	1.9	2.54	1,000–2,700	0.3 in 10^4	4,000
E	15.2	4.50	Contact plunger with 2 in diameter disc		200–1,000	1 in 10^4 to 10 in 10^4	1,300

head was used. It is convenient in the normal applications of the micrometer to be able to adjust the zero readily, and the drum J (Fig. 1) is therefore held relative to the barrel E only by the friction between the spring washer F and the sleeve G which is pushed down to compress the washer and then locked by a grub screw. This friction fixing is inadequate for the present purpose since a rotation of the drum, on which the vertical scale of the micrometer is inscribed, would alter the calibration of the wavemeter. Such a rotation is therefore prevented by the screw H. In order that this screw should not distort the drum, a light pressure on a spring washer is used. The thimble I of the head is fixed to the spindle K by means of a conical friction clamp Q. This fixing has been found sufficiently secure, although here again a rigid fixing would be preferable.

The tightness of the micrometer screw is adjusted by means of the nut M. A suitable compromise between ease of operation and freedom from backlash is obtained if the thimble continues to rotate for about one turn when it is spun by hand and released.

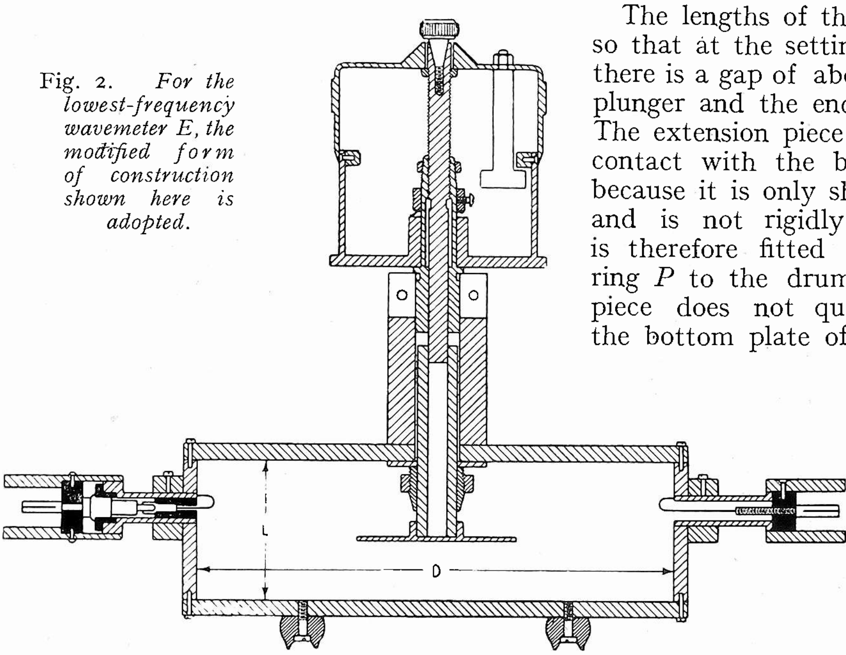


Fig. 2. *For the lowest-frequency wavemeter E, the modified form of construction shown here is adopted.*

The lengths of the plungers are adjusted so that at the setting O on the micrometer there is a gap of about 0.5 mm between the plunger and the end face of the resonator. The extension piece N must not come into contact with the body of the wavemeter because it is only shrunk on to the spindle and is not rigidly fixed. The stop O is therefore fitted to the thimble and the ring P to the drum so that the extension piece does not quite make contact with the bottom plate of the resonator or with the barrel E of the micrometer. A counterweight, not shown in the diagram, is fixed in a diametrically opposite position on the thimble.

The movement of the plunger in wavemeter A is only 1.5 cm and it is unnecessary in this case to extend the micrometer spindle. It is instead silver-plated on one half of its length.

The dimensions of the wavemeters for different frequency ranges are given in Table 1.

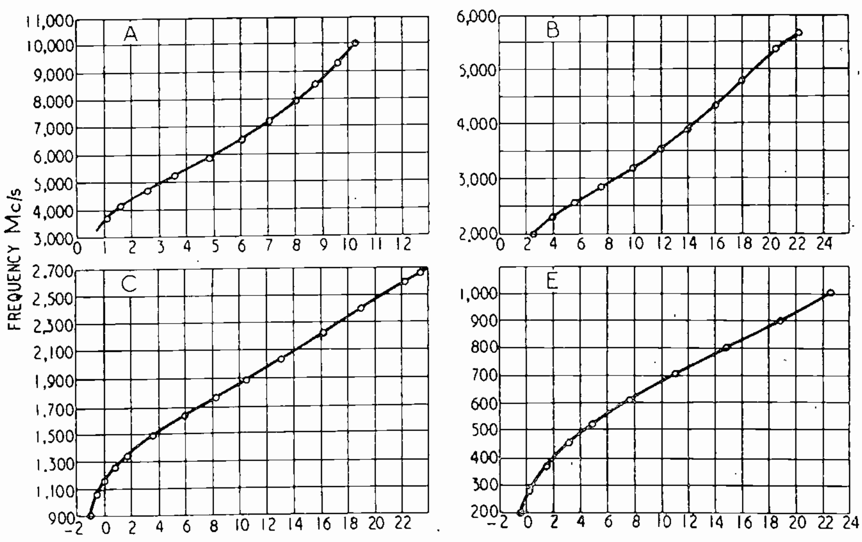


Fig. 3. *Calibration curves of the four wavemeters described.*

3. Details of the Wavemeter of Range 200 Mc/s–1,000 Mc/s.

Experiments were made with a non-contact plunger in a resonator of diameter 11.8 cm and length 4.5 cm, the values of l_1 and l_2 being 2 cm and 3.3 cm respectively. Satisfactory operation was obtained at frequencies between 500 Mc/s and 1,700 Mc/s. In order to obtain lower frequencies of resonance a disc of 2 in diameter was fitted on the end of the plunger, and the frequency range was then 200 Mc/s to 1,000 Mc/s. The instrument was very insensitive at frequencies below 500 Mc/s, however, and it was found to be very much improved when electrical contact was made between the plunger and the walls of the resonator by means of sprung fingers. The model shown in Fig. 2 was therefore designed for this range of frequency. The design is considered to be inferior to that of the other three wavemeters. It is nevertheless a very useful instrument which can be used with an accuracy better than 1 part in 1,000 in a frequency range not at present covered by other forms of resonant wavemeter. Its dimensions are included in Table 1.

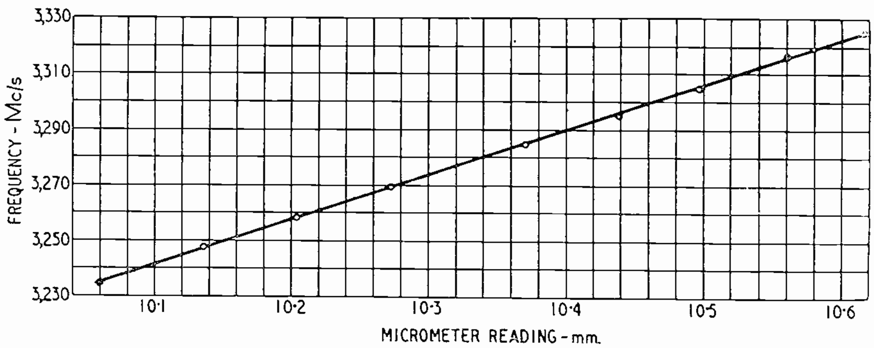


Fig. 4. *Small part of the calibration curve of wavemeter B on a large scale.*

4. The Performance of the Wavemeters

The ranges, average accuracies, and Q-factors of the different wavemeters are given in Table 1; and the calibration curves are shown, on a small scale, in Fig. 3. With this mode of oscillation, as the plunger penetrates into the cylinder, the frequency variation is at first small, it is then larger and fairly uniform for the greater part of the movement, and becomes increasingly large when the gap between the end of the plunger and the end face of the resonator becomes small. The wavemeters are designed so that as far as possible only the middle portion of this range is used. The curves do not show the initial small variation of frequency, but to obtain an overlap between wavemeters C and E it is necessary to use a part of the range of C where the frequency variation with setting is becoming large. Three models of each of the wavemeters A, B and C have been tested and gave a satisfactory performance.

The indications of resonance were smooth and sharp and there was no evidence of the irregularities associated with faulty contacts. The Q-factors were sufficiently high to give a precision of setting better than 1 part in 10^4 of frequency.

The stability of the wavemeters has not been checked over a long period, but measurements made with types B and C at an interval of six months agreed to 1 part in 10^4 of frequency. After the same interval of time the calibration of type A had changed by several parts in 10^4.

Suitable conditions of coupling were obtained with the tip of the loop withdrawn 2 mm from the inside wall of the resonator of the wavemeter A, flush with the wall of wavemeter B, and protruding within the resonators of wavemeters C and E by 1 mm and 3 mm respectively. With these settings the resonant frequencies of wave-

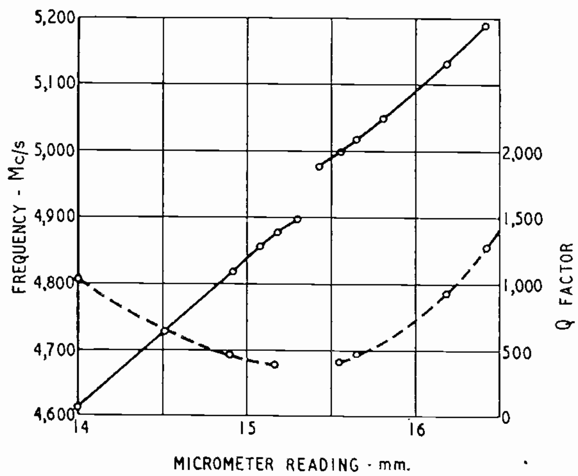


Fig. 5. *These curves show the effect on the resonance frequency and Q-factor of a subsidiary resonance behind the cavity.*

meters B, C and E were not influenced by changes in the input and detector circuits to an appreciable extent, but that of wavemeter A was changed by about 2 parts in 10^4 when the length of the input cable was changed in steps by a total of one half-wavelength. Trouble was also experienced because of a resonance in the crystal detector circuit at a frequency near 9,500 Mc/s. This resulted in an effective increase in the coupling over this region of frequency and a consequent reaction on the resonant frequency of the wavemeter. The difficulty was overcome by making the insulating support of the crystal detector and coupling loop from a material of high dielectric loss.

To check the uniformity of the variation of the resonant frequency with movement of the plunger, the frequencies corresponding to a number of closely spaced settings were measured at one portion of the range of each instrument. The results obtained for wavemeter B are shown graphically in Fig. 4, and it is seen that no point lies off the straight line by more than 1 part in 10^4 of frequency. Similar results were obtained with the other wavemeters; but when one of the plungers was deliberately made eccentric so that the clearance gap between the plunger and wall varied with the rotation of the plunger there was a periodic variation of frequency of about ± 20 parts in 10^4 superimposed on the general line of the calibration curve.

In the first model of wavemeter B, the dimension l_2 was 2.54 cm, thus permitting the full movement of the micrometer. It was found, however, that a resonance effect occurred giving the irregularity in the calibration curve and decrease in the value of "Q" shown in Fig. 5. These effects were accompanied by a large decrease in sensitivity. When the dimension l_2 was decreased to 2.23 cm there was no such irregularity in the curve, but the values of Q were low at the highest frequencies, suggesting that such a resonance would have occurred at a frequency a little above the range of the wavemeter.

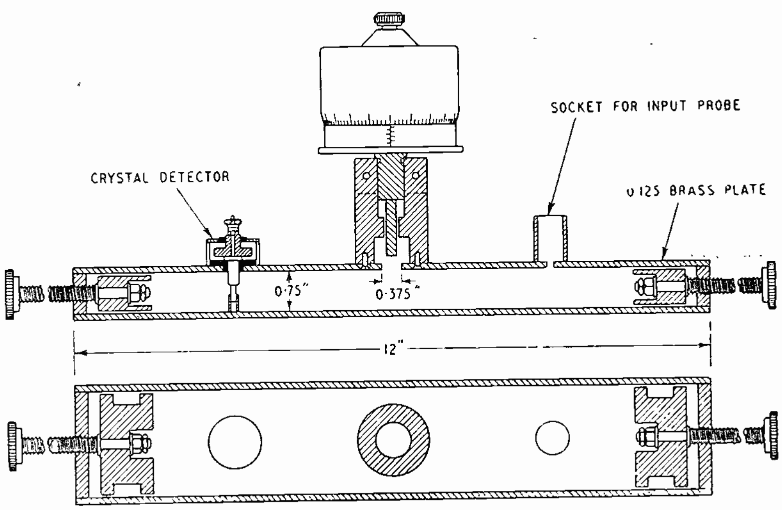


Fig. 6. *Wavemeter A is shown attached to the wall of a waveguide.*

5. Modified Wavemeters B and C

There are two drawbacks to fixing an extension to the micrometer spindle as shown in Fig. 1. The first is that considerable care is required to make the extension and the spindle concentric, and the second is that the micrometer cannot be dismantled for cleaning. A micrometer was therefore made with the spindle extended by the appropriate amount, the extension being of slightly smaller diameter than the normal spindle. After being silver-plated the extension could then still be withdrawn from the barrel of the micrometer. Wavemeters were made with these micrometers, the gap between the spindle and the walls of the wavemeters again being 0.002 in. They gave a satisfactory performance with frequency ranges and Q-factors not very different from those previously obtained. They have some advantages, therefore, but this extension could not easily be fitted to a standard micrometer without softening the spindle.

6. The Use of Waveguide Feeds

In many applications at frequencies of 3,000 Mc/s, or over, the energy is transmitted through waveguides, and it is convenient to couple a wavemeter to the system by means of coupling holes in the guide and in the wall of the wavemeter. To check the use of the wide range wavemeters described, under such conditions, the highest frequency model A was fitted on a guide as shown in Fig. 6, the dimensions of the guide being chosen to permit the propagation of TE_{11} waves at frequencies above 4,000 Mc/s. It was found that in order to obtain an absorption dip of convenient amplitude the diameter of the coupling window needed to be $\frac{3}{8}$ in.

The calibration curve of the wavemeter under these conditions was not very different from that shown in Fig. 3, except that the slope of the curve did not increase at the low frequency end. No troubles due to different input or detector conditions were experienced with this method of coupling.

7. Acknowledgements

The work described above was conducted as part of the programme of the Radio Research Board, to whom confidential reports were circulated during 1944. This paper is published by permission of the Department of Scientific and Industrial Research.

Some preliminary tests concerned with the development of the wavemeters were made by Dr. J. E. Johnston, and the calibration of the wavemeters was largely done by Mr. D. R. Dicks. The wavemeters were made in the workshop of the Radio Division of the National Physical Laboratory.

ABSOLUTE BELS*

By F. S. G. Scott

SUMMARY.—It is shown that, by the use of a simple operator and the choice of a suitable power reference level, not only power but many other factors (for example, dynes, lengths, resistances, volts, etc.) which are not of themselves power, but which condition power in certain circumstances, may be expressed in a particular form of power ratio described as "Absolute bels," that the term "Absolute bels" is justified, and that such an expression gives a direct indication of how these factors will condition the power in any circuit into which they may be introduced.

It is further shown that where the ratio of two powers is involved, this can be converted mentally and instantaneously into decibels or a difference in phons. Examples are given of the use of the absolute bel which indicate clearly the advantages which this unit possesses.

Introduction

IT has often been emphasized that the bel is a pure ratio between two powers and that if any power ratio is expressed in bels or decibels, no idea of the absolute value of either power is available, unless the value of one of the powers is stated, or by some implication is known.

To increase the value of this very useful mathematical device, it has been suggested that some standard power should be used for reference purposes, and certain values are, in fact, often used. Two examples are :—one milliwatt expended in 600 ohms, and six milliwatts expended in 500 ohms. These different standards tend, by their very variety, to defeat their own ends and cause confusion. Further, standards of this nature lead to endless difficulties if, for example, a decibel meter calibrated for one particular circuit, is required for use in another circuit with a different impedance.

* MS. accepted by the Editor, February 1946.

It should be, and indeed is, possible, to arrange matters in such a way that these difficulties do not occur.

Fundamental Considerations

If a power P_x is compared with a universally recognised and accepted standard power P and that answer is expressed in bels, then implicit in that answer is the absolute value of P_x and, in the same way

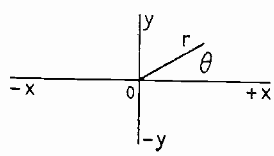


Fig. 1. *The line r is defined as $r = |r|(\cos\theta + j\sin\theta)$.*

that a line r having a defined position in space

$$r = |r|(\cos\theta + j\sin\theta) \quad . \quad . \quad . \quad . \quad \text{(Fig. 1)}$$

gives more information than any simple line r and is known not as a line but as a vector, so the bel mentioned above gives more information than the power ratio and is entitled to a distinguishing adjective to indicate this fact.

As "Absolute" values are determinable with such a convention, the adjective "Absolute" appears to be eminently suitable.

The above statement may be expressed mathematically as follows :—

If N_{px} be the value of P_x expressed in absolute bels then $\log_{10}(P_x/P) = N_{px}$ which may be rewritten

$$\log_{10} P_x - \log_{10} P = N_{px}$$

Now P is an arbitrary reference power, which should be standardized at the value which will offer maximum simplicity, and it is obvious that the complete elimination of the term $\log_{10} P$, by equating P to unity, satisfies this condition.

Definition

When any power (P_x) *is compared (in bels) with one watt, the resultant answer is expressed in absolute bels.* (B = 10 dB = *ten absolute decibels*).

$$N_{px} = \log_{10} P_x \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

The practical meaning of this is best realized by an example. Assume that it is required, for correction purposes, to apply a "boost" at 50 c/s of 12 db to an amplifier, having a maximum rated output of 40 watts (this is described as 1.6 B in an absolute bel system) which is at present supplying 3 watts (0.48 B) at all frequencies. It is required to know :—

(*a*) Whether the amplifier has sufficient power output to meet this demand without overloading.

(*b*) What is the maximum permissible "boost."

The normal method of answering these questions is :—

(*a*) Let P_x be the power output at 50 c/s with 12 db "boost."

Then $10 \log_{10}(P_x/3) = 12$ db

$\therefore \quad \log_{10}(P_x/3) = 1.2 = \log_{10} P_x - \log_{10} 3$

or $\quad \log_{10} P_x = 1.2 + 0.48 = 1.68.$

Consequently,

$$P_x = \text{antilog}_{10}\, 1.68 = 48 \text{ watts.}$$

This is greater than 40 watts and the output of the amplifier is not sufficient to permit a "boost" of 12 db.

(*b*) Maximum permissible "boost" = $10 \log_{10}(40/3) = 10 \log_{10}(13.\dot{3}) = 10 \times 1.12 = 11.2$ db.

With the Absolute bel method the procedure is :—

(*a*) let N_{px} be the power output (in absolute bels) at 50 c/s with 12 db "boost." Then

$$N_{px} = 0.48 + 1.2 = 1.68 \text{ B}$$

The maximum rated output of 1.6 B is therefore inadequate.

(*b*) Maximum permissible "boost" = 1.6 B − 0.48 B = 1.12 b = 11.2 db.

Extension of the Principles of the Absolute Bel

In communications engineering it is often necessary to know what power will be developed under given conditions in a load which may be either acoustical or electrical.

It is, therefore, very convenient to express the value of any factor (F) or factors (F_1, F_2, F_3, . . . F_n) which will condition the power in a load, or to express the value of the load itself, in terms of the effect on the power developed in the load in absolute bels, and to describe such an expression as "the value of the factor or factors in Absolute Bels" $N_{(F)}$, or $N_{(F1, F2, F3, \ldots Fn)}$.

The following definitions and conventions are used throughout this paper.

(1) $N_{(F)}$ = the value of any factor (F) expressed in absolute bels.

(2) Any impedance $R_s \pm jX_s$ (see Fig. 2). is described as $Z_s \underline{|\theta_s}$ the subscripts relating the various terms to each other.

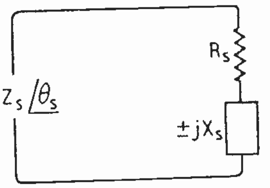


Fig. 2. *Any impedance* $R_s \pm jX_s$ *is expressed as* $Z_s\underline{|\theta_s}$.

The term $\underline{|\theta_s}$ is a simple method of remembering that strictly speaking

$$Z_s = Z_s(\cos\theta_s \pm j \sin\theta_s) = R_s \pm jX_s$$

Where $\theta = \tan^{-1}(X_s/R_s)$, and may be positive or negative. This ensures that junior engineers using these formulae are reminded that

Z_A added to Z_B is not $Z_A + Z_B$ but

$$(Z_A \cos\theta_A + Z_B \cos\theta_B) + j(Z_A \sin\theta_A + Z_B \sin\theta_B)$$

(3) Bels are written b. Decibels are written db.

Absolute Bels are written B. Absolute decibels are written dB.

(4) For brevity $\log_{10}$ is written A.

(5) The conversion of any factor (F) to the form $N_{(F)}$ is performed by means of an operator $O_{(F)}$.

Thus $N_{(F)} = O_{(F)}\,(F)$ .. .. .. (2)

We are now in a position to consider $O_{(F)}$ for various factors.

To determine O_{P_x} where P_x is any power (measured in watts).

From (2) $O_{P_x} P_x = N_{P_x}$

From (1) $N_{P_x} = AP_x$

$\therefore \quad O_{P_x} P_x = AP_x$

$\therefore \quad O_{P_x} = A = \log_{10}$ .. .. (3)

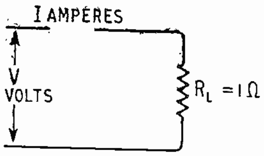


Fig. 3. *The power in a load resistor is expressed relatively to a standard power of 1 watt.*

In Fig. 3 the power P_L developed in the load resistor R_L of 1Ω may be expressed

$$P_L = V^2/1$$

Now by the definition given for $N_{(F)}$ and from equation (2)

$$AP_L = N_V = O_V\,V$$

But $\quad P_L = V^2$

$\therefore \quad AP_L = AV^2 = 2AV = O_V V$

and $\quad O_V = 2A = 2\log_{10}$

Thus $\quad N_V = 2AV$ .. .. .. (4)

Similarly

$$P_L = I^2 \times 1$$

and $\quad AP_L = N_I = O_I I$

$\therefore \quad AP_L = 2AI = O_I I$

$\therefore \quad O_I = 2A = 2\log_{10}$

Thus $\quad N_I = 2\,AI$ .. .. .. (5)

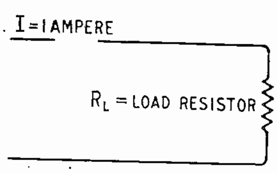


Fig. 4. *Development of the load factor N_{R_L} in terms of current.*

In Fig. 4

$$P_L = 1^2 \times R_L = R_L$$

Now by definition

$$N_{R_L} = O_{R_L}\,R_L = AP_L$$

But $\quad P_L = R_L$

$\therefore \quad O_{R_L} = A = \log_{10}$

Thus $\quad N_{R_L} = AR_L$ .. .. .. (6)

In Fig. 5

$$I = 1/Z_L$$

$\therefore \quad P_L = 1^2/(Z_L)^2 \times 1 = 1/Z_L^2 = Z_L^{-2}$

By definition

$$N_{Z_L} = O_{Z_L}\,Z_L = AP_L$$

But $\quad P_L = Z_L^{-2}$

$\therefore \quad O_{Z_L}\,Z_L = -\,2AZ_L$

$\therefore \quad O_{Z_L} = -\,2A = -\,2\log_{10}$

Thus $\quad N_{Z_L} = -\,2AZ_L$ .. .. .. (7)

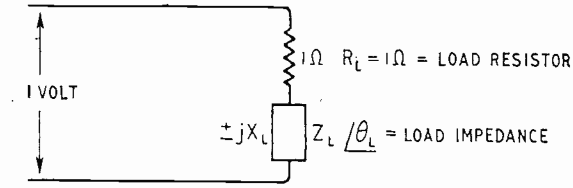


Fig. 5. *Illustrating a load circuit containing both reactive and resistive elements.*

To indicate clearly fundamental principles, up to this point only individual factors have been considered, but this technique is not necessary.

Let us now deal with a case of some importance illustrated in Fig. 6.

V_G is the "open circuit" voltage of the generator. By definition

$$N_{(V_G Z_G Z_L R_L)} = O_{(V_G Z_G Z_L R_L)}\,f\,(V_G Z_G Z_L R_L) = AP_L \quad .. \quad .. \quad (8)$$

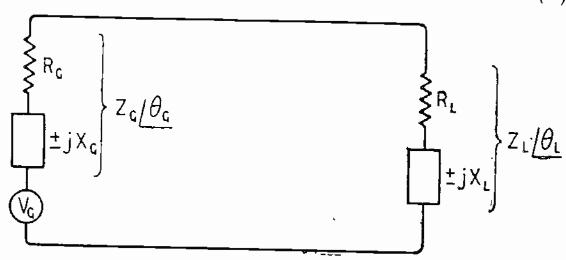


Fig. 6. *General case of both generator and load with reactive and resistive elements.*

Now by inspection

$$P_L = \frac{V_G^2\,R_L}{(Z_G|\theta_G + Z_L|\theta_L)^2}$$

$$\therefore AP_L = A\left[\frac{V_G^2\,R_L}{(Z_G|\theta_G + Z_L|\theta_L)^2}\right]$$

i.e. $\quad N_{(V_G Z_G Z_L R_L)} = 2AV_G + AR_L$

$$-\,2A\left[(Z_G|\theta_G + Z_L|\theta_L)\right] \quad .. \quad (9)$$

Considering the first two terms on the right-hand side of the equation we notice that, as we should expect, volts and the load resistance are expressed in absolute bels in the form deduced in equations (4) and (6) and, further it is obvious that

$$O_{(F_1,F_2,F_3 \ldots F_n)} = +O_{(F_1)} + O_{(F_2)} + O_{(F_3)} \ldots + O_{(F_n)}$$

The third term on the right of equation (9) is known as the matching factor (M) for it indicates the effect that the relative values of the load impedance and the generator impedance have upon the final power produced.

A useful "particular" case to remember is that where the load is "matched" to the generator, i.e. $R_L = R_G$ and $\pm jX_L = \mp jX_G$ then (since we have optimum matching N_M is written N_{OM})

$$N_{OM} = -2A[2R_L] = -2[AR_L + 0.3] \quad \ldots \ldots (10)$$

a further useful case to consider, is that in which the voltage across the load impedance is known; this is really the case of

$$Z_G = O\,|\underline{\theta^\circ}$$

and equation (9) becomes

$$AP_L = 2AV_G + AR_L - 2AZ_L|\underline{\theta_L} \quad \ldots \ldots (11)$$

which, if the load is purely resistive, simplifies to

$$AP_L = 2AV_G + AR_L - 2AR_L = 2AV_G - AR_L \quad \ldots \ldots (12)$$

General Applications of B

It should now be clear that a long "chain" network may be much simplified by the following technique. Let Fig. 7 represent any such network.

It is obvious that if all terms are expressed in absolute bels

$$N_{P_L} = 2AV + AR_L + N_{F_1} + N_{F_2} + N_{F_3} \ldots + N_{F_n} \quad \ldots (13)$$

Thus all the essential facts regarding an amplifier (impedances, rated output, etc.) should be expressed in absolute bels. It may be noticed in passing that while this arrangement presents all data in their most simple form for speedy calculations, information in more normal notation is readily obtainable since to determine (F) from $N_{(F)}$ only requires one simple and obvious operation.

In Fig. 8 a "transformer" is inserted between a generator $Z_G|\underline{\theta_G}$ and a load $Z_L|\underline{\theta_L}$ which, with both generator and load connected, "looks like" $Z_P|\underline{\theta_P}$ to the generator and $Z_S|\underline{\theta_S}$ to the load. This "transformer" may be a transformer, as the term is normally understood, in which case it will transmit x per cent. of the power applied to it, or the "transformer" may be an amplifier, in which case (neglecting the "raw" power supplied to it) it will transmit more power than it receives.

These transformers have a gain factor G which in the case of an amplifier having a gain control, is marked upon the control in such a manner that, in the position of maximum gain, the value of N_G is shown, while in all other positions, the effect of the gain control upon the N_G figure is taken into account.

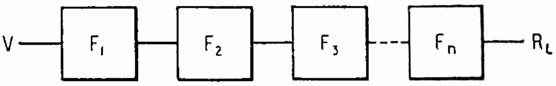


Fig. 7. *A chain network is represented symbolically here.*

Thus in an amplifier having a gain control in 3 db stages, with a maximum gain in the, clockwise direction, and an N_G of 10 dB, the gain control would be marked in the way indicated in Fig. 9.

N_G is determined in the following manner:

Let $\dfrac{mVZ_P|\underline{\theta_P}}{Z_G|\underline{\theta_G} + Z_P|\underline{\theta_P}}$ be the "generator" volts in the secondary circuit (see Fig. 8) when

$$\frac{VZ_P|\underline{\theta_P}}{Z_G|\underline{\theta_G} + Z_P|\underline{\theta_P}} \text{ Volts}$$

are applied across the primary $Z_P|\underline{\theta_P}$

Then

$$P_L = \frac{\left[\dfrac{mVZ_P|\underline{\theta_P}}{Z_G|\underline{\theta_G} + Z_P|\underline{\theta_P}}\right]^2}{(Z_S|\underline{\theta_S} + Z_L|\underline{\theta_L})^2} R_L$$

$$\therefore \quad AP_L = 2AV + AR_L - 2A(Z_G|\underline{\theta_G} + Z_P|\underline{\theta_P}) - 2A(Z_S|\underline{\theta_S} + Z_L|\underline{\theta_L}) + 2A(Z_Pm) \quad \ldots \ldots (14)$$

$2A(Z_Pm)$ is the gain factor (N_G)

and we see that equation (14) is in what is now rapidly becoming a familiar form (reading the right side from left to right) with an E.M.F. factor, load factor, primary and secondary matching factors and a gain factor to indicate what is occurring in the "transformer."

If $Z_G|\underline{\theta_G} = Z_P|\underline{\theta_P} = Z_S|\underline{\theta_S} = Z_L|\underline{\theta_L} = R_L$

equation (14) reduces to

$$AP_L = 2AV - 3AR_L + N_G - 1.2 \quad \ldots \ldots (15)$$

A loudspeaker is, of course, a "particular" case of the transformer problem, in this case transforming electrical into acoustical power. Consider equation (14). The terms $-2A(Z_S\underline{|\theta_S} + Z_L\underline{|\theta_L})$ and $2A\,(Z_Pm)$ are electro-acoustical and obviously depend upon the construction of the instrument, while AR_L (a purely acoustical term) is for practical purposes a constant. (See note on K below). They may therefore be "lumped" and described as the transformation factor of the loudspeaker (T).

does not from a practical viewpoint convey the desired information.

What is of interest is not what is happening "in the box" but what is happening at a point a reasonable distance from it.

With the types of loudspeaker normally used the sound is diverging at the distance from the instrument at which one may expect to find a listener and, generally it is found, in the writer's experience, that anyone who is attempting to obtain optimum "listening" tends to sit on, or within a reasonable angle off, the centre line which is at right angles to the "plane of diffusion" of the machine.

In these conditions no appreciable error is involved in assuming that the power is varying inversely with the square of the distance from the "front" of the loudspeaker.

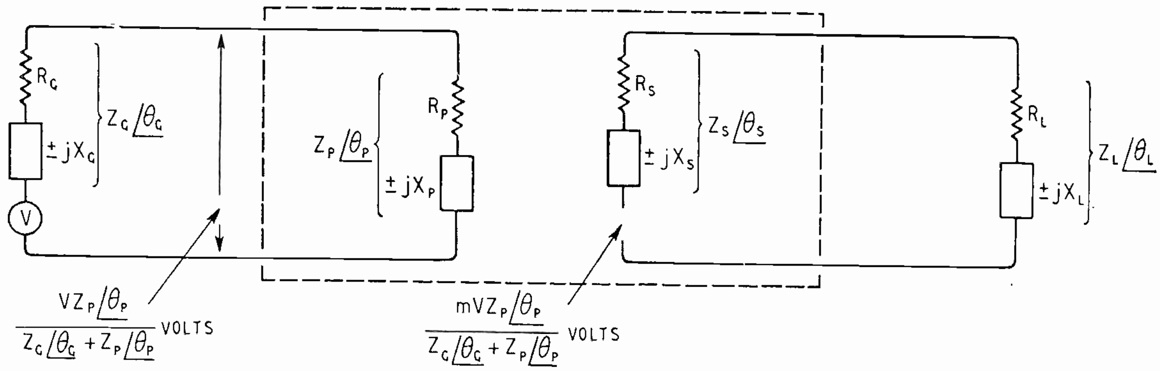


Fig. 8. *A transformer or amplifier represented by Z_p and Z_s is connected between generator and load.*

Then if P_A is the total acoustical power produced by the instrument

$$AP_A = 2AV - 2A(Z_G\underline{|\theta_G} + Z_{LS}\underline{|\theta_{LS}}) + N_{T_{LS}} \quad \ldots \quad (16)$$

Where $Z_{LS}\underline{|\theta_{LS}}$ is the electrical input impedance of the unit. Let us suppose that we are able to determine experimentally that when R_{LS} is the "in phase" component of a loudspeaker the application of an electrical power

$$P_E = \frac{V^2 R_{LS}}{(Z_G\underline{|\theta_G} + Z_{LS}\underline{|\theta_{LS}})^2}$$

produces a total acoustical power P_A and let $P_E = \beta P_A$.

Then

$$AP_A = 2AV + AR_{LS} - 2A(Z_G\underline{|\theta_G} + Z_{LS}\underline{|\theta_{LS}}) - A\beta \quad (17)$$

From 16 and 17.

$$2AV - 2A(Z_G\underline{|\theta_G} + Z_{LS}\underline{|\theta_{LS}}) + N_{T_{LS}} = 2AV + AR_{LS} - 2A(Z_G\underline{|\theta_G} + Z_{LS}\underline{|\theta_{LS}}) - A\beta$$

$$\therefore \quad N_{T_{LS}} = AR_{LS} - A\beta \quad \ldots \quad \ldots \quad (18)$$

To determine P_A (and hence β the "badness" of the loudspeaker) accurately presents some difficulties and the resultant β

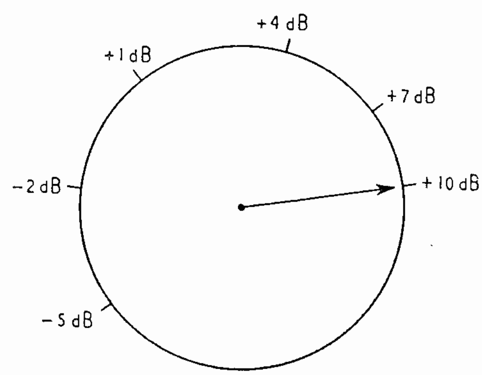


Fig. 9. *Scale of gain control calibrated in absolute decibels.*

We can then make an arbitary and untrue assumption (which does not introduce any error in determining the acoustical pressure at a listener's ear) that the loudspeaker is radiating all the power evenly through a solid angle of $2\cos^{-1}\dfrac{2\pi - 1}{2\pi}$ (about 66°)

so that the acoustical power per unit area at any distance l is inversely proportional to l^2.

Then if the acoustical power per unit area (P_{AT}) at a suitable test distance l_t be measured by a convenient means when a known electric power P_E is applied to the instrument

$$A\beta = AP_E - AP_A = AP_E - AP_{AT} - 2Al_t \quad \ldots \quad \ldots \quad (19)$$

We see, therefore, that for acoustical purposes any length l may be expressed in absolute bels (N_l) from the formula

$$N_l = 2Al$$

This convention does not of course give any indication of the actual total acoustical power produced by the instrument, but it does give an accurate indication of the usable power, which is what is of interest.

The above principles may with advantage be applied in reverse to microphone problems.

The Phon and Dyne/cm²

The phon, although expressed in decibel notation, is of course more than a power ratio as all powers are referred to a known power of 10^{-16} watts.

In other words, it would be an " Absolute bel expression " if only the reference level were different (10° watts) and phons at 1,000 c/s may be converted to dN_{Ph} by the simple deduction of the constant 160.

Thus at 1,000 c/s $x/10$ phons $- 16 =$ Acoustic power expressed in absolute bels.

At any frequency other than 1,000 c/s it is necessary to add a correction C (in bels) to provide for the characteristics of the human ear as indicated in the curves by Fletcher and Munson.

If P_A = acoustical power expressed in watts/cm²

d = dynes/cm²

K = a constant for any given conditions

Then $$\frac{d^2}{K} = P_A$$

$$\therefore \quad AP_A = 2Ad - AK \text{ or } AK = 2Ad - AP_A \quad \ldots \quad \ldots \quad (20)$$

Now under normal conditions of loudspeaker working a force of 204×10^{-6} dynes/cm² produces a power of 10^{-16} watts.

From equation (20)

$$AK = 2(\bar{4}.31) + 16 = -7.38 + 16 = 8.62$$

A summary of all the results appears in Table 1.

As an example, it is required to know what voltage and what electrical power should be applied to a speech coil (having a resistance of 0.3 B and impedance of -0.8 B both at 50 c/s, a transformation factor -2.2 B and a frequency discrimination compared with 1,000 c/s of -1 b at 50 c/s), in order to produce 75 phons at 50 c/s at a distance of 184 cm, from the cone on the centre line.

A study of the Fletcher and Munson curves indicates that it requires 0.7 bels more power to obtain 75 phons at 50 c/s compared with the power required at 1,000 c/s, i.e. $C = 0.7$ b.

The acoustical power at the loudspeaker is

$$\frac{75}{10} - 16 + 0.7 + 4.53 = AP_A = -3.27\text{B}$$

The first three terms are concerned with the conversion from phons to watts, and the fourth with the distance of 184 cm.

Now $$N_{P_A} = N_V + N_{Z_{LS}} + N_T - 1$$
(Compare with equation 16).

$$\therefore \quad N_V = 1 - N_{Z_{LS}} - N_T + N_{P_A}$$
$$= 1 + 0.8 + 2.2 - 3.27 = 0.73 \text{ B}$$

$$V = \text{Antilog}_{10} \frac{0.73}{2} = 2.3 \text{ volts.}$$

and

$$N_{P_E} = N_V + N_{R_{LS}} + N_{Z_{LS}} = 0.73$$
$$+ 0.3 - 0.8 = 0.23 \text{ B}$$

$$\therefore \quad P_E = 1.7 \text{ watts.}$$

Where it is desired to ascertain relative as well as quantitative readings on linear volt or ampere meters, they may be marked as in Fig. 10. This scale is one which the author finds most useful for his particular

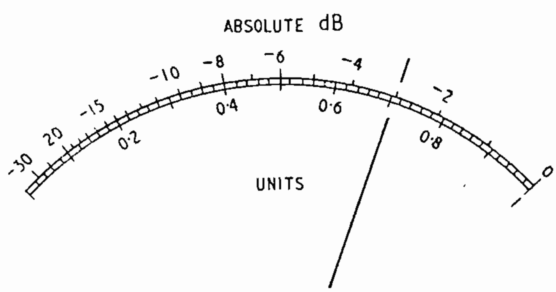


Fig. 10. *Metre scale with calibration in absolute decibels.*

class of work. He is always interested in two things, viz. :

(1) what is happening in the circuit to which the meter is attached and,

(2) what is happening (in phons) in space 200 cm, from standard types of loudspeakers

which may be located anywhere in a very large area.

Table 2 indicates the relation between the dB and Unit scales. The long mark right through the dial (Fig. 10) indicates the normal maximum reading for the instrument. This gives a margin on the meter of 3 db in hand, so that, if at any time, through bad control, the power is being transmitted at too high a level, there is a direct indication of the value of this overload and also a margin of safety as far as the meter itself is concerned.

It will be realised that the scale is correct only for a maximum R.M.S. voltage or current of unity applied to a non-reactive resistance of 1 ohm, but it holds good wherever it may be installed, if read in conjunction with a small correction card, which is attached to the outside of the meter and, changed whenever the meter is installed in a different circuit.

Fig. 11 shows a typical card, and this paper may well close by showing the extreme ease and speed with which the data for this card may be obtained. The case con-

	Apply Corrections.	
(a) ⟶	Volts	× 0.01
(b) ⟶	mA	× 0.016
(c) ⟶	Power	— 68 dB
(d) ⟶	Phons	+ 78

Fig. 11. *Typical correction card for a meter scale.*

sidered is that of the network shown in Fig. 12. The card is for use with a voltmeter which is across the input terminals of an amplifier (No. 1) which normally

TABLE I

POWER (P) $N_p = AP$

Volts (V)	$N_V = 2AV$	**Current (I)**	$N_I = 2AI$
Resistance (R)	$N_R = AR$	**Impedance (Z)**	$N_Z = -2AZ$
Matching Factor (M) (Where $Z_G\|\underline{\theta_G}$ and $Z_L\|\underline{\theta_L}$ are generator and load impedances, or sending and receiving impedances respectively).	$N_M = -2A (Z_G\|\underline{\theta_G} + Z_L\|\underline{\theta_L})$	**Optimum Matching** ($R_G \pm jX_G = R_L \pm jX_L$)	$N_{OM} = -2[AR_L + 0.3]$
Gain Factor (G) (Where Z_p is the primary impedance and m equals the volts appearing across the secondary when it is "on open circuit" divided by the volts at that time being applied across Z_p).	$N_G = 2A\,[Z_p m]$	**Distance (l)**	$N_l = 2Al$
		Dynes/cm (d)	$N_d = 2Ad - 8.62$
Loudspeaker transformation factor (T) (Where R_{LS} equals the input resistance of the loud speaker).	$N_T = AR_{LS} - A\beta$	**Effective badness (β)** of Loudspeaker. (Where P_E equals electric power applied to the loudspeaker for an accoustic power P_{AT} per cm² at a test distance l_T.)	$N_\beta = AP_E - AP_{AT} - 2Al_T$

CONVERSIONS

Dynes/cm² (d) to phons (Ph)	$2Ad + 7.38 - C = \frac{Ph}{10}$	**Phons (Ph) to dynes/cm² (d)**	$\frac{Ph}{10} + C - 7.38 = 2Ad$
Phons (Ph) to watts/cm² (P_A)	$\frac{Ph}{10} + C - 16 = AP_A$	**Watts/cm² (P_A) to dynes/cm² (d)**	$AP_A + 8.62 = 2Ad$
Watts/cm² (P_A) to phons (Ph)	$AP_A + 16 - C = \frac{Ph}{10}$	(Where C is the additional power (in bels) required at any frequency in accordance with the Fletcher and Munson Curves).	

receives a maximum R.M.S. voltage of 0.007 volts. This amplifier feeds an identical amplifier (No. 2) via a line having an insertion loss of 25 db.

It is a convenient and simple practice with absolute bels to assume that any two pieces of equipment actually joined by a having a 1-db insertion loss. The loudness in phons is to be computed at a distance of 200 cm on the centre line from the instrument.

Since normal maximum volts = 0.007 (R.M.S.) (read at normal maximum line 3 db below full scale.)

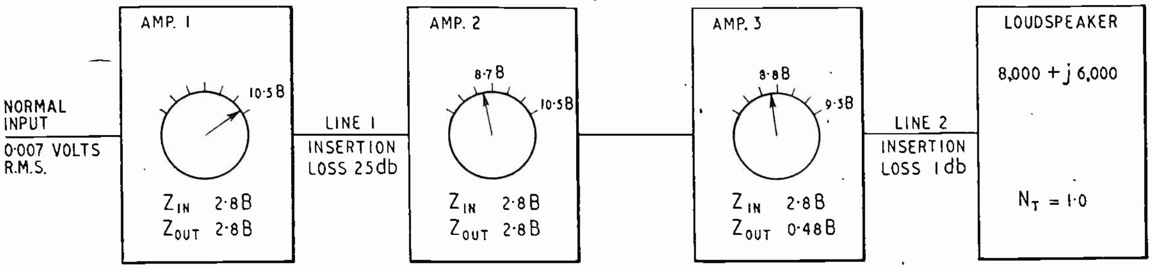


Fig. 12. *Amplifier arrangement used to illustrate the application of absolute bels.*

line are directly joined and to describe the line as having an insertion loss in accordance with the facts.

Amplifiers (1) and (2) are indentical line amplifiers, each having resistive inputs and outputs of 2.8 B and an N_G of 10.5 *B*, the gain control in amplifier (1) being in the full gain position, and that in amplifier (2) is applying an insertion loss of 18 db.

TABLE II

dB	Units	dB	Units
1	0.89	12	0.25
2	0.79	13	0.22
3	0.71	14	0.20
4	0.63	15	0.18
5	0.56	16	0.16
6	0.50	17	0.14
7	0.45	18	0.12
8	0.40	19	0.11
9	0.36	20	0.10
10	0.32	25	0.06
11	0.28	30	0.03

Amplifier (2) feeds a third amplifier (3) having a resistive input of 2.8 B, an N_G of 9.3 B and an output impedance of $3 + jO$ ohms (0.48 B). Its gain control is set to an insertion loss of 5 db. This amplifier in turn feeds a loudspeaker having an input impedance of $8000 + j6{,}000$ (— 8 B) a transformation factor (N_T) of 1.0 B fed by a line

Full-scale reading $N_V = 0.3 + 2A\ 0.007 = 0.3 - 4.3 = -4$B, i.e. 0.01 volt R.M.S. .. .. (a)

From first principles

$$2AI = -4 - 5.6 = -9.6 \text{ B}$$

$\therefore \quad AI = -4.8$B, i.e. 0.016 mA .. (b)

and $N_P = -4 - 2.8 = -6.8$B .. (c)

$\frac{\text{Phons}}{10}$ equals

$+ 16$ = w/Ph conversion constant
$- 4$ = Applied volts
$- 5.6$ = Input match amp. 1
$+ 10.5$ = N_G amp. 1
$- 2.5$ = Insertion loss line 1
$- 6.2$ = Matching amp. 1 to amp. 2
$+ 8.7$ = N_G amp. 2 corrected for attentuator setting
$- 6.2$ = Matching amp. 2 to amp. 3
$+ 8.8$ = N_G amp. 3, corrected for attenuator setting
$- 0.1$ = Insertion loss line 2
$- 8$ = Matching amp. 3 to loudspeaker
$+ 1.0$ = N_T
$- 4.6$ = 200 cm

= 7.8

i.e. 78 phons .. .. (d)

BEAM TETRODE CHARACTERISTICS*

The Effect of Electron Deflections

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SUMMARY.—In this paper the anode-current—anode-voltage characteristic of a beam tetrode is deduced on the assumption that the electrons entering the screen-to-anode space are not all projected normally to the screen plane, but that they possess a distribution-in-angle given by a particular continuous function, for convenience given in terms of the sine of angle of entry. This supplements previous treatments of the problem, in which it has been assumed that above a maximum angle the relative number of entering electrons falls abruptly to zero, i.e. the distribution is represented by a discontinuous function.

It is shown that, although this discontinuous feature is lacking in the newly assumed distribution, "regions of instability" yielding sharp knees are still obtained, due to the action of space charge.

Introduction

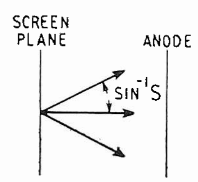
IT has been recognised for some time that the anode-current—anode-voltage characteristics of beam tetrodes are greatly modified by the fact that the electrons which enter the screen-to-anode space have previously been deflected at the grid and screen wires[1–5]. The main consequence of such deflections is that the forward electron velocities are diminished, so that the strongly deflected electrons are brought to rest and then reflected back to the screen from some plane intermediate between the screen and anode where the potential is sufficiently low, but still positive. If the current were carried by undeflected electrons such reflection could occur only at a "virtual cathode," where the potential is zero, but the "virtual cathode" theory leads to tetrode knee-voltages which are much too high.

In this paper attention is restricted to the plane parallel electrode arrangement, with an infinitely long and infinitely wide emitting cathode, so that if a section of the beam is taken at a plane parallel to the cathode, the area of the beam is infinitely large. In this case edge effects can be neglected. It is assumed that the electron trajectories at entry into the screen-to-anode space are inclined to the normal to the screen plane, and it is further necessary to make some assumption regarding the distribution-in-angle of the current projected into this space. For the calculations which follow a modified expression for the distribution function has been adopted; this gives the current density distribution as a function of the sine s of the angle of entry; thus

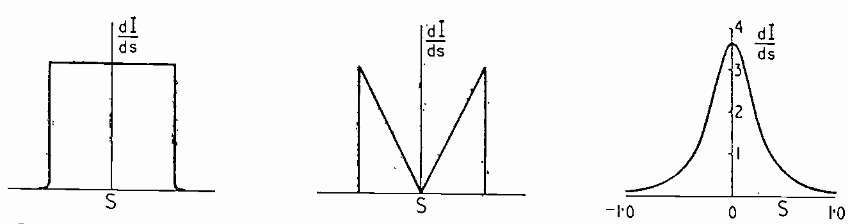
$$dI = I_T i(s)\, ds$$

where $I_T i(s)$ is the current density comprised between values of the sine of the angle of entry ranging from s to $s + ds$.

I_T is the total current density, i.e. the current flowing across unit area of the screen plane.



(a)



$\frac{dI}{ds}$ CONSTANT OR ZERO (b)

$\frac{dI}{ds}$ LINEAR OR ZERO (c)

$\frac{dI}{ds}$ A CONTINUOUS FUNCTION (d)

Fig. 1. *Various assumed distributions plotted against sine of angle of entry.*

dI/ds [i.e. $I_T i(s)$] is the distribution function as shown in Fig. 1. When $i(s)$ is known, the potential throughout the screen-to-anode space can be precisely evaluated. This has already been done, for several simple assump-

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tions regarding $i(s)$, by Strutt and van der Ziel, by G. B. Walker and by the writer. It is the object of the present paper to extend these calculations to the important case where $i(s)$ is a continuous, instead of a discontinuous function, and to show that "regions of instability"[4] yielding sharp knees, are still obtained.

The Current reaching the Anode

Let it be supposed that the screen plane is at a potential V_1 above the cathode, with the anode at a potential V_2, and that there is a potential minimum, of magnitude V_m, somewhere between the screen and anode.

[In what follows we shall write

$$V/V_1 = W\,;\ \sqrt{V/V_1} = w\,;\ \sqrt{V_m/V_1} = w_m\,;$$
$$\sqrt{V_2/V_1} = w_2\,;\text{ and } \sqrt{V} = v]$$

The condition that an electron should reach the anode is that $V_1 s^2$ should be less than V_m, i.e. s lies between $-w_m$ and $+w_m$. The primary current incident on the anode is therefore

$$I_A = I_T \int_{-w_m}^{+w_m} i(s)\,ds \quad \ldots \quad (2)$$

This equation for I_A gives the anode current as a function of w_m; for fixed conditions of grid and screen voltage this characteristic should be independent of the screen-to-anode gap. For small values of I_T, or for short gaps, a potential minimum will not exist, but if the anode voltage is lower than the screen voltage the anode voltage V_2 will be the lowest in the screen-to-anode space, and hence w_2 should replace w_m as the limits in the integral. With regard to the form of $i(s)$ it may be shown that when the deflections at the grid and screen wires are cumulative, as in a tetrode, the basic I_A—w_m characteristic approaches the full value gradually, and therefore the function $i(s)$ should represent a continuous curve[5].

In order to reproduce this the following function has been chosen for $i(s)$

$$i(s) = \frac{1}{2\tan^{-1}k}\cdot\frac{k}{1+k^2s^2} \quad \ldots \quad (3)$$

where k is an arbitrary constant.

This yields on integration with respect to s, with limits $-w_m$, $+w_m$

$$I_A = I_T\left[\frac{\tan^{-1}kw_m}{\tan^{-1}k}\right] \quad \ldots \quad (4)$$

These relations are shown in Figs. 1(d) and 2.

The Space Charge Conditions between Screen and Anode

If the space-charge density is known throughout the screen-to-anode space we can find the potential distribution by effecting a solution of Poisson's equation.

Now if dI is the current density comprised between s and $s+ds$ the corresponding contribution $d\rho$ to the negative space-charge density ρ is dI/u, where u is the forward electron velocity.

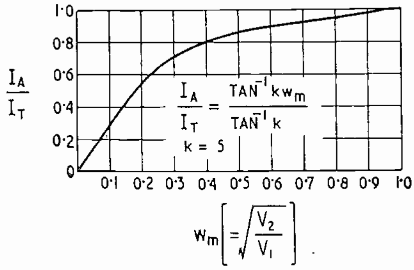

Fig. 2. *I_A/I_T plotted againt w_m for assumed distribution.*

At a plane where the potential is V (E.S.U.) the value of u is

$$\sqrt{2\epsilon/m}\,\sqrt{V - V_1 s^2}$$

where ϵ = charge of electron in E.S.U.

m = mass of electron

But $dI = I_T\, i(s)\,ds$

$$\therefore \quad d\rho = \frac{I_T\, i(s)\,ds}{\sqrt{2\epsilon/m}\,\sqrt{w^2 - s^2}} \quad \ldots \quad (5)$$

If sufficient current density is projected across the screen plane a potential minimum will be formed. On the anode side of the potential-minimum plane there are present only electrons for which $V_1 s^2$ is less than V_m, but on the screen side of the potential-minimum plane the circumstances are more complicated, since there are present both forward and returning electrons. The forward electrons, crossing a plane where the potential is V, comprise those for which $V_1 s^2 < V$, while the returning electrons comprise those for which $V_1 s^2$ lies between V_m and V (the electrons for which $V_1 s^2 < V_m$ go on to the anode).

Hence the value of ρ at a plane lying on the screen side of the potential minimum is given by

$$\sqrt{2\epsilon/m\,V_1}\,.\,\rho = I_T\left[\int_{-w}^{+w}\frac{i(s)\,ds}{\sqrt{w^2-s^2}} + \int_{-w}^{-w_m}\frac{i(s)\,ds}{\sqrt{w^2-s^2}} + \int_{w_m}^{w}\frac{i(s)\,ds}{\sqrt{w^2-s^2}}\right] \quad (6)$$

If $i(s)$ is an even function, which is the practical case, this simplifies to

$$\sqrt{2\epsilon/m}\,V_1\,.\,\rho = 2I_T\left[2\int_0^w \frac{i(s)\,ds}{\sqrt{w^2-s^2}} - \int_0^{w_m}\frac{i(s)\,ds}{\sqrt{w^2-s^2}}\right] \quad \ldots \quad \ldots \quad (7)$$

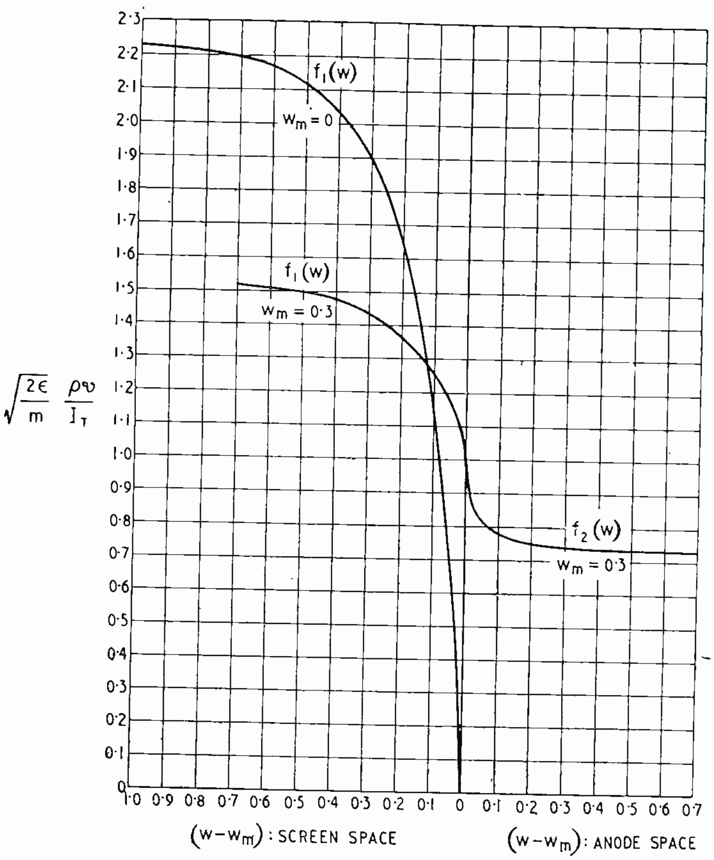

Fig. 3. *$\sqrt{2\epsilon/m}\,\rho v/I_T$ plotted against $(w - w_m)$.*

In a similar manner the space charge density at a plane on the anode side of the potential minimum is given by the expression

$$\sqrt{2/\epsilon m}\,V_1\,.\,\rho = 2I_T\int_0^{w_m}\frac{i(s)\,ds}{\sqrt{w^2-s^2}} \quad (8)$$

It is interesting to consider the product ρv instead of the space charge density ρ; thus if each side of the above expressions is multiplied by w, we have, since

$$\sqrt{V_1}\,.\,w = v$$

$$\sqrt{2\epsilon/m}\,.\,\rho v = 2I_T\left[2w\int_0^w \frac{i(s)\,ds}{\sqrt{w^2-s^2}} - w\int_0^{w_m}\frac{i(s)\,ds}{\sqrt{w^2-s^2}}\right] \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

and

$$\sqrt{2\epsilon/m}\,.\,\rho v = 2I_T\left[w\int_0^{w_m}\frac{i(s)\,ds}{\sqrt{w^2-s^2}}\right] \quad \ldots \quad \ldots \quad (10)$$

on the screen and anode sides of the potential minimum, respectively.

When $i(s) = \dfrac{1}{2\tan^{-1}k}\cdot\dfrac{k}{1+k^2s^2}$ the integrals can be evaluated (see Appendix) and give the following results :—

(1) *On screen side of potential minimum*

$$\sqrt{2\epsilon/m}\,.\,\rho v = I_T\frac{\sin\alpha}{\tan^{-1}k}\,[\pi - (\psi + \chi)]$$
$$= I_T f_1(w),\ \text{say} \quad \ldots \quad \ldots \quad (11)$$

(2) *On anode side of potential minimum*

$$\sqrt{2\epsilon/m}\,.\,\rho v = I_T\frac{\sin\alpha}{\tan^{-1}k}\,[\psi + \chi]$$
$$= I_T f_2(w),\ \text{say} \quad \ldots \quad \ldots \quad (12)$$

where

$$\alpha = \tan^{-1}kw\,; \quad \psi = \sin^{-1}w_m/w\,;$$

$$\chi = \tan^{-1}\left[\frac{\sin 2\psi\,\tan^2(\alpha/2)}{1-\cos 2\psi\,\tan^2(\alpha/2)}\right]$$

The courses of $f_1(w)$ and of $f_2(w)$ are shown in Fig. 3, with k chosen to be 5.

Determination of the Potential Distribution, knowing ρv

Poisson's Equation is $d^2V/dx^2 = 4\pi\rho$ where ρ is the density of negative space charge in E.S.U., and x is measured in cm. If both sides are multiplied by $2dV/dx$ (i.e. by $4v\,dv/dx$) we get

$$dV/dx\,(dV/dx)^2 = 16\pi\,\rho v\,dv/dx$$
$$= 16\pi\,V_1^{\frac{1}{2}}\,\rho v\,dw/dx$$

$$\therefore \quad (dV/dx)^2 = 16\pi\,V_1^{\frac{1}{2}}\int_{w_m}^{w}\rho v\,.\,dw$$

or since

$$W = V/V_1$$

$$(dW/dx)^2 = \frac{16\pi}{V_1^{3/2}} \int_{w_m}^{w} \rho v \, . \, dw$$

Now ρv is of the form $\dfrac{I_T}{\sqrt{2\epsilon/m}} f(w)$

$$\therefore \quad (dW/dx)^2 = \frac{16\pi \, I_T}{\sqrt{2\epsilon/m} \; V_1^{3/2}} \int_{w_m}^{w} f(w) \, dw$$

In order to simplify this, we may note that the current which flows in a diode of gap x_a with anode maintained at a potential V_1 is

$$\frac{\sqrt{2\epsilon/m} \; V_1^{3/2}}{9\pi \, x_a^2} \text{ E.S.U/cm}^2 = I_d, \text{ say,}$$

If then I_T is put equal to $J_T \, . \, I_d$

$$(dW/dx)^2 = 16/9 \; J_T/x_a^2 \int_{w_m}^{w} f(w) \, dw$$

and

$$\therefore \quad \frac{x - x_m}{x_a} = \frac{3}{2\sqrt{J_T}} \int_{w_m}^{w} \frac{w \, dw}{\sqrt{\int_{w_m}^{w} f(w) \, dw}} \quad .. \quad .. \quad (13)$$

From this the potential distribution against x can immediately be derived. Thus if the distance from the potential minimum to the screen is x_1

$$x_1/x_a = \frac{3}{2\sqrt{J_T}} \int_{w_m}^{1} \frac{w \, dw}{\sqrt{\int_{w_m}^{w} f(w) \, dw}} \quad .. \quad (14)$$

the upper limit being unity, since $w = 1$ at the screen.

Again, when the total gap x_a from screen to anode is fixed, the potential minimum to anode distance x_2 must equal $(x_a - x_1)$ The value of the upper limit w must then be found which gives this value for x_2; thus the anode voltage V_2 is such that

$$x_2/x_a = \frac{x_a - x_1}{x_a} = \frac{3}{2\sqrt{J_T}} \int_{w_m}^{w_2} \frac{w \, dw}{\sqrt{\int_{w_m}^{w} f_2(w) \, dw}} \quad .. \quad .. \quad (15)$$

The integrals must be evaluated by numerical methods; when this is done, there is at our disposal complete means for finding the anode-current—anode-voltage characteristics.

In order to do this, we first plot w_m against $\sqrt{J_T} \, x_1/x_a$ the values being computed from Equ. (14), This gives the boundary curve shown in Fig. 4, and indicates the relative position of the potential minimum plane. The course of w for any assigned w_m is next calculated from Equ. (13), with $f(w) = f_2(w)$, and plotted on the same graph against $\sqrt{J_T} \, x/x_a$. This is done for a suitable set of values of w_m. Now draw a vertical line displaced $\sqrt{J_T}$ from the origin; this will cut the family of w curves, and will give the values of w_2 corresponding to the values of w_m. Since, however, each w_m corresponds to a specific value of J_A/J_T we can plot J_A/J_T as a function of w_2 (Fig. 5), or better still, plot J_A against V_2/V_1. Fig. 6 shows J_A against V_2/V_1 for $J_T = 2$ and $J_T = 4$, and these are the computed shapes of the anode - current — anode - voltage characteristics.

In some ways the computed curves differ notably from the measured characteristics. It would be found in practice that the initial rising part of the $J_T = 4$ curve would approximately coincide with the initial rising part of the $J_T = 2$ curve. The writer does not think that this difficulty can

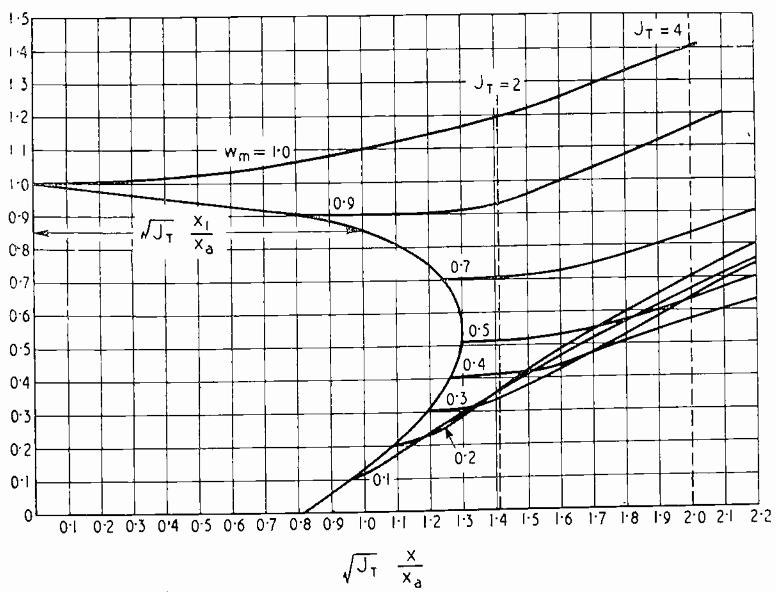

Fig. 4. *w plotted against* $\sqrt{J_T} \, x/x_a$ *for various values of* w_m.

be overcome as long as attention is confined to beams which are of large cross-sectional area in relation to the length. The negative resistance region, from W_σ to W_K, also is not so well marked in practice, although the space charge due to secondary

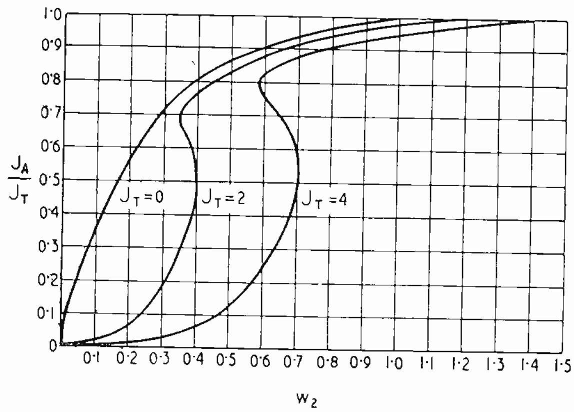

Fig. 5. *J_A/J_T plotted against w_2.*

electrons from the anode helps to reduce the effect.

If we identify W_σ the beginning of "the region of instability," as the beam tetrode "knee voltage" (since here, with increasing anode voltage, the anode current will shoot sharply up to a greater value), the calculations once more strikingly confirm that there is a large reduction in the knee voltage if the electrons are projected into the screen to anode space over a range of angles, as compared with the case when they all projected normally through the screen plane. The curves of Fig. 6 also verify the thesis of this paper that "knees" are obtainable even if the $i(s)$ characteristic is itself free from kinks.

Simplification where k is large

When k is sufficiently large, the equation for χ reduces to

$$\chi = \tan^{-1}\left[\frac{\psi}{\sin^2\psi + 1/kw}\right]$$

and if $w \gg w_m \,.\, kw_m$ this becomes

$$\chi = \tan^{-1} kw_m.$$

w can be large in comparison with w_m, so that ψ can be neglected in the expression $(\psi + \chi)$. It is then found that as $(w - w_m)$ is increased $\sqrt{2\epsilon/m}\,\rho v$ rapidly tends to the constant values I_A and $(2I_T - I_A)$ respectively on the anode and screen sides of the potential minimum (see Fig. 3). The calculations then give

$$x_1/x_a = \frac{(1 + 2w_m)(1 - w_m)^{\frac{1}{2}}}{\sqrt{2J_T - J_A}}$$

$$x_2/x_a = \frac{(w_2 + 2w_m)(w_2 - w_m)^{\frac{1}{2}}}{\sqrt{J_A}}$$

so that

$$1 = \frac{(1 + 2w_m)(1 - w_m)^{\frac{1}{2}}}{\sqrt{2J_T - J_A}} + \frac{(w_2 + 2w_m)(w_2 - w_m)^{\frac{1}{2}}}{\sqrt{J_A}}$$

In these equations we may put

$$J_A = J_T\,(2/\pi)\tan^{-1} kw$$

and on plotting obtain the anode-current—anode-voltage characteristic as shown in Fig. 7. The region of negative slope extends from W_b back to W_K with an abrupt change at Wb intermediately. If W_2 lies between W_K and $W_{\sigma\sigma}$ there are seen to be *three* possible values of J_A for an assigned value of W_2. As k tends to infinity* the upper parts of the curve become coincident, so that the distinction is no longer graphically evident. The condition that $k = \infty$ represents the case in which a "virtual cathode" is formed between screen and the anode (when I_A is less than I_T). Fig. 7 shows that, as already stated, the corresponding "virtual cathode" knee-voltage, given by W_σ is extremely high in comparison with the practical values obtained by measurement, which are normally much

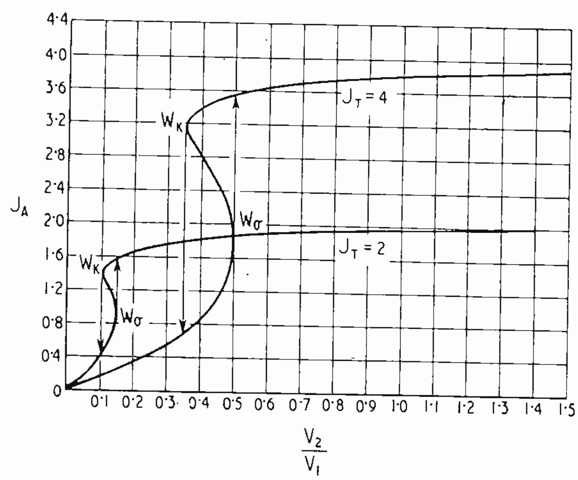

Fig. 6. *Computed anode-current—anode-voltage characteristics.*

more in agreement with the value of W_σ given by $k \simeq 5$.

* Or, if $I_A = I_T$ abruptly above some value of w_m, as in the distributions hitherto studied.

Acknowledgement

The writer wishes to accord his thanks to Mr. E. Y. Robinson, Chief Engineer of the Cosmos Manufacturing Co., Ltd., for his permission to publish this article.

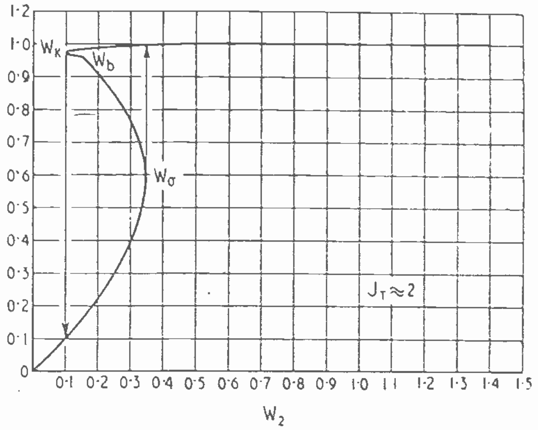

Fig. 7. *Anode-current—anode-volts characteristic when k is large.*

APPENDIX

Expressions (10) and (11) are derived from integrals of the form

$$\int_0^{w_m} \frac{i(s)\ ds}{\sqrt{w^2 - s^2}} \qquad \text{where } w > w_m$$

These occur, for example, in equations (7), (8), (9) and (10).

Let $i(s)$ be developed as a Fourier Integral for an even function.

$$i(s) = \int_0^{\infty} b(\lambda) \cos \lambda s\, d\lambda$$

where $$b(\lambda) = 1/\pi \int_{-\infty}^{+\infty} i(z) \cos \lambda z\, dz$$

Thus if $i(s) = \dfrac{ck}{1 + k^2 s^2}$ $\qquad b(\lambda) = c\epsilon^{-\lambda/k}$

Substitute $s = w \sin \phi$

then $$\frac{b(\lambda) \cos \lambda s\, ds\, d\lambda}{\sqrt{w^2 - s^2}}$$

$$= c\, d\lambda\, \epsilon^{-\lambda/k} \cos \left[\lambda w \sin\phi\right] d\phi$$

Now $$\cos (\lambda w \sin \phi) = J_0(\lambda w) + 2 \sum_1^{\infty} J_{2n}(\lambda w) \cos 2n\phi$$

where J_0 J_{2n} are the Bessel Functions.

Integrate $\cos [\lambda w \sin \phi] d\phi$ from ϕ = zero up to $\phi = \sin^{-1} w_m/w$ i.e. up to ψ.

$$\int_0^{\psi} \cos [\lambda w \sin\phi]\, d\phi = J_0(\lambda w) \cdot \psi + \sum_1^{\infty} J_{2n} (\lambda w) \frac{\sin 2n\psi}{n}$$

We next integrate

$$c\epsilon^{-\lambda/k} \left[J_0(\lambda w)\psi + \sum_1^{\infty} J_{2n}(\lambda w) \frac{\sin 2n\psi}{n}\right] d\lambda$$

from $\lambda = 0$ to $\lambda = \infty$

using the standard result $\displaystyle\int_0^{\infty} \epsilon^{-\lambda/k} J_{2n}(\lambda w) d\lambda$

$$= \frac{k}{\sqrt{1 + k^2w^2}} \left[\frac{\sqrt{1 + k^2w^2} - 1}{kw}\right]^{2n}$$

Then $$\int_0^{w_m} \frac{i(s)\ ds}{\sqrt{w^2 - s^2}}$$

$$= ck \cos \alpha \left\{\psi + \sum_1^{\infty} \tan^{2n} (\alpha/2) \frac{\sin 2n\psi}{n}\right\}$$

$$= ck \cos \alpha\left\{\psi + \chi\right\}$$

where

$$\tan \alpha = kw\,;\ \chi = \tan^{-1} \left[\frac{\sin 2\psi \cdot \tan^2 (\alpha/2)}{1 - \cos 2\psi \cdot \tan^2 (\alpha/2)}\right]$$

c is chosen to meet the requirement that the total current $= I_T$, when Equ. (2) is integrated with limits for s equal to $+1$, -1.

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[1] Rodda, *Wireless Engineer*, June 1936, p. 315.
[2] Strutt and van der Ziel, *Physica*, Oct. 1930, p. 977.
[3] Rodda, *Science Forum*, June 1943.
[4] Walker, *Wireless Engineer*, April, May, June 1945, pp. 157, 212, 276.
[5] Rodda, Lecture, Institute of Physics, Oct. 1944. *Electronic Engineering*, June, July, Aug., 1945.

RADIATION OF SHIP STATIONS ON 500 kc/s*

By J. Marique

(*Professor, Institute of Telecomunications, University of Brussels*)

Introduction

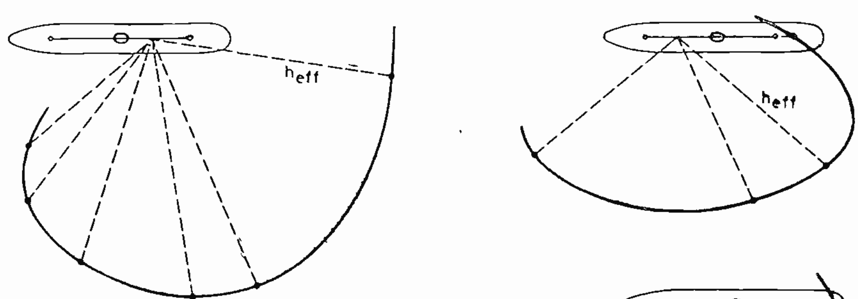
THE question of the radiation of ship stations on 500 kc/s is of more than purely academical interest, since the distress traffic takes place on this frequency and, in order that this traffic be effective, it is necessary that the range be sufficient. It is obvious that ships in a position to help should be within range under all conditions and that the distressed ship should receive their messages. The International Convention for Safety of Life at Sea[1] imposes minimum ranges to be obtained on 500 kc/s from ship stations transmitting on waves of types A2 and B, assuming that the receiving set makes use of a crystal. Nevertheless, as the range of a transmitter is not well defined without precise measurements, which are not normally carried out, the Convention has established, on the data they had at their disposal at the time (1929), the following rule :—

" Unless a more precise and practical method is available to determine the range of transmitters it is recommended that, as a guide, the following relations between the range in nautical miles (from ship to ship under normal conditions in daytime) and the power of the ship transmitter in metre-amperes for 500 kilocycles per second (600 m) be used :

100 nautical miles	..	60 *MA*
80 nautical miles	..	45 *MA*
50 nautical miles	..	25 *MA*

M being the actual height in metres of the aerial from its highest point to the load line, *A* being the current in amperes measured at the base of the aerial in case of B, or fully modulated A2 transmitters."

The General Radio Regulations of Cairo (1938) have made use of the same notion of " metre-amperes " and this value calculated for 500 kc/s must be inserted in the official list of the " Particulars of Ship stations " (G.R.R. appendix 8). The aim of this study is to make use of the results of a number of measurements made in actual conditions of working on type A2 waves, in order to establish a more rational basis of calculation for the predetermination of the ranges of ship stations. Most of these results were obtained before the war in experiments conducted by the International Radio-Maritime Committee.



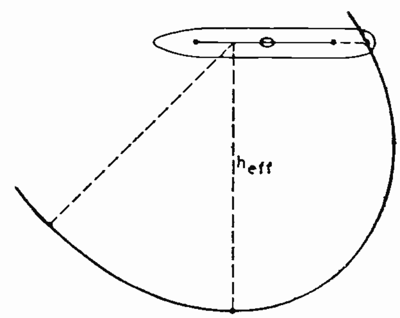


Fig. 1. *The apparent effective height of the aerials on three different ships is shown as a function of horizontal angle.*

1. Radiation Diagrams of Ship Aerials

It is well known that although ship aerials are generally of simple shapes, they are installed near numerous metal elements of large dimensions such as funnels, masts, rigging, etc., which influence the radiation. The radiation polar diagram must, therefore, be far from circular.

* MS. accepted by the Editor, November 1945.

By measuring the field strength and the intensity of the current at the base of the aerial, it is possible to calculate the radiated power and the effective height of the aerial. Taking advantage of a bend of the river Scheldt where the course of ships changes by about 120° in a few minutes, it has been possible to carry out special measurements which made it possible to draw a part of the radiation diagram for three ships, as represented in Fig. 1. The full diagram is probably symmetrical to the fore and aft line. The frequency chosen was 454 kc/s (660 m) in order to avoid the jamming on 500 kc/s; on the latter frequency the diagram must be very similar.

It can be seen that the apparent effective-height is not the same in all directions, and the graphs show that it can vary in the ratio 1 to 2 according to the direction in which the measurement is made. This well-known fact justifies the use of mean values calculated from several measurements when calculating ship-aerial radiation, and it will be adopted in the course of this study.

2. Radiated Power *v.* Metre-Amperes

In a paper published in 1939[2], we gave the results of numerous measurements of the power radiated by ship stations on 454 kc/s, the measurements being made at rather short distances. We showed that, in using the classical radiation formulae:

$$E = 120\pi \frac{\alpha h}{\lambda} \cdot \frac{I}{d} \cdot f(\rho) \qquad \ldots \qquad \ldots \qquad (1)$$

$$W_r = 160\pi^2 \left(\frac{\alpha h}{\lambda}\right)^2 I^2 \qquad \ldots \qquad \ldots \qquad (2)$$

and in considering the antenna height H as defined by the International Convention for Safety of Life at Sea, the following average relation between the radiated power W_r and the number of metre-amperes MA was found:

$$W_r = \left(\frac{MA}{K}\right)^2 \qquad \ldots \qquad \ldots \qquad \ldots \qquad (3)$$

K being a function of the form factor α of the antenna and of the wavelength:

$$K^2 = \frac{\lambda^2}{160\pi^2\alpha^2}$$

Fig. 2 shows the experimental results (small circles) and three curves corresponding to three values of K in equation (3). In log — log coordinates, these curves are straight lines. It must be borne in mind that each dot represents the mean value of several measurements made from the same ship, in order to eliminate as far as possible the influence of the radiation diagram.

Experience shows that K varies approximately between 25 and 50 at 454 kc/s. $K = 35$ seems to correspond the best to the greatest number of measurements made on this frequency.

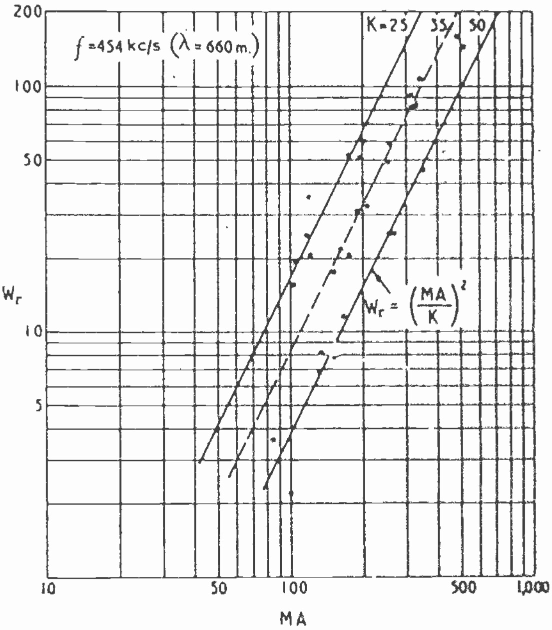


Fig. 2. *Measured results are shown by circles and the relation between radiated power and metre-amperes by the solid lines.*

From the values 25 to 50 it is deduced that the form factor lies between 0.33 and 0.66, *i.e.* that the effective height of ship aerials is between one-third and two-thirds of their actual height as defined by the Safety Convention.

As seen above, K is proportional to the wavelength:—for 500 kc/s, the extreme values of K are then 22.5 and 45 and the average value to be adopted for normal radiation conditions is $K = 32$.

The value of K does not seem to have any definite relation to the actual height of the aerial, since high values of K (which correspond to bad radiation) were experienced even with aerials as high as 40–50 metres.

From the above formulae it is possible to calculate the field strength corresponding to the values imposed by the Safety Convention for the ranges and numbers of metre-amperes. It is found that, in the worst conditions ($K = 45$) the field strength at the limit of the range must be of the order of 50 to 60 μV/m.

3. Metre-Amperes *v.* Antenna Power

As the number of MA can be used to calculate from the above formulae the radiated power W_r and consequently the field strength at a distance, it is interesting to investigate if there exists a simple relation between MA and the power W_a the transmitter is delivering to the aerial.

When a transmitter is designed the power delivered to the aerial is measured, using a dummy aerial consisting generally of a resistance R in series with a capacitance. The aerial power is then

$$W_a = RI^2 \quad .. \quad .. \quad .. \quad .. \quad (4)$$

It must be pointed out that R does not include the resistance of the circuits inside the set itself (coil inductance, variometer, etc.) but is only the apparent resistance of that part of the aerial circuit external to the set.

The resistance of the actual aerial is generally unknown, and is measured only in exceptional cases; but it is known that its value lies normally between 4 and 8 ohms, and often 6 ohms is considered as an average value.

If the actual value of R were known, the measurement of I would permit the determination of W_a from equation (4), and of MA when the actual height H is known. In these circumstances the whole determination of the performance of a given ship station would be very easily dealt with.

Let us now investigate if this simple method, applicable to individual cases, could be generalized. At first sight, this may seem questionable, because ship aerials are so diverse, their heights are so different, their capacitances and natural wavelengths show such deviations that it would not be unsound to expect very important discrepancies which would prevent the use of a general method of calculation.

In order to check this fact, we have carefully examined the first-hand data concerning about 150 ship installations of A2 type transmitters of various nationalities. In

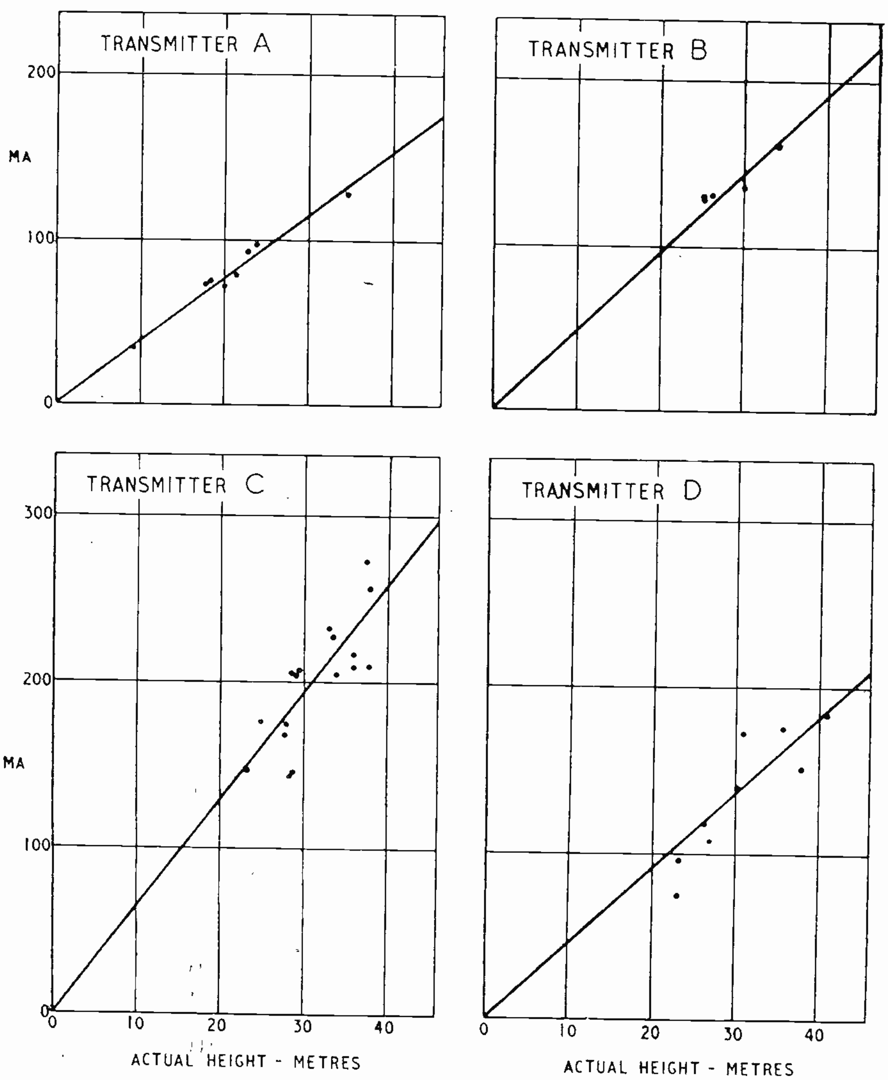


Fig. 3. *These graphs show measured values of MA for four different transmitters as a function of actual aerial height. Each dot corresponds to a ship.*

the graphs of Fig. 3 we have plotted the number of MA obtained as a function of the actual height for four different types of transmitters installed on several ships. Each dot corresponds to a ship. The number of MA was chosen as ordinate instead of the current I, since it is one of the figures to be published in the official lists of ship stations.

One can realize that in practice MA varies nearly proportionally to the actual height H, which means that the intensity of the current delivered by a certain type of transmitter is nearly constant whatever the ship aerial to which it is connected may be. It is then possible to write for each type of transmitter the average relation

$$I = \frac{MA}{H} = \text{constant} \quad .. \quad .. \quad (5)$$

In each of the four graphs of Fig. 3, the mean relation between MA and H can be represented by a straight line, the slope of which corresponds evidently to the mean value of the current. It must be pointed out that for the transmitter A, the proportionality between MA and H holds for aerials having actual heights between 9.2 m and 35 m.

This leads to the conclusion that it is by no means unreasonable to consider, for each type of transmitter, a mean value of the aerial current I characterizing that type of set. The discrepancies which may be experienced from one installation to another, and which, in the 150 data examined, do not exceed $\pm$ 33 per cent. of the mean values, are certainly due to local circumstances such as absorption by the rigging, very abnormal electrical characteristics of the aerial, or even to bad matching of the output circuit.

Incidentally, it is worth while to point out that manufacturers mention sometimes as " rated aerial power " the power which a transmitter is capable of delivering to the aerial, as defined in equation (4).

If, on the other hand, it has been possible to collect experimental data on actual installations of the same type of transmitter, and thus to calculate the corresponding mean value of the aerial current, a mean experimental value of the aerial resistance can be deduced by the reverse process, assuming that in each case the rated power has been actually delivered to the aerial

In doing so for four different types of transmitters, we obtained the figures of Table 1.

TABLE 1

Rated aerial power (Watts)	Experimental mean aerial current (Amps)	Deduced mean value of resistance (Ohms)
100	3.8	7
200	6.35	5
250	6.5	5.9
1000	12.2	6.8

These figures, however questionable the method of obtaining them may be considered, are well within the above-mentioned limits of 4 to 8 ohms.

4. Radiated Power W_r *v.* Aerial Power W_a

The considerations developed in Sect. 3 have shown that it is reasonable to consider a mean value of the aerial current characterizing each type of transmitter. The power delivered to the aerial is then

$$W_a = RI^2 = R\left(\frac{MA}{H}\right)^2 \quad .. \quad .. \quad (6)$$

This implies, of course, that the aerial resistance R has a normal value, which we shall assume to be 6 ohms in the following.

On the other hand, it has been shown in Sect. 2 that the radiated power W_r and the MA are fixed by equation (3). By eliminating MA between (3) and (6), one finds :

$$W_r = \frac{H^2}{R \,.\, K^2} \,.\, W_a \quad .. \quad .. \quad .. \quad (7)$$

The term $\frac{H^2}{RK^2}$ represents the ratio of the radiated power to the aerial power, or, in other words, the fraction of the aerial power that is radiated.

Assuming the average conditions :

$R = 6$ ohms $\qquad K = 32$

it comes to : $\frac{W_r}{W_a} = \frac{H^2}{6000}$ (see Table 2)

These figures show, for instance, that under the average conditions of radiation ($K = 32$) and with an aerial of 6 ohms resistance, an aerial of 25 m actual height radiates only one-tenth of the power delivered by the transmitter.

Under the worst conditions of radiation ($K = 45$), $\frac{H^2}{RK^2} = \frac{H^2}{12000}$

TABLE 2

H	$\frac{W_r}{W_a} = \frac{H^2}{6000}$
10 m	0.0167
15	0.038
20	0.067
25	0.105
30	0.150
35	0.205
40	0.27
45	0.24
50	0.42

and the radiated power is only one-half of the figures of Table 2.

5. Generalized Graph of Ship Station Radiation

It is possible to put together all the above-mentioned elements and to draw a graph giving in a very simple way, under the average conditions met with in practice, the value of the field strength at any distance from a ship when the actual aerial height and the aerial power are known.

We found above the relation (7) which exists between the aerial power and the radiated power. Knowing the value of the latter, it is possible to draw the curve of variation of the field strength with distance. It is, therefore, only necessary to make use of the propagation curves published on the matter. The latest available are those calculated by the propagation of radio-electric waves sub-committee of the C.C.I.R. and presented to the Cairo Radiocommunications Conference by the British Administration[4].

In this document the curve of propagation during daytime over sea for 500 kc/s gives the value of the field strength as a function of the distance for 1 kW radiated. It is easy to deduce the curves for any given radiated power.

By a change of coordinates, the curves can be drawn to the axes "radiated power—distance" with the field strength values as parameter. In this manner the right-hand side part of Fig. 4 was obtained.

The curves of the above-mentioned sub-committee are drawn only for distances greater than about 130 km. For smaller distances, we calculated the field strength from the Sommerfeld-van der Pol formulae (1) and (2) mentioned at the beginning of this paper; this gives the dotted line curves of Fig. 4.

On the other hand, equation (7) can be represented by a set of curves to the axes $(W_r - H)$ with W_a as parameter as drawn on the left-hand side of Fig. 4 for $R = 6$ ohms and $K = 32$.

The ordinate axis corresponds to the radiated power for both sides of Fig. 4, thus giving the connection between them.

The use of the graph is self-evident, the left-hand side elements being connected to the right-hand side ones by a simple construction like ABCDE drawn as an example.

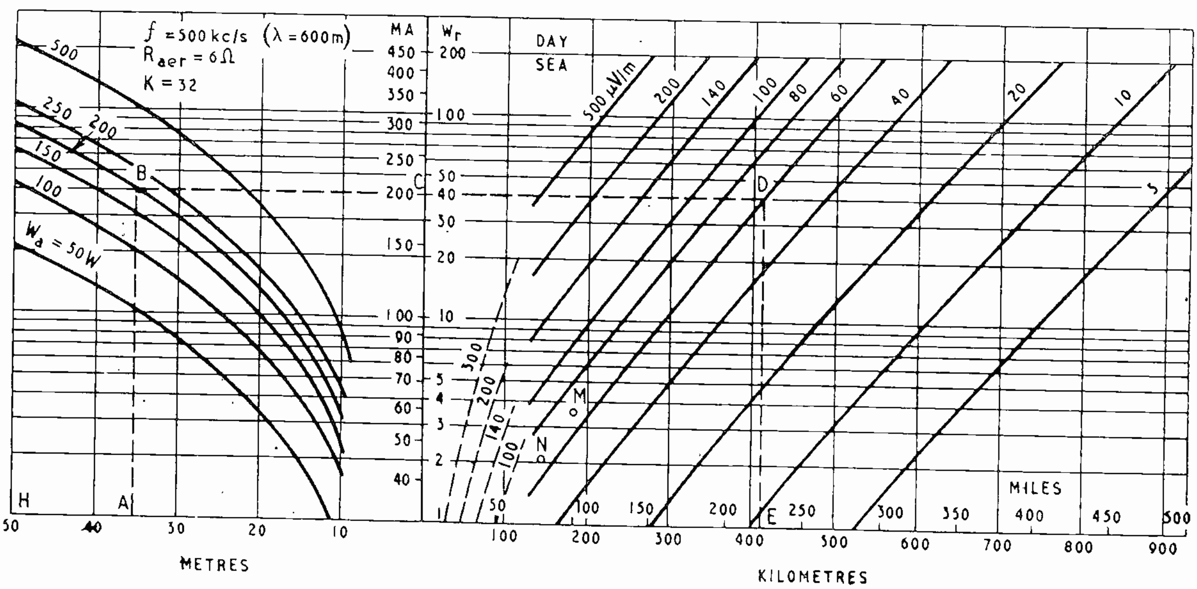


Fig. 4. *Generalized curves giving the relation between aerial power, aerial height and the field strength at the receivers for daytime conditions over sea on 500 kc/s.*

This construction shows that a transmitter delivering 200 watts in a ship aerial of 35 m actual height and 6 ohms resistance radiates under average conditions ($K = 32$) a power of 41 watts and gives during daytime over sea on 500 kc/s, a field strength of 60 μV/m at a distance of 415 km.

Under the worst conditions of radiation ($K = 45$) the radiated power would be one-half of the previous figure, *i.e.*, 20 watts and the same field strength figure would be obtained at 350 km.

Thanks to equation (3) it has been possible to graduate the ordinate axis in radiated watts and in metre-amperes assuming the value of K to be 32. The graph gives then at the same time the number of MA and the corresponding radiated power: the above-mentioned transmitter gives for instance 200 MA.

It must be pointed out that the right-hand side of the Fig. 4, representing the propagation curves of the wave of 500 kc/s during day-time over sea, is independent of the conditions of the aerial. On the contrary the curves of the left-hand side and the graduations in MA depend on these conditions. They could of course be calculated for any other value of R or K.

Fig. 4 can of course be used without change for $A1$ as well as $A2$ types of transmission, the values of the current intensity and of the field strength used above being all R.M.S. values. But it must be borne in mind that the power of a given transmitter is generally not the same for both types of waves.

Remark.—The points M and N on the right-hand side of Fig. 4 correspond to two figures ruled by the Safety Convention; M corresponds to 60 MA giving a range of 100 miles and N to 45 MA with a range of 80 miles. The corresponding values of the field strength are about 70μV/m for $K = 32$. The third figure (45 MA giving a range of 50 miles) cannot be plotted since it corresponds to a radiated power of less than 1 watt, which is the lowest limit of the graph.

6. Conclusion

Taking advantage of numerous experimental data obtained from actual installations on board ships, we have designed a generalized graph drawn for the average conditions met with in ship transmissions on 500 kc/s during day-time over sea: this graph gives the average relations between the actual height of the aerial, the power delivered by the transmitter, the MA, the radiated power, the field strength and the distance.

This result is based on the existence of a characteristic value of the aerial current for each type of ship transmitter or, in other words, on the approximate constancy of the ratio $\frac{MA}{H}$ for a type of transmitter whatever the height of the aerial may be.

This implies of course that the transmitter is effectively able to deliver its rated power to any type of ship aerial, *i.e.*, that it is provided with the necessary elements of electrical matching.

REFERENCES

[1] "International Convention for the Safety of Life at Sea," London, 1929. Art. 31. §§8, 10 and 12.

[2] "Relation between the Power Radiated by a Ship Station and the Number of 'Metre-Amperes.' *L'Onde électrique*, Feb. 1939, pp. 92–96. Summarised in *The Wireless Engineer*—June 1939, p. 321.—In this abstract, the formula should be read $W = (MA/K)^2$, instead of $W = MA/K$.

[3] van der Pol. Z.f.H. April 1931.

[4] "Conference Internationale des Radiocommunications," Cairo 1938. Vol. I—Doct. 558R; p. 445.

University of Glasgow

DR. BERNARD HAGUE has been appointed to the James Watt Chair of Electrical Engineering at the University of Glasgow which is being vacated later in the year by Dr. G. W. O. Howe. Born in 1893, Dr. Hague was educated at the Grammar School, Eccles and the Central School, Rochdale. After practical training with Carter Bros., Rochdale, and Ferranti, Ltd., he proceeded to the Department of Electrical Engineering of the City and Guilds College. He graduated B.Sc. (London) and received the diploma of the Imperial College for advanced study and research. In 1919 he proceeded to the London M.Sc., and in 1927 to the D.Sc. degrees, while he took the Ph.D. (Glasgow) degree in 1926.

From 1916–1920 Dr. Hague was associated with the Royal Aircraft Establishment, afterwards becoming a lecturer at the City and Guilds College. Since 1923 he has occupied positions at the University of Glasgow, being given leave of absence in 1929–30 to act as visiting professor in the Polytechnic Institute of Brooklyn, New York. He has published four books and twenty-one papers on electrical and allied subjects.

Electronic Semi-Conductors

A LECTURE on "Electronic Semi-conductors" will be given by Dr. R. W. Sillars at a joint meeting of the Institute of Physics and the Institution of Electronics to be held at 7 p.m. on Friday, May 17th, in the large physics lecture theatre at the University, Manchester. Tickets may be obtained from Dr. F. A. Vick at the University, Manchester, or from L. F. Berry, 105 Birch Avenue, Chadderton, Lancs.

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.

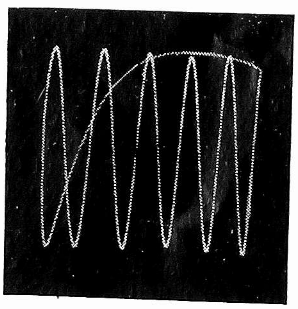
"Time-base Converter and Frequency-divider"

To the Editor, "Wireless Engineer."

SIR,—In connection with the discussion on the respective merits of the above and of the "signal converter," I am gently chided by Messrs. Nagy and Goddard in your October 1945, issue for what they are pleased to describe as an unprogressive attitude. It will be recollected that in my original article in the August 1945 issue, I suggested that it was a retrograde step to employ a new and specialized type of valve (the signal converter) for an application which could be met by the use of conventional valves.

It seems necessary for me to expand my thesis a little more fully, although it must, of course, be admitted that discussions along these lines are matters of opinion and not of fact.

My contention is that it is undesirable to produce a very large number of *types* of components and that the introduction of any new type is unjustified unless it leads to technical or economic superiority of some finished instrument as compared with what can be achieved by the use of existing components. It will be noted that it is not a sufficient condition for the new component to replace several existing ones, since the cost of components depends enormously on their demand and the process of rigorous limitation of component types along the lines discussed would greatly reduce production costs. To me, an examination of any valve data manual is a somewhat depressing reflection on the lack of collaboration which exists between designers, and I view with alarm the suggestion that deflection-modulated valves should be added to the huge list of types now available.



Wave of 1.2 Mc/s taken with a time-base frequency of 200 kc/s.

Ultimately, the acid test of justification is the relative performance and cost of the finished instrument. At the moment it does not seem to me that Messrs. Nagy and Goddard have succeeded in establishing any great superiority in time-base technique as a result of the use of the signal converter. In addition, their letter in the October issue contains one or two statements of a very controversial nature.

Speaking about driven time bases in general, and my own in particular, they say, "When the frequency is such that the capacitances are of the order of the resistances, synchronization is unreliable and the linearity of the scan is destroyed." This observation seems inaccurate, because a driven time base is not synchronized, and the only effect of raising the frequency is to reduce progressively the steepness of the wave fronts of the discharge pulses from the squaring circuits. As a result, the commencement of the flyback time becomes less definite. However, the stability of the pattern can be in no way affected, since the device is working under cyclic and repetitive conditions. Included herewith is a photo taken on a driven-type time base at a sweep frequency of 200 kc/s (1.2 Mc/s wave). The exposure time was 20 seconds. The sharpness of the flyback shows the high stability obtainable.

Later on they suggest that the signal converter is superior to the conventional valve because two parameters are available in its operation. Presumably they imply (correctly) that this leads to greater range of application. However, I contend that this is a doubtful advantage, for looked at from another angle it also implies that closer control of the device is necessary to secure a given result. Surely one of the most desirable developments in circuit technique generally is the construction of networks which will do one thing only and which do not require close control of operating voltages, etc., in order to keep their performance on the "straight and narrow path."

However, the major drawback of the signal converter appears to me to reside in its high output impedance and in the necessity for a load which is almost wholly reactive. Appendix 1 in their September article indicates the result of a shunt resistance across the charging capacitor. It appears that a shunt resistance of 10-megohms value results in a 20 per cent. linearity error. Reference to my article on deflector-plate characteristics of cathode-ray tubes in the *Wireless Engineer* for August 1941 will show that for positive deflector-plate excursions 10 megohms is an optimistic estimate for the shunt resistance on an average tube and, therefore, it would appear that a high degree of linearity cannot be expected. In addition, it is an axiom of cathode-ray tube work that the deflector-plate driving-source impedance should be kept low and this condition is violated by the "signal converter."

The trace photographs published by Messrs. Nagy and Goddard indicate a much higher degree of linearity than would be expected from the theoretical reasoning, unless the time-base plates were pre-biased so as to operate always negatively with regard to the final anode. An examination of the circuit diagrams indicates that no special steps have been taken to ensure such negative operation under all conditions, and I should be glad if they could suggest an explanation for the discrepancy.

HILARY MOSS.

Highbury, N.5.

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.

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

573 857.—Push-pull amplifier, particularly for indicating physiological reactions, in which provision is made for offsetting an input circuit which is not balanced to earth.

Standard Telephones and Cables Ltd. (assignees of J. R. Banker). Convention date (U.S.A.) 23rd December, 1942.

573 869.—Telephone or like relay for regenerating and responding to definitely-spaced sequences of signal-impulses of uncertain duration.

Standard Telephones and Cables Ltd., G. C. Hartley, and W. J. Reynolds. Application date 15th December, 1942.

AERIALS AND AERIAL SYSTEMS

573 762.—Flexible mounting for the rod aerial of a motor vehicle, to prevent breakage by impact with the branch of a tree or similar obstruction.

D. W. Mitchell. Application date 27th November, 1942.

574 418.—Aircraft aerial made of a rod of plastic material which is metallically coated for part of its length, the rod being supported where it is uncoated and therefore non-conducting.

Boulton Paul Aircraft Ltd. and J. D. North. Application date 29th November, 1940.

DIRECTIONAL WIRELESS

573 774.—Remote-control tuning arrangement, particularly suitable for a multi-band automatic direction finder.

A. H. Stevens (communicated by Lear Avia Inc.). Application date 24th November, 1943.

573 896.—Spiral aerial of controllable directivity, wherein the length of each turn, and the spacing between turns, are specifically related to the operative wavelength.

Marconi's W.T. Co. Ltd. and C. S. Franklin. Application date 24th March, 1941.

573 922.—Offsetting the effects of banking and lateral drift when an aeroplane is homing on to a radio transmitter.

S. Smith & Sons (Motor Accessories) Ltd. and F. W. Meredith. Application date 6th April, 1940.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television)

573 168.—Receiver, including a frequency-doubling device, for restoring the higher harmonics that are normally lost owing to circuit, or other, limitations.

Ferranti Ltd. and M. K. Taylor. Application date, 2nd December, 1943.

573 354.—Shunt circuit including a non-linear device, such as a copper-oxide rectifier, for automatically allowing the signal current to by-pass an amplifier or repeater that has failed.

Automatic Telephone and Electric Co. Ltd. Convention date (U.S.A.) 5th March, 1943.

573 837.—Coaxial-line end-coupling and mounting for a crystal detector of the "cat's-whisker" type, designed for rectifying centimetre waves.

The British Thomson-Houston Co. Ltd., T. H. Kinman, and B. A. C. Tucker. Application date 1st May, 1944.

573 978.—Reducing strong interference by superposing locally-generated oscillations so as to form an interference field-pattern having a voltage-node at the pick-up point.

J. Robinson. Application dates 4th April, 1940, *and 29th April,* 1941.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION

573 272.—Television scanning system in which the higher harmonics of the modulated scanning frequencies are eliminated, in order to correct for "keystone" distortion.

Farnsworth Television and Radio Corporation. Convention date (U.S.A.) 1st April, 1942.

573 274.—Method of modulating the scanning frequencies, and for cutting-out the resulting harmonics, in order to correct "keystone" distortion in television.

Farnsworth Television and Radio Corporation. Convention date (U.S.A.) 30th April, 1942.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

573 269.—Controlling the periodicity of amplitude changes in a thermionic or like oscillator by utilizing the transit-time of a group of pressure waves in passing through a liquid.

Scophony Ltd. and S. H. M. Dodington. Application date 19th September, 1940.

573 406.—Frequency-modulation system in which a carrier-wave is combined with the current produced from a photo-electric cell under the action of a beam of light, after it has been passed through crossed Nicol prisms and a Kerr cell to which the signal voltage is applied.

Philips Lamps Ltd. Convention date (U.S.A.), 11th July, 1942.

573 508.—Heptode valve with two discharge paths in series, one of which operates as a cathode-follower, the combination serving as a multi-vibrator to generate either continuous oscillations, or a series of pulses.

T. E. Ivall. Application date 19th August, 1943.

573 629.—Secret telephony system in which control signals, based on the vowel frequencies, and otherwise, are incorporated to facilitate accurate restora-

tion of the original message at the receiving end.

"Patelhold" Patentverwertung & Holding A.G. Convention date (Switzerland) 3rd December, 1941.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

573 207.—Short-wave generating-valve, of the beam-deflection type, with auxiliary electrodes to allow the electron-stream to be decelerated cyclically whilst maintaining full output.

J. H. O. Harries. Application date 5th September, 1940.

573 208.—Mounting and cooling arrangement for a short-wave generating-valve, of the beam-deflection type, connected to coaxial-line input and output circuits.

J. H. O. Harries. Application date 5th September, 1940.

573 209.—Method of ensuring accurate alignment of the electrodes of a high-power valve of the beam-deflection type.

J. H. O. Harries. Application date 23rd September, 1940.

573 232.—Gas-filled discharge-tube fitted with a resilient screen, in order to control and localize the ionization, and to minimize ionic bombardment of the cathode.

Western Electric Co. Inc. Convention date (U.S.A.) 5th June, 1942.

573 395.—Location of an auxiliary grid for controlling the electron velocity and concentration in a valve of the beam-deflection type (addition to 571 678).

G. R. E. Cleveland. Application date 27th July, 1944.

573 569.—Arrangement and spacing of the electrodes of a diode or other double-ended discharge tube, particularly of the midget type, for short-wave working.

Ferranti Ltd., A. L. Chilcot, and S. Jackson. Application date 18th April, 1942.

573 570.—Process for coating the cathode of a valve, after evacuation of the bulb and degassing of the electrodes.

Ferranti Ltd. and A. L. Chilcot. Application date 18th April, 1942.

573 571.—Jig process for assembling and spacing the electrodes of a short-wave or like valve, where the input and output leads are located at different parts of the bulb.

Ferranti Ltd., A. L. Chilcot, and J. L. Miller. Application date 18th April, 1942.

573 572.—Jig process for the assembly of a diode or like discharge tube comprising two cup-like parts.

Ferranti Ltd., A. L. Chilcot, S. Jackson, and F. W. Taylor. Application date 18th April, 1942.

573 587.—Discharge tube of the cathode-ray type in which a high-frequency transformer is housed inside the evacuated envelope.

The British Thomson-Houston Co. Ltd. Convention date (U.S.A.) 7th December, 1942.

573 605.—Multi-pin valve-socket in which one pin is mounted, asymmetrically with the others, on a metal band surrounding the socket.

Standard Telephones and Cables Ltd. and W. T. Gibson. Application date 2nd November, 1943.

573 612.—Process for coating the cathode of a glow-discharge tube with an alkali metal, to reduce the striking voltage.

Standard Telephones and Cables Ltd. and R. R. Back. Application date 3rd December, 1943.

573 852.—Arrangement for controlling the "gettering" process, in order to prevent undesirable deposition, particularly in the manufacture of high-powered diode rectifiers.

The British Thomson-Houston Co. Ltd. (communicated by the General Electric Co.). Application date 13th October, 1943.

SUBSIDIARY APPARATUS AND MATERIALS

573 173.—Photo-electric cell fitted with retarding and collecting electrodes to ensure a response to illumination over a large solid angle.

W. Blackman, Cinema-Television, Ltd. and G. A. R. Tomes. Application date 13th December, 1940.

573 345.—Bridge-circuit input for cyclically displacing the ignition-point of a grid-controlled discharge-tube so as to stabilize the operation, say of a magnetron valve controlled by it.

Akt Brown, Boverie et Cie. Convention date (Switzerland) 23rd May, 1942.

573 348.—Inter-electrode resistance-coupling to enable a pentode or tetrode valve to be operated efficiently as a triode or diode, say for a voltage-stabilizer or full-wave rectifier.

B. M. Hadfield. Application date 5th November, 1943.

573 365.—R.F. transformer for centimetre waves, consisting of a hollow tuned resonator, into which are inserted, to a variable extent, the ends of the primary and secondary coaxial-line circuits.

J. Collard. Application date 3rd June, 1941.

573 405.—Selective remote-control relay in which a pair of valves with different working characteristics is arranged to give a "peak" output for a predetermined control-bias.

Standard Telephones and Cables Ltd. (assignees of G. Deakin). Convention date (U.S.A.) 14th September, 1942.

573 418.—Bridge circuit in which a pair of capacitors is varied, whilst maintaining a constant ratio, in order to measure inductance and "Q"

The General Electric Co. Ltd., H. C. Turner, and W. H. Fisher. Application date 24th September, 1943.

573 451.—Compact arrangement of an artificial line for attenuating ultra-high frequencies.

Standard Telephones and Cables Ltd. (assignees of C. B. Watts Junr). Convention date (U.S.A.) 17th August, 1942.

573 483.—High-frequency ignition system designed to off-set the variable-shunt effect due to the partial sooting of a sparking-plug.

The British Thomson-Houston Co. Ltd. and D. F. Welch. Application date 11th June, 1943.

573 621.—Projectile fitted with a fuse which is subject to remote radio-control so that it is detonated automatically in the proximity of the target.

G. W. Walton. Application date 11th January, 1941.

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

534.1 : 621.396.619.018.41 **1144**

Push-Pull Frequency Modulated Circuit and its Application to Vibratory Systems.—A. Badmaieff. (*J. Soc. Mot. Pict. Engrs*, Jan. 1946, Vol. 46, No. 1, pp. 37–51.) A circuit in which the push-pull action is accomplished by using two capacitors with a common plate to vary the resonant frequencies of oscillator and discriminator in opposite phase relation. This circuit can be used for measuring vibrations or for monitoring purposes if the common plate is the moving element of a vibratory system. For application to the calibration of gramophone recording heads, see 3548 of 1945 (Roys).

534.121.1 **1145**

The Fundamental Frequency of Vibration of Rectangular Wood and Plywood Plates.—R. F. S. Hearmon. (*Proc. phys. Soc.*, 1st Jan. 1946, Vol. 58, No. 325, pp. 78–92.) Results of theoretical and experimental investigation.

534.321.9 **1146**

Ultrasonic Interference at Angular Reflection.—G. W. Willard. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 284.) Abstract of an Amer. Phys. Soc. paper.

534.321.9 : 538.652 **1147**

Magnetostrictive Oscillator Coupling.—H. Thiede. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, p. 96.) A ceramic piston coupler allows the application of a magnetostrictive oscillator under circumstances beyond its normal operative range, such as ultrasonic excitation of liquids (acids or bases) up to 700°C. Abstract of a paper in *Akust. Z.*, Vol. 8, No. 1.

534.321.9 : 620.179 **1148**

Supersonic Flaw Detector.—R. B. De Lano, Jr. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 132–136.) The radar principle of pulse reflection from discontinuities is used with longitudinal supersonic waves of frequency 0.5–12 Mc/s. Pulses, a few microseconds long, and with a 60 c/s repetition rate, are applied by a quartz crystal transducer to the material under test, efficient coupling being obtained by a film of liquid. The same crystal serves as a pickup for the reflected pulses, which are amplified and displayed on a c.r. tube with an exponential time base and time marks, enabling the depth of the discontinuity to be measured.

The supersonic characteristics of various materials and pictorial examples of the performance of the instrument are given. See also 822 of April (Firestone).

534.321.9 : 620.179 **1149**

Ultrasonic Vibrations Reveal Hidden Flaws.—(*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 64..166.) Supersonic waves (50 kc/s–1 Mc/s) are transmitted from a crystal vibrator to a crystal microphone through a moving strip or sheet to be tested. A flaw causes a change in attenuation, and the change in the received signal actuates a relay. The arrangement is useful for examining extruded products.

534.41 + 534.781 **1150**

Visible Speech Patterns Transmit Intelligence.—(*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 200..202.) A short account of 823 of April (Potter).

534.42 **1151**

Electronic Sound Effects Circuit.—H. Syzling. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 214..220.) Description of a battle-sound generator giving an output of 200 W, with automatic operation. Circuits for generating the sounds of near and distant shell bursts, machine guns, etc., are briefly described.

534.43 : 621.395.61 1152
FM Phonograph Reproducer.—W. Hausz. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, p. 106.) A capacitive pickup unit. The needle vibrations vary the frequencies of two h.f. oscillators in push-pull, and the frequency-modulated difference frequency is filtered and detected. The mechanical design reduces the effect of eccentric records. Summary of U.S. Patent 2 386 049.

534.43 : 621.395.61 1153
New Vibrating Reed Magnetic Pickup.—R. G. Leitner. (*Radio*, Dec. 1945, Vol. 29, No. 12, pp. 25..63.) Design and construction. Output 2.5 mV at 1 000 c/s. Cut-off 6 000 c/s, but a special broadcast model cuts off at 12 000 c/s.

534.43 : 621.395.61 1154
[Gramophone] **Pickup with Low Mechanical Impedance.**—H. P. Kalmus. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 140–145.) Amplitude modulation of a 2.5 Mc/s oscillator is produced by the motion of a resistive vane which is coupled to the stylus and varies the Q of the oscillator circuit. The triode oscillator acts simultaneously as a detector and a.f. amplifier. High compliance and small mass of the moving element result in low mechanical impedance, so that only 14 grammes weight is needed for satisfactory tracking. The response falls sharply at 4 000–5 000 c/s.

534.845 : 534.373. 1155
The Application of the Helmholtz Resonator to the Measurement of Sound Absorption.—W. S. Tucker. (*Phil. Mag.*, July 1945, Vol. 36, No. 258, pp. 473–485.) The resonance curve of a Helmholtz resonator excited by a sound field depends on, among other factors, the absorbing power of its walls. In the experiments described this fact was utilized to determine the absorbing power of porous earthenware over the range 150–600 c/s. A hot-wire (Tucker) microphone, located in the open mouth of the resonator, was used as the detector.

534.845 : 677.521 1156
A Discussion of the Acoustical Properties of Fiberglas.—W. M. Rees & R. B. Taylor. (*J. Soc. Mot. Pict. Engrs*, Jan. 1946, Vol. 46, No. 1, pp. 52–63.) The absorbing properties are discussed, with particular reference to aircraft sound insulation. Absorption tables for frequencies up to 4 000 c/s are given.

534.862.6 1157
Intermodulation Distortion of Low Frequencies in Sound Film Recording.—F. G. Albin. (*J. Soc. Mot. Pict. Engrs*, Jan. 1946, Vol. 46, No. 1, pp. 4–16.) An account of the phenomenon in variable-density recording, due to the photographic process.

537.228.1 1158
The Order of Magnitude of Piezoelectric Effects.—Jaffe. (*See* 1264.)

621.395.6 1159
War Influence on Acoustic Trends.—H. S. Knowles. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 81, 192.) An account of some of the special measures needed to transmit intelligence through the very high noise levels of battle conditions. Summary of an I.R.E. paper. See also *Electronics*, Jan. 1946, Vol 19, No. 1, pp. 246..248.

621.395.613.37 1160
Antinoise Characteristics of Differential Microphones.—H. E. Ellithorn & A. M. Wiggins. (*Proc. Inst. Radio Engrs, N.Y.*, Feb. 1946, Vol. 34, No. 2, pp. 84–89.) The noise discrimination is obtained as a function of frequency and pressure-gradient for both practical and theoretical microphones. It is shown that the differential microphone is ideally suited for noise cancellation in the usual noise fields, in which the frequencies are often predominantly in the lower frequency range. The noise discrimination increases rapidly with the order of the pressure gradient upon which the microphone operates, but the use of high order gradients presents constructional difficulties. The noise discrimination of the nth-order gradient is derived.

621.395.613.4 1161
Dynamic Microphone.—W. Baer. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, p. 99.) Illustrated description of the design of a moving-coil microphone. Air pockets behind the diaphragm give resonances at 450, 2 500 and 8 000 c/s, and thereby give high sensitivity and comparatively level frequency response. Diagrams illustrate the directional properties. The sensitivity is at least 100 μV/dyne.cm^2 for an output resistance of 200 Ω at 800 c/s. Overall efficiency 0.4%. Summary of a paper in *Akust. Z.*, Vol. 8, No. 4.

621.395.623.8 1162
Improved Sound Reproducer.—C. A. Volf. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 38..100.) General description of the system referred to in 531 of March.

621.395.623.8 1163
Psychological and Technical Considerations Employed in the Bucky Sound Reproduction and Public Address Systems.—P. A. Bucky. (*J. Soc. Mot. Pict. Engrs*, Jan. 1946, Vol. 46, No. 1, pp. 75–79.) Reactions of the physical senses to musical sounds are discussed. Replacement of conventional highly directive theatre or auditorium loudspeakers by another system with nondirectional characteristics is suggested. Reverberation from several speakers replaces the original sound picture, and an r.f. carrier is used for signal distribution.

621.395.625.3 1164
High Quality Sound Recording on Magnetic Wire.—L. C. Holmes. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 236..240.) Another report of the I.R.E. paper. See also 836 of April.

621.395.645 + 621.396.61/.62 1165
Low Power Transmitting/Receiving/and Hailing Equipment. Type CNY.1.—Morcom. (*See* 1386.)

621.395.645.3 1166
An Analysis of the Comparison of Beam Power and Triode Tubes Used in Power Amplifiers for Driving Loudspeakers.—J. K. Hilliard. (*J. Soc. Mot. Pict. Engrs*, Jan. 1946, Vol. 46, No. 1, pp. 30–36.) The beam power tube is equally efficient with the same or less distortion, has an improved signal/noise ratio, and the associated circuit need not be complicated. Excellent output transformers are required. Results of listener and objective tests.

621.395.645.3 1167
Bridging [a. f.] Amplifier for F-M Monitoring.—Beggs. (*See* 1199.)

621.395.645.36 1168

Quality Amplifiers.—(*Wireless World*, Feb. 1946, Vol. 52, No. 2, p. 61.) Correction to a circuit in 838 of April.

621.395.665 1169

Mixing Crystal Microphones.—G. N. Patchett. (*Wireless World*, Feb. 1946, Vol. 52, No. 2, pp. 57–58.) The difficulty of providing high-impedance inputs and adequate volume control, when it is required to mix the outputs from two or more crystal microphones, is overcome by using heptodes with a common anode load. Each microphone output is connected separately to the control grid of a heptode of which the amplification is controlled by the bias of its third grid.

621.395.667 1170

A Three-Band Variable Equalizer.—L. D. Grignon. (*J. Soc. Mot. Pict. Engrs*, Jan. 1946, Vol. 46, No. 1, pp. 64–74.) Provides suppression and emphasis in three frequency bands, adjustable by three controls. The features include zero insertion loss, and small change in apparent insertion loss as equalization is varied.

621.396.611.21.029.3 + 621.317.761 1171

Stabilizing Frequency in LF [1–10 kc/s] **Crystal Oscillators.**—Cox. (*See* 1294.)

AERIALS AND TRANSMISSION LINES

621.392 1172

Contribution to the Theory of Telephone Cables with Twisted Conductor Groups.—C. G. Aurell. (*Ericsson Technics*, 1944, No. 45, p. 3.) The transmission properties are developed along the same lines as for a system of parallel homogeneous conductors. Explicit formulae for the propagation constants and characteristic impedances for the conductors of such groups are deduced. The analysis is applied to the crosstalk problem.

621.392 1173

The Solution of Transmission-Line Problems in the Case of Attenuating Transmission Line.—G. Glinski. (*Trans. Amer. Inst. elect. Engrs*, Feb. 1946, Vol. 65, No. 2, pp. 46–48.) Demonstration of how "by application of the standard transmission line theory the standing-wave method of measuring impedance can be extended to the case of transmission lines with attenuation, if the appropriate corrections are introduced." The paper assembles and systematizes information on the subject in other literature.

621.392 1174

Discontinuity Effects.—G. Glinski. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, pp. 97–98.) The effect of a discontinuity in a transmission line is determined by locating the voltage minimum on each side of it. For a coaxial line, the position of the voltage minimum on one side of a discontinuity is graphed *versus* the position of a short-circuit on the other side, and the diagram is interpreted.

621.392 1175

Minimum Attenuation in Waveguides.—E. N. Phillips. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 137–139.) Algebraic and graphical presentation of the attenuation in rectangular and circular wave guides for various modes of propagation. The ratio of the frequency of minimum attenuation (f_{min}) to the cut-off frequency (f_c) for H modes in a rectangular guide is derived as a function of the ratio a/b of the sides, and the mode numbers n, m. For E modes, $f_{min} = \sqrt{3}f_c$. The attenuation of an $H_{0,1}$ wave in a typical rectangular brass guide is evaluated by way of illustration, and compared with brass concentric lines of the same cross-section area or the same periphery.

621.392 : 621.396.67 1176

Aerial Resistance and Cable Impedance.—G.W.O.H. (*Wireless Engr*, March 1946, Vol. 23, No. 270, pp. 65–66.) The approximate equality of the radiation resistance of a half-wave dipole in free space to the characteristic impedance of a coaxial cable with conductor diameter ratio giving minimum attenuation loss, is shown to be coincidental.

621.392 : 621.396.692 1177

Radio-Frequency Resistors as Uniform Transmission Lines.—D. R. Crosby & C. H. Pennypacker. (*Proc. Inst. Radio Engrs, N.Y.*, Feb. 1946, Vol. 34, No. 2, pp. 62–66.) A theoretical analysis, using the classical transmission line equations, of concentric lines with resistive inner conductors, the resistance being in the form of a film so that skin effect is negligible. The resistive element is long compared with the diameter of the outer conductor. The case where the resistor is intended to match a coaxial line is given particular attention, and the results are presented in a number of graphs which should be convenient for engineering use.

621.392.43 1178

Shunt and Series Sections of Transmission Line for Impedance Matching.—C. T. Tai. (*J. appl. Phys.*, Jan. 1946, Vol. 17, No. 1, pp. 44–50.) Expressing the terminal impedance to be matched as a hyperbolic function enables the matching conditions of both series and shunt sections to be simply expressed in terms of the resistance and reactance of the load and the characteristic impedance of the line. A graphical representation of the solutions shows that matching for each case is only possible inside certain areas bounded by a circle and straight line, on a graph of load resistance against load reactance. The series section permits matching over a wider range of impedances than the shunt section, but the latter is useful in the region where the series section cannot yield a match. If an additional section of line is added between the matching section and the load, then both sections can be made to match any load.

621.396.11 + 621.396.82 1179

Notes on the Reception of Vertically Polarized Electromagnetic Waves; Some Notes on Circuit Shielding.—(*Radio, N.Y.*, Dec. 1945, Vol. 29, No. 12, pp. 39–40.) A radio design worksheet.

621.396.67 1180

Three New Antenna Types and Their Applications.—A. G. Kandoian. (*Waves and Electrons*, Feb. 1946, Vol. 1, No. 2, pp. 70–75.) All are primarily for v.h.f. and u.h.f. operation. Their radiation is substantially omnidirectional in the horizontal plane. A disk and cone type has a high-pass cut-off frequency above which the input impedance varies little over a 5 : 1 frequency range. A co-axially fed horizontal loop ("magnetic dipole") can be designed to match a coaxial line of *e.g.* 50, 70, 100 Ω characteristic impedance at a particular frequency. An "electric-magnetic dipole" consisting of a coaxially fed horizontal loop with a vertical radiator rising from its centre gives an elliptically polarized field distributed roughly as for an ordinary λ/2 dipole. It may be useful for counteracting severe fading conditions, when vertical and horizontal field components will probably not vary at the same rate. Constructional details of all types are shown, and the applications, singly and in multiple arrays, are discussed.

621.396.67 **1181**
Remote Tuned Antenna.—(*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, p. 77.) A motor operates the telescopic arms of a rotatable horizontal dipole, to cover a range 46.5 to 215 Mc/s.

621.396.67 **1182**
Currents in Aerials and High Frequency Networks. [Book Review]—F. B. Pidduck. Oxford University Press, London, 8s. 6d. (*Wireless Engr*, March 1946, Vol. 23, No. 270, p. 90.) "The book is of an ultra-mathematical character."

CIRCUITS

621.3.011.2.012 **1183**
Impedance-Admittance Conversion Chart.—R. C. Paine. (*Electronics*, Jan. 1946, Vol. 19, No. 1, p. 162.) Simple chart for converting $Z = R \pm jX$ to $Y = G \pm jB$ and *vice versa*.

621.3.017 : 621.3.012.3 **1184**
Loss due to Shunt Resistance Inserted Between Matched Source and Sink.—(*Radio, N.Y.*, Dec. 1945, Vol. 29, No. 12, p. 37.) A design chart.

621.314.12 **1185**
D.C. Amplifier Coupling.—P. K. Chatterjea & C. T. Scully. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, p. 118.) The use of a non-linear resistance element, such as a thermistor, permits the transmission of a large proportion of a voltage change from an anode to a grid, without transmitting a corresponding proportion of the mean anode potential. Summary of U.S. Patent 2 383 710.

621.318.572 : 621.385.38 **1186**
Pulse Response of Thyratron Grid-Control Circuits.—C. H. Gleason & C. Beckman. (*Proc. Inst. Radio Engrs, N.Y.*, Feb. 1946, Vol. 34, No. 2, pp. 71–77.) Advantages of peaked-waveform grid signals are discussed, and graphs given from which the influence of grid-circuit components on the grid-potential waveform can be predicted for several commonly used signal waveforms. The analysis is based on the assumption that the thyratron presents a relatively high impedance to the grid circuit, and the effect of grid current during the period prior to the initiation of the discharge is examined. In many cases the grid current is reasonably constant over a considerable range of negative grid voltage and the correction required to take account of it amounts to a shift in the d.c. bias value.

621.385.2/.5].012.8 **1187**
Valve Equivalent Circuit.—H. Biefer. (*Wireless Engr*, March 1946, Vol. 23, No. 270, pp. 91–92.) In valve circuit analysis, ambiguity can be avoided in the derivation of an equivalent circuit by attaching a definite sign to both current and voltage symbols. Comment on 3505 of 1945 (G. W. O. H.).

621.392.52 **1188**
Transient Response of Filters [part II].—D. G. Tucker. (*Wireless Engr*, March 1946, Vol. 23, No. 270, pp. 84–90.) The method given in part I (870 of April) for the analysis of the transient response of multistage filters is inapplicable to single-section filters, and a new method of approach, using operational methods, is given. The build-up and decay envelopes of a single-section filter, used between resistance terminations equal to its design resistance, are analysed, and the results compared with oscillographic records. The effects of slight variations in signal frequency are determined empirically by oscillographic methods.

621.394/.397].645 **1189**
Cathode-Follower Dangers: Output Circuit Capacitance.—W. T. Cocking. (*Wireless World*, March 1946, Vol. 52, No. 3, pp. 79–82.) It is shown that the particular advantages of the cathode-follower circuit are not maintained at frequencies so high that the time constant of the cathode circuit becomes significant. Very great care is needed in the design of cathode-follower circuits for television and radar frequencies, because the feed-back feature accentuates the distortion effect of this time constant on pulse shape, and the effects of momentary cut-off of anode current by excessive input. ". . . so far from the cathode-follower being able, by virtue of its low output resistance, to feed a circuit of high capacitance, it is usually necessary to restrict the capacitance to the lowest possible value."

621.394/.397].645.2 **1190**
Wide-Band Amplifiers — 1. Single Circuit RF and IF Couplings: Coincidence Tuning.—(*Wireless World*, March 1946, Vol. 52, No. 3, pp. 90–92.) General principles and detailed design formulae for wide-band couplings consisting of circuits individually tuned to the same frequency.

621.394/.397].645 : 621.396.822 **1191**
Noise Factor of Valve Amplifiers.—N. R. Campbell, V. J. Francis & E. G. James. (*Wireless Engr*, March 1946, Vol. 23, No. 270, pp. 74–83.) Conclusions of earlier papers are restated and applied to the design of valve amplifiers. General formulae for the noise and gain of an amplifier stage are used to derive particular formulae for the common-grid triode and the common-cathode pentode, account being taken of lead inductances and inter-electrode capacitances. Properties of perfect and dissipative four-terminal passive networks are discussed. The results are used to determine the effect on signal/noise ratio of the addition of extra stages to a cascade amplifier. The first of two parts. See also 1037 of April (Campbell & Francis) and 2918 of 1945 (Campbell, Francis & James).

621.394/.397].645.3 **1192**
Negative Feedback — 1.—"Cathode Ray." (*Wireless World*, Feb. 1946, Vol. 52, No. 2, pp. 41–44.) A simple explanation of the principle of negative feedback in amplifiers, dealing particularly with the difference between current and voltage feedback and their effects on the apparent internal resistance of the valve, considered in relation to the output load. For part 2 see 1193.

621.394/.397].645.3 1193
Negative Feedback — 2. Its Effect on Optimum Load and on Distortion.—"Cathode Ray." (*Wireless World*, March 1946, Vol. 52, No. 3, pp. 76–78.) For part 1 see 1192. The present article gives a graphical demonstration of the reduction of distortion by negative feedback, and explains why the best load resistance does not differ materially from that appropriate to the same valve without feedback.

621.394/.397].645.3 : 621.314.25 1194
Phase-Inverter Circuit.—C. B. Fisher: D. L. Drukey. (*Proc. Inst. Radio Engrs, N.Y.*, Feb. 1946, Vol. 34, No. 2, p. 92.) An application of the circuit described by Drukey (3846 of 1945). A high degree of balance and independence of tube characteristics is obtained, together with suppression of hum, tube noise, or distortion produced in the driver stage. A circuit diagram is given with component values.

621.394/.397].645.3 : 621.314.25 1195
An Analysis of Three Self-Balancing Phase Inverters.—M. S. Wheeler. (*Proc. Inst. Radio Engrs, N.Y.*, Feb. 1946, Vol. 34, No. 2, pp. 67–70.) "A self-balancing phase inverter is a circuit converting one driving voltage to two output voltages of opposite phase but of essentially equal magnitude by an inherent characteristic of the device and not by virtue of any critical adjustment. The algebraic solution of three self-balancing phase inverters is given, assuming all circuit elements are linear. Included in the solution are the conditions for self-balance, the balance ratio, and the voltage gain. From this information, the type of inverter for a particular service may be selected and designed."

621.395.44 : 621.395.645 1196
Carrier-Frequency Amplifiers: Transient Response with De-Tuned Carrier.—C. C. Eaglesfield. (*Wireless Engr*, March 1946, Vol. 23, No. 270, pp. 67–74.) An analysis by operational methods of the transient response of an amplifier whose central frequency may differ from the carrier frequency. The importance of the depth of modulation of the test input waveform is investigated, and reasons are given for making it small. Numerical solutions are given for typical arrangements of a chain of eight stages. See also 68 of January (Eaglesfield).

621.395.645.29 1197
A Cathode-Coupled [a.f.] **Isolating Amplifier.**—C. Travis. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 202..204.)

621.395.645.3 1198
An Analysis of the Comparison of Beam Power and Triode Tubes Used in Power Amplifiers for Driving Loudspeakers.—Hilliard. (*See* 1166.)

621.395.645.3 1199
Bridging Amplifier for F-M Monitoring.—G. E. Beggs, Jr. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 152–155.) The amplifier uses push-pull triodes throughout. The input stage is followed by a driver with a five-step gain control. Transformer coupling to the output stage is used, with negative feedback from output anodes to driver cathodes. A uniform response within ± 0.5 db, with 15 W output for 0.3 V r.m.s. input is obtained over the frequency range 20 c/s–25 kc/s and the signal/noise ratio at maximum output is about 80 db. The amplifier is designed for use with a balanced input but may be used with a single-ended input by earthing the unused grid.

621.395.645.36 1200
Quality Amplifiers.—(*Wireless World*, Feb. 1946, Vol. 52, No. 2, p. 61.) Correction to a circuit in 838 of April.

621.395.665 1201
Mixing Crystal Microphones.—Patchett. (*See* 1169.)

621.396.11 + 621.396.82 1202
Notes on the Reception of Vertically Polarized Electromagnetic Waves; Some Notes on Circuit Shielding.—(*Radio, N.Y.*, Dec. 1945, Vol. 29, No. 12, pp. 39–40.) A radio design worksheet.

621.396.611.1 1203
The Series and Parallel Components of Impedance.—W. N. Tuttle. (*Gen. Radio Exp.*, Jan. 1946, Vol. 20, No. 8, pp. 1–3.) Equations relating the series and parallel components of an impedance are applied to the case of parallel resonant circuits with high coil losses.

621.396.611.1.012.3 1204
Nomogram for Frequency Formula [$f = 1/(2\pi\sqrt{LC})$].—C. P. Nachod. (*Elect. Engng, N.Y.*, Dec. 1945, Vol. 64, No. 12, p. 469.)

621.396.611.21 1205
Electrodynamic Theory of Piezoelectric Oscillations.—W. F. G. Swann. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 282.) The problem is that of an x-cut crystal with self-induction and resistance in series, and vibrating with its two ends in different media. It is solved on the basis of Maxwell's general dynamical theory. Abstract of an Amer. Phys. Soc. paper.

621.396.611.21 : 621.396.662.34 1206
Crystal Filter Theory.—F. J. Lehany & K. G. Dean. (*Radio, N.Y.*, Dec. 1945, Vol. 29, No. 12, pp. 8, 16.) Illustrated summary of 3820 of 1945.

621.396.615 1207
A New Type of Electrical Resonance.—E. E. Schneider. (*Phil. Mag.*, June 1945, Vol. 36, No. 257, pp. 371–392.) Utilization of phase inversion in a valve leads to a method of obtaining resonance with circuits containing only R and C or R and L. Such circuits are compared with known R-C oscillatory circuits, and the properties of reactance valve networks are discussed and analysed in detail. Experimental response curves are given for single and coupled R-C circuits at very low frequencies.

621.396.615.14.029.62/.63 1208
Asymmetrical Butterfly Circuit.—A. Landman. (*Proc. Inst. Radio Engrs, N.Y.*, Feb. 1946, Vol. 34, No. 2, p. 92.) A circuit of good stability, using an RL16 tube. The frequency range of the oscillator is restricted, in this case, to 290–350 Mc/s. See also 3260 of 1945 (Karplus) and 1209.

621.396.615.14.029.63 1209
Coaxial Modification of the Butterfly Circuit.—E. E. Gross. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 222 .. 226.) Another abstract of the I.R.E. paper. See also 883 of April.

621.396.615.17 1210
A New Pulse Generator Circuit.—B. M. Banerjee. (*Indian J. Phys.*, June 1945, Vol. 19, No. 3, pp. 75–82.) For many purposes, in particular for testing Geiger-Müller tube circuits, accurate synchronization between a pulse generator and a c.r.t. time base is needed. This is achieved by the generation of a separately available synchronizing pulse preceeding the main pulse by a fixed time interval. The assembly has three main parts—an unsymmetrical multivibrator, a pair of pulse generating networks, and a pair of pulse amplifiers biased beyond cut-off. The performance of the particular model described is:—pulse repetition frequency 2 c/s–200 kc/s; pulse separation 2 μs–0.25 s; pulse durations, main 1 μs–100 μs, sync 1 μs–500 μs. These are all independently variable. The generator produces negative pulses, triangular, 12 V peak. It is claimed that the generator is "a simple solution of all the radio sounding problems associated with ionospheric apparatus. It is therefore expected that it will find wide use in this field."

621.396.615.17 : 621.384.6 1211
Betatron Pulsing System.—I. Paul & T. J. Wang. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 156–160.) A circuit is described for producing high-power pulses for the orbit-shift coils of a betatron; it has other applications, *e.g.* resistance welding and stroboscopic illumination.

A square-wave generator obtained from the sinusoidal voltage of the betatron coils is followed by a differentiator and flip-flop pulse amplifier producing a positive pulse of about 70 V amplitude. This is used to trigger a thyratron, which, suddenly discharging, fires an ignitron, which discharges a 60-μF capacitor through the orbit shift coils, giving a 1 000-A peak pulse, about 40 μs long at half amplitude.

621.396.615.17 : 621.397.3 1212
Television Sweep Oscillators.—Noll. (*See* 1381.)

621.396.619.018.41 : 534.1 1213
Push-Pull Frequency Modulated Circuit and its Application to Vibratory Systems.—Badmaieff. (*See* 1144.)

621.396.66 1214
Control and Recording with Floating Grid.—E. L. Deeter. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 172–198.) A large alternating voltage is applied through a very small capacitance (about 0.2 μμF) to the top-cap grid of a valve, normal grid leakage being avoided as far as possible. With a suitable voltage the capacitance provides a sensitive control of the anode current, which may be made to work a relay or recorder.

621.38 1215
Electronics for Engineers. [Book Review]—Markus & Zeluff. (*See* 1428.)

621.392 : 621.3.015.33 1216
Pulsed Linear Networks. [Book Review]—E. Frank. McGraw-Hill Book Co., New York, 1945, 262 pp., $3.00. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 348 .. 350.) See also 582 of March.

GENERAL PHYSICS

530.12 : 531.18 1217
Derivation of the Lorentz Transformations.—H. E. Ives. (*Phil. Mag.*, June 1945, Vol. 36, No. 257, pp. 392–403.) New derivation shows that the transformations can be obtained by imposing the laws of conservation of energy and momentum on radiation processes as developed by Maxwell's method. The solution of apparent conflicts demands the variation of mass with velocity, and the variation of linear dimensions and clock rate. The space and time concepts of Newton and Maxwell are retained without alteration.

530.12 : 538.3 1218
Relativistic Interaction of Electrons on Podolsky's Generalized Quantum Electrodynamics.—D. J. Montgomery. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 287.) Extension of the basis for a generalized electrodynamics involving higher derivations in the field equations formulated by Podolsky and Kikuchi (*Phys. Rev.*, 1944, Vol. 65, p. 228, and 1945, Vol. 67, p. 184.). Results are applied to the relativistic interaction of two electrons. Abstract of an Amer. Phys. Soc. paper.

531.4 + 539.62 + 621.394.653 + 621.395.653 1219
The Physics of Rubbing Surfaces.—F. P. Bowden. (*J. roy. Soc. N.S.W.*, 3rd Dec. 1945, Vol. 78, Part 3, pp. 187–219.) A comprehensive review of experimental information on the mechanism of frictional forces. The area of true contact is only a very small fraction ($\sim 10^{-4}$) of the total area of the apparently touching surfaces. The electrical conductance between two given materials is independent of the area of the apparently touching surfaces, and is little affected by their state of roughness; it depends mainly on the mechanical force between them. The deformation of the material at the points of true contact is mainly plastic rather than elastic.

The temperature at the true contact points when metals are rubbed together depends on load, speed of sliding and thermal conductance, but can be very high. Polishing is mainly due to melting at the contact points. A material with a high melting or softening point will polish a material that has a lower melting or softening point. The relative hardnesses at room temperature are unimportant.

Friction and surface damage of metals sliding very slowly so that contact temperature rise is not great depends on the relative hardnesses. The surface of the softer metal of a pair is ploughed out and torn; the harder surface is comparatively undamaged, but fragments of the softer metal are welded on to it; the damage to rubbing surfaces of similar homogeneous metals is more profound. Work hardening and deformation of rubbing metals occurs to a considerable depth below the actual track of the contact.

The theory of solid friction is examined. The use of metallic films as lubricants, and the use of bearing alloys are discussed. The effect of naturally occurring films of oxide and other impurities on the reduction of friction between metal surfaces is shown to be very large.

534 + 538.56 1220
The Wave Equation in a Medium With a [space-] **Variable Index of Refraction.**—P. G. Bergmann. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 286.) Abstract of an Amer. Phys. Soc. paper.

535.317 : 621.397 1221
[Optical] **Lens Aberrations in Picture Projection.**—Montani. (*See* 1379.)

535.43 1222
On the Theory of Light-Scattering. — A Note.—S. Parthasarathy. (*Phil. Mag.*, July 1945, Vol. 36, No. 258, pp. 510–514.) A continuation of an argument with Krishnan (see 3334 of 1940). The writer claims that Krishnan's results "have been vitiated by grave errors" and gives detailed reasons.

537.221 : 621.317.32 1223
A Modified Kelvin Method for Measuring Contact Potential Differences.—Meyerhof & Miller. (*See* 1282.)

537.525 1224
Small Perturbations of the Electric Discharge.—V. L. Granovsky. (*C.R. Acad. Sci. U.R.S.S.*, 10th July 1940, Vol. 28, No. 1, pp. 40–44. In English.) Equations were developed in a previous paper (*C.R. Acad. Sci. U.R.S.S.*, Vol 26, No. 9—Granovsky) describing the dynamic states of the plasma under diffusion conditions. In this paper conclusions are deduced from them for conditions of small perturbations. (a) The relations between the variable components of the discharge parameters do not depend on the external circuit. (b) The passage of a transient is aperiodic for gas pressures greater than a critical value, and damped oscillatory for lower pressures. (c) Forced oscillations (modulated discharge) are considered, and various semi-quantitative conclusions reached on the relationship between the modulating e.m.f. and the current, particle concentration, etc.

37.531(091) 1225
X-Rays an Early Institute Topic.—(*Elect. Engng, N.Y.*, Dec. 1945, Vol. 64, No. 12, pp. 435–436.) Excerpts from papers delivered before the A.I.E.E. in 1896 on theoretical and practical aspects of X-rays.

7.533.8 1226
Erratum : Secondary Emission of Pyrex Glass.—W. Mueller. (*J. appl. Phys.*, Jan. 1946, Vol. 17, No. 1, p. 62.) Correction to the composition of the glass quoted in 3648 of 1945.

8.1 1227
Note on Magnetic Energy.—E. A. Guggenheim. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, pp. 273–276.) A note to correlate the magnetic energy equations obtained by Livens (2825 of 1945) with the author's previous results (3221 of 1936). These equations apply to any unique relation between *B* and *H* whereas those of Livens are based on "linear laws of induction". In the two cases considered by Livens it is shown that the formulae only differ from the author's by constants.

.569.4 + 621.396.11.029.64 1228
The Absorption of Microwaves by Gases.—Hershberger. (*See* 1336.)

.16.08 1229
Counters for Use in Nuclear Spectroscopy.—L. Wiedenbeck. (*Rev. sci. Instrum.*, Jan. 1946, Vol. 17, No. 1, pp. 35–37.) A description of several self-quenching counters for counting conversion electrons with energies as low as 20 000 eV arising from an excitation process having a cross section of the order of 10^{-34} cm^2.

539.16.08 : 621.385.5 1230
Use of 6AK5 and 954 Tubes in Ionization Chamber Pulse Amplifiers.—Parsegian. (*See* 1404.)

539.163.2.08 1231
The Theory of the 180° Magnetic Focusing Type of Beta Ray Spectrometer.—A. K. Saha. (*Indian J. Phys.*, June 1945, Vol. 19, No. 3, pp. 97–119.) Development of an expression for the transmission factor as a function of the magnetic field and the electron momentum. It is illustrated by the complete calculation of the factor for the Lawson and Tyler spectrometer.

621.385.833 1232
Space-Charge-Limited Beams in Electrostatic Fields.—Rose. (*See* 1313.)

5 1233
Science in Progress. Fourth Series. [Book Review]—Univ. Press, Yale, Oxford Univ. Press, London, 331 pp., $3.00. (*Proc. phys. Soc.*, 1st Jan. 1946, Vol. 58, No. 325, pp. 129–130.) A set of eleven essays by eminent scientists, including one by Rabi on molecular beams and r.f. spectroscopy.

530.145.6 1234
Elementary Wave Mechanics. [Book Review]—W. Heitler. Oxford Univ. Press, London, 1945, 136 pp., 7s. 6d. (*Proc. phys. Soc.*, 1st Jan. 1946, Vol. 58, No. 325, pp. 127–128.) "It is truly elementary, both in the demands which it makes on the previous knowledge and mathematical ability of the reader, and also in that it deals only with the elements of wave mechanics."

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.746.5 : 621.396.11 : 551.51.053.5 1235
The New Sunspot Cycle.—T. W. Bennington. (*Wireless World*, March 1946, Vol. 52, No. 3, pp. 83–85.) The rise in the sunspot number from its minimum in 1944 has been unusually rapid. The next maximum may be considerably higher than the last. It may occur before May 1948, or in 1949. The curves of 12-month running averages of sunspot numbers and of critical frequency show a remarkable parallelism and should enable the prediction of the long-period variation of these quantities for a short time ahead with great accuracy. The article gives very detailed anticipation of usable frequencies for various routes : *e.g.*, "Frequencies up to 22 Mc/s ought to be usable for good periods during the day in the early months [of 1946] for communication with U.S.A., falling to about 17 Mc/s during the summer and increasing to about 29 Mc/s next winter. When all the path is in darkness, 7 Mc/s will at first be the highest safe frequency, but next summer frequencies up to 14 Mc/s should be usable most of the night. By next winter 10 Mc/s may be usable throughout the night."

550.38 + 551.594.5 1236
The Aurora and Geomagnetism.—C. W. Gartlein. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 76–77.) An electron device now under development is expected to overcome the difficulty of observing weak auroral activity during the full moon period. Closer correlation between solar and

magnetic intensity observations is foreseen. A brief survey of the relation between sunspots and magnetic storms produced by currents in the upper atmosphere, and their effect on communications. Summary of an I.R.E. paper. See also *Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 242..244.

550.38 **1237**
Secular Magnetic Variations as Transients.—W. M. Elsasser. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 285.) The higher harmonic components of the earth's magnetic field are subject to secular variations within periods of the order of a few hundred years. The inductance of the earth's metallic core is large and periods of spontaneous decay of currents in the core are calculated to be of the order of 10^4–10^5 years. Abstract of an Amer. Phys. Soc. paper.

551.594.223 **1238**
What are Fireballs?—E. A. Logan. (*Elect. Rev., Lond.*, 8th March 1946, Vol. 138, No. 3563, pp. 381–383.) It is suggested that fireballs (or ball lightning), which may be produced by cloud-to-cloud lightning, may be analogous to the vortex ring in structure.

LOCATION AND AIDS TO NAVIGATION

621.383 **1239**
Photoelectric Aid for the Blind.—(*See* 1309.)

621.396.82 : 621.396.9 **1240**
Radar Countermeasures.—D.G.F. (*See* 1356.)

621.396 [.9 + .94 **1241**
A Note on the Detection of Undersea Craft by Means of Low Frequency Radiation from Aircraft.—D. W. R. McKinley. (*Canad. J. Res.*, Nov. 1945, Vol. 23, Sec. A, No. 6, pp. 77–85.) " A semiquantitative examination is made of the chief factors affecting both the transmission of low frequency radiation from an aircraft to a submarine and the return of this energy to the aircraft by scattering. A general expression is derived for the returning field strength and graphs are shown for a representative set of conditions. It is indicated that, even under the most favourable conditions, the amount of energy returned is below the level of detectability if the submarine is submerged more than 10 ft. However, it is also pointed out that communication between a shore station and an undersea craft should be feasible under certain conditions."

621.396.9 **1242**
Decca Navigator: Continuous-Wave Navigation System.—(*Wireless World*, March 1946, Vol. 52, No. 3, pp. 93–95.) Marine position finding by means of pulse transmissions is limited by the propagation characteristics of the very high frequencies implicit in the use of very short pulses. The Decca system uses continuous waves and can therefore take advantage of the more favourable ground-wave propagation characteristics of frequencies of the order of 100 kc/s. For two synchronized transmitters the loci of receiving points associated with given constant phase differences are a family of hyperbolae. A third synchronized transmitter similarly determines another family of hyperbolae, and the ship can be located on the intersection of two hyperbolae by observations of the phase differences between the received signals. This is the essential theoretical basis of the Decca system. In practice, the master transmitte controls two remote phase-locked slave transmitters The difficulty of distinguishing between three transmissions on the same frequency is overcome by using three different frequencies, each of which is a submultiple of the same higher frequency (*e.g.*, 85 kc/s and 113.33 kc/s, which are both submultiples of 340 kc/s). The receiver receives each transmission separately and generates the appropriate harmonics for comparison of phase differences. This, and other working details are described. See also 331 of February.

621.396.9 **1243**
Principles of Loran in Position Location.—R. W. Kenyon. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 106..140.) See also 605 and 606 of March (D.G.F.).

621.396.9 **1244**
The Future of Radar.—L. A. DuBridge. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 77, 80.) Sea and air navigation will be greatly improved by the use of Loran (long-range navigation) systems and by new microwave systems over shorter ranges. Summary of an I.R.E. paper. See also *Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 254..256.

621.396.9 **1245**
Fundamentals of Radar [:4].—(*Wireless World*, Feb. 1946, Vol. 52, No. 2, p. 65.) Correction to 927 of April.

621.396.9 **1246**
Radar in Merchant Ships.—S. T. Allsop. (*Wireless World*, Feb. 1946, Vol. 52, No. 2, pp. 66–67.) General description of a compact set, easy to install and maintain, intended to give warnings of icebergs, other surface craft and, with its p.p.i. presentation, to show the position and outline of a coastline. The accuracy is about 2° in bearing and 200 yards in range, with a maximum range of about 6 miles on a trawler target, but considerably more for larger ships or for a coastline. Three p.p.i. displays are provided, one in the main chassis and two in remote positions convenient for navigation. Operating frequency evidently about 10 000 Mc/s.

621.396.9 **1247**
Navigational Radar: Experimental Equipment for Use in Merchant Ships.—(*Wireless World*, March 1946, Vol. 52, No. 3, p. 89.) A description of a demonstration of a centimetre-wave p.p.i. system. " A demonstration run of nearly an hour's duration down one of the busiest shipping channels in the Thames Estuary showed that the ship could be conned with complete confidence through the traffic, leaving ships and buoys a cable's length on either hand. During the whole time the navigator based his helm orders solely on information given by the p.p.i. display."

621.396.9 **1248**
SCR-545 Radar.—(*Electronics*, Jan. 1946, Vol. 19, No. 1, p. 198.) Correction to data given in 612 of March.

621.396.9 **1249**
Radar on 50 Centimeters.—H. A. Zahl & J. W. Marchetti. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 98–104.) Description of the general arrangement, the aerial, and h.f. system, of a light-weight 600 Mc/s early warning radar type AN/TPS-3. Total weight, including generators and aerial,

1 200 lb. Range 120 miles. The equipment can be erected by four men in half an hour. The transmitter uses a single VT158 pulsed at 200 c/s by a spark-gap modulator, and feeds an array of three dipoles with reflectors, mounted in the focal plane of a 10-ft-diameter paraboloid. The outer dipoles can be switched in or out of circuit, to alter the coverage. The set gives range and azimuth only. Details are given of the rotating joint in the coaxial aerial feeder, and the t.r. system is illustrated. There is A-scope and p.p.i. display. To be continued.

621.396.9 **1250**

The [AN/] MPG-1 Radar.—H. A. Straus, L. J. Rueger, C. A. Wert, S. J. Reisman, M. Taylor, R. J. Davis & J. H. Taylor. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 110–117.) An account of the transmitting, r.f., receiver, and aerial systems of the 10 000 Mc/s fire-control radar described in 610 of March. The modulator is of the hard-valve, capacitor-discharge type, with a pair of pulse transformers to enable the high-voltage pulse from the modulator to be taken by line to the magnetron. The step-up transformer has a double secondary connected to make the magnetron filament transformer remain at earth potential as the filament itself becomes highly negative. The r.f. system consists of a "squeeze box" standing wave adjuster, t.r. and anti-t.r. switches, directional coupler monitor, rotating feed, horn and reflector. The squeeze box enables the greatest magnetron frequency stability to be obtained. The radiator consists of a folded horn with a parabolic cylinder as reflector, and produces a beam about 0.6° wide and 3° high. The scanning system is described.

621.396.9 : 061.6 **1251**

History and Activities of the Radiation Laboratory at the Massachusetts Institute of Technology.—L. A. DuBridge. (*Rev. sci. Instrum.*, Jan. 1946, Vol. 17, No. 1, pp. 1–5.) A war-time institution under the Office of Scientific Research and Development, set up to develop microwave radar.

621.396.9 : 623.454.25 **1252**

Radio Proximity Fuze.—Trotter. (*See* 1326.)

621.396.933.2 **1253**

Fundamentals of Radar : 5. Beacons Employing Pulse Technique.—(*Wireless World*, Feb. 1946, Vol. 52, No. 2, pp. 55–56.) Radar beacons, developed from the IFF system (3915 of 1945), with a transponder on the ground and an interrogator and responder in the aircraft, are used as homing and beam approach aids. With ranges up to 100 miles the aircraft may be within the working area of several beacons, so identification is given to each by interrupting the responses from the transponder. The equipment involved is simple, light and cheap, and should be of great value in peacetime flying. See also 3914 of 1945.

621.396.933.2 **1254**

Direction Finder.—M. Relson. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 120, 164.) "A rotating radiation pattern is frequency modulated with a frequency identical [with], or an exact multiple of the frequency of rotation of the beam . . . . Upon amplitude and frequency demodulation, two signals are obtained in the receiver, phase comparison of which indicates the position of the aircraft with respect to the transmitter station." Summary of U.S. Patent 2 377 902.

621.396.933.23 **1255**

Microwave Instrument Blind Landing System.—Sperry Gyroscope Co. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, pp. 60..136.) Equipment operating at 2 617 Mc/s. Two transmitters in separate trailers and operating 23 Mc/s apart feed parabolic reflectors to produce the glide and localizer paths. The beams are switched at 60 c/s to produce intersecting lobes which are modulated at 600 and 900 c/s respectively. The receiver has a mechanical indicator to give the position of the plane relative to the correct approach line.

621.396 : 629.13 **1256**

Aviation Radio. [Book Review]—H. W. Roberts. W. Morrow & Co., New York, 1945, 637 pp., $5.00. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, p. 162.) "A complete study of the subject usable both by the novice and the professional."

MATERIALS AND SUBSIDIARY TECHNIQUES

531.788 **1257**

Calibration of Ionization Gauge for Different Gases.—S. Dushman & A. H. Young. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 278.) Preliminary notice, including a table of results, of calibrations for He, Ne, A, Kr, Xe, Hg, H_2, N_2.

533.5 **1258**

A Metal Packless Vacuum Valve.—E. Topanelian, Jr. & N. D. Coggeshall. (*Rev. sci. Instrum.*, Jan. 1946, Vol. 17, No. 1, p. 38.) An all-metal valve requiring no sealing grease or lubricant. A steel needle connected to a movable bellows engages a brass sealing. Pipe line connexions are through Kovar-to-glass seals.

534.845 : 677.521 **1259**

A Discussion of the Acoustical Properties of Fiberglas.—Rees & Taylor. (*See* 1156.)

537.228.1 + 539.32 + 621.3.011.5] : [546.32.85 + 546.39.85 **1260**

The Elastic, Piezoelectric and Dielectric Constants of Potassium Dihydrogen Phosphate (KDP) and Ammonium Dihydrogen Phosphate (ADP).—W. P. Mason. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 282.) Measurements have been made of all the elastic, piezoelectric, and dielectric constants of KDP and ADP crystals through temperature ranges down to the Curie temperatures. KDP behaves in accordance with theory, but ADP undergoes a transition at $-125°C$ unconnected with the H_2PO_4 hydrogen bond system which controls the dielectric and piezoelectric properties. Abstract of an Amer. Phys. Soc. paper.

537.228.1 + 621.396.611.21 **1261**

The Acid Etching and Steam Treatment of Quartz Oscillator Plates.—D. Fairweather. (*Marconi Rev.*, Oct./Dec. 1945, Vol. 8, No. 79, pp. 136–146.) The methods of finishing quartz oscillator plates to the desired frequency, for frequencies of 3 Mc/s and higher, are examined critically. It is shown that for an etched plate $R = KF^2$, for constant etchant strength, where R is the rate of change of frequency, K is a constant and F is the plate frequency. Steam treatment, with a similar law, has little value as a method of adjusting plates to frequency, but does provide an alternative method of ageing and may be used to test the effectiveness of the etching processes.

537.228.1 1262
Methods of Orienting and Cutting Synthetic Crystals.—W. L. Bond. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 282.) The methods include optically orienting on a mounting board, securing by fast setting cement, grinding a reference face at a predetermined angle from the board edges, sawing with solution-cooled abrasive blades, and grinding to dimension with abrasive belts. The application of these to ADP is discussed. Abstract of an Amer. Phys. Soc. paper.

537.228.1 1263
Apparatus for Growing Single Crystals from Solution.—A. N. Holden. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 283.) Abstract of an Amer. Phys. Soc. paper.

537.228.1 1264
The Order of Magnitude of Piezoelectric Effects.—H. Jaffe. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 282.) Piezoelectric coefficients are given as figures of merit for the selection of different materials for various applications. For sound generators, pickups and microphones, Rochelle salt is still preferable, but for ultrasonic work in liquids, synthetic crystals may be preferred. Abstract of an Amer. Phys. Soc. paper.

537.228.1 : 537.531.9 : 549.514.1 1265
Relation Between Darkening by X-ray Irradiation and Permanence of Dauphiné Twinning in Quartz.—E. Armstrong. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 282.) Quartz plates were subjected to inversion to the high-temperature form and reinversion to low quartz. Each plate was then irradiated with X-rays from a copper target tube. There was positive correlation between the amount of darkening caused by the X-ray irradiation and the permanence of their Dauphiné twin boundaries when subjected to the inversion treatment. Abstract of an Amer. Phys. Soc. paper.

621.315.52 + 621.315.559].018.44 1266
The Electrical Resistance of Iron Wires and Permalloy Strips at Radiofrequencies.—A. W. Smith, J. H. Gregory & J. T. Lynn. (*J. appl. Phys.*, Jan. 1946, Vol. 17, No. 1, pp. 33–36.) Substitution of test specimens of the materials in place of a series of standard resistors in a circuit resonant at the required radio frequency f (between 1.5 and 6 Mc/s) enables the a.c. resistance R of the specimens to be obtained by interpolation. Comparison with the d.c. resistance R_0 gives an empirical equation $R/R_0 = 0.4 + 1.5\,d(f\mu\sigma/10^3)^{\frac{1}{2}}$ for iron wire and $R/R_0 = A + f(a/b)\ 1.12\ (fab\sigma\mu/10^3)^{\frac{1}{2}}$ for permalloy strip of dimensions $a \times b$. d = wire diameter (cm), f = frequency (Mc/s), μ = permeability (gauss/oersted), σ = conductivity (mho/cm), A = empirical constant for each specimen, $f(a/b)$ = a function obtained from Cockroft (1929 abstracts, p. 224). These results are compared with existing theoretical work. "The relatively simple form of the empirical equation supports the hope that a definite physical meaning can be assigned to . . . A and . . . $f(a/b)$."

621.315.61 1267
Radio Insulating Materials: Part 4.—A. H. Postle. (*Radio, N.Y.*, Dec. 1945, Vol. 29, No. 12, pp. 33..60.) Preparation and properties of compression-moulded and transfer-moulded glass-bonded mica (permittivity 7). Higher permittivity materials (ϵ up to 20) in moulded forms, and temperature compensating materials having permittivities up to 80 and a temperature capacitance coefficient of 1 in 10^3 are available. For part 3 see 632 of March.

621.315.613.1 1268
Electrical Properties of Indian Mica: II. The Effect of Varying Relative Humidity.—P. C. Mahanti, M. K. Mukherjee & P. B. Roy. (*Indian J. Phys.*, June 1945, Vol. 19, No. 3, pp. 83–92.) A continuation of the work described in 3543 of 1943 (Datta, Gupta & Mahanti). The measurement was by substitution by a standard air capacitor, in a Schering bridge. Various methods of maintaining a known humidity in an enclosed space are described, including the use of saturated aqueous solutions of a range of salts such as calcium chloride, calcium sulphate, etc. The method chosen was the use of aqueous solutions of glycerin. This has the important advantage that the relative vapour pressure is substantially independent of temperature over the range 0–70°C, and that the solutions are easily standardized by measurement of refractive index. The results confirm those obtained by previous workers. The power factor begins to rise at about 40% relative humidity and rises steeply beyond 80%.

621.315.614 : 621.315.615 1269
The Electrical Resistivity of Resin-Treated Wood and Laminated Hydrolyzed-Wood and Paper-Base Plastics.—R. C. Weatherwax & A. J. Stamm. (*Trans. Amer. Inst. elect. Engrs*, Dec. 1945, Vol. 64, No. 12, pp. 833–838.) A report on measurements, giving experimental details. Graphs and data supplied show the variation of surface and volume resistivity with moisture content, resin content, and relative humidity, for the types of wood examined.

621.318[.22 + .322 1270
Magnetic Materials.—F. E. Robinson. (*Marconi Rev.*, Oct./Dec. 1945, Vol. 8, No. 79, pp. 125–135.) A review of recent improvements in the properties of hard and soft magnetic materials, obtained by cold working, heat treatment and variations of composition. The materials considered are divided into three groups, those suitable for permanent magnets, for power apparatus such as low-frequency generators, motors and transformers, and for sound and radio apparatus at frequencies up to 1 Mc/s.

621.318.322.017.3 1271
Hysteresis and Eddy Losses in Single Crystals of an Alloy of Iron and Silicon.—A. J. C. Wilson. (*Proc. phys. Soc.*, 1st Jan. 1946, Vol. 58, No. 325, pp. 21–29.) The total energy dissipated in single crystals of iron containing 2.1% silicon has been measured calorimetrically, for fields in the three crystallographic directions [100] [110] and [111], the losses being analysed by variation with frequency. The eddy losses do not depend on field direction, but the hysteresis loss for [100] is about one-third that for the other directions. A tentative theory is put forward.

621.385.832 1272
Phosphors and Their Behavior in Television [Part I].—I. Krushel. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 100..134.) A general account of the properties of phosphors, including graphs showing spectral properties of common types, with a description of manufacturing processes.

621.385.832 1273
Phosphors and Their Behaviour in Television [Part II].—I. Krushel. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 92..150.) The following production methods of coating tubes are described and their advantages discussed :—spraying, dusting, settling, " flowing-on", and electrostatic deposition. Problems of " ion burn " and dissipation of screen charges are specifically treated. Contrast and brilliancy, although sufficient for direct viewing, are not at present adequate for satisfactory projection. For Part I see 1272.

621.315.6(083.75) 1274
ASTM Standards on Electrical Insulating Materials (with related information). [Book Review]—ASTM Committee D-9. American Society for Testing Materials, Philadelphia, Pa., 1945, 560 pp., $3.25. (*Elect. Engng, N.Y.*, Feb. 1946, Vol. 65, No. 2, pp. 97–98.)

621.357.7 1275
Electroplating, A Survey of Modern Practice, including the Analysis of Solutions. [Book Review]—S. Field & A. D. Weill. Pitman Publishing Corp., New York, 5th edn. 1945, 483 pp., $5.00. (*Elect. Engng, N.Y.*, Dec. 1945, Vol. 64, No. 12, p. 470.)

MATHEMATICS

517.432 1276
The Steady-State Operational Calculus.—D. L. Waidelich. (*Proc. Inst. Radio Engrs, N.Y.*, Feb. 1946, Vol. 34, No. 2, pp. 78–83.) " The direct and inverse transforms of the steady-state operational calculus are presented, together with two methods of evaluating the inverse transform, the first resulting in a Fourier series and the second giving a sum function. A proof of the inversion theorem connecting the two transforms is outlined in the Appendix. Two examples are presented illustrating the application of this operational calculus to circuit problems, and a comparison is made between the ordinary and the steady-state operational calculuses."

517.941.91 1277
Computation of the Solution of Mathieu's Equation.—N. W. McLachlan. (*Phil. Mag.*, June 1945, Vol. 36, No. 257, pp. 403–414.)

517.5(021) 1278
Lehrbuch der Funktionentheorie— Vols. I & II. [Book Review]—L. Bieberbach. Chelsea Publishing Co., New York, 1945, Vol. I (4th edn., 1934) 320 pp., $ 3.50, Vol. II (2nd edn., 1931) 368 pp., $ 3.25. (*Waves and Electrons*, Feb. 1946, Vol. 1, No. 2, p. 104.) American reprint of the German text.

517.564.4 : 518.2 1279
Tables of Associated Legendre Functions. [Book Review]—Mathematical Tables Project. Columbia University Press, New York, 1945, 303 pp., $5.00. (*Electronics*, Jan. 1946, Vol. 19, No. 1, p. 344.) Fourteen major tables of functions and their first derivatives with five supplementary tables. To about six significant figures at intervals of 0.1.

621.396.029.6 1280
The Mathematics of Ultra-High Frequencies in Radio. [Book Review]—L. N. Brillouin. Brown Univ., Providence, R.I., 1943, 210 pp. (*Proc. phys. Soc.*, 1st Jan. 1946, Vol. 58, No. 325, pp. 128–129.) A mimeographed record of a course of lectures at Brown University.

MEASUREMENTS AND TEST GEAR

621.3.012.3 : 621.3.081.4 1281
Decibel Conversion Chart.—R. C. Miedke. (*Waves and Electrons*, Feb. 1946, Vol. 1, No. 2, pp. 76–77.) The chart gives decibels directly from any two values of voltage, current, or power, for ratios up to 10 to 1, with an extended range for ratios up to 10^6 to 1.

621.317.32 : 537.221 1282
A Modified Kelvin Method for Measuring Contact Potential Differences.—W. E. Meyerhof & P. H. Miller, Jr. (*Rev. sci. Instrum.*, Jan. 1946, Vol. 17, No. 1, pp. 15–17.) The two surfaces are brought rapidly together and give a pulse to an electrometer tube used as a cathode follower. By adjusting the bias, this pulse is reduced to zero and measures the contact potential difference to 0.01 V.

621.317.32.015.33 : 621.385.2 1283
Pulse Response of Diode Voltmeters.—A Easton. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 146–149.) A theoretical and experimental investigation. Equation (11) gives the mean rectified voltage in terms of the parameters of the pulse and the voltmeter, and is closely confirmed by experiment. It is stressed that the input impedance may be relatively small for short pulses. When measuring very short pulses the voltmeter performance can be improved by the use of a cathode follower and a pulse-stretching circuit ; a practical arrangement is shown.

621.317.382.029.3 1284
Power Measurements at Audio Frequencies.—D. L. Waidelich. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, pp. 68–70.) Describes the three-voltmeter method as given by Laws in his book " Electrical Measurements " (2508 of 1938). A second method, using a network and two thermo-junction milliammeters with the output e.m.f.s connected in opposition has a linear calibration. Variable resistors are used for setting up the scale accurately. The relative advantages of the two systems are enumerated.

621.317.39 1285
Electric Measuring Instruments.—D. M. Nielsen. (*Elect. Engng, N.Y.*, Feb., 1946, Vol. 65, No. 2, pp. 66–74.) A survey of the instruments used for the measurement of process variables such as temperature, pressure, flow, pH, etc., in terms of electrical variables, and of the way in which electronic devices are influencing the design of the sensitive elements, measuring mechanisms, and controlling mechanisms of the instruments. Table I lists electrically sensitive elements in terms of the physical variable measured, and Table II gives additional applications where the electrical element is combined with another responsive element. The basic features of electronic measuring instruments in general are given together with detailed descriptions of a commercial self-balancing bridge and three self-balancing potentiometers. Reasons are given for the increased use of electronic and electro-mechanical devices.

621.317.41 + 621.317.43] : 621.318.323.2.029.5 **1286**
Proposed Test Coils.—(*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, p. 71.) "Tentative standards for testing permeability and Q of powdered iron slugs ⅜ inch in diameter and ¾ inch long."

621.317.42 **1287**
Fluxmeter.—Marion Electric Instrument Co. (*Rev. sci. Instrum.*, Jan. 1946, Vol. 17, No. 1, p. 41.) A direct-reading fluxmeter with overall accuracy better than 1%. A D'Arsonval movement is situated in the field to be measured, and the current observed that is required to give a standard deflexion. Field range 1 200–9 600 gauss.

621.317.7 + 621.38 + 621.396.69 **1288**
Physical Society's Exhibition: First Post-war Show of Testing and Measuring Gear.—(*Wireless World*, Feb. 1946, Vol. 52, No. 2, pp. 48–52.) See also 1131/1133 of April.

621.317.7 **1289**
The Physical Society's Thirtieth Annual Exhibition: Electrical Instruments.—G. H. Rayner. (*J. sci. Instrum.*, Feb. 1946, Vol. 23, No. 2, pp. 31–34.) A review of instruments including the electron microscope, voltmeters, frequency meters, a.c. bridges, oscillators, signal generators, and a new a.c./d.c. comparator. See also 1131/1133 of April.

621.317.71 : 621.396.67 **1290**
Remote Indicating Antenna Ammeter.—C. R. Cox. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 210..214.) A diode rectifier coupled to the antenna through a current transformer, with a d.c. microammeter giving approximately linear calibration.

621.317.734 **1291**
A Simple Ohmmeter.—"Calibrator". (*Wireless World*, Feb. 1946, Vol. 52, No. 2, p. 44.) Brief description of a circuit in which a single milliammeter is used alternately for measuring the current through and the p.d. across the unknown resistor. Resistances up to $10^5\ \Omega$ can be measured.

621.317.734 **1292**
Resistance Measurements.—S. Litt. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 44..135.) Review of various methods of resistance measurement, including commercial ohmmeters with accuracy of 1% for very low resistance values, and bridge-type ohmmeters of greater accuracy.

621.317.76 : 621.396.621 **1293**
Laboratory Receiver.—W. F. Frankart. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, pp. 71, 144.) Circuit details of a high-stability v.h.f. receiver for frequency deviation and mean carrier frequency measurements. It includes an r.f. stage, a frequency changer, and separate i.f. channels for a.m. and f.m.

621.317.761 + 621.396.611.21.029.3 **1294**
Stabilizing Frequency in LF [1–10 kc/s] **Crystal Oscillators.**—L. R. Cox. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, pp. 106..124.) The amplitude-frequency effect in duplex flexure mode is reduced from 2 in 10^5 to a few parts in 10^7 by the use of a varistor in a voltage-limiting circuit. Summary of U.S. Patent 2 385 260.

621.317.761.029.62/.64 **1295**
Introduction to U.H.F. Frequency Measurements.—G. Dexter. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 32..114.) The principles and limitations of various methods of frequency measurement above 150 Mc/s are described, including inductance-capacitance wavemeters and Lecher wire systems. A cavity resonator with crystal detector, and a heterodyne instrument with butterfly oscillator and crystal mixer, are described rather more fully.

621.317.79 : 537.228.1 **1296**
Quartz Crystal Measurement.—C. W. Harrison. (*Radio, N.Y.*, Dec. 1945, Vol. 29, No. 12, pp. 16..22.) Illustrated summary of 3325 of 1945.

621.317.79 : 621.396.615.12 **1297**
Test Oscillator for New AM-FM-Tele Needs.—W. Muller. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, pp. 86–89.) The necessary and desirable properties of a versatile standard-signal generator for f.m. and television frequencies are considered, and the design of a suitable instrument is discussed in detail. It covers the ranges 100 kc/s to 150 Mc/s, and 1μV to 1V, with provision for f.m. and a.m., and incorporates crystal-controlled oscillators at 100 kc/s and 1 Mc/s. It is claimed to be "almost fool-proof and obsolescence-proof".

621.317.79 : 621.396.615.14 **1298**
135 to 500 Mc. Signal Generator.—J. Wonsowicz & H. S. Brier. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 35..116.) A design within the scope of a home workshop is described. The frequency range of nearly 4 to 1 on a single band is given by a tank circuit of novel construction. An unbalanced output is obtained through a simple coaxial tapped line attenuator. Modulation at 400 and 1 000 c/s is provided.

621.317.79 : 621.396.62 **1299**
R.F.-I.F.-A.F. Signal Tracer [for receiver testing].—V. Cavaleri. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 50..133.) A 3-valve a.f. amplifier of which the input circuit acts as grid-leak detector for modulated r.f. and i.f. signals. A magic eye indicator is used for c.w. signals. Constructional details.

621.392.43 **1300**
Shunt and Series Sections of Transmission Line for Impedance Matching.—Tai. (*See* 1178.)

621.315.6(083.75) **1301**
ASTM Standards on Electrical Insulating Materials (with related information). [Book Review]—ASTM Committee D-9. (*See* 1274.)

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

534.321.9 : 620.179 **1302**
Supersonic Flaw Detector.—(*See* 1148/1149.)

537.531 **1303**
Some Experiences with the X-Ray.—W. D. Coolidge. (*Elect. Engng, N.Y.*, Dec. 1945, Vol. 64, No. 12, pp. 423–426.) Personal reminiscences of the author's work in the early days of X-ray development. Voltage-supply difficulties are mentioned and also modifications to tubes for practical application of X-rays. The article also appears in *Amer. J. Roentgenol.*

537.531 : [5 + 6 **1304**
Scientific Importance of X-Rays.—L. H. Garland. (*Elect. Engng, N.Y.*, Dec. 1945, Vol. 64, No. 12, pp. 437–444.) An outline of the applications and value of X-rays to industry and science in general, and particularly to medical science.

537.531 : 62 **1305**
Industrial X-Ray Developments.—C. D. Moriarty. (*Elect. Engng., N.Y.*, Dec. 1945, Vol. 64, No. 12, pp. 433–435.) An account giving special attention to modern methods of recording results. Radiographic, fluoroscopic and electrical methods of recording are discussed.

612.82.014.421 : 621.395.645 **1306**
Brain Wave Records in Medical Diagnosis.—F. Offner. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 72 . . 161.) The recording of potential differences on the surface of the scalp needs amplifiers with a frequency response from a fraction of a cycle to 10 kc/s, and an amplification of about 140 db. Four- or five-stage R-C coupled push-pull amplifiers with balanced input are used. A Rochelle-salt crystal-driven recorder gives a satisfactory recording speed for use up to 100 c/s.

621.365 [.5 + .92 **1307**
Case Studies of RF Heating.—Westinghouse Electric Corp. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 84–85.) Eight annotated photographs showing methods of solving typical industrial problems.

621.365.92 : 615.452 penicillin **1308**
Radio-Frequency Dehydration of Penicillin Solution.—G. H. Brown, R. A. Bierwirth & C. N. Hoyler. (*Waves and Electrons*, Feb. 1946, Vol. 1, No. 2, pp. 58–65.) Preliminary concentration of the solution under reduced pressure is effected by using a 2-kW 28-Mc/s oscillator. Further dehydration in bottles revolving at high speed reduces the moisture content to 4% in 3 minutes. The equipment can produce 2 000 dry bottles each hour.

621.383 **1309**
Photoelectric Aid for the Blind.—(*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 204 . . 210.) A device which is used to scan the path ahead. A beam of light is projected and any reflection from objects is detected by a photocell which produces coded tone signals in an earphone. The range limit is 20 ft, and the coded signal heard indicates the distance of the object. The equipment weighs 9 lb, but may be reduced to about 2 lb.

621.383 : 535.33.071 **1310**
Electronic Spectroscopy.—G. C. Sziklai & A. C. Schroeder. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 284.) The colour content of light falling on a photocell may be directly observed on an oscilloscope. The method lends itself to colour matching by using two similar devices giving signals of opposite polarity and hence zero combined output when the colours match. Abstract of an Amer. Phys. Soc. paper.

621.384 **1311**
Production of Particle Energies Beyond 200 Mev.—L. I. Schiff. (*Rev. sci. Instrum.*, Jan. 1946, Vol. 17, No. 1, pp. 6–14.) The betatron, synchrotron, microtron, linear resonator accelerator, linear waveguide accelerator, and relativistic ion cyclotron are proposed and briefly described.

621.385 **1312**
Physical Limitations in Electron Ballistics.—Pierce. (*See* 1395.)

621.385.833 **1313**
Space Charge-Limited Beams in Electrostatic Fields.—M. E. Rose. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 287.) The case dealt with is the circularly symmetric beam of finite cross section. Only first-order optics in which the aberration is due to space charge is treated. Abstract of an Amer. Phys. Soc. paper.

621.385.833 **1314**
On the Improvement of Resolution in Electron Diffraction Cameras.—J. Hillier and R. F. Baker. (*J. appl. Phys.*, Jan. 1946, Vol. 17, No. 1, pp. 12–22.)

621.385.833 **1315**
Complete Computation of Electron Optical Systems.—H. Motz & L. Klanfer. (*Proc. phys. Soc.*, 1st Jan. 1946, Vol. 58, No. 325, pp. 30–41.) The field of the system is calculated by relaxation (see also 658 of March—Motz & Worthy), and the electron trajectories by step-by-step integration. "The position of focal and cardinal points and the spherical aberration of the lens are found to be in fair agreement with experimental and semi-empirical determinations by other authors."

621.385.833 **1316**
Applied Electron Microscopy.—J. H. L. Watson. (*Canad. J. Res.*, Nov. 1943, Vol. 21, Sec. A, No. 11, pp. 89–98.) The technique of taking stereoscopic photographs, and its adaptation to give electron diffraction patterns, is described in relation to the examination of mine dust, clays, and the structure of botanical specimens.

621.385.833 **1317**
Electron Microscope Society of America.—(*J. appl. Phys.*, Jan. 1946, Vol. 17, No. 1, pp. 66–68.) Abstracts of 25 papers from the Society's programme.

621.385.833 **1318**
Applications of Metallic Shadow-Casting to Microscopy.—R. C. Williams & R. W. G. Wyckoff. (*J. appl. Phys*, Jan. 1946, Vol. 17, No. 1, pp. 23–33.)

621.385.833 **1319**
A High Speed Microtome for the Electron Microscope.—E. F. Fullam & A. E. Gessler. (*Rev. sci. Instrum.*, Jan. 1946, Vol. 17, No. 1, pp. 23–35.)

621.389 : 778.52 **1320**
Electronic Timing of Sequence Photographs.—C. H. Coles. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, pp. 74–76.) Circuit details and photographs of apparatus for photographing bullets in flight. A rising voltage is applied to a number of valves biased to different amounts beyond cut-off. As each valve conducts, it applies a pulse to a stroboscopic lamp. 6 lamps may be fired in succession in a time between 35 microseconds and ½ second.

621.398 : 621.318.5 **1321**
Industrial Relay Control Circuits.—R. R. Batcher. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, pp. 94 . . 134.) Methods of remote control are outlined. The operation of simple relays is described, and it is shown how complex problems

are solved by combinations of relays. Selective control is effected by pulse-operated switching circuits of the types used in telephone exchanges.

621.398 : 623 **1322**
Radio Control of German V-2 Rockets.—(*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, p. 89.) Brief note only. See also 4135 of 1945.

621.398 : 629.13 **1323**
Radio Operated Airplane.—S. R. Winters. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 29..159.) Four a.f. tones on a u.h.f. carrier control a small plane. Switching off a fifth tone stops the engine and releases a parachute. See also 1324 below.

621.398 : 629.13 **1324**
Radio-Controlled Target Airplane Developed by ATSC.—(*Radio News*, Jan. 1946, Vol. 35, No. 1, p. 66.) See also 1323 above and 1013 of April.

623.26 : 621.396.9 **1325**
Vehicular-Mounted Mine Detector.—H. G. Doll, M. Lebourg & G. K. Miller. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 105–109.) A device that automatically stops the vehicle on detection of a metal mine or on failure of the electronic apparatus. Four circular horizontal coils side by side and in series are for transmitting (presumably a.f.). Four receiving coils are fixed on top of the transmitters, and the mutual inductance between transmitting and receiving circuits is neutralized by a group of transformers in opposite polarity in series with the coils. The coil assembly forms the detector element, and is electrostatically screened. Residual signals in the receiving circuit are neutralized by the injection of a signal automatically controlled by a long-time-constant circuit to counteract drift from balance. Passage of the detector over a mine causes a sudden change in mutual impedance between the coils, too quick for automatic compensation, and the resulting signal in the receiver operates braking relays. The arrangement is particularly sensitive to change in the resistive component of the mutual impedance, which is of advantage in discriminating against false signals. The complete circuit diagram is given with component values.

623.454.25 : 621.396.9 **1326**
Radio Proximity Fuze.—H. Trotter, Jr. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 226..228.) Summary of an I.R.E. paper describing the history of the subject.

016 : 621.386.1 : 620.179 " 1942/1945 " **1327**
Bibliography on Industrial Radiology. [Book Review]—H. R. Isenburger. St. John X-Ray Service, Inc., Long Island City, N.Y., 16 pp. $1.00. (*Electronics*, Jan. 1946, Vol. 19, No. 1, p. 344.) Mimeographed list of about 400 items published between 1942 and 1945. Supplement to 723 of 1944.

621.38 : 62 **1328**
Elementary Engineering Electronics. [Book Review]—A. W. Kramer. Instruments Publishing Co., Pittsburgh, Pa., 1945, 344 pp., $2.00. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, p. 128.)

PROPAGATION OF WAVES

534 + 538.56 **1329**
The Wave Equation in a Medium With a [space-] Variable Index of Refraction.—P. G. Bergmann. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 286.) Abstract of an Amer. Phys. Soc. paper.

621.396.11 **1330**
Polarized Radiation.—J. Grosskopf & K. Vogt. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, p. 113.) Summary of 2842 of 1944, with two graphs.

621.396.11 **1331**
Propagation Effects.—(*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, pp. 65..142.) A brief report of a conference held at the Cosmic Terrestrial Research Laboratory, Needham, Mass., on 11th Dec. 1945 on ionospheric and tropospheric propagation. Ionospheric and path absorption, sporadic " E " and scatter were discussed. Extended fade-outs were reported on 110 Mc/s over a distance of 70 miles which were greatly reduced by operation in the 40–50 Mc/s band. See also 1334.

621.396.11 : 523.746.5 : 551.51.053.5 **1332**
The New Sunspot Cycle.—Bennington. (*See* 1235.)

621.396.11 : 621.396.812.3 **1333**
Irregularities in Radio Transmission : Part I.—O. P. Ferrell. (*Radio, N.Y.*, Dec. 1945, Vol. 29, No. 12, pp. 27..61.) A review of evidence that " bursts " are due to low-level ionospheric reflections. A graph representing measurements made over 337- and 720-mile paths at a frequency of 42.3 Mc/s shows the average number of bursts per hour against field intensity of the received signal. The curve falls from 80 bursts per hour exceeding 6 μV/m, to 2 bursts per hour exceeding 26 μV/m. Twenty references are given.

621.396.11.029.62 **1334**
Tropospheric Study of FM Transmission.—C. W. Carnahan. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 78..146.) A long account of the I.R.E. paper by Carnahan. See also 1028 of April, and 1335 below.

621.396.11.029.62 **1335**
FM Tests.—F. C. C. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 80–81.) Report of controversy over the significance of results given in 1028 of April and in 1334 above (Carnahan). F.C.C. tests at 20 miles range are stated to indicate the reverse of the conclusions drawn from Carnahan's measurements.

621.396.11.029.64 + 538.569.4 **1336**
The Absorption of Microwaves by Gases.—W. D. Hershberger. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 284.) Fourteen gases give absorptions at about 1 cm wavelength comparable with that of ammonia. The frequency at which the absorption coefficient is maximum is obtained from graphs of the coefficient against pressure. Abstract of an Amer. Phys. Soc. paper.

621.396.615.17 **1337**
A New Pulse Generator Circuit [useful for ionosphere sounding].—Banerjee. (*See* 1210.)

RECEPTION

621.394/.397].813 **1338**

Defining Distortion.—M. G. Scroggie. (*Wireless World*, March 1946, Vol. 52, No. 3, pp. 99–100.) A letter criticizing the following definitions in the British Standard Glossary of Terms used in Telecommunication:— 1301 Distortion; 1302 Attenuation Distortion; 1304 Delay Distortion; 1305 Non-Linear Distortion; 1307 Harmonic Distortion; 1308 Intermodulation Distortion.

621.396.61/.62 + 621.395.645 **1339**

Low Power Transmitting/Receiving/and Hailing Equipment. Type CNY.1.—Morcom. (*See* 1386.)

621.396.62 : 621.396.662 **1340**

A Simple Remote Tuning Device for Receivers.—E. L. Hannum, Jr. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 76..82.) Band-spread about a selected communication frequency is achieved by varying the grid bias of a reactor valve connected across the tuned circuit of the receiver local oscillator, using a d.c. line circuit with remote potential-divider control. The control line is also used to carry the receiver a.f. output to the control point. The system is useful when it is necessary to locate a receiver perhaps several miles from the control centre in order to avoid noise interference with reception.

621.396.621 : 621.317.76 **1341**

Laboratory Receiver.—Frankart. (*See* 1293.)

621.396.621.54 **1342**

Practical Radio Course: Part 40. — A. A. Ghirardi. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 57..151.) "The effects [and causes] of resonant frequency "drifts" in the preselector, i.f. amplifier, and oscillator tuning circuits of a superheterodyne-type receiver."

621.396.621.54 **1343**

Amateur Communication Receiver.—H. B. Dent. (*Wireless World*, Feb. 1946, Vol. 52, No. 2, pp. 36–40.) The basis of the design of a short-wave superheterodyne receiver with two frequency conversions. The conversion is firstly to 1.8 Mc/s, secondly to 100 kc/s, giving good second channel and adjacent channel selectivity. The circuit diagram is given.

621.396.621.59 **1344**

Discriminating between Signals of Different Amplitude.—E. H. Ullrich. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 120, 170.) "A method which permits the separation of pulse modulated waves where the frequency and the energy at the receiver may be identical, but the amplitude and/or duration are different." Summary of U.S. Patent 2 381 847.

621.396.621.59 **1345**

"Exalted-Carrier Amplitude- and Phase-Modulation Reception".—M. G. Crosby. (*Proc. Inst. Radio Engrs, N.Y.*, Feb. 1946, Vol. 34, No. 2, p. 90.) Discussions of 3516 of 1945.

621.397.8 **1346**

Television for Urbanized Areas [siting of aerials].—Duvall. (*See* 1384.)

STATIONS AND COMMUNICATION SYSTEMS

621.396.619 **1347**

Phase and Frequency Modulation.—E. Green. (*Marconi Rev.*, Oct./Dec. 1945, Vol. 8, No. 79, pp. 113–118.) Vector diagrams are used to show the relationship between phase and frequency modulation, and to derive the relative gain in signal/noise ratio of these types of modulation over amplitude modulation for various values of modulation index.

621.396.619 : 621.385.5 **1348**

Phasitron Converts from AM to FM Directly.—(*See* 1405.)

621.396.619.018.41 **1349**

Frequency Modulator.—D. A. Bell. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 118, 120.) When two signals at different frequencies are applied to a limiter, one component of the output has a frequency intermediate between the input frequencies, dependent on the relative amplitude of the inputs. Thus if one input is amplitude modulated, this output component is correspondingly frequency modulated. Summary of U.S. Patent 2 384 789.

621.396.619.16 **1350**

Pulse Position Modulation Technic.—(*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 82..190.) A detailed general technical account of the Bell system described in 740 of March, including block diagrams and some circuit diagrams of the equipment.

621.396.619.16 **1351**

Pulse Modulation.—F. F. Roberts & J. C. Simmonds. (*Wireless Engr*, March 1946, Vol. 23, No. 270, p. 93.) Suggested definitions and abbreviations for terms used in the various forms of pulse modulation. Sharp leading and trailing edges are assumed. See also 1053 of April (Cooke) and 183 of January (Roberts & Simmonds).

621.396.619.16 **1352**

Pulse-Time Modulation: An Explanation of the Principle.—(*Wireless World*, Feb. 1946, Vol. 52, No. 2, pp. 45–46.)

621.396.65.029.62/.64 **1353**

The [U.S.] **Army's Radio Relay Equipment.**—A. R. Boone. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 25..155.) The AN/TRC-1 is an f.m. set transmitting at 70–100 Mc/s from a double-H aerial, providing four telephone channels. The AN/TRC-8 is similar but operates at 230–250 Mc/s, using a dipole with a V-reflector. The AN/TRC-6 (4 300–4 900 Mc/s) uses eight interlaced pulse-position-modulated channels. The aerial is a parabolic reflector with waveguide feed. The AN/TRC-5 is similar, but uses a dipole with paraboloid reflector (1 350–1 450 Mc/s.). Advantages over wire circuits include reduction in installation time, and in the number of repeater stations needed. For descriptions of AN/TRC-5 and AN/TRC-6 see 1055/1056 of April and back references.

621.396.7 **1354**

The [U.S.] **Signal Corps on and in the Air.**—C. E. Jackson. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 94..98.) A complete airborne radio station to meet the speed, mobility and power required in Pacific operations was prepared, using three cargo planes. The 3-kW transmitter and

15-kW diesel generator were carried in separate planes, parked nose to nose, with a 38-ft horizontal aerial using the aircraft as counterpoise. The receiver plane, some half mile away, was linked by land line. A two-tone teletype system was used.

621.396.712 **1355**

FM in Canada.—D. Holloway. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 30..140.) An account of controversial problems of broadcasting policy.

621.396.82 : 621.396.9 **1356**

Radar Countermeasures.—D.G.F. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 92–97.) Description of methods of searching for, locating and jamming enemy radars. Wide-range automatically tuned receivers with tape recording and an oscillographic analyser are used for searching. Jamming is provided by tunable high-power transmitters having random-noise modulation, or by reflecting foil strips of suitable length (" window " or " chaff "). Wide-band aerial systems and the resnatron (a tetrode giving 30 kW c.w. at 500 Mc/s) are briefly described. The more commonly used equipment is described in tabular form. See also 1059/1061 of April.

621.396.931.029.62 **1357**

Multi-Carrier Communication System : Diversity Transmission for Mobile Working.—(*Wireless World*, Feb. 1946, Vol. 52, No. 2, pp. 59–61.) General description of a system used by the London police and fire services. Reliable two-way telephone communication with mobile units can be maintained over a service range of 20 miles using amplitude modulation, and frequencies near 100 Mc/s, with a 400–500 ft mast at the control centre. The service area is extended by using additional fixed stations, supplied with synchronized and correctly phased modulation, operating at frequencies sufficiently close to one another to be within the bandwidth of the receivers, but sufficiently far apart to avoid audible beats. Signals from the mobile transmitters can be received at any of the fixed stations and relayed to the control centre. The system is described in detail in an I.E.E. paper by J. R. Brinkley, not yet printed.

621.396.931.029.63 **1358**

2,660-Mc Train Communication System.—E. A. Dahl. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 118–122.) A description of a two-way f.m. system, for communication between front and rear of train, and from train to wayside stations. The equipment consists of two compact units, transceiver and power supplies. The 10-W transmitter uses a crystal-controlled oscillator, its frequency multiplied up to 2 660 Mc/s in five stages, the last by a klystron. The signal is then klystron-amplified and fed to the aerial. For reception, the same frequency-multiplying chain is used with a crystal of slightly different frequency to serve as local oscillator, which, mixed with the incoming signal, gives an i.f. of 7 Mc/s. The omni-azimuthal antenna consists of six vertically stacked units, each having three curved dipoles, arranged in a circle at the focus of a biconical parabolic reflector.

621.396.97 : 356.251.11 **1359**

Listening to the World.—C. Cross. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 64..141.) A non-technical review of the B.B.C.'s wartime monitoring service. See also 197 of January.

621.396 : 629.13 **1360**

Aviation Radio. [Book Review]—Roberts. (*See* 1256.)

SUBSIDIARY APPARATUS

539.16.08 **1361**

Experiments with Triode [particle-] **Counters.**—S. A. Korff. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 284.) Abstract of an Amer. Phys. Soc. paper.

621–526 **1362**

Electrical Analogy Methods Applied to Servo-mechanism Problems.—G. D. McCann, S. W. Herwald & H. S. Kirschbaum. (*Trans. Amer. Inst. elect. Engrs*, Feb. 1946, Vol. 65, No. 2, pp. 91–96.) The treatment of angular position mechanisms and a description of the transient analyser are given, with typical transient response curves. Effects of varying controlling parameters are shown.

621.314.634 : 621.396 **1363**

Dry-Contact Rectifiers for Radio Applications.—G. Herbert. (*Radio, N.Y.*, Dec. 1945, Vol. 29, No. 12, pp. 29..61.) Details of construction and performance of selenium rectifiers, including efficiency, regulation and current characteristics. A chart shows sizes and current capacity of rectifier plates.

621.314.67 **1364**

Capacitor-Charging Rectifier.—H. J. Bichsel. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 123–125.) Experimental determination of design criterion for a reactance-limited rectifier required to charge a large capacitor bank in the shortest time and with the least power demand on the mains. The capacitor normally charges rapidly until the charging pulses become discrete, and then the charge rate falls. This point, when $E \approx 0.63E_{max}$, is the most economical point at which to discharge.

621.316.722.1.078.3 **1365**

Electronic A-C Voltage Regulator.—L. D. Harris. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 150–151.) The d.c. output from a rectifier is compared with the potential drop across a stabilizing tube. The difference is used to alter the d.c. load on another rectifier system with its transformer primary in series with the mains. The change of reactance of this winding reduces the fluctuations at the mains output terminals to about 6% of their original value. Third-harmonic content of the supply is also reduced.

621.316.722.1.078.3 **1366**

Stabilized D-C High-Voltage Supply.—A. M. Gurewitsch & P. C. Noble. (*Gen. elect. Rev.*, Dec. 1945, Vol. 48, No. 12, pp. 46..52.) The supply was designed for an electron diffraction instrument. A 35-kc/s power oscillator output is amplified, transformed to 15 kV and rectified by means of a voltage-quadrupling circuit to give 60 kV with an output of 60 W. The filaments of the rectifiers and also the filament of the electron gun are each supplied from separate 250-kc/s power oscillators. Automatic regulation is obtained by applying some of the output voltage to the screen of the driving oscillator. A 10% change in input voltage, or a load varying from 0.5 to 1.0 mA, causes the output voltage to vary less than 0.1%. The a.c. ripple is about 0.05%.

621.316.722:1.078.3 1367

A Voltage Regulator for X-Ray Circuits.—W. P. Davey. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 285.) Changes in the rectified mains voltage operate a relay train to a motor which moves the field rheostat of a 20-kVA alternator in the appropriate direction. The a.c. voltage is regulated to ±0.02 V in 110 V. Abstract of an Amer. Phys. Soc. paper.

621.317.083.7 + 621.398 1368

New Power Operated Sensitive [meter] **Recorder.**—P. G. Weiller. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 88..140.) Contact of the meter pointer with one of two graphite blocks starts a motor, through a triode and relay, which moves the block away from the pointer, and simultaneously operates a means of remote indication or control. Precautions taken avoid hunting, sticking of contacts, or interruption of operation by electrostatic forces or absorbed gases on the contacts. Any meter with a torque of 0.02 gm.cm or more for full-scale deflexion may be used.

621.318.42.029.6 1369

R.F. Chokes at U.H.F.—W. J. Stolze. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 54..114.) Chokes should have very high impedance at the working frequency, sufficiently low resistance, and the wire should have sufficient current-carrying capacity. Choke connexions should be as short as possible. A design chart gives recommended numbers of turns for frequencies from 40–160 Mc/s. Examples of uses for chokes are given, and the use of transmission lines as chokes is mentioned.

621.384.6 1370

100 Million Volt Electron Accelerator.—(*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 90..168.) An account of the device described in 438 of February (Westendorp & Charlton).

621.386 (091) 1371

X-Ray History and Development.—W. D. Coolidge & E. E. Charlton. (*Elect. Engng, N.Y.*, Dec. 1945, Vol. 64, No. 12, pp. 427–432.) See 770 of March. This paper also appears in *Radiology*, Dec. 1945.

621.386(4) 1372

50 Years of X-Ray Progress in Europe.—J. H. van der Tuuk. (*Elect. Engng, N.Y.*, Dec. 1945, Vol. 64, No. 12, pp. 444–448.)

621.398 : 621.318.5 1373

Industrial Relay Control Circuits.—Batcher. (*See* 1321.)

621.398 : 621.396.662 1374

Automatic Positioning Control Mechanisms.—R. W. May & N. H. Hale. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 58..158.) A review of types of mechanisms suitable for rapid readjustment of the controls of multifrequency transmitters. The Collins Autotune is described in detail.

621–526 1375

Fundamental Theory of Servomechanisms. [Book Review]—L. A. MacColl. D. Van Nostrand, New York, $2.50. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, p. 163.) "It is scholarly and will well repay the expert or would-be expert for its study."

TELEVISION AND PHOTOTELEGRAPHY

621.383.8 1376

High Sensitivity Pickup.—(*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 88–89.) A short account of the R.C.A. Image Orthicon, a television camera tube about 100 times more sensitive than previous instruments. Electrons are emitted from a photoelectric screen, and are attracted electrostatically to a non-conducting target, where they cause the emission of secondary electrons, leaving a pattern of positive charges corresponding to the original light image. The back of the target is scanned by an electron beam that has just enough energy almost to reach the screen before being turned back to the gun by the electrostatic forces. When the beam scans a part of the target that is positively charged, sufficient electrons are attracted from the beam to neutralize the charge, leaving the returning beam correspondingly deficient. The returning beam is therefore modulated according to the electrical pattern on the target. It strikes the front of the electron gun, causing the emission of secondary electrons that are attracted by the plates of an electron multiplier from which the output is obtained. For another account see *Electronics*, Dec. 1945, Vol. 18, No. 12, p. 330.

621.385.832 1377

Phosphors and Their Behaviour in Television [parts I & II].—Krushel. (*See* 1272/1273.)

621.397 1378

[U.S.] **Industry Standardization Work in Television.**—D. B. Smith. (*Electronic Industr.*, Dec., 1945, Vol. 4, No. 12, pp. 192, 194.) A brief survey of proposals for further standardization of the television service on the lower frequency range of operation. Reference is made to three-dimensional colour television. Summary of an I.R.E. paper. See also *Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 244..246.

621.397 : 535.317 1379

[Optical] **Lens Aberrations in Picture Projection.**—A. Montani. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 86, 87, 150.) Qualitative description of six types of aberration which should be corrected in television equipment.

621.397 : 621.396.619.1 1380

Amplitude Modulator for Facsimile.—Artzt. (*See* 1390.)

621.397.3 : 621.396.615.17 1381

Television Sweep Oscillators.—E. M. Noll. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 52..74.) The basic theory of sawtooth voltage generators, including the multivibrator, blocking oscillator, and gas-discharge oscillator. Part II of a series beginning with 782 of March.

621.397.5 : 621.396.619.16 1382

Transmission of Television Sound on the Picture Carrier.—G. L. Fredendall, K. Schlesinger & A. C. Schroeder. (*Proc. Inst. Radio Engrs, N.Y.*, Feb. 1946, Vol. 34, No. 2, pp. 49–61.) A discussion of duplex transmission using several types of pulse modulation. "The advantages of duplex transmission are: (1) elimination of a separate sound transmitter, (2) elimination of the ambiguity and difficulty which may occur when a standard frequency-modulated sound signal is tuned in, (3) freedom of the audio output from the type of distortion which occurs in frequency-modulated receivers as a consequence of excessive drift of the frequency of the local oscillator, and (4) improvement of the phase characteristic of the picture intermediate-frequency amplifier resulting from elimination of trap circuits.

"With the exception of pulsed frequency modulation, the signal-to-noise ratios of sound in duplex systems are not so great as the ratio offered by the transmission of a standard frequency-modulated carrier. The comparison is subject to the condition that the amplitude of the frequency-modulated carrier is 0.7 of the peak amplitude of the duplex carrier. The signal-to-noise ratio of a pulsed frequency-modulated signal may equal the ratio of a standard frequency-modulated signal up to a critical distance from the transmitter, but is less at greater distance."

621.397.62 **1383**

Television Psychology: Is the Large Screen Essential?—P. Bellac. (*Wireless World*, Feb. 1946, Vol. 52, No. 2, p. 40.) A small, close object may subtend the same angle at the eye as a large object seen from a distance, but the convergence of the eye axes in viewing the close object gives an impression of nearness and therefore of smallness. An unpleasant impression is produced by the discrepancy between the smallness of the image and the intensity of the sound. These faults can be overcome only by a television receiver with a projection system giving an image size comparable with that of home moving pictures.

621.397.8 **1384**

Television for Urbanized Areas.—G. Duvall. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 88..92.) There is no ready-made solution for the best siting of television aerials, when line of sight reception is impossible. Due to reflections from physical barriers, the proper orientation of the dipoles is a matter of experiment. Maximum height consistent with feeder cable cost is an over-all aim.

TRANSMISSION

621.385.3.029.63 : 621.396.615.16.029.63 **1385**

A Vacuum-Contained Push-Pull Triode Transmitter [Type VT158].—Zahl, Gorham & Rouse. (*See* 1403.)

621.396.61/.62 + 621.395.645 **1386**

Low Power Transmitting/Receiving/and Hailing Equipment. Type CNY.1.—W. J. Morcom. (*Marconi Rev.*, Oct./Dec. 1945, Vol. 8, No. 79, pp. 119–124.) This transportable equipment has facilities for telephony and telegraphy transmission, reception and hailing. The transmitter power is 5–8 W on 1.5–9 Mc/s. The receiver gives an output of 3.5 W and the a.f. power input to the hailing loudspeaker is 10 W.

621.396.61 : 621.396.619.018.41 **1387**

Concentric Line [88–108 Mc/s band] **FM Transmitter for 250 W.**—(*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, pp. 78..146.) Description of a Transmitter Equipment Mfg. Co. equipment. Use of miniature valves and push-pull circuits reduces problems of frequency multiplication, stability, and modulation. Electro-mechanical tuning maintains the frequency relative to a crystal-controlled oscillator.

621.396.61.029[.58 + .62 **1388**

Unusual Transmitter for 28-54 Mc/s.—R. P. Turner. (*Radio News*, Jan. 1946, Vol. 35, No. 1, pp. 40..126.) Constructional details of a 30-W transmitter, continuously tunable throughout the frequency band, with provision for crystal control. The controlled oscillator works on the fundamental or second harmonic of a crystal with frequency about 7 Mc/s. The frequency is quadrupled in the driver stage. Use of a dual beam tetrode, type 815, link-coupled to the driver stage, avoids the necessity for neutralization.

621.396.615.12 **1389**

Transitron Oscillator for High Stability.—W. Muller. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 110..138.) An oscillator to cover the range 40–175 kc/s with a stability of ± 4 c/s between − 40°C and 60°C, and for line voltage variations of ± 25% was required. Of three types considered (including phase-shift and electron-coupled oscillators), the transitron oscillator best fulfilled the requirements. A detailed description is given of the design of the circuit and of the experiments on which it was based.

621.396.619.1 : 621.397 **1390**

Amplitude Modulator for Facsimile.—M. Artzt. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, p. 172.) A method of modulating a wave from an RC-coupled oscillator at the maximum possible keying rate, with freedom from transients. Summary of U.S. Patent 2 373 737.

VALVES AND THERMIONICS

537.525 **1391**

Small Perturbations of the Electric Discharge.—Granovsky. (*See* 1224.)

537.533.8 **1392**

Erratum: Secondary Emission of Pyrex Glass.—C. W. Mueller. (*J. appl. Phys.*, Jan. 1946, Vol. 17, No. 1, p. 62.) Correction to the composition of the glass quoted in 3648 of 1945 (Mueller).

621.38(083.72) **1393**

The Tron Family.—W. C. White. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 80..136.) A glossary of names of valves and other electronic devices having the suffix "tron", with bibliographic references to early use of the words.

621.385 + 621.396.615 + 538.561 **1394**

Interchange of Energy between an Electron Beam and an Oscillating Electric Field.—J. Marcum. (*J. appl. Phys.*, Jan. 1946, Vol. 17, No. 1, pp. 4–11.) "Relations between various parameters are obtained which describe the behavior of an accelerated electron beam which is caused to traverse an alternating electric field. In particular, a mechanicographical means for obtaining the gain or loss of energy is described. It is shown that under the most favorable conditions a maximum of 17 per cent. of the energy in the accelerated beam may be transferred to the alternating field. Application of these principles to a type of ultra-high frequency oscillator is treated."

621.385 1395

Physical Limitations in Electron Ballistics.—J. R. Pierce. (*Bell. Syst. tech. J.*, July/Oct. 1945, Vol. 24, Nos. 3/4, pp. 305–321.) Mainly a consideration of devices with large beam currents, dealing with the following points. Electron lens aperture; distribution of initial velocities of electrons; space-charge effects; power-dissipation limits, and effect of scaling down electron devices.

621.385 — 1396

Electron Ballistics in High-Frequency Fields.—A. L. Samuel. (*Bell. Syst. tech. J.*, July/Oct. 1945, Vol. 24, Nos. 3/4, pp. 322–352.) The five fundamental functions of an electronic device are—production of an electron beam, modulation of the beam, conversion of this modulation into a usable form, abstraction of energy from the beam, and collection of spent electrons. Conversion mechanisms in which electrons are sorted according to velocities and the "bunching" of electrons as used in magnetrons, Barkhausen tubes, diode oscillators and klystrons, are considered. The mathematical analysis of electron motions in the klystron is outlined, and diagrams given which illustrate graphically the bunching effect. The influence of space charge in modifying the bunching effect and electron paths within the magnetron is briefly discussed.

621.385 1397

Factors Determining Industrial Tube Life.—J. F. Dreyer, Jr. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, pp. 94..156.) Apart from mechanical defects and careless handling, the normal life of a valve depends solely on the rate of cathode emission. A curve showing the relationship between emission and expected life is given, followed by a detailed discussion on methods of obtaining optimum efficiency at minimum cost.

621.385 : 623.454.25 1398

Proximity Fuze Tubes.—M. A. Acheson. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 228..236.) Summary of an I.R.E. paper describing the special requirements and the expedients by which they were met.

621.385.029.64(43) 1399

Germany's UHF Tubes.—Combined Intelligence Objectives Sub-Committee. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, pp. 81..122.) Describes construction and design principles of velocity-modulated and magnetron valves for c.w. and pulse operation on bands between 10 cm and 3·7 mm wavelength. Exploration of intense electron beams is made with pieces of carbonized paper which glow when inserted in the beam. Information taken from Combined Intelligence Objectives Sub-Committee reports, index nos. 58, 59, 69, 78 and 95.

621.385.1 1400

Reflex Oscillators Utilizing Secondary Emission Current.—C. C. Wang. (*Phys. Rev.*, 1st/15th Dec. 1945, Vol. 68, Nos. 11/12, p. 284.) To increase the power output of velocity-modulated tubes, a secondary-emission electrode is introduced to increase the beam current delivered to the gap where r.f. energy is absorbed from the beam. The tubes have been successfully operated at 4 000 Mc/s. Abstract of an Amer. Phys. Soc. paper.

621.385.16.029.63/.64 1401

Cavity Magnetrons.—D. G. F. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 126–131.) Details of the development and construction of centimetric-wave tubes used for radar. A list of types developed for pulsed operation in the L-band (25–50 cm), S-band (8–11 cm), and X-band (3 cm) is given, with the power and duty-cycle ratings. Efficiency, undesired modes, magnet construction, and output matching are discussed. The Rieke diagram showing the effect of load impedance on output power and frequency of a typical magnetron is given. Peak powers up to and beyond a megawatt have been obtained.

621.385.16.029.63/.64 1402

Theory of Magnetron Tubes and Their Uses.—H. G. Shea. (*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 66–70.) A simple derivation of cavity magnetron theory, with discussion of the results and of application to the construction of standard types. Particular reference is made to mode stability and to the "strapping" of alternate barriers. Frequency/power (Rieke) diagrams, and typical operating conditions are given for the 4J36–4J41 type.

621.385.3.029.63 : 621.396.615.16.029.63 1403

A Vacuum-Contained Push-Pull Triode Transmitter [Type VT158].—H. A. Zahl, J. E. Gorham & G. F. Rouse. (*Waves and Electrons*, Feb. 1946, Vol. 1, No. 2, pp. 66–69.) The resonating grid and plate circuits are contained in the vacuum and form integral parts of the grid and plate structures. The tube is used with a tuned filament line. It can oscillate in a narrow frequency band between 200 and 700 Mc/s. It will give 200–300 kW pulsed peak powers, and can also be used for c.w.

621.385.5 : 539.16.08 1404

Use of 6AK5 and 954 Tubes in Ionization Chamber Pulse Amplifiers.—V. L. Parsegian. (*Rev. sci. Instrum.*, Jan. 1946, Vol. 17, No. 1, pp. 39–40.) Results based on tests to obtain high signal/noise ratio with floating grid and with very high grid leak operation.

621.385.5 : 621.396.619 1405

Phasitron Converts from AM to FM Directly.—(*Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 78–79.) A horizontal circular disk of electrons from the cathode of the phasitron is modulated at the crystal-controlled carrier frequency by a grid system that bends the electron trajectories in a vertical direction so that the edge of the electron sheet follows a line that is sinusoidal in the vertical direction. The grid system is composed of a number of similar elements equally spaced around the vertical axis so that there are several wavelengths of vertical modulation around the complete electron sheet. Also, each grid element is threefold and fed with a three-phase voltage so that the modulation profile of the sheet rotates about the vertical axis. There is a coaxial cylindrical screen around the sheet, with holes punched in it at equi-angular intervals, through which, on account of the rotation of the fluted electron sheet, are projected streams of electrons that vary in intensity at the carrier frequency. A coil of wire coaxial with the electron sheet carries a.f. current and produces an alternating magnetic field that deflects the electron trajectories in a circumferential direction, and consequently phase-modulates the streams of electrons passing through the holes in the screen. An anode outside the screen collects the projected electrons and therefore carries a current alternating at the carrier frequency and phase-modulated at the audio frequency.

621.385.5 : 621.396.621.54 **1406**
Recent Developments in Converter Tubes.—W. A. Harris & R. F. Dunn. (*Electronics*, Jan. 1946, Vol. 19, No. 1, pp. 240..242.) Description of the 6SB7Y converter which has a conversion transconductance of 0.95 mA/V, and an oscillator transconductance of 8 mA/V. It is said to give improved gain and signal/noise ratio in the medium- and short-wave bands. Some details of operation around 100 Mc/s are given. Summary of an I.R.E. paper. See also *Electronic Industr.*, Dec. 1945. Vol. 4, No. 12, p. 81.

621.385.831 : 621.396.619.018.41 **1407**
Ratio-Controlled Amplifier.—C. W. Hansell. (*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12, p. 120.) An amplifier tube intended for use with a balanced discriminator, avoiding the necessity of a limiter in frequency- or phase-modulation detector circuits. Summary of U.S. Patent 2 383 855.

MISCELLANEOUS

001.8 : 62 **1408**
A Plea for the Scientific Method.—L. Hoffer. (*Waves and Electrons*, Feb. 1946, Vol. 1, No. 2, pp. 56–57.) The importance of critical discrimination, proper classification of data, scientific technique and pure research in engineering are outlined.

001.89 **1409**
Science and the Government.—H. M. Kilgore. (*Science*, 21st Dec. 1945, Vol. 102, No. 2660, pp. 630–638.) Discussion of a proposal to set up a National Scientific Research Foundation in the U.S.A., in the form of a government agency, dealing with research into all problems related to national welfare.

001.891 : 6(410) **1410**
Alliance of Industry and Scientific Research in Great Britain.—B. J. A. Bard. (*Science*, 4th Jan. 1946, Vol. 103, No. 2662, pp. 6–8.) Present plans for closer liaison include endowments and scholarships to be offered to the universities by industry, interchange of staff, and joint research councils.

519.283 **1411**
Statistical Methods in Quality Control—VII.—A.I.E.E. Subcommittee on Educational Activities. (*Elect. Engng, N.Y.*, Dec. 1945, Vol. 64, No. 12, pp. 448–450.) The use of control charts and the analysis of samples in a manufacturing process, to determine factors which might need correction. For previous parts see 805 of March. See also 1412 below.

519.283 **1412**
Statistical Methods in Quality Control—IX.—A.I.E.E. Subcommittee on Educational Activities. (*Elect. Engng, N.Y.*, Feb. 1946, Vol. 65, No. 2, pp. 81–83.) Discussion of acceptance sampling based on the method of attributes, including single sampling, double sampling, and multiple sampling. The "operating characteristics" are plotted to compare the various methods. See also 1411 above.

62 **1413**
Progress Depends on Sound Engineering.—J. A. Stobbe. (*Electronic Industr.*, Feb. 1946, Vol. 5, No. 2, pp. 72–73.) Emphasizes the need for close contact between engineer and consumer, and for designing for reduction of production costs.

621.3.012.3 : 621.3.081.4 **1414**
Decibel Conversion Chart.—Miedke. (*See* 1281.)

621.3.085.6 + 621.3.017.72 **1415**
Heat Dissipation from Cabinets for Electrical Instruments.—H. C. Littlejohn. (*Gen. Radio Exp.*, Jan. 1946, Vol. 20, No. 8, pp. 4–5.) A table is given showing the relative heat-dissipation properties of various materials. The most efficient dissipator is a metal case with an internal and external dull black finish.

621.38 : 621.317.2 **1416**
A Laboratory for Basic Electronics.—P. M. Honnell & W. E. Strohm. (*Elect. Engng, N.Y.*, Feb. 1946, Vol. 65, No. 2, pp. 75–80.) A description of the 140-position electronics laboratory installed at the U.S. Military Academy. A central switchboard distributes alternating or direct voltage, including a.f. and r.f. up to 18 Mc/s, to any of twelve benches, each of which has several student positions equipped with its own switchboard. Protective measures include automatic isolating of small sections to facilitate fault tracing.

621.394/.395].653 + 531.4 + 539.62 **1417**
The Physics of Rubbing Surfaces.—Bowden. (*See* 1219.)

621.396/.397](058.7) **1418**
1945 Electronic Engineering Directory.—(*Electronic Industr.*, Dec. 1945, Vol. 4, No. 12.) A 56-page directory of U.S. sources of supply of radio and allied equipment. A supplement giving names of patent attorneys and consulting engineers appears in *Electronic Industr.*, Jan. 1946, Vol. 5, No. 1, pp. 98, 100.

621.396.62.017.72 **1419**
Ventilation Problems.—W. Tusting. (*Wireless World*, March 1946, Vol. 52, No. 3, pp. 72–75.) Suggests that the need for dissipating the heat (60–200 W) generated by radio receivers is not always given due consideration in the early design stage. Excessive temperature rise may reduce component life. It is also liable to cause considerable frequency drift. The provision of unimpeded channels for air-flow around valves is the chief recommendation.

621.396.9 : 061.6 **1420**
History and Activities of the Radiation Laboratory of the Massachusetts Institute of Technology.—DuBridge. (*See* 1251.)

621.38 **1421**
Electronics for Engineers. [Book Review]—J. Markus & V. Zeluff (Eds.). McGraw-Hill Book Co., New York, 1945, 390 pp., $6. (*Elect. Engng, N.Y.*, Feb. 1946, Vol. 65, No. 2, p. 98.) A collection of 142 articles, reference sheets, charts and graphs reprinted from *Electronics*.