Wireless World

RADIO, TELEVISION AND ELECTRONICS

VOLUME LVIII

JANUARY - DECEMBER 1952

Published from the Offices of "WIRELESS WORLD"
ILIFFE & SONS LTD., DORSET HOUSE, STAMFORD ST., LONDON, S.E.1.

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Radio Politics

WE may all be thankful that the important part played by radio in our national life is universally recognized. There are fewer grounds for self-congratulation, however, in the undoubted fact that radio in general, and in particular the control of broadcasting, is becoming increasingly a matter for political controversy.

Of course, no reasonable person would deny that the future of broadcasting in this country should be debated in Parliament before the B.B.C. charter and licence are renewed. Equally, the wisdom of extending the charter for six months to allow of mature consideration and preliminary discussion will be conceded. But there seems to be a danger that the issue may be clouded by party-political acerbity and doctrinaire ideology.

When the Beveridge Report was issued about a year ago, nearly everybody believed it would form at least the basis for the new charter; in other words, that there would be no drastic changes. Even now, such an exhaustive report, prepared under the leadership of such a distinguished chairman, can hardly be ignored, but there is a probability that certain matters of principle may come under attack.

Can a good case be made out by those concerned in the future of radio generally for violent and disruptive changes? On the face of it, the best argument to the contrary is that the broadcast licence figures show something very closely approaching saturation. Hazarding a guess as to the number of those unlicensed "pirates" who have lately been giving the Postmaster General some concern, we may say that 95 per cent of homes are already radio-equipped. We hope we are not unduly over-cautious or conservative in wondering whether it is worth taking the risk of introducing some drastic change (that may antagonize many existing listeners) on the off-chance of drawing the remaining 5 per cent into the fold.

So far as the main sound service of the B.B.C. is concerned, it may safely be assumed that the retention of the monopoly will not be strongly questioned, though the question of advertising or sponsored programmes will be hotly debated. This battle, however, promises to be most violent in regard to television, where the high cost of programme material provides an argument in favour of it.

It seems to us that the advocates of advertising programmes would do well, as a start, to press for experimental use of metre-wave broadcasting for this purpose. The Beveridge Report has already paved the way for independent operation of stations in this band, but, as we tried to show in our November issue, it is extremely doubtful if such stations could be successfully operated without advertising revenue. This is an experiment that might well be tried, and we do not imagine that the idea would meet with the widespread opposition that would certainly be forthcoming to any suggestion for interfering with existing services.

The question of television in the cinemas seems also likely to become an issue in which political intervention is particularly undesirable. The Post Office, by saying in evidence to the Beveridge Committee that cinema television "amounted to something very like broadcasting," was originally responsible for throwing this particular victim into the political arena. We are sorry to see that the present Postmaster General has apparently adopted very much the same attitude as that of his predecessor in office by refusing to grant licences until the matter is put before Parliament. Surely it is within his present rights to grant the necessary licences; no new principle is involved. Under the Telegraph and Wireless Telegraphy Acts, it seems reasonable to us to say, in the legal sense, that television in the cinema amounts to nothing more than moving pictures sent by line or radio telegraph. *Wireless World* does not remember that the Post Office sought Parliamentary sanction when it first allowed its licencees to transmit still pictures by radio. Unfortunately, this matter of cinema television has become thoroughly confused and nothing seems to have been done to clarify it since we first drew attention to the muddle in March, 1951. Here is a case where a particularly promising development in which Britain has played a leading part is being held up quite unnecessarily.

LOUDSPEAKER WITHOUT DIAPHRAGM

Direct Modulation of Ionized Air

THE loudspeaker, as we know it today, is admittedly the weakest link in the chain of elements required for faithful sound reproduction. Attempts to improve the moving-coil-driven diaphragm unit are inevitably balked by the limitations imposed by its mass and the difficulty of controlling flexure of the diaphragm. Then why not scrap the principle and try something fresh? Ionize the air particles and move them directly under the influence of an electric field, for instance.

The idea is not new. It was used by Duddell in 1900 in his singing arc, and has been tried with electrodes introduced into the highly-ionized regions of gas flames. Neither method is particularly efficient or convenient for general use, and the idea has lain dormant for many years, awaiting the development of a more efficient source of ionization.

In 1946, S. Klein described[1, 2] a prolific source of positive ions consisting of a mixture of 50 per cent precipitated platinum, 40 per cent aluminium phosphate, 5 per cent precipitated iridium and 5 per cent graphite, and showed that it could be used as an active anode to produce powerful ionization of air at normal atmospheric pressure under the action of an electric field. He suggested that an ionization cell of this nature could be used for the generation of infra- and super-sonic waves in air, and as a microphone or loudspeaker.

In the original design the anode was heated by a separate filament, and modulation was superimposed on a steady potential of about 700V between the emissive anode and a cylindrical cathode. An alternative arrangement showed the introduction of a control grid, which gave an arrangement rather like a polarity-inverted triode. Curves of current against applied voltage showed the relationship to be non-linear, but the author stated that oscillograph examination of the current had shown a sensibly linear relationship over the range of pressures used when the cell was tested as a microphone down to frequencies of a few cycles per second.

Further work on the device as a loudspeaker has caused Klein to revise his original circuit and he now uses a high-frequency field (400 kc/s) of about 10 kV between anode and cathode. The active material is no longer separately heated by a filament but is maintained at a temperature of the order of 1,000°C by electron and ion bombardment.

Fig. 1 shows one form of cell which we have recently had the opportunity of seeing and hearing. The active anode coating is at the tip of a quartz tube through which a single connecting wire passes. The electrode slips inside another quartz tube with a locating constriction and this tube is contained in a fused quartz envelope, the intervening space being evacuated to provide, according to the designer, thermal insulation and additional dielectric strength. The cathode is an aluminium cylinder of about 3in diameter and 4in long and is provided with a screw joint for connection to an exponential horn. The inside diameter of the quartz cell is about ¼in and is of parallel bore in the specimen illustrated, but there is no reason why it should not be given an exponential taper to match the horn. The space between the quartz cell and the cathode is filled with glass wool.

Two pentodes in parallel (each of the order of 20 watts anode dissipation) are used to generate the r.f. excitation. The basic circuit is shown in Fig. 2 from which it will be seen that modulation of both anode and screen voltage is employed. The modulated r.f. output voltage is high and is capable of sustaining a spark of ½in or so in air between ordinary electrodes.

According to the original descriptions, the cell requires a warming-up period of anything from several seconds to a minute, though in the demonstrations we saw, the discharge seemed to strike as soon as the r.f. is applied, and re-establish itself instantly after being allowed experimentally to cool down. The discharge between the active deposit and the aperture in the tube is orange in colour and violet for the half-inch or so to which it extends on the other side of the constriction. It appears to be quite stable in shape and fans out along the equipotential lines towards the cathode until it impinges on the walls of the tube. Occasional bright points may be seen travelling through the discharge, always in a direction from anode to cathode, from which it may be concluded that the average drift of some of the heavier positive ions is relatively slow and also that some rectification of the r.f. current is taking place.

The unmodulated discharge generates a characteristic random background hiss which is at a slightly higher level than that of the surface noise on the average shellac gramophone disc. A test demonstration with recordings of the singing and speaking voice, played through a pickup and a 10-watt a.f. amplifier and applied to the modulating winding of the r.f.

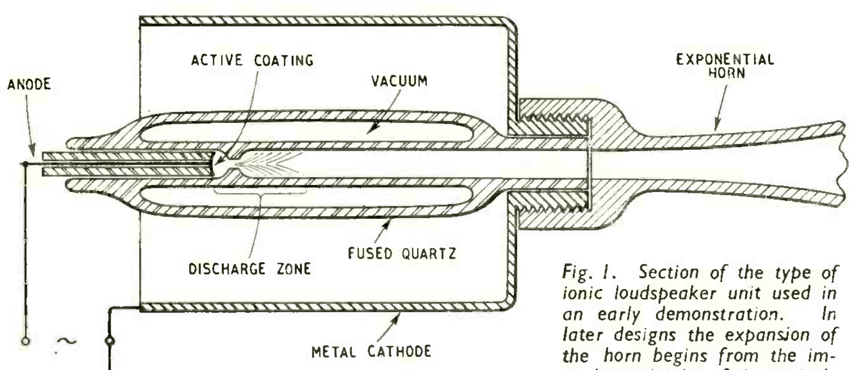

Fig. 1. Section of the type of ionic loudspeaker unit used in an early demonstration. In later designs the expansion of the horn begins from the immediate vicinity of the actively ionized gas.

generator, gave surprisingly good quality at a level approximating to that at which the average table model radio set is used. Above this level some distortion was obvious, and the discharge in the cell was visibly interrupted on peaks. It is only fair to add that some trouble had been experienced with the generator just prior to the demonstration and that near equivalents to the designer's original valves had to be substituted at the last minute. This probably restricted the power handling capacity of the generator.

Frequency response curves for constant voltage input have been published[3, 4, 6] and are remarkably uniform, showing deviations of ± 5db or less over the range from 25 c/s to 10 kc/s. The curves show no signs of falling off as the latter frequency is approached. It is virtually certain that "hangover" transients will be completely absent, since the inertia of the active gas molecules is negligible compared with that of the lightest conventional diaphragms.

What is not so certain is that the amplitude characteristic is linear over the dynamic range required for the reproduction of orchestral music. As far as we know, nothing has yet been disclosed on this score and it may turn out that non-linearity, with consequent intermodulation, is the Achilles heel of what otherwise appears to be a very promising principle. The ionization process in a gas is very complex and the relationship between current and the applied voltage is not linear, even under conditions of constant pressure. The relationships between gas pressure and temperature, and the kinetic energy imparted to ions under the influence of the electric field have been explored by Klein[5], with special reference to the action of the cell as a microphone; but the results are only tentative and do not necessarily apply to the case of the loudspeaker, where the instantaneous temperature, pressure and volume are varying over a much wider range.

Final judgment may reasonably be deferred until measurements of the electro-acoustic amplitude transfer characteristic have been published. If first results are unfavourable there is still the possibility of applying feedback to straighten things out, though whether this is feasible without a monitoring microphone and its attendant complications remains to be seen. A pair of auxiliary probe electrodes in the high-pressure region of the horn throat might afford a solution.

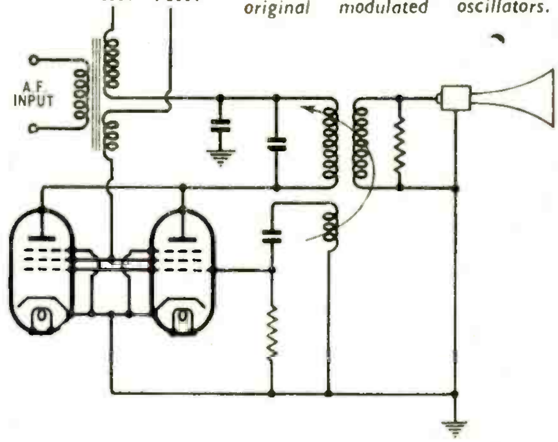

Fig. 2. Basic circuit of one of the original modulated oscillators.

If a satisfactory answer to these questions is forthcoming, the "Ionophone" loudspeaker, as it has been named in France, may herald a drastic revolution in receiver design. It has been suggested[7] that since the input to the loudspeaker is modulated i.f., all one needs is a power i.f. amplifier between the frequency changer and the loudspeaker terminals, with a separate synchronized r.f. source which may be added to the input carrier to vary the effective depth of modulation and thus to provide a means of volume control. In this way the second detector and a.f. stages and their possible distortions would be eliminated. F. L. D.

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TECHNICAL WRITERS' PREMIUMS

IN last month's issue we gave some particulars of the Radio Industry Council's scheme for encouraging technical writing. Full details have now been announced.

From 1st January, 1952, the R.I.C. will award premiums of 25 guineas each, up to an average of six a year, to the writers of published articles which, in the opinion of a panel of judges, deserve to be commended by the industry.

Any non-professional writer is eligible—and by this is meant anyone not paid a salary mainly or wholly for writing and not earning 25 per cent or more of his income from fees for articles or from book royalties.

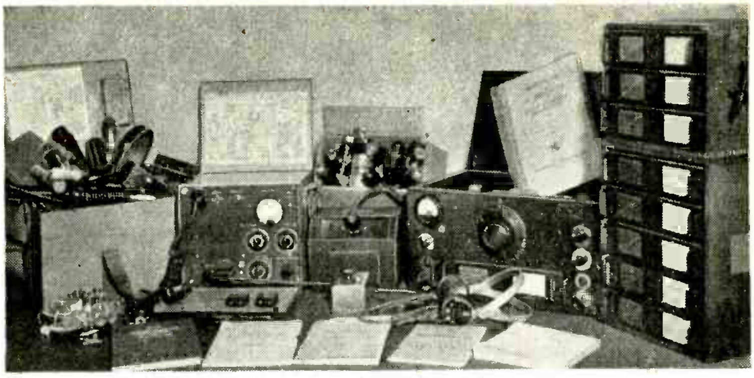
The awards will be made for articles published at home or abroad in papers or periodicals which can be bought by the public on the bookstalls or by subscription. Articles in the following classes of journals will not be eligible: journals circulating exclusively to members of a trade or manufacturers' journals; the privately published journals of professional institutions or learned societies. Writers and editors will be invited to submit published articles for consideration to the Secretary, R.I.C., 59, Russell Square, London, W.C.1 (with, if possible, five copies of the journal, proofs or reprints). The judges will consider also unsubmitted published articles.

The judges are given the greatest possible freedom in choosing articles for awards, but they are asked broadly to take into consideration: value of the article in making known British achievement in radio and electronics; originality of subject; technical interest; presentation and clarity.

The judges are: E. M. Lee and T. E. Goldup, Technical Directive Board, R.I.C.; W. M. York, Chairman, Public Relations Committee, R.I.C.; Vice-Admiral J. W. S. Dorling, Director, R.I.C.; Professor Willis Jackson, Professor of Electrical Engineering, Imperial College of Science and Technology, University of London. The panel will have power to co-opt specialists.

R.N.V.W.R.

Reserve of Naval Telegraphists and Radio Electricians



Equipment issued to Reservists for use at home includes a 30-watt portable h.f. transmitter (Type 5G) and a communication-type receiver.

IT might be as well before discussing the present need for recruits to the Royal Naval Volunteer Wireless Reserve to review the history of the organization. Formed in 1932, as a result of consultations between Vice-Admiral J. W. S. Dorling (representing the Admiralty), H. Bevan-Swift, A. E. Watts and J. Clarricoats (R.S.G.B. representatives) and H. S. Pocock, it had a membership of 270 by 1938, when it was amalgamated with the Telegraphist Branch of the Royal Naval Volunteer Reserve, bringing the combined total to 381. In 1939 it was given its present title. During the war the reservists filled with distinction posts in the Signals Branch of the Navy, both afloat and ashore. In 1945 it was decided to reconstitute the Reserve, which now has a strength of some 600 ratings. Whilst this is in excess of the 1939 figure, it is well below the total strength allowed by the Admiralty—39 officers, 1,200 telegraphists and 240 electrical ratings for maintenance work.

The main object of the Reserve is to train telegraphists who, in an emergency, would fill the gap in the Fleet until the mobilized men had been trained for the task. Training is essentially operational rather than theoretical, although some basic theory is taught. Having reached the required standard of proficiency, a telegraphist may be lent transmitting and receiving equipment for use at home. He does not, however, have to pass the normal P.M.G. licence examination but is issued with a licence on the recommendation of his District Officer.

Each of the nine Districts into which the United Kingdom is arbitrarily divided for the purpose of the Reserve contains a number of training centres where regular instruction is given by full-time telegraphist instructors. Recruits must be between the ages of 17 and 45 and must sign on for five years. Training consists of sixteen hours' instruction per quarter, plus four periods of eight days' continuous training with the Navy during the five years. Young men liable for National Service, who join the R.N.V.W.R. and attain the requisite standard of proficiency, are certain of acceptance in the Navy for their period of service.

A bounty of £9 is paid to Reservists at the end of each year, plus a proficiency grant of up to £3 p.a. Travelling and training expenses are also paid, and those using Naval transmitting equipment at home are granted a maintenance allowance of £3 p.a.

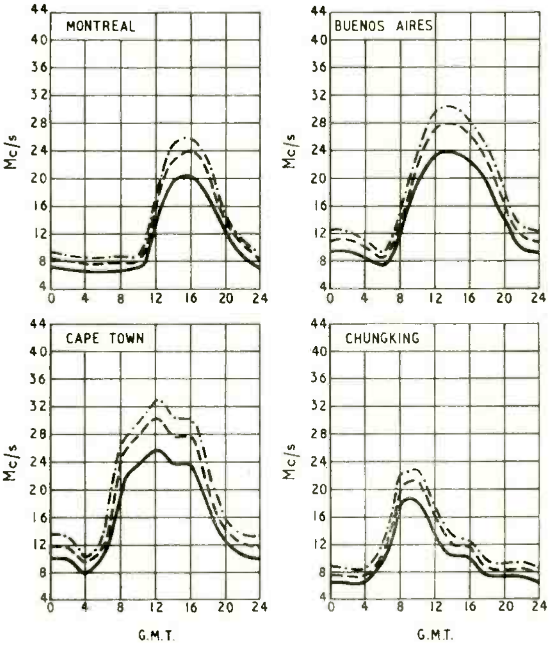
In conformity with modern practice, Reservists are taught touch-typing so that they can take down morse messages direct on to the typewriter. The Naval speed is 22 w.p.m.

Particulars of the Reserve, which now has thirty-nine training centres and units, are obtainable from the R.N.V.W.R., Queen Anne's Mansions, London, S.W.1.

Short-wave Conditions

Predictions for January

FROM this month the publication of the written matter on short-wave conditions will be discontinued, but the predictions will continue to be given in the form of four sets of curves, indicating the highest frequencies likely to be usable over four long-distance circuits from this country during the coming month. The curves, together with their caption, will be self-explanatory.



Propagation of V.H.F. *via* Sporadic E

By T. W. BENNINGTON *

Analysis of Some European Data

THERE frequently form, within the normal E layer of the ionosphere, "patches" or "clouds" of abnormally dense ionization, which are capable of reflecting radio waves of frequencies much higher than those reflected by the E layer itself or, indeed, by any of the regular ionospheric layers. The patches take the form of thin sheets of ionization having an apparently quite limited geographical area. They are of a random and intermittent character, both as to the time and position of their occurrence and as to their ionization density, and, for this reason, are called "Sporadic E." Nevertheless, as will be seen later, Sporadic E does display marked diurnal and seasonal features in the frequency of its occurrence at any one geographical location.

Clouds of this nature are capable of reflecting radio waves, at oblique incidence, on frequencies frequently exceeding 30 Mc/s and on remote occasions extending up to 100 Mc/s, and they are thus capable of propagating over relatively long distances frequencies within the v.h.f. band, whose normal range is the limited one attained by the travel of the ground and tropospheric waves. It is thus apparent that if channel-sharing by stations working on frequencies in the v.h.f. band is established on the basis of the normal ranges, the services may at times be subject to mutual interference by waves travelling by way of Sporadic E. That is, perhaps, the most important consequence of the occurrence of Sporadic E, since, because of its nature, it cannot be relied upon to be of use in any *regular* radio communication service.

Transmission by way of Sporadic E is practically always confined to a one-hop mode owing to the remote possibility of its simultaneous existence with a high ionization density at the widely distributed geographical points necessary for multi-hop transmission. The maximum range by way of the medium is therefore about 1,400 miles, i.e., a one-hop mode via the E layer with the largest possible angle of incidence.

There are, in fact, three distinct *types* of Sporadic E, these being, apparently, due to widely different causative agencies. The first is the auroral-zone type, which was first investigated in detail by Appleton, Naismith and Ingram using observations taken at Tromsö in 1932-33.[1] Many observations by stations in high latitudes have since been made upon this type of Sporadic E, including some very recent ones at Kiruna, in the north of Sweden,[2] and from all these its characteristics are now fairly clear. It is closely associated with ionospheric and magnetic disturbances, and with auroral activity. Its occurrence has a maximum around midnight, as also, generally speaking, has its intensity, and it has a minimum centred around noon. It can, on occasions, reflect frequencies of up to 90 Mc/s.

The second—and most important—type of Sporadic E may be called the temperate-zone type, since it is the main feature of the sporadic ionization which is observed in mid-latitudes. It is to be noted, however, that the auroral type of Sporadic E sometimes spreads to these latitudes, whilst the temperate type is frequently observed in high latitudes, co-existent with the auroral type.[2] The temperate-zone type, however, displays markedly different characteristics from the auroral type. It has no relation to ionospheric or magnetic disturbances, it has a diurnal maximum around noon and is at a minimum at night, and a marked seasonal variation such as to give a large maximum at midsummer with a very low rate of occurrence during the winter. Because of the noon peak it has been suggested[2] that its primary causative agent may be the sun's ultra-violet radiation, whereas the auroral type, with its night-time maximum and its association with ionospheric storms, may be due to bombardment of the ionosphere by solar corpuscles.

The third type is observed only in low latitudes, but at present little seems to be known about it.

Temperature-zone Type

It is with the temperate-zone type of Sporadic E that the rest of this article will deal. The present writer has previously published an analysis of some Sporadic E measurements made in England during 1945, 46 and 47[3], giving the percentage of time during which propagation could be maintained by Sporadic E over a range of 1,400 miles. It should now be useful to analyse the measurements for 1948, 49 and 50, and to see whether the derived curves are similar to those for the previous years.

For this purpose the hourly measurements made at the Slough station of the Department of Scientific and Industrial Research have been mainly used.[1] Use has also been made of the published measurements made at Fraserburgh,[4] De Bilt,[5] Lindau,[6] Freiburg,[7] Domont and Poitiers.[8]

Sporadic E does not have a definite "critical" frequency, as do the regular ionospheric layers, but reflects waves above a certain frequency with a reflection coefficient which decreases with frequency, so that the highest reflected frequency observed depends, not only upon the density of the phenomenon, but also upon the power of the transmitter and the sensitivity of the receiver. Thus the observations made at different stations may not be strictly comparable, though those for any one station are, of course, indicative of the density of the observed Sporadic E, in terms of the reflected frequency. Because, however, of the considerable variation in the density of the phenomenon, the

* Engineering Division, B.B.C.
[1] References to be found at end of article.

average of the highest frequencies reflected would have little meaning, so it is better to make the analysis on some other basis. The best course seemed to be to examine the Slough measurements in order to find out the percentage of the total time that Sporadic E was observed each month. Since we are mainly interested in the propagation by Sporadic E of only the higher frequencies (30-300 Mc/s), it was considered better to ignore the lower frequency reflections recorded at vertical incidence, and to use only those greater than 5 Mc/s. Sporadic E capable of reflecting 5 Mc/s at vertical incidence would sustain propagation on about 26 Mc/s over 1,400 miles. So it is here considered only when capable of propagating waves on that or higher frequencies, the symbol fE_s indicating the highest frequency reflected at vertical incidence.

In Fig. 1 (a) are plotted the monthly rates of occurrence of Sporadic E for the years 1948, 1949 and 1950, in terms of the percentage of the total time during each month when it was present and capable of reflecting frequencies greater than 5 Mc/s at vertical incidence, as obtained from the hourly measurements made at Slough. Fig. 1 (b) gives the mean monthly distribution for the three years. During the winter and early spring, it will be seen that very little Sporadic E is recorded, the minimum being in February or March. From April to May there is a very rapid increase, a maximum occurs in June or July, and, following a somewhat less rapid decrease, low rates of occurrence are recorded from September onwards. The general variation in the occurrence of Sporadic E, as here shown, corresponds fairly well with that found for previous years, except that the September decrease is here more rapid. During the months September to April inclusive Sporadic E was present generally for less than 6 per cent of the total time, whilst during May to August inclusive it was generally present for 20 per cent or greater of the total time. These are the mean values—those for 1949 were often lower, whilst those for 1948 were exceptionally high. One could therefore say that,

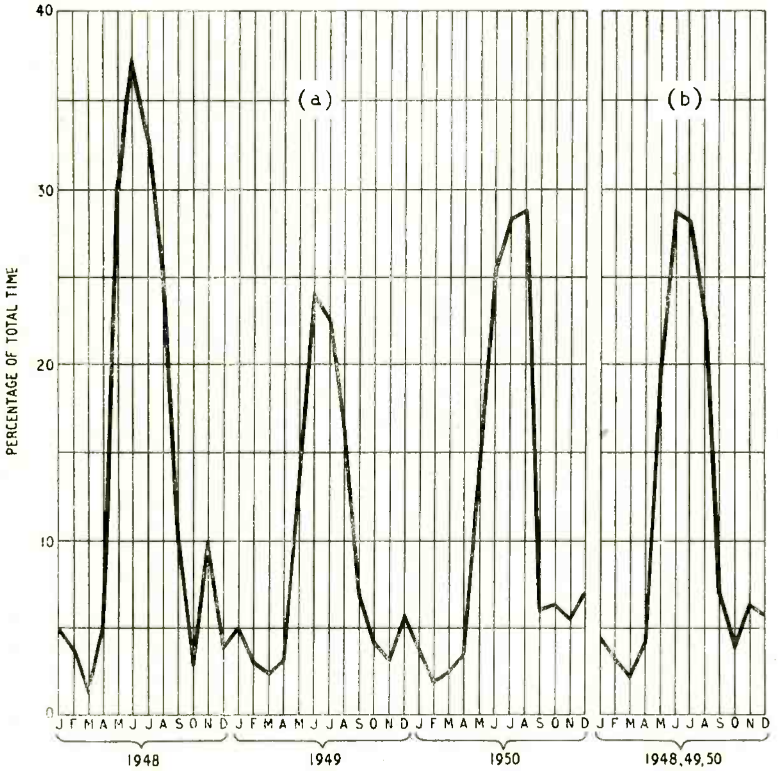


Fig. 1. (a) Monthly distribution of Sporadic E at Slough ($fE_s > 5$ Mc/s.) (b) Mean monthly distribution for the years 1948, 49, 50.

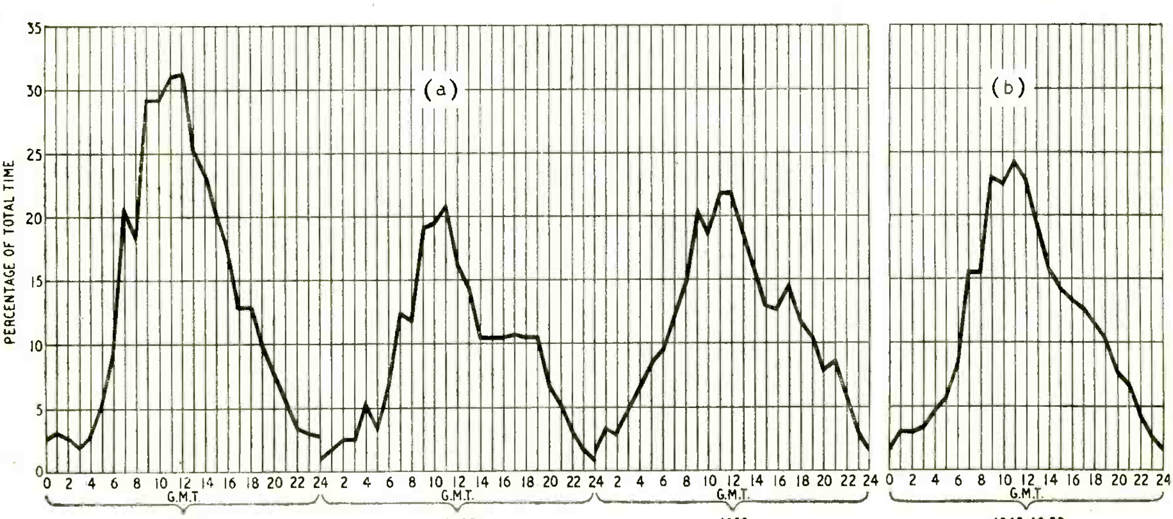


Fig. 2. (a) Mean annual 24-hour distribution of Sporadic E at Slough ($fE_s > 5$ Mc/s). (b) Mean 24-hour distribution during the period 1948, 49, 50.

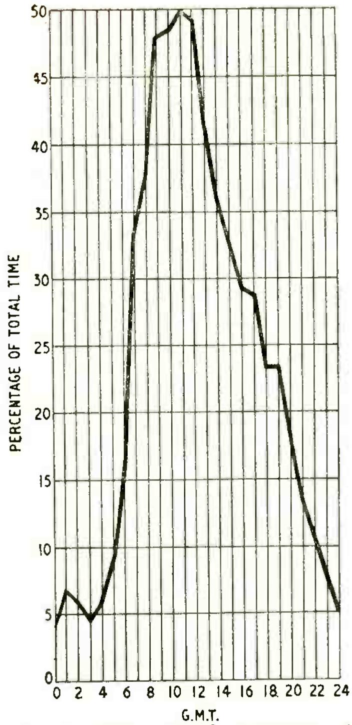


Fig. 3. Mean 24-hour distribution during the four months May-August, for the three years under consideration, 1948, 49, 50.

whilst Sporadic E capable of propagating frequencies of 26 Mc/s or higher may be present only occasionally from September to April, during the period May to August it is likely to be present for something like a quarter of the total time.

The diurnal variation in Sporadic E is shown in the graphs of Fig. 2, from which it is seen that minimum activity occurs during the night, that there is a very rapid increase in the early morning, a maximum centred near noon, and a rapid decrease thereafter. In the analysis for the years 1945/47[3] there was found a distinct tendency for a subsidiary peak to occur around sunset, and the recent Swedish measurements[2] indicate the same effect, though only during the months May/August. In the Slough measurements there are slight indications of it during 1949 and 1950, but, as Fig. 2(b) shows, it does not appear to be a prominent or settled feature of the diurnal variation. Whilst the curves of Fig. 2 (a) show as mean values for each year the percentage of the total time at each hour of the day when Sporadic E was observed and that of Fig. 2 (b) the mean values for the three years, none of them brings out the maximum proportions of Sporadic E, in terms of percentage of time. As the seasonal curves of Fig. 1 show, it is during the months May to August that Sporadic E is chiefly in evidence, and Fig. 3 is produced to show the mean diurnal distribution during those four months only for the period 1948/50. This curve shows an approximately 100 per cent. increase in the values, both by day and night, as compared with those given in Fig. 2(b). Again the subsidiary peak at sunset is absent. It is seen that, for several hours before and near noon, Sporadic E is present for roughly half of the total time during the summer. It is, therefore, of considerable importance in the propagation of frequencies in the v.h.f. band during those months, and, especially from the point of view of shared-channel interference. It remains to be seen, however, to what extent the propagation by Sporadic E is likely to deteriorate with increasing frequency.

Propagation Characteristics

Although, as has been said, *mean* values of Sporadic E highest reflected frequencies are largely meaningless because of the great and seemingly erratic variations in the incidence and intensity of the medium, yet some idea of its propagation potentialities for various

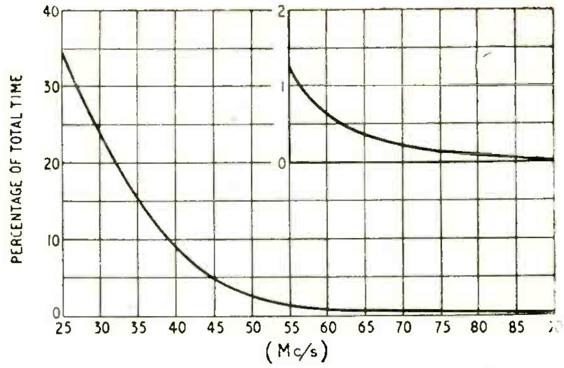


Fig. 4. Mean percentage of time when Sporadic E would sustain propagation over 1,400 miles during daytime in Summer months (May-August inclusive) ; 0600-2200 G.M.T.

frequencies was obtained in the following way. The recorded measurements were classified into frequency bands, each band being 1 Mc/s wide (>5 Mc/s, >6 Mc/s, etc.). Then the percentage of time during which Sporadic E existed with each band was established. Multiplying by the Sporadic E m.u.f. factor appropriate to 1400 miles converted the results into frequency bands which would have been propagated over this distance. It was decided to confine this examination to the periods when Sporadic E was present for more than 10 per cent of the total time, namely, from May to August inclusive (Fig. 1b), and from 0600 to 2200 G.M.T. (Fig. 3).

The results are plotted in Fig. 4, which gives the mean percentage of the total time, for the three years and for the summer months and hours of day mentioned, during which propagation could have been maintained by Sporadic E over a range of 1400 miles, plotted as a function of frequency. This curve is not very different from that obtained in the previous analysis for the years 1946 and 1947, so far as the highest frequencies are concerned, but the values for the lower frequencies are, in the present case, somewhat larger. It is seen that there is a very rapid decrease in the rate of incidence of Sporadic E capable of sustaining propagation over the distance considered, with increasing frequency. However the effect of the temperate-zone type of Sporadic E in long-distance propagation would appear to extend up to a frequency of about 88 Mc/s (occasionally even higher) during the summer months, though on frequencies above 55 Mc/s it may be considered to occur so infrequently as to be of little importance. It may be considered, therefore, that, from the shared channel point of view, stations working on frequencies between 30 and 55 Mc/s would be subject to a considerable amount of mutual long-distance interference during the summer months, whilst those operating in the 55 to 88-Mc/s band would suffer such interference only occasionally. Stations on frequencies above 100 Mc/s would rarely suffer such interference. This curve, now generally substantiated by an examination of measurements taken during more than five years, may, it would seem, be taken as being practically true for interference conditions in the v.h.f. band in the temperate zones.

It would, of course, be extremely interesting if one could obtain some idea of the geographical extent of Sporadic E clouds at any time, to see if they were subject to any systematic movement or "drift" and to learn something about the way in which they grow in ionization density. As has already been pointed out,

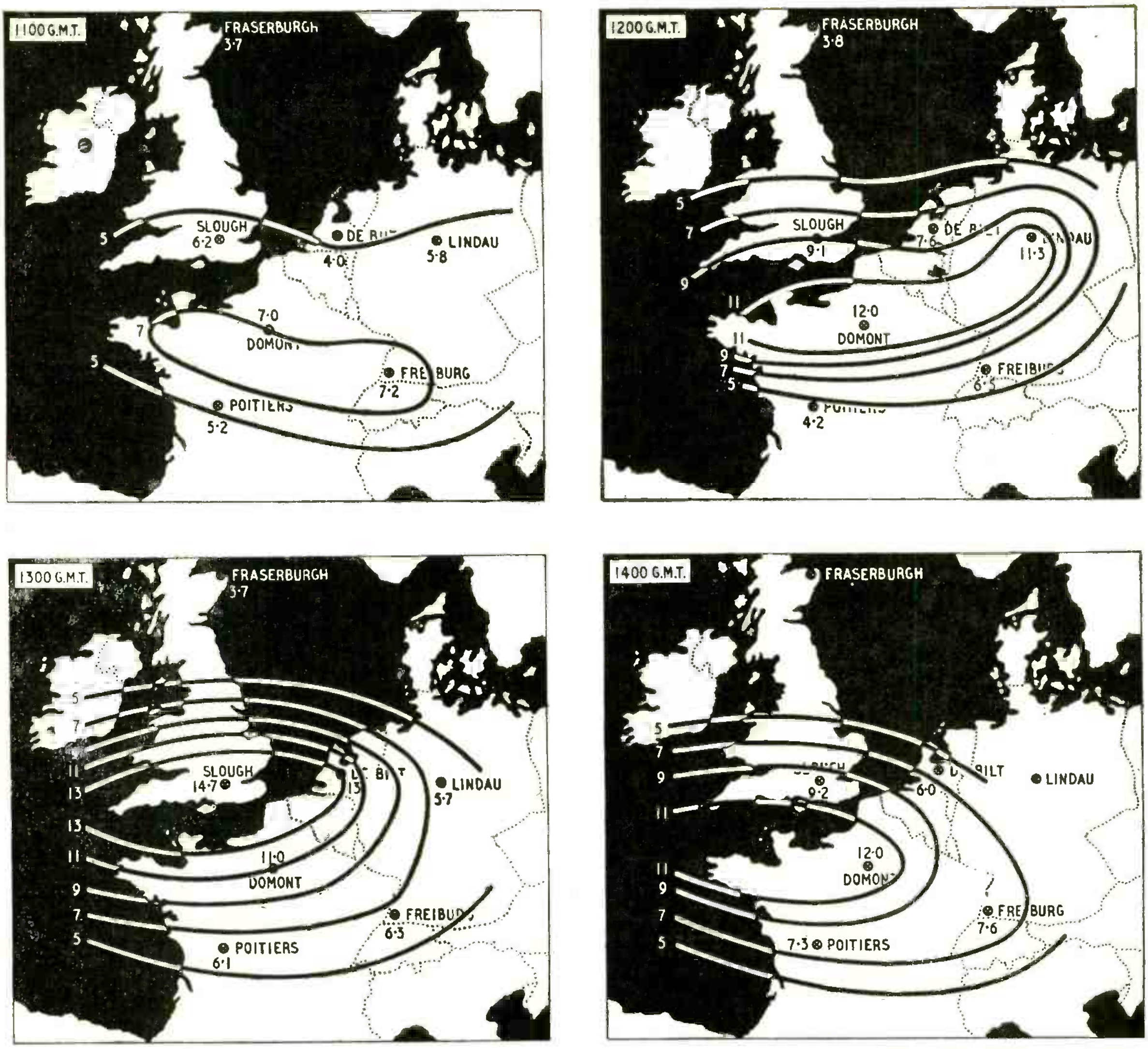


Fig. 5. Probable features of the growth and early decay of a Sporadic E " cloud " over Europe on 24th May, 1950. By 1500 G.M.T. it had decreased to approximately the density at 1100. The contours represent lines of equal vertical incidence fE_s.

intense Sporadic E has limited geographical area, but O. P. Ferrell[9] has shown that it can, even in an intense form, extend over an area of some 200,000 square miles. Using the Sporadic E reflections obtained by radio amateurs in the 50-54-Mc/s band as his basic data he located the approximate positions of Sporadic E "clouds" over the United States, deduced their density variations with time, and found that they drifted due west with a velocity of 130 metres per second in one case, and north and northwest with a velocity of 40 metres per second in another.

So far as is known no similar work has been done in Europe, although it is believed that attempts have been made to correlate the vertical incidence measurements made by different stations, both in Europe and America, with little success.

The records of the stations at Slough and Fraserburgh in Great Britain, De Bilt in Holland, Lindau and Freiburg in Germany and Domont and Poitiers in France were therefore examined to see whether there was any correspondence between their Sporadic E measurements taken at times when the phenomenon was being observed at one or other of the stations in an intense form.

The measurements at these stations are generally made at hourly intervals and, in order to obtain a synoptic picture for a given time, the measurements were compared for the same hour (G.M.T.). Unfortunately the measurements at Freiburg are made at intervals which are one half-hour different from those for the other stations, so some liberty was taken in assuming the measurements were made a half hour later. Symbols were allotted to Sporadic E vertical incidence measurements of highest reflected frequency lying within different frequency bands, and by setting out the results for different stations one above the other in diagrammatic form it could be seen whether there was any correspondence in their measurements. It was realized that the measurements from different stations are not *strictly* comparable, but, since the frequency bands were 2 Mc/s wide, it was hoped, at least, to detect whether intense Sporadic E was present simul-

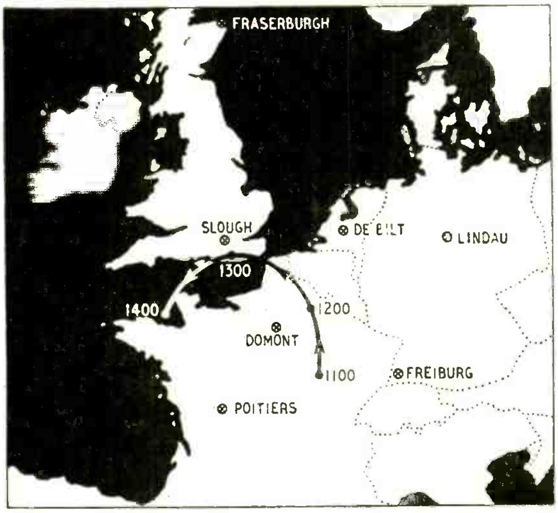


Fig. 6. Probable track of the "centre" of the Sporadic E "cloud" shown in Fig. 5.

taneously above different stations. As an example the results for the 23rd-25th May, 1950, may be mentioned. On 23rd May there was relatively little intense Sporadic E recorded, though the diagrams showed that there was a certain correspondence between some of the measurements at different stations. On the 24th and 25th, however, it became intense during certain hours, and the diagrams clearly showed that it was recorded in an intense form simultaneously, or with an indicated time lag, at different stations.

Selecting certain daily periods during which intense Sporadic E was present over a large part of Europe, it was then attempted to plot its contours in terms of highest frequency reflected, with a view to ascertaining its geographical extent, and its direction and velocity of movement or drift. The best result obtained is that shown in Fig. 5, which, it is thought, shows with rough accuracy, the growth and early decay of a Sporadic E "cloud" over Europe during 3 hours on 24th May, 1950. The contours are marked in terms of the highest frequency reflected at vertical incidence, so that the "outer" contour represents, at each hour, Sporadic E capable of propagating 26 Mc/s over 1400 miles, whilst the "inner" contour at 1300 G.M.T. (indicating the most intense Sporadic E recorded during the period shown) represents that capable of propagating 67.6 Mc/s over this distance.

At the time of its maximum density the "cloud" apparently covered an area of at least 500,000 square miles, although it is, of course, impossible to be at all certain about its area, because, for one reason, there were no measuring stations at its western boundaries. It is to be noted, in this connection, that in Fig. 5 the outer contours are for much less intense Sporadic E than was observed by Ferrell, but if the area enclosed by the 9 Mc/s contour is taken—and this would correspond roughly in intensity to the Sporadic E observed by him—then the area covered would be roughly similar to that observed in the U.S.A. In the present case, at 1300 G.M.T. the Sporadic E (inside the 5 Mc/s contour) would appear to have extended some 600 miles in a north-south direction and some 800 miles in an east-west direction. It should be pointed out that this must have been an *exceptionally* intense cloud, for such high vertical incidence measurements are not frequently recorded.

An attempt was made to trace the direction of movement and velocity of the "cloud" during the period under consideration. This was done by locating the approximate position of the "centre" of the cloud at each hour, and the result is plotted in Fig. 6. From this it would appear that the "drift" was at first northerly, and then north-westerly, and finally, after the decay of the cloud had begun, south-westerly. The total drift during the 3 hours under consideration was about 470 miles, giving a mean velocity of about 70 metres per second. The directions and velocity of drift are therefore similar to those observed by Ferrell. Similar directions of drift were deduced for other clouds of Sporadic E which were examined in the same way, though none of these was so intense as that in the example given.

It does seem possible, therefore, to trace the growth and movement of Sporadic E clouds from the vertical incidence measurements made at a number of stations. Much further work will, however, be necessary on this matter before any definite conclusions as to the real geographical extent, and the direction and velocity of movement of Sporadic E clouds can be drawn.

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[3] T. W. Bennington. "Radio Propagation in the Frequency Range 40-100 Mc/s," *B.B.C. Quarterly*, Vol. II, No. 4, 1948.
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[5] Data published by the Royal Netherlands Meteorological Institute.
[6] Bulletin published by Institut für Ionosphärenforschung, Lindau, Germany.
[7] Bulletin published by Service de Prevision Ionospherique Militaire, Paris.
[8] Bulletin d'Information du Bureau Ionospherique Française, Bagneux, France.
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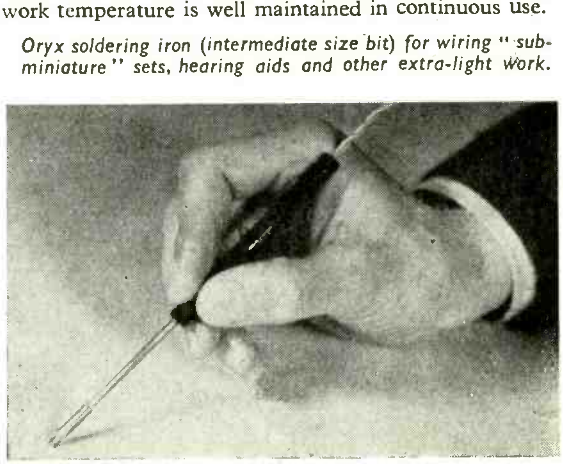
"SUB-MINIATURE" SOLDERING IRON

WORKING on the principle that the assembling of present-day "sub-miniature" equipment calls for special tools and appliances of appropriate size, Oryx Electrical Laboratories (BCM/ORYX, London, W.C.1) have produced a series of electrical soldering irons of exceptional smallness. Measuring under 6in in length and weighing about a quarter of an ounce, these irons are made in two basic types—with or without replaceable push-on bits. Ratings vary from 6V, 6W to 24V, 9W. A test shows the Oryx irons are capable of doing heavier work than that for which they are clearly designed; on light work temperature is well maintained in continuous use.

Oryx soldering iron (intermediate size bit) for wiring "sub-miniature" sets, hearing aids and other extra-light work.



V.H.F. BROADCASTING

B.B.C. Recommendations Based on Recent Tests

AFTER a long period of rumour, controversy and guesswork some concrete facts are now emerging regarding the proposed v.h.f. broadcasting service for this country An article in the Autumn 1951 issue of *The B.B.C. Quarterly* gives an outline of the case for the establishment of a three-programme service in the frequency range 88-100 Mc/s, and the tests which have been made, both in the laboratory and in the field, to decide on the best method of modulation.

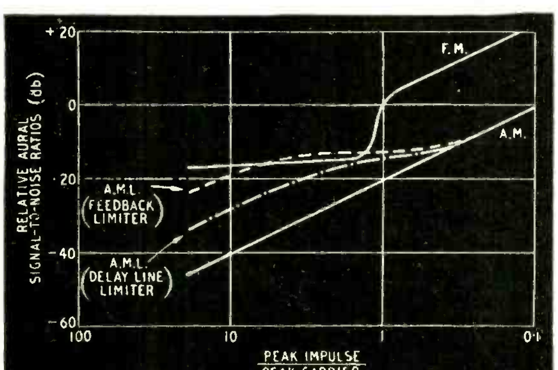
In view of the importance of keeping receiver costs low, only three systems of modulation have been investigated—a.m. (amplitude modulation), a.m.l. (amplitude modulation with a noise limiter incorporated in the receiver), and f.m. (frequency modulation). To quote the report: "Pulse modulation systems have also been considered, but are not thought to offer sufficient advantages for broadcasting to merit further consideration."

Signal/Noise Ratio

As far as quality of reproduction is concerned there is little to choose between the alternatives considered, provided that in the case of a.m.l. a carefully designed limiter is employed. The criterion used in judging the relative merits of the systems has therefore been signal/noise ratio, and this has been studied both for background hiss and impulsive interference of the type caused by motor cars and some domestic appliances.

In the laboratory, f.m. has shown a 26db advantage over a.m. as far as background noise from receiver hiss is concerned. Under normal listening conditions, this advantage is confirmed by observation with a simple dipole aerial which shows that for background hiss to be classified as "perceptible" but not "disturbing," a signal field strength of 1,000 μV/m is necessary with a.m. or a.m.l. whereas with f.m. the corresponding figure is only 50 μV/m.

Fig. 1. B.B.C. experimental results showing comparison of f.m., a.m. and a.m.l. from the point of view of impulsive interference.



Impulsive interference, which is generally random in character, is more difficult to measure, and to get consistent results for comparison an artificial source giving repeated uniform impulses was used. The curves shown in Fig. 1 confirm theoretical predictions of the "improvement threshold" at unity signal/noise ratio with f.m., and for ratios greater than unity, f.m. shows a 25db superiority over a.m.

The field strength contours for Wrotham, which apply to either of the 20kW transmitters used at that station, are shown in Fig. 2. It will be appreciated that at 90 Mc/s these contours are average and that considerable local variations are possible, particularly in hilly or built-up areas.

In addition to these measurements of field strength the B.B.C. has asked the opinion, in the form of a questionnaire, of a number of listeners in all parts of the projected service area who were provided with a standard receiver of reasonable but not abnormally good specification, which could be switched at will to each of the three modulation methods under review. The results have been analysed and tabulated on the basis of a first-class service area in which the interference from 50 per cent of cars on a busy road 30 to 60ft from the receiver is imperceptible and of the remainder occasional cars may give rise to interference which is "slightly disturbing"; and a second-class area in which at least 50 per cent of cars is never graded as worse than "perceptible," though occasional cars may be graded as "disturbing." The approximate field strengths at the lower limit of these two areas and the corresponding ranges are given in the Table.

The report states that to cover the country using a.m. would require from three to four times the number of stations using f.m. Apart from the difficulty in obtaining agreement for the larger number of high masts, the increase in the cost of equipment, high-grade landlines, buildings and maintenance would be serious.

Whichever system of modulation is used, the necessity for common-channel working will have to be

TABLE

System	First-class Service Area		Second-class Service Area	
	Field-strength (mV/m)	Approx. range (Miles)	Field-strength (mV/m)	Approx. range (Miles)
f.m.	1	45	0.25	60
a.m.l.	3	35	1	50
a.m	10	25	3	35

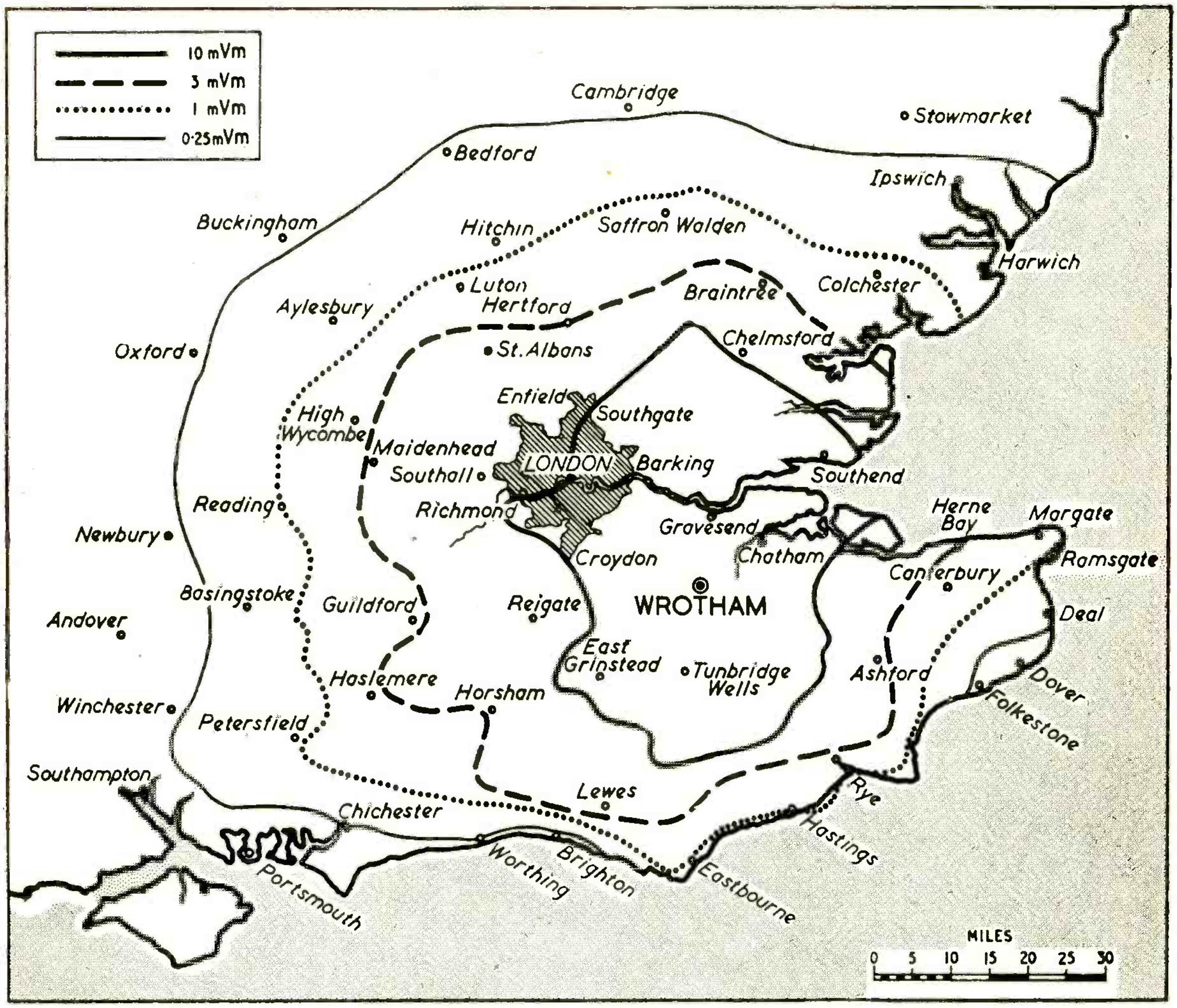


Fig. 2. Contour map of field strength from the Wrotham v.h.f. transmitter, based on measurements taken by the B.B.C.

faced. Close synchronization, as practised at medium frequencies, is not feasible at v.h.f. and the report discusses experiments to determine the possibilities of interference under freak tropospheric propagation conditions between distant stations with frequency differences from zero to 15 kc/s. The provisional national scheme will be planned to avoid interference on this score for all but 5 per cent of the time on those days in the year when propagation conditions are conducive to long-range transmission.

The scheme will give a three-programme service to 87 per cent of the population of Gt. Britain and Northern Ireland under "first-class" conditions, and a "second-class" service (or better) to 96 per cent.

E.M.I. INSTITUTES

THE National Institute for the Blind recently announced that two of their blind trainees had completed the year's course in radio servicing at the E.M.I. Institutes and had secured first and second-class passes in the terminal examinations. Reference was made in our Earls Court Show report to the universal Avometer adapted to enable blind users to take a reading by touch. A signal generator was also adapted for the use of these two blind trainees, who took the normal course with the sighted students. Circuit diagrams and service manuals were prepared for them in Braille by the N.I.B.

This example of the training provided by E.M.I. Institutes must not be taken as typical, but it does serve to show the versatility of the organization in meeting a special need.

The college, in Pembridge Square, Notting Hill Gate, London, W.2, provides a variety of courses, ranging from three-week practical courses on radio and television servicing to a four-year course in electronic engineering. Between these two extremes lie a three-year telecommunications-engineering course and a one-year course covering the principles and practice of radio for servicemen. At the beginning of the

Autumn term there were 164 students taking the one-, three-, or four-year courses, and there are generally some twenty-five taking the short-term course.

While, of course, the parent company, E.M.I., Ltd., has a claim on the college, Prof. H. F. Trewman, M.A., the principal, has stressed that the college courses are open to any student. In addition to the college courses, which are under the direction of J. B. McMillan, M.A., B.Sc., the Institute also sponsors an extensive series of postal tuition courses. These are under the direction of P. T. V. Page, B.Sc., and are administered from 43, Grove Park Road, Chiswick, London, W.4. They include electronics, telecommunications engineering and draughtsmanship.

SOUND RECORDING ORGANIZATION

Work of the Association of Professional Recording Studios

THE high quality of reproduction now attainable in direct recording has created a widespread demand from musicians, amateur and professional, public speakers and others who use the medium as a means of self-expression and criticism, and from humbler folk who have learned the pleasure that permanent sound pictures of social gatherings and the voices of their growing children can give.

Under the stimulus of this demand a growing number of sound studios have opened in all parts of the country and their skill is being enlisted not only for domestic sound portraiture but also by the medical profession and many branches of scientific research.

It goes without saying that a successful recording studio must possess first-class technical equipment. It was appropriate, therefore, that the annual general meeting of the Association of Professional Recording Studios held this year in London on November 23rd should open with a discussion on "Amplifiers for Recording," which was prefaced by a résumé by H. J. Leak of the problems of applying feedback from the cutter head itself, and of some of the circuit arrangements which have proved reliable in use.

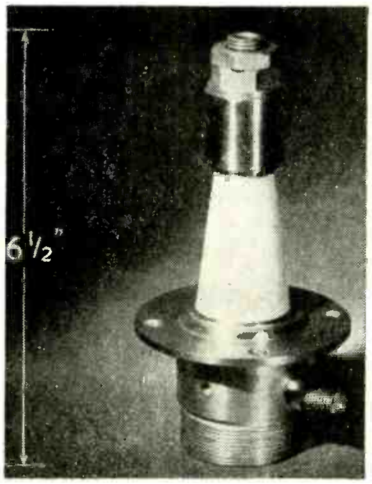
That technical excellence of the recording apparatus itself is only the first step in establishing a professional service was emphasized by Morris Levy, who spoke during the afternoon session on the factors contributing to the achievement of an atmosphere in which artists could give of their best.

Derek Faraday (vice-president) gave members an account of the work of the larger private studios engaged in recording complete programmes and features for broadcasting stations on the Continent, in the Dominions and the U.S.A.

In reviewing the work of the year H. L. Fletcher (chairman) emphasized the importance of corporate representation at the highest levels in all matters affecting the interests of recording studios. Valuable concessions in the matter of purchase tax had resulted from consultations with the Inland Revenue and representations had been made to the committee investigating the law of copyright regarding proposals which the Association considered inequitable. They had also maintained discussions on matters of mutual interest with the Musician's Union and the Mechanical Copyright Protection Society.

The general secretary of the Association (M. K. Howells, 14, Wynchgate, Harrow Weald, Middlesex), in his report, stated that the membership numbered 83 and that application for a certificate of incorporation of the Association had been made.

CORUNDITE CABLE TERMINATION



Pressurized "Corundite" termination for use on Telcon television transmitter coaxial feeder cables.

THE good electrical properties, exceptional mechanical strength, heat- and damp-resisting qualities of Corundite, the insulating material used in certain grades of K.L.G. sparking plugs, led to an investigation into its possible applications as a radio insulator. As a result, a range of connectors for hermetically sealed radio components was produced.

More recently, further work has been carried out at the instigation of the Telegraph Construction and Maintenance Company to ascertain its usefulness as the terminal connector and seal for certain types of Telcon pressurized coaxial cables used as feeders for television transmitters. These end-connectors have to withstand pressures up to 100 lb per square inch and must be suitable for tropical, temperate and arctic conditions.

The type of termination evolved by K.L.G. Sparking Plugs, Ltd., for this purpose is shown in the illustration. The steel body can be fixed to the sheath of the cable and sealed mechanically by any of the well-known methods, and it incorporates a Schrader air valve for introducing the gas into the cable.

The technique of joining the Corundite insulator, which, incidentally, is a fused aluminium-oxide substance, to the steel body and also of making a pressure-tight joint between centre conductor and insulator is similar to that used in the manufacture of K.L.G. sparking plugs, as the working requirements are closely related.

All Corundite termination seals are tested at 300 lb p.s.i. and the material appears to be quite capable of withstanding the high axial thrusts brought about by varying rates of expansion of cable and aerial elements.

AMATEUR RADIO SHOW

Larger-than-Usual Display of Home-constructed Equipment

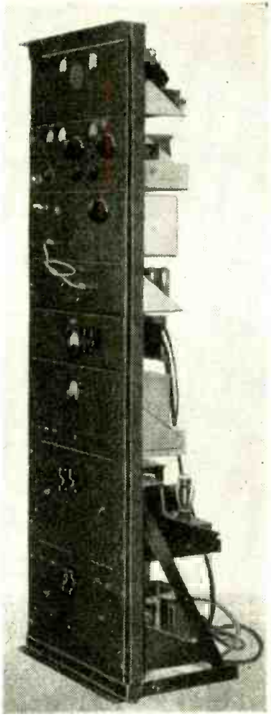
THIS year the amateur radio exhibition organized by the Radio Society of Great Britain was more in the nature of a truly amateur show than usual as a vast amount of home-constructed equipment was on view.

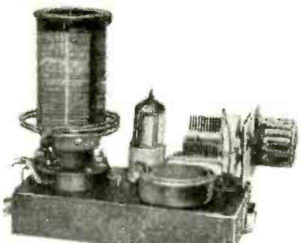
Some of the credit for the fine appearance of the amateur exhibits must go to makers of components, such items as mains, modulation and audio transformers taking on a different appearance when neatly cased. The "potted" varieties shown by Woden well examplified this practice.

E.M.I. have always been staunch supporters of the amateur movement and their contribution to this exhibition took the form of a comprehensive display of special test and measuring equipment, a series of 465-kc/s i.f. transformers in large, medium and midget sizes, eliptical loudspeakers and some transformers.

One of the worst nightmares of the transmitting amateur is the thought that he may be causing interference to local broadcast listening and to television. Many cases of interference are erroneously attributed to his activities; nevertheless it behoves all amateurs to make their equipment as TVI-proof as possible. To achieve this, complete screening is needed, as well as harmonic and spurious radiation filtering. Filters for the latter purpose were shown by Panda Radio, while all requirements for screened boxes and cabinets were catered for by Philpotts Metalworks.

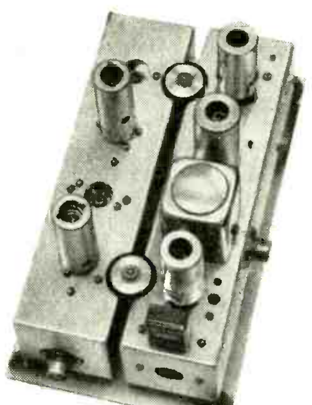
G.E.C. had a display of modern valves and a test set, but the exhibit that caught the eye on this stand was a neat Yagi aerial constructed from light-alloy tubes and special castings. It embodies a balance to unbalance matching transformer.

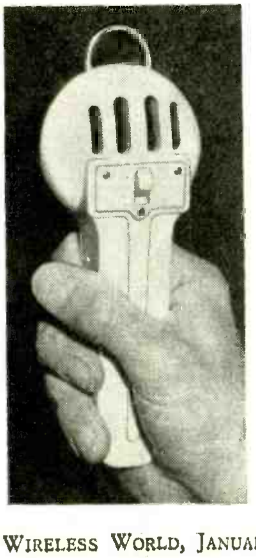


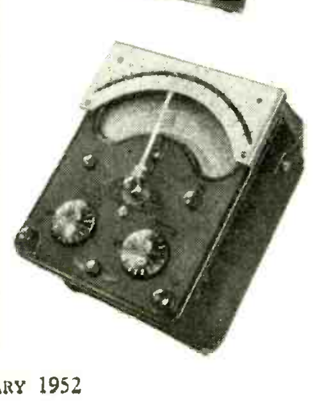


The largest single amateur exhibit for use on 160 and 2 metres—shown by S. Sharp (G3CKX).

One of the smallest crystal controlled transmitters shown by C. Cutts (G3HRC).







Right: Well-constructed crystal controlled two-metre converter shown by E. Yeomanson.

Bottom right: Model 7 Avometer modified for use by a blind person.

Below: New Acos hand crystal microphone Type Mic 30.

Among the piezoelectric crystal devices shown by Cosmocord was a new hand-type microphone. Available in various colours it contains a double-crystal element, has a switch in the hand grip and is said to have a response sensibly flat up to 5 kc/s.

Prominent among the Avo exhibits was a Model 7 Avometer with a blind man's attachment consisting of an external indicator and Braille scales, a log one for ohms and a linear one for all other purposes. The external pointer is independent of the internal one and is moved by hand. When the two coincide a locking device comes into action and the slight resistance it imposes is easily determined by feel.

This report would be incomplete without some reference to the very fine displays staged by the Navy and the Royal Air Force.

The main interest on the Navy's stand was an exhibit showing some of the activities of the Royal Naval Volunteer Wireless Reserve, but there were also some of the latest communications receivers used by this Service.

The R.A.F. showed examples of the latest miniaturized radio and radar airborne equipments, also a research section where the present idea of miniaturization is made to look a little foolish. Comparisons were made between sub-assemblies now in use and how they will appear in the future when sub-miniaturization gets into its stride.

LIST OF EXHIBITORS

Automatic Coil Winder and Elect. Equip. Co., Ltd., Winder House, Douglas Street, Westminster, London, S.W.1.
Cosmocord, Ltd., Enfield, Middlesex.
E.M.I. Sales and Service, Ltd., Hayes, Middlesex.
English Electric, Ltd., Queen's House, Kingsway, London, W.C.2.
General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2.
Panda Radio Co., 58, School Lane, Rochdale, Lancs.
E. J. Philpotts Metalworks, Ltd., Chapman Street, Loughborough.
Salford Electrical Instruments, Ltd., Silk Street, Salford, 3.
Woden Transformer Co., Ltd., Moxley Road, Bilston, Staffs.

VALVE VOLTMETER

without calibration drift

"Infinite-input, Zero-output-resistance" Adaptor for use with any D.C. Voltmeter

By M. G. SCROGGIE, B.Sc., M.I.E.E.

ALTHOUGH much has been written about valve voltmeters (including at least one large book), so far as the writer is aware the subject has never been pursued to its logical conclusion. If we are to attempt to do so, we must consider what a valve voltmeter essentially is—a voltmeter in which the connection of the indicating instrument to the voltage to be measured is indirect, through an impedance-converting device, in order to eliminate as far as possible any loading effect on the source of the voltage.

It will be noticed that no mention has been made of a rectifier. That is because it is required only when measuring alternating voltages, and although most valve voltmeters include provision for doing this it is not a *sine qua non*. The essential element is the impedance converter, and it is the fact that valves can so readily be arranged to have a very high input impedance and relatively low output impedance that makes them so useful for that purpose. Some of the simpler types of valve voltmeter combine rectifying and impedance-converting functions in one valve, but the tendency nowadays is to separate them. The design of the rectifying portion has already received much publicity; in the following article it is intended to confine attention to the impedance converter, which is required for both alternating and direct voltages.

It will be assumed that the indicating instrument is a moving-coil meter, as experience has shown this to be the most generally convenient. Preferably it should not have to be highly sensitive, because microammeters are both expensive and easily damaged.

Clearly, then, the ideal converter would be one with infinite input impedance (for it would then have no effect at all on the voltage being measured), and zero output resistance (for then the whole of the meter circuit resistance could be wire-wound and highly constant). Although one of the main objects in valve voltmeter design has long been to make the output resistance as stable as possible, the results are usually quite a long way from the ideal zero. And it seems to be too often assumed that any valve worked with negative bias has negligible d.c. input conductance. The purpose of this article is, first, to show that where valve voltmeters are concerned this assumption is false, and, secondly, to explain how the output resistance can be made practically zero, so that the valve gear can be added to any ordinary moving-coil voltmeter, to adapt it for "infinite-impedance" measurements, without affecting its calibration. It follows that the calibration is unaffected by even large changes in the valve characteristics, because a variable factor multiplied by 0 remains constant at 0.

First, then, the matter of input conductance. The elementary book or instructor explains that current through a hard valve flows to the cathode only from a positive electrode; so as long as the grid is negative to cathode there is no grid current. For ordinary amplifier and receiver circuits, in which the resistance in series with the grid seldom exceeds 1MΩ, and nobody is any the worse for a slight shift of grid bias, that is a fair enough simplification. The trouble comes if one carries this early impression into work on measuring apparatus, where grid circuits may be much above 1MΩ and an unintended shift of even a small fraction of a volt is intolerable.

In the work which led to this article it was considered that a valve voltmeter in which the reading was noticeably affected by a grid circuit resistance of 20MΩ would be a poor thing. The fact that published valve voltmeter circuits showed rectifier load resistances of anything up to 100MΩ, followed by (as far as could

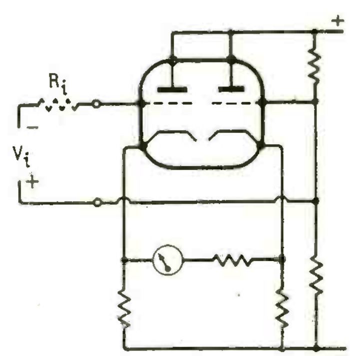


Fig. 1. Conventional valve voltmeter circuit.

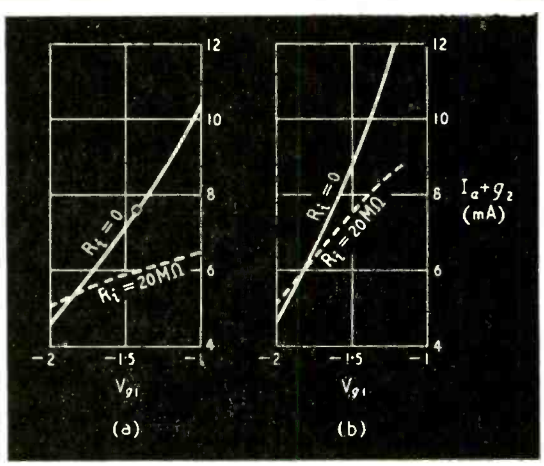


Fig. 2. Portions of characteristic curves of typical triode-connected samples of (a) EF50 and (b) SP61, with and without 20MΩ in series with the source of V_{g1}, showing unsuitability for measuring apparatus with high-resistance input circuit. Results with other types of high-slope valves were, in general, similar.

be seen) ordinary amplifier valves, suggested that there should not be much difficulty in this respect. But there was.

In the original trial circuits, the impedance converter or d.c. amplifier followed the present-day practice of using a twin triode somewhat as sketched in Fig. 1. The merit of this arrangement, of course, is that variations in supply voltage tend to affect both triodes equally, so that the zero setting is not appreciably affected. And the negative feedback due to using the valves as cathode followers has a stabilizing and scale-linearizing influence.

But just now we are considering the input circuit. To observe possible error due to input circuit resistance the effect on the reading of inserting high resistances at R_i was noted. With the original valve, as little as 5MΩ caused a considerably larger change in reading than could be tolerated. A number of other valves were then tried—ancient and modern, separate and combined, triode and pentode. The results varied from indifferent to bad. Even glass-based valves of the EF50 type were not really satisfactory, nor was the valve holder responsible. It must be understood that the types tested were those considered reasonably suitable as cathode followers feeding a meter movement taking 1mA or so full scale. That is to say, they were chosen for a fairly large slope, not less than 3mA/V and preferably more, in the interests of an approach to the other clause of the ideal—zero output resistance. Figs. 2 (a) and (b) show the changes in anode current on inserting 20MΩ in series with the grid bias source, for typical samples of EF50 and SP61 valves respectively. (In fairness to the makers it must be said that such a grid resistance is far above the limit rating.) One notable feature is that with normal heater voltage the grid has to be as much as 1.5-2V negative to cut off grid current. With greater negative bias the error is of opposite sign, due apparently in the main to leakage from the anode. This was especially so with some of the twin-triodes. Assuming that the anode is at +100V, the leakage resistance to make the grid potential 0.02V more positive when 20MΩ is inserted in the grid lead is as high as 10^5MΩ; which shows that the demands of a valve voltmeter are not easy to meet, at any rate with mass-produced high-slope valves.

The conclusion from this was that to fulfil the input requirements it would be necessary to use a type of valve such as the EF37, which was known to have an extremely low input conductance, especially when run at low anode voltage and current and somewhat sub-normal heater voltage. It had been found possible to use such a valve to measure resistances up to well over a million megohms. Unfortunately these conditions of type and operation are diametrically opposed to those for low-resistance output. There seemed to be nothing for it but to use two pairs of valves—one for high-resistance input, coupled to the other for low-resistance output.

At this stage we can turn our attention to the output resistance. A valve with a slope of 5mA/V under operating conditions has an output resistance as a cathode follower of about 200Ω. In Fig. 1 there are two in series, making 400Ω. Assuming that the lowest range is 0-1V, and the meter is 0-1mA, and (for the moment) that there is a one-to-one coupling between input and output valve grids, the total resistance in the meter circuit on this range would have to be 1,000Ω. Of this, 400 would be in the valves, and therefore varying inversely as their slope. Although the effect of varying supply voltage on zero setting would largely be balanced out by the symmetrical valve arrangement, the effect on slope and consequently calibration would not, and stabilization would be essential to ensure accuracy under present-day electricity supply conditions. The gradual change in slope with age would also cause error, and valves could not be replaced without recalibration or adjustments of a fairly elaborate kind.

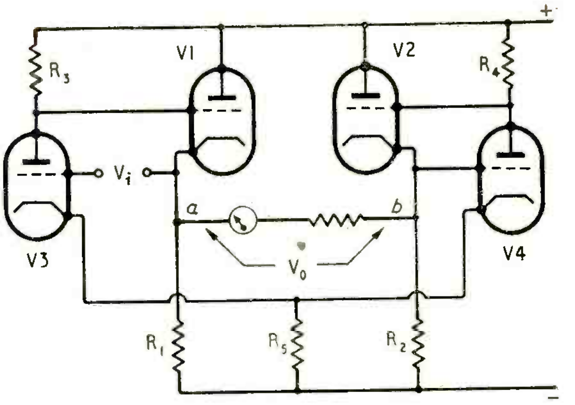


Fig. 3. Outline circuit of system having very high input resistance and almost zero output resistance. V_i is the voltage to be measured, and V_o (the output voltage) is less than 1% lower even when feeding a resistance as little as 500Ω.

So altogether we seem to be arriving at quite a complicated and expensive piece of apparatus, with a not very attractive performance. A voltmeter of any kind cannot really be considered satisfactory if a substantial part of its resistance on any range depends on the mutual conductance of a valve or valves. One would much prefer to see it all as wire.

Self-stabilizing Circuit

At this point it occurred to the writer that a stabilized power supply can easily be made to have an output resistance (R_0) of a few ohms, or, with a little care, a fraction of an ohm. The type of circuit in mind operates as a cathode follower with amplified feedback. Whereas the output resistance of a simple cathode follower is approximately $1/g_m$, this figure is divided by any voltage gain that is provided in the feedback loop. A valve of the EF37 class is excellent for providing voltage gain. Applying the voltage-stabilizer technique to a balanced valve-voltmeter circuit resulted in the arrangement shown in its simplest form in Fig. 3. V1 and V2 are the output valves. V3 and V4 are the high-input-resistance valves, connected so that their full gain in conjunction with V1 and V2 is fed back. With normal values, the difference between the output and input voltages V_o and V_i is of the order of only 1 per cent, so a d.c. voltmeter connected between *a* and *b* need not be recalibrated when used to measure voltages applied to the V_i terminals. As will be shown later it is an easy matter to eliminate even this small error.

V1 and V2, being used as cathode followers, are necessarily triode-connected whether or not they are in fact triodes. Seeing that R_0 is now of the few-ohm order, the possible error in calibration due to variations in the characteristics of these valves is quite negligible, and if this consideration were the only one

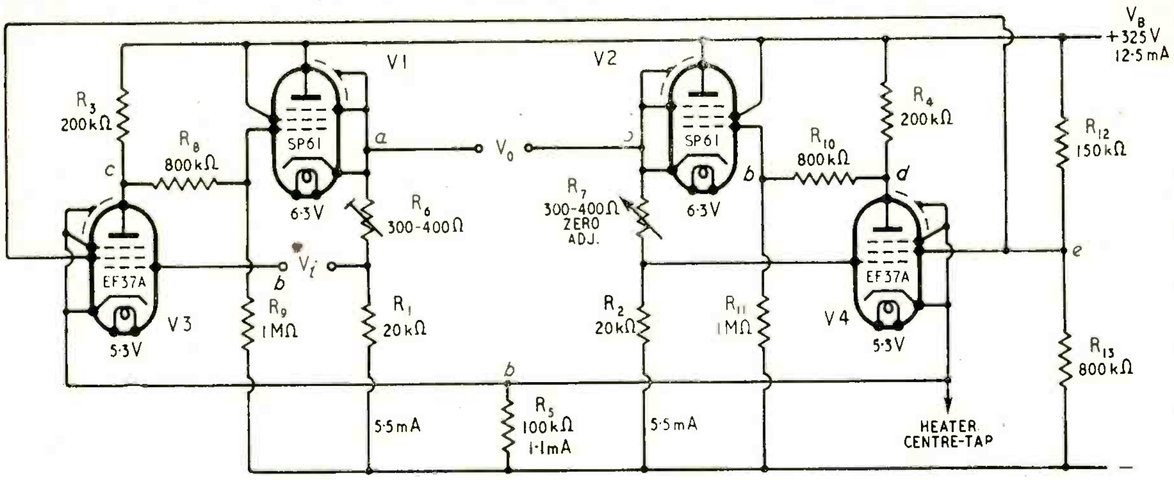


Fig. 4. Circuit diagram of the Fig. 3 type as finally evolved. The heaters of V3 and V4 are underrun to ensure low input conductance.

almost any type of valve could be plugged in without any readjustment or recalibration whatever, even on the lowest range. It is only when designing for the highest range that the characteristics are of much importance. As in designing voltage stabilizers for a large range of output voltage, one aims at high μ in conjunction with low g_m. Two SP61 valves are used in the writer's design, but an ECC33 twin triode can be substituted for them without making any noticeable difference except about 5 per cent. reduction in the highest measureable voltage.

Another advantage of the scheme is that almost any voltmeter can be connected between the cathodes; the full-scale current does not matter, within reason. The meter adopted actually has a full-scale current of just over 3mA. So most makes of multi-range test meters are suitable for use with this "electronic adaptor," which is so stable and error-free that a 5-inch scale can be used to advantage.

The range-changing switch on a multi-range voltmeter is operative when the adapter is in use, but only up to a certain limit depending on the circuit design and the supply voltage. It is here that the action of the circuit must be considered in greater detail.

A full mathematical analysis would probably just be confusing to most readers at this stage. The most helpful way to consider a problem of this kind, perhaps, is as an approximation, supplemented by a good idea of the factors controlling the departures from the approximate. For instance we know already that the output resistance of the system, as a source of d.c. for the meter, is (to a first approximation) zero; and that what resistance there actually is can be made more nearly zero by increasing the total voltage gain round the feedback loop. To a second approximation

$$R_0 \simeq \frac{2}{g_m m}$$

where g_m is the slope of V1 and m is the voltage gain of V3. The 2 comes in because V2 and V4 (assumed to be the same as V1 and V3) introduce a second equal resistance. The gain of a resistance-coupled valve of the EF37 type (including EF36, EF37A, and any similar) is not very large as a triode, but can easily be of the order of 100 in a pentode circuit. Taking $m = 100$ and $g_m = 0.006$A/V, we calculate that $R_0 = 3.35\,\Omega$, which is of the order realizable in practice.

Let us disregard initial voltages in Fig. 3 and take a as the zero point. The usual method of connecting a diode for alternating voltages makes V_i negative; so to begin with let us suppose $V_i = -1$. This negative voltage on the grid of V3 will reduce its anode current, raising the voltage of its anode and lowering that of its cathode. The raised anode voltage will make the grid of V1 (and hence its cathode) more positive, too. This positive movement, being fed back to the grid of V3, will tend to neutralize V_i. In fact, assuming for the moment that the cathode of V3 is somehow kept at a constant potential, and that the gain from the grid of V3 to the cathode of V1 is of the order of 100, only about -0.01V change in the grid potential of V3 would be needed to raise the cathode of V1 by 1 volt. In effect, then, introducing V_i does not lower the potential of its grid end appreciably; it raises its cathode end by practically the full amount. Although we know, therefore, that a change in grid-to-cathode potential necessarily occurs when a voltage V_i is applied, to a first approximation it is negligible compared with V_i.

Now we can consider the drop in cathode potential of V3. It is equivalent to a rise in the grid potential of V4, and tends to increase the anode current of V4. This tends to neutralize the change in common cathode potential of V3 and V4, and also to lower the grid (and consequently cathode) potential of V2. So while point a goes up, b goes down. And since, for the reasons given in connection with V1 and V3, the change in grid-to-cathode potential of V4 is negligible compared with V_i, it follows that the change in potential between the grids of V3 and V4 must also be relatively small. If one were to neglect it altogether then it would follow that V_i plus the output voltage V_0 would always have to be zero; in other words, the voltage reaching the meter would be opposite *and equal* to that applied at the "infinite resistance" input terminals. Which, as Euclid used to say, is what was to be done. The only difference between this ideal and the actual is of the order of 1 per cent caused by the fact that the gain of V3 and V4 is not quite infinite.

We see that when V_i is applied a must rise and b fall, but it is probably not obvious in what proportions. It is obvious that the movement cannot be perfectly symmetrical, *b* falling by the same voltage that *a* rises, because if it were (with matched valves) there could be no change of current through the common cathode resistor of V3 and V4, and therefore V4 would receive no "signal." Which, as Euclid again would have said, is absurd. So it is clear that *b* must fall less than *a* rises, and the common cathode potential of V3 and V4 must fall by about the same amount as *b*. Analysis shows that the rise/fall ratio is approximately $1 + R_3/R_5$, but this result is not very reliable in practice because of complications such as maintenance of g_2 potential in V3 and V4.

These practical complications are now due to be considered. In the first place, Fig. 3 clearly would not work as it stands, because if all the valves had their appropriate grid biases the anode voltages of V3 and V4 would be negative. The first method to be tried for correcting this was to insert resistances of about 6kΩ in the positions R_6 and R_7 in Fig. 4. Fortunately a pentode can work down to a very low anode voltage; say 20. If V_i is always negative, then the initial anode voltage for V3 can be near its minimum, because its movement is always towards positive. The anode of V4 goes negative, but (with typical component values) only about one-third to one-quarter the extent, so if 50 or 60V is to be the top range, it is sufficient to give the anodes of V3 and V4 about 40V, which will leave some margin. But if both negative and positive voltages are to be measured this would not be enough.

The cathode resistor method was found unsatisfactory for at least two reasons. Firstly, if the meter terminals are kept at the cathodes, V_0 becomes substantially greater than V_i and the original calibration does not hold; if they are not, the extra cathode resistors increase R_0 substantially, and the calibration is again upset, though not so badly. Secondly, it was desired to tap off about −1.5V from R_1 for ohmmeter purposes, and the slight change in the value of R_1 when the ohmmeter terminals are short-circuited shifts the zero slightly when V1 has a cathode resistor "above" R_1. So although it throws away a good deal of the voltage gain, a potential divider (R_8R_9 in Fig. 4) was tried, and worked better than expected.

Although cathode resistors in the positions R_6 and R_7 were abolished because of the disadvantages just mentioned, those disadvantages were due to the high value of resistance (about 6kΩ) required to provide V3 and V4 with anode voltage, rather than to their presence itself. In fact one of the disadvantages—the increase in V_0 for a given V_i—can be turned into an advantage by choosing a much lower resistance for R_6 and R_7. By making R_6/R_1 (and R_7/R_2) equal to the proportionate error $(V_i - V_0)/V_i$ the discrepancy between V_0 and V_i can be completely eliminated. And varying R_7/R_6 is a convenient method of zero setting. The values required for this purpose are too low to cause appreciable trouble in the ohmmeter circuit.

Fig. 4 also shows the g_2 feed for V3 and V4 (R_{12} R_{13}).

Determining the component values in this circuit to ensure the desired top range, for the minimum supply voltage, is rather complicated, and would distend this article excessively if described in full and in general. But some idea of how a particular specification was arrived at may be helpful. The voltage diagram Fig. 5, obtained by measuring currents in the various leads over a range of positive and negative V_i and multiplying them by the appropriate resistances, is very illuminating. It is drawn for a supply voltage of 300, and shows the potentials of the correspondingly lettered points in Fig. 4. The differences in potential between the various parts marked *b*, which are only a few volts, are neglected in Fig. 5; and similarly for *a*. With the circuit values in Fig. 4, arrived at by several trials, we see that at $V_i = 0$ the anode voltage on V3 (V_{bc}) is about 90, rising to 165 at $V_i = -50$V and falling to 15 at $+50$V. Obviously this is the limiting factor for measurement of positive voltage. The limit for negative voltage is set by V3 cutting off, which it would do when *c* reached 270V. The limit in both directions is thus set by V3 because it handles a greater amplitude than V4, so it is desirable to equalize the swing between these valves as much as possible. If, working on the formula $1 + R_3/R_5$, we reduce R_3 we reduce the gain, which is undesirable; so instead R_5 is made as large as practicable. Increasing it increases the current through V1 and V2 and ultimately restricts their swing. An incidental advantage of the potential dividers R_8 R_9 and R_{10} R_{11} is a tendency to equalize the swings; the approximate theoretical ratio is altered from $1 + R_3/R_5$ to $1 + p\,R'_3/R_5$, where p is the step-down ratio $R_9/(R_8 + R_9)$ and R'_3 is the resistance of R_3 in parallel with $R_8 + R_9$. Fig. 5, shows even better equality than theoretical, due presumably to the fact that this simple formula ignores screen-grid current. Note, incidentally, that the "push-pull" operation prevents the screen-grid voltage (V_{be}) from varying as widely as it otherwise would.

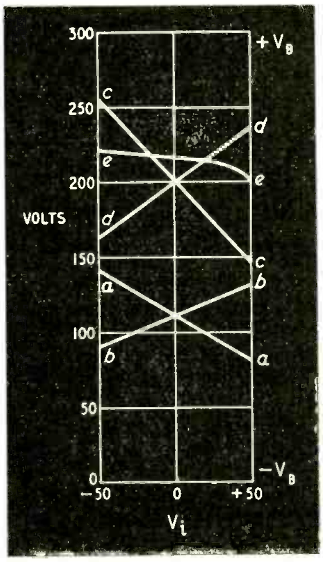


Fig. 5. Voltage diagram relating to Fig. 4, showing how the potentials of the parts marked a to e vary as V_i is varied from −50V to +50V. The differences between grid and cathode potentials of valves, being relatively small, are not shown.

Before completing the design it is necessary to check absence of grid current in V3 and V4 at the extremes of input, and if necessary modify component values or V_B if not satisfactory.

A suitable working margin must be be allowed above the maximum scale V_0, to allow for variations in mains voltage and valve characteristics. Beyond the working limits of V_i the system cuts off sharply and there is no further increase in current through the meter, which is thus automatically protected. It is advisable, however, to have it on its highest range when switching on and off, to avoid excessive transient unbalances while the heater temperatures are varying. The type of scale in the meter used made it convenient to have ranges of 0-1.5, 5, 15, and 50V. These were obtained in the usual way by series resistors. An extension of this procedure for higher ranges would have necessitated an unduly high supply voltage, so they were provided by means of an input potential

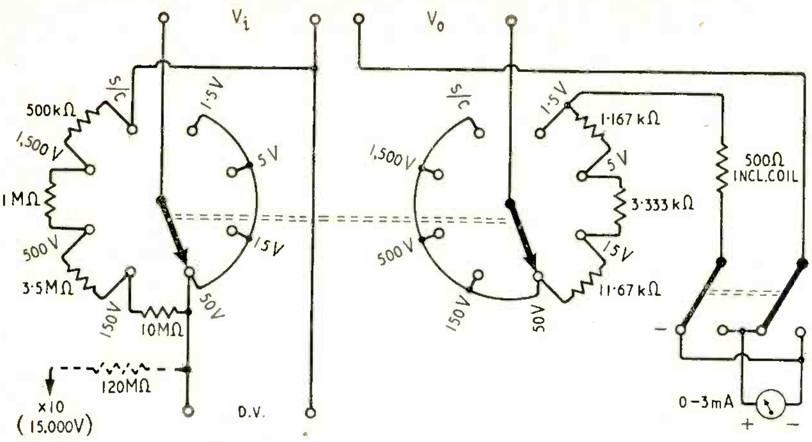


Fig. 6. Details of switching for d.v. (direct voltage) range and polarity, associated with the circuit of Fig. 4.

divider, which places 15MΩ (high-stability carbon) across the input terminals on all ranges. If desired this could be open-circuited on ranges lower than 150V. Fig. 6, which joins up with Fig. 4 at the V_i and V_0 terminals, shows the range switching, including a reversing switch for reading positive voltages when required. The dotted multiplier is suggested for television voltages, etc., but should not be attempted by anyone inexperienced in high-voltage technique, as the chain of resistors totalling 120MΩ must be suitably mounted to avoid corona and leakage.

Resistance Measurements

A valuable feature of a valve voltmeter is the ease with which wide-range ohmmeter facilities can be incorporated. Fig. 7 shows how this was done in the present instance. The arrow marked D.V. leads to the arm of the range switch shown in Fig. 6, the resistance measuring components being cut out in the most clockwise position of the switch above. It is possible to combine the two switches in one, but it would have to be provided with rather a large number of ways. The values in Fig. 7 are based on 5.5mA through R_1, with readings taken on the −1.5V range. This voltage is tapped off R_1 273Ω from the top, and the 731Ω shown in Fig. 7 is the amount required to bring it up to 1kΩ (allowing for the rest of R_1 in parallel) to constitute the lowest resistance standard. The other standards are 10kΩ, 100kΩ and 1MΩ. The resistance to be measured is connected to the R_x terminals and forms with the selected standard a potential divider, so the resistance scale is of the usual ohmmeter type in which mid-scale reading corresponds to R_x equal to the standard.

Satisfactory readings are given from 100Ω to 10MΩ, with rough indications at 10Ω and 100MΩ. An additional facility is shown for testing insulation: a tapping at −78V in conjunction with 1MΩ across the V_i terminals, giving a minimum reading (at full-scale) with 50MΩ applied to the " Ins." terminals. A separate scale is, of course, necessary for this range. For insulation measurements three termimals are available, for employing the usual guard ring technique to exclude effects due to undesired leakage paths. Satisfactory readings are given up to 1000MΩ, and an indication at 5,000MΩ. The tapping is at 78V to allow for the full-scale drop of 1.5V across the standard, 75V across the 50MΩ, and 1.5V across a safety 1MΩ at the tapping. This last prevents the greater part of R_1 being short-circuited but does not prevent the pointer being driven off the scale, so before using this range a test should be made on the 1MΩ range.

Accuracy of the ohmmeter readings depends on constancy of the current through R_1. Ideally V_B should be stabilized, but since the current can be checked at any time by open-circuiting the R_x terminals it was decided to adjust V_B by hand, leaving enough margin to give full-scale with bottom-limit mains voltage.

Finally, a few data on performance. In spite of half the gain of V3 and V4 being thrown away by the potential divider, the total output resistance is only 4Ω, so that even on the lowest range and with a meter taking as much as 3mA full-scale, V_0 is only 0.8 per cent less than V_i, and as we have seen this small error is eliminated by R_6 and R_7. A 10 per cent drop in V_B produces a barely perceptible (about 0.004V) shift of zero, and no perceptible change in calibration. A 10 per cent drop in heater voltage produces 0.01V zero shift and no perceptible change in calibration. Even the drastic test of connecting a second SP61 in parallel with V1 was equally satisfactory. The characteristics of V3 and V4 are much more influential; doubling V1 shifted the zero 0.61V, but when this was taken up on the zero adjustment the lowest-range calibration was again not perceptibly altered. In practice the change in characteristics of V3 and V4 even over a long period is likely to be small, and certainly not more than a very small fraction as drastic as this test. Experience so far has shown that even with ordinary carbon resistors, provided that they are conservatively rated and kept away from the heat of the valves, the zero is remarkably stable; but high-stability or wire-wound resistors are to be preferred for the more critical values.

It is hoped at a later date to describe the arrangements for measuring alternating voltage.

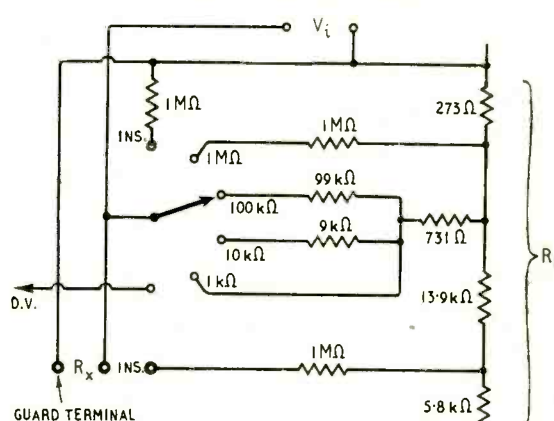


Fig. 7. Details of ohmmeter and insulation testing arrangements associated with Fig. 4.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents

Earls Court Television

YOUR correspondent, I. G. Benbough (December, 1951, issue) has, I venture to suggest, missed the main purpose behind the demonstrations of television at the Earls Court Radio Show. All exhibitions, whether of a technical nature or otherwise, try as a rule to show the various products to the best advantage in order to create that interest in the customer which may in this case lead subsequently to his buying a television receiver.

The pictures shown were therefore the best that could be produced within the limits of a 405-line system transmitted by radio and subsequently relayed throughout the exhibition by cable. It is to this end that the signal level was kept at 1 mV $\pm$ 3 db at the 70-ohm outlet and extraordinary precautions were taken to safeguard it from interference of all kinds. I suggest that few, if any, would-be purchasers of television receivers neglect to go and see the receiver of their choice operating under reception conditions near their home, especially since they would in most cases be buying it through their radio dealer.

If Mr. Benbough's suggestion were adopted, who is to say how much degration of picture by noise should be allowed? Those in quiet districts near the transmitter, of whom there are many, would undoubtedly regard any such interference as excessive, while those in the "fringe" would find it insufficient. Further, why stop at aeroplane effect and motor car ignition; why not some diathermy interference for good measure?

In my view, the signal fed to "Television Avenue" should be as good or better than that to which the British domestic set will do justice, always remembering that British television at such times comes under the critical eye of many who have never seen it before, both in this country and from overseas.

The demonstration and proper interpretation of the other points of a television receiver should be the job of the dealer who sells it, leaving to the Radio Show, as always, the creation of television interest.

Woking, Surrey. R. W. ADDIE.

Two-triode R.F.?

I HAVE reason to believe a number of your readers, besides myself, tried out the two-triode r.f. amplifier circuit in one form or another and were impressed by the high quality and stability obtained. The designer of the original *Wireless World* Q.A. Receiver stated in 1935, I believe, that the efficiency of a stage of two-triode amplification was virtually governed by the inter-electrode capacitance of the valves employed, and I have often wondered whether, with the tremendous advance in valve design since then, it might be profitable to investigate anew the possibilities of this circuit. The main objection to the original receiver—lack of selectivity—can be met to some extent by the use of the negative-feedback anode bend detector (not developed by 1935). Might it be possible, also, to use two stages of such amplification employing double-triode valves?

It would be interesting to have the opinion of other readers on whether the two-triode circuit is dead and gone for ever or can with advantage be resuscitated.

Caterham, Surrey. DOUGLAS A. FINCH.

"Universal Meter Shunt"

THE statement in your July issue that "to eliminate temperature error it is essential for the movement to have a swamp of Eureka or other low-temperature-coefficient wire in series with it" is true for most ordinary single shunted meters, but needs a little qualifying when applied to universal shunts.

It should have been made clear that the temperature error of a shunted meter depends not on the movement-to-swamp ratio but on the ratio between the movement and the total non-varying resistance in parallel with it. Therefore, in cases where the lowest range of a universal shunt exceeds the movement by a factor of less than 2, i.e., the total shunt resistance is greater than the movement, an appreciable amount of compensation is already present even without swamp. On a rise of temperature, the shunt develops a higher voltage drop by accepting the current which the meter refuses, and *vice versa*.

It is also a fact, not perhaps immediately obvious, that for a given temperature change the error of a universally shunted meter is the same percentage of the reading no matter where the input takes place: on the lowest possible range, i.e., directly across the movement terminals, or on the highest range, when most of the shunt is acting as swamp.

Those of your readers who wish to make the best practical use of the information contained in the article should, therefore, take the total resistance of the universal shunt they intend using into consideration in assessing the necessity or otherwise of swamp.

High Wycombe, Bucks. T. H. FRANCIS.

Units of Capacitance

THE issue raised in your columns of a more convenient sub-unit of capacitance seems to have been brought to a satisfactory conclusion by V. J. de Grijs (November, 1951, issue), who points out that the nano-farad (nF) for 10^{-9} farad is already in use in Central Europe and Indonesia. I therefore disown the "lillifarad" and from now on shall be relieved to write every capacitance above 820 pF and below 1 μF in nano-farads.

I should imagine our capacitor manufacturers will be delighted to avoid printing rows of noughts and illegible decimal points on their products. Whichever of them gets in first with an announcement that they will adopt this simplification will earn much goodwill.

Incidentally, it is an interesting commentary on the current recasting of world relations that the lead comes from Indonesia. Perhaps Mr. de Grijs would return the compliment by abandoning milliard for 10^9 in favour of the widely used billion of 10^9, since the initial letter of milliard is going to be confused with those of mega, milli and micro when abbreviated. V. MAYES.

Prestwich, Manchester.

More New Units

THE suggestions to adopt new prefixes, "nano" and "pico" for small capacitance values, would permit any value to be expressed as a whole number, thus reducing the possibility of mistake in the position of the all-important decimal point.

As an aid to the rapid calculation of the effect of a given capacitance in a circuit, a small unit of susceptance is required, since the capacitance becomes, in many cases, an "unwanted" but inevitable shunt element in a circuit. A convenient unit for dealing with the relative shunting effect is the micro-mho, conveniently debased to "jumbo," the "j" indicating that it is a susceptance and not a conductance. Thus a capacitor has, at a given frequency, $\omega C \times 10^6$ "jumbos" with the advantages of working in whole numbers, and of dealing with the two possible variables f and C in direct proportion.

Using the symbol "J" for this unit, a 10-pF capacitor possesses 62.8J at 1 Mc/s and at any other frequency, say 41.5 Mc/s, the susceptance becomes 41.5×62.8 or 2.6kJ. The "J" itself includes the ill-used prefix "μ."

Resistor values invariably yield a whole number if the conductance, 1/R, is expressed in μmhos; thus the relative disturbing effect of the capacitor can easily be estimated. Incidentally, the admittance of this parallel combination $Y = G + J$ ("umbos" plus "jumbos"?) is the vector sum of both (in μmhos).

Another "new" unit for comparing the overall performance of a device such as an oscillator, amplifier or receiver is available if the ratio of signal/noise is generalized into "wanted/unwanted" ratio, the wanted part being the signal voltage but the unwanted part to include *all* the disturbing voltages. The ratio then becomes a measure of the goodness factor of the device and can conveniently be expressed in db, i.e., the goodness factor $= 20\log V/\sqrt{v_1^2 + v_2^2 + v_3^2 + \ldots}$ where V is the r.m.s. value of signal, v_1, v_2 and v_3 being the r.m.s. values of hum, noise and distortion, so that the denominator represents the r.m.s. value of all the unwanted voltages in the output of the device.

Thus an oscillator with a hum content of 60db down, noise 60db down, and distortion of 0.1 per cent (also 60db down) would have a goodness factor of +55.4db, showing that the required signal exceeds the combined disturbing effect by this ratio. This method gives a useful figure for comparison purposes.

When dealing with the response/frequency characteristics of a device the only available unit of frequency ratio is the "octave" or eight-note ratio which is 2:1 in frequency. Much larger and very much smaller frequency ratios are commonly considered and a new unit of frequency ratio called the "decave" might be used. I decave (symbol D) would correspond to a frequency ratio of 10:1 so that the number of decaves in a given frequency spectrum $= \log_{10} f_2/f_1$.

The octave then corresponds to 0.3D so that the older unit could still be used.

For very small frequency ratios, the value of 0.001D or 1mD corresponds to the frequency ratio due to 0.012 per cent frequency change, i.e., 1.2 parts in 10^4.

This method of dealing with the log of the frequency ratio simplifies calculation and keeps it in line with the usual method of plotting response curves on log/linear graph paper.

Finally, in lighter vein, there is the O/P ratio of a radio or television set. This is the ratio of Ostentation, judged by the external appearance, to the Performance judged, of course, from the results. It is a very subjective factor found by giving each of the two qualities a mark out of ten and comparing the two. In these days of austerity few radio or radio-cum-television sets seem to have an O/P ratio in excess of unity. E. McEWAN REID.

Sanderstead, Surrey.

Safer A.C./D.C. Sets

THE trend of thought on a.c./d.c. techniques appears to be going slightly astray these days. Thus, the argument for a "live" chassis in a broadcast or television receiver is that this dispenses with a bulky and expensive mains transformer.

The other aspect of the matter seems to have escaped the notice of manufacturers. I refer to the method agreed by technicians to prevent common paths and coupling between stages in a receiver—the common earth per stage. It is even more important to carry out this practice in television receivers with the high frequencies involved. If we keep to this beneficial layout a normal commercial receiver would require approximately five earthing tags, and in a television receiver about 20. Is there any reason why these earthing tags should not be insulated from the chassis at a cost of a few pence to the manufacturers? The chassis could then be earthed in a normal manner, and I am sure this practice would provide a strong selling point for the receiver, particularly in view of the danger which the public now knows exists.

An interesting variation of this train of thought is for a spare insulated tag to be provided on valveholders for use as a common earth, which is particularly easy to arrange on the B7G base.

Perhaps fellow readers can point out the fallacy in the above arguments. C. E. THORN.

Newcastle-on-Tyne.

Hope for AIRMET?

AS a solution to the problem of finding a channel for AIRMET broadcasts, would it be possible to employ existing navigational aid transmitters? The modulation could be restricted in depth, frequency and time duration, as necessary, to prevent interference with the navigational facilities. G. F. JOHNSON.

Welling, Kent.

"Modifying 'Surplus' Meters"

THERE exists a hazard to the health of many of your readers. Since the publication of the above article (September, 1951, issue), this hazard has probably reached a much greater section of the community. It is one of radio activity.

Many aircraft instruments are fitted with luminous dials activated by radium compounds having strengths several hundred times that considered a safe working tolerance at atomic energy research establishments. If a dust particle from the luminous paint on these instruments were accidentally inhaled, it might become lodged in the body and serve to shorten the life of the unsuspecting experimenter. R. J. ELLIS.

Aldermaston, Berks.

[We understand that the radiation from the paint on the Type 3 (10Q/4) meter exceeds the safe working tolerance and might be injurious to anybody exposed to it for long periods. With the glass front on, however, the meter is quite safe as the radiation consists mainly of beta rays which have low penetrating power. A particle of the material inhaled or swallowed would definitely be dangerous, so we advise readers to work on the meter in the open air, or with a mask over the nose and mouth, and to be particularly careful about washing their hands before eating anything.—ED.]

Oval Spot?

WITH the present tendency leaning towards bigger television tubes and consequent line-spacing problems, it occurred to me that tube manufacturers could deliberately introduce astigmatic construction. By this means the spot could easily be made oval in shape, and by polarizing this in a vertical sense spot-wobbling, and the effect of viewing through a venetian blind, would be obviated. I should be interested in the B.V.A. reaction to this suggestion.

London, W.1. A. S. TORRANCE.

Tinning Litz Wire

I HAVE noticed on several occasions reluctance on the part of radio technicians to use Litz stranded wire, whether covered with silk or enamel, owing to the difficulty of obtaining an absolutely perfectly tinned joint on all the strands.

Readers may be interested in a method which I have used since 1934. Double the wire back on itself, and give it half a twist, to keep it together. Then heat it in a spirit-lamp flame until it is red hot and, while hot, immerse in methylated spirits.

It will be found that after a little practice the wire comes out bright and shiny and completely free from any oxide—or even carbon from the burnt silk or enamel. All that needs to be done then is to apply a small amount of good quality soldering paste and tin with a clean iron.

Worthing, Sussex. F. TURTON.

WORLD OF WIRELESS

B.B.C. Status Quo ♦ Wavelength Reallocation ♦ 1,000,000 Viewers Solar and Galactic Radio ♦ British Television Conference

New Charter

AS was anticipated, the Government has decided to renew for a period of six months the B.B.C. Charter, which, granted in January, 1947, terminates on December 31st. This will enable the Government to have further time to consider its policy in relation to the recommendations of the Beveridge Committee and the late Government's White Paper.

The new Charter and Licence will incorporate the provisions of the existing documents except for a change in the financial arrangements. The late Government's proposal, that the B.B.C. should receive 85 per cent of the net licence revenue—i.e., after deduction of 7½ per cent by the Post Office for "collection charge"—has been incorporated in the licence.

Geneva Conference

AFTER a session lasting three and a half months the extraordinary administrative radio conference, which, sponsored by the International Telecommunication Union, opened in Geneva on August 16th, has adopted a plan for the reallocation of frequencies between 4 and 27.5 Mc/s to such services as broadcasting, aviation and shipping.

Although at the time of going to press specific details of the plan and the agreement—approved by 52 of the 70 participating nations—are not available, it is known that the provisions regarding short-wave broadcasting are not to be introduced until after the 1955 international conference.

We hope to be able to review the findings of the conference in our next issue.

Television Progress

IN response to recent questions in the House of Commons regarding the progress in completing the remaining two high-power television stations, it was stated by the Asst. P.M.G. (Mr. David Gammans) that work on the £330,000 Wenvoe station is proceeding according to plan but it is uncertain whether the transmitter will be operating by the middle of 1952 as anticipated. The cable linking the station with London, which is being laid by the G.P.O., will not be ready for service before November, but a temporary radio link will, it is hoped, be available by the middle of the year.

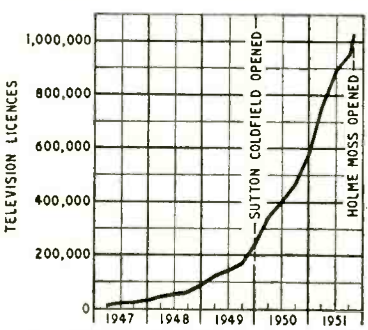
The Asst. P.M.G. stated that the cost of the radio link between Manchester and Kirk O' Shotts (the Scottish station) will be about £520,000. One of the relay towers for the radio link to Scotland will be on Pontop Pike, nr. Newcastle-upon-Tyne, the site of the proposed North-East low-power transmitter. It has, therefore, been suggested that this 5-kW station, costing some £200,000, should be the first of the five projected low-power stations to be built, but no such undertaking would be given by the P.M.G.

By the time this note is published test transmissions, using the 5-kW standby transmitter, at Kirk O' Shotts, will have been started. It is hoped by the B.B.C. to begin tests with pictures received over the radio link from Manchester in February. The nine relay stations will operate on frequencies around 4,000 Mc/s. No date has so far been given for the Scottish station to be brought into service.

Millionth Television Licence

DURING October the millionth television receiving licence was issued by the Post Office. By the end of the month, during which the number of licences increased by 73,450 (a record), the total was 1,031,950. It was recently stated by the Asst.-P.M.G. that it was estimated that there were some 100,000 unlicensed television sets in use. In an endeavour to stir the consciences of delinquents, the Post Office has issued a poster stating "don't be a pirate."

The number of "sound" licences in force in the U.K. at the end of October was 11,417,000, bringing the total number of licences to 12,448,950.



QUARTERLY GROWTH in the number of television licences in the U.K. since March, 1947, prior to which date viewers where permitted to operate receivers with "sound" licences.

Extra-Terrestrial Noise

SO far there has not been any international agreement on the frequencies to be used for the study of extra-terrestrial radio noise, which, of course, means that it is extremely difficult to correlate the measurements made in various countries. It has therefore been recommended by the International Scientific Radio Union (U.R.S.I.) that the International Frequency Registration Board be asked to assign on a world-wide basis seven frequencies with specified guard bands for "the international study of solar radiation and galactic radio noise."

The recommended frequencies are: 40, 80, 200, 320, 640, 1,280, and 3,000 Mc/s; and the respective guard bands ± 20, 25, 140, 500, 1,000, 3,000 and 3,000 kc/s.

It is pointed out by the U.R.S.I. that the Netherlands telecommunications authority has already made an effort to reach an agreement with adjacent countries on the use of frequencies for the study of solar radiation.

Radio Astronomy

RECEPTION of noise-like signals with strengths far below receiver noise level was recently demonstrated at the Royal Institution by Dr. J. H. Ratcliffe, of the Cavendish Laboratory. He used a faint electric bulb to represent a distant radio star, with a photo-cell and amplifier for the aerial and receiver. Heard over a loudspeaker the noise signal from the light source was normally indistinguishable from the amplifier noise, but by rotating a "chopper" disc in front of the photo-cell an audible note was produced proportional to the signal strength. In practice an interferometric aerial system is used (see *W.W.*, July, 1951, p. 276) and the chopping is done by switching in and out a quarter-wave line with a motor-driven capacitance switch, so altering the phasing of the two spaced aerials in a periodic fashion.

Television Convention

DURING the technical sessions of the Television Convention being organized by the Institution of Electrical Engineers (April 28th-May 3rd), which will cover all aspects of television from the programme production to the viewer, there will be demonstrations of equipment, including large-screen projection television and, it is hoped, an early Baird 30-line receiver. Whilst the Convention will be open to anyone, the visits of inspection, which will include B.B.C. television studios and transmitters, the Post Office Research Station, the terminal equipment of the London-Birmingham co-axial cable link, and some commercial organizations, will be open to registered members of the Institution only.

The sessions into which the Convention is being divided are:

Opening Ceremony, followed by an introductory survey by Sir Noel Ashbridge; Historical—a paper showing the evolution of television from the end of the nineteeth century to the opening of the regular B.B.C. service in November, 1936; Programme Origination — covering cameras, camera channels, studio lighting and film scanners; Point-to-Point Transmission—cable and radio links, television-transmission measuring equipment; Broadcasting Stations—vision transmitters and techniques, aerials and feeders; Propagation—ionospheric influences in television reception, selection of transmitter sites; Receiving Equipment—Part I, receiver circuit techniques, Part II, cathode-ray tubes and valves; Non-Broadcasting Applications—large-screen television design problems, medical applications, film-aids and television wire broadcasting; and System Aspects—fundamental aspects of colour television, subjective aspects of viewing, contrast etc.

Copies of the programme and combined registration and order form for the Convention on "The British Contribution To Television" will be available soon from the Secretary of the Institution, Savoy Place, London, W.C.2.

Servicing Certificates

THE results of the 1951 Television Servicing Certificate Examination, held under the auspices of the Radio Trades Examination Board, have now been announced. Of the 53 candidates, 19 satisfied the examiners in all papers, 16 were referred in the practical examination and six who were referred in the 1950 practical examination qualified for the certificate. Twenty-nine candidates living outside the service areas of existing television stations sat for the written papers; 21 passed.

Closing dates for entries for the 1952 television and radio servicing examinations are January 15th and February 1st, respectively. Regulations and entry forms are obtainable from the Secretary, R.T.E.B., 9, Bedford Square, London, W.C.1.

Industry, Please Note

TWO pleas to the radio industry were made in speeches at the opening of the Radio Society of Great Britain's annual exhibition. C. I. Orr-Ewing , M.P., suggested that sub-standard television camera tubes might be made available to amateur television transmitters at low prices or on loan. F. Charman, president-elect of the R.S.G.B., urged makers of television receivers to design them to be as far as possible immune from interference from transmitters in the amateur bands—presumably mainly by choice of appropriate values of intermediate frequency.

Colour Television

THE October, 1951, issue of the *Proceedings of the I.R.E.* (America) is devoted almost entirely to contributions on colour television. Among the twenty articles one deals with the F.C.C. standards for colour transmission, and another, by Donald Fink (Editor-in-chief, *Electronics*), compares the relative merits and demerits of the frame-sequential and the colour sub-carrier systems.

A recent announcement from the U.S. Office of Defence Mobilization requests manufacturers to drop plans for the mass production of colour television receivers. It was, at first, intimated that it would "suspend all further development of colour television in order to free highly skilled electronics engineers for important military projects," but it has since been announced that research will not be interrupted.

"W.W." Index

THE index to the 1951 volume of *Wireless World* is now ready and is available from our Publisher, price 1s (postage 2d). Cloth binding cases for the volume are also obtainable, with index, price 6s 5d by post. The binding of readers' own issues can be undertaken by our Publisher; the cost, including binding case and index, being 17s 6d, plus 10d for the postage on the bound volume.

C. I. ORR-EWING, O.B.E., M.P., speaking at the opening of the R.S.G.B. show. Also in the picture are (left to right) H. Freeman, exhibition manager; L. Cooper, hon. sec.; W. Scarr, president; and J. Clarricoats, gen. sec.

PERSONALITIES

M. G. Scroggie, B.Sc. (Elec. Eng.) Edin., M.I.E.E., who describes a novel type of valve voltmeter in this issue, has been a contributor to *Wireless World* since 1923, and to *Wireless Engineer* since 1924. He was chief engineer of Burndept Wireless, Ltd., from 1928-1931, and since then, except for the war years, has been a consulting radio engineer. He was in charge of the early CH radar station at Pevensey and then at No. 9 R.A.F. radio school (radar) before going to the Air Ministry. Mr. Scroggie is the author of "Television" (Blackie) and of the *Wireless World* books "Radio Laboratory Handbook" and "Foundations of Wireless," the 5th edition of which has just appeared.

T. W. Bennington, writer of the article on "Propagation of V.H.F. *via* Sporadic E" in this issue, has had a long radio career, starting from 1926. He joined the B.B.C. in 1934, and since 1939 has been in charge of the ionospheric and short-wave propagation work of the Overseas Engineering Department. He has been a frequent contributor to *Wireless World* since 1932, and is author of the book "Short-wave Radio and the Ionosphere."

James Cleland has been appointed Engineer-in-Charge of the Scottish television station which is being erected at Kirk o' Shotts, between Glasgow and Edinburgh. He was at Alexandra Palace from 1936 to 1938, when he returned to the Scottish Regional station at Westerglen where he had previously been for four years. For the past few months he has been Acting Engineer-in-Charge at Westerglen. Mr. Cleland's assistant at Kirk o' Shotts will be W. L. Nicoll, one of the senior engineers at the Skelton short-wave station.

OBITUARY

It is with regret that we record the death of **Leslie McMichael,** chairman of McMichael Radio, Ltd., on November 17th at the age of 67. His associations with both the radio industry and the amateur radio fraternity extend over very many years. He was among the founder members of the National Association of Radio Manufacturers and Traders (subsequently R.M.A. and now B.R.E.M.A.) and, in 1913, of the London Wireless Club which became the Wireless Society of London—forerunner of the R.S.G.B. He was for two years president of the Brit. I.R.E. (1944-46) and for his services to the amateur cause was elected an honorary member of the R.S.G.B. His appreciation of the part played by the amateur in the progress of radio was expressed in these words when addressing the Brit. I.R.E.: "As professional engineers, we should pay our tribute to the serious experimental work carried out without profit or reward by the radio amateur, who was among the first to appreciate and help forward the dissemination of radio knowledge."

We learn with regret of the death in Sydney, N.S.W., a few months ago of **Dr. A. L. Green**, who was officer-in-charge of the Ionospheric Prediction Service of the Commonwealth Observatory, Canberra. He was 46. Prior to joining the staff of the Radio Research Board in Sydney in 1930, he was for three years assistant to Sir Edward Appleton. He was with Amalgamated Wireless (Australasia) from 1935 until he joined the Observatory staff in 1947.

THE LATE Leslie McMichael photographed during test transmissions from a train in 1924.

IN BRIEF

Transatlantic Valve Liaison.—In response to an invitation from the Radio-Television Manufacturers' Association of America, the British Radio Valve Manufacturers' Association sent a representative to the first general conference of the Joint Electron Tube Engineering Council held in New Jersey at the end of November. P. A. Fleming, technical assistant to the B.V.A. secretary, represented the Association.

Technical Manpower.—The Technical Personnel Committee, reconstituted by the Government under the chairmanship of Lord Hankey, has set up a sub-committee to examine the problem of the manpower needs of the defence programme for radar, radio and electronics. Both the Radio Industry Council and the I.E.E. are represented on the committee.

Apprenticeship Scheme.—At the annual general meeting of the Radio and Television Retailers' Association it was announced that the Association, in conjunction with the Guild of Radio Service Engineers, was preparing a national apprenticeship scheme for the radio service trade. Full details of the scheme, which has yet to be approved by the Ministry of Labour, will be announced later.

India Television Project.—It is learned from our Bombay contemporary *Radio Times of India* that the Scientific Advisory Committee, recently appointed by the Government to advise the Ministry of Information and Broadcasting on the development of broadcasting, has recommended that a pilot television station be set up in India in order to study the art.

A.P.A.E.—The annual exhibition organized by the Association of Public Address Engineers will again be held at the Horse Shoe Hotel, Tottenham Court Road, London, W.C.2, on May 29th from 10 a.m. to 8 p.m. It will include this year a series of demonstrations. Further particulars are obtainable from the secretary, A. J. Walker, 394, Northolt Road, South Harrow, Middx.

R.T.E.B.—The Radio Trades Examination Board announces that S. A. Hurren, who recently retired from the Northern Polytechnic, has retired from the position of chairman of the R.T.E.B., which he has held since its formation in 1946. He is succeeded by E. J. Emery, who is managing director of E.M.I. Sales and Service. H. A. Curtis, director and secretary of the Radio and Television Retailers' Association, is deputy chairman.

Indian Exhibition.—A liaison committee was recently set up to act as the U.K. centre of information regarding the International Radio & Electronics Exhibition to be held in Bombay next November instead of February as planned. Wren Cowley, of Leland Instruments, is chairman of the committee, and B. A. Pettit, of Racal, Ltd., secretary. Enquiries regarding the exhibition, which has been postponed because of the failure of the monsoon, resulting in drastic cuts in supplies of water and electricity, should be addressed to the secretary at 41, Kingsway, London, W.C.2.

B.B.C. Reception.—The sixth of the twelve low-power stations to be brought into use by the B.B.C. to improve reception of the Home Service in certain areas was opened at Scarborough on November 11th. It radiates on 1,151kc/s. By the end of the year it is anticipated that the seventh station —a mobile transmitter—will be opened at Eastbourne.

Radar Prizes.—Bronze medals have been awarded by the Institute of Navigation for two radar papers read at meetings of the Institute. The recipients are: R. F. Hansford, of Sperry's, for his paper "Development of Shipborne Navigational Radar," and Capt. F. J Wylie, R.N. (ret.), Director of the Marine Radio Advisory Service, for "Radar and the Rule of the Road at Sea."

Correction.—In the list of components to "Radio Feeder Unit" (December issue, page 482), the type number of V_3 should be EB91.

For Teenagers.—The sixth Christmas lecture for older schoolchildren organized by the Institution of Electrical Engineers will be given at 3.0 on January 3rd and 4th. The subject is "Electricity in Civil Aviation," in which Capt. Peter Bressey, senior pilot of British European Airways, will review the contributions of electricity to safer and more reliable civil aviation—including radio, radar and other electronic navigational aids. Tickets are available from Savoy Place, London, W.C.2.

C.B.C. Finance.—Despite the fact that the revenue from sponsored programmes has increased fivefold compared with the pre-war figure, the Canadian Broadcasting Corporation incurred a loss of $1,271,874 in the year 1950-51. The Corporation's income was $8,301,379; nearly a third of which came from advertising. The Canadian license fee is $2.50. It is recommended that a statutory grant of $6,250,000 be made to the Corporation for each of the next five years. About 67 per cent of the past year's income came from licences and 30 per cent from sponsored programmes.

WHAT THEY SAY

G. Darnley-Smith, vice-chairman of the Radio Industry Council, speaking at the R.I.C. annual dinner on the f.m.-a.m. broadcasting controversy: "The a.m. bird gets the worm."

Sir James Barnes, K.C.B., K.B.E., a Permanent Under-Secretary of State for Air, addressing the Boy Entrants of Nos. 2 and 3 R.A.F. Radio Schools from Yatesbury and Compton Bassett, Wilts: "We are now spending on radio and radar as much money as we spent on all the aircraft we were buying shortly before the war. . . Electronic equipment is in fact the eyes, the ears and the whole nervous system of the Royal Air Force."

INDUSTRIAL NEWS

Pamphonic Reproducers, Ltd., have developed commercially the system of delayed sound reinforcement described by P. H. Parkin and W. E. Scholes in our February, 1951, issue. D.S.R., as it is called, uses controlled time delays on each loudspeaker in order to preserve realism and the sense of direction.

Canadian Market.—Exporters of radio sets and components to Canada are recommended by the Board of Trade to ascertain the patent position regarding equipment before exporting. Most of the patents likely to be infringed are held by Canadian Radio Patents, Ltd. (receiving equipment), and Thermionics, Ltd. (valves). This and other useful information is given in the "Market Digest on Radio Components (Canada)," issued under the reference CRE(IB)60680/51 by the Commercial Relations and Exports Department, Thames House North, Millbank, London, S.W.1.

Murphy Staff Changes.—A new executive post, that of Director of Engineering, has been created by Murphy to "bring into closer relationship all the radio engineering and production activities." The new director is K. S. Davies, who joined the firm in 1933. He was in charge of the television design section prior to the war. Since the war he has been general manager of the Electronics Division. P. Mc.C. Potter becomes works manager, with R. S. Miller taking his place as production manager. Mr. Potter joined the company in 1931 and Mr. Miller in 1937. Dr. G. David Reynolds, who joined the firm in 1933 and whose main interest has been set testing, is to be Chief Inspector of Television and Domestic Radio.

F. C. Robinson and Partners, Ltd., who specialize in the design and application of electronic control gear, have transferred their departments concerned with development, manufacture and servicing to new premises in Councillor Lane, Cheadle, Cheshire. Correspondence should continue to be sent to 287, Deansgate, Manchester.

Rees Mace Marine, Ltd., the radio marine subsidiary of Pye, Ltd., are now installed in their new factory at Oulton Broad, Lowestoft. The company's sales manager, R. I. T. Falkner, who was a naval communications specialist during the war, has been appointed to the Board.

Manufacturers' Register. — The 1951-52 "F.B.I. Register of British Manufacturers" (the 24th edition), which is published for the Federation of British Industries by Kelly's Directories and Iliffe and Sons, includes a Buyers' Guide listing over 6,000 F.B.I. firms classified under some 5,000 "products and services"; and directories of trade associations, trade names and trade marks. The information in this 882-page directory, which costs two guineas, is classified in English, French and Spanish.

MEETINGS

Institution of Electrical Engineers

Radio Section.—"Two Electronic Resistance or Conductance Meters" by L. B. Turner, M.A., Sc.D., and "A Bridge for the Measurement of the Dielectric Constants of Gases" by W. F. Lovering, M.Sc., and L. Wiltshire, M.Sc., on January 8th. (Joint Meeting with Measurements Section).

"Comparison of Ionospheric Radio Transmission Forecasts with Practical Results" by A. F. Wilkins, O.B.E., M.Sc., and C.M. Minnis, M.Sc., on January 16th.

Discussion on "Should further Television Development be Concentrated on Colour to the Exclusion of Black and White?"; opener, L. C. Jesty, on January 28th.

Education Circle. — Discussion on "Essentials of a First Course in Electricity and Magnetism"; opener, H. Kayser, B.Sc., at 6.0 on January 23rd.

The above meetings will be held at 5.30 (except where otherwise stated) at the I.E.E., Savoy Place, London, W.C.2.

Cambridge Radio Group. — "The Sutton Coldfield Television Broadcasting Station" by P. A. T. Bevan, B.Sc., and H. Page, M.Sc., at 8.15 on January 15th at the Cavendish Laboratory, Cambridge.

North Eastern Radio & Measurements Group.—"The Automatic Monitoring of Broadcast Programmes" by H. B. Rantzen, B.Sc. (Eng.), F. A. Peachey, and C. Gunn-Russell, M.A., at 6.15 on January 7th at King's College, Newcastle-upon-Tyne.

North Midland Centre.—"Crystal Diodes" by R. W. Douglas, B.Sc., and E. G. James, Ph.D., and "Crystal Triodes" by T. R. Scott, B.Sc., at 6.30 on January 8th at the Hotel Metropole, Leeds.

Discussion on "Is the Scope of Electrical Engineering Courses too Narrow?"; opener, R. A. H. Sutcliffe, B.Sc. (Eng.), at 6.0 on January 29th at the Lighting Service Bureau, 24, Aire Street, Leeds.

North-East Scotland Sub-Centre.—Informal Lecture on "The Operation and Maintenance of Television Outside-Broadcast Equipment" by T. H. Bridgewater at 7.30 on January 9th at the Caledonian Hotel, Union Terrace, Aberdeen, and at 7.0 on January 10th at the Royal Hotel, Union Street, Dundee.

South Midland Radio Group.—"Crystal Diodes" by R. W. Douglas, B.Sc., and E. G. James, Ph.D., and "Crystal Triodes" by T. R. Scott, B.Sc., at 6.0 on January 28th at the James Watt Memorial Institute, Great Charles Street, Birmingham.

Rugby Sub-Centre.—"The Use of Saturable Reactors as Discharge Devices for Pulse Generators" by W. S. Melville, B.Sc.(Eng.), at 6.30 on January 16th at the Rugby College of Technology & Arts, Rugby.

Western Centre.—Faraday Lecture on "Sound Recording—Home, Professional, Industrial, and Scientific Applications" by G. F. Dutton, Ph.D., B.Sc.(Eng.), at 6.45 on January 10th at the Sophia Gardens Pavilion, Cardiff.

British Institution of Radio Engineers

London Section.—"Crystal Triodes" by E. G. James, Ph.D., and G.M. Wells, B.A. (G.E.C. Research Laboratories) at 6.30 on January 9th at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

Scottish Section. — "Television Aerials" by G. L. Stephens (Belling & Lee) at 7.0 on January 17th at the Natural Philosophy Department, The University, Drummond Street, Edinburgh.

North Eastern Section.—"Test Gear Design" by A. W. Wray, M.A., at 6.0 on January 9th at Neville Hall, Westgate Road, Newcastle-upon-Tyne.

South Midlands Section.—"Propagation and Reception of Television Signals" by G. L. Stephens (Belling & Lee) at 7.15 on January 15th at the Public Library, Rugby.

British Sound Recording Association

London Section. — Discussion on "Gramophone Motors"; opener, E. Mortimer, at 7.0 on January 18th at the Royal Society of Arts, 6, John Adam Street, London, W.C.2.

Portsmouth Centre.—"The Processing and Pressing of Disc Recordings" by E. B. Pinniger at 7.30 on January 9th at the Central Library, Guildhall Square, Portsmouth.

Television Society

"The Planning and Development of Television Broadcasting Stations" by P. A. T. Bevan, B.Sc., M.I.E.E. (B.B.C.), at 7.0 on January 25th at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

Leicester Centre.—"Valves for Television Receivers" by K. S. Phillips (Edison Swan) at 7.0 on January 7th at the Leicester College of Technology, Room 45, The Newarkes, Leicester.

Institution of Electronics

Southern Branch.—"The Synchrodyne" by D. G. Tucker, D.Sc., A.M.I.E.E. (Royal Naval Scientific Service), at 6.30 on January 16th at Southampton University College.

Institute of Practical Radio Engineers

North Eastern Section.—"Test Instruments," by C. A. Pratt (Avo), at 7.30 on January 17th at the Roma Café, Hindmarsh Square, Heber Street, Newcastle-upon-Tyne, 1.

NEWS FROM THE CLUBS

Edinburgh.—A wide range of subjects is included in the current programme of the Lothians Radio Society, which meets on alternate Thursdays at 7.30 at 25, Charlotte Square. The January meetings will be held on the 17th and 31st. Sec.: J. Mackenzie, 41, Easter Drylaw Drive, Edinburgh, 4.

Exeter.—January meetings of the Exeter Radio & Television Club include a talk and demonstration on the detector (10th), a competition for home-constructed gear (17th) and a talk on the uses of vectors and the "j" operator in practical radio (31st). Meetings are held at 7.30 at the Exeter Hobbies Association Hut, Haldon Road. Sec.: L. R. Jenkin, 16, South Avenue, Exeter.

Manchester.—A demonstration of home-constructed television equipment will be given to members of the South Manchester Radio Club at their meeting on January 4th. Meetings are held on alternate Fridays at 7.30 at the Tatton Arms, Northenden. Sec.: F. H. Hudson, 21, Ashbourne Road, Stretford, Manchester.

Worthing.—Meetings of the Worthing & District Amateur Radio Club are held on the second Monday of each month at the Adult Education Centre, Union Place. The Mullard film-strip on valves will be shown at 7.30 on January 14th. Sec.: F. H. Betterley, 42, Anweir Avenue, Lancing, Sussex.

Radio Control.—January meetings of three of the groups of the International Radio Controlled Models Society have been received from the secretary, C. H. Lindsey, VI, 3rd Court, Christ's College, Cambridge. The Birmingham Group will meet at 2.30 on January 5th at the International Centre, 83, Suffolk Street, Birmingham, when there will be a talk on the development of a 27-Mc/s crystal-controlled transmitter. The London Group meets at 2.0 on January 13th at the Horseshoe Hotel, Tottenham Court Road, W.C.1. At the meeting of the Tyneside Group at 7.0 on January 26th at 176, Westgate Road, Newcastle-upon-Tyne, members will discuss transmitter and receiver circuits.

SERVO-MECHANISMS

A Simple Approach from First Principles

By P. L. TAYLOR,* M.A.

MANY people are aware that there is a large and growing class of automatic controlling and regulating devices, developed over the past few decades, which promises to revolutionize our ideas of how accurately machines and processes can be controlled. Such devices perform diverse functions—for example, the automatic piloting of an aircraft, gunlaying aboard ship, the milling to shape of hard metal from a wooden master pattern, or keeping a telescope trained on a star. Nevertheless, there is such a strong family resemblance in the mode of operation that they are all called servo-mechanisms, or "servos" for short. Unfortunately, anyone who would like to know more about how they work and what their characteristics are is rather poorly served by the available literature, which tends to be very mathematical. This is a pity because, although complicated systems naturally demand complicated mathematical treatment, the fundamental principles involved are in reality quite simple. Indeed, many of them are already familiar to the radio engineer.

To answer the question, "What is a servo-mechanism?" it is perhaps best to consider first why servos have been developed at all. Since the discovery of the power of steam, and its harnessing in the industrial revolution, man has been enabled by building and controlling machines to perform tasks previously beyond his powers and at the same time to reduce the effort required of him. But it has become increasingly apparent that sometimes he is an imperfect controller of the machines he has created, which inherently are capable of better results than he can produce with them. Hence the replacement of the human operator by an automatic controller, resulting in the servo-mechanism.

This replacement is possible because the task of the controller (human or mechanical) is essentially simple (Fig. 1). The operator has in his mind's eye a picture of the result he desires to achieve, and at the same time can see what is actually happening. His sole function is to compare the two impressions, and so to operate the machine as to reduce the difference between them. He is thus primarily an error-determining device; and the amount of error determines how he causes the machine to release energy from the external source to produce the desired result.

Compare this with a typical simple position-control servo (Fig. 2). Here a load with some inertia (for example, a gun mounting) has to be rotated so that its angle θ_0 corresponds to the angle θ_i of a controlling shaft. The load is driven by a motor, whose torque is controlled in turn by an amplifier. The positions of the input and output shafts are compared, and an error signal ϵ proportional to the difference between them supplies the controlling input to the amplifier. The sense of rotation of the motor is so arranged that it will tend to reduce any error, i.e., to drive the output shaft into alignment with the input shaft.

Thus Figs. 1 and 2 are essentially the same except that the human operator has been replaced by a mechanical or electrical error-measuring device. The similarity is complete if we consider the amplifier/motor system to be simply a machine which produces a torque T on the output shaft equal to K times the error. The higher the gain of the amplifier, the larger is the constant K.

This simple system has all the characteristic parts of a servo-mechanism—an error-determining device comparing the input and output quantities, and controlling through some machine the flow of energy from an external source to a load. In particular, little or no torque is required to turn the input shaft. This is a great advantage where this shaft is turned by some other mechanism—e.g., a predictor—which is capable of only a small power output. It will be seen from Fig. 2 that there is a closed loop or sequence of dependence of the various quantities on each other. This gives rise to the alternative name for a servo-mechanism—that of a "closed-loop control mechanism."

How will such a system behave? This depends not only on the constants of the system, but also on the

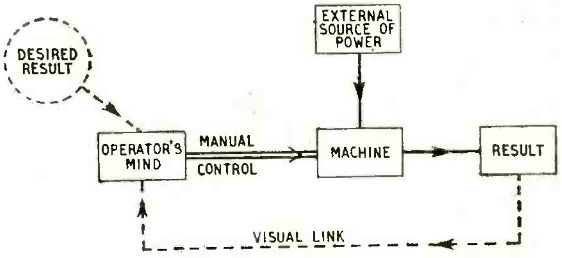


Fig. 1. Functions of a human controller.

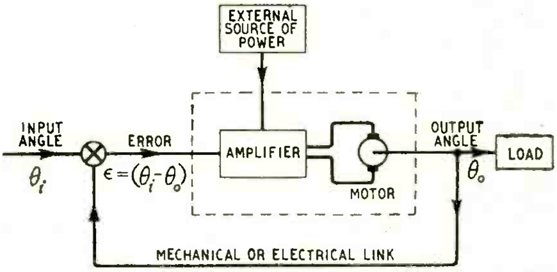


Fig. 2. Simple position-control servo.

*College of Aeronautics, Cranfield.

way in which θ_i varies with time. Thus in servo work it is common to find various types of input variation considered; the choice of the most suitable for a particular purpose depending on the job the servo is to perform. For example, if the load of Fig. 2 is a gun which is to fire at fixed targets, i.e., its bearing is to be changed from one fixed angle to another, then performance may be analysed in terms of the step-function input of Fig. 3 (a). It is assumed that initially the system is at rest, with $\theta_o = \theta_i$, and at *a* θ_i suddenly changes to a new value. θ_o cannot follow immediately due to the inertia of the load. The error therefore increases from zero to θ_i and a large torque is applied to the load. As the load accelerates and θ_o increases, so the error and torque are reduced until at *b* θ_o reaches the required value and they become zero. But by this time the load has acquired considerable kinetic energy and consequently overshoots. The error increases in the opposite sense and a reverse torque is applied which eventually brings the load to rest at *c*, and then accelerates it back again until once more it passes through the required position at *d*. But again it has acquired kinetic energy in the period *c-d* and another overshoot occurs. In the simple system considered this oscillatory behaviour continues indefinitely and the system is therefore unstable and useless. It is said to " hunt."

To find a cure, it is necessary to seek the cause of the instability. This has been hinted at above; it is the time-delay between the application of the signal and the arrival of the load at the required position. During this time there is an error signal due to the closed-loop arrangement, with consequent release

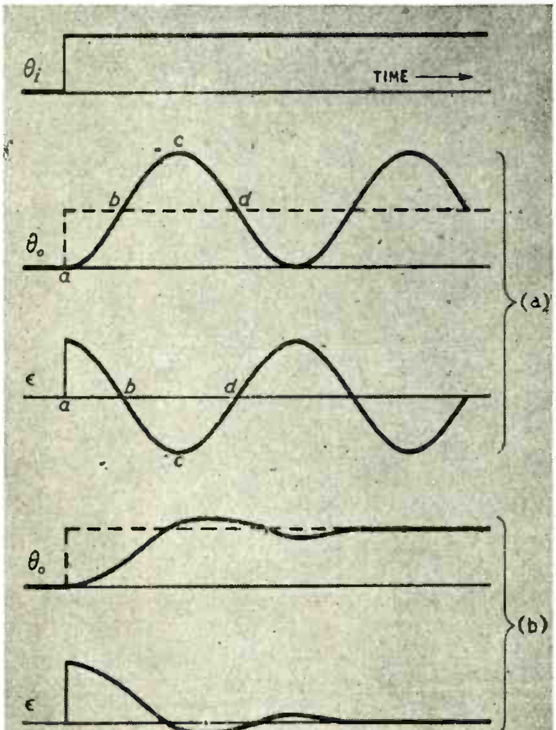
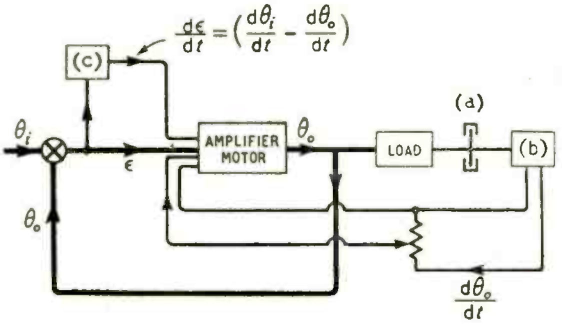


Fig. 3. Response of simple servo of Fig. 2 to a step input (a) without damping (b) with nearly critical damping.

Fig. 4. Alternative methods of stabilization. (a) damping on output shaft, (b) velocity feedback, (c) error-rate feedback.



of energy from the source into the load, and it is this energy which causes the load to overshoot. To stabilize the system, therefore, the energy released must somehow be absorbed—for example, in an eddy-current brake on the output shaft, (a) in Fig. 4, or in the general case by some damping device which will produce a retarding torque proportional to the speed of rotation.

It is worth noting here the inherent tendency to instability exhibited by servo-mechanisms, due to (a) the inevitable time-delay in a practical system in the transmission of signals round the closed loop, and (b) the consequent release of surplus energy into the system. From this follows the fact that a large part of servo work is devoted to minimizing time-delay and hence the surplus energy, or to dissipating it harmlessly once released.

With a suitable amount of damping a response such as that of Fig. 3(b) can be obtained, which would be quite suitable for the application just described. To increase the speed of response, the factor K can be increased, but it is important to note that this will also mean increasing the damping if the same degree of stability is to be maintained. Another factor influencing the choice of K is the effect of an external torque applied to the load; for example, wind loading on the gun turret of a bomber. Such a torque will tend to deflect the load and will ultimately be balanced by an error-torque from the servo. The higher K is made the less will be the error required to produce the balancing torque, i.e., the harder it will be to deflect the load against the restraining action of the servo. K is therefore sometimes known as the " stiffness " of the system.

Velocity Feedback

The above method of damping is wasteful in that any energy drawn from the source is ultimately dissipated as heat in the damping device, which would be a serious matter in a large servo. The question can naturally be asked, is it possible to stabilize the system by some other method which is not wasteful of energy?

A clue to an answer can be found in studying the behaviour of a human controller faced with the same task of rotating a load from one bearing angle to another. On receipt of his instructions (corresponding to the step input of Fig. 3) he will cause the driving motor to apply a torque accelerating the load. The motor will draw the necessary energy from the supply. As the load gathers speed and approaches the required position, the operator anticipates that it will overshoot, and therefore reverses the motor torque. Under this condition the load will be driving the motor—i.e. passing back to it the energy acquired earlier. The motor will therefore be acting as a generator, and the excess energy is returned to the supply instead of being dissipated. If the operator is skilful the result is that the load comes to rest just as it reaches the required position. This is shown in Fig. 5(a).

In the case of the servo this behaviour is imitated by attaching a tachometer generator to the output shaft, (b) in Fig. 4. A voltage is produced proportional to the velocity of this shaft and a suitable fraction of this voltage is fed back to the input of the amplifier in opposition to the error signal—a process known as velocity feedback. The action is shown in Fig. 5(b). Initially the error signal predominates and the load is accelerated. As the load velocity rises and the error falls, the net input to the amplifier drops rapidly and then increases in the opposite sense, so that a decelerating torque is applied to the load before it reaches the required position. In addition to the advantage over a physical damping system of not causing a waste of energy, the velocity feedback method possesses the important practical advantage that the amount of voltage fed back, and hence the damping, can be simply controlled by setting a potentiometer.

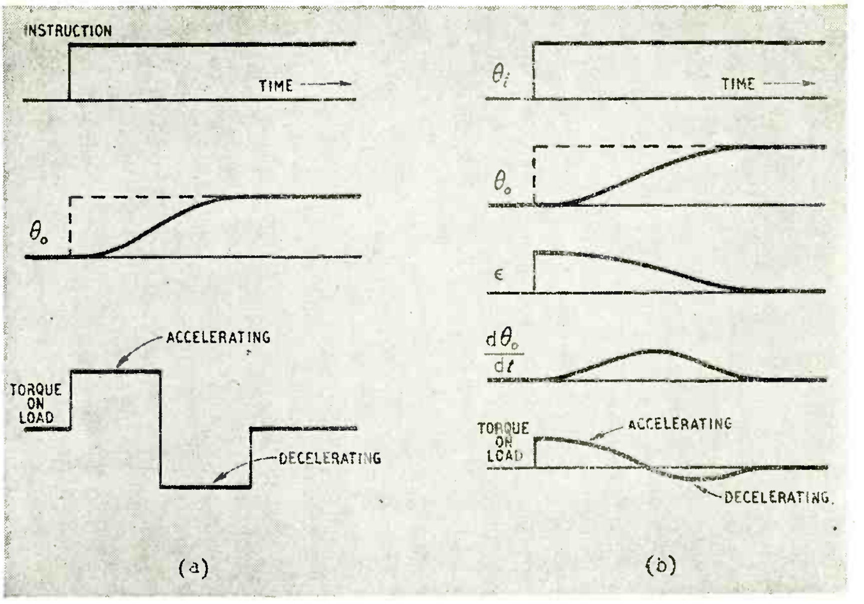


Fig. 5. (a) control by human operator, (b) action of velocity feedback.

Error-Rate Feedback

So far so good. But suppose the servo is required to perform a somewhat more difficult task? For example, suppose the gun is an anti-aircraft gun, which is required to follow a moving target? Behaviour in this case might be investigated in terms of the type of input shown in Fig. 6. This corresponds to the input shaft suddenly being rotated with a constant velocity, i.e. θ_i increasing linearly with time. For a servo with velocity feedback the ultimate result, after any initial transients have had time to die out, is that the output shaft will rotate at the same speed as the input shaft but will lag behind it by some (constant) angle, an effect known as "velocity error." (The term is perhaps a bit misleading as the error is not one of actual velocity—both input and output shafts rotate at the same speed—but is an error of position due to the fact that the shafts are moving.)

It arises in the following way. Since the output shaft is rotating, the tacho-generator will produce a voltage input to the amplifier. On the other hand, since the load is neither being accelerated not decelerated, no torque is required from the motor, i.e. the net input to the amplifier must be zero. This can only be so if there is an error signal (and consequently an error) to compensate for the velocity feedback signal. It follows that the error will be proportional to the speed of the output (and input) shaft.

However, if some other signal proportional to speed can be used to offset the velocity feedback, then the error can be made zero. This might be done by attaching a second tacho-generator to the input shaft and feeding its output into the amplifier. There

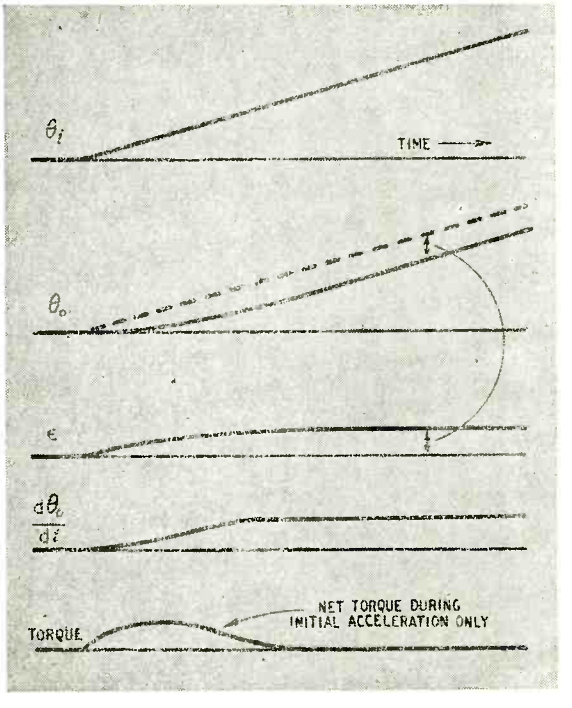


Fig. 6. Showing velocity error in a velocity-feedback stabilized servo.

would then be three signals fed into the amplifier: (a) the error, (b) the velocity feedback signal proportional to $d\theta_0/dt$, and (c) a signal in opposition to this proportional to $d\theta_i/dt$.

In practice a simplification is possible. Since $\epsilon = \theta_i - \theta_0$, then $d\epsilon/dt = d\theta_i/dt - d\theta_0/dt$, so that it is possible to produce both of the signals proportional to velocity, in opposition to each other, by differentiating the error signal. Both tacho-generators can thus be dispensed with, giving "error-rate feedback." This differentiation might be effected, for example, by applying the voltage output of the error-measuring device to a series CR circuit of suitably short time-constant. The voltage appearing across the resistance is then proportional to the differential of the input (i.e. error) voltage.

It is possible to continue this process of considering more complicated performance requirements in terms of different input signals, and discussing methods of eliminating any errors that may arise, but enough has been written to show the general picture, and to explain some of the terms in common use.

Servos as Feedback Amplifiers

The reader will have noticed the strong resemblance between Fig. 2 and the usual block diagram of an amplifier with negative feedback, having a feedback factor of unity. (The most obvious similarity is the possibility of instability. In the case of the feedback amplifier this is usually investigated in terms of a phase-shift round the loop of 180 degrees, but such a phase-shift is, of course, the same as a time-delay of half a cycle.) It follows that the methods that have been developed for feedback amplifier work can be transferred, almost lock, stock and barrel to the servo field. For example, analysis can be conducted in terms of the response to sinusoidal signals rather than to transients such as those mentioned above. This can simplify calculations by permitting the use of the j notation and obviating the necessity of having to solve complicated differential equations. This is possible because the equations of motion of mass, stiffness and damping resistance are the same, with a change of symbols, as those of inductance, the reciprocal of capacitance, and electrical resistance (see Table). One can therefore write down an "equivalent circuit" to represent an arrangement of masses, stiffnesses, etc., and analyse behaviour in terms of this circuit. There is also the practical advantage with sinusoidal signals when it comes to measuring the performance of an actual servo that the oscillations, being continuously repeated, can be studied at leisure, whereas with transient signals and a quick-acting servo it may be necessary to resort to recording first.

Stability can be studied in terms of the Nyquist diagram, and when necessary improved by inserting

TABLE

Electrical Quantity		Mechanical Quantity	
E.M.F.	E	Force	F
Current	I	Velocity	V
Charge	Q	Displacement	S
Capacitance C ; $\frac{1}{C} = \frac{E}{Q}$		Stiffness D ; $D = \frac{F}{S}$	
Inductance L ;		Mass M ;	
$E = L\frac{dI}{dt} = L\frac{d^2Q}{dt^2}$		$F = M\frac{dV}{dt} = M\frac{d^2S}{dt^2}$	
Resistance R ; E = IR		Resistance R ; F = VR	

suitable phase-advancing networks in the loop. (This is the same thing, of course, as reducing the time delay round the loop). There is, however, the disadvantage that it is not easy to obtain the transient response of a system (where this is required, as it usually is with a servo) directly from the frequency response without laborious calculation in terms of Fourier synthesis. The television and radar engineer is familiar with this drawback: he often will design an amplifier in terms of its frequency response because that is the simplest method, whereas its performance in practice is better represented by its response to pulses.

The Human Operator

It was stated above that the human operator has certain characteristics which may limit the performance of any system of which he forms a part. By studying these, two lines of thought are opened up. First, a guide can be obtained as to whether a human operator should be used or not for a particular system; and second, if a human operator must be used, his characteristics can be taken into account in designing the machines he controls so that the best overall result is obtained.

Much work has yet to be done in this field, and results so far obtained can only be expressed generally as there is considerable variation between one person and another. The principle characteristics appear to be these. First, there is an inherent time delay of about 0.2-0.3 second between a stimulus and the operator's response, known as reaction time. This is by no means constant for a particular person, but can vary with the amplitude and nature of the stimulus. Second, the amplitude of the response is not necessarily proportional to that of the stimulus—indeed, for certain type of small stimuli, there may be no response at all. Thirdly, there is the obvious characteristic of fatigue. As the operator tires his reaction-time increases, and in bad cases he may even do the wrong thing in response to a stimulus. Against these obvious drawbacks must be set the facts that an operator is capable of learning and adjusting himself to a particular situation. For a repetitive job, he can offset some of his inherent time delay by anticipation, corresponding to the use of velocity feedback as seen above. With practice he can produce progressively better results, corresponding to an adjustment of the amount of feedback.

It will thus be seen that, other considerations apart, the human operator is unsuitable where a very rapid response is required, or where there is likely to be excessive fatigue. Two examples will suffice to show what can be done by suitable design of the system where a human operator must be used. We have seen above that the possible stiffness of a system is limited by the time delay in the loop. It follows that there is an optimum value of stiffness corresponding to the reaction time of the operator (plus other time delays in the system), and an attempt to give him more precise control by increasing the stiffness will actually lead to instability and a worsening of the overall performance. The second example is that of a radio aid to the navigation of an aircraft, in which the pilot is given a left/right indication on a meter as to how far he is from the required track. If he is to keep to the track accurately the indication must obviously be sensitive, and the performance requirement may be such that this sensitivity corresponds to too great a system stiffness. If, somehow, velocity feedback could be introduced the pilot's performance could be much improved; for instance, by making the meter indication proportional not to error alone, but to a combination of error and the rate at which the track is being approached—a process known as "rate-aiding."

What of the future? Speculation is interesting, though actual prophecy may be dangerous. But following the line of thought suggested earlier, it would seem safe to say that as man designs machines to perform more and more complicated tasks, and at the same time tries to reduce his own physical and mental effort in controlling them, servo-mechanisms will become increasingly important.

Germanium

Recent Progress in its Application to Crystal Valves

By T. H. KINMAN, M.B.E., M.I.E.E.*

THE discovery, about 1948, that a germanium crystal rectifier could be converted into an amplifier, or made to generate oscillations like a thermionic valve, by the addition of a second catswhisker aroused considerable interest and speculation.

The crystal triode was first demonstrated in America, operating radio sets, microphone amplifiers and other electronic equipment from a single dry battery consuming only a few milliamperes. Consequently there was general anticipation that this novel device would soon be made available for use in other electrical apparatus, for example, deaf aids, or for applications where the use of electric power to heat the valve filaments was a serious difficulty.

There were, however, many reasons why these original crystal triodes could not be made to replace the valve. Apart from the difficulty of uniform mass production, their electrical characteristics compared unfavourably with those of valves. In brief, there seemed to be no advantage in using them except for experimental purposes. It was appreciated by those with some knowledge of the subject that further development would be required before serious competition with the valve was possible.

It is interesting to recall that the use of microwaves in radar during the late war[1] stimulated work first in Britain and then in America on semi-conductors, or crystal detectors as they are more generally known, as a means of converting very high frequencies—difficult or impossible to amplify—into lower or intermediate frequencies by the superheterodyne principle, as used in radio and television sets.

Silicon was found to be the most suitable material for this purpose, but although a very efficient frequency converter it was easily damaged or destroyed if electrically overloaded. Consequently, a search was made for a more suitable material, having similar characteristics to silicon as a frequency converter but more electrically robust. Germanium seemed to be the most promising substance to work on. It was soon realized, however, that whilst germanium would withstand relatively heavy electrical overloads without impairment it would not compete with silicon, either as a converter or detector of very high radar frequencies. Fig. 1 illustrates the falling-off in efficiency with frequency of a germanium rectifier, compared with a silicon rectifier at that time. However, other applications were apparent.

Since the rectification efficiency of the germanium crystal was very good over a wider frequency range than other solid-state rectifiers and it was able to withstand higher applied voltages—of the order of 80 volts or more—there was an immediate demand for this rectifier to replace thermionic diodes in many radio and electrical circuits.

In this country The British Thomson-Houston Company started production in 1946, when the only available source of germanium was the United States—where commercial manufacture had started during the war by utilizing residues recovered from zinc and cadmium production. The total estimated yield from this source, however, was not more than 2,000 lb per annum, and its purity was not guaranteed with any certainty. Nevertheless, British and American manufacturers continued to expand their production of germanium rectifiers, although mass production methods could not then easily be applied.

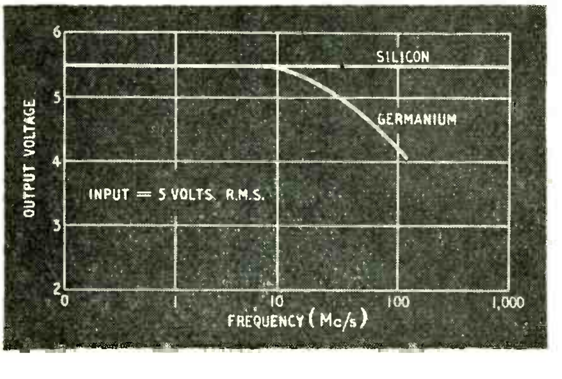
Later, the work of American industrial scientists[2] on the germanium crystal triode led to a better appreciation in Britain of the importance of germanium as a means of producing many revolutionary electronic devices. It was also realized that latent stocks of this valuable material were present in British coal as a by-product.

The initiative taken by the General Electric Company in extracting germanium from the flue dust collected in the chimneys of our gas production plants all over the country and the development of an economic method of extraction by Johnson Matthey & Company has already been described.[3] Equally im-

[1] References at end of article.

* The British Thomson-Houston Company.

Fig. 1. Frequency response curves of typical silicon and germanium crystal rectifiers.



portant was the work of the manufacturer in extracting grosser impurities from the raw material, so that, for example, it could be guaranteed to contain less than 1 part per million of the contaminating arsenic.

The assurance of an abundant home supply of germanium, coupled with a defined standard of purity, encouraged British manufacturers to organize their production of germanium devices, especially diodes, on a much larger scale, approaching the mass-production technique common in the manufacture of valves. Fig. 2 shows the cross-section of a germanium crystal diode moulded in a thermo-setting plastic material.

In the meantime, industrial scientists in America had been working hard to eliminate the injurious impurities from the metallic germanium—using the progressive solidification technique, well-known to metallurgists. In this process impurities present in the crystal lattice are driven towards the molten end of an ingot as recrystallization takes place; the impure end of the ingot is then cut off. The process may be be repeated many times to obtain the highest possible purity, judged by the resistivity of the metal.

A much more important and revolutionary development has since been reported.[4] Instead of processing the surface of the germanium, where the normal rectification phenomenon is observed, rectifying barriers can now be produced *inside* the metal, thus dispensing with the somewhat haphazard surface contact with a catswhisker. With this internal barrier, or p-n junction as it is called, end wires can be soldered solidly on

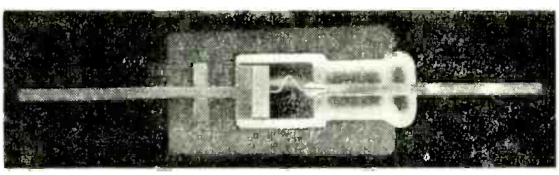
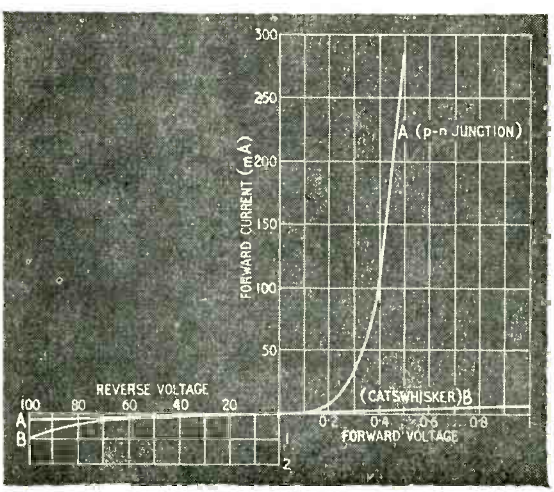


Fig. 2. Cross-section of a germanium crystal rectifier moulded in thermo-setting plastic.

Fig. 3. Static characteristics of (A) B.T-H. experimental p-n junction germanium diode and (B) typical commercial germanium diode with catswhisker. (Different scales are used for forward and reverse voltage and current).



to the plated surface of the metal for connection to the electrical circuit, thus providing a much better mechanical job than is possible with a surface-contact diode or triode.

The theory of rectification and transistor performance with p-n junctions has been described in many technical articles and publications,[5] but it many not be generally know that to make these new devices a new technique is required for the production of the germanium metal. It must be intrinsically pure and in the form of a single crystal, as distinct from the polycrystalline material used for the earlier types of diodes and triodes with catswhiskers. Thus, the purification and production of single-crystal material is in itself a most important advance in the art of crystal manufacture, and is likely to be adopted in all future production—whether for p-n junction devices or for the surface-contact rectifier or triode.

The p-n junction diode or p-n-p junction triode is found to be much more efficient than the surface-contact type. The power handling capacity of the catswhisker-type diode, for example, is seriously limited because of the small contact area, usually not more than about 0.0005 sq. in. On the other hand the p-n junction area may perhaps be as large as 0.1 sq. in, depending on the particular application, i.e., whether for low or high power service. It is also claimed that p-n barrier type diodes and triodes generate much less internal noise than surface-contact types, although the reason for this is not yet fully understood. Fig. 3 illustrates the improved d.c. static characteristic of an experimental p-n junction type germanium diode made in the B.T-H. Research Laboratory. For comparison, the d.c. characteristic of an average point-contact germanium crystal diode is also shown.

There seems no doubt that an important turning point has been reached in the understanding and better use of this hitherto rare element, germanium.

If the production of p-n junction devices can readily be translated from the laboratory to the factory, we may look forward to a new era in electronics: small and robust diodes and triodes to replace valves with great reduction in power consumption and better electrical efficiencies and longer lives. Some limitations, however, must be expected. For example, germanium, in common with all semi-conductors, is sensitive to temperature changes; its characteristic changes rapidly above some critical temperature—usually over 100 deg C. Nevertheless, the number of useful applications justifies an intense effort being made in this country to exploit to the full our natural resources of the material.

With the present limited demand, British germanium production is not much more than about 1,000 lb of metal per annum. The mass production of these new crystal valves, however, might easily require the stepping-up of our production several hundred times, not only for home consumption but for export—especially to America.

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ENERGY

—Not Something Theoretical but the Real Stuff of Electricity

says "CATHODE RAY"

MOST people, no doubt, think energy is the thing they haven't much of on Monday mornings. And certainly that idea fits quite well into the usual scientific textbook definition of energy as "capacity for doing work." But then "work" in this definition has a special and limited meaning, which may or may not include what we do for a living. Of course anybody who has had to study the science of engineering is familiar with the special meanings of "work" and "energy." But just now I have in mind the many *Wireless World* readers whose knowledge of electricity is practical rather than academic. They feel quite at home with volts and amps, but if they have thought at all about electrical energy they may look on it as something rather theoretical. If so, they will be surprised when I say that energy is the real stuff, and volts and amps are of secondary importance.

But surely, if there is anything about electricity that is on a strictly practical basis it is the amount charged on the bill. If we were to treat that as of merely theoretical interest, the local Electricity Board would soon disillusion us. We are charged for so many units at so much per unit. Units of what? Not of pressure. Volts are not priced at so much each. Nor of current. My account says current, but in that respect at least it is wrong. Otherwise a step-down transformer would raise the value of the electricity supply by stepping up the current. What about power—watts? True, "watts = volts × amps," which rules out the transformer effect; what is gained in amps is lost in volts. But a person who used 1,000 watts for a few minutes each day would not be charged ten times as much as one who used 100 watts day and night. Time must be taken into account. The units of electricity bills are in fact kilowatt-hours. That happens to be a convenient size for commercial transactions. But clearly it is not one of the set of units that includes the volt, the amp, and the watt. For one thing, the "kilo" introduces a thousand-fold multiplication. And then the hour is not the basic unit of time. Whether one embraces the new m.k.s. series of units, or sticks to the old c.g.s., there is no doubt about time being reckoned in seconds. So the practical or absolute unit of what one pays for—energy—is the volt-amp-sec or watt-sec and is called the joule, a name that may not even ever have been heard of by many whose trade is in volts and watts. Obviously one "unit" of commerce equals $1000 \times 60 \times 60 = 3.6$ million joules, so joules are very cheap (Ha-ha!).

Energy in Various Guises

I hope that by now I have convinced everybody who needed to be convinced that energy is the real stuff. Like food. The advertisements may have a lot to say about the flavour, colour, aroma, etc. of food, but these qualities alone would not sustain one for long. And the voltage at which electrical energy is delivered may be important, but not so important as the energy itself. As a matter of fact the analogy between food and electricity is closer than one might think. The energy value of food, as every newspaper reader knows nowadays, is measured in calories (strictly, kilocalories). It could easily be measured in joules, or even kilowatt-hours, because one kilocalorie equals 4,184 joules. So the 3,000 or so needed to keep a person going for a day is the equivalent of $3\frac{1}{2}$ kilowatt-hours, purchasable in most areas for about fourpence. It would save a great deal of trouble and expense if instead of having to eat we could plug ourselves into the mains overnight, during the off-peak period. Perhaps, however, not; I have just reckoned that even if spread over eight hours it would create such a load that the resulting power cuts would cause mass starvation.

But although the human body is not constructed to receive its intake of energy in electrical form, an important thing about energy is that it does exist in various forms—electrical, thermal, magnetic, mechanical, chemical—and there is a fixed "rate of exchange" between them all, so that it is possible to measure all in the same units. For instance, the electrical energy received by a resistor is directly converted into heat energy, and each joule of electrical energy always creates the same amount of heat. So heat can be measured in joules too. And so can the energy of motion possessed by a flying bullet or the magnetic energy stored in a field core. This fixed rate of exchange means that the total energy of all kinds in the universe can neither be increased nor decreased; all that can be done is to vary the distribution among the different kinds. This observed fact is called the Law of Conservation of Energy.

Mass and Energy

Until recently there was what seemed to be an entirely separate Law of Conservation of Mass, which said that the amount of material stuff in the universe was also fixed. You couldn't reduce the amount by burning or any other process; you merely changed it into an equal amount of carbon dioxide and water vapour, or whatever it might be. It is now known that these two laws are really one; there is rate of exchange not only between different kinds of energy but also between energy and mass, these two being just different forms of the same thing.* An atomic explosion differs from ordinary kinds in that some of the explosive not only disappears from view but is completely annihilated, being directly converted into a large amount of energy. But this process is not yet one that can fittingly be employed in the homes of even *Wireless World* readers, so as far as we are concerned conservation of energy holds.

However, those who still find it rather difficult to

* The basic equation is $E = c^2m$, where E is energy, m is mass, and c is the velocity of light, all in c.g.s. units. So the energy value of one gram is no less than 90,000,000,000,000 joules, or 25,000,000 kilowatt-hours.

grasp the idea of energy as a definite commodity, worth so much money per unit, may find it useful to remember that it is so closely related to mass. Mass, by the way, is reckoned for most practical purposes as weight but of course it is more fundamental than that because the weight of a thing depends on where it is—in outer space it is almost nil—whereas its mass is constant.

One difficulty about energy is the way the word is commonly used. If we found a friend pushing a lawnmower at high speed, we might remark "What energy!" But in the scientific sense of words it would be more accurate to say "What power!" For power is the rate at which energy is expanded. If our friend's effort were short-lived, his energy would in fact be smaller than that of a less spectacular worker who kept going until the job was finished.

Gas—Another Viewpoint

All this may seem to be getting far away from radio. But it is, as the French are supposed to say, *reculer pour mieux sauter*—stepping back to get a better jump. Most people find it difficult or even impossible to think about such things as electrical energy without some sort of analogy. And as mass is not only the basis on which most materials are sold, and at the same time is scientifically a disguised form of energy, it makes a suitable analogy. This is particularly so of such a thing as gas. Even though we cannot actually see it, we know it comes through pipes, and we can smell it, feel its pressure, measure its volume, and if necessary weigh it. The amount of gas (of a given composition) we receive, in terms of the heat or power it can give, is not its volume, nor its pressure. If it were delivered in high-pressure steel cylinders instead of through a gas main, the volume could be much less. Actually, given constant temperature, the amount could be measured in units of volume × pressure. But, you may say, surely the household gas meter measures only its volume, in cubic feet? Quite so; but this is allowable because gas is always delivered to the home at atmospheric pressure plus about one per cent, and for this purpose it is assumed that the variations above and below atmospheric pressure (and temperature) cancel out. The electrical people might assume that their pressure was, on the average, constant too, and install meters taking account of current and time only, but fortunately for us in these days, when the variations are always downward, they don't.

The reckoning of gas supply could be further elaborated into pressure, volume per unit of time, and time. The point in doing so is that volume per unit of time (say cubic feet per hour) is the analogue of electric current, which is the *rate* at which electricity flows, not the quantity that flows. And so we have the following comparison, in which I have also listed some possible units:

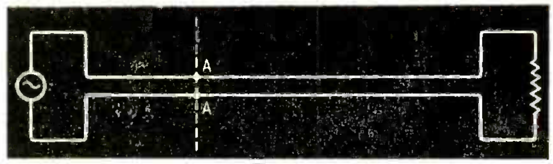


Fig. 1. The dotted line marks any chosen boundary at some stage along a feeder joining a generator to a load. The energy leaving one side of the boundary must always equal that entering the other side.

(Just in case somebody coming fresh from last month's issue cannot resist calculating the dimensions of the rather complicated final unit of gas and finds the result is not mass, I would remind him that there is the hidden assumption of constant temperature.)

I hope that by now energy has lost a little of its abstractness and can be clearly visualized as the most practical measure of electricity. If so, I will go on to suggest that it is helpful to do so, not only in commercial transactions with the B.E.A., but also in studying communication circuits and transmission lines. Such studies are apt to be carried out in an atmosphere of abstract mathematics, or, failing that, not at all. But if one hangs on firmly to the idea that energy is something definite, sold at a penny a unit, a mental picture may emerge from the mists.

To take an example; when gas is delivered through a pipe, there is no difficulty in grasping the fact that the supply has first to occupy the pipe before it can be received at the far end. The greater the pressure of the delivered gas supply, the greater the amount of gas needed to fill the pipe. Something of the same kind happens when goods are first released by the manufacturers; it takes time to fill the "pipe-line" of distribution before they are generally available. So it is not surprising if corresponding conditions apply to electrical transmission. If one starts to push electrical energy into one end of a line it first has to fill the line before any can be delivered at the far end. And the greater the delivered pressure—voltage—the greater the amount of energy *en route*. The same applies when signals are radiated through space, with no line. And although electrical energy travels at such a high speed that the delay is hardly noticeable, the "pipe-line" effect may be important even in such things as amplifier circuits. So the subject really is up our street after all.

If you have been thinking about the line you may well ask how electrical energy can exist while it is in transit along it. Fig. 1 represents a line joining a generator to a load, and for the sake of argument we can assume the resistance of the line itself is negligible. If an imaginary partition is erected anywhere, say at AA, it is easy to see that multiplying the voltage across

Gas	Electricity
Pressure—lb per square inch	E.m.f.—volts
Rate of flow—cu. feet per hour	Current—amps (= coulombs per sec)
Time—hours	Time—seconds
Useful amount delivered = mass—lb/sq. in × cu. ft/hr × hours	Useful amount delivered = energy—volt-amp-secs = joules

AA by the current flowing through the wires gives the rate of energy flow from one side of the partition to the other. But with zero line resistance there is no voltage drop actually along the line itself, so one might think that as current multiplied by zero voltage equals nil there is no energy in existence along it.

This consideration applies equally to d.c. and a.c., but so as not to make things unnecessarily difficult let us say d.c. The current flowing along the line sets up a magnetic field. And here, of course, one runs into the question of what exactly is a field. I am not going to attempt to answer that question rigorously, but seeing we have been using a material analogy, it is perhaps fair to liken the energy stored in a magnetic field to the energy stored in any material substance set in motion (i.e. kinetic energy). The energy stored in a railway wagon when the shunting engine sets it in motion is capable of carrying it quite a distance against frictional opposition. The gas flowing along the pipe, even, has some kinetic energy, but since this is not the kind of energy that gas is actually supplied for, you had better not press that part of the analogy too far.

The line is, in effect, a coil having one turn; and although the coming and going wires are close together, so that the magnetic fields set up by the currents in them tend to cancel out, there is bound to be some field so long as the wires do not completely coincide. It is not very simple to demonstrate the storage of energy in a line, but if a heavy current is passed through a large iron-cored coil, and the coil is suddenly open-circuited the stored energy tends to keep the current flowing, and there is a formidable flash. If the resistance of the coil were negligible and there were no such thing as a magnetic field, then no appreciable voltage could be set up between its terminals by any amount of current, so no energy could enter into it. But, as can easily be demonstrated, when the current is switched on there is, for a few moments, a considerable back-voltage, and it is the product of the supply voltage needed to overcome it, and the current, and the time taken to establish the current, that is a measure of the energy stored in the magnetic field; and it is this energy that is suddenly released when the coil circuit is broken.

The same applies on a smaller scale to the line; before a current can be established in it from end to end, a certain amount of energy must be devoted to setting up a magnetic field around the wires.

Storage in an Electric Field

But that is not all the pipe-line storage. Any difference of potential between two points sets up an electric field in the space between the points. Just as a certain voltage is needed to set a current going (even when there is no resistance) because of the back-voltage induced by the magnetic field, so a certain current is needed (over and above that supplied to the load) to establish a p.d. anywhere. This is the capacitive or charging current. So even if the load terminals of the line were open-circuited, some current would have to flow temporarily into the line in order to establish the generator voltage across it from end to end. This storage of energy can be demonstrated by charging a large capacitor to a high voltage and then (after having disconnected the charging source) short-circuiting it. Again there is a formidable flash. The mechanical analogue is the motionless energy called potential energy which internal pressure creates in a balloon by distending it, or can be stored by compressing a spring or raising a weight. The energy due to the line voltage is stored in the space between the wires as an electric field.

So we find that none of the energy travelling along a resistanceless line exists in the wires themselves; it is entirely in the space around. This may surprise some people. But it surely makes it easier to visualize how energy can travel from place to place without a line at all, as in radio transmission.

It is only when a line or circuit has some resistance (as, of course, it always does) that electromagnetic energy enters into it from the surrounding space. It is then converted into heat energy.

If the d.c. generator is replaced by a high-frequency alternator, each cycle pushes a definite wad of energy into the line, and these wads travel along it. When the wires are close together, so that the capacitance is large and the inductance small, a given voltage requires a relatively large amount of current to recharge the capacitance in opposite polarity each cycle; and a large ratio of current to voltage means a low impedance. Provided that the load resistance matches this, all the energy will be absorbed by it and converted into heat; but if not, some of it is bound to return, and it is the resultant of the energy travelling in both directions at once that sets up standing waves along the line. But that is another story.*

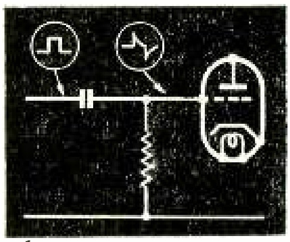


Fig. 2. Example of a circuit in which the intended result is modified by the energy demands of capacitance and inductance.

While it is easy to see that there must be pipe-line energy along a transmission line, it may not always be realized that the same effect can be important in quite concentrated circuits. Even the shortest length of wire needs some charging current to establish a voltage across it, and current flowing through it sets up some magnetic field and so generates an opposing voltage. The delay caused by having to fill up a "pipe-line" consisting of a lead to a valve grid may be perhaps one hundred-millionth of a second, which can be neglected at audio or low radio frequencies, but alters the whole behaviour of the system at television frequencies, because by the time one cycle has been completed at the input it is only part-way at the output. So if, perhaps, negative feedback is attempted, at very high frequencies it may be veering towards positive feedback, with undesired results. In other words, the brief fill-up delay causes a serious phase-shift.

Fig. 2 is an example—a "differentiating circuit" for converting square waves into peaks, as shown by the little waveform diagrams attached. Ideally the waveform reaching the input of the valve has a perfectly vertical front—or at least as vertical as the original square wave—because a series capacitance communicates an applied potiential difference instantaneously. But if one is attempting a really steep front one must not overlook the fact that the grid of the valve is a

* "Standing Waves on R.F. Cables." August, 1950.

small capacitor, and this has to be filled up with energy before the wave voltage can be established.

At v.h.f., too, the wires connecting the valve electrodes to the pins have appreciable inductance, and the energy taken in by the magnetic field may have a very profound effect on the working of the valve.

Audio frequencies are low enough for these undesirable effects in the circuits to be be avoided unless one is very careless, but it is not so when the electrical energy is transformed into mechanical energy in the loud speaker. If it were possible to make a diaphragm having rigidity without mass all would be well; or nearly all, anyway. The vibrations applied at the centre of the diaphragm would affect all parts of it at once, so the whole would be in phase. But, as things are, quite a lot of kinetic energy has to be imparted to the cone before it will all move, and by the time it has been "filled up" the drive has begun the next cycle. So the outer parts lag behind or may even be moving in direct opposition to the centre, and things become very complicated.

Electrical filters, of course, are essentially energy traps. As far as possible they are made without resistance, so clearly they are not intended to waste energy in themselves. The idea is to pass energy at some frequencies freely and throw back energy at other frequencies, somewhat as a coffee filter lets the liquid through and holds back the grounds.

Every impedance (in the widest possible sense of the term) can be expressed as a resistance plus a reactance. Both resistance and reactance can be either positive or negative. An impedance which consists of a positive resistance (+R) is one which takes in electrical energy and does not give it back. If it is a resistance in the narrow sense, the energy goes as heat. In the broader sense of resistance it may go as radiation or iron-core losses or mechanical energy developed by a motor. A negative resistance (−R) is one that gives back energy without taking it away; for example, an amplifier with positive feedback. It is capable of setting up oscillation in a positive resistance connected to it; in other words, it gives energy in the form of a.c. Reactance is the kind of impedance that accepts energy as a short-term loan, but hands it back in its original form at the first opportunity. A spring has mechanical reactance, because if you feed it with energy by pushing or pulling, it hands you back the energy as a counter push or pull. "Positive" and "negative" applied to reactance do not signify the same thing as when applied to resistance. They are an arbitrary means of distinguishing between energy stored in a magnetic field—inductive reactance, +X—and energy stored in an electric field—capacitive reactance, −X.

So we see, then, that the four kinds of impedance, +R, −R, +X, and −X, indicate what is happening to the electrical energy. Most impedances—strictly speaking, all impedances—include both resistance and reactance, so that when energy is flowing there is a permanent transfer to or fro combined with a cycle-by-cycle exchange to *and* fro.

Tying Up the Ends

I hope I have made quite clear the oft-confused distinction between energy and power. For example, if a capacitor is charged very slowly the power employed is very small. But if it goes on a long time the total energy may be considerable, because energy is power × time. Now if the capacitor is discharged suddenly, the power of the discharge may be enormous compared with the charge. This does not mean that the capacitor is giving us something for nothing; the *energy* given back can be no more than that put in. The different rates of charge and discharge are quite incidental beside the great principle of conservation of energy.

There is just one other thing that sometimes confuses; *work*. If energy is capacity for doing work, then work can be—and is—measured in the same units. Work can be regarded as the effect produced by energy. They are just two aspects of the same thing, much as a punch on the nose is one thing with two aspects. The "work" aspect is the ruin of the victim's face; the "energy" aspect is the effort put forth by the aggressor. In electrical circuits, energy is associated with e.m.f.; work with p.d. We went into the distinction between those in the December, 1950, issue.

Let me finish by summarizing the advantages of thinking in terms of energy:

(1) Voltage can be traded for current or time—these factors are often stepped up or down merely as a matter of convenience; the one thing for which there is always an exact balance-sheet of "in" and "out" or "before" and "after" is energy.

(2) In terms of energy one can follow a transaction beyond the confines of the electrical circuit, without even needing to change the unit of measurement.

(3) Because energy includes the time factor, and time is the inverse of frequency, the differences in performance at different frequencies largely explain themselves.

NEW BOOKS

"Foundations of Wireless."—Having now reached its fifth edition, this book can justly be described as a classic of radio literature; since 1936, when it was first published, many thousands of readers have gained their first knowledge of fundamental radio principles from its pages. The author, M. G. Scroggie, is already well known for his lucid, easy-to-read style, but in this completely rewritten version his powers of exposition show to even greater advantage. He takes care to start with a general view of transmission and reception, to give the reader something really "radio" to get his teeth into, then reverts to fundamental electrical notions and works his way up through a.c. theory, tuned circuits and valves to the subject of oscillation. This provides a good basis for the following detailed chapters on transmission and reception, which include one on aerials and another on audio-frequency circuits. Finally come power supplies, cathode-ray tubes and transmission lines, and some useful appendices.

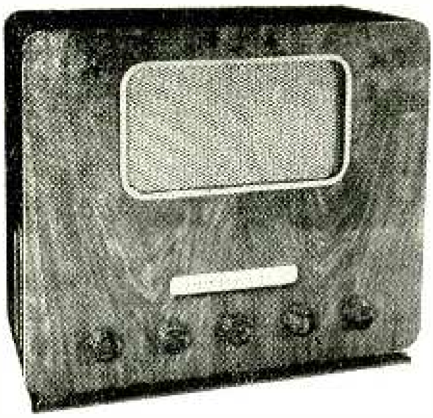
A feature of special interest to the beginner is the introductory section explaining the use of algebraic symbols, graphs and circuit diagrams—what the author calls the "shorthand" of wireless.

"Foundations of Wireless," published for *Wireless World*, is available from all booksellers, price 12s 6d, or direct from our Publishers at 13s 2d.

"Advanced Theory of Waveguides."—This new book by L. Lewin, also from our Publishers, is sponsored by our sister journal *Wireless Engineer*. It requires a knowledge of advanced mathematics and assumes that the reader is already familiar with the essentials of waveguide theory and practice. Topics and problems selected for discussion are representative of the general field in which the waveguide engineer is now engaged. The price of the book is 30s (postage 7d).

A.M.-F.M. COMPARATOR

Receiver Designed for Subjective Comparison of the Two Systems



Front view of the Ambassador Comparator A.M./F.M. receiver.

WHEN the B.B.C. decided to carry out tests for comparing the relative merits of the f.m. and a.m. systems of modulation for v.h.f. broadcatsing, it was realized that for a true comparison a special receiver would be required.

A performance specification was accordingly prepared and R. N. Fitton, Ltd., makers of Ambassador sets, undertook the design and production of the receivers. Some of the requirements in the specification were extremely exacting; it is not proposed to enumerate them here as they were given in a paper by F. H. Beaumont, read at the 1951 Radio Convention held by the British Institution of Radio Engineers, and to be published in the institution's *Journal.*

Admittedly this receiver is very specialized but it includes a number of circuit features which might, with advantage, be embodied in a f.m. receiver when a better-than-usual performance is desired. There are also a few interesting a.m. circuit details.

Before dealing with these a brief description of the Ambassador Comparator A.M./F.M. Receiver, as it is called, might be of some interest. In order to ensure a true comparison, be it of modulation systems or anything else, as much as possible of the equipment should be employed for all the tests.

In an a.m.-f.m. receiver it is possible to make a very large part of the set common to both systems, although it may happen that in some cases the actual arrangement might not be the one that would normally be employed. For example, with ± 75kc/s deviation in the f.m. transmission the receiver's bandwidth has to be considerably wider than would be needed for an a.m. transmission of comparable fidelity. There is, however, no very serious objection to using a bandwidth wider, than necessary for a.m. provided the signal-noise ratio does not exceed a pre-determined value. That has been looked after in the specification of this receiver.

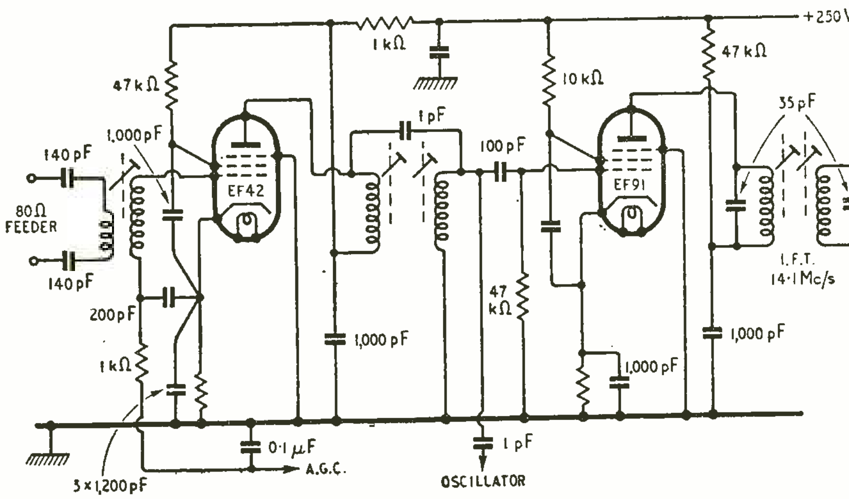
The general circuit arrangement consists of one broad-band r.f. amplifier, separate mixer and oscillator, a.f.c. stage, three i.f. amplifiers centred on 14.1 Mc/s, a.g.c. diode (a.m.), two limiters (f.m.), impulse noise limiter (a.m.), a.f. amplifier and output stage. Two full-wave rectifiers are used in the h.t. supply unit. With the exception of the output valve all are miniature all-glass types.

For the discriminator the well-known Foster-Seeley circuit was chosen. This choice was greatly influenced by the fact that a carrier-generated d.c. voltage is available for automatic control of the oscillator frequency.

Although the tuning range specified was 87.5 to 95 Mc/s it was felt that this could be covered in the r.f. stage by wideband couplings, so avoiding the complications of ganging. An r.f. pentode, the Mullard EF42, is used with a single tuned circuit on the input side and an inductively coupled pair, assisted by a little top-end capacitance, on the output. Provision is made for use of a balanced aerial feeder, not a coaxial, and each lead is joined to the grid circuit coupling coil through a 140-pF capacitor.

In the r.f. stage the de-coupling capacitors consist of several miniature ceramics joined in parallel in preference to a single capacitor of larger physical size. For example, the cathode resistor by-pass capacitor consists of several miniatures totalling about 4,000 pF, a value larger than would be thought necessary, but which has been found to give an improvement in the spurious response ratio. By connecting one of the cathode by-pass capacitors to a point on the bias resistor lead slightly displaced from the others, a broadly tuned rejector circuit effective over the image frequency band is obtained, but it is an arrangement that may not always be satisfactory. The r.f. part of the circuit together with the mixer valve, is shown in Fig. 1.

Fig. 1. R.F. and mixer stages of the Ambassador A.M./F.M. Comparator receiver.



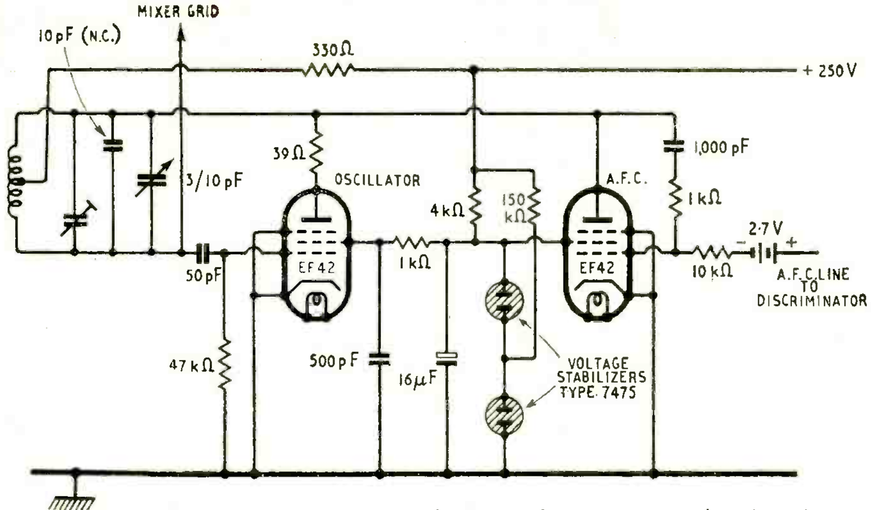


Fig. 2. A separate oscillator is used with an a.f.c. stage, arranged as shown here.

A Colpitts is used for the local oscillator, the only unusual feature being that the valve is a pentode and not the customary triode. The oscillator is placed on the high-frequency side of the carrier and covers 101.5 to 109 Mc/s, it was felt that interference from image signal responses would be less troublesome from the higher image signal band of 115.5 to 123 Mc/s than from the lower one of 59.5 to 67 Mc/s.

Apart from initial frequency drift on warming up any subsequent wandering of the oscillator is corrected, when tuned to a signal, by a reactance valve joined across the oscillator tuned circuit, which behaves as a variable inductance. Control voltage for this valve is derived from the discriminator.

Since control is affected by varying the grid voltage of the reactance valve the inclusion of a cathode resistor for standing grid bias was considered undesirable as it would introduce some degeneration and limit the range of control available. The grid bias is therefore obtained from two mercury-type dry cells in series with the a.f.c. voltage supply line as shown in Fig. 2.

Further measures taken to correct for frequency drift consist of the inclusion of a negative temperature co-efficient capacitor in the oscillator tuned circuit and a stabilized voltage supply to the screen grids of the two EF42 valves.

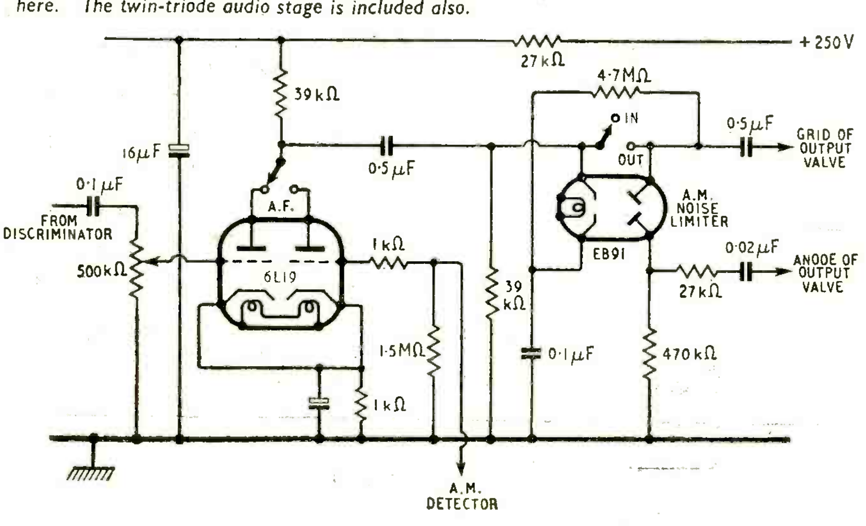
The a.m. impulse noise limiter is the type which follows the modulation and lops off all peaks of noise which exceed the instantaneous modulation level. It was developed by Murphy Radio and consists of a diode inserted in the audio path between a.f. and output valves with the signal applied to the cathode. It is held normally in the conducting state by a positive potential on the anode obtained by rectifying a part of the audio signal at the anode of the output stage.

In order that the anode of the series diode shall follow normal modulation changes it is given a time constant of about 10μ sec, and the positive anode voltage is just sufficient to maintain it conducting at all normal signal amplitudes. When a strong noise pulse arrives the cathode potential rapidly goes very positive, but owing to its lower time constant the anode cannot follow so quickly and the diode opens and signals are cut off from the output valve.

It is convenient to include both diodes in one valve and in this case an EB91 is used, the circuit arrangement being shown in Fig. 3 which includes also the audio amplifier. This stage is a little unusual as it employs separate triodes for the a.m. and f.m. signals, but for convenience they are embodied in one valve. Both anode circuits feed into a common load, which is joined by the a.m.-f.m. changeover switch to one or other as required. This arrangement avoids breakthrough of signals from the unwanted system and enables the audio inputs from the two channels to be adjusted to the same level and overcome the troubles often encountered with switching in the grid circuit.

The total h.t. consumption of the set is about 130 mA at 250 volts and while this could be supplied by a single full-wave rectifier the unusually good audio response achieved in this set, coupled with the use of single output valve, made it desirable to guard against "motor-boating" by providing a separate h.t. supply for the output stage. There are separate rectifiers and smoothing circuits, one supplying all the receiver stages and the other the output valve only. L.T. is provided by a separate filament transformer.

Fig. 3. Principal features of the a.m. noise limiter, which follows the modulation, is shown here. The twin-triode audio stage is included also.

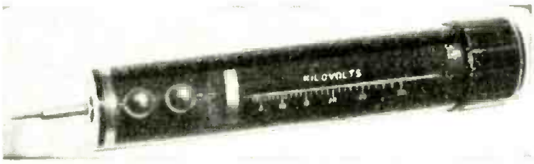


Manufacturers' Products

New Equipment and Accessories for Radio and Electronics

E.H.T. Indicator

A HANDY instrument for measuring e.h.t. voltages on television cathode ray tubes has recently made its appearance. Called the "Kilovolter," it is actually a variable-width calibrated spark-gap enclosed in a tube fitted with test prods. In use, the spark-gap electrodes are screwed together until a flash-over occurs, then the position of the moveable electrode on a scale gives the number of kilovolts necessary to break down that width of gap. The instrument has a range of 3 to 30 kV and can be used on line-flyback, r.f. and pulse e.h.t. systems (a series resistor is necessary in the measurement of mains-derived supplies). It is produced by Waveforms Ltd., 26 Oakleigh Road, New Southgate, London, N.11, at a price of £3 17s 6d.



"Kilovolter" by Waveforms Ltd.

Extension Loudspeaker

NOTABLE for its low price is the new "Bonnie" Bafflette extension loudspeaker produced by Richard Allan Radio Ltd., of Taylor Street, Batley, Yorkshire. Although the loudspeaker itself is only a 5-in model it has quite a high maximum power input—1.5 watts. It is provided with a volume control and is built into a semi-baffle type of cabinet measuring $8\frac{1}{2}$in × $6\frac{3}{4}$in × 3in. The price is £1 19s 6d, with 8s 6d extra if a transformer is required.

Soldering Flux

FOR jobs in which it is preferable to use solid soldering wire rather than resin-cored solder, H. J. Enthoven & Sons Ltd., of 89 Upper Thames Street, London, E.C.4, have brought out a new liquid flux called "Telecene." It consists of high-quality resin dissolved in methylated spirit and contains an activating agent similar to that used in the Superspeed "White Flash" resin-cored solder made by the same firm. The flux is claimed to be particularly effective in mass dip-soldering operations.

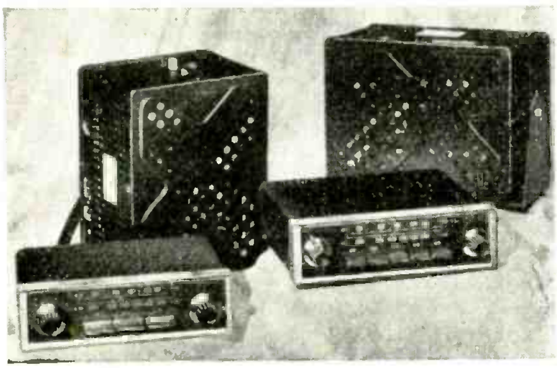
Car Radio Units

H.M.V. car radio receivers are now constructed as a series of units, from which a number of different sets may be assembled. For the home market there are two control units covering medium and long waves and allowing for both free tuning and push-button selection of a limited number of stations.

One control unit (on left in illustration) provides preselection of three stations and just behind it is the smaller of the two amplifiers (Type A). Together these make up a five-valve superhet capable of working one loudspeaker at good volume and quality.

The other control unit gives choice of four medium-wave stations and one long, also free tuning. Behind it is the Type B amplifier and these two form an eight-valve superhet capable of giving sufficient audio power for two loudspeakers. Either control unit can be used with either amplifier.

The eight-valve installation costs £22 12s plus purchase tax of £11 6s. Alternative control units covering medium and short waves are available for overseas markets. The makers are S. Smith and Sons (Radiomobile), Ltd., 179-185, Great Portland Street, London, W.1.



With these four basic units a range of "H.M.V." car radio sets can be assembled for the home market.

RANDOM RADIATIONS

By "DIALLIST"

A.M. Versus *F.M.*

THE B.B.C.'S REPORT on the results of the Wrotham experimental transmissions has come out strongly in support of f.m.'s claim to be the better system for broadcasting on the metre waves. So far as I can see, the comparative tests of a.m. and f.m. were absolutely fair. The transmissions were made simultaneously from the same aerial and with the same output power. The results obtained were judged not only by field and laboratory tests, conducted by engineers, but also by the reports from numerous listeners, many completely non-technical, who had been provided with receiving sets of the same standard design. Frequency modulation was found by far the best against both receiver hiss and motor ignition interference. To provide a first-class service (no interference from 50 per cent of cars passing within 30-60 feet of house; none to give rise to interference that is more than "slightly disturbing") a.m. must have about ten times the field strength of f.m.; f.m. can give a second-class service (interference from 50 per cent of cars no worse than perceptible; from a few cars interference may be disturbing) with a field strength of only 0.25 mV/m. The service area of a 25-kW f.m. transmitter is much the same as that of a 100-kW station working on the medium waves. For a country-wide v.h.f. service four times as many a.m. stations as f.m. would be needed.

No Doubt About It

We may say, then, that f.m. comes out the winner of the contest by a very handsome margin from the engineers' point of view; but that is by no means all. The financial considerations are equally important, and the smaller number of transmitters required means lower initial outlay, reduced running costs and smaller manpower demands. And what of the listener? So far as he is concerned the B.B.C.'s report contains two very considerable surprises. The first is that, though the f.m. receiver may cost a bit more than the a.m., this is very largely offset by the much simpler aerial system needed; an indoor aerial, in fact, will often suffice for f.m. reception where it would be quite inadequate for a.m. We have been led to believe that the f.m. receiver's alignment would require frequent attention by the serviceman and that oscillator creep would play havoc with reception unless expensive precautions were taken against it. Neither of these things was found to occur in practice. The B.B.C. found that ordinary folk had no difficulty in handling their sets and that if there was slight mistuning its effects were no worse than on the medium waves.

A Television Problem

THERE'S A STORY (true, I believe) of a professor who proved conclusively by mathematics of the most advanced kind that it was absolutely impossible for anyone to drive a golf ball more than a certain number of yards. Whereupon, his son picked up a club and a ball, went out on to the near-by links, teed up and drove a beauty a long way further than the calculated limit of possibility. My reason for telling the story is that something of the same kind seems to be going on in television to-day. People who went to the recent television show in Paris are generally agreed that it was a case of 819 lines first and 441 lines nowhere in it. This does not quite fit in with the calculations that most of us have met with in print or made for ourselves; for these appear to show conclusively that 441 lines, or our 405, should provide the domestic viewer with just about as high a degree of definition as his eye can make use of. Are the calculations really in error? I don't think that they are. I gather that what most impressed visitors who saw 819-line and 441-line images appearing simultaneously on screens placed side by side was the absence of lininess in the high-definition system.

Lininess and the Viewer

People differ a great deal in their reactions to imperfections in both aural and visual reproduction. Many folk, for instance, can make themselves more or less unconscious of needle-scratch when listening to a gramophone playing records. Others find the scratch so offensive to the ear that it is impossible for them to listen to any disc recording with genuine pleasure. In the matter of television lininess few are able to disregard the lines when sitting close to the screen. The great majority of viewers find them so trying that they are compelled to move back from the screen, sometimes to such a distance that they find the image ill-defined. Hence my feeling that it was comparative absence of lininess, rather than better definition in the image, that prompted visitors to the Paris television show to plump so overwhelmingly for 819 lines. I am still not convinced that 405-line television could not give us all the definition we wanted, if only it were sufficiently "unliny" to let us sit close enough to the screen to take full advantage of that definition. There are several possible ways out of the difficulty. The most promising that I have seen is spot-wobble and I simply cannot think why more television receiver manufacturers have not incorporated it in their sets. It is not an expensive addition but it does make an immense difference to the pleasure that a viewer can get from his television receiver. With spot-wobble more widely used, I do not think there would be much call in this country for more than 405 lines, particularly when the increased cost of the high-definition receiver is taken into account.

Thermal Fuses

A FRIEND ASKED ME the other day how he could obtain a small amount of some metal suitable for making those thermal fuses about which you have no doubt read in *Wireless World.* Had it been twenty-five years ago, I would have suggested his trying the nearest wireless shop and asking for Wood's metal, which was used a great deal for mounting the crystals of the old catswhisker receivers. I really do not know where you can buy it nowadays, except, possibly, from shops which specialize in laboratory materials. Luckily, though, I was able to find a piece in my junk box and he went away happy. His request set me thinking, with the result that I made up a very satisfactory thermal fuse from odds and ends I had by me. In my young days, such imps of Satan as numbered me amongst them could buy quite elegant teaspoons made of Wood's metal from toyshops. I cannot help feeling a mite sorry for those of the younger generation who have never witnessed the embarrassment of some pompous afternoon tea guest when he or she found, after a stir or two, that nothing but the handle was left of the "silver" spoon.

Fusible Metals

There are quite a number of fusible metal alloys and it occurs to me that some readers may care to try one or two of them for making very low-temperature thermal fuses. The melting temperatures are in brackets. Wood's metal (66°-71°C) is: Bismuth 50%, lead 25%, tin 12½%, cadmium 12½%. Lipowitz made the following alloy (55°-60°C): Bismuth 50%, lead 25%, tin 14%, cadmium 11%. By adding mercury (if you can get it these days!) to Lipowitz's recipe, the melting point may be brought down to as low as 45°C, or 113°F. You can also much reduce the melting temperature of Wood's metal in the same way. All fusible metals reach a pasty state sometime before they actually liquefy. Provided that the spring arm of a thermal fuse is of fairly stiff metal, the contacts fly apart cleanly as soon as the pasty state is reached. When you fix the contacts together it is necessary to use sufficient heat to make the metal run freely. If you don't do this, it will not "wet" the contact points and you will get a typical dry joint.

Iodized Layers

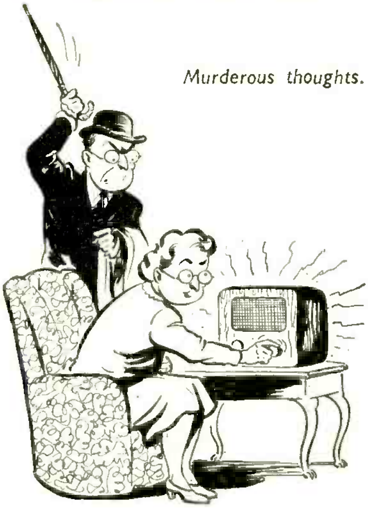
A PERTH READER is kind enough to send me a cutting from a Scots newspaper containing an article on the unsatisfactory conditions for broadcast reception which appear to prevail in the north. It contains some startling new ideas about the behaviour of the Heaviside layer which I feel it is my duty to pass on at once to other readers. First, the said layer consists of iodized air—was the article, perhaps, dictated at a time when its author was suffering frob a code id the dose? The effects of iodization are remarkable, as might well be expected. During the day, it appears, the great height of the layer gives the broadcast signals that reach it heaps of elbow room; but with the approach of darkness it descends and kind of squashes them together, with the result that mutual interference occurs between this station and that. Whereupon Caledonia ceases to be merely stern and gets wild. The writer is nothing if not fair-minded; despite all its faults, he assures us, the B.B.C. is not responsible for iodizing the upper air or for the dire things that happen to Scottish listeners as the result of this awesome photo-chemical reaction.

UNBIASED

By FREE GRID

Old Idea Rehashed

I WONDER if you recollect a pre-war receiver designed to stop women provoking their husbands to homicidal mania with the cacophonic results of their "eccentric" tuning. Some set makers tried to mend matters by incorporating luminous tuning indicators to which, in order to appeal to the psychology of women, they gave such names as "Aladdin's Lamp" and "Magic Eye." But the maker of the set I have in mind showed true genius when he designed a set which, if tuned off centre, pulled itself into correct adjustment electronically.



Murderous thoughts.

Unfortunately, the set is no longer made as it was found to encourage betting among men, because, