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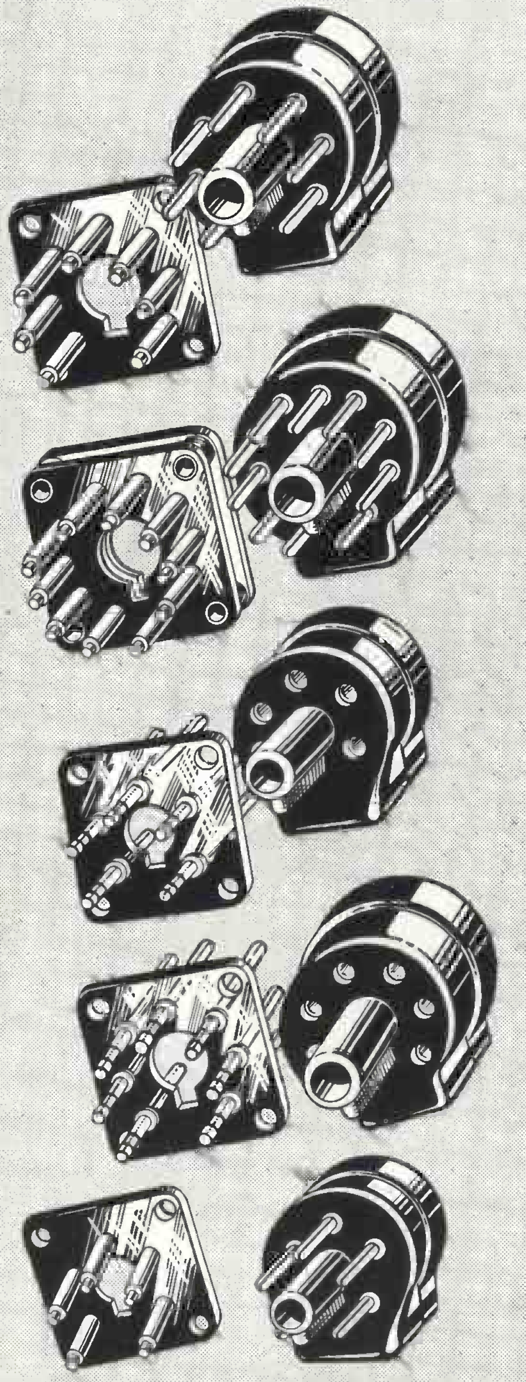

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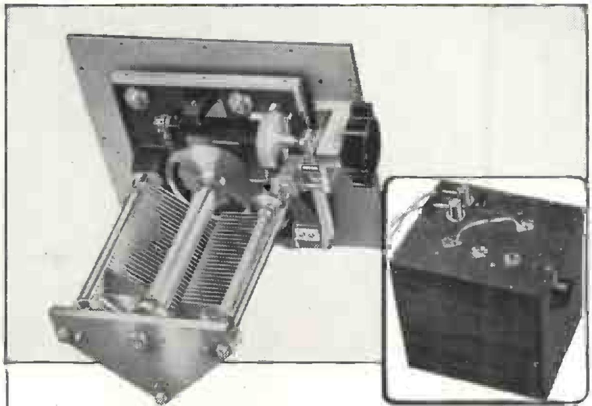

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WIRELESS ENGINEER

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VOL. XXI SEPTEMBER, 1944 No. 252

Editorial

The Non-reflecting Termination of a Concentric Line

ACCORDING to the generally accepted theory of the transmission of electromagnetic waves along lines, if a line is terminated by an impedance equal to the characteristic impedance Z_0 of the line, there is no reflection and the wave on the line is exactly the same as it would be if the line were infinitely long. If the line losses are negligibly small Z_0 is a resistance equal to $\sqrt{L/C}$, which for a concentric line with air insulation is equal to 60 $\log_e r_2/r_1$ ohms where r_1 and r_2 are the inner and outer radii of the dielectric. Considerations of symmetry suggest the use of a thin disc of some material such as graphite for the purpose of experiment. If the above-mentioned theory is correct, when the line is terminated by a disc of the calculated resistance there should be no trace of reflection with resulting standing waves, and therefore no nodes or antinodes, but the same amplitude at every point. In the Bell System Technical Journal of October 1934 S. A. Schelkunoff says: "We now take up a problem . . . viz. the design of a disc which, when clapped on the end of such a pair will not give rise to a reflected wave," by which he meant a disc having the above resistance.

In a Paper recently read before the Wireless Section of the Institution of Electrical Engineers Professor Willis Jackson and Dr. Huxley described some experiments which proved conclusively that there was something seriously wrong with this simple application of transmission line theory. The line employed had a ratio r_2/r_1 of 3.55 which, substituted in the above formula, gives a Z_0 of 76 ohms. A disc of this value can be obtained in the form of a film of graphite supported on bakelised paper. For such a film of thickness h cm and specific resistance ρ, $R = \frac{\rho}{2\pi h}\log_e\frac{r_2}{r_1}$; putting $R = 76$ ohms and $\rho = 0.5 \times 10^{-3}$ gives a thickness h of about 1.3×10^{-6} cm., so that we need not worry about skin effect even if ρ is considerably greater than we have assumed. Using such a disc for the line termination there was marked reflection, and, quite contrary to the simple theory, standing waves were observed with a ratio of maximum to minimum of 3.57. Tests were also made with the line short-circuited and open-circuited. With the line short-circuited the standing waves observed agreed with theory, but on open-circuit this was only true when the wavelength was long compared with the radial dimensions; as the wavelength was decreased the standing waves departed more and more from their theoretical position in the direction towards the open end, indicating that the line appeared to be longer than it actually was. The analogous acoustic phenomenon is well known in connection with closed and open organ pipes. The former give the correct note corresponding to their length whereas an end-correction has to be applied to the latter. In the case of the open-circuited line the ordinary theory and formulae assume that the electric field is radial right up the end and then suddenly vanishes, whereas it is obvious that the field will be distorted as it approaches the end and will spread out into the space immediately beyond the end, some electric lines of force passing between the end of the central conductor and the outside of the outer conductor. The line is really terminated in an extraneous capacitance. With the shortest waves employed it was calculated that the observed standing waves corresponded to a termination having an effective impedance of $28-j54$ ohms, which is a long way from infinity. The real component corresponds to a loss of power due perhaps to radiation from the open end together with dielectric losses in the surroundings. How can this capacitive termination be corrected or eliminated ? We shall see that its correction involves its elimination. To correct it a symmetrical fitting is required having a certain inductance. This can hardly take any form other than that of a piece of the same transmission line. A piece with a length $\lambda/4$ short-circuited at the other end has an infinite impedance ; by making the length less than $\lambda/4$ its inductive impedance can be adjusted to any desired value. Imagine such a piece of short-circuited line, excited by some means so that its open-end voltage has the same value and phase as the voltage at the open end of the transmission line, and gradually brought up to it along the axis (Fig. 1). As it approaches, it will act more and more as a guard ring, reducing the stray field which it has to compensate ; but as the stray field is reduced and its capacitive impedance therefore increased, so the correct length of the short piece of line approaches more nearly $\lambda/4$. Finally, when the two are brought into contact, separate excitation of the added piece is no longer necessary, the stray capacitance has vanished, its capacitive impedance has become infinite and the correct length of the added piece is that which gives infinite inductive impedance, viz. $\lambda/4$. The correction has not only involved the elimination of the terminating capacitance but also of the open-circuited line, which has been transformed into a short-circuited line with an additional length of $\lambda/4$!

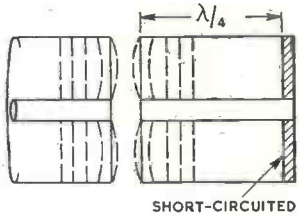


Fig. 1.

We have gone into this relatively simple case in such detail because it throws light on the more difficult problem of the non-reflecting termination of the line. The authors of the Paper referred to above calculated the inductance necessary to compensate for the observed capacitance but do not appear to have realised that this capacitance would be profoundly modified by the application of the correcting piece of line. They made the length of the piece $0.88\lambda/4$ to correspond to an effective shunt reactance for the disc of about 400 ohms (capacitive) and the result showed that the termination was then approximately non-reflecting. Without the added piece of line the disc will certainly modify the stray capacitance, but it has a resistance of 76 ohms and the line is therefore far from being short-circuited. There will be stray electric field between the ends of the conductors and between parts of the disc itself, in fact the authors found that at the shortest wave-length employed the termination was equivalent to 43.7 ohms in parallel with a capacitive reactance of 370 ohms. What we have said above shows, however, that all this is profoundly modified by adding the short-circuited length of line, which acts as a guard ring and suppresses the stray electric field as it is brought near the disc (assuming it to be separately excited as before), so that when it ultimately makes contact with the end of the line the stray capacitance has been reduced to zero and the length of the piece added should therefore be exactly $\lambda/4$, assuming the dielectric to be air. If the disc is backed with any appreciable thickness of dielectric of higher permittivity, the correct length of the short-circuited end piece will be somewhat reduced.

That the length of the added piece of line should be exactly $\lambda/4$ and not somewhat less was emphasised by Dr. Moullin in the discussion on the Paper.

It is interesting to consider the nature of the electromagnetic field of the wave transmitted along the line and arriving at the disc. If in an air-insulated concentric line the air is replaced at any point by a plug of some other dielectric of higher permittivity occupying the whole annular space, the radial character of the electric field is not affected. If the plug, however, only occupies a portion of the annular space, say the inner half, as shown in Fig. 2, then the field will be distorted as shown and the flow of energy will be deflected as shown because there must now be more energy per cubic centimetre in the air around the plug than there would otherwise be. If, however, the plug occupies the whole of the radial space as shown on the right, the field remains radial and the energy flow is not deflected in any way. This point was also mentioned in the discussion by Dr. Moullin. The same is true when the wave meets the resistive disc with the added quarter-wave short-circuited line. The electric field is strictly radial and of the same strength on both sides and throughout the thickness of the disc. The energy travels axially and enters the surface of the disc, the power entering per square centimetre being proportional to the product $\mathcal{E}B$ of the electric and magnetic fields, each of which is inversely proportional to the radius, so that the density of the power is inversely proportional to the square of the radius. The density of the current in the disc is also inversely proportional to the radius and the I^2R loss in each element of the disc therefore inversely proportional to the square of the radius. The power arriving axially at each element is thus dissipated in that element. The radial electric field is unaffected, but the circular magnetic field and therefore also the product $\mathcal{E}B$ decreases linearly to zero in passing through the disc. Hence the magnetic field has its full value on the inner side of the disc and is zero on the outer side, which must obviously be the case if the whole current which flows along the core passes radially through the disc and returns along the outer conductor. On the inner side of

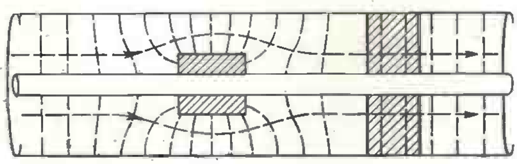


Fig. 2.

the disc one is inside the toroid, whereas on the outer side of the disc one is outside the toroid. This mention of toroid reminds us of another point raised by Dr. Moullin in the discussion, viz., the "truly amazing property" as he called it, that the magnetic field at any point in the cross-section depends only on the current in the core at that cross-section and is independent of what the current may be at other points along the core. The explanation of this is that any change in the current along the core must be associated with radial displacement currents in the dielectric as shown in Fig. 3. The magnetic field at P is just the same as if the maximum current persisted at its maximum value in both directions. In both cases P is sur-

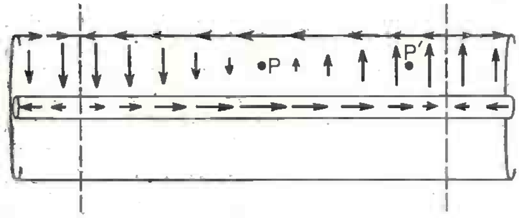


Fig. 3.

rounded by toroidal distributions of current of the same total amount. The shape of the toroid is immaterial. If a unit pole were placed at P and moved round the circle, each line of force radiating from it would cut the same total current but made up of conduction and displacement currents in different amounts. The same is true at P'; the current in the core at that point determines the magnetic field strength at P', for it is equal to that portion of the toroidal current distribution that embraces P'. In Fig. 3 the displacement and conduction currents are not drawn to the same scale; the conduction current at its maximum point must be equal to the total displacement current between this point and the point of zero current. It is thus seen that if one pictures the complete system of currents, both conduction and displacement, there is nothing strange in the fact that the value of H at any point depends on the current at that point.

The experiments of Professor Willis Jackson and Dr. Huxley and the contribution to the discussion by Dr. Moullin constitute a very valuable addition to our knowledge of this subject. They have certainly uprooted some very widely held misconceptions.

G. W. O. H.

EXTREME CLIMATIC CONDITIONS*

A Resumé of Climatic Factors, Their Influence on Radio Equipment and Components, and of Methods of Testing

By Philip R. Coursey, B.Sc., M.I.E.E., F.Inst.P.

TO help in an adequate consideration of the proper testing of radio equipment and components which have to operate under extreme climatic conditions it is necessary, in the first place, to ascertain the nature and extent of those extreme conditions which may be encountered in various localities. In addition thereto there are applications of high altitude operation in aircraft and for Naval uses higher atmospheric pressures in submarines also. Taken together these all imply an extremely wide range of climatic conditions. In addition, in certain parts of the earth's surface there are other factors which, while not strictly of a climatic character, are peculiar to those abnormal climates and as such can, therefore, well be considered at the same time.

The temperature range may run from about $-50°$ C. up to $+40°$ C. to which figures must be added any additional heat in the local enclosure in which the equipment is operating whether that additional heat arises externally to, or internally as part of, the equipment itself. This may raise the actual ambient up to $+100°$ C. Fortunately this additional heating operates at the low temperature end also, so that although the equipment and its parts may be subjected to the lowest temperature when out of use it will usually work up quickly to much above the lowest figure just mentioned. For most practical purposes, therefore, a low temperature limit of about $-30°$ C. suffices to represent the worst operating conditions of the majority of components used in radio equipment. For test purposes a figure of $-40°$ C. would be preferable to provide a margin of safety; but in many instances practical difficulties are encountered in meeting that lower figure. Many of the materials used in radio components to-day cannot withstand the still lower temperatures which may at times be encountered, without risk of serious deterioration.

The humidity in different places may cover the entire range from practically zero up to complete saturation, i.e. 100% relative humidity. At high altitudes in aircraft the air pressure may fall from the normal 760 mm of mercury down to 120 mm or even slightly lower; while for undersea uses it may rise to as much as 1,000 mm of mercury.

Somewhat similar ranges of ambient temperature, pressure and humidity have been recognised in the Inter-Service Specifications for certain radio components published recently by the B.S.I.†

In using the term "Radio Equipment," it is intended to be understood to include all other allied equipment, such as radar, even although it is not strictly used for radio communication purposes, since the majority of it utilises components and materials of exactly similar character to those included in equipment which is strictly intended for radio communication purposes.

Simulating Abnormal Conditions

It should be evident that departures from normal atmospheric conditions in either direction will have some influence upon the performance of the equipment itself, its components and the materials of which it is made. Usually these influences are mainly deteriorative and where two or more abnormal ambient conditions act jointly, a much greater rate of deterioration may occur than would be experienced if they acted independently. This fact imposes difficulties when planning tests for equipment and materials in order to simulate the abnormal operating conditions, since it is obviously impossible to envisage all the combinations of ambient conditions which might occur and it becomes necessary to divide the testing up into sections so as to deal with

* MS. accepted by the Editor, June, 1944.

† The specifications referred to are those in the BS/RC series.

the most deteriorative ambient effects, to some extent, independently of each other; but to do it in such a way as will emphasise the effects of such conditions as regards deterioration of the component or material.

The following five climatic factors can be distinguished, namely :—

Heat, Cold, Moisture, Dryness, Air Pressure and pressure changes. Combinations of these factors alone can produce at least a dozen different types of deterioration of the components and materials as is indicated by the chart, Fig. 1, which shows the main connections between the climatic factors already referred to and the main types of deterioration which can result therefrom. At the bottom of the chart six different forms of failure are indicated which can result from these deteriorations. While at times it may be hard to distinguish the effects of one deterioration from another, or of one ultimate failure from another, at least on theoretical grounds these six types of failure can be distinguished. Generally the nature of a failure that takes place will be fairly evident but it should not be overlooked that any one effect can be complicated by the incidence of another occurring simultaneously, or of another type of deterioration which, while not actually producing failure, has accelerated the ultimate failure which has occurred.

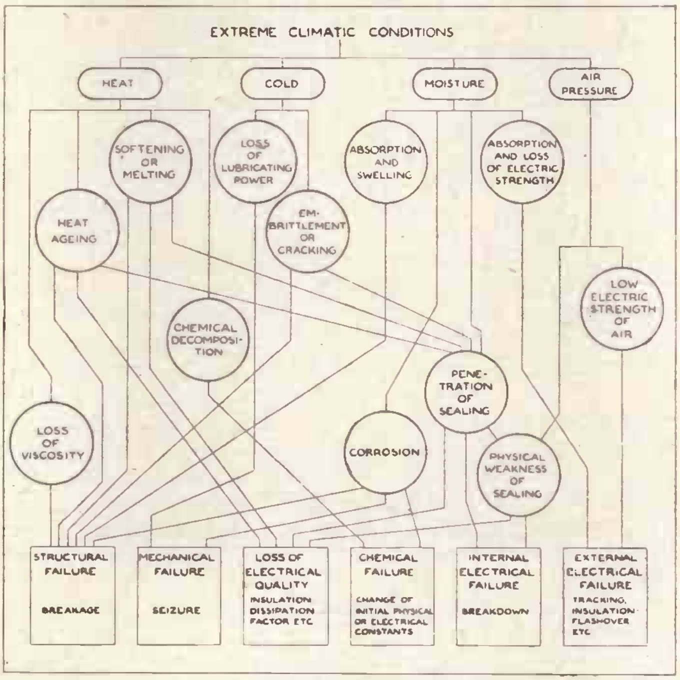


Fig. 1. *Some effects of extreme climatic conditions on radio components.*

Apart from the ambient climatic factors the extraneous factors arising from location and use—at sea, in the air, etc.—can usefully be considered at the same time as the ambient climatic factors, since the ultimate types of failure to which they can give rise are necessarily of the same general nature, although the intermediate phase of the deterioration that takes place may differ. Strong sunlight which has powerful actinic properties, salt carried by sea winds, desert dust, growth of fungus on equipment and its parts, and the ravages of certain types of voracious tropical insects may be mentioned in this connection. These are obviously extraneous influences which cannot act under all the various climatic conditions which are possible, but will be accentuated in their action under certain and frequently limited ranges of the climatic factors in certain locations.

It is possible to distinguish at least twenty-one different forms of deterioration caused by climatic factors or the extraneous influences consequent upon peculiar climatic conditions. These may be classified as follows :—

1. Softening of the material at high temperatures resulting in loss of strength or actual melting of some parts, such for example, as waxes or filling compounds.

2. Heat ageing of materials whereby any given substances loses its mechanical or electrical properties as a consequence of prolonged subjection to high temperatures. This is fundamentally a time effect which determines the useful life of the material when operated under heat conditions which result in the ageing.

3. Loss of viscosity at high temperatures whereby, for example, a liquid may become so thin that it seeps out of what would otherwise be a sealed joint or journal.

4. Embrittlement or cracking of a material at low temperatures. This is a factor which

very seriously limits the low range of temperature to which certain materials can be subjected without damage. It applies to many waxes and sealing compounds and also especially to many of the newer synthetic rubber and rubber-like materials, some of which develop hardness and tendency to crack at moderately low temperatures.

5. Loss of lubricating power of oils at low temperatures whereby seizure or freezing together of moving parts may take place.

6. Increase of viscosity or freezing at low temperatures whereby a fluid filling material becomes solid and thereby causes structural fracture of its container with resultant failure of the component.

7. Lowering of the electric strength of air by reason of reduction of air pressure through operation of equipment at high altitudes which may result in flashover of insulation or of insulators over much longer distances than at normal air pressures.

8. Structural collapse under high atmospheric pressure whereby material and/or electrical failure may occur.

9. Physical weakness of the sealing or of sealing materials used to prevent the ingress of moisture to the interior of components or equipment, resulting in fracture at low or at high pressures due to the pressure difference across the sealing or the pressure difference between the interior of a casing or container, of which the seal forms a part, and the outer air.

10. Penetration of the seal of terminals, etc., or of sealing material which may surround or enclose a given component or article by water or water vapour which may be accelerated very largely by combinations of other climatic conditions, particularly that of high temperature.

11. Corrosion of materials by the action of water vapour which again is much accelerated by the other climatic conditions such as high temperature and by extraneous climatic factors such as salt particles in the air which may deposit salt upon the material or component in question.

12. Absorption of water by materials resulting in their swelling which may destroy their functional utility, their physical strength or their ability to stand up to other factors such as air pressure changes.

13. Absorption of water by insulating materials with consequent deterioration of their electric strength and of their ability to resist surface tracking when subjected to electric stress.

14. Chemical decomposition which may by itself be a time factor if the material is not inherently stable. This action, however, will, with certain materials be much accelerated by heat or may actually take place at higher temperatures when it would not do so at normal ambient temperatures. Such decomposition may produce changes in the physical state of the material or in its initial electrical properties.

15. Dessication of materials and mechanical failure resulting therefrom by reason of extreme dryness of the atmosphere as a result of which water which would normally be held bound in and forming part of the structure of the material becomes dried out.

16. Disintegration by attacks of termites and other voracious insects or animals.

17. Surface deterioration or destruction by the actinic rays of sunlight. This does not affect the majority of materials but has a pronounced influence on certain plastics such, for example, as rubbers and materials made therefrom.

18. Excessive mechanical wear of moving parts resulting from clogging of their movement with dust or sand deposited on them or blown into them, particularly under desert conditions.

19. Clogging up of parts and their general deterioration due to growth of fungus on their surface including electrical short circuits which may be caused by layers of fungus forming across insulating materials or connecting live conductors.

20. Glazed ice formation on surfaces due to the combined action of cold and humid atmosphere resulting in total or partial short circuiting of insulation.

21. Vibration or excessive movements due to wind action which may cause structural failure or fracture of sealing if that is a brittle material such, for example, as some of the waxes. This factor of vibration which may result from violent movements of sea or air may also act as an accelerant to other climatic factors and increase the liability of failure resulting from these factors.

These twenty-one types of deterioration or effects of the climatic and other factors upon materials and components can give rise to the same six different types of failure of the equipment or its components to which reference has already been made. Three of these six are electrical failures, two are structural and mechanical, and one is of a chemical nature. The chart, Fig. 2, is an elaborated form of Fig. 1, showing the connections between this wider range of deteriorations and the various climatic and extraneous factors already listed. The full lines on the chart indicate the direct climatic connections and the chain lines, those which are peculiar to the extraneous factors resulting from location of use rather than from the climate itself. These connections can only be the main ones and it is obvious that in certain circumstances various combinations

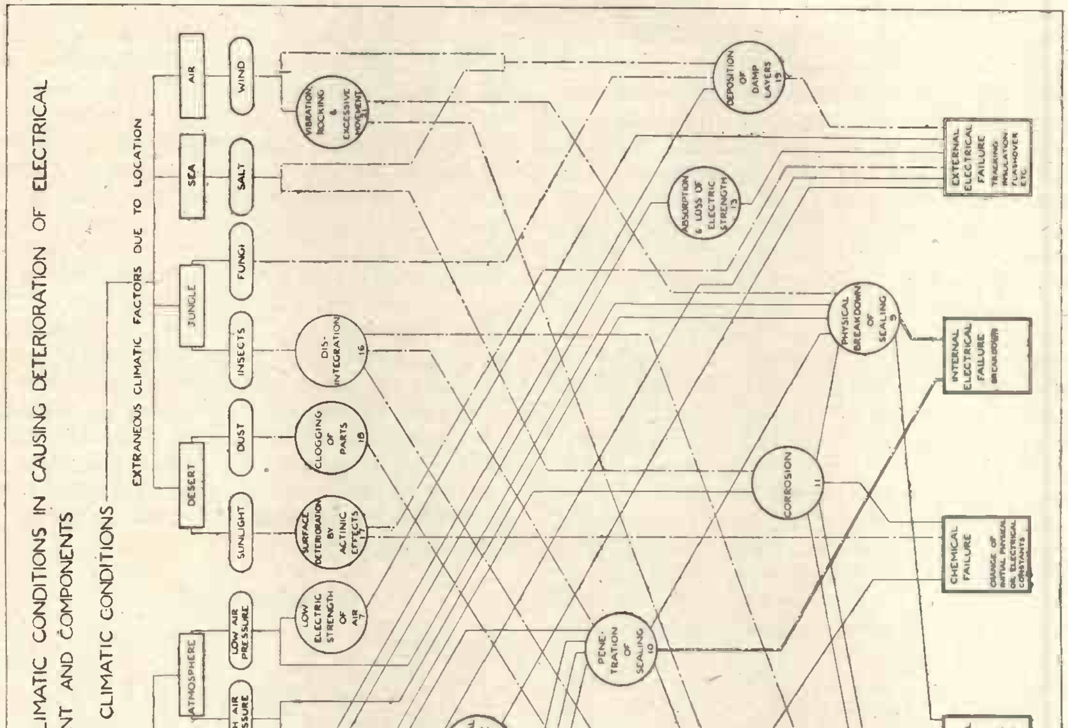


Fig. 2. *Chart illustrating deteriorating effects of direct and indirect climatic factors on electrical components. The chain lines show the connections due to the indirect climatic factors arising from the location of use.*

of climatic factors may give rise to simultaneous deteriorations or may accelerate any particular one of them. For instance, the deterioration effect No. 10 which is marked " Penetration of Sealing," is primarily an effect of water or water vapour. It is, therefore, connected directly to the climatic conditions marked " Moisture," but such penetration can obviously be very much accelerated if cracking of the sealing material has taken place by previous application of low temperature or if the material has been softened or melted by operation at high temperatures. Again the resistance of a sealing material to the ingress of water may gradually become lessened by heat ageing of that material due to prolonged operation at high temperatures. This again is a time factor determining the useful life of the material as a seal to prevent the ingress of moisture. All these factors, are, therefore, shown as connected to deterioration effect No. 10, and it is obvious that while such cross connections are of major importance, there may also be others which will likewise have an accelerating action on the breakdown of the sealing. The extraneous factors such, for example, as fungal growth will usually take place only over very limited ranges of ambient atmospheric factors such as temperature and humidity. With temperatures below 20° C. and above 40° C. this trouble is practically non-existent whatever the humidity may be, but with humid conditions around 30° C. the growth may be very rapid. By itself it cannot produce a direct deterioration of a material or component, but may, nevertheless, result in failure of the complete equipment by clogging up its parts and/or short-circuiting of them by the damp material, resulting in burning or tracking of insulation materials if these are of an organic nature.*

Dust in amounts likely to cause difficulties in the operation of radio equipment is an extraneous factor associated particularly with dry hot desert conditions. In those places, particularly during dust storms, it percolates into almost everything and rapidly accelerates failure of mechanical parts such as bearings. In other respects it is not likely to give rise to any special deterioration. Of the other auxiliary climatic factors shown in the chart, the destructive action of sunlight will be more rapid in dry climates than in the more temperate ones and particularly where the humidity of the atmosphere is low. Salt carried by sea winds, as it may often be over considerable distances, will produce in itself little harm except that it may be a deliquescent material and absorb water from the atmosphere. Under these conditions it will produce rapid corrosion of parts unless they have been well protected against it. Protection against the ravages of termites and the like involves the selection of materials which are less readily attacked, and this may impose a considerable limitation upon the nature of the materials which can be permitted for the outside enclosures of equipment. High winds in themselves are not likely to produce any direct deterioration of radio equipment but as they may give rise to violent sea or air movements, the equipment when carried in craft operating under those conditions is likely to be subjected to rapid changes of movement which tend to cause structural failure and thereby to accelerate the action of other climatic deteriorating factors.

Combined Tests

In order to cover all these factors and effects in a completely adequate manner would obviously entail a very wide range of tests, and their design and application to Service equipment becomes of prime importance since such equipment is naturally expected to have a high level of reliability even when operated under very abnormal climatic conditions. Even with a wide range of tests, however, it is impossible to be certain of covering all the wide ranges of conditions or even of all the single effects without involving such a prolonged series of tests as would render it impossible either to type-approve or to sample in production. Such tests as can be applied must, therefore, be designed not only to imitate the operating conditions in service—since as such they would then merely be life tests—but must combine therewith some form of acceleration of the testing conditions and effects whereby some indication at least can be obtained in a reasonably short time of what is likely to be the performance of equipment or a component over a much longer period of use. The extent of such acceleration depends upon two factors, namely, the time it is practicable to employ in carrying out type testing or sampling

* To assist in overcoming this defect recourse may be had to fungicides incorporated in lacquer or other coatings applied to the parts. Certain mercury salts have been claimed to be most effective.

testing and the duration of life which is expected for the equipment. For many uses of Service equipment this may be a much shorter one, although in more severe conditions, than would normally be anticipated for the majority of industrial uses. This implies that in some instances at least some components can be operated under more stringent conditions than would generally be considered good commercial practice, but such overloading must not be done indiscriminately or failure will quickly result. Furthermore, the design of the equipment and its parts and the nature of the material used in them must be such that they will withstand storage (frequently under difficult climatic conditions) without serious deterioration and still give a sufficient length of useful life at the end of some indefinite storage period. It is useful, therefore, at times to consider conditions of storage quite apart from conditions of use. Under storage conditions electrical components, for instance, will not normally be subjected to electrical stresses in addition to the climatic actions, but in service both will frequently be superimposed one upon the other and will, therefore, give rise to a more rapid deterioration or shorter life of the article in use than will occur in storage.

The simple testing of materials to withstand a given temperature range without direct mechanical or even electrical failure is a relatively simple matter, as also is the testing of materials or equipment under a range of air pressures; since the direct effects likely to be encountered are of a relatively simple nature. This does not imply, however, that the question of fatigue, such as is indicated by " heat ageing " on the chart, must not be overlooked, but normal testing for fatigue can never be done in the course of short type-approval and sampling testing, and cannot be made the subject of acceptance tests applicable to all equipment.

Accelerated Testing

Various forms of accelerated testing to represent tropical conditions were unified in the W.T. Board Specification No. K110. This specification was modified in 1942 to incorporate more specific description of the testing methods in order to render the results of such tests more consistent and reliable. Since that modification the number and extent of humidity tests that have been carried out on components and materials have increased vastly and a much greater amount of attention has been given to the subject generally. Quite recently it has been suggested that it requires still further modification, particularly to meet the higher temperature conditions which have been already indicated and which are not covered by the existing form of the specification, which has a maximum dry heat temperature of 71° C. and humidity conditions at 60° C. It has widely been said that the specification of two cycles of humidity even when a cold cycle is included between them is too short a test to give any reliable indication of the performance of present-day equipment. In addition thereto an increase in the temperature of the dry heat cycles is necessary for components which have to operate at higher temperatures than 71° C.

In practice at the present time three categories of components are recognised, namely, those which would operate up to 71° C., those which can be used up to 85° C., and the much smaller number of very special ones which can be used up to 100° C. It is generally felt that since testing at a relative humidity of over 95% at 60° C., as called for in the present specification, represents much worse conditions than can occur anywhere in practice that this type of humidity cycle is quite adequate to apply to any component provided that it is interleaved with an adequate number of tests for the maximum temperature at which the component is to work. The cycle of testing should, therefore, include both the highest temperature, the lowest temperature and a humidity cycle, and this complete cycle of three parts needs to be repeated at least ten or perhaps twenty times in order to give a useful test of present-day components and materials.

The utility of this type of test is judged from the viewpoint that if any test or test method is to give really informative data about any component or material the test must be of such a character that an appreciable number of specimens in the sample from each batch fail under the test (if it is of the go—no-go type) or if the test is a measurement one a determinable amount of deterioration must be measurable. If the test is of such a nature or degree of severity that all the specimens in a sample pass it easily without any measurable change in electrical or physical characteristics, it can be of value only if ample large scale and long time correlation exists between the actual operating conditions for the equipment or parts and the test results. Unless the design of any particular equipment has been stabilised without changes over many years, such conditions of working are not possible. In practice, therefore, such correlation is never likely to be adequate, and in these circumstances if there is no measurable change in properties during the test no information whatever is provided by that test as to whether the particular components or materials are just passing the test requirements or whether there is an ample margin of safety. On the other hand, when the test is of such a nature or degree of severity that it permits a measurable deterioration or proportion of failures to occur during it, it gives a true gauge whereby one batch of articles can be compared with another, or the products of different manufacturers can similarly be compared. With any reasonably efficient sealing of components or equipment against ingress of moisture, the present K110 specification, with two humidity cycles only, is inadequate to differentiate properly in the manner just indicated or to give any useful data concerning the maintenance of quality of the product during manufacture of successive batches.

To overcome this defect a prolongation of the humidity test cycles of the K110 type, continuing them for at least ten or perhaps twenty cycles of humidity, has been suggested, but this alone with only one initial heat cycle, and when required a cold one also, is still an inadequate form of test for all the higher temperature categories of components, namely, those intended to be able to work up to 85° C. or 100° C. One method of overcoming this defect is to combine the higher temperature of the first heat cycle with each of the subsequent humidity cycles. If this is done while maintaining a relative humidity of 95–100% the test becomes vastly more severe, since the flow of water vapour through the pores or channels existent in all sealing materials is a much more rapid one when no air is present, that is to say, when the humidity reaches saturation at approximately 100° C. Since saturation at 40° C. represents the most severe practical working conditions, there is no absolute necessity to make this humidity cycle with any higher water vapour pressure. To make a test under these conditions, however, implies that the apparatus must include also some reliable method of controlling humidity in the test enclosure to a defined figure which is below 100%, depending upon the actual temperature of operation. This introduces an additional complication into the apparatus which can easily be overcome only by hermetically sealing it and controlling the atmospheric conditions inside by means of certain salt solutions. From a practical point of view, where relatively unskilled labour is involved in executing tests of this character there are disadvantages in such a method and an alternative type of test in which the existing conditions of the K110 specification (viz. saturation at 60° C.) are retained with repeated interleaved cycles of the higher working temperature, has much to commend it from the point of view of simplicity of execution. A further advantage of a test of this character is that most manufacturers already possess a considerable amount of information upon the performance of their materials and products under repeated cycles of humidity at 60° C. corresponding with the present K110 specification.

The most useful possible alternative types of test which can be carried out are set out in graphical form in Fig. 3 at the top part of which is given also the existing forms in which humidity tests are already being carried out. In part (E) of this diagram is introduced the repetitive form of heat (and cold if required) test combined with humidity cycles. Each portion can be part of a twenty-four hour period. As an alternative, in part (F) is shown a somewhat shortened form which can be executed as long as a time switch control of the temperatures in the testing cabinets can be provided, since it combines the heat (and/or cold) portion of each cycle with a humid portion in the same twenty-four hour period.

Reviewing all the factors concerning these types of test the form indicated in part (F) of Fig. 3 has much in its favour and a normal repetition of fifteen or twenty complete cycles of humidity suffices for ordinary uses but the duration can be extended where necessary to give more complete information as to the performance of, and ultimate failure time of, any given material or component.

In the sections (E) and (F) in Fig. 3, an alternative cold cycle has been shown, by dotted lines, in place of alternate heat cycles. As has already been indicated the interposition of a cold cycle during the test does provide an additional degree of severity since it opens other possibilities of deterioration but where a given equipment or component is not required to work under extreme cold conditions it is obvious that this part of the test can with advantage be omitted. Wherever the equipment may be used in aircraft or under arctic conditions, however, it should be included and from the point of view of uniformity of results it is preferable that it should be interposed at each alternate cycle if at all possible as is already indicated in part (F) of Fig. 3.

In general far more consideration has been given both by manufacturers and users of radio components to the execution of tests under humidity conditions than to tests relating to any of the other factors detailed in Fig. 2. Partly this is because these methods are more open to variation both as regards the way in which they are carried out and also as regards the interpretation which is placed upon the test measurements obtained; partly because of the existence of inadequate correlation data between operational results on the equipment or components and test results made under laboratory conditions — due mainly to insufficient time of use and test; and partly because moisture penetration through the sealing of electrical components has almost certainly been the most common

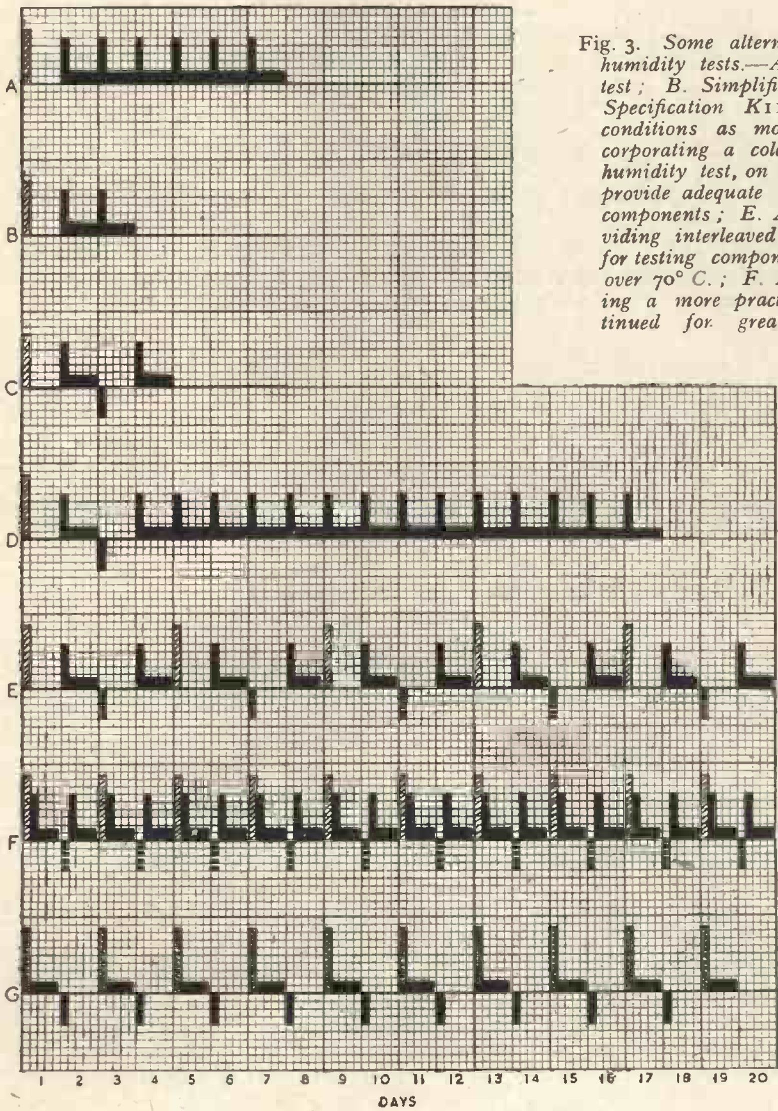


Fig. 3. *Some alternative forms of heat-cold and humidity tests.—A. Original type of humidity test; B. Simplified test as incorporated in Specification K110; C. K110 humidity test conditions as modified for aircraft uses, incorporating a cold cycle; D. Long duration humidity test, on lines of K110 conditions, to provide adequate sealing test for good quality components; E. Alternative form of (D) providing interleaved heat and wet cycles suitable for testing components for use at temperatures over 70° C.; F. Modified form of (E) providing a more practical test which can be continued for greater number of cycles as desired, without unduly lengthening test period; and G. Alternative long period test for high temperature components, combining the humidity and dry heat cycles into a test cycle at full temperature but reduced humidity.*

Hatched rectangles represent dry heat.

Cross-hatched rectangles represent heat plus less than 100 per cent. R.H.

Solid rectangles above base line represent full humidity.

Solid rectangles below base line represent cold cycle, which may be accompanied by iceing.

Dotted rectangles below base line represent optional cold cycles, which may alternatively be replaced by dry heat cycles, if cold test is not required.

Ordinates represent temperature of test chamber, omitting gradual changes during heating and cooling periods.

cause of the (comparatively few) failures that have occurred in service.

Apart from these humidity conditions, tests to simulate the effects of the other climatic factors do not present undue difficulties either in execution or in their interpretation. Temperature (and testing at both high and low temperatures) has already been mentioned ; atmospheric pressure tests both at increased and at lower than normal pressures are easy of execution. They do not involve any time-deterioration defects (such as do the humidity and heat ageing tests) except as regards, for example, any slow leakage that might occur equalising a pressure difference through a sealing construction or medium.

A time factor is, however, involved in determining the resistance of a material to the deteriorating action of sunlight. Tests of this effect may be carried out by exposing the material to ultra-violet rays augmenting this if desired by infra-red heating for a prolonged period. Resistance to the effects of salt may be determined in some instances by immersing the material in salt water or more generally by subjecting it to a salt spray and measuring the mechanical or electrical deterioration, or examining whether corrosion occurs in a given time of exposure. Resistance to the growth of fungus in or on materials used in radio equipment may be increased by coating or impregnating them with suitable fungicides and the efficiency of this treatment can be tested by exposure to the combination of dampness and warmth already mentioned as favourable to fungal growth.

The development and use of the appropriate tests of the general character outlined in this article has already done much towards improving the general quality of the materials and components chosen for the construction of radio and allied equipment. This has augmented the overall reliability of such apparatus but adequate inspection testing of batch sampling of production as it proceeds is essential to the maintenance of this quality. Whether much further progress is possible or even necessary is open to debate. From the point of view of cost it probably is not, but considerations of economy weigh much less in Service uses of equipment in wartime than they do in normal peace-time requirements.

CYLINDRICAL CAVITY RESONATORS*

By C. F. Davidson and J. C. Simmonds

Introduction

GENERALLY speaking, the resonance frequency and the selectivity are the most important of the quantities associated with a resonator, and this is true of cavity resonators. The " Q " of a cavity resonator, which is a measure of the selectivity, is usually found from a consideration of the field components inside the resonator. In certain cases, however, this parameter can be derived from transmission line theory quite simply, and it is instructive to derive it in this way as it leads to some correlation between the familiar ideas of transmission lines and lumped circuits and the seemingly new ideas required in waveguide technique. The analysis of this problem by transmission-line methods makes use of the impedance concept, which is being applied to waveguide problems to an increasing extent.† The M.K.S. system of units is used throughout this paper.

The Input Impedance of a length of Wave-Guide, terminated at one end by a Conductor.

Consider first the length of guide shown

* MS. accepted by the Editor, May, 1944.

† See " Electro-magnetic Waves," by S. A. Schelkunoff (Van Nostrand). Reference may be made to this work for the derivation of formulae quoted in this paper without proof.

in Fig. 1. Any cross-section capable of supporting the required type of wave is assumed, and it is desired to determine the input impedance Z_i. Now the arrangement shown in the figure consists of two lengths of similar section guide—one air-filled (or possibly with some other dielectric) and the other filled with the material of the conductor.

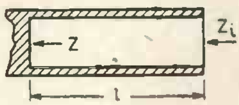


Fig. 1.

The wave impedance, for any type of wave, of the conductor-filled guide is equal to the intrinsic impedance of the conductor, which has equal resistive and reactive components at frequencies under consideration (cm. wavelengths) given by :—

$$Z_{wc} = R + jX = \boldsymbol{R}(1 + j) \quad \ldots \quad (1)$$

where $\boldsymbol{R}$ is the surface resistivity of the conductor. Since the attenuation in a conductor is extremely great this section of guide can be considered as infinitely long in the electrical sense, that is, no reflection from the far-end will return to the near-end, even though the actual thickness of the conductor may be quite small. The input impedance of the conductor-filled guide will therefore be equal to the characteristic impedance of the guide. This latter quantity is not in general unique, but in this particular problem any ambiguity can be avoided by considering only wave impedances ; this is permissible because there are no changes of section in the systems under investigation. Thus the arrangement shown in Fig. 1 can be represented by an air-filled section of guide terminated in an impedance Z, say, where :—

$$Z = \boldsymbol{R}(1 + j) \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Let the wave impedance of the air-filled guide be Z_{w0}. At frequencies above the cut-off frequency of the guide the wave impedance is a pure resistance R_{w0}*. In this particular problem the wave impedance is to be taken in place of the characteristic impedance of ordinary transmission theory, so that :—

$$Z_0 = R_{w0} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

From the transmission-line theory, it now follows that :—

$$Z_i = Z_0 \cdot \frac{Z + Z_0 \tanh \gamma l}{Z_0 + Z \tanh \gamma l} \quad \ldots \quad (4)$$

where $\gamma = (\alpha + j\beta)$, and is the propagation constant of the wave in the guide. Since αl is small,

$$\tanh \gamma l = \frac{\alpha l + j \tan \beta l}{1 + j\alpha l \tan \beta l} \quad \ldots \quad \ldots \quad (5)$$

Now put :

$$\beta l = n\pi + \Delta \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

where Δ is small, that is to say, let the air-filled guide be very nearly a multiple of half-wavelengths long. Equation (5) can then be simplified to :—

$$\tanh \gamma l = \alpha l + j\Delta \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

Substituting from equations (2), (3) and (7) in equation (4) gives :—

$$Z_i = R_{w0}\alpha l + \boldsymbol{R} + j(R_{w0}\Delta + \boldsymbol{R}) \quad (8)$$

Thus for small values of Δ the input impedance Z_i is the same as that of the lumped impedance shown to the right of the terminals TT in Fig. 2.

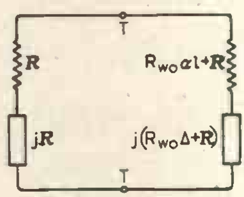


Fig. 2.

Conditions in a Closed Cavity

If now the cavity is closed by a metal plate the input impedance looking into the plate will be given by equation (2). Therefore the termination at the end can be represented by an impedance as shown to the left of TT in Fig. 2. It follows that the closed resonator as viewed from one end can be represented, so long as Δ is small, by the equivalent lumped circuit shown in Fig. 2. The resonance condition is obviously :—

$$\boldsymbol{R} = -(R_{w0}\Delta + \boldsymbol{R}) \quad \ldots \quad \ldots \quad (9)$$

---

* Actually, since attenuation is to be assumed in the guide, there will be a small reactive component associated with R_{w0} in Z_{w0}. However, from equation (8) it may be seen that it is justifiable to neglect this reactive component.

whence

$$\Delta = -\frac{2\boldsymbol{R}}{R_{w0}} \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

The Determination of the "Q" of the Cavity

To obtain the "Q" of the resonator the change δf in the operating frequency f necessary to make the impedance of the equivalent circuit equal to $\sqrt{2}$ times the impedance at resonance is calculated. Let the change in R_{w0}, $\boldsymbol{R}$, α and β be δR_{w0}, $\delta\boldsymbol{R}$, $\delta\alpha$ and $\delta\beta$ respectively, corresponding to the

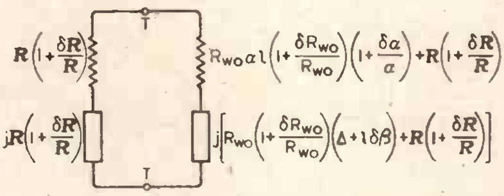


Fig. 3.

change δf in f. It can be shown that the fractional change in these quantities is comparable with the fractional change in f for all sections of guide and field modes.

The total change in βl will be $\delta\beta l$, so that Δ will in effect be increased by an amount $\delta\beta l$. Fig. 3 shows the equivalent lumped circuit with resistance

$$2\boldsymbol{R}\left(1+\frac{\delta\boldsymbol{R}}{\boldsymbol{R}}\right)+\boldsymbol{R}_{w0}\alpha l\left(1+\frac{\delta R_{w0}}{R_{w0}}\right)\left(1+\frac{\delta\alpha}{\alpha}\right)$$

Since the fractional change in $\boldsymbol{R}$, R_{w0} and α will be extremely small it follows that the resistance is given sufficiently accurately by the expression :—

$$2\boldsymbol{R} + R_{w0}\alpha l$$

which is equal to the resistance at resonance.

Similarly, the reactance of the circuit is seen to be :—

$$2\boldsymbol{R}\left(1+\frac{\delta\boldsymbol{R}}{\boldsymbol{R}}\right)+R_{w0}\left(1+\frac{\delta R_{w0}}{R_{w0}}\right)\left(\Delta+l\delta\beta\right)$$

which on substituting for Δ from equation (10) becomes :—

$$R_{w0}\left(1+\frac{\delta R_{w0}}{R_{w0}}\right)l\delta\beta+2\boldsymbol{R}\left(\frac{\delta\boldsymbol{R}}{\boldsymbol{R}}-\frac{\delta R_{w0}}{R_{w0}}\right)$$

and this approximates to :—

$$R_{w0}l\delta\beta+2\boldsymbol{R}\left(\frac{\delta\boldsymbol{R}}{\boldsymbol{R}}-\frac{\delta R_{w0}}{R_{w0}}\right).$$

It is not obvious that the second term of the last expression is negligible. If, however, the equation is written in the form :—

$$R_{w0}\beta l\frac{\delta\beta}{\beta}+2\boldsymbol{R}\left(\frac{\delta\boldsymbol{R}}{\boldsymbol{R}}-\frac{\delta R_{w0}}{R_{w0}}\right)$$

and it is remembered that βl is large since the resonator will be one or more half-wavelengths long, then it follows that the second term may be neglected since R_{w0} will normally be very large compared with $\boldsymbol{R}$. Hence the change in reactance is simply :—

$$R_{w0}l\delta\beta\,.$$

This change in reactance must clearly equal the resistance at resonance. $\delta\beta$ is therefore determined by the equation :—

$$R_{w0}l\delta\beta = R_{w0}\alpha l + 2\boldsymbol{R} \quad \ldots \quad \ldots \quad (11)$$

or

$$l\delta\beta = \alpha l + 2\frac{\boldsymbol{R}}{R_{w0}} \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

Now in any section guide the phase constant is given by :—

$$\beta = \frac{\omega}{v}\left[1-\left(\frac{f_0}{f}\right)^2\right]^{\frac{1}{2}} \quad \ldots \quad \ldots \quad (13)$$

where v is the velocity of phase propagation in unbounded space and f_0 is the cut-off frequency of the guide, i.e., the frequency below which free propagation is impossible. From equation (13) it is seen that :—

$$\delta\beta = \frac{2\pi\delta f}{v(1-\nu^2)^{\frac{1}{2}}} \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

where $\nu = f_0/f$.

Therefore,

$$\delta f = \frac{\left(\alpha l + 2\dfrac{\boldsymbol{R}}{R_{w0}}\right)}{2\pi l} \times v(1-\nu^2)^{\frac{1}{2}} \quad \ldots \quad (15)$$

and

$$Q = \frac{f}{2\delta f} = \frac{\omega l\sqrt{\epsilon\mu}}{2\times\left(\alpha l + 2\dfrac{\boldsymbol{R}}{R_{w0}}\right)\times(1-\nu^2)^{\frac{1}{2}}} \quad \ldots \quad \ldots \quad (16)$$

since $v = 1/\sqrt{\epsilon\mu}$, ϵ and μ being the permittivity and permeability of air, the dielectric in the cavity, respectively.

It is possible, in certain circumstances, to excite a resonator in such a way that the field components do not vary along the length of the cavity. Equation (16) will not apply, of course, to such a condition because a field variation along the length of the cavity was implied at the outset of the analysis. Apart from this, however, it is quite general, and can be made to agree with expressions obtained by other methods for special cross-sections, as demonstrated below.

Although no reference has been made to the field equations, they are necessary in the calculation of α, but α may, of course, be obtained by measurement. In fact, equation (16) suggests a possible method of measuring α—it is perhaps relevant to point out that calculated values of α at cm. wavelengths do not agree closely with experimental values.

The result given in equation (16) will now be applied to several specific cavities.

Coaxial Resonator (Principal Mode)

In a coaxial transmission line the cut-off frequency for the principal mode is zero, thus $f_0 = 0$. Further, the wave impedance is simply $\sqrt{\frac{\mu}{\epsilon}}$ and it is not difficult to show that α is given by :—

$$\alpha = \frac{R}{4\pi Z_0}\left(\frac{1}{a}+\frac{1}{b}\right) \quad \ldots \quad \ldots \quad (17)$$

where $Z_0 = \frac{1}{2\pi}\sqrt{\frac{\mu}{\epsilon}}\log\frac{b}{a}$ and is the characteristic impedance of the line and "a" and "b" are the inner and outer radii respectively. In equation (17) it is assumed that the material of the two conductors is identical and that there is no dielectric loss. Thus, from equation (16), for a cavity 'p' half wavelengths long

$$Q = \frac{4\pi^2 Z_0}{R\left[\left(\frac{1}{a}+\frac{1}{b}\right)\lambda + \frac{8}{p}\log\frac{b}{a}\right]} \quad \ldots \quad (18)$$

Circular Section Resonator

In this type of resonator it is necessary to distinguish between transverse electric and tranverse magnetic modes. Consider first any transverse magnetic mode. Here :

$$\alpha = \frac{R}{a}\sqrt{\frac{\epsilon}{\mu}}\left(1-\nu^2\right)^{-\frac{1}{2}} \quad \ldots \quad \ldots \quad (19)$$

$$Z_{w0} = \sqrt{\frac{\epsilon}{\mu}}\left(1-\nu^2\right)^{\frac{1}{2}} \quad \ldots \quad \ldots \quad (20)$$

where a is the radius of the section and the value of ν is taken according to the mode of operation. Substituting equations (19) and (20) in equation (16) results in :—

$$Q = \frac{\omega a \mu}{2R\left(1+\frac{2a}{l}\right)} \quad \ldots \quad \ldots \quad \ldots \quad (21)$$

Thus the "Q" is independent of the mode of transmission but not independent of the length of the resonator. As previously stated, this expression does not apply to the case where the field does not vary along the length of the cavity.

Now consider transverse electric modes. Here,

$$\alpha = \frac{R}{a}\sqrt{\frac{\epsilon}{\mu}}\left(\frac{n^2}{k^2-n^2}+\nu^2\right)\left(1-\nu^2\right)^{-\frac{1}{2}} \quad \ldots \quad \ldots \quad (22)$$

and

$$R_{w0} = \sqrt{\frac{\mu}{\epsilon}}\left(1-\nu^2\right)^{-\frac{1}{2}} \quad \ldots \quad \ldots \quad (23)$$

where n is an integer depending upon the mode of the field in the cavity and k is a real number again depending upon the mode. Further,

$$(1-\nu^2)^{\frac{1}{2}} = \lambda/\lambda_t \quad \ldots \quad \ldots \quad \ldots \quad (24)$$

where λ is the wavelength in unbounded space corresponding to f, and λ_t is the wavelength in the guide corresponding to f. If p is the number of half wavelengths along the length of the cavity, then

$$p = \frac{2l}{\lambda_t} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (25)$$

Also, it can be shown that :

$$\lambda_0 = \frac{2\pi a}{k} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (26)$$

λ_0 being the wavelength in unbounded space corresponding to f_0, and that :—

$$\frac{1}{\lambda_t^2} = \frac{1}{\lambda^2} - \frac{1}{\lambda_0^2} \quad \ldots \quad \ldots \quad \ldots \quad (27)$$

whence,

$$(1-\nu^2) = \frac{\pi^2 a^2 p^2}{\pi^2 a^2 p^2 + k^2 l^2} \quad \ldots \quad \ldots \quad (28)$$

From equations (16), (22), (23) and (28) it then follows that :—

$$Q = \frac{\omega a \mu (k^2-n^2)(\pi^2 a^2 p^2 + k^2 l^2)}{2R[\pi^2 n^2 p^2 a^2 + k^4 l^2 + 2\pi^2 a^3 l^{-1} p^2 (k^2-n^2)]} \quad \ldots \quad \ldots \quad (29)$$

Rectangular Section Resonators

Let a rectangular section guide be formed by conducting planes at $x = 0$, $x = a$, $y = 0$ and $y = b$. If the guide is now closed by conducting planes at, say, $z = 0$ and $z = l$ a cavity resonator is obtained. As before, let the cavity be 'p' half wavelengths long, that is

$$p = \frac{2l}{\lambda_t}$$

where λ_t is the wavelength in the guide. For the transverse magnetic mode,

$$\alpha = \frac{2R}{b}\sqrt{\frac{\epsilon}{\mu}}\frac{b^3m^2 + a^3n^2}{b^2am^2 + a^3n^2}\left(1 - \nu^2\right)^{-\frac{1}{2}} \quad \ldots \quad \ldots \quad (30)$$

and

$$Z_{w0} = \sqrt{\frac{\mu}{\epsilon}}\left(1 - \nu^2\right)^{\frac{1}{2}} \quad \ldots \quad \ldots \quad (31)$$

where m and n are dependent on the mode of the field, and are related to λ_0 according to the equation

$$\lambda_0 = 2\left[\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2\right]^{-\frac{1}{2}} \quad \ldots \quad \ldots \quad (32)$$

Substituting equations (30) and (31) in equation (16) results in :—

$$Q = \frac{\omega l \mu}{4R\left[1 + \frac{b^3m^2 + a^3n^2}{ab^3m^2 + a^3bn^2}\right]} \quad \ldots \quad (33)$$

In the case of the transverse electric mode

$$\alpha = \frac{2}{b}R\sqrt{\frac{\epsilon}{\mu}}\left[\left(\frac{b^2m^2 + abn^2}{b^2m^2 + a^2n^2}\right)\left(1 - \nu^2\right)^{\frac{1}{2}} + \left(\frac{a + b}{a}\right)\nu^2\left(1 - \nu^2\right)^{-\frac{1}{2}}\right] \quad \ldots \quad (34)$$

and

$$Z_{w0} = \sqrt{\frac{\mu}{\epsilon}}\left(1 - \nu^2\right)^{-\frac{1}{2}} \quad \ldots \quad \ldots \quad (35)$$

where m and n are integers other than zero, again dependent on the mode and related to λ_0 according to equation (32).

Equations (24) and (27) are applicable to rectangular guides and with the aid of equation (32) it is seen that

$$\nu^2 = \frac{l^2(b^2m^2 + a^2n^2)}{l^2(b^2m^2 + a^2n^2) + a^2b^2p^2} \quad \ldots \quad (36)$$

$$1 - \nu^2 = \frac{a^2b^2p^2}{l^2(b^2m^2 + a^2n^2) + a^2b^2p^2} \quad (37)$$

From equations (16) and (34) to (37) it readily follows that :—

$$Q = \frac{\omega lab\mu(b^2m^2 + a^2n^2)\,[l^2(b^2m^2 + a^2n^2) + a^2b^2p^2]}{4R\{a^3b^3p^2[l(bm^2 + an^2) + (b^2m^2 + a^2n^2)] + (a + b)l^3(b^2m^2 + a^2n^2)^2\}} \quad \ldots \quad (38)$$

For a field mode where $n = 0$,

$$\alpha = \frac{R}{b}\sqrt{\frac{\epsilon}{\mu}}\left[\left(1 - \nu^2\right)^{\frac{1}{2}} + \left(\frac{a + 2b}{a}\right)\nu^2\left(1 - \nu^2\right)^{-\frac{1}{2}}\right] \quad \ldots \quad (39)$$

$$\nu^2 = \frac{l^2b^2m^2}{l^2b^2m^2 + a^2b^2p^2} \quad \ldots \quad \ldots \quad (40)$$

and

$$1 - \nu^2 = \frac{a^2b^2p^2}{l^2b^2m^2 + a^2b^2p^2} \quad \ldots \quad (41)$$

Equations (16), (35) and (39) to (41) now give

$$Q = \frac{\omega lab\mu(l^2b^2m^2 + a^2b^2p^2)}{2R[a^3b^2lp^2 + 2a^3b^3p^2 + (a + 2b)l^3b^2m^2]} \quad \ldots \quad \ldots \quad (42)$$

In the case of a field mode where $m = 0$, m is replaced by n and the a and b are interchanged in equations (39) to (42).

Conclusions

A general expression for the "Q" of a cavity resonator has been derived by analysis based simply on transmission line theory. The expression involves the attenuation of a wave-guide of the same cross-section when operating in the same transmission mode, the surface resistance of the material of the cavity and other quantities which are functions of the dimensions of the cavity and the operating frequency. For the expression to be of practical use the attenuation must be known and if this is to be calculated resort must be made to the field equations. If, however, the attenuation is determined experimentally then the expression is of immediate value—the attenuation of a wave-guide could, perhaps, be calculated from the measured "Q" of a resonator. In any case, the analysis is thought to be sufficiently instructive to justify its publication.

Certain special cross-sections of cavity have been considered and the "Q" derived from the general expression; the formulae obtained in this way agree with formulae derived from a consideration of the field within the cavity.

THREE-POINT TRACKING IN SUPER-HETERODYNES—II *

By Kurt Fränz

(Communication from Telefunken G.m.b.H.)

SUMMARY.—This is an addition to a previous paper (1) in which a systematic procedure was described for the design of three-point tracking circuits with error curves of the type shown in Fig. 1; in these curves the maximum errors—of which two occur at the end of the frequency range used and two within it—are of equal magnitude. Curves are now given which permit a convenient determination of the tracking error and of the constants of the usual pair of tracking circuits shown in Fig. 2 for ranges of high-frequency variation v_h and oscillator frequency variation v_0 (i.e. ratios of maximum to minimum frequency) of $1.2 \leq v_h \leq 3.8$ and $1 \leq v_0 \leq v_h$. This covers practically all receivers in which the oscillator frequency ω_o lies above the resonant frequency of the H.F. circuit ($\omega_0 > \omega_h$). These curves are also used for the calculation of three-point tracking circuits which differ from those shown in Fig. 2, e.g. for the circuits of Fig. 3, which contain redundant trimmers (i.e. more trimmers than necessary for three-point tracking, which give, nevertheless, zero tracking error at three points only) and for the circuits of Fig. 4 which do not contain superfluous trimmers. If the usual circuits according to Fig. 2 lead to possible, but inconvenient values for the trimmers, alternative possibilities are offered by the circuits of Fig. 3 and their variations. These might be used, for instance, if the circuits of Fig. 2 make it difficult to obtain temperature compensation. Additional stray capacitances introduced by switches may also make it necessary to base the calculations on a more complicated circuit pair. Finally, an appendix is added dealing with the limiting case $v_0 = 1$, which it was not possible to include in the charts in the previous paper.

Procedure for the Calculation of the Tracking Error and of the Padding Condensers for Three-point Tracking

A THREE-POINT tracking circuit is designed for optimum performance if the maximum detuning of the H.F. circuit $Y = 2\Delta\omega/\omega$ has been brought down to its minimum value; the maximum tracking error is then reached—with alternating sign—four times. An example of such an error curve is given in Fig. 1, which represents the tracking error over the medium wave band of a broadcast superhet. All circuits calculated according to the following formulae possess this optimum quality. The principle of the method of calculation had been explained in the previous paper; however, only part of the auxiliary calculations were given which are required if the remaining calculations are to be carried out with sufficient accuracy by the aid of a slide rule.

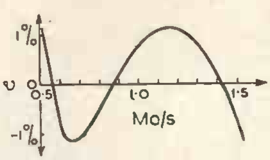


Fig. 1. *Example of the tracking curve for the medium-wave range of a broadcast superhet. Abscissa: frequency of reception; Ordinate: detuning. The nominal limiting frequencies are 1530 and 510 kc/s., and the intermediate frequency is 468 kc/s.*

We repeat, therefore, here the explanation of the method of calculation, and give detailed charts for the design of the most commonly employed circuits of Fig. 2.

The error for three-point tracking according to the circuits of Figs. 2–4 can be taken from the chart of Fig. 5. The abscissae of this chart are the required H.F. variations

$$v_h = \frac{\omega_{ha}}{\omega_{he}} = \frac{\text{upper frequency limit}}{\text{lower frequency limit}} > 1$$

The ordinates are the oscillator variations

$$v_0 = \frac{\omega_{0a}}{\omega_{0e}}$$

The curves drawn in full lines are curves of constant maximum detuning

$$Y = \frac{2\Delta\omega}{\omega_h}$$

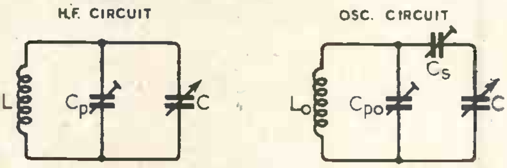


Fig. 2. *The circuit pair most commonly used for three-point tracking.*

* Translated from the original article "Design Calculations of the Three-Point Balance-Circuit for the Tracking in Superheterodyne Receivers," in *Hochf:tech. u. Elek:akus.*, Aug. 1943, Vol. 62, p. 44.

of the H.F. circuits. The region between the dotted curves

$$2v_0 = v_h + 1 \text{ and } v_0 = v_h(2 - v_0)$$

are scarcely of practical interest as they refer to cases where the intermediate frequency falls within the operating range of the receiver.

The trimmers of the circuits of Fig. 2 are calculated according to the following formulae in which C_a and C_e denote the minimum and maximum capacity of the tuning condenser.

$$C_p = \frac{C_e - v_h^2(1 + 2|Y|)C_a}{v_h^2(1 + 2|Y|) - 1} \quad \ldots \quad (1)$$

$$L = \frac{1 + |Y|}{\omega_{he}^2(C_e + C_p)} \quad \ldots \quad \ldots \quad (2)$$

For the calculation of the series con-

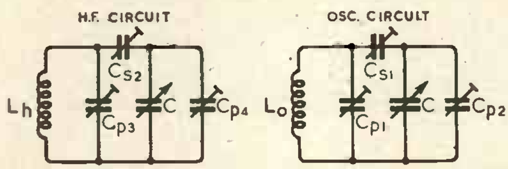


Fig. 3. *Circuits containing more trimmers than the circuits of Fig. 2, yet capable only of three-point tracking.*

denser C_s the auxiliary magnitude A is needed. It is represented in Figs. 6–11 as function of v_h and v_0 in the form of curves A = const on a v_h, v_0-plane.

$$C_s = A(1 - |Y|)(C_e + C_p)\frac{v_0}{v_h - v_0} + C_p \quad \ldots \quad \ldots \quad (3)$$

$$C_{p0} = \frac{\frac{C_e C_s}{C_e + C_s} - v_0^2 \frac{C_a C_s}{C_a + C_s}}{v_0^2 - 1} \quad (4)$$

$$L_0 = \frac{1}{\omega_{0e}^2\left(C_{p0} + \frac{C_e C_s}{C_e + C_s}\right)} \quad (5)$$

The H.F. circuit of Fig. 4 requires the same values of C_p and L as given above; C'_{p0}, C'_s, L'_0 are to be calculated from the following formulae:

$$C'_{p0} = \frac{C_{p0} C_s}{C_{p0} + C_s} \qquad C'_s = \frac{C_s^2}{C_{p0} + C_s}$$

$$L'_0 = L_0 \frac{(C_s + C_{p0})^2}{C_s^2} \quad \ldots \quad (6)$$

Equivalence of Circuits for Three-point Tracking

The detuning y of the H.F. circuit is given by

$$y = 2\frac{\omega_0 - \omega_z - \omega_h}{\omega_h} \quad \ldots \quad \ldots \quad (7)$$

where ω_z denotes the intermediate frequency.

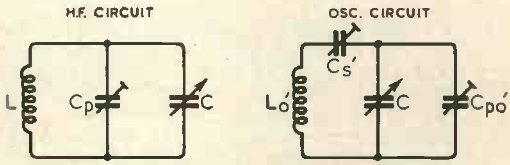


Fig. 4. *Another circuit pair giving three-point tracking with the minimum number of trimmers.*

The circuits of Fig. 3, from which those of Figs. 2 and 4 can be derived by specialisation, are subject to the following relations:

$$\omega_0^2 L_0\left[C_{p1} + \frac{C_{s1}(C_{p2} + C)}{C_{s1} + C_{p2} + C}\right] = 1 \quad (8)$$

$$\omega_h^2 L_h\left[C_{p3} + \frac{C_{s2}(C_{p4} + C)}{C_{s2} + C_{p4} + C}\right] = 1 \quad (9)$$

According to this C is a linear function of both ω_0^2 and ω_h^2; therefore ω_h^2 is also a linear function of ω_0^2. The most general linear function

$$w = \frac{az + b}{cz + d} \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

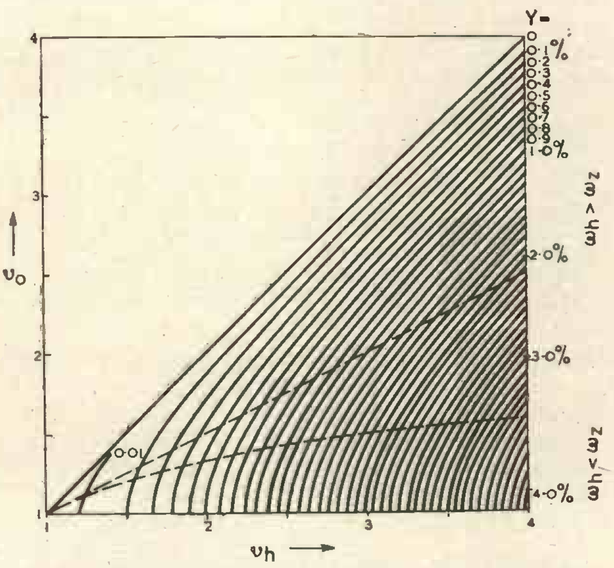
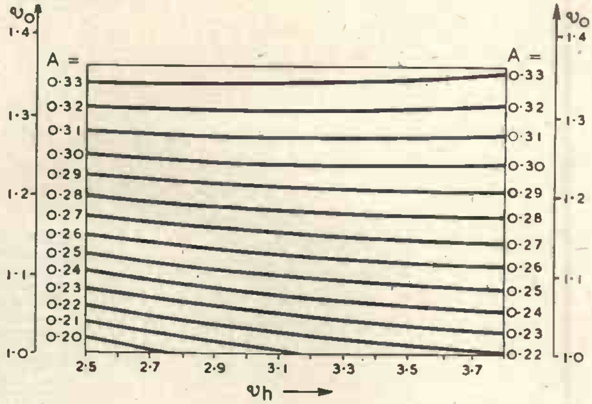


Fig. 5. *Maximum tracking error Y as function of the H.F. variation v_h and of the oscillator frequency variation v_0. The region between the dotted lines is scarcely of technical interest.*

contains only three essential parameters. If in

$$\left(1 + \frac{y}{2}\right)^2 = \frac{(\omega_0 - \omega_2)^2}{\omega_h^2} \quad \ldots \quad (11)$$

we replace $1/\omega_h^2$ by its linear expression in terms of ω_0^2 derived from equations (8) and (9) we obtain an equation with only three essential parameters; hence, in spite of the many trimmers contained in the circuits of Fig. 3 we obtain only three-point tracking. This is no better than in the usual case shown in Fig. 2, which is obtained from Fig. 3 by putting $C_{p2} = C_{p3}$ and $C_{s2} = \infty$. With the notation of Fig. 2 we get:



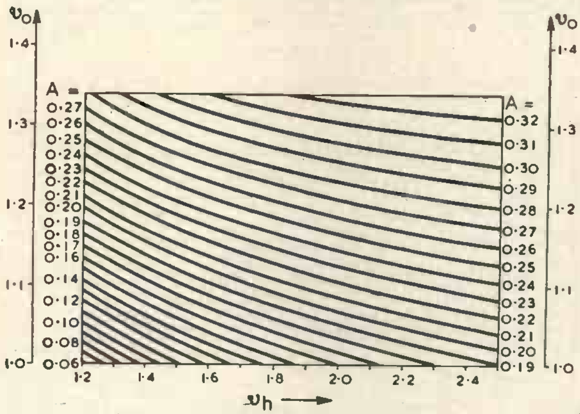


Fig. 6. (*Left*).

Fig. 7. (*Above*).

Fig. 8. (*Below*).

Auxiliary magnitude A for the determination of the series trimmer of the oscillator circuit when the H.F. variation v_h and the oscillator frequency variation v_0 are given.

$$\frac{L[\omega_0^2 L_0(C_{p0}C_s - C_p C_{p0} - C_s C_p) - (C_s - C_p)]}{1 - \omega_0^2 L_0(C_{p0} + C_s)} = \frac{1}{\omega_h^2} \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

This is already the most general linear function. Similarly we have with the notation of Fig. 4

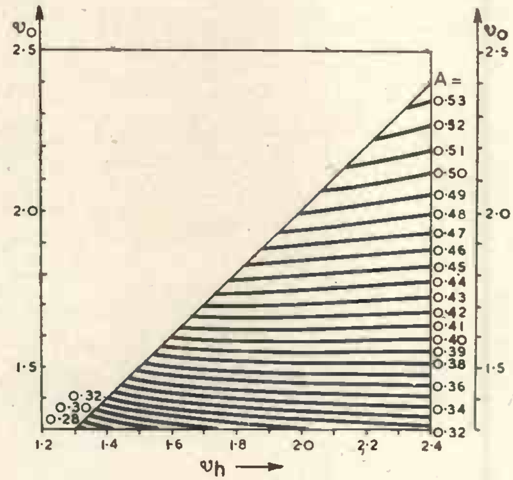
$$\frac{1}{\omega_h^2} = \frac{L[\omega_0^2 L'_0(C'_{p0}C'_s - C_p C'_s) - (C'_s - C_p) + C'_{p0})]}{1 - \omega_0^2 L'_0 C'_s} \quad \ldots \quad \ldots \quad (13)$$

This, too, is the most general linear function. These circuits, too, give three-point tracking and the error curves in all three cases are therefore identical if the circuits are designed for optimum performance.

APPENDIX

The case of very small variation of oscillator frequency ($v_0 \rightarrow 1$).

In Part I of this article[1] the problem of obtaining three-point tracking was reduced



to that of solving a pair of algebraic equations for the magnitudes z_1 and z_2

$$z_1^3 - z_1^2 + 2z_1^2 z_e - 2z_1 z_e + z_1 z_e^2 - z_2^3 + z_2^2 - 2z_2^2 z_a + z_2 z_a - z_2 z_a^2 = 0 \quad (14)$$

$$\frac{1}{1 - z_a} + \frac{2}{1 - z_2} + \frac{1}{z_a + 2z_2 - 1} - \frac{1}{1 - z_e} - \frac{2}{1 - z_1} - \frac{1}{z_e + 2z_1 - 1} = 0 \quad \ldots \quad (15)$$

In these equations

$$z_a = \frac{\omega_{0a}}{\omega_z} \text{ and } z_e = \frac{\omega_{0e}}{\omega_z}$$

If we select an intermediate frequency which is extremely high compared with the received frequency then z_1, z_2, z_a, z_e tend towards 1 and an auxiliary magnitude B, which entered the method of calculation used so far, becomes infinite, whilst the auxiliary magnitude A, introduced into the final formulae, remains finite. In order to calculate A and Y for the case $v_0 \rightarrow 1$ we transform equations (14) and (15) by the aid of the substitutions: $z_a - 1 = x_a$; $z_1 - 1 = x_1$, and so on, so that for $z \rightarrow 1$ $x \rightarrow 0$. We find, then, by retaining only the lowest powers of x

$$2(x_1 - x_2) = x_a - x_e\,;\; x_1 x_2 = x_a x_e$$

with the solutions

$$x_1 = \sqrt{\frac{(x_a - x_e)^2}{4} + x_a x_e} + \frac{x_a - x_e}{4} \qquad \ldots \quad \ldots \quad (18)$$

$$x_2 = \sqrt{\frac{(x_a - x_e)^2}{4} + x_a x_e} - \frac{x_a - x_e}{4} \qquad \ldots \quad \ldots \quad (19)$$

From equation (29) in the previous paper[1] we find for the tracking error

When trimming a receiver which is designed according to the formulae here given it should be noted that the actual variation of the oscillator frequency coincides with its nominal variation, whilst the H.F.

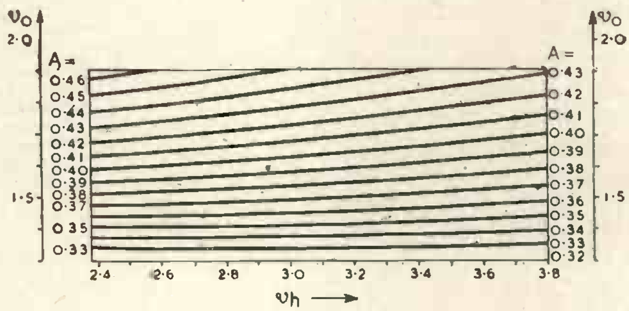


Fig. 9.

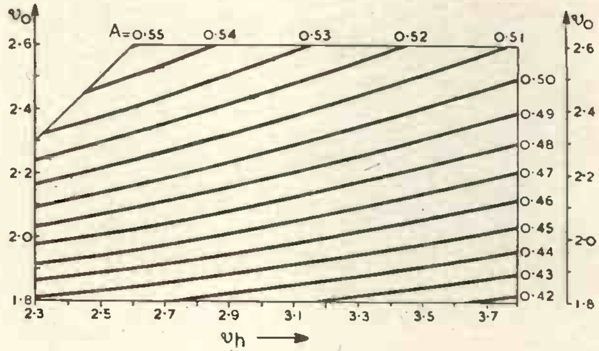


Fig. 10.

Auxiliary magnitude A for the determination of the series trimmer of the oscillator circuit when the H.F. variation v_h and the oscillator frequency variation v_0 are given.

$$Y = \frac{v_h(x_2/x_1)^2 - 1}{v_h(x_2/x_1)^2 + 1} = \frac{v_h\left[\dfrac{\sqrt{1 + \dfrac{16v_h}{(v_h - 1)^2}} - 1}{\sqrt{1 + \dfrac{16v_h}{(v_h - 1)^2}} + 1}\right]^2 - 1}{v_h\left[\dfrac{\sqrt{1 + \dfrac{16v_h}{(v_h - 1)^2}} - 1}{\sqrt{1 + \dfrac{16v_h}{(v_h - 1)^2}} + 1}\right]^2 + 1} \qquad \ldots \quad \ldots \quad \ldots \quad (20)$$

A is obtained from equations (30) and (30a) of [1]:

$$A = (1 - |Y|)\,\frac{v_h - 1}{v_h}\,\frac{1 + \sqrt{1 + \dfrac{16v_h}{(v_h - 1)^2}}}{\dfrac{7v_h + 1}{v_h - 1} + \sqrt{1 + \dfrac{16v_h}{(v_h - 1)^2}}} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (21)$$

circuit in its limiting positions is to be detuned by the amount of the tuning error shown in Fig. 5; this is in contrast to older procedures. This detuning is negative for ω_a (tuning condenser at minimum capacitance) and positive for ω_e (tuning condenser at maximum capacitance); negative detuning means that the received frequency is smaller than the resonant frequency.

Circuits in which the received frequency lies above the oscillator frequency are less commonly used and will be dealt with in a subsequent publication. The derivation of the formulae given here and further explanations are to be found in the first part of this paper [1].

BIBLIOGRAPHY

[1] K. Fränz. *Hochf:tech. u. Elek:akus.*, Vol. 59 (1942), p. 144. Translation *Wireless Engineer*, Vol. 20 (1943), p. 331). This paper contains further references.

[2] E. Hudec, *Elektrische Nachrichtentechnik*, Vol. 19 (1942), p. 235.

[3] O. Meisinger, *Funktechnische Monatshefte* (1943), p. 23.

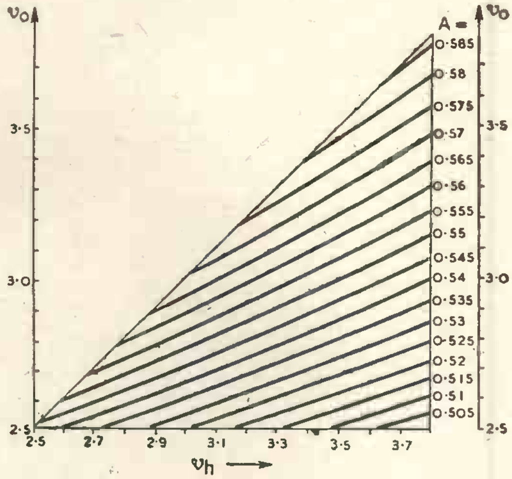


Fig. 11.

Book Reviews

Erzwungene elektrische Schwingungen an rotationssymmetrischen Leitern bei zonaler Anregung.

By Dr. E. Metzler. Pp. 100, with 17 Figs. Price 6.80 Fr. (Swiss).

The work which is the subject of this doctorate thesis was carried out in conjunction with the Swiss Government Telegraph and Telephone Department and with the help of the staff at the Beromünster transmitting station; the author also thanks Prof. Sommerfeld of Munich among others for help. It is mainly a mathematical investigation of the problem of setting up oscillations in a long cylindrical conductor by inserting the generator not necessarily at the middle but at any other "zone." With the object of improving the broadcast distribution over the very difficult Swiss terrain, insulated towers have been erected at Beromünster with a platform at about two-thirds of the total height, where the tower is interrupted by insulators across which the secondary of the exciting transformer is connected. Measurements have been made of the input impedance and of the current distribution along the tower under varying conditions and the results are compared with the calculated values.

It is a pity that more care was not taken in checking some of the formulae. On p. 91 it states correctly that the "blind" or wattless current $J_B = J_{eff}\dfrac{X}{\sqrt{R^2+X^2}}$, but on the next line it states as a consequence that

$$\frac{d}{dz}J_{eff} = \frac{X}{\sqrt{R^2+X^2}}\frac{d}{dz}J_B,$$ which is obviously upside down. This is no mere misprint but is carried forward and employed in the numerical calculations on p. 94. If the correct formula were employed the calculations would agree more closely with the observations.

G. W. O. H.

Die Beziehung zwischen Nutzspannung und Störspannung bei der Frequenz-umsetzungen der drahtlosen Mehrkanaltelefonie.

By Dr. E. Huber. Pp. 95, with 20 Figs. Price 7.20 Fr. (Swiss).

This is a somewhat mathematical discussion of the relation between the useful voltage and the noise voltage in the frequency transformation in multichannel radio-telephony. The work was carried out in 1940–1942 as a thesis for the doctorate at the Institut für Hochfrequenztechnik at Zürich. In such a multi-channel system each telephonic unit has to be transformed to a different high frequency so that the different "channels will be properly spaced on the carrier wave; at the receiver the frequency has to be transformed down again. All these processes involve difficult questions as to the resulting noise ratio. These questions are discussed very fully by the author and the book will undoubtedly prove of great interest to those engaged in this highly specialised branch of radiotelephony.

G. W. O. H.

Ein Röhrengerät zur Messung von Leistung, Spannung und Strom.

By Dr. Alfred Spälti. Pp. 69 with 38 Figs. Price 6 Fr. (Swiss).

The development of a valve wattmeter at the Electrotechnical Institute in Zurich where the author is an assistant is described in this book. The measurement of voltage and current is quite secondary. The accuracy of the valve wattmeter depends on the accuracy with which the valve characteristic follows the square law. In principle it is very similar to Irwin's hot-wire wattmeter in which you have two currents one I proportional to the main current and one i to the voltage; the squares of their sum and difference are $(I + i)^2$ and $(I - i)^2$. A device depending on the difference between these two squares will give $4\ Ii$ and may thus be used to measure the power. The author discusses fully the problem of obtaining the correct form of characteristic to give accurate results when two voltages are similarly superposed. He finds that considerable improvement is obtained by using four valves in a push-pull arrangement, the error with sinusoidal currents and voltages being reduced to ± 0.6 per cent. The construction of the actual instrument is described. Over the frequency range 30 to 5,000 cycles per second powers as low as 10^{-5} watt can be measured. The possibility of using two or three such instruments for the measurement of the volt-amperes and of the reactive power is also discussed. G. W. O. H.

The above three books are published by Gebr. Leemann & Co., Zürich.

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.

Deflected Electron Beams

SIR,—In his letter in the July issue of *Wireless Engineer* Dr. D. Gabor makes two criticisms of my paper which appeared on pp. 267–277 of your June issue.

I must still disagree with Dr. Gabor when he states that Recknagel's formula for infinite deflecting plates represents the " transit power." As explained in my letter on pp. 176–177 of the April issue, such a statement involves a violation of the principle of the conservation of energy. This is because an " infinite field," which terminates suddenly without an end field, violates the Maxwell equations. Any field which violates these equations is clearly not an electric field at all. It has no physical existence. Computations based upon it are meaningless.

With regard to Dr. Gabor's second criticism, I fear there has been a misunderstanding. May I refer Dr. Gabor to page 271 in my paper, when he will see that the " sine shaped field " which I employ is one possessing curl, and is that which occurs, for instance, in a cubical resonant cavity resonating at the H_{101} mode. If Dr. Gabor will refer to such a treatise as Dr. R. L. Lamont's " Wave Guides," p. 74, he will see that there is no x-directed component in any part of such a field.

The field Dr. Gabor has called a " sine shaped " field, and which is illustrated in his letter, is quite a different one, and was not considered in my paper. Therefore Dr. Gabor's arguments based upon it are not relevant to my calculations.

OWEN HARRIES.

London, S.W.18.

Standard Frequency Transmissions

THE United States National Bureau of Standards has issued a revised schedule of the standard frequency transmissions broadcast continuously by the Bureau's station, WWV, near Washington, D.C.

At least three carrier frequencies are now transmitted at all times to ensure reliable coverage. They are:

2.5 Mc/s broadcast from 2300 to 1300 G.M.T.

5 Mc/s broadcast continuously throughout the 24 hours.

10 Mc/s broadcast continuously throughout the 24 hours.

15 Mc/s broadcast from 1100 to 2300 G.M.T.

The transmissions are radiated by 10-kW stations with the exception of that on 2.5 Mc/s for which a power of 1 kW only is used.

Two standard audio frequencies, 440 c/s, the standard musical pitch corresponding to A above middle C, and 4,000 c/s are broadcast continuously on 10 and 15 Mc/s. Both are also transmitted on the 5 Mc/s carrier frequency in the daytime but only the 440 c/s from 2300 to 1100 G.M.T. The lowest radio frequency (2.5 Mc/s) carries the 440 c/s only.

The audio frequencies are interrupted precisely at the hour and each five minutes thereafter for one minute during which the station's call letters are given in morse except at the hour and half-hour when a detailed announcement is given by 'phone.

On all carrier frequencies a pulse of 0.005-second duration occurs at intervals of precisely one second. The time interval marked by this pulse, which consists of five cycles, each of 0.001-second duration and is heard as a faint tick, is accurate to 0.00001 second. On the 59th second of every minute the pulse is omitted.

The accuracy of all the frequencies, audio and radio, as transmitted is better than one part in 10^7.

Information on how to receive and utilise this service is given in the Bureau's pamphlet " Methods of Using Standard Frequencies Broadcast by Radio," obtainable on request from the National Bureau of Standards, Washington, D.C. The Bureau welcomes reports of difficulties, methods of use, or special applications of the service.

Prize for an Invention

THE Council of the Royal Society of Arts is again offering under the Thomas Gray Memorial Trust, the objects of which are " the advancement of the science of navigation and the scientific and educational interests of the British Mercantile Marine ", a prize of £50 for an invention. The prize will be awarded to any person of British or Allied nationality who may bring to the notice of the Council an invention, publication, diagram, etc., which in the opinion of the Judges is considered to be an advancement in the science or practice of navigation, proposed or invented by himself in the period 1st January, 1939, to 31st December, 1944. Entries which have already been considered by the Judges in the years 1939–43 are not eligible for further consideration unless they have since been materially modified.

Competitors must forward their proofs of claim, between 1st October and 31st December, 1944, to the Acting Secretary, Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.

Twenty-seven entries were submitted in 1943, and the full Prize of £50 was awarded jointly to Drs. J. T. Randall and H. A. H. Boot for their radar invention.

University Research Fellowships

WITH a view to strengthening the general facilities in British universities for scientific teaching and research, and in the belief that academic and industrial research are indivisible and interdependent, the Directors of Imperial Chemical Industries have offered to provide eighty Fellowships in scientific research at nine universities.

The subjects laid down in this scheme, which is to operate for an initial period of seven years, are physics, chemistry and the sciences dependent thereon, including chemotherapy; that is to say, any branch of physics or chemistry may be included as well as applied sciences such as metallurgy and engineering.

This offer has been made to the larger universities, and those near to I.C.I.'s main sources of production. Thus, Oxford, Cambridge and London have been each offered twelve Fellowships; Glasgow, Edinburgh, Liverpool, Manchester and Birmingham eight; and Durham four.

The Fellowships will be of the average value of £600 per annum, though the universities will have power to determine the emoluments for each appointment.

Institute of Physics

AT the next meeting of the Electronics Group of the Institute on September 19th at 5.30, in the rooms of the Royal Institution, 21, Albemarle Street, London, W.1, Dr. A. Sommer, of Cinema-Television, Ltd., will deliver a paper on "Principles of Photo-Electric Emission and Their Application in Photo-Electric Cells."

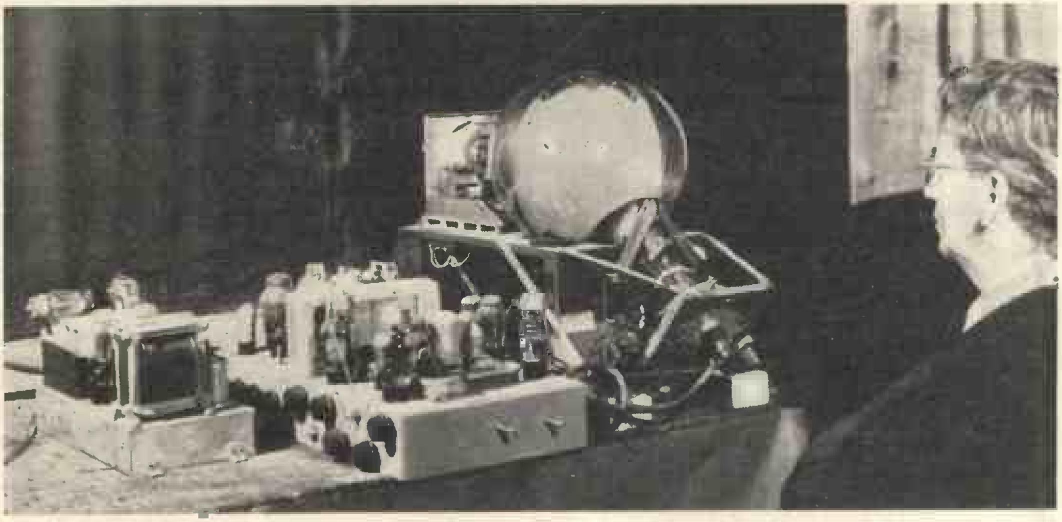
Institution of Electronics

THE Electron Microscope will be dealt with by Dr. D. G. Drummond at a meeting of the North-West Branch of the Institution on September 22nd at 6.30. At the October meeting of the Branch, arranged for the 27th at 6.30, Dr. J. A. Darbyshire will lecture on "Hot-Cathode Mercury Vapour Rectifiers." The venue is the Reynolds Hall, College of Technology, Manchester. Non-members may obtain tickets from L. F. Berry, 14, Heywood Avenue, Austerlands, Oldham, Lancs.

Brit. I.R.E.

WE have been advised that the Annual General Meeting of the British Institution of Radio Engineers has been postponed until October. Leslie McMichael, the recently nominated president-elect in succession to Sir Louis Sterling, will deliver his presidential address to the North-Eastern Section of the Institution on September 20th, and before the Midland Section on September 27th.

BAIRD "TELECHROME"



Mr. J. L. Baird has recently demonstrated in London a simplified version of his two-colour system of television in which the picture is viewed directly on a mica screen coated on one side with orange-red and on the other with blue-green fluorescent powders. Separate cathode-ray beams scan back and front surfaces, and excellent stereoscopic effects are obtained when displaced images are transmitted through the two channels and the picture is viewed through "anaglyphic" coloured spectacles.

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

560 727.—Loudspeaker movement comprising external and internal pole-pieces with an air gap between them, in which the internal pole-piece is bored to provide an auxiliary throat opening in order to utilise the back pressure from the diaphragm.

Parmeko; S. N. S. Mee; and F. J. Toone. Application date 10th December, 1942.

561 304.—Frequency-modulating circuit, particularly adapted for generating " siren " or like alarm signals.

G. R. Fountain; H. J. Houlgate; and G. C. Wheeler. Application date 4th November, 1942.

561 501.—Construction and support of the stylus for acoustic pick-ups of the electro-optical or variable-capacitance type.

A. A. Thornton (communicated by Philco Radio and Television Corporation). Application date 6th August, 1942.

561 591.—Construction and support of the cutting arm and stylus of a gramophone designed for home recording.

Philco Radio and Television Corporation (assignees of W. J. Green). Convention date (U.S.A.) 4th December, 1941.

AERIALS AND AERIAL SYSTEMS

560 271.—Omni-directional aerial in which a pair of metallic sheets are mounted spirally about a two-wire feeder or transmission line to simulate a " turnstile " array.

Standard Telephones and Cables (assignees of A. B. Bailey). Convention date (U.S.A.) 8th November, 1941.

561 251.—Short-wave aerial for horizontally-polarised waves, comprising a stack of closely-spaced " open " loops symmetrically coupled to a single feed or transmission line.

The British Thomson-Houston Co. Convention date (U.S.A.) 15th November, 1941.

DIRECTIONAL WIRELESS

560 364.—Radio beacon in which two oppositely-directed navigational courses are defined by overlapping beams, and in which each quadrant is distinctively modulated to enable a pilot to identify his position.

Standard Telephones and Cables (assignees of A. Alford). Convention date (U.S.A.) 17th December, 1941.

561 277.—Aerial system and keying arrangements for reducing the normal width of the blind-approach path in a radio navigational system of the overlapping-beam type.

Standard Telephones and Cables and L. J. Heaton-Armstrong. Application date 10th November, 1942.

561 633.—Goniometer device for checking the angle given by a radio direction finder against the compass reading on a mobile craft.

Marconi's W.T. Co., and J. H. Moon. Application date 23rd November, 1942.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

560 779.—Valve sockets of the type in which a rotary movement is required to make connection between the circuit terminals and prongs on the valve.

S. Y. White. Convention date (U.S.A.) 7th July, 1941.

560 886.—Field set adapted to receive I.C.C. or telephony signals at will, wherein the operation of the A.V.C. circuit is not affected by the beat-frequency voltage applied when receiving telegraphic signals.

Murphy Radio and P. C. Carver. Application date 2nd November, 1942.

561 088.—Wave-band filter in which a mechanical oscillator, consisting of a cruciform element made of aluminium, is used as a resonant coupling between two piezo-electric crystals.

Western Electric Co., Inc. Convention date (U.S.A.) 25th November, 1941.

561 091.—Arrangement for testing the serviceability of the aerial circuit in a ship's automatic SOS receiver when the operator goes off duty (addition to 556 319).

Standard Telephones and Cables; J. D. Holland; and D. D. Robinson. Application date 30th October, 1942.

561 160.—Stabilising the frequency of an electron-coupled oscillation generator, as used in carrier-wave signalling, by means of a non-linear impedance in combination with an iron-cored tuning inductance.

Automatic Telephone and Electric Co. and C. F. Campbell. Application date 4th November, 1942.

561 382.—Automatic gain regulation for a signalling system in which means are provided for minimising the effect of any failure of the control or pilot current.

Standard Telephones and Cables (communicated by Western Eletric Co., Inc.). Application date 13th November, 1942.

561 405.—Means for preventing "lock-up" in the echo-suppressing circuits of a telecommunication system.

Automatic Telephone and Electric Co.; C. Gillings; and E. A. Cowley. Application date 4th November, 1942.

561 459.—Frequency changer, for a superhet receiver, in which the transconductance of the tube is doubled by utilising the local oscillator as a phase-reversing switch.

Marconi's W.T. Co. (assignees of E. W. Herold). Convention date (U.S.A.) 17th May, 1941.

561 779.—F. M. receiver in which amplitude variations are first removed from one half of the modulated wave, the resultant output being then employed to remove all residual amplitude variations.

Philco Radio and Television Corporation (assignees of F. J. Bingley and R. C. Moore). Convention date (U.S.A.) 12th January, 1942.

561 787.—Tuning device comprising an inductance coil with an adjustable powdered-iron core and a coaxially arranged trimming condenser.

C. A. W. Harmer; J. W. Dalgleish; and Pye. Application date 19th February, 1943.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

560 749.—Interlaced scanning system for television with means for increasing the signal storage along each line, particularly when producing coloured pictures.

Hazeltine Corporation. Convention date (U.S.A.) 23rd April, 1941.

560 773.—Synchronising the movement of colour filters with the interlaced scanning lines in a coloured system of television.

Hazeltine Corporation (assignees of J. C. Wilson). Convention date (U.S.A.) 23rd April, 1941.

560 894.—Saw-tooth oscillation generator for television scanning in which one condenser is charged through an inductance which is fed by the discharge from a second condenser under the control of an arc-discharge tube.

The British Thomson-Houston Co. and V. E. Milward. Application date 30th October, 1941.

560 904.—Television transmitter tube utilising a low-velocity scanning stream and secondary emission targets, with which is incorporated means for minimising inherent sources of distortion.

Marconi's W.T. Co. (assignees of H. A. Iams). Convention date (U.S.A.) 29th January, 1941.

561 209.—Television system wherein two different coloured pictures are transmitted in sequence by frequency and amplitude modulation respectively, whilst a third coloured picture is synchronously and continuously transmitted.

The British Thomson-Houston Co. (communicated by The General Electric Co.). Application date 5th August, 1942.

561 347.—Arrangement for reducing the effect of extraneous light on the reflecting surface or viewing screen of a television receiver.

Marconi's W.T. Co. (communicated by the Radio Corporation of America). Application date 11th November, 1942.

561 425.—Rotary optical system comprising a doubly-refracting element, interposed between a light polariser and analyser, for projecting television pictures in natural colour.

B. T. Hewson and A. Locan. Application date 13th August, 1942.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

560 780.—Method of stabilising the frequency of a thermionic oscillation-generator by means of shunting one of the tuned circuits by a non-linear resistance.

Telephone Manufacturing Co. and L. H. Paddle. Application date 13th August, 1942.

560 906.—Safety device against surge voltages comprising a series-connected impedance and rectifier, which are arranged in shunt with the anode choke and anode-cathode circuit of a modulating valve.

Marconi's W.T. Co. and N. H. Clough. Application date 10th September, 1942.

561 148.—Printing telegraph transmitter with switching mechanism under the control of a "sensing" device for routing the message over selected channels.

Teletype Corporation (assignees of M. T. Goetz). Convention date (U.S.A.) 20th September, 1941.

561 322.—Frequency-modulating circuit comprising a resistance-capacitance-coupled oscillator and a phase-shift control network including a non-linear resistance.

G. R. Fountain; H. J. Houlgate; and G. C. Wheeler. Application date 4th November, 1942.

561 323.—Frequency-modulation system wherein the tuning of a circuit is varied by the application of a control voltage to a condenser having fixed electrodes and a dielectric which acts as a "blocking layer."

"Patel Hold" Patentverwertungs, &c. A.G. Convention date (Switzerland) 28th October, 1941.

561 705.—Safety device for automatically cutting-off the power supply to a wireless transmitter on the occurrence of a flash-over.

T. C. Macnamara; P. A. T. Bevan; and C. G. Mayo. Application date 26th October, 1942.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

560 925.—Signalling system in which polyphase modulation is utilised in combination with filters (*a*) to reduce the effective band-width of the resulting signals, and (*b*) to render them secret except to an authorised receiver.

P. P. Eckersley and R. E. H. Carpenter. Application dates 24th December, 1940, and 16th December, 1941.

560 928.—Apparatus including cathode-ray tubes for determining *inter alia* the precise time-interval or phase difference between two periodic phenomena such as occur in certain methods of pulsed signalling.

G. W. Walton. Application date 3rd September, 1941.

560 930.—Secret signalling system in which polyphase modulation is utilised to produce a speech-scrambling effect, or "folded spectrum" method of transmission over a signal channel.
P. P. Eckersley and R. E. H. Carpenter. Application date 21st July, 1942.

560 982.—Ultra-short-wave generator or receiver comprising an evacuated tube which contains an electron-emitting cathode and two or more spaced electrodes which act as "resonator antennae."
G. W. Walton. Application dates 16th October and 22nd November, 1939.

561 331.—Signalling system in which a primary wave is first continuously modulated by a second wave to produce a frequency-modulated wave, which is then modulated by the message and thereafter radiated in short pulses having a constant repetition frequency.
Marconi's W.T. Co. (communicated by T. L. Gottier). Application date 21st December, 1941.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

560 689. — Auxiliary focusing electrodes which serve to increase the mutual conductance in a beam-deflection valve.
A. C. Cossor; L. Jofeh; and B. C. Fleming-Williams. Application dates 26th June, 1940, and 7th May, 1941.

560 959.—Velocity-modulation tube in which the electron stream is subjected to alternating radial fields, in order to separate the accelerated and decelerated electrons and guide them to different collectors.
Marconi's W.T. Co. (assignees of L. S. Nergaard). Convention date (U.S.A.) 30th October, 1941.

561 111.—Process for sealing the metal walls of an evacuated radio or like tube by the application of pressure without heat.
Marconi's W.T. Co. (assignees of L. P. Garner and W. K. Bricker). Convention date (U.S.A.) 1st November, 1941.

561 177.—Process for the manufacture of coiled cathodes for electron discharge tubes.
The British Thomson-Houston Co. Convention date (U.S.A.) 29th July, 1941.

561 199.—Ultra-high-frequency generator of the velocity-modulation type wherein feed-back is provided by a tubular resonator which encloses the operative electrodes of the tube.
Akt. Brown, Boverie & Cie. Convention date (Switzerland) 28th February, 1940.

561 554.—Construction and arrangement of the focusing electrodes in a cathode-ray tube or electron microscope.
The British Thomson-Houston Co. Convention date (U.S.A.) 3rd October, 1941.

561 594.—Construction and arrangement of a multi-strand filament assembly, taking polyphase current, for a high-powered electron discharge tube.
Standard Telephones and Cables (assignees of L. C. Goodall and L. A. Backer. Convention date U.S.A.) 3rd March, 1942.

561 599.—Construction of small electron discharge tubes, intended for short-wave working, so that their final assembly is effected by a metal-to-metal seal.
Standard Telephones and Cables (assignees of C. V. Litton). Convention date (U.S.A.) 5th February, 1942.

561 644.—Focusing means and circuit arrangement for ensuring a trigger-like operation, comparable with that of a gas-filled relay, in a discharge tube of the beam type.
Western Electric Co. Inc. Convention date (U.S.A.) 31st July, 1941.

561 710.—Means for permitting the mechanical adjustment, from outside, of an electrode or other element mounted inside an evacuated or gas-filled discharge tube.
Standard Telephones and Cables and C. T. H. Foulkes. Application date 26th November, 1942.

SUBSIDIARY APPARATUS AND MATERIALS

560 536.—Holder for a piezo-electric crystal comprising a shallow tray in which the crystal is secured by spring contact plates, the tray assembly then being inserted, like a drawer, into an outer covering.
A. J. Perkins and W. G. Roberts. Application date 1st October, 1942.

560 565.—Manufacture and processing of selenium-coated electrodes for contact rectifiers and light-sensitive cells.
Standard Telephones and Cables (assignees of A. von Hippel). Convention date (U.S.A.) 13th April, 1942.

560 644.—Spring holder for a piezo-electric oscillator in which movement of the crystal plate in its own plane is restricted within narrow limits.
Automatic Telephone and Electric Co. and T. B. D. Terroni. Application date 7th October, 1942.

560 652.—Photo-electric cell in which the sensitive material is ribbed or corrugated, to increase the area of activity, and is covered by a translucent metallic electrode a few molecules thick.
Sangamo Weston. Convention date (U.S.A.) 3rd April, 1942.

560 755.—Method of heating a wire by high-frequency current in which the principle of cavity resonance is utilised.
Marconi's W.T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.) 10th July, 1941.

560 769.—Device for subduing or quenching the arc formed when a sliding collector leaves a current-supplying line or rail.
N. H. Thomas and London Passenger Transport Board. Application date 9th October, 1942.

560 869.—Rectifier of the selenium type in which the counter electrode consists of a coating of indium or of an alloy or mixture in which that element preponderates.
Westinghouse Brake and Signal Co.; L. E. Thompson; and A. Jenkins. Application date 19th October, 1942.

560 873.—Arrangement of the lead contact washers in a unit or pile of dry-contact rectifiers of the copper-oxide type.
A. V. Tomlinson (communicated by The Union Switch and Signal Co.). Application date 20th October, 1942.

560 887.—Single-valve relay circuit for measuring short time intervals.
Siemens Bros. & Co. and D. A. Christian. Application date 19th November, 1942.

560 891.—Relay circuit for repeating trains of impulses with a predetermined ratio of "make to break" irrespective of the ratio of the received pulses; and for measuring their time intervals (divided from 560 887).
Siemens Bros. & Co. and D. A. Christian. Application date 19th November, 1942.

561 086.—Control circuit for synchronising the conductivity of two pairs of gas-filled rectifiers in a system for supplying a D.C. load from a polyphase generator.
The British Thomson-Houston Co. Convention date (U.S.A.) 1st October, 1941.

561 101.—Selenium type of rectifier with "spot" counter-electrodes of thallium, particularly for use as a radio detector.
Westinghouse Brake and Signal Co.; L. E. Thompson; and A. Jenkins. Application date 30th October, 1942.

561 258.—Arrangement of the terminals of a fixed condenser of the "rolled" type so as to render it substantially non-inductive.
J. H. Cozens and The Telegraph Condenser Co. Application date 16th February, 1943.

561 269.—Utilising the change of reluctance in a magnetic circuit as a means for stabilising a desired condition, say the rate of flow of a fluid.
G. Kent (assignees of J. C. Peters and I. M. Stein). Convention date (U.S.A.) 19th February, 1942.

561 303.—Screening device for sparking plugs designed to allow for its rapid attachment or removal.
The AC-Sphinx Sparking Plug Co.; D. B. Brown; F. W. Clare; and R. H. G. Painter. Application dates 30th October 1942, and 16th January, 1943.

561 332.—Means for reducing erosion of the make and-break contacts in a current converter of the vibratory or interrupter type.
A. H. Stevens (communicated by Electronic Laboratories Inc.). Application date 20th May, 1942.

561 389.—Circuit for producing a stabilised D.C. voltage through a network which includes a pentode valve in series, and a neon lamp in shunt, with the supply.
Siemens Bros. & Co.; A. Rosen; and G. W. Arcus. Application date 31st December, 1942.

561 434.—Electron-beam discharge tube arranged to stabilise an existing set of conditions, such as the rate of flow of a fluid.
H. Ziebolz. Convention date (U.S.A.) 30th December, 1941.

561 529.—Method of cutting and coating the electrodes of rectifiers of the selenium type.
Standard Telephones and Cables and E.A. Richards. Application date 18th November, 1942.

561 530.—Treating the metal electrodes of selenium rectifiers by a process of sand-blasting.
Standard Telephones and Cables and F. Gray. Application date 18th November, 1942.

561 631.—A self-balancing photo-electric recorder with means for preventing the marking pen from "overshooting" or ocsillating, when a sudden change takes place in the conditions under observation.
Cambridge Instrument Co.; W. H. Apthorpe; and G. S. Rayner. Application date 23rd November, 1942.

561 632.—Device for controlling the speed of traverse of the registering pen in a self-balancing electric recorder of the photo-electric type.
Cambridge Instrument Co.; W. H. Apthorpe; and G. S. Rayner. Application date 23rd November, 1942.

561 693.—A.C. balanced bridge network for measuring impedances of the order 0.01 to 1000 ohms, whether resistive or reactive.
C. G. Mayo. Application date 8th February, 1943.

ABSTRACTS AND REFERENCES

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Comparative Length of the Abstracts.—*It is explained to new readers that the length of an abstract is no sign, by itself, of the importance of the work concerned. An important paper in English may be dealt with by a short abstract, or even, if it is in a journal readily obtainable, by a square-bracketed addition to the title; while a paper of similar importance in a language other than English may be given a long abstract. In addition to these questions of language and accessibility, the nature of the work has, of course, a great effect on the useful length of its abstract.*

PROPAGATION OF WAVES

2838. A NEW APPROACH TO THE SOLUTION OF HIGH-FREQUENCY FIELD PROBLEMS, *and* EQUIVALENT CIRCUIT OF THE FIELD EQUATIONS OF MAXWELL: I.—J. R. Whinnery & S. Ramo: G. Kron. (*Proc. I.R.E.*, May 1944, Vol. 32, No. 5, pp. 284–288: pp. 289–299.)

These are two of the three papers dealt with by McAllister (2124 of July): the third has still to appear: it deals in detail with the experiments mentioned in (i), below.

(i) "Kron recently has called attention [2 of January and ii, below] to certain distributed-constant networks which give approximate representations of Maxwell's equations. This report is concerned with one of those networks that has to do with waves with no variation along one coordinate . . . The feeling of the writers that the equivalent-circuit approach may have important and immediate usefulness comes in a large part from the results of a preliminary experimental investigation. What was first thought to be an inadequate board, enough impedance elements to yield the equivalent of only 60 units of space, was connected into a network representing wave-guides and transmission lines which were two-dimensional or axially symmetric. Uniform cases and some containing large discontinuities were tried. The results were compared against calculated values, and differences of only a few per cent were noted in many cases . . . It had been more or less assumed that thousands of units would be needed in the network analyser to be of practical value. Now it appears that a board with hundreds of units might easily prove valuable. . . ."

(ii) "Both transient and sinusoidal field phenomena may now be studied by the network analyser or by numerical and analytical circuit methods. Examples are radiation from antennas, propagation through wave-guides and cavity resonators of arbitrary shapes, eddy currents in conductors, stresses in current-carrying structures, and other general problems in which moving charges either do not enter or, if they do, they may be replaced by equivalent dielectric constants, as in small signal waves on stationary or moving space charge . . . The electromagnetic field may be non-homogeneous, non-isotropic (of a special form), and may be divided into blocks of uneven length in different directions. . . . The appearance of the two types of ideal transformer plays a basic part in the identification of the scalar, vector, and Hertzian potentials and their duals on the equivalent circuit. The latter definitions will be treated in a subsequent part." For the original guiding principle *see* 2905 of 1943.

2839. THE IMPEDANCE OF A TRANSVERSE WIRE IN A RECTANGULAR WAVE-GUIDE [including the Case of a Wire broken by a Short Gap].—Schelkunoff. (*See* 2862.)

2840. ELECTROMAGNETIC WAVES IN A BENT PIPE OF RECTANGULAR CROSS SECTION.—K. Riess. (*Quarterly of Applied Math.* [Brown University], April 1943/Jan. 1944, Vol. 1, p. 328 onwards.)

"This analysis of electromagnetic wave propagation . . . is based on the Maxwell field equations expressed in cylindrical coordinates. It is shown that the usual methods for the analysis of a straight pipe cannot be applied. Instead, the equations are solved completely by a method of approximation using the theory of the Schrödinger equation with perturbations. Continued propagation from a straight pipe into a bent pipe is also discussed." A 6-page paper.

2841. ULTRA-HIGH-FREQUENCY *versus* MICRO-WAVES IN TWO-WAY RADIO COMMUNICATIONS.—Freedman. (*See* 3003.)

2842. Polarisation Measurements in the Field of a Horizontal Transmitting Dipole.—J. Grosskopf & K. Vogt. (*Hochf:tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, pp. 131–133.)

"For certain investigations in propagation research, the generation of an electromagnetic field with any desired type of polarisation is necessary. A simple method which enables such fields to be produced, and which will now be described, depends on the polarisation effects occurring in the field of a horizontal transmitting dipole near to the ground."

Fig. 1 illustrates the theory of the interference field produced in such a case by the direct and ground-reflected rays. The horizontal dipole, rotatable about a central vertical axis, is at a height a above the ground; the receiver, at a distance r, is at a height z: both these heights are small compared with r. Using certain approximations, eqns. 3 are obtained for E_z, E_r, and E_ϕ, the vertical, radial, and azimuthal components of the dipole field; from these equations it is seen that at the ground ($z = 0$) the radial component E_r and the vertical component E_z have a constant ratio $1/\sqrt{\bar{\epsilon}}$. Here $\bar{\epsilon}$ represents $\epsilon + j \cdot 2\sigma/f$; to obtain these equations the distance from the transmitter, measured in wavelengths, is taken large enough for r/λ to be greater than $|\bar{\epsilon}|$.

The two components combine to give the well-known Zenneck rotating field. It is seen, also, that the vertical component E_z and the azimuthal component E_ϕ have an arbitrary phase relation to each other, so that these two components also form a rotating field. Further, all three components are seen to depend on the azimuth Φ. In the direction of $\Phi = \pi/2$ pure horizontal polarisation is found; in the direction $\Phi = 0$, vertical polarisation with a subsidiary radial rotating-field component. At the intermediate points there are elliptical polarisations whose planes, through the addition of the radial component, take up an arbitrary position in space. These theoretical conclusions are confirmed by an experimental investigation outlined below.

The self-supporting horizontal transmitting dipole, 9.3 m long, was pivoted at a height of 3.4 m. The receiving point was at a distance of 50 m and at a height of 2.3 m: here the polarisation ellipse was measured for various values of the azimuth Φ by means of a "conductivity meter" of the type described in earlier papers (1833 of 1941, 376 & 2955 of 1942). Fig. 2 is a photograph of a new, compact model of this instrument, simple to operate: the knapsack receiver, pivoted on a tripod, carries on its top the measuring dipole, rotating on its horizontal axis, together with its leads and transformer. The test frequency used was 14 Mc/s. The fixed position of the receiving gear, used in this method, has the advantage that the ground conditions remain unchanged during the measurements.

Fig. 3 shows the measured horizontal diagrams of the vertical component (curve "1") and the horizontal (curve "2") each as a function of Φ. In both cases the figure-of-eight diagram is obtained. Fig. 4 gives the ratio ρ of E_z to E_ϕ and also the angle of inclination γ of the major axis of the ellipse to the vertical, both as functions of Φ. From these two values the phase difference ϕ between E_z and E_ϕ is calculated by the formula $\cos \phi = \{(1 - \rho^2)/2\rho\} \cdot \tan 2\gamma$, and the rotating-field ellipses can thus be constructed. Fig. 5 shows a series of half-ellipses, each with a value of Φ between 0° and 90° as middle point. "It is, as could be foreseen from what has been said, a matter of the projection of the polarisation ellipses on to the planes perpendicular to each particular path. The radial component, not taken into account in this diagram, would (as already pointed out above) lead to a warped distortion of the ellipse surfaces."

2843. On the Theory of the F_2 Layer: Remark on Burkard's Paper "The Seasonal Height and Ionisation Variations of the F_2 Layer" [2940 of 1943], *and* Reply to the Above Note.—G. Michel: O. Burkard. (*Hochf:tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, pp. 157–159: p. 159.)

"Herr Burkard has succeeded, by the skilful working out of the observational material, in obtaining a number of new relations concerning the F_2 layer which extend our knowledge of this layer to an important degree and which appear to be based on a completely new foundation.

"Some of these newly obtained relations can, as will be shown below, be understood if it is assumed that the charge-carrier density in the F_2 layer does not depend solely on the numbers of ions freshly formed by radiation-ionisation and disappearing by recombination, but that an important contribution to the number of charge-carriers in the F_2 layer and in the layers of the upper atmosphere in general is made by particles which are brought to, or carried from, the layer by electrical conduction. This assumption is suggested by the appearance of the permanent positive current flowing in the vertical direction to the earth's surface. For since this geoelectric vertical current has no effect in changing the earth's charge, the same amount of charge must flow *from* the earth as is brought *to* it by the vertical current. An obvious possibility is that the current flowing from the earth makes its way over the parts of the earth's surface near the poles. After passing through the troposphere over the poles it may either flow through the upper atmosphere and from there, by way of the troposphere at low latitudes, again to earth, or it may take an extra-terrestrial course. Exactly what happens must be left undecided, but in any case the current must pass through the upper atmosphere. We shall assume in what follows that the geoelectric vertical current is a purely terrestrial phenomenon, flowing through the upper atmosphere; and shall set ourselves to find out about the direct voltage which maintains this current continually flowing in the same direction.

"As the cause of this voltage, three effects may be adduced: (1) the tidal motion of the electrically charged atmosphere with respect to the earth's magnetic field (dynamo theory): (2) the unipolar induction of the earth: and (3) the induction due to the passage of the earth's magnetic poles through the circuit earth/atmosphere ionised in the cone of the sun's rays/earth. The voltages and currents produced by the tidal motions play an important rôle in the theory of the periodic variations of the terrestrial magnetic field (Schuster, Chapman). It seems also possible to derive from the daily periodic tidal motions of the atmosphere a direct-current component constant over long periods of time, if one assumes that the atmosphere during the tidal displacement produced by the sun is on the average more strongly ionised than during the recovery from this displacement. This theory, which may also be of importance for the elucidation of the geoelectric vertical current, has so far as we know not yet been worked out."

With regard to (2) the writer quotes his own theory, dealt with in 2086 of 1941, which bridges the gaps encountered by other workers in attempting to develop Faraday's original ideas. This theory assumes that that part of the earth's upper atmosphere which is exposed at the time to the sun's radiation represents a conductor which is stationary with respect to the earth, since it is ionised on its entrance into the cone of illumination and de-ionised again on leaving it. This conductor links the poles together and is in conductive connection with the earth's surface through an only imperfectly insulating lower atmosphere. The geomagnetic component falling in the direction of the earth's axis of rotation produces in this system, by unipolar induction, a direct voltage, the system becoming positive at the magnetic poles and negative at the equator.

Those components which do not fall in the direction of the axis of rotation will also induce voltages in the circuit earth/illuminated-upper-atmosphere/earth: these would reach a maximum twice a day, when the north and south poles pass through mid-day.

The writer continues:—" The charges present in the upper atmosphere, in passing to the troposphere, cannot simply follow the primary voltage drop, but must undergo complex transitional effects (*e.g.* change from electron conduction to ion and complex-ion conduction) at the passage through the border between the upper highly rarefied layers and the lower, higher-pressure layer. Consequently there is formed in the upper atmosphere a definite space-charge distribution (similar to that in a gaseous-discharge gap), with a negative space charge over the poles and a positive over the low and medium latitudes. The positive space charges flow, owing to the relatively high conductivity of the troposphere, as the geoelectric vertical current to earth at the equator and lower latitudes. The negative space charges over the poles also flow through the troposphere to the poles in the normal case. Thus there exists a current system in both the northern and southern hemispheres. The positive current flows in each system from the pole through the upper atmosphere, through the troposphere to the earth's surface, and from there back to the pole. The two current systems are separated by the magnetic equator.

" The conductivity of the lower atmosphere, however, is not constant, but depends on solar irradiation. A specially great effect on the currents flowing in the two systems is exerted by the conductivity-changes in those parts of the troposphere which are over the poles, because even comparatively few positive ions, additionally produced here and transferred to the negative space-charge cloud over the poles, may result in the break-up of the whole space charge and a consequent large leakage current. If, on the other hand, sufficient positive ions were lacking in the troposphere over the poles, the negative space charges collected in the upper atmosphere would be unable to flow away, or would be delayed in so doing: the potential at this point of the lower atmosphere would rise, and collision-ionisation processes might ensue which we know as aurora. This would particularly be the case if auxiliary voltages appeared in the conduction system as a result of the passage of the poles: this would be at 19.17^h and 2.45^h, Berlin time. Since the passage of the north magnetic pole is the important one for the northern hemisphere, there should be an increased probability of aurora at 19^h.

" If we apply the ideas developed above to the F_2 layer, the discovery made by Burkard of a connection between the critical frequency and the sun's position relative to the magnetic meridian is the first thing to be explained. Maxima of the critical frequency, and consequently also of charge-carrier density, appear as the sun passes through the magnetic meridian because here the number of ions produced by irradiation near the equator and in medium latitudes has a maximum value, whereas the irradiation of the poles and consequently the conductivity of the troposphere over the poles is comparatively feeble. As a result, only a fraction of the newly generated charges can flow away over the poles. It is also comprehensible that at this relative position of sun and earth the thickness of the ionised layer should reach a maximum, as Burkhard deduced from the Kochel observational data (section IV of his paper)."

The writer next explains the appearance of a minimum in the critical frequency at both the summer and winter solstices in the northern hemisphere: in the first case the leakage over the north pole increases more strongly than the ion formation, in the second case the ion formation through irradiation decreases more strongly than the leakage over the north pole, which is sustained by collision-ionisation processes (*see* above).

The assumptions made also explain the connection between morning ionisation and sunrise at the layer level (Burkard, section V). The rise in ionisation begins in summer about 4 hours after sunrise, in winter only about ½ to 1 hour after, for the following reason: during the summer months the pole is constantly illuminated, the leakage over the pole is therefore large, and it takes longer for the ions newly produced by radiation to catch up and exceed the number of charge-carriers lost by leakage, than it takes in winter, when the pole is not (or only briefly) illuminated and the troposphere over it has therefore a comparatively low conductivity. Burkard seeks to explain the observed phenomenon by a corpuscular radiation from the sun, but the objection to this theory is that the particles proceeding from the sun would have to have about four times as high a velocity in winter as in summer; there seems to be no foundation for this supposition.

" The curves given for the daily course of the ionisation at Kochel also support the correctness of our explanation. It would be expected that the additional voltages induced by the passage of the poles through the meridian would make themselves evident in the course of the ionisation during a day; particularly in the northern hemisphere, the passage of the north pole around 19^h [*see* above]. The additional voltages induced by this pole would be expected to result in a change in the space-charge distribution in the upper atmosphere, in the sense that the positive space charges over the low and medium latitudes, and the negative over the north pole, would all be increased. Actually, the curves (Burkard's Figs. 13 & 14) for the variation with time of n in June and July show a clear maximum at 19^h. These months are distinguished by the fact that the atmosphere at the F_2 level, and at the north pole also, is exposed to the solar radiation even during the night; the thermal conditions and the ionisation are therefore much more stable than during the other months. The pole-transit effect is thus observable in these two months and also in April, May, and August—the months in which the north pole is illuminated during the 24 hours; whereas in the other months it is masked by other, probably thermal, effects.

" Another fact, that the measured charge-carrier density in the upper layers is always greater than the number of atoms and molecules in a unit of space which can be present at the pressures reigning at these heights, also becomes intelligible on the hypothesis of a conduction current through these layers. Some of the charges do not originate from ionisation of the atoms or molecules existing in the layer but are generated in the lower layers and migrate, along the lines of force, into the higher layers.

" As this brief treatment shows, the assumption that the upper atmosphere is part of a current circuit acted on by a voltage excited by the earth itself enables a large part of Burkard's results on the F_2 region to be accounted for qualitatively. A complete theory of the F_2 layer and the electrical layers of the upper atmosphere in general will be worked out as soon as war duties permit. It must take into account also the thermal effects (thermal expansion and contraction of the atmosphere) which naturally depend closely on the climate. Attention must further be paid to the fact that the electrical particles migrating from the pole to the equator, and in the reverse direction, are subjected to Coriolis forces which result in certain definite currents in the upper atmosphere. The theory of the electrical layers will be a part of a general theory of the geoelectrical phenomena which will cover the geoelectric vertical current, auroras, earth currents, and perhaps certain types of thunderstorm.

" Whereas the explanation of these phenomena has hitherto been either impossible or dependent on special and sometimes highly questionable assumptions, the recognition of the fact that the earth functions as a generator allows all the phenomena to be explained on a single consistent principle without special assumptions. It will show that all these geoelectric effects are closely interconnected and that one cannot be understood apart from the others."

In his reply, Burkard (writing under difficulties on war service far outside the borders of Germany) agrees that Michel's use of "a hitherto unconsidered assumption" does succeed, by and large, in explaining the observational data collected by himself; but wishes to make certain brief criticisms. He considers that to attribute the repeated rise in ionisation during the evening of the summer months (the dn/dt maxima in his own Figs. 13, 14) to the more stable thermal conditions at the pole in summer is less illuminating than the explanation (" not given by me alone") which assumes, precisely for those summer months, stronger thermal effects corresponding to the stronger alternation of the solar radiation. " Here, it is true, a point of observation in medium latitudes was taken; but the latest, not yet fully worked-out observations indicate that even in the polar region, in summer, thermally caused expansion and contraction of the layers play a not unimportant rôle. Also the fact that the maximum in question occurs later and later in the evening as April passes into midsummer, and in August and September again appears at earlier hours, supports my own explanation, by which this displacement in time of the dn/dt maximum is directly comprehensible.

" A much greater difficulty seems to me to lie in the fact that the electrical processes in the lower atmosphere cannot, directly, be brought into agreement with Michel's assumptions. It is true that Mauchly (ref. " 1 ", 1926) had already found that the potential gradient of the earth's electric field at all points on the sea reaches its maximum at the same absolute time, namely 19^h GMT, and Simpson seems to have been the first to point out the relation of this maximum to the position of the earth's magnetic pole. But the many available observations of the potential gradient, including as they do values for high latitudes, provide no grounds (as may be seen from Benndorf's survey in his *Lehrbuch der Geophysik*) for assuming that a reversal of sign occurs at the poles, as would be demanded by the assumption of a vertical current directed upwards at the poles.

" The density of this vertical conduction current amounts (on quiet days) only to about 3×10^{-16} A/cm^2 and the changes which could be caused by it in the charge-carrier density of the F_2 layer are thus, at a conservative estimate, about two to three orders of magnitude smaller than the changes observed, or calculated from the critical frequencies, which Michel seeks to explain by the conduction current. It seems therefore very necessary to await a quantitative working-out of the theory, in which the atmospheric-electricity specialist should have an important say; it will be the duty of ionospheric research to have ready further and comprehensive observational data, particularly from the polar regions. Perhaps it will then be possible to solve at one blow both the difficulties of the upper atmosphere and the problems of atmospheric electricity."

2844. The Oblique Incidence of Plane Electromagnetic Waves on the Ionosphere [neglecting the Influence of the Earth & the Earth's Magnetic Field: the " Optimum Transmission Distance."]—W. Becker. (*Hoch:tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, pp. 137–148.)

Report on the results of the calculations derived from an extensive investigation (German Academy of Aviation Research) which will appear soon in *Ann. der Physik*. Author's summary:—" The paper describes an examination of the influence of a plane ionospheric layer, inside which the electron concentration steadily decreases towards zero both above and below a maximum, on the space radiation proceeding from a horizontal aerial; for this purpose the approximately spherical wave leaving the aerial is replaced by plane waves which impinge on the ionospheric layer at various inclinations [this simplification, and the neglect of the influence of the earth and of its magnetic field, " seem to be justified because for long-distance transmission the waves are mostly 'beamed' by directive arrays and are not spherical waves, and the ground wave does not in general come into the question."]

" Particular attention is paid to the question where the signals radiated by such an aerial can best be received—best as regards the least possible distortion of the received signal, and best as regards the magnitude of the received amplitude. The 'apparent path-length' of the signal is calculated. Further, the values of the reflection- and transmission-coefficients of the ionospheric layer for plane electromagnetic waves incident on it at an arbitrary angle ϕ are calculated.

"The term 'optimum transmission distance for the reflected (or refracted) wave' is introduced to locate the point where the space wave has an 'optimum' reception. The term is interpreted as signifying the horizontal distance between the transmitting and receiving stations, when the latter is at the same distance from the middle of the layer as the transmitting station, and may be either below the layer (that is, on the surface of the earth, assumed to be plane) or above it, which of course is only possible in theory [so that consideration of this case might be thought to be illusory: "it possesses, however, a theoretical as well as a practical interest, especially where the simultaneous effect of several layers on the wave propagation is to be studied."]

"By the 'apparent path-length' of a signal is understood, according to the results of practical ionospheric research, the length of path which the signal would traverse during the same transmission time if it were propagated throughout the transmission with the velocity of light.

"Between the 'optimum transmission distance' for the reflected and the refracted wave and the 'apparent path-length' of the 'optimum' received signal, a relation is found which agrees completely, if the attenuation inside the layer is neglected, with the relation known from ray theory; namely that the apparent path-length is equal to twice the length of the equal sides of the isosceles triangle erected on the optimum transmission distance, with an angle 2ϕ at its vertex, ϕ being the angle between the incident ray and the normal at the point of incidence on the layer. This relation is independent of the data of the layer, provided only that the attenuation is neglected. The height of this triangle is called the 'apparent height' h_s [if the attenuation inside the layer is taken into account, "this result changes as shown in eqns. 23 and 24," the first of which is $2x_0/\lambda_0 = (h_s + z_0/\lambda_0) \tan \phi$, where x_0 is half the base of the triangle, that is, half the optimum transmission distance. If the receiver is assumed to be *above* the ionosphere, eqn. 23 still gives (for the refracted ray) the optimum transmission distance, as it did for the reflected ray. But if the attenuation inside the layer is taken into account, the apparent path-length of the refracted ray is given by eqn. 25, which differs from eqn. 24 in its last (correcting) term in the bracket, $(\Delta h_s)_D$, which is not the same as the $(\Delta h_s)_R$ of eqn. 24, though both become zero when ν, the number of collisions per second, is zero. For this correcting term *see* also Fig. 8 and the end of p. 145].

"This apparent height h_s is calculated for various working conditions and layer data, and represented graphically. It is seen at once from these diagrams that for any given angle of incidence ϕ of the space radiation on the ionosphere there is only *one* definite 'optimum transmission distance' corresponding to it; and further, that an 'optimum transmission' (in the sense defined above) by means of 'glide' waves [waves guided along the surface of separation between two layers: hypothesis supported by Burkard, 690 of 1941] is not possible [end of p. 142, continued on p. 143].

"For the estimation of such long-distance transmission possibilities the only determining factor is the ratio $\omega/\omega_0 = \xi$ between the working frequency ω and the limiting frequency ω_0. If $\xi \cos \phi$ is made greater than unity, a long-distance transmission of signals is no longer possible: $\xi \cos \phi = 1$ is the upper limit for this. Long-distance communication is the more liable to break down, the nearer $\xi \cos \phi$ approaches unity; particularly so where ϕ is very large, *i.e.* for grazing incidence.

"The absolute value of the reflection coefficient $|R|$ of a plane ionospheric layer is unity for a value of $\xi \cos \phi$ less than unity, if the attenuation in the layer is neglected. If $\xi \cos \phi$ is made about equal to or greater than unity, $|R|$ decreases exponentially and very rapidly. If the layer attenuation is considered, $\xi \cos \phi = 1$ is the limit for a strong exponential decrease of $|R|$ as $\xi \cos \phi$ is increased. $\text{Log}_e |R|$ is, in a first approximation, proportional to the layer thickness measured in limiting (vacuum) wavelengths.

"Partial reflection at an ionospheric layer is in practice only possible (theoretically it is always possible) if $\xi \cos \phi$ is about equal to unity. The frequency band for partial reflection becomes narrower with the increase either of ϕ or of $|\xi - 1|$: it is therefore at its widest for zenithal reflection." A signal reaching the ionosphere with a marked carrier-frequency spectrum is strongly distorted at reflection. "On account of the rapid exponential decrease of the reflection coefficient on an increase of ξ or a decrease of ϕ (*see* also Fig. 11), only that part of the frequency spectrum for which $\xi \cos \phi$ is less than or equal to unity is reflected appreciably from the ionosphere. The receiver will therefore register a signal of a somewhat lower middle carrier frequency than that radiated out to the ionosphere; the mean propagation velocity of this signal will consequently be smaller than c, the velocity of light. Corresponding considerations for the case $\phi = 0$ have already been dealt with by Rawer (359 [*see* also 2938] of 1942). The previously discussed super-light-velocities of the signals for the *refracted* wave, when $\xi \cos \phi$ is appreciably smaller than unity (p. 144), thus finds its explanation: in this connection we were dealing with super-light-velocities for a fluctuation [with $\Delta\omega$ about 50 per second] and not for an actual signal": extract from p. 145.

2845. ON THE ORIGIN OF THE IONOSPHERIC E LAYER.—J. Gauzit. (*Comptes Rendus* [Paris], 2nd/30th Aug. 1943, Vol. 217, No. 5/9, pp. 179–181.)

No one so far has proposed a completely satisfactory hypothesis for the origin of the E layer, nor for the maintenance of a comparatively high ionisation during the night. Certain writers attribute the formation of the layer to photochemical ionisation of the oxygen molecules, but it is generally considered that the ultra-violet solar radiation is much too weak to produce the observed ionisation; "we hesitate to admit, with N. Saha [2860 of 1937], that this radiation would be 10^6 times more intense than that of a black body at 6800° K. An ionisation starting from a metastable level (for example that of oxygen ^1S atoms), as suggested by Jouaust (*ibid.*, Vol. 214, 1942, p. 441), is evidently possible, but does not explain the nocturnal ionisation.

"We wish to call attention to a mechanism capable of provoking the appearance of a con siderable number of electrons at about the height of the E layer: two metastable ^1S atoms of oxygen may combine by double impact to form an ionised molecule and an electron: $O(^1S) + O(^1S) \rightarrow O_2^+ (X^2\Pi)$ + electron . . . (reaction "1"); the liberation of the electron permits the fulfilment of the conditions of conservation of energy and of momentum at the time of the collision; moreover, the combination of the two ^1S atoms provides an energy of 13.5 ev, greater than the ionisation energy of the molecule formed (12.5 ev). If it is agreed, with Wentzel, that a spontaneous ionisation requires a time of the order only of 10^{-15} s, it may be anticipated that each collision of two ^1S atoms would be followed by the above-mentioned reaction, since the duration of these collisions is about 10^{-13} s.

"The abundance of ^1S atoms of oxygen is relatively great at about 10 km, in the narrow zone forming the transition between the upper atomic atmosphere and the lower molecular atmosphere (Gauzit, 1891 of 1942). The recombinations by triple collision liberate an amount of energy sufficient to carry the oxygen atoms to the ^1S level (Chapman, 2068 of 1937); lower down, the proportion of atomic oxygen decreases, while at higher levels the triple collisions rapidly become more rare.

"Between the formation of oxygen atoms, by photochemical dissociation of the molecules, and the liberation of an electron there is only a short time interval at 100 km, since 10^3 s is on the average long enough for an atom of oxygen to undergo a triple collision which will raise it to the ^1S level, whose length of life is only 0.5 s but long enough for the reaction ("1") to occur. Thus the complex mechanism, photochemical dissociation of O_2, excitation by triple collision of the O atoms to the ^1S state, encounter between the two ^1S atoms leading to the liberation of an electron, presents analogies to a direct photochemical ionisation and offers an explanation of the increase of ionisation towards mid-day and its decrease during solar eclipses.

"The recombination of the oxygen atoms continues all night, creating ^1S atoms and electrons. It tends to propagate itself slowly in altitude, but at the same time a contraction of the upper atmosphere occurs towards the region of the E layer, where the recombinations have produced a diminution of pressure.

"Moreover, the maintenance of ionisation during the night can equally well result from a combination of our process with that proposed by Martyn & Pulley (2073 [& 3677] of 1936), namely the formation of negative ions by fixation of the electrons on the atoms of oxygen, followed by a recombination of these ions with the normal atoms; since this last mechanism can supply the liberated electrons with an amount of energy sufficient to shock-excite the normal oxygen atoms and carry them to the ^1S level.

"We are led to conjecture a parallelism between the ionisation of the E layer and the intensity of the green ray of the night sky, for both phenomena depend on the concentration of the upper atmosphere in ^1S atoms of oxygen. Up to the present there are few data available to verify such a relation, but it is at least known that the E-ionisation presents in general a rapid decrease at sunset, followed by a weak maximum towards midnight, which is true also of the green-ray intensity."

2846. Excitation Processes in the Night Sky and the Aurora [Emission Spectra, and Their Intensity Distributions & Diurnal Variations, explained on view that All Upper-Atmospheric Excitation & Quenching Processes are Collisions of Second Kind between Metastable Atoms & Molecules of N_2 & O_2].—Wu Ta-You. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 67.)

2847. Dissociation Energy of Nitrogen [New Value of 9.764 eV instead of the Accepted 7.383 eV (van der Ziel): and 6.49 eV for Nitric Oxide instead of 5.29 eV].—A. G. Gaydon. (*Nature*, 1st April 1944, Vol. 153, No. 3883, pp. 407–408.) Following on 3493 of 1942: for other recent work *see* 1851/2 of June.

2848. Singlet Terms in the Spectrum of Molecular Nitrogen [Suggested Revised Notation to avoid Confusion: List of Known Singlet States].—A. G. Gaydon & R. E. Worley. (*Nature*, 17th June 1944, Vol. 153, No. 3894, p. 747.) Prompted by the danger of confusion in the two papers dealt with in 1851 of June and 1111 of April, respectively.

2849. A New Forbidden Transition of the Neutral Nitrogen Molecule.—Renée Herman. (*Comptes Rendus* [Paris], 2nd/30th Aug. 1943, Vol. 217, No. 5/9, pp. 141–143.)

2850. Application of Pulses of X-Rays to the Measurement of the Probability of Fixation of Electrons on Oxygen Molecules [and Comparison of Results with the Bloch-Bradbury Electron-Capture Formula (344 of 1936)].—P. Herreng. (*Comptes Rendus* [Paris], 2nd/30th Aug. 1943, Vol. 217, No. 5/9, pp. 135–137.) For previous work *see* 2985 of 1942 and 1586 of 1943.

2851. On the Origin of Cosmic Rays and on the Mean Lifetime of Atoms.—B. Fessenkoff & N. Parijskij. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 20th May 1943, Vol. 39, No. 5, pp. 184–186: in English.)

It is shown that the Galaxy is nearly transparent to cosmic radiation and that this has its origin in the Metagalaxy. The mean lifetime of atoms is found to be 1.6×10^{17} years. "The recognition of the spontaneous annihilation of matter leads directly to many consequences of astronomical importance."

2852. Anomalous Rate of Nuclear Disintegration effected by Cosmic Rays [Preliminary Report].—A. P. Zhdanov & others. (*Phys. Review*, 1st/15th March 1944, Vol. 65, No. 5/6, pp. 202–203.)

"It is of great interest to find out whether the increase [of the components responsible for nuclear disintegrations] is a general one and how long it will last (it may be the result of a cosmic catastrophe and thus a similar anomaly could be observed in other places of the globe) or whether it is a local one . . ." From the Kazan Radium Institute.

2853. The Use of the Interference Polarising Monochromator [for Viewing & Photographing the Solar Chromosphere, Prominences, & Bright Eruptions].—E. Pettit. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 49.)

2854. TENTATIVE THEORY OF SOLAR PROMINENCES.—H. Alfvén. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 50.)

2855. THE OUTER SOLAR CORONA AT THE TOTAL ECLIPSE OF 21ST SEPTEMBER, 1941.—B. Fessenkoff. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 30th May 1943, Vol. 39, No. 6, pp. 213–214: in English.)

"The conception of a spherical shape of the outer corona, put forward by some American astronomers, is not correct. The zodiacal light is totally absent from the eclipse sky, in contradiction to the indication of some Japanese observers. The above-described method provides a simple means of judging the real form of the corona, as it might be observed without our atmosphere."

2856. EARTH SURFACE UNDER ULTRA-VIOLET AND INTEGRAL RADIATION OF THE SKY, *and* SOLAR RADIATION INTENSITY FOR REAL AND IDEAL ATMOSPHERE.—N. N. Kalitin. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 20th April 1943, Vol. 39, No. 2, pp. 53–56: 10th May 1943, Vol. 39, No. 4, pp. 133–136: both in English.)

(i) "The results are summed up of a study of alterations in the ultra-violet and integral flow of atmosphere-scattered radiation, as depending on meteorological conditions, mainly on cloudiness. . . . Still greater interest attaches to a similar work in which the spectrum will be divided into several separate parts. . . These data are necessary for observations made from aeroplanes (air-survey, choice of contrasting filters, etc.)."

(ii) Among other points, the results, based on abundant data, are so consistent that "one feels authorised to speak of a mean, or in other words a normal, magnitude of the intensity of solar radiation for a mean state of atmosphere transparency."

2857. RELATION BETWEEN THE DISPERSION OF REFRACTION IN THE INFRA-RED ON THE ONE HAND AND THE VISIBLE AND ULTRA-VIOLET ON THE OTHER [Discovery that the Curve representing the Variations of the Square of the Refractive Index as a Function of the Logarithm of the Wavelength presents a Point of Symmetry: leading to a New Dispersion Formula].—L. Amy. (*Comptes Rendus* [Paris], 2nd/30th Aug. 1943, Vol. 217, No. 5/9, pp. 227–229.)

2858. EQUATION OF RADIANT ENERGY TRANSFER AS APPLIED TO PROBLEMS OF SEA OPTICS.—B. V. Ovchinsky. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 30th April 1943, Vol. 39, No. 3, pp. 96–101: in English.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2859. LIGHTNING: MEASURING LIGHTNING CURRENT PHOTOGRAPHICALLY: EQUIPMENT, PROCEDURE, AND EXAMPLES OF RESULTS.—J. W. Flowers. (*Gen. Elec. Review*, April 1944, Vol. 47, No. 4, pp. 9–15.)

2860. FIELD DISTURBANCES PRODUCED BY LIGHTNING.—G. D. McCann & D. E. Morgan. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 67.) *Cf.* Wichmann, 3277 of 1943.

2861. THE DETERMINATION OF VERTICAL VELOCITIES IN THUNDERSTORMS: II, *and* DYNAMICS OF THUNDERSTORMS.—C. E. Buell: S. L. Malurkar. (*Sci. Abstracts*, Sec. A, Feb. 1944, Vol. 47, No. 554, p. 46: p. 46.)

PROPERTIES OF CIRCUITS

2862. THE IMPEDANCE OF A TRANSVERSE WIRE IN A RECTANGULAR WAVE-GUIDE.—S. A. Schelkunoff. (*Quarterly of Applied Math.* [Brown University], April 1943/Jan. 1944, Vol. 1, p. 78 onwards: an 8-page paper.)

"Approximate formulae are derived for the impedance of a transverse wire extending from side to side of a rectangular wave-guide, the radius of the wire being small, the current uniformly distributed over the wire, and the wave-guide infinitely long on both sides of the wire. The internal impedance of the wire is given by the usual theory. The external impedance is obtained as an infinite series, each term of the series being associated with an individual *TE* (transverse electric) wave generated by the current in the wire. The series thus obtained converges slowly; it is shown how to transform this series into a more rapidly convergent series. The analysis is extended to include the use of a split wire, that is, a transverse wire extending from side to side of a rectangular wave-guide as before, but broken by a short gap in the wire." (summary by R. M. Foster in *Math. Reviews*). *Cf.* Miles, 2476 of August.

2863. DETERMINATION, BY MEANS OF THE IMPEDANCE TRANSFORMATION, OF THE VOLTAGE OR CURRENT PHASE DIFFERENCE BETWEEN INPUT AND OUTPUT OF A FOUR-TERMINAL NETWORK.—A. Weissfloch. (*Hochf: tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, pp. 149–150.)

In the earlier paper dealt with in 3286 of 1943, the writer showed how the impedance transformation of a quadripole yields directly the ratio of the current or voltage values at the input and output: thus if a quadripole transforms the terminating impedance $\mathfrak{R}_2 = R_2 + jX_2$ (*see* Fig. 1) into the value $\mathfrak{R}_1 = R_1 + jX_1$, then for example, for a loss-free quadripole, $|J_2^2|/|J_1^2| = R_1/R_2$. As regards the *phase* between the currents J_2 and J_1 the paper stated that for its determination it would be necessary to construct an equivalent-circuit diagram of the quadripole, from which the phase difference could be calculated. "If such a construction is actually made, a suprisingly simple result is obtained which is reported below . . ."

Dealing first with the phase relation between J_1 and J_2 for a loss-free quadripole, it is pointed out that the mere statement that for a particular case of loading the loss-free quadripole transforms, for instance, the impedance $\mathfrak{R}_2$ into $\mathfrak{R}_1$ (Fig. 1), is not sufficient to determine unequivocally its transformation properties at the frequency in question. It is still necessary to know that, for example, it transforms the direction-element $d\mathfrak{R}_2$ through $\mathfrak{R}_2$ into the direction-element $d\mathfrak{R}_1$. "Now it is also possible to construct an equivalent-circuit diagram which represents unequivocally the transformation properties of the quadripole for the frequency concerned. For our purpose the diagram of Fig. 2 is found to be suitable. Starting from the terminating resistance $\mathfrak{R}_2 = R_2 + jX_2$ we come first to the series reactance $-jX_2$, then to an ideal transformer converting R_2 into R_1. This leads to a section of uniform line of characteristic impedance R_1 and length $l = \alpha\lambda/720$, where α is the angle (positive in the clockwise direction) through which the direction $d\mathfrak{R}_2$ must be rotated to the direction $d\mathfrak{R}_1$. Finally, in front of the whole circuit, comes the series reactance $+jX_1$.

"Of the whole arrangement of Fig. 2 only the uniform line has a phase-rotating action on the current: except that the ideal transformer can rotate the phase through 180°, and also the length of the uniform line is fixed unequivocally only within multiples of $\lambda/2$: consequently the impedance transformation by itself will only give the phase to within multiples of 180°. But the uniform line of length $l = \alpha\lambda/720$ rotates the phase of the current by just the angle $\alpha/2$. Thus the following very simple result is obtained :—if the direction-element $d\mathfrak{R}_2$ has to be rotated in the clockwise direction through the angle α in order to take up the direction $d\mathfrak{R}_1$, then the current J_2 lags behind the current J_1 by the phase-angle $\alpha/2 + n.180$, where $n = 0, 1, 2 \ldots$"

Considering next the phase relation between the currents J_1 and J_2 in the case of an arbitrary passive quadripole, this quadripole can be resolved into a loss-free and a loss-endowed component as in Fig. 3 (*see* also end of 3286 of 1943). The rule then obtained is as follows :—"If a quadripole transforms the terminating impedance $\mathfrak{R}_2$ into $\mathfrak{R}_1$, and simultaneously the direction-element $d\mathfrak{R}_2$ through $\mathfrak{R}_2$ into $d\mathfrak{R}_1$, where the direction $d\mathfrak{R}_2$ must move into the direction $d\mathfrak{R}_1$ through the angle α, then the current J_2 in $\mathfrak{R}_2$ will lag by the phase-angle $\alpha/2 + n.180$ ($n = 0, 1, 2 \ldots$) behind the current J_1 in $\mathfrak{R}_1$." Finally, the voltage phase-relation in an arbitrary passive quadripole can be derived from the last result, or alternatively a precisely similar rule can be derived directly from the admittance diagram, or even, without drawing the latter, from additions to the impedance diagram.

In a postscript the writer points out that since the rotation of the direction-element in Fig. 1 corresponds to the phase-rotation of the current, the rule derived in his earlier paper can be extended to read :—"There is always a loss-free quadripole which, for constant frequency, fulfils the requirement that it should transform a given impedance into any other desired value (*not* a reactance) and at the same time should rotate the phase of the current or voltage through any required angle. With these requirements the transformation properties of the quadripole for the frequency concerned are unequivocally determined."

2864. *Q* OF *LC* CIRCUITS [Calculation in Resonant Circuits using Transmission Lines as Part of Circuit].—F. M. Bailey. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, Supp. pp. 13–15.)

2865. THEORETICAL GAIN AND SIGNAL-TO-NOISE RATIO OF THE GROUNDED-GRID [Cathode-Input] AMPLIFIER AT ULTRA-HIGH FREQUENCIES.—Dishal. (*See* 2883.)

2866. THE RELATIONS BETWEEN SIGNAL VOLTAGE AND NOISE VOLTAGE IN THE FREQUENCY CONVERSIONS OF WIRELESS MULTI-CHANNEL TELEPHONY.—Huber. (*See* 2884.)

2867. CONTRIBUTION TO THE THEORY OF CORRECTED NON-LINEAR NETWORKS [with Special Reference to Negative Feedback].—J. Peters. (*Hochf:tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, pp. 150–156.)

A transmission path may include certain components which can be regarded as linear within a certain range of control but which, when this limit is passed, produce non-linear distortions. In the desire to fulfil a technical task as economically as possible, successful attempts have been made to diminish the non-linear distortion of the whole network by devices of circuit technique. It then becomes possible to use the transmission path to fuller advantage and with only slight non-linear distortion, and in many cases to attain the highest value of output power which the system as a whole can give. It is just this considerable success in reducing non-linear distortion that makes it specially desirable to have a method of calculation by which the corrected non-linear characteristic can be calculated for any given static characteristic (for since individual circuit elements may be taken past their limits of linearity well before the distortion limit of the whole network is reached, the functioning of such an arrangement can no longer be dealt with by purely linear methods of calculation). Then when the two characteristics have been worked out by the power-series method described in an earlier paper (400 of 1942), a comparison will give the reduction of the non-linear distortions.

Author's summary and conclusion :—"Whereas according to theory a complete removal of non-linear distortion by the method of compensation should be possible, in practice it leads to only a partial success. But in addition it is possible, by the use of negative feedback, to reduce *all* non-linear distortions within a certain control region down to an arbitrarily small residue. It is shown that the distortions, in the region where the original distortions were small, decrease in proportion to the negative-feedback coefficient. In the region with high non-linear distortion a certain portion decreases similarly in proportion to the negative-feedback coefficient, but there occur also additional distortions of higher order, owing to which the total distortion decreases less than proportionately [p. 153]. Negative feedback therefore causes a steepening of the distortion-rise towards the limit of control.

"It should be added here that the possible reduction of non-linear distortion by negative feedback has also a practical limit. It has been assumed up to the present that the input voltage could be increased without limit to make up for the drop in amplification due to the negative feedback. This is naturally not the case in practice. A pre-amplifier introduced for the purpose would also provide distortions, which would increase with increase of level.

"The above considerations may now be extended to a complete cascade of amplifiers, each stage of which has negative feedback. While more precise investigations will be kept back for a later occasion, it may be mentioned here that in this way the non-linear distortions are more completely reduced by negative feedback than all other amplifier errors. It is only the non-linear distortions that increase with increasing control, and therefore appear less strongly in the earlier stages; the other errors are not dependent on the degree of control. It may be stated that the calculations made elsewhere, for linear errors, as to the optimum amplification ratio are not valid for the improvement of non-linear errors. On otherwise similar assumptions the non-linear distortions diminish by a higher factor than the linear. The law for the amplifier cascade derived *here* is only strictly valid when the non-linear errors in the early amplifiers are so slight, owing to the lower level, that they practically fail to raise the total result. But that level can be lower only if the negative-feedback coefficient is smaller than the original amplification factor, since otherwise the remaining amplification would be less than unity. Thus in the case of non-linear distortions also the improvement factor is dependent on the original amplification factor. The highest value of the attainable improvement factor is therefore, for non-linear distortions, at least equal to the value holding for all other amplification errors (Peters, 2981 of 1942), and at most equal to the amplification factor enclosed by the negative-feedback path."

2868. CORRESPONDENCE ON "CONTRIBUTIONS TO THE THEORY OF AUTOMATIC CONTROLLERS AND FOLLOWERS" [2166 of July].—D. G. Prinz. (*Journ. of Scient. Instr.*, June 1944, Vol. 21, No. 6, pp. 110–111.)

2869. USE OF A RECTIFIED-RETROACTION RELAY AMPLIFIER IN AN ELECTRONIC "BABY ALARM."—Worthington. (*See* 3081.)

2870. THE GRAPHICAL DESIGN OF CATHODE-OUTPUT AMPLIFIERS [Cathode-Followers].—D. L. Shapiro. (*Proc. I.R.E.*, May 1944, Vol. 32, No. 5, pp. 263–268.)

"Where triodes are concerned, the information contained in these cathode-follower graphs is the same as that in these published characteristics [manufacturers' plate-current/plate-voltage characteristics], and hence can be drawn accurately from them. They can be approximated more quickly from a knowledge of the transconductance and plate resistance of the tube concerned.

"Published pentode characteristics do not generally contain the required information for construction of cathode-follower graphs, and so the approximate characteristics must be resorted to until such time as more appropriate data are published by the tube manufacturers. However, these approximate characteristics are satisfactory for most applications.

"The use of these graphs will simplify cathode-follower design considerably as compared with a trial-and-error method. They will supply directly the information in a given design as to where cut-off of the tube or drawing of grid current may be expected, and as to the ratio of output to input voltage levels.

"Further investigation of cathode-followers should include the operation of several variations of the basic circuit [for recent German work *see* 36 of 1943, 410 & 411 of February, and 1880 of June] and should, perhaps, cover more thoroughly than has been done in the past the effect of reactive elements in the circuit, as well as other high-frequency effects."

2871. ADDITIONAL CORRECTING POSSIBILITIES FOR THE UNIVERSAL AMPLIFIER TYPE I [in the German Long-Distance Telephone Cable Network].—K. Oettl. (*T.F.T.*, Nov. 1943, Vol. 32, No. 11, pp. 225–231.)

2872. GRAPHICS OF *RC* NETWORKS [Graphical Method of Analysis, with Particular Reference to Various Types of *RC* Oscillator].—R. C. Paine. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, Supp. pp. 7–9 and 30.)

2873. DIFFERENTIATING AND INTEGRATING NETWORKS.—C. H. Foell. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, Supp. pp. 24–26 and 36.)

2874. A METHOD FOR DETERMINING THE NORMAL MODES OF FOSTER'S REACTANCE Networks.—W. R. LePage. (*Sci. Abstracts*, Sec. B, March 1944, Vol. 47, No. 555, p. 50.) A summary was dealt with in 2681 of 1943.

2875. THE CALCULATION OF INDUCTIVE CIRCUITS WITH SWITCHING ARCS [Invalidity of Ayrton-Type Equation $u_B = f(i)$: Tests leading to Equation of Type $u_B = f(t)$ and to an Integrable Approximation Function of Practical Use].—J. von Hake, H. Mackh, & F. Moeller. (*E.N.T.*, Jan. 1943, Vol. 20, No. 1, pp. 5–10.)

2876. PAPER ON AN ANALYTICAL INVESTIGATION OF TRANSIENT PROCESSES WHEN THE SPEED OF A SHUNT MOTOR IS CONTROLLED BY THE CHANGE OF THE EXCITATION FLUX [Inadequacy of Usual Methods consisting in Integrating the Differential Equations of Electric-Drive Theory: Method involving Use of Non-Elementary Transcendental Functions].—V. P. Nikitin & others. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 10th May 1943, Vol. 39, No. 4, pp. 129–132: in English.)

2877. ON MECHANICAL ANALOGIES.—R. O. Kapp. (*Distribution of Elec.*, July 1944, Vol. 17, No. 155, pp. 270–272.)

TRANSMISSION

2878. MAGNETRON OSCILLATOR FOR INSTRUCTION AND RESEARCH IN MICROWAVE TECHNIQUES.—J. T. Tykociner & L. R. Bloom. (*Proc. I.R.E.*, May 1944, Vol. 32, No. 5, pp. 299–308.) Already dealt with in 2572 of August.

2879. A THREE-PHASE ROTATING-FIELD TRANSMITTER FOR ULTRA-SHORT WAVES [for Omnidirectional Broadcasting, especially in Television].—W. Dieterle. (*Hochf:tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, pp. 160–161: summary only.)

This is a long illustrated summary of the Swiss paper, an abstract of which was dealt with in 3340 of 1943. The requirement that the aerial shall radiate in every direction in the horizontal plane a field with its electric vector horizontal can be fulfilled by a horizontally mounted rotating-field (turnstile) aerial, equivalent to a rigid electric dipole rotating with the frequency of the radiated waves. It can take various forms, for example that of two dipoles at right angles to each other and supplied with currents phased at 90° to each other. The present work deals with an alternative form, the symmetrical tripole aerial seen in Fig. 1, fed with three-phase energy from the rotating-field transmitter described, with the basic circuit of Fig. 2. The question of matching the three-phase feeder to the aerial is discussed, together with the calculation of the radiation resistance of the aerial and the total radiated output (for the experimental model, about 300 watts). *See* also Hardung, 2897, below.

2880. Low-Frequency Radio-Telephone Transmitter : Constructional Details of a Military-Style Transmitter operating at the Lower Frequencies, 440–660 kc/s, which are used for Dependable Communications.—McMurdo Silver. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, pp. 28–30 and 72..78.)

2881. Broadcast Transmitter Maintenance [Analysis of Common Failures, with Suggestions for Correction].—P. A. Berg. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, Supp. pp. 18–22 and 46, 47.)

2882. The Development of a New Wheatstone Transmitter [Speed Range 13–250 Words per Minute without Gear Change, Governed Speed at All Settings (Variations about ± ½%) with Direct Speed Indication, & Other Advantages].—K. L. Jensen. (*P.O. Elec. Eng. Journ.*, April 1944, Vol. 37, Part 1, pp. 7–10.)

RECEPTION

2883. Theoretical Gain and Signal-to-Noise Ratio of the Grounded-Grid [Cathode-Input] Amplifier at Ultra-High Frequencies.—M. Dishal. (*Proc. I.R.E.*, May 1944, Vol. 32, No. 5, pp. 276–284.)

At radio frequencies both the classic grid-input ("grounded-cathode") circuit and the cathode-follower ("grounded-plate") circuit suffer from undesired feedback between the output and input circuits, leading to the need for neutralisation. A third method of using a triode as an amplifier is to apply the input signal between the grid and the cathode and to obtain the output between the grid and the plate: this is the "grounded-grid" or "cathode-input" circuit ("inverted amplifier": Strong, 4230 of 1940), with low input impedance and high output impedance and the capability of enabling a suitable triode to be used without neutralisation at very high and ultra-high frequencies.

Apart from the extra stability of the grounded-grid circuit, the question of signal/noise ratio is of importance. "Because it was felt that there is a real advantage, in so far as circuit adjustments are concerned, in working with circuits designed for maximum gain, no attempt has been made to find the values of N_1 and N_2 [effective step-ups of input and output circuits] which make the signal/noise ratio a maximum. Rather, the maximum-gain condition will be used and the signal/noise ratio for this condition will be found. . . ." When these maximum-gain conditions have been derived, it is found that for a specific valve (acorn 955) the noise factor of a receiver using the grounded-grid circuit is almost 3.5 db smaller than that of a receiver using the grid-input circuit. This is for a frequency of 100 Mc/s: at higher frequencies the two noise factors approach the same values, so that at about 400 Mc/s there is practically no advantage, so far as signal/noise ratio is concerned, in using cathode feed.

2884. The Relations between Signal Voltage and Noise Voltage in the Frequency Conversions of Wireless Multi-Channel Telephony.—E. Huber. (*Hochf:tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, p. 160: summary only.)

This is the Dissertion mentioned in 798 of March. "From general considerations the conditions are discussed which should be obtained in a wireless multi-channel system intended as a substitute or supplementary means of communication in a wired telephonic system. The starting point is provided by the fact that the same requirements as to transmission-quality apply to a wireless link as to an ordinary telephone link. Comparison of the two noise-level diagrams brings out a critical point in a wireless link—the susceptibility to interference at the receiver-input. The various possible sources of interference are discussed, and it is shown that the magnitudes of the individual interference-voltages can easily be found and the signal/noise voltage ratio at the receiver input thus be calculated.

"The multi-modulated signal undergoes in the receiver a multiple frequency-conversion; how the interference-voltages behave in this process cannot be derived by direct considerations, and the signal/noise voltage ratio in the a.f. speech channel at the receiver output has no simple relation to the ratio at the input. The complex relation is due to the non-linear processes in the receiver, without which no frequency-conversion would be possible. If the r.m.s. values of all the signal and noise spectra falling in the a.f. transmission channel are calculated, the signal/noise voltage ratio can be derived, and this gives, through the equation obtained, the dependence on the signal/noise voltage ratio at the receiver input." If this measurable and usually predetermined signal/noise voltage ratio in the a.f. speech channel at the receiver output is denoted by Q, and the ratio of the unmodulated voltage of the h.f. carrier at the receiver input (a measure of the transmitter power) to the noise voltage at the receiver input by x (this is the quantity generally looked for), then it is shown how the quantity $P = x/Q$ may be calculated for multi-channel systems of quite different types of design, with different numbers of transmission channels, and so on: the calculation is limited to the case of amplitude modulation.

If however the arriving signal cannot be considered as free from interference, and a certain noise-level of signal/noise voltage ratio R is transmitted with it, then $P = xR/Q\sqrt{R^2 + x^2}$, or $x = P \cdot Q \cdot R/\sqrt{R^2 - P^2 \cdot Q^2}$, a relation which for $R = \infty$ (zero interference voltage) becomes the original $x = PQ$. The discussion of the calculated expressions for P shows among other things the influence of the statistical speech-voltage distribution, the good effect of contrast compression (raising of the modulation factor), the unfavourable effect of the size of the h.f. carrier (leading to a recommendation of the reduction of the h.f. carrier for a constant transmitting power), and so on. Further, the importance of a partial suppression of the auxiliary carriers and of their second sidebands is discussed. The task of the designer is now, knowing the relations between the various variants in the construction of a wireless multi-channel system and the signal/noise voltage ratio at the receiver output, to find that system which will give, for a tolerable expenditure, a favourable value of this ratio.

2885. THE ELECTRICAL OSCILLATIONS IN IONIC RECTIFIERS.—Hochrainer. (*Elektrot. u. Masch:bau*, 6th Aug. 1943: short summary in *Génie Civil*, 15th Jan. 1944, Vol. 121, No. 2, p. 20.)

2886. HIGH-VOLTAGE OUTDOOR PORCELAIN INSULATORS AND THE POLLUTION PROBLEM.—G. H. Gillam. (*Distribution of Elec.*, July 1944, Vol. 17, No. 155, pp. 284–287.) "The latest and most hopeful method of attack" (the use of a semiconducting glaze: 2993 of 1943) is discussed at the end: *cf.* 2374 of 1943: *also* 1358 of 1941.

2887. ACTIVATION OF CATALYTIC SUBSTANCES BY ELECTRIC WAVES [Catalytic Action of Metal Powders is Increased by Irradiation, explaining Coherer Effect as due to Generation of Active Centres formed by Sintered Bridges: Measurements on Decomposition of N_2O in presence of Ni].—J. A. Hedvall & G. A. Algren. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 63.)

2888. ON THE OCCURRENCE OF ACOUSTICAL FEEDBACK IN SHORT-WAVE RECEPTION WITH HETERODYNE RECEIVERS, AND POSSIBILITIES OF HINDERING IT.—W. Piltz. (*E.N.T.*, Jan. 1943, Vol. 20, No. 1, pp. 17–27.)

A summary of this paper was dealt with in 1917 of June. A large part of it (pp. 20–24) is devoted to a theoretical and experimental investigation of the capacitance fluctuations (due to mechanical and electrical influences) of a high-quality modern variable air-condenser; including the description of the equipment used for measuring these periodic variations in the frequency range 30–10 000 c/s. The main improvement was obtained by increasing the plate thickness from 0.6 mm (a thickness which is satisfactory in the workshop and economical in material) to 1.0 mm: to prevent an increase in the size of the condenser the thicker plates were mounted closer together (air-gap reduced from 0.4 mm to 0.3 mm) so that the number of plates could be reduced.

Elsewhere in the paper, "the occurrence of frequency modulation of the oscillator oscillations, owing to the capacitance fluctuations of its condenser, is dealt with, and it is shown that the frequency deviation Δf is proportional to the fundamental frequency of the oscillator. From this it is possible to calculate the factor by which the variable condensers must be improved. The deviation Δf transfers itself at its full amount to the intermediate frequency. . . As the resonance curve of a band-filter shows, the transmission equivalent away from the resonance frequency is highly dependent on frequency, so that fluctuations of the intermediate frequency are transformed into fluctuations of its amplitude. The amount of the amplitude modulation depends on the steepness of the resonance curve. It is shown theoretically and experimentally that with loosely coupled band-filters the detuning df, corresponding to the point of 'optimum' amplitude modulation, is smaller than with critical coupling; it is therefore of advantage in short-wave reception to give up loose coupling for the band-filter."

2889. GRAPHICAL GANG CALCULATIONS [in Superheterodyne-Receiver Tracking Problems].—J. J. Adams. (*Proc. I.R.E.*, May 1944, Vol. 32, No. 5, pp. 272–275.)

From the Zenith Radio Corporation. "It is possible to calculate graphically the inductance and capacitance for cut gangs and padded gangs for superheterodyne receivers. The method for cut gangs [*i.e.* with differently shaped plates in the two sections] is as accurate as the plotting [and "much less laborious"]. For the padded gang [where the same plate shapes are used in the two sections and a padding condenser is added] this is very nearly true. One assumption made in the calculations is found to be very accurate" [the assumption that, in the padded-gang circuit of Fig. 3, $C_2 = C_2C_3/(C_2 + C_3)$]. For the padded gang, "the tracking-error curve can be found from the hyperbola. To do this, a smooth curve must be drawn through the points already obtained. For the determination of the circuit constants, only four points on the hyperbola need be plotted, excepting the three given points. These solutions involve considerable work, but probably not as much as the involved formulae and calculations necessary with the regular solution, and they present a picture of the problem that the formulae fail to do."

2890. SERVICING RADIO OSCILLATORS: MODERN METHODS OF EFFICIENTLY SERVICING SUPERHETERODYNE OSCILLATOR CIRCUITS, USING PRESENT-DAY EQUIPMENT.—J. B. Crawley. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, pp. 26–27 and 58..62, 83, 84.)

2891. G.I. RADIO SERVICING: THE PROBLEMS OF A G.I. RADIO TECHNICIAN IN SERVICING RADIO RECEIVERS, USING AVAILABLE PARTS.—W. Fernald. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, pp. 47 and 78, 80.) Article prompted by experience of the common excuse that repairs are impossible owing to lack of parts and valves.

2892. WAR-TIME CIVILIAN RADIO RECEIVER [Regulations as to Prices].—(*Electrician*, 7th July 1944, Vol. 133, No. 3449, p. 20.)

2893. "THE TECHNIQUE OF RADIO DESIGN," *and* "RADIO RECEIVER DESIGN, PART I" [Book Reviews].—E. E. Zepler: K. R. Sturley. (*Proc. I.R.E.*, May 1944, Vol. 32, No. 5, p. 312: pp. 312–313.) For previous reviews *see* 2191 of July and back references.

AERIALS AND AERIAL SYSTEMS

2894. A New Approach to the Solution of High-Frequency Field Problems, *and* Equivalent Circuit of the Field Equations of Maxwell : I.—Whinnery & Ramo : Kron. (*See* 2838.)

2895. Polarisation Measurements in the Field of a Horizontal Transmitting Dipole [in connection with the Production, for Propagation Research, of Arbitrarily Polarised Fields].—Grosskopf & Vogt. (*See* 2842.)

2896. A Three-Phase Rotating-Field Transmitter for Ultra-Short Waves [with Symmetrical Horizontal Tripole Aerial for All-Round Radiation].—Dieterle. (*See* 2879.)

2897. The Radiating Properties of Rotating-Field Aerials [Theory].—V. Hardung. (*Hochf:tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, pp. 161–162 : long summary, from *Bull. Assoc. Suisse des Élec.*, Vol. 32, 1941, of a 10-page paper with 10 diagrams.)

The aerials considered are the symmetrical horizontal tripole (Fig. 1a) dealt with by Dieterle (2896, above) fed with currents with 120° phase differences, and the crossed-dipoles arrangement (Fig. 1b) with currents at 90° : for ultra-short waves each arm is generally a quarter-wavelength long for both types, and the radiation is polarised linearly in the plane of the aerial, circularly in the normal direction, and elliptically in intermediate positions. Fig. 2 shows the radiation diagram of a simple (tripole or crossed-dipoles) rotating-field aerial in free space, Fig. 3 the characteristics when the aerials are at various heights h above a conducting ground, and Fig. 4 the characteristics of two aerials, excited in phase, arranged in free space one above the other at various distances $2h$. This last arrangement gives a distinct beaming action in the plane of the aerial or in the direction of the normals to it.

Defining the radiation resistance R as the ratio of the total radiated power to the square of the effective current in an aerial "arm", formulae are given for R for the aerial variations just mentioned, both tripole and crossed-dipoles. These are based on the assumption of uniform current distribution along each arm, and except in the two cases of the simple aerial in free space they involve a function $F_1(x)$ (simple aerial at h above ground) or $F_2(x)$ (two aerials one above the other at distance $2h$). These functions, which are $2/3 - \sin x/x + (1/x^2)(\sin x/x - \cos x)$ and $2/3 + \sin x/x - (1/x^2)(\sin x/x - \cos x)$, respectively, can be read off the two curves of Fig. 5. If each arm is $\lambda/4$ long and the current distribution follows the cosine law, R for the simple tripole in space comes out at 90 ohms to a first approximation, while for the other two tripole arrangements the approximate values are $135 \,.\, F_1(x)$ and $270 \,.\, F_2(x)$ ohms.

2898. The Absolute Measurement of Absorption Surfaces and Power Densities for Short [Decimetric] Waves.—K. Fränz. (*Hochf:tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, pp. 129–131.)

"For measuring the power gain resulting from the beaming action of a directive aerial—or what comes to the same thing, for measuring its absorption surface [*see* 1886 of 1943]—two methods have so far been known. Either the ratio of the received powers is determined when a dipole aerial is replaced by the directive aerial (Brömel, 105 of 1937, for micro-wave parabolic-mirror arrangements), or else the gain is obtained by a numerical integration of the spatial directional diagram derived from a large number of separate measurements (Southworth & King, 1888 of 1939, for metal horns as directive receivers). In the decimetric-wave region the first method has an accuracy that is hard to estimate, since the radiation diagram of the dipole departs from the theoretical cosine-diagram owing to the influence of apparatus, cables, operators and so on. Also, the feeble beaming action of a single dipole makes it difficult to remove the influence of ground reflection from the measurements. The dipole is therefore little suited to act as a standard for measurements, however desirable it may be as a standard radiator for theoretical treatments.

"The second method consumes a lot of time, owing to the multi-lobed diagrams of the directive aerial which have to be measured in every direction. The method now described requires about the same labour as the comparison with the dipole, but enables more suitable aerials than a single dipole to be employed as the standard radiator. It is based on the measurement of the transmission efficiency between two aerials in free space. Representing the radiated power of the transmitter by N_s, the received power (with the receiver matched to the aerial) by N_e, the two absorption surfaces by F_s and F_e, the distance between the aerials by r, and the wavelength by λ, the transmission efficiency is given by $\eta = N_e/N_s = F_s F_e/r^2\lambda^2$ (*see* Fränz, 3240 [and 3564] of 1942).

"Thus with two identical aerials ($F = F_s = F_e$) the absorption surface is given by $F = r\lambda\sqrt{\eta}$. If two identical aerials are not available, the transmission efficiency can naturally be measured between two unlike aerials : this gives the product of the absorption surfaces, a comparative measurement then gives their ratio, and from the combination the required absolute values for the surfaces is obtained. If part of the power supplied to the aerial is transformed not into radiation but into heat, our method gives directly the technically interesting product of absorption surface and aerial efficiency. Correctly designed 'short-wave' aerials have in practice an efficiency of 100%."

The transmission efficiency is obtained by measuring u_s, the voltage produced directly by the transmitter, and u_e, the voltage resulting from the interposition of the transmission path, consisting of the two aerials (with their stub and trombone-type matching transformers : Meinke, 3048 of 1942) and the space between them : Fig. 1 : $\sqrt{\eta} = \sqrt{N_e/N_s} = u_e/u_s$. The standard radiators take the form of shallow parabolic boxes 3.5λ wide at the opening and $\lambda/2$ deep (Fig. 2), with a short bared length of the core of the feeder-cable (entering the bottom of the box) serving as radiator at the focus of the parabola. The two voltages are measured after transformation to long-wave frequencies by heterodyne reception. The absorption surfaces of other aerials are measured by comparison with the standard radiator. In the actual tests r was 20 m, b (the greatest linear dimension of the aerial) was about 2 m, and λ was 0.6 m, so that $b^2/4r\lambda$ (which must be much less than r in order that the field at the receiver may be a true "distant" field) was 0.08. The aerials were raised about 5 m above the ground.

If an absolutely calibrated signal generator for receivers (Fränz, *loc. cit.*) is available, the power density (value of the Poynting vector) can be determined with the help of an aerial whose absorption surface has been measured: the deflection at the receiver output produced by the field under investigation, using the measured aerial, is reproduced by the signal generator (whose internal resistance must match that of the aerial) from which the received power N_e is read: then the power density S is given by $S = N_e/F_e$.

The method was employed to measure the absorption surface of a square fir-tree aerial consisting of four fed radiators spaced $\lambda/2$ and four reflectors, the wavelength being 0.6 m. Since the absorption surface can be calculated fairly accurately, a check against theoretical results can thus be made. On grounds of symmetry all four identical aerials are excited with the same amplitude and phase, and it is easily shown (Fränz, 1891 of 1939) that such an aerial should have a gain of 4. The reflectors double this, so that the absorption surface should have the value $F = 8 \cdot 3/8\pi \cdot \lambda^2 = 0.344$ m². The measured value was 0.35 m². It was found that the presence of apparatus and people behind the standard radiators had no influence on the measurements.

2899. THE ANTENNA PROBLEM.—L. Brillouin. (*Quarterly of Applied Math.* [Brown University], April 1943/Jan. 1944, Vol. 1, p. 201 onwards.)

"The recent expansion of radio towards ultra-short waves has aroused a new interest in theoretical problems of electromagnetism and especially in the problem of antenna oscillation and radiation properties. The aim of this paper is to emphasise the practical importance, for this problem, of a method based on the use of retarded potentials. By means of this method an integro-differential equation is vigorously obtained, the solution of which is the actual required current distribution along the antenna wire. A complete statement of the problem for a cylindrical wire of finite radius is given, and a comparison is made with the results obtained for a very thin wire by means of the usual elementary theory of antennas. The importance of the rôle of both end-surfaces, whose exact shape must be considered, is also stressed." A 14-page paper. For other work *see* 2558 of August.

2900. ON THE ANTENNA PROBLEM [Quantitative Comparison of Various Approximate Solutions].—S. A. Schelkunoff. (*Quarterly of Applied Math.* [Brown University], April 1943/Jan. 1944, Vol. 1, p. 354 onwards.) A 2-page paper. *Cf.* 1930 of June.

VALVES AND THERMIONICS

2901. MAGNETRON OSCILLATOR FOR INSTRUCTION AND RESEARCH IN MICROWAVE TECHNIQUES.—J. T. Tykociner & L. R. Bloom. (*Proc. I.R.E.*, May 1944, Vol. 32, No. 5, pp. 299–308.) Already dealt with in 2572 of August.

2902. A METAL TRIODE FOR ULTRA-HIGH-FREQUENCY OPERATION [Decimetric-Wave Band: the Type DCM-1].—N. D. Deviatkov, M. D. Gurevich, & V. K. Khokhlov. (*Proc. I.R.E.*, May 1944, Vol. 32, No. 5, pp. 253–256.) Translation of the paper dealt with in 773 of 1943. For predecessors of this valve *see* 124 of 1940 and 2144 of 1943.

2903. HEAT DISSIPATION IN TRANSMITTER TUBES [the Basic Problems "with Sufficient Co-ordinated Data to enable the Engineer to cope with This Situation in Its Many Varied Forms."]—H. E. Ennes. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, Supp. pp. 10–12 and 34, 35.)

ACOUSTICS AND AUDIO-FREQUENCIES

2904. PAPERS ON THE PIEZOELECTRIC AND ELECTRO-OPTICAL BEHAVIOUR OF CRYSTALS AKIN TO ROCHELLE SALT [KH_2PO_4 & KD_2PO_4].—M. de Quervain, B. Zwicker, W. Bantle, C. Caflisch, P. Scherrer. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 56: pp. 56–57: p. 57: p. 57.)

From *Helvetica Phys. Acta*, 1943. With KH_2PO_4, "in certain cases temperature coefficients at room temperatures of the same order as for quartz were obtained, suggesting that further orientations may exist for vanishing temperature coefficients."

2905. LOUDSPEAKER RESPONSE MEASUREMENTS: PART II—A CONTINUATION OF ACOUSTICAL LABORATORY MEASUREMENTS AND THE POSSIBLE MISINTERPRETATIONS OF FREQUENCY-RESPONSE CURVES.—Jensen Radio Mfg. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, pp. 32–34 and 110.) For Part I *see* 2605 of August.

2906. WOW METER: SIMPLIFIED ELECTRONIC INSTRUMENT FOR MEASURING INSTANTANEOUS SPEED VARIATIONS OF PHONOGRAPH TURNTABLES.—C. R. Miner. (*Gen. Elec. Review*, April 1944, Vol. 47, No. 4, pp. 31–34.) "Developed for production measurements, but also useful in broadcasting studios, recording studios, laboratories, and radio-service organisations." *Cf.* Roys, 1137 & 1711 of 1943.

2907. SPECIAL MICROPHONES FOR THE TRANSMISSION OF SPEECH AND MUSIC.—H. Colberg. (*Zeitschr. f. Fernmeldetech.*, Vol. 23, 1942, p. 168 onwards: a 3-page paper.)

2908. LOW-DISTORTION AUDIO OSCILLATORS: SUMMARY OF MANY SPECIAL TYPES OF OSCILLATORS WHICH PRODUCE THE UNUSUALLY PURE WAVE-FORMS NECESSARY IN PRESENT-DAY LABORATORY TESTS.—R. P. Turner. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, pp. 41–43 and 70, 122, 128.)

2909. THE AUTOMATIC LEVEL RECORDER.—H. Williams. (*P.O. Elec. Eng. Journ.*, Jan. 1944, Vol. 36, Part 4, pp. 103–106.)

"The frequency scale as specified by the C.C.I.F. is as follows:—Linear from 0–100 c/s. Logarithmic from 100 c/s to 10 000 c/s. The band 30 c/s to 100 c/s is sent in 15 seconds, and each octave of the logarithmic range takes 15 seconds to transmit. This is obtained in the instrument described entirely by the design of the main tuning condenser in the sending element and is thus independent of aging effects liable to occur in any electrical method of accomplishing this."

2910. A NEW STANDARD ATTENUATION EQUALISER [No. 9A: primarily for use with Amplifier No. 32 but applicable to Any Type of Audio Amplifier].—F. Pyrah. (*P.O. Elec. Eng. Journ.*, April 1944, Vol. 37, No. 1, pp. 22–25.)

2911. THE ACOUSTICAL TERMINAL CONDITIONS [Artificial Ear] FOR THE TESTING OF TELEPHONE RECEIVERS.—K. Braun. (*T.F.T.*, Nov. 1943, Vol. 32, No. 11, pp. 237–239.)

2912. ON DEFINING THE α-PHONEME [by means of Dedekind Sections: and the Possibility of defining Vowel & Consonant Phonemes by Certain (so far Undiscovered) Positive Characters *V* & *C*].—C. R. Sankaran. (*Current Science* [Bangalore], Jan. 1944, Vol. 13, No. 1, pp. 11–12.)

2913. ON PROPAGATION OF SOUND WAVES IN EDDYING FLOW.—A. M. Obukhov. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 20th April 1943, Vol. 39, No. 2, pp. 46–48: in English.)

"In a paper by Andreev & Russakov [in 1934: ref. "1"] certain problems of wave acoustics of a medium in motion are solved on the basis of equations obtained for the case of a potential field of velocities. However, in the most interesting cases from a practical point of view, such as the propagation of sound in a turbulent atmosphere, one has to deal with an eddying flow which, strictly speaking, does not come under the scope of the equation derived in the above-mentioned paper. In the present note approximate equations are derived for the acoustics of an eddying flow. . . It is seen from eqn. 13 that for a flow with a variable vorticity a correction term of, generally speaking, first order of smallness, depending upon the derivatives of the flow rot $\vec{v}$, has to be introduced in Andreev's equation. This term can only be neglected when the dimensionless vorticity is much less than the dimensionless velocity of flow $\vec{u}$; that is, when the non-uniformity of the velocity field of the main flow is much greater than the length of the acoustic wave. This is the case on transition from wave acoustics to geometrical acoustics. . ."

2914. ON SUPERSONIC WAVES IN CYLINDRICAL TUBES AND THE THEORY OF THE ACOUSTIC INTERFEROMETER [taking into Account the Non-Uniformity of the Acoustic Field, and leading to Interpretation of Pielemeier's Satellite Peaks & an Improved Formula for Determination of Absorption Coefficients from Observational Data].—P. E. Krasnooshkin. (*Phys. Review*, 1st/15th March 1944, Vol. 65, No. 5/6, pp. 190–195.)

2915. REFRACTION OF ULTRASONICS AND VELOCITIES IN COLOURED LIQUIDS AND IN SOLIDS [Method based on Fact that in Debye–Sears Light-Diffraction Arrangement the Intensity of Lines on Both Sides of Central Line is Symmetrical only when the Sound Waves are exactly at Right Angles to the Light Beam].—R. Parshad. (*Current Science* [Bangalore], Jan. 1944, Vol. 13, No. 1, pp. 13–14.)

2916. "DER ULTRASCHALL UND SEINE ANWENDUNG IN WISSENSCHAFT UND TECHNIK" [Third Edition: Book Review].—L. Bergmann. (*Hochf:tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, pp. 163–164.) *Cf.* 2628 of August.

PHOTOTELEGRAPHY AND TELEVISION

2917. A TELEVISION STUDIO PLAN FOR THE POST-WAR PERIOD [with Revolving Stage carrying Four Sets].—(*Science*, 14th April 1944, Vol. 99, No. 2572, Supp. p. 10.)

2918. OPTICAL VIEW-FINDERS FOR TELEVISION CAMERAS.—P. Lindner & R. Möller. (*Fernseh G.m.b.H.*, Vol. 2, 1942, p. 151 onwards: a 6-page paper.)

2919. A PHOTOELECTRIC CELL VERY SENSITIVE TO THE EXTREME ULTRA-VIOLET.—J. Mattler. (*Comptes Rendus* [Paris], 2nd/30th Aug. 1943, Vol. 217, No. 5/9, pp. 143–145.)

"We have shown (2446 of July) that the photon counters made by Audubert & van Doormal, with CuI as photosensitive material, have given very good results from the viewpoint of absolute sensitivity. It seemed therefore of interest to construct, with this substance, ordinary (photoemissive) photoelectric cells, and to study their properties and characteristics. . . . This new cell with CuI photocathode, by reason of its very high sensitivity and comparative ease of preparation, should be useful for the detection and measurement of ultra-violet light between 1900 and 2600 A.U., a region where the classic arrangements have a poor sensitivity. In view of the position of its threshold, its use is specially indicated when parasitic light of long wavelengths (above 3000 A.U.) is present in the ultra-violet beam."

2920. FATIGUE IN SELENIUM RECTIFIER PHOTO-CELLS.—J. S. Preston. (*Nature*, 3rd June 1944, Vol. 153, No. 3892, pp. 680–681.)

"Elvegård, Lindroth, & Larsson (1984 of 1938), and more recently Houstoun (3433 of 1941 [for later work *see* 1445 & 3641 of 1942]), found that the degree of fatigue depends on the spectral quality of the radiation. They attempted no explanation of their results in terms of other properties of the cells, however. Incidental observations made at the National Physical Laboratory, during measurements of the spectral sensitivity of a number of cells, afford some new results of which a tentative explanation is possible. . . ." The writer concludes: "The behaviour described here is probably connected with the extent of penetration of the radiation into the selenium. Selenium has a fairly high transmission for wavelengths greater than 0.64μ, and is practically opaque for wavelengths less than 0.60μ. This would account for the different behaviour observed on exposure to the two spectral regions, for the photoelectric action would take place in layers situated at different depths depending on the penetration of the radiation. Moreover, we should expect the fatigue to be greatest when the action is in the deeper layers, and least when only the superficial layer is concerned, the effect observed in our experiments."

MEASUREMENTS AND STANDARDS

2921. THE ABSOLUTE MEASUREMENT OF ABSORPTION SURFACES AND POWER DENSITIES FOR SHORT [Decimetric] WAVES.—Fränz. (*See* 2898.)

2922. STANDARD SIGNAL GENERATORS FOR THE FREQUENCY BAND 50 . . . 600 Mc/s.—A. Klemt. (*Hochf:tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, pp. 133–137.)

From the H. Kimmel laboratories, Munich. The usual signal generators for broadcasting and short waves have a frequency range of 50 or 100 kc/s to about 50 Mc/s. The writer now deals with instruments for the range 50 to 600 Mc/s, which thus link on to the lower-frequency type. "It is shown how even at these high frequencies suitable electrical and constructional design will yield the same signal-generator properties as at lower frequencies. General viewpoints for the construction of signal generators in this frequency band are discussed. Finally, the properties of two instruments which have been developed are examined: one is a 'power' test oscillator [with an h.f. output of about 1.5 w], the other a receiver-testing signal generator" [for an American design, 50–400 Mc/s, *see* 2260 of July].

The general question of the generating circuit is first considered, a triode circuit with retroaction being assumed. The oscillatory circuit consists of the concentrated tuning capacitance ΔC (Fig. 1), with the grid/anode capacitance C_{GA} in parallel, and the concentrated inductance L. Special measures must be taken to keep the retroaction factor $\mathfrak{R} = -\mathfrak{U}_g/\mathfrak{U}_a$ approximately constant, both in magnitude and phase, for all frequencies. Since the point K (where the cathode goes to earth), which helps to determine the retroaction factor, depends not only on the internal valve capacitances but largely on the external circuit, the latter must be so designed that the position of K is independent of frequency. This means that the ratio of the space capacitances (anode/cathode, C_{AK}, and grid/cathode, C_{GK} [wrongly labelled C_{GA}]) must not vary, and the point A at the middle of the inductance L must have the same h.f. voltage as the point K. Similarly, the appearance of any voltage between K and K' (the end of the cathode) must be avoided. If such a voltage were pure in phase, all that would happen would be a negative feedback, somewhat reducing the slope of the valve; but much more serious is a phase difference between K and K', which may easily occur owing to the self-inductance of the cathode and heating-filament connections inside the valve, and to the filament/cathode capacitance, and which may lead to a stoppage of oscillation.

The writer continues: "The equality of C_{AK} and C_{GK}, as well as the voltage equality between K and A, can be obtained easily in practice, even over a wide range of frequencies, by the symmetrical design of all circuit elements; whereas the voltage equality between K and K', which is equivalent to a phase-pure h.f. earthing of the cathode (since the space capacitances of the other components moor themselves to the point K as a high-frequency earth) is difficult to realise both in magnitude and phase. An approximate phase equality between K and K' over the whole range of frequencies can be obtained by introducing chokes into the heater leads and a real resistance (not capacitively short-circuited) into the cathode lead: *see* Fig. 2." But the amplitude condition for K and K' is not fulfilled, since the cathode-lead resistance causes a voltage drop which is equivalent to a current-type negative feedback, and which may produce a decrease in valve-slope of roughly 20% at the upper end of the frequency band, where the negative feedback is greatest owing to the resonance resistance being lowest.

The range 50 . . . 600 Mc/s is divided into four parts, 50 . . . 100 . . . 200 . . . 400 . . 600 Mc/s. By a "revolver"-type change-over of coils it is possible to equalise the initial capacitance for each range so as to allow the use of only one scale (calibrated in Mc/s) right up to 400 Mc/s. Further, in the higher frequency region part of the variable condenser can be cut out, so that the resonance resistance at the lower end of this range is not too small.

By the use of castings and of ceramic insulation, frequency constancy over long periods is ensured. Frequency variations on coming into service, or due to mains fluctuations, are within the usual signal-generator accuracy of $\pm 1\%$: Fig. 3 shows some measurements over 160 minutes from switching-on. An inductive coupling for the output voltage is employed for the sake of the matching of the generator to the characteristic impedance of the h.f. cable used to convey the voltage to the load. The variation of the output voltage over the whole frequency range, measured at the cable terminated by its characteristic impedance, with $z = 70$ ohms, is consequently less than $\pm 30\%$.

For the receiver-testing signal generator, where large voltages are not required, the advantage of a continuously-variable ratio provided by a capacitive voltage-divider is utilised; by the design seen in Fig. 4b, in which an earthed metal disc with a continuously narrowing slit is rotated between two metal electrodes, frequency-independent calibratable ratios up to 1000 can be obtained over the whole frequency range. In the "power" oscillator, on the other hand, where as much of the total output as possible has to be taken to the load, so that ratios up to about 1 : 50 are sufficient, an ohmic divider is used, since its fundamental damping is low compared with that of the capacitive type, and its defect (the impossibility of making it independent of frequency over a wide range of continuously variable ratios) does not come into the question.

Screening, at any rate in the receiver-testing generator, must be so complete that the interfering voltages outside the instrument must not exceed a few tenths of a microvolt [*cf.* 2260 of July, already quoted]. Since the maximum voltages in the generator are of the order of 100 v, there must be a screening attenuation of at least 10^9 times between the oscillator-stage and outer wall of the generator and the voltage provided by the voltage-divider. By the use of harmonics this value could be reduced by about two orders of magnitude, with a non-linear-distortion factor of a few per cent. Another way would be to generate the required frequency by the mixing of two other frequencies (Nitsche, 3449 of 1941: "for special purposes" only [for a later paper *see* 181 of 1942]): but for series production it was decided that it was preferable to use the directly produced frequency even at the price of the 10^9 screening attenuation. "By the double screening seen in Fig. 5 the necessary attenuation was obtained easily. The oscillator and voltage divider were built into completely closed boxes of a material with small depth of penetration (*e.g.* aluminium), and all the components inside the outer screen were arranged like a concentric cable (inner screen) which was connected to the outer casing only at its point of exit, to prevent transient equalising currents." To avoid spoiling the double screening by mechanical parts such as the adjusting spindles, insulating couplings were provided for these. Further, leads for the heating, anode, and modulating voltages were carefully "choked" so that no interfering h.f. voltages could emerge. The basic construction of such chokes, consisting of a series inductance (single-layered cylindrical coil) and a parallel capacitance (disc-type condenser), is to be seen in Figs. 5 and 6.

The question of modulation methods is discussed at some length on pp. 135–136. In simple sets, where a special stage for modulation and pulse-keying is out of the question, it does not matter what type of modulation is used—grid-voltage or anode-voltage, for example: an anode-current variation will always occur, and since this produces a change in the valve capacitances there is bound to be frequency modulation present. In the "power" instrument (Fig. 10b) the amplitude modulation is actually carried out on the anode voltage: the highest possible modulation percentage is 50%, at which the frequency modulation amounts to about 1‰. The pulse-keying is carried out by positive pulses on the negatively biased grid. In the receiver-testing generator, on the other hand, a special modulating and pulse-keying stage is provided (Fig. 10a): the reasons for adopting the "inverted amplifier" type of triode circuit (Strong, 4230 of 1940) with its grid earthed for h.f. and the input voltage applied between the cathode and this grid, the output voltage being taken between anode and grid, are discussed fully: Kleen's classifying treatment of this and other types of circuit (410 of February), where such an arrangement is named the "grid-basis connection," is referred to. In such a circuit the only capacitive coupling between input and output circuits lies in the penetration capacitance cathode/anode: with the usual decimetric-wave triodes, whose grid/anode capacitance is of the order of 1–2 pF, this cathode/anode capacitance was found to be only 0.05–0.2 pF when the grid was earthed for h.f.. Consequently the instrument could be given a modulation percentage of as much as 80% even at 600 Mc/s.

In this receiver-testing generator the oscillator stage supplies to the modulating stage a voltage which can be adjusted, by a control in the oscillator stage and a "magic eye" voltage indicator, to a constant value; as a result, the output voltage at the capacitive voltage divider (connected on the far side of the modulating stage) can be read directly. It can be adjusted continuously between 1 μV and 30 mV.

Both in the receiver-testing and the "power" generator, the output is through a special symmetrical transformer of the toroidal type. The reasons for the choice of this, and its design, are discussed in the penultimate section on p. 136.

2923. DIODE VOLTMETERS FOR DECIMETRIC WAVES.—H. Boucke & H. Lennartz. (*Funk*, No. 17/18, 1942, p. 241 onwards: a 3-page paper.)

2924. MILITARY RADIO SHOULD BE SIMPLIFIED AND STANDARDISED.—S. K. Wolf: D. R. Hull. (*Electronic Industries*, Jan. 1944, Vol. 3, No. 1, pp. 100–101 and 266, 268: pp. 101 and 264, 266.)

(i) "Radio & Radar Division, WPB, outlines necessity for applied standardisation to improve production efficiency." (ii) "The Navy offers some practical suggestions to attain fewer types of components with greater dependability." For an Editorial prompted by these articles see *Electronic Eng:g*, April 1944, Vol. 16, No. 194, p. 447.

2925. PAPERS ON THE PIEZOELECTRIC AND ELECTRO-OPTICAL BEHAVIOUR OF CRYSTALS AKIN TO ROCHELLE SALT.—de Quervain & others. (*See* 2904.)

2926. THE THICKNESS OF A RIGID WATER LAYER ON QUARTZ FROM MEASUREMENTS OF NEWTON'S RINGS.—W. G. Eversole & P. H. Lahr. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, pp. 55–56.)

2927. TIME FLUCTUATIONS OF A PENDULUM CLOCK [with Graham Escapement: the Amplitude at which the Period is Insensitive to Amplitude Fluctuations, and hence the Most Satisfactory Driving Torque].—H. Schilt. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, pp. 52–53.) From *Helvetica Phys. Acta*, 1943.

2928. MODULATED-BEAM CATHODE-RAY PHASE METER.—A. Watton, Jr. (*Proc. I.R.E.*, May 1944, Vol. 32, No. 5, pp. 268–272.)

Developed primarily for measuring the phase-shift characteristics of amplifiers (stabilised by negative feedback) used in vibration-measurement work. "The method is not new; it is noted by von Ardenne ["Cathode-Ray Tubes"] and an instrument of this type has been described by Nijenhuis [*see* 2485 of 1941 (and reference "3")]. Apparently it has not received attention in American journals. It is readily adapted to use at sub-audible frequencies and possesses other advantages in accuracy and convenience," including indication of the sense of the phase difference.

The c.r. tube is used in conjunction with a circular-time-base circuit and a biased-diode "clipper" circuit fed in turn by the two voltages whose phase difference is to be measured. The change in angular position of the semicircle on the screen gives this phase difference. No calibration is required, the dial being accurately engraved in degrees of angle.

2929. A NEW CAPILLARY ELECTROMETER, OF LASTING RELIABILITY, AS A SUBSTITUTE FOR A GALVANOMETER.—F. A. Uhl. (*Z. f. analyt. Chem.*, Vol. 124, 1942, p. 324 onwards: a 4-page paper.)

2930. RADIO-FREQUENCY RESISTANCE BOX [Type D-9-A, with Switching System ensuring that Residuals due to Switches & Connections are Constant, whatever the Switch Setting: Carbon Compound Resistors].—Muirhead & Company. (*Journ. of Scient. Instr.*, June 1944, Vol. 21, No. 6, p. 109.) Design due to P.O. Engineering Department.

2931. MATERIALS FOR THE RESISTANCE WINDING OF POTENTIOMETERS [with Remarks also on Slider Material].—K. W. Fröhlich. (*Elektrot. u. Masch:bau*, 4th Feb. 1944, Vol. 62, No. 5/6, pp. 75–76 : summary.)

From *Degussa Metall-Berichte*, No. 26, 1943 : *cf.* 2237 of 1943. Pure platinum was early discarded, because of its large resistance variation with temperature, in favour of platinum–iridium alloys with 20% iridium, having considerably smaller temperature-dependence and greater mechanical strength. As the requirements of independence of temperature became more stringent, and simultaneously iridium became less available, these alloys were replaced, even before the war, by cheaper alloys of platinum or palladium with silver. The 1 : 1 (by weight) silver–palladium alloy shown in Table 1 represented a real advance from the platinum–iridium material, its temperature coefficient of resistance being five times as small ; its strength was not so high, but even so was 50% higher than that of pure platinum ; and only one half was imported material. Raw material considerations made it desirable, about three years ago, to come back from the palladium base to a platinum alloy. At first the silver–platinum alloy (70/30) seen in the table appeared very suitable, corresponding as it did quite closely in electrical and mechanical properties to the palladium alloy : it was found, however, that cases of fusing frequently occurred in potentiometers wound with fine wire of this material, owing to the unexpected formation of ordered phases in domains rich in silver. For this and other reasons mentioned, the silver–platinum alloy was discarded.

Leaving the noble metals, prolonged tests on nickelin, manganin, constantan, and chrome nickel showed a decided suitability, for potentiometer construction over a wide range, of certain types of constantan alloys : a suitability considerably higher than was anticipated. Such a " potentiometer-constantan " (a particular type, of unmentioned composition, is shown in the table) possesses good electrical properties and strength, and a satisfactory resistance to salt-water and other corrosion. It is not suitable for precision potentiometers, which need the absolutely clean surface only given by high-quality noble metals ; but it is now widely used for other types. An unexpected discovery was that constantan materials differing only slightly in composition from the successful types were failures : the exact reason is not yet known.

For precision potentiometers, the search for materials free from platinum and palladium led to the development of " potentiometer-gold-alloy PA 74 " (*see* table), composed of 70% of gold with additions of silver and small quantities of base metals. The gold content is so chosen that the alloy remains " noble " under all conditions ; that is, no films are formed to give electrical trouble. The chief object of the silver is to reduce the amount of gold used, without decreasing the " noble " character ; it also improves the specific volume and the mechanical properties. The small total percentage of base metals also increases the specific resistance and considerably reduces the temperature coefficient of resistance : the mechanical strength is raised again to 50% over that of platinum. The base metals, finally, make the metal structure, otherwise homogeneous, a fine-grained one, which is important in improving the wearing property of the wire. This " PA 74 " has properties closely approaching those of the silver–palladium alloy discussed above. An important point is that in all its states of manufacture the alloy shows no " tension corrosion," so that there is no fear of the winding cracking or becoming brittle.

Perhaps its one fault is that it consists, to the amount of two-thirds, of a material which has to be imported like platinum and palladium, though certainly available much more readily than these two metals. But tests on low-gold-content gold–silver alloys for precision potentiometers have shown that these are unsuitable, because in prolonged service they do not give perfect electrical contact.

As regards the material of the sliding contact, this must give sure contact everywhere but must not wear away the wire quickly. Nor must it itself wear away quickly, or it will leave metal dust on the wire and cause much trouble. An appreciable thermoelectric voltage in contact with the wire must also be avoided, and finally it, just as much as the wire material, must resist atmospheric and other corrosion. Some of these points are best satisfied by using the same material for both wire and slider, but in a rather softer form for the latter so that it, and not the wire, may wear away. This is made easier by the fact that for machine winding the wire has in any case to be treated so as to have a certain minimum strength.

2932. 250-DEGREE INSTRUMENTS [Long-Scale Design specially for Navy].—Westinghouse. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, Supp. pp. 28 and 36.)

2933. VOLTAGE-MEASURING AND -CONTROL EQUIPMENT FOR ELECTROSTATIC GENERATORS [Use of the Electrostatic Analyser as Calibrated Instrument equipped with Electrical Detectors which operate Automatic Regulating Devices stabilising the High-Voltage Source].—A. O. Hanson. (*Review Scient. Instr.*, March 1944, Vol. 15, No. 3, pp. 57–63.)

" With the equipment described it is possible to measure and control the average energy of the protons accelerated by the electrostatic generator with an accuracy of about 0.1% " : *see* also 2282 of July.

2934. A CLIMATIC TEST CHAMBER FOR TESTING ELECTRICAL AIRCRAFT EQUIPMENT [with Automatic Operation by Electro-Pneumatic Switching System].—R. H. W. Burkett & H. K. Henisch. (*Journ. of Scient. Instr.*, June 1944, Vol. 21, No. 6, pp. 106–107.)

2935. MAGNETIC TESTING TO CONTROL THE QUALITY OF FERROUS-ALLOY PARTS [Use of D.C. Magnetic Residual Tester & A.C. Inductance Comparator].—W. K. Kehoe. (*Gen. Elec. Review*, April 1944, Vol. 47, No. 4, pp. 59–60.) For the " Metroflux " magnetic sorter (Metropolitan–Vickers) see *Engineer*, 26th May 1944, p. 414.

2936. " PRAXIS DER MAGNETISCHEN MESSUNGEN " [Book Review].—R. Bock. (*Zeitschr. V.D.I.*, 8th Jan. 1944, Vol. 88, No. 1/2, p. 31.)

2937. " UMRECHNUNGSTAFELN " [Conversion Tables : Sheet 1 — Values of Electric & Magnetic

Quantities: Sheet 2—Values of Mechanical Quantities: Conversion into International (m–s–V–A) System from Other Systems: Review].—U. Stille. (*Hochf:tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, p. 164.)

SUBSIDIARY APPARATUS AND MATERIALS

2938. DECIMETRIC-WAVE OSCILLOGRAPHY.—Masing. (*Messtechnik*, Vol. 18, 1942, p. 167 onwards: a 6-page paper.)

2939. A NEW FILM-" LOCK " FOR CATHODE-RAY OSCILLOGRAPHS, ELECTRON MICROSCOPES, AND ELECTRON-DIFFRACTION APPARATUS.—Berger. (*Bull. Assoc. Suisse des Élec.*, 3rd May 1944, Vol. 35, No. 9, pp. 236–239: in German.)

Both the barometer-tube method (Holzer & Knoll, 1933 Abstracts, p. 51 and back reference) and the long narrow slit device (Matthias, ref. "6") are intended for continuously running film: at each cutting of the film there is a waste equal to the tube or slit length—about 1 metre, so that neither plan is suitable for single records. With the present "lock" device, which is claimed to remove a serious objection to internal recording and to simplify speedy operation of film-using cathode-ray apparatus, only about 10 cm of film is wasted. The film runs from the spool *V* in the supply chamber 1 (Fig. 1) under the fluorescent screen to an inner "lock-gate," the door *J* at the side, and from there (if *J* is open) to the winding-off spool *A* in its box in the "lock" chamber *S*. If the door *J* is shut, by pressing it against its seating by the adjusting screw *D* (made vacuum-tight by flexible bellows), the film is squeezed between the elastic pads *P* which form the joint between *J* and its seating. With this constructional feature as a basis, the procedure for removing the exposed part of the film, through the outer door *T* of the "lock," is obvious: it is described in full in the paper. The only part of the film which is wasted is the 10 cm length between the edge of the fluorescent screen and the cutting knife *M*.

2940. THE LIMIT OF RESOLVING POWER OF THE EMISSION-TYPE ELECTRON MICROSCOPE.—Brüche. (*Kolloid-Zeitschr.*, Vol. 100, 1942, p. 192 onwards: a 15-page paper.)

2941. ON THE IMAGE FIDELITY OF OBJECT STRUCTURES NEAR THE LIMIT OF RESOLUTION, IN OPTICAL AND ELECTRON MICROSCOPES.—von Ardenne. (*Kolloid-Zeitschr.*, Vol. 100, 1942, p. 206 onwards: a 6-page paper)

2942. THE BEHAVIOUR OF CELLULOSE FIBRES IN THE ELECTRON MICROSCOPE, *and* REMARK ON THE DISCUSSION OF THE ELECTRON MICROSCOPY OF CELLULOSE FIBRE.—Hamann: Frey-Wyssling. (*Kolloid-Zeitschr.*, Vol. 100, 1942, p. 248 onwards: a 7-page paper: *and* p. 304 onwards: a 2-page note.)

2943. ON APERTURES OF TRANSMISSION-TYPE ELECTRON MICROSCOPES USING MAGNETIC LENSES.—Marton & Hutter. (*Phys. Review*, 1st/15th March 1944, Vol. 65, No. 5/6, pp. 161–167.)

A summary was referred to in 1296 of April. In addition to the optimum conditions for size and location of apertures ("an aperture placed at $x = x_m$ on the optical axis can have a considerably greater size [with reduced machining difficulty and other advantages] than one placed at the centre of the lens and yet have the same ray-limiting effect"), the behaviour of the condenser-lens/objective-lens system with respect to the angular aperture of the illuminating electron beam is discussed.

2944. QUARTZ FILAMENTS FOR ELECTRON-MICROSCOPE CALIBRATION.—Westinghouse. (*Science*, 21st April 1944, Vol. 99, No. 2573, Supp. p. 10.)

2945. POLYSTYRENE AIDS ELECTRON MICROSCOPE [Precision Polystyrene Moulding as Replica: Technique].—(*Sci. Abstracts*, Sec. B, March 1944, Vol. 47, No. 555, p. 50.)

2946. PHOSPHORS *versus* THE PERIODIC SYSTEM OF THE ELEMENTS.—Leverenz. (*Proc. I.R.E.*, May 1944, Vol. 32, No. 5, pp. 256–263.)

From the R.C.A. laboratories. Author's summary:—"The properties of a number of well-known inorganic luminescent materials (phosphors) are described as a function of variations of their constituents. Chemical substitutions made according to the ordered series in the periodic system of the elements are shown to produce many anomalous energy changes which appear as shifts in the spectral emission colours of the phosphors. The anomalous energy changes indicate that the mechanisms of luminescence in solids cannot be given a simple interpretation.

"The relative cathode-luminescences of forty-five phosphors are codified and presented in tabular form for the convenience of cathode-ray-tube engineers."

The writer conludes: "The mechanism of luminescence in a phosphor crystal is on an atomic scale, involving intangible interactions of photons, electrons, ions, atoms, and lattice forces. There are, as yet, no theories which give quantitative agreement with experiment. . . . Research in this field must be guided by 'scientific intuition' rather than by logic. Scientific intuition derives its discernment from colligating and applying myriad bits of latent knowledge, sometimes from apparently unrelated fields." For another recent paper *see* 2682 of August.

2947. FLUORESCENCE SPECTRA OF NAPHTHACENE MOLECULES IN SOLID SOLUTION OF ANTHRACENE WITH THE VARIATION OF WAVELENGTHS [Results contrary to Bowen's Hypothesis, 1151 of 1939].—Ganguly: Bowen. (*Nature*, 27th May 1944, Vol. 153, No. 3891, pp. 652–653.) Bowen replies that the results "can scarcely be said to refute the idea of energy transfers in crystals. . . We are therefore forced to assume an 'exciton' mechanism . ."

2948. FLUORESCENCE OF SOLID SUBSTANCES IN COMPACT AND DISPERSED STATES.—Kuhn. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 55.)

2949. A REVERSIBLE FOUR-WAY STOP-COCK USEFUL IN WORK CONNECTED WITH CIRCULATION OF GASES AND LIQUIDS, *and* SOME IMPROVE-

MENTS TO THE TÖPLER PUMP.—Purushotham. (*Current Science* [Bangalore], Jan. 1944, Vol. 13, No. 1, p. 14 : p. 15.)

2950. SOME MEASUREMENTS OF ULTIMATE VACUUM AND PUMP SPEED OF MOLECULAR PUMPS.—Eklund. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, pp. 53–54.)

2951. GAUGE FOR HIGH VACUA [" Micro-Vacuum Gauge " with 4-Wire Bridge Unit].—Cambridge Instrument. (*Engineering*, 5th May 1944, Vol. 157, No. 4086, p. 357.) For indicating or recording.

2952. VOLTAGE-MEASURING AND -CONTROL EQUIPMENT FOR ELECTROSTATIC GENERATORS [Use of the Electrostatic Analyser].—Hanson. (*See* 2933.)

2953. A SMALL PRESSURE-INSULATED ELECTROSTATIC GENERATOR [van de Graaff Type, to work at about 1 Million Volts : at Johns Hopkins University].—Jennings & others. (*Review Scient. Instr.*, March 1944, Vol. 15, No. 3, pp. 64–68.)

2954. MEASUREMENT OF THE TEMPERATURE DEPENDENCE, VOLTAGE DROP, AND REVERSE CURRENT IN DRY-PLATE RECTIFIERS [and the Difficulties encountered in the Last Two Measurements owing to the Marked Temperature Dependence of the Semiconductor & Barrier-Layer Resistances : Difficulties due to Condensation of Moisture (Objections to Measurement in Vacuum, in Liquids : the Use of a Dried Gas Atmosphere) : the Wide Scatter of Data for Individual Plates, and the Need for Statistical Procedure (1490 of 1943) : etc.].—Maier. (*Elektrot. u. Masch:bau*, 4th Feb. 1944, Vol. 62, No. 5/6, pp. 74–75 : summary, from *Arch. f. Tech. Messen*, 1943.

2955. THE ELECTRICAL OSCILLATIONS IN IONIC RECTIFIERS.—Hochrainer. (*Elektrot. u. Masch:bau*, 6th Aug. 1943 : short summary in *Génie Civil*, 15th Jan. 1944, Vol. 121, No. 2, p. 20.)

2956. AN ELECTRODELESS-DISCHARGE LAMP WITH VARIABLE PRESSURE [Device based on Permeability (rising rapidly with Temperature) of Quartz to Neon].—Nicolle. (*Comptes Rendus* [Paris], 2nd/30th Aug. 1943, Vol. 217, No. 5/9, pp. 170–172.)

2957. RESCON, A HIGH-RESISTANCE PAINT [and Its Use for an Impregnated-Cloth High Resistance].—General Electric. (Mentioned in paper by Jennings & others, 2953, above.)

2958. ON EXTREMELY DEHYDRATED GELATIN FILMS AND THEIR ELECTRICAL CONDUCTIVITY.—Gombay. (*Kolloid-Zeitschr.*, Vol. 100, 1942, p. 350 onwards: a 6-page paper.)

2959. INFLUENCE OF NON-UNIFORM DEVELOPMENT OF HEAT [due to Increase of Resistance with Temperature] UPON THE TEMPERATURE DISTRIBUTION IN ELECTRICAL COILS AND SIMILAR HEAT-SOURCES OF SIMPLE FORM.—Jakob. (*Sci. Abstracts*, Sec. B, March 1944, Vol. 47, No. 555, p. 47.)

2960. THE SINTERING PROCESSES IN POWDERS CONSISTING OF A SINGLE COMPONENT : A CONTRIBUTION TO ELUCIDATING THE PROCESSES OF METAL CERAMICS AND OXIDE CERAMICS.—Hüttig. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 62.)

2961. REACTION BETWEEN SOLIDS [Investigation of the Formation of Spinel from Magnesia & α-Alumina above 1000° C (" Reaction probably Characteristic of Others encountered in Refractory & Ceramic Industries . . . ") : the Effect of a Reducing Atmosphere].—Castell & others. (*Nature*, 27th May 1944, Vol. 153, No. 3891, pp. 653–654.)

2962. THE FREEZING TEMPERATURE OF HIGH-MOLECULAR GLASSES AND THEIR CHEMICAL CONSTITUTION.—Jenckel. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 62.)

2963. " PORCELAIN AND OTHER CERAMIC INSULATING MATERIALS : VOL. 1—RAW MATERIALS, MANUFACTURING PROCESSES, TESTING, AND CHARACTERISTICS " [Book Review].—Rosenthal. (*Electrician*, 30th June 1944, Vol. 132, No. 3448, p. 565.) For recent papers *see* 227 of 1942 and 1968 of 1943.

2964. THE DESIGN OF SMALL CERAMIC COMPONENTS [with Illustrations showing the Wrong & Right Shapes, for Economy in Labour & Material, etc.].—Wallich. (*Zeitschr. V.D.I.*, 8th Jan. 1944, Vol. 88, No. 1/2, pp. 9–14.)

2965. THE INFLUENCE OF POLARISATION ON THE ELECTRIC BREAKDOWN STRENGTH [of Mica & KBr] AND ITS DEPENDENCE ON TEMPERATURE.—Malmlöw. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 58.)

2966. MYCALEX [and Its Special Advantages : Grades of G.E. Mycalex and Their Use or Typical Properties : etc.].—Barringer. (*Gen. Elec. Review*, April 1944, Vol. 47, No. 4, pp. 53–55.)

2967. PROPERTIES OF LAMINATED PHENOLICS.—Caldwell. (*Sci. Abstracts*, Sec. B, March 1944, Vol. 47, No. 555, p. 44.)

2968. SYNTHETIC RESINS : MECHANICAL BEHAVIOUR AT LOW TEMPERATURES.—Röhrs & Hauck. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 68.)

2969. THE ELECTRICAL PROPERTIES OF POLYVINYL ACETATE [and Its Three Regions of Permittivity Dispersion].—Dakin. (*Sci. Abstracts*, Sec. B, March 1944, Vol. 47, No. 555, p. 44.)

2970. EXTENSIVE SYMPOSIUM ON PLASTICS, PHILADELPHIA, 22ND AND 23RD FEBRUARY, 1944 [Summaries].—American Soc. for Testing Materials. (*ASTM Bulletin*, Jan. 1944, No. 126, pp. 9–16.)

2971. RADIO-FREQUENCY HEATING OF PLASTICS : THE SELECTION OF THE PROPER EQUIPMENT.—Mittelmann. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, Supp. pp. 3–6 and 35, 36.)

2972. Plastics and Electrical Technology [I.E.E. & Soc. Chemical Industry Joint Discussion on the Newer Thermoplastics, Radio-Frequency Heating, & "Tracking"].—Nancarrow, Hartshorn, Rushton. (*Nature*, 27th May 1944, Vol. 153, No. 3891, pp. 641–643.)

2973. "High Polymers" [Book Review].—Fuoss & others. (*Nature*, 3rd June 1944, Vol. 153, No. 3892, pp. 665–667.) Joint discussion, Physics and Chemistry Sections of the New York Academy of Sciences. For the series edited by Mark, Kraemer, & Whitby, under the same title, *see* 3140 of 1943.

2974. Synthetic Rubbers and Plastics: VI—The Theoretical Aspect of Cross-Linkages in Synthetics.—Penn. (*Distribution of Elec.*, July 1944, Vol. 17, No. 155, pp. 273–280.)

2975. A Brief Survey of Synthetic Alternatives to Natural Rubber [including the Products produced by Compounding with Sulphur, Carbon Black, etc.].—Glover. (*P.O. Elec. Eng. Journ.*, April 1944, Vol. 37, Part 1, pp. 11–16.)

2976. "Modern Synthetic Rubbers" [Book Review].—Barron. (*Current Science* [Bangalore], Jan. 1944, Vol. 13, No. 1, p. 20.)

2977. The Chemical Treatment of Wood [Process using Methylolurea: Soft Woods become Harder than Hard Maple and Maple Harder than Ebony: also "Case-Hardening" Results].—Berliner. (*Science*, 21st April 1944, Vol. 99, No. 2573, Supp. p. 10.) From the du Pont de Nemours Company: *cf.* 2030 of June.

2978. Voltage Stress upon Dielectrics [and the Danger of the Random Use of A.C. & D.C. Tests, in causing Delayed Faults likely to provide False Data, False Security, & Further Trouble].—Tree. (*Electrician*, 30th June 1944, Vol. 132, No. 3448, pp. 562–563.)

2979. Dielectric Properties of Dipolar Substances.—Fröhlich & Sack. (*Proc. Roy. Soc.*, Series A, 16th June 1944, Vol. 182, No. 991, pp. 388–403.)

Authors' summary:—"From an investigation of structure it is shown that there exists a large group of dipolar organic solids whose dipoles have two equilibrium positions with opposite dipole direction. To calculate the dielectric properties, Onsager's theory has been extended and developed into a systematic approximation which converges above a critical temperature. To derive the local field acting on the dipole, we have replaced the surroundings by a continuum whose dynamic dielectric properties we have taken into account. As a result we find larger dielectric constants and smaller dielectric losses than in Onsager's theory. We have also shown that liquids with high viscosity behave similarly to solids, while for liquids with low viscosity there are no such deviations from Onsager's theory."

2980. Rapid Measurement of the State of Charge of Accumulators [Apparatus comparing the Resistance of Electrolyte with That of a Standard Electrolyte].—Dauphin. (*Génie Civil*, 15th Jan. 1944, Vol. 121, No. 2, p. 19.) Description of a French patent, primarily for electric vehicles but capable of general application.

2981. Beryllium Copper in Instrument Design [Springs, Flat & Helical: Hair Springs: Corrugated Diaphragms & Flexible Bellows, etc: Fabrication & Heat Treatment: Soldering & Brazing: Electroplating].—Hunt. (*Journ. of Scient. Instr.*, June 1944, Vol. 21, No. 6, pp. 97–105.) *Cf.* 237 of January and back reference.

2982. Beryllium Windows for X-Ray Tubes [and the Production of Malleable Beryllium by a New Vacuum-Melting Process].—British Unicorn, Ltd. (*Journ. of Scient. Instr.*, June 1944, Vol. 21, No. 6, p. 109.)

2983. Frictional Phenomena: XV—External Friction of Solids [and the Complicating Factors during Sliding Motion].—Gemant. (*Journ. Applied Phys.*, Sept. 1943, Vol. 14, No. 9, pp. 456–464.) For previous parts *see* 2821 of 1943.

2984. Some Measures of Electrical-Brush Disintegration.—Coover & Jones. (*Elec. Engineering*, Dec. 1943, Vol. 62, No. 12, Transactions pp. 750–754.) "These concepts are believed to be significant and useful tools that may further an understanding of the basic problem of sliding electrical contacts. . . ."

2985. Materials for the Resistance Winding of Potentiometers [and the Good Performance of "Potentiometer Gold Alloy PA·74"].—Fröhlich. (*See* 2931.)

2986. Silver [and Silver Alloys] for Electrical Purposes.—Collacott. (*Distribution of Elec.*, July 1944, Vol. 17, No. 155, p. 308: summary, from *Elec. Times*.)

2987. The Use of Silver as a Contact Metal in Switchgear.—Gibson. (*BEAMA Journal*, Oct. 1943, Vol. 50, No. 76, pp. 304–308.)

2988. The Calculation of Inductive Circuits with Switching Arcs.—von Hake & others. (*See* 2875.)

2989. Four New Vacuum Switches.—General Electric. (*QST*, Feb. 1944, Vol. 28, No. 2, p. 57: paragraph & photograph only.)

2990. An Impulse Test Set for Relays.—Ivanov. (*Automatics & Telemechanics* [in Russian], No. 3, 1941, pp. 67–72.)

A set is described for testing relays and measuring their operating and release times. The duration of the impulse applied to the relay under test can be continuously varied from 0 to 300 msecs. No valves are used in the set.

2991. On Estimating the Sensitivity of Electro-Magnetic Relays.—Zaks & Mil'shteyn. (*Automatics & Telemechanics* [in Russian], No. 4/5, 1941, pp. 65–70.)

It is pointed out that in designing systems with d.c. relays, especially in automatics, it is not always convenient to regard the operating current of a relay as a criterion of its sensitivity. It is therefore suggested that the operating power should be referred to instead. It is shown that the new criterion enables the designer to estimate the suitability of a relay for obtaining the desired sensitivity, and to analyse the effects of various parameters of a relay on its sensitivity.

2992. RELAY WITH LEAF SPRING [which acts as Bearing and also supplies Restoring Torque].—Control Corporation. (*Electronics*, Oct. 1943, Vol. 16, No. 10, p. 293.)

2993. MAGNETIC DUST CORES [General Discussion of Properties obtainable by Various Degrees of Subdivision of Core Material, followed by Review of Various Methods for the Manufacture of Dust Cores, and Examples of Their Uses].—Polgreen. (*P.O. Elec. Eng. Journ.*, April 1944, Vol. 37, Part 1, pp. 1–6.)

2994. THE HYSTERESIS IN THE RAYLEIGH REGION OF WEAK MAGNETIC FIELDS, FOR "SHEARED" MAGNETISATION CURVES [with Special Reference to Dust Cores].—Kornetzki. (*E.N.T.*, Jan. 1943, Vol. 20, No. 1, pp. 10–17.)

This is the paper referred to in 2039 of June. "The hysteresis resistance R_h of a coil with a magnetisable core can be calculated, for small a.c. field strengths, from the hysteresis coefficient h according to the equation $R_h = h \cdot f \cdot L \cdot H$ . . . (eqn. 1), where H is the effective value of the magnetic field strength in the core.

"Experience shows that h may often be regarded as constant so long as the field strength does not go beyond the Rayleigh region. Now if, through the introduction of an air-gap in the core, the initial permeability μ_a of the core material is 'sheared down' to a smaller value μ_{wa}, for an ideal 'shearing' [" Scherung "] the hysteresis coefficient will sink theoretically to $h_w = h(\mu_{wa}/\mu_a)^2$ . . . (eqn. 2). In deriving this equation it is assumed (Deutschmann, 1933 Abstracts, p. 113) that the 'unsheared' material is homogeneous—that it has, for instance, the same permeability at all points—and that the Rayleigh law holds good: further, that the 'shearing' is distributed uniformly throughout the whole core, so that the induction also is uniform. In actual practice there is always a certain lack of uniformity in the distribution of the magnetic constants, and consequently of the induction, both in 'unsheared' and (even more so) in 'sheared' cores. This explains the deviations from the simplified eqn. 2. It is found experimentally that h_w is always larger than the value calculated from eqn. 2. It is also assumed of h_w that it is practically independent of H, though it was known (Deutschmann, *loc. cit.*) that in deriving eqn. 2, which comes from a series development, terms of higher order were neglected.

"Although for a long time investigations of the departures from the Rayleigh law at low field strengths have been reported, and calculations carried out on the loss coefficients of magnetic cores whose magnetisation curves do not follow the Rayleigh law, there has been no success (apart from the above-mentioned case of eqn. 2) in finding the causes of the departures. Nor has it been shown whether a 'shearing' may cause departures from Jordan's eqn. 1. And yet such investigations are important, since eqn. 1 not only forms the general basis for the calculation of the hysteresis losses of a coil with magnetisable core, but provides the possibility of separating the hysteresis losses from the after-effect (viscosity) losses.

"The question as to the validity of eqn. 1 received a new impulse when Kiessling & Ludl published their measurements of the dissipative impedance of coils with Sendust powder cores (211 of 1943) showing that even at the lowest field strengths there was no linear relation between loss resistance and current strength [" in the paper in question an initial permeability of about 100 000 is given, obviously in error "]. The writers expressed their belief that an effect of the 'shearing' in the powder core might be involved, seeing in the field-strength dependence of μ_a (in eqn. 2) the cause for the decrease of h_w with field strength which was found in their measurements.

"It seems, therefore, timely to investigate, both theoretically and experimentally, the influence of a 'shearing' of the magnetisation curve on the hysteresis coefficient at low fields. The investigations showed that, in fact, a 'shearing' may cause serious departures from the Rayleigh law."

Author's summary:—"It is shown by calculation that the magnetisation curve of a 'sheared' magnetisable material cannot be a Rayleigh loop, if the unmagnetised material follows the Rayleigh law. The previously employed 'shearing' equation [eqn. 2] is valid theoretically only for infinitely low field strengths. The hysteresis coefficient of a 'sheared' magnetic core falls with increasing field strength, at first about linearly and then more slowly, without there being, at low fields, any region with constant hysteresis coefficient. The form of curve for the dropping-off, calculated on the basis of uniform induction, is qualitatively in agreement with the measured results, but the measured drop is greater than it should be by calculation. The cause of the discrepancy must be taken to be the lack of uniformity in the induction, neglected in the calculation but actually existing in practice."

2995. ON THE DAMPING OF MECHANICAL VIBRATIONS BY MAGNETIC [Magnetostrictive] HYSTERESIS [Theoretical Treatment, and Comparison with Förster & Köster's Experimental Results (3416 of 1937), etc.].—Kornetzki. (*Zeitschr. f. Phys.*, 24th Aug. 1943, Vol. 121, No. 9/10, pp. 560–573.) From the Siemens & Halske laboratories.

2996. CLASSIFICATION OF PERMANENT-MAGNETIC MATERIALS ACCORDING TO THEIR MAGNETIC PROPERTIES [with Data on 50 Alloys used in Germany].—Zumbusch. (*Sci. Abstracts*, Sec. B, March 1944, Vol. 47, No. 555, p. 47.) Short reference only to a 1940 German paper.

2997. "ELECTRO-MAGNETS AND WINDINGS" [Book Review].—Windred. (*Electronic Eng:g*, Feb. 1944, Vol. 16, No. 192, p. 394.)

2998. THE EFFECT OF TORSIONAL OSCILLATIONS ON THE BARKHAUSEN EFFECT [made evident in Loudspeaker: Explanation].—Koch. (*Naturwiss.*, 7th May 1943, Vol. 31, No. 19/20, pp. 233–234.)

2999. On the Appearance and Interpretation of Buckled Curves in the Representation of Magnetic Susceptibility as a Function of the Reciprocal Field Strength [including Criticisms of Other Workers' Conclusions].—Knappwost. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, p. 511.)

3000. Magnetic Investigations on a Nickel–Carbon Alloy [and Its Anomalous Properties].—Gerlach & von Rennenkampff. (*Zeitschr. Elektrochem.*, April/May 1943, Vol. 49, p. 200 onwards.) *See* also 585 of February.

3001. The Influence of a Thin Superficial Deposit on the Magnetisation of a Block of Steel: Application to the Magnetic Properties of Rocks.—Bayard-Duclaux. (*Comptes Rendus* [Paris], 3rd/31st May 1943, Vol. 216, No. 18/22, pp. 727–728.)

3002. "Ferromagnetismus und Werkstoff," *and* "Über den Einfluss von Erschütterungen auf den Magnetisierungszustand ferromagnetischer Körper: der magnetische Zustand von Fahrzeugen" [Book Reviews]. — Houdremont: Lange. (*Zeitschr. V.D.I.*, 8th Jan. 1944, Vol. 88, No. 1/2, pp. 31–32.) The second author deals with compass disturbances due to the use of steel as aeroplane material.

STATIONS, DESIGN AND OPERATION

3003. Ultra-High-Frequency *versus* Micro-Waves in Two-Way Radio Communications.—Freedman. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, pp. 24–25 and 99..104.)

Thus in the table of "functional comparisons", the maximum f.m. deviation ratio for max. clarity and signal strength withour exceeding receiver natural band-pass is given as 3 to 1 unless receiver has band-pass exceeding 100 kc/s, for u.h.f., while for micro-waves it is "about 300 to 1: signal clarity and signal strength can be 100 times greater than for u.h.f." The minimum range in miles "may be reliably computed [for both types of wave] by multiplying the square root of the total antenna heights in feet [heights of land above surrounding terrain or sea, at transmitting and receiving points, added to heights of transmitting and receiving aerials above ground] by the coefficient 1.225 for the curvature of the earth." Various personal experiences (including with dead-spots) are described.

3004. Radio Telephones on the L.N.E.R. [Experiments carried forward a Further Stage].—Rediffusion, Ltd. (*Engineer*, 19th May 1944, Vol. 177, No. 4610, p. 398.) For a previous report *see* 250 of January, and *cf.* 249 of same month.

3005. The Planning of the Wire-Broadcasting Extension Amplifier [with regard to Economy in Cost, Material, & Labour].—Lanzerath. (*T.F.T.*, Nov. 1943, Vol. 32, No. 11, pp. 234–237.)

GENERAL PHYSICAL ARTICLES

3006. Application of Pulses of X-Rays to the Measurement of the Probability of Fixation of Electrons on Oxygen Molecules.—Herreng. (*See* 2850.)

3007. Cold Dense Matter [Summary of Indian Science Congress Address].—Kothari. (*Nature*, 27th May 1944, Vol. 153, No. 3891, p. 658.) "A welcome summary of the main features of temperature- and pressure-ionisation of matter at high and low temperatures and at high and low densities" (E. A. Milne).

3008. Impact of a Wave Packet on an Absorbing Particle [Assumptions of Conservation of Energy & Momentum applied to Mass Equivalent of Radiation].—Ives. (*Journ. Opt. Soc. Am.*, April 1944, Vol. 34, No. 4, pp. 222–228.)

Stationary absorbing particle: system in uniform motion: pressure of radiation: discussion. The previous paper, dealing with a reflecting particle, appeared in Vol. 33, 1943: for earlier work *see* 938 of 1942.

3009. Finite Self-Energies in Radiation Theory: Part III.—Landé & Thomas. (*Phys. Review*, 1st/15th March 1944, Vol. 65, No. 5/6, pp. 175–184.)

3010. Theory of Gravitation [based on the Perfect Fluid projected against the Flat Space-Time of the Special Theory of Relativity].—Birkhoff. (*Sci. News Letter*, 1st April 1944, Vol. 45, No. 14, p. 220.) "Not only is the theory in perfect accord with ordinary gravitational phenomena, but it explains in another way the three most delicate effects of the famous Einstein theory of 1916. . . ."

3011. Kinematic Relativity [Paper on E. A. Milne's "New Kind of Relativity" (2246 of 1943)].—Wilson: Milne. (*Phil. Mag.*, April 1944, Vol. 35, No. 243, pp. 241–249.) "While greatly admiring Milne's effort, I find difficulties in accepting his results—including his eqn. 4, which appears to be fundamental."

3012. The Evaluation of the Cosmical Number.—Eddington. (*Proc. Cambridge Phil. Soc.*, March 1944, Vol. 40, Part 1, pp. 37–56.)

3013. Direct Derivation of Balmer Spectra.—Kosambi. (*Current Science* [Bangalore], March 1944, Vol. 13, No. 3, pp. 71–72.) "Thus, the Balmer formula is derivable as a property of Planck's law and the ambivalent measurement of energy; without any assumption as to the planetary structure of the atom . . ."

3014. "Vorlesungen über theoretische Physik: Band I—Mechanik" [Book Review].—Sommerfeld. (*Hochf:tech. u. Elek:akus.*, Nov. 1943, Vol. 62, No. 5, p. 163.) These Munich University lectures are appearing in six volumes, the others dealing with the mechanics of deformable media, electrodynamics, optics, thermodynamics & statistics, and the partial differential equations of physics.

3015. Asymptotic Formulae relating to the Physical Theory of Crystals.—Ledermann. (*Proc. Roy. Soc.*, Series A, 16th June 1944, Vol. 182, No. 991, pp. 362–377.)

3016. Molecular Weight, Gram Molecule, and Avogadro's Number [and the Suggested Term of Quantity, the "Avogadron"], *and* Terminology and Symbols in Physics [and the Difficulties & Errors resulting from Loose or Wrong Terminology: Some Suggested Symbols].—Duncanson. (*Phil. Mag.*, Feb. 1944, Vol. 35, No. 241, pp. 73–80: pp. 81–90.)

3017. Relaxation Processes in Statistical Systems.—Krylov. (*Nature*, 10th June 1944, Vol. 153, No. 3893, pp. 709–710.)

3018. New Experiments about the Magnetic Current [Summary of Am. Phys. Soc. Paper (with Demonstrations at C. Zeiss, Inc.)].—Ehrenhaft. (*Phys. Review*, 1st/15th Jan. 1944, Vol. 65, No. 1/2, pp. 62–63.) *See* also 937 of March, and *cf.* 1718 of May.

MISCELLANEOUS

3019. Application of the Method of Variation of Constants to the Study of Non-Linear Oscillations.—Jouguet. (*Comptes Rendus* [Paris], 2nd/30th Aug. 1943, Vol. 217, No. 5/9, pp. 218–220.)

3020. Forced Vibrations of Systems with Non-Linear Restoring Force [including Jump Phenomena & Subharmonic Resonance].—Friedrichs & Stoker. (*Quarterly of Applied Math.* [Brown University], April 1943/Jan. 1944, Vol. 1, p. 97 onwards.) "Precision is combined with extreme simplicity, so that the results obtained will be widely available . . ." (N. Levinson in *Math. Reviews*). A 19-page paper.

3021. Economical Apparatus for the Demonstration of Damped Forced Oscillations.—Finke. (*Zeitschr. V.D.I.*, 13th Nov. 1943, Vol. 87, No. 45/46, p. 731.)

3022. Asymptotic Properties of Functions and Characteristic Values in Certain Vibration Problems [including Extension, by Analogy, to Problems of Isothermal Electromagnetic Vibrations in a Reflecting Enclosure].—Pleijel. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 54.)

3023. Erratum: Resolution of Boundary Value Problems by means of the Finite Fourier Transformation: General Vibration of a String.—Brown. (*Journ. Applied Physics*, March 1944, Vol. 15, No. 3, p. 292.) *See* 973 of March.

3024. On an Analogy between the Summation of Fourier Series and That of Interpolation Trigonometric Polynomials.—Losinsky. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 30th April 1943, Vol. 39, No. 3, pp. 83–87: in English.)

3025. Corrections to "The Three Infinite Harmonic Series and Their Sums (with Topical Reference to the Newton and Leibnitz Series for π)."—Soddy. (*Proc. Roy. Soc.*, Series A, 16th June 1944, Vol. 182, No. 991, p. 416.) Referred to in 955 of March.

3026. On the Stability of Inverse Problems [involved, *e.g.*, in deducing Structure of Earth's Crust from Electrical-Conductivity Measurements].—Tikhonov. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 20th May 1943, Vol. 39, No. 5, pp. 176–179: in English.)

3027. Some Processes for the Solving of Functional Linear Equations by the Method of Iteration.—Gercevanoff. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 30th May 1943, Vol. 39, No. 6, pp. 207–209: in French.)

3028. On A. C. Aitken's Method of Interpolation [Simplification, applying to Odd as well as Even Number of Data: a Method of Iteration, using neither Differences nor Tables of Interpolation Coefficients: Well Adapted to Machine Computation].—Feller. (*Quarterly of Applied Math.* [Brown University], April 1943/Jan. 1944, Vol. 1, p. 86 onwards.)

3029. Quasi-Latin Squares in Experimental Arrangements, *and* Distribution of Fisher's g_1 for Samples of Three from a Continuous Rectangular Distribution.—Rao: Sekar. (*Current Science* [Bangalore], Dec. 1943, Vol. 12, No. 12, pp. 322–323: Jan. 1944, Vol. 13, No. 1, pp. 10–11.)

3030. Probability-Integral of the t-Function [Graphical Representation using Non-Uniform Probability Scale, with Advantages over Evans's Diagram (628 of February)].—Bainbridge: Evans. (*Engineering*, 5th May 1944, Vol. 157, No. 4086, p. 355.)

3031. Coefficients for Numerical Integration with Central Differences.—Salzer. (*Phil. Mag.*, April 1944, Vol. 35, No. 243, pp. 262–264.) *See* also 2070/1 of June.

3032. A Chart for plotting Relations between Variables over Their Entire Real Range [Method of Graphical Representation consisting in making ordinary Cartesian Plot over Range -1 to $+1$ and adjoining Cartesian Plots of Reciprocals of the Variables over Ranges 0 to -1 and $+1$ to 0: Examples].—Donnell. (*Quarterly of Applied Math.* [Brown University], April 1943/Jan. 1944, Vol. 1, p. 276 onwards.)

3033. "Laplace-Transformation" [Book Review].—Hameister. (*Hochf:tech. u. Elek: akus.*, Nov. 1943, Vol. 62, No. 5, p. 163.) An unfavourable review was dealt with in 635 of February. The present one, by Zenneck, is favourable.

3034. "Umrechnungstafeln" [Conversion Tables: Review].—Stille. (*See* 2937.)

3035. Basic Mathematics [and the Need for Standardisation of Symbols: the Work of the Coordination & Guidance Committee for the Teaching of Physics, and Its Notation Subcommittee].—Woodland. (*Engineer*, 12th May 1944, Vol. 177, No. 4609, p. 370.)

3036. Tooling Up Mathematics for Engineering [Dialogue between a Mathematician & an Engineer: the Applied Mathematician as a Tool Designer].—von Kármán. (*Quarterly of Applied Math.* [Brown University], April 1943/Jan. 1944, Vol. 1, p. 2 onwards.)

3037. "Methoden der mathematischen Physik" [Book Review].—Courant & Hilbert. (*Nature*, 27th May 1944, Vol. 153, No. 3891, pp. 633–634.) For another review *see* 2361 of July.

3038. "The Mathematics of Physics and Chemistry" [Book Review].—Margenau & Murphy. (*Journ. Acous. Soc. Am.*, April 1944, Vol. 15, No. 4, p. 227.)

3039. "Physico-Chemical Methods" [Fourth Edition, Revised: Book Review].—Reilly & Rae. (*Nature*, 10th June 1944, Vol. 153, No. 3893, p. 696.)

3040. "Principles of Aeronautical Radio Engineering" [Book Review].—Sandretto. (*Proc. I.R.E.*, March 1944, Vol. 32, No. 3, p. 183.) Previous reviews were referred to in 2091 of June.

3041. "Fundamental Radio Experiments" [Book Review].—Higgy. (*Proc. I.R.E.*, March 1944, Vol. 32, No. 3, p. 184.) For another review *see* 2402 of July.

3042. Military Radio should be Simplified and Standardised.—Wolf: Hull. (*See* 2924.)

3043. Radio in a Theatre of War: Personal Observations of Electrical and Electronic Equipment that is being used by Allied Forces in the European Theatre [with Discussion of Their Possible Post-War Applications, in Great Britain & America]. —Porter. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, pp. 21–23 and 64..69.)

3044. The First Meeting of Sir William Preece and Signor Marconi [in 1896: with Sketch of the Apparatus demonstrated].—Mullis. (*P.O. Elec. Eng. Journ.*, April 1944, Vol. 37, No. 1, p. 29.)

3045. On the Strategy of Applied Research. —Daeves. (*Zeitschr. V.D.I.*, 8th Jan. 1944, Vol. 88, No. 1/2, pp. 3–7.)

3046. Training the Citizen-Engineer.—Dent. (*Distribution of Elec.*, July 1944, Vol. 17, No. 155, pp. 296–300 and 305.)

The writer ends: "There are the full and valuable reports of the various Institutions and of other authoritative bodies to study at length. There does seem, however, a need to consult the student himself, through his representative societies, about the future of engineering education, because he often has good ideas and, in addition, he sees his work and functions through different eyes . . ."

3047. Science and the Public Welfare [and the "One per Cent" Idea].—Hill. (*Current Science* [Bangalore], Dec. 1943, Vol. 12, No. 12, pp. 315–317.) For the subsequent lecture to the Indian Science Congress *see* 2380 of July.

3048. "Post-War Plans for Science" [Review of Memorandum criticising Recent Statements & Reports].—Association of Scientific Workers. (*Nature*, 17th June 1944, Vol. 153, No. 3894, p. 740.)

3049. Chungking Industrial and Mining Exhibition.—Needham. (*Nature*, 3rd June 1944, Vol. 153, No. 3892, pp. 672–675.)

3050. The Natural Science Society of China [and the Publication of *Acta Brevia Sinensia* & Other Periodicals].—Chang-Wang Tu. (*Science*, 14th April 1944, Vol. 99, No. 2572, p. 298.) A letter from Chungking: it includes a request for cooperation.

3051. Power Distribution for Murray Hill Buildings.—Siebs. (*Bell Lab. Record*, Feb. 1944, Vol. 22, No. 6, pp. 273–281.) For these laboratories *see* 663 of February.

3052. The U.S. Radio and Sound Laboratory.—Hammond. (*Journ. Applied Physics*, March 1944, Vol. 15, No. 3, pp. 240–242.)

3053. The I.R.E. Amended Constitution: a Protest concerning the New Names for the Various Grades, and Alternative Proposals.—Bird. (*Proc. I.R.E.*, May 1944, Vol. 32, No. 5, pp. 311–312.) For submitted Amendments in accordance with these proposals of the Montreal Section, *see* p. 310.

3054. The Dunlop Suggestion Scheme [*cf.* 300 of January: Further Information].—Bond. (*Engineer*, 19th May 1944, Vol. 177, No. 4610, p. 391: *Engineering*, 19th May 1944, Vol. 157, No. 4088, p. 395.)

3055. The British Patent System [Abridgment of Report].—Chartered Institute of Patent Agents. (*Engineering*, 5th May 1944, Vol. 157, No. 4086, p. 356.)

3056. Patent Law and Procedure in Austria [with Special Reference to the Treatment of the Scientific Worker in His Quality as Inventor].—Abel. (*Nature*, 10th June 1944, Vol. 153, No. 3893, p. 716.) This Austrian Patent Act of 1925 "seems to be the most progressive legislation in this field of law."

3057. "Drawing Office Organisation: B.S. 1100, Part 9" [Book Review].—British Standards Institution. (*Engineering*, 19th May 1944, Vol. 157, No. 4088, p. 392.) One of a series entitled "Booklets on Office Aid to the Factory."

3058. Proposed Institution of Engineering Draughtsmen.—Short. (*Engineering*, 5th May 1944, Vol. 157, No. 4086, p. 355.) For a leading article on "The Draughtsman and His Status" *see* pp. 351–352, and for correspondence *see* issue for 19th May, No. 4088, pp. 394–395.

3059. SOCIETY OF INSTRUMENT TECHNOLOGY [Formation of].—(*Nature*, 17th June 1944, Vol. 153, No. 3894, pp. 739–740.) For other new formations *see* 2383/5 of July.

3060. ARBITRARY EDITORIAL CHANGES IN SCIENTIFIC PAPERS [Correspondence started by a Protest from W. C. Boyd, Issue for 27th Aug. 1943].—(*Science*, 24th March 1944, Vol. 99, No. 2569, pp. 239–241.)

3061. "THE LOOM OF LANGUAGE: A GUIDE TO FOREIGN LANGUAGES FOR THE HOME STUDENT" [and an Outline of a "Planned" Language: Book Review].—Bodmer. (*Nature*, 17th June 1944, Vol. 153, No. 3894, pp. 729–730.) Edited and arranged by L. Hogben.

3062. THE USE OF AN INTERNATIONALLY UNDERSTANDABLE LANGUAGE IN SCIENTIFIC PUBLICATIONS AND IN CONGRESSES [Present Enormous Waste of Intellectual & Material Efforts: Summaries & Abstracts merely a Palliative: Objections to Artificial Languages: English *versus* Latin: Suggestion that American Assoc. for the Advancement of Science should tackle the Problem].—Wasicky. (*Science*, 14th April 1944, Vol. 99, No. 2572, pp. 297–298.) A letter from Brazil.

3063. TRANSLITERATION OF RUSSIAN NAMES [the Russian Academy of Sciences' Rules (1906): Desirability that These should be observed Internationally: the Revised Rules complying with the New Orthography introduced about 25 Years ago].—Hoare. (*Science*, 21st April 1944, Vol. 99, No. 2573, p. 321.) From the Wellcome Research Institution, London. For the previous correspondence *see* 1775 of May & back reference.

3064. STUDY OF THE DYNAMIC LENS [Theoretical Analysis & Experiments with Plexiglas, Melopas, & Cellon as Shell Materials].—Meier. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 54.) From *Helvetica Phys. Acta*, 1943.

3065. DETERMINING THE SPEED OF A CAMERA SHUTTER BY A THERMOELECTRIC METHOD [particularly for Astronomical Work].—Pettit. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 49.)

3066. VISIBILITY OF SIGNAL LIGHTS.—Lash & Prideaux. (*Sci. Abstracts*, Sec. B, March 1944, Vol. 47, No. 555, p. 57.)

3067. APPARATUS FOR COINCIDENCE MEASUREMENTS OF VERY HIGH RESOLVING POWER [0.8×10^{-7} Second].—Bradt & Scherrer. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 60.) From *Helvetica Phys. Acta*, 1943.

3068. A PHOTOELECTRIC CELL VERY SENSITIVE TO THE EXTREME ULTRA-VIOLET [with CuI Photocathode].—Mattler. (*See* 2919.)

3069. CORRESPONDENCE ON "CONTRIBUTIONS TO THE THEORY OF AUTOMATIC CONTROLLERS AND FOLLOWERS" [2166 of July].—Prinz. (*Journ. of Scient. Instr.*, June 1944, Vol. 21, No. 6, pp. 110–111.)

3070. AUTOMATIC CONTROL [and the Use of the Astatic Relay].—Norris. (*Electrician*, 30th June 1944, Vol. 132, No. 3448, pp. 555–558.)

3071. AN ELECTRONIC BABY ALARM [Low Whimper at 2 Ft from Microphone operates Buzzer at Remote Point: Use of Rectified-Retroaction Relay Amplifier].—Worthington. (*Electronic Eng:g*, April 1944, Vol. 16, No. 194, pp. 476–477.) *Cf.* 4188 of 1938 and 1290 of 1940.

3072. HYGROPHONE MOISTURE-CONTENT MEASURING INSTRUMENT [for Grain].—Tamm. (*Sci. Abstracts*, Sec. B, March 1944, Vol. 47, No. 555, p. 46.)

3073. AN ELECTRONIC INDICATOR FOR LIQUID SEPARATION [where Internal Electrodes and Visual & Photoelectric Devices are Impossible: Passage of Conducting Liquid through Oscillator Inductance causes Eddy-Current Loss and destroys Magnetic Feedback: Hartley Circuit, 1–10 Mc/s].—Broadhurst. (*Journ. of Scient. Instr.*, June 1944, Vol. 21, No. 6, pp. 108–109.)

3074. ANALYSIS OF [Mixtures of Hydrocarbon] GASES BY THE SCATTERING OF ELECTRONS.—West. (*Sci. Abstracts*, Sec. A, March 1944, Vol. 47, No. 555, p. 58.) From *Geophysics*, 1943.

3075. ACTIVATION OF CATALYTIC SUBSTANCES BY ELECTRIC WAVES [and the Coherer Effect].—Hedvall & Algren. (*See* 2887.)

3076. HIGH-FREQUENCY CURRENT USED FOR DEHYDRATION.—Vang. (*Sci. News Letter*, 1st April 1944, Vol. 45, No. 14, p. 221.) U.S. Patent 2 344 754.

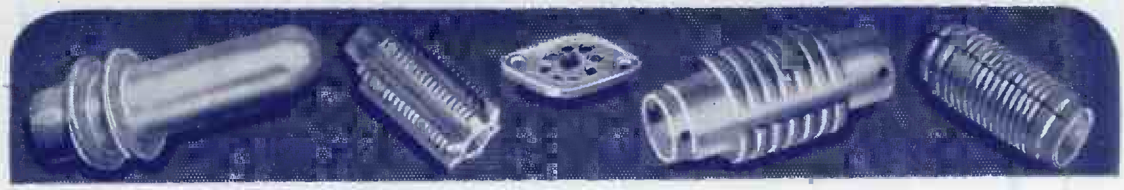
3077. RADIO-FREQUENCY HEATING OF PLASTICS: THE SELECTION OF THE PROPER EQUIPMENT.—Mittelmann. (*Radio News* [Chicago], May 1944, Vol. 31, No. 5, Supp. pp. 3–6 and 35, 36.)

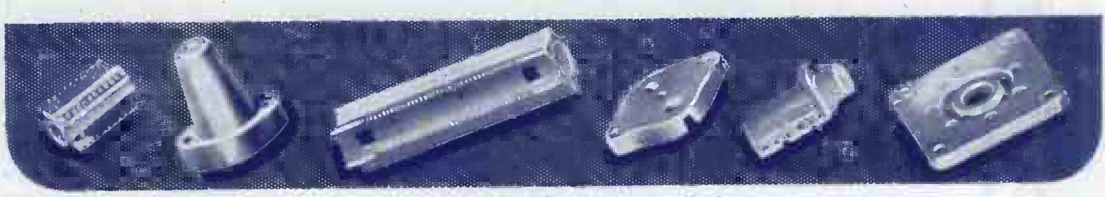
3078. MODULATED-BEAM CATHODE-RAY PHASE METER [primarily for Measurements on Amplifiers used in Vibration Measuring].—Watton. (*See* 2928.)

3079. WIRE-WOUND ELECTRICAL RESISTANCE STRAIN GAUGES.—Dorey. (*Engineer*, 12th & 19th May 1944, Vol. 177, Nos. 4609 & 4610, pp. 375–376 [Discussion pp. 371–372] & 386–387.) Long abstract of an Institution of Naval Architects' paper.

3080. A NOTE ON THE BEHAVIOUR OF THE EARTH AS AN ELECTRICAL CONDUCTOR.—Gould. (*P.O. Elec. Eng. Journ.*, Jan. 1944, Vol. 36, Part 4, pp. 118–120.)

"Examples are given where earth leakage current from power and tramway systems may cause the potential of the surrounding earth to be raised appreciably above its normal value, with consequent risk of damage to adjacent telecommunications or other plant."





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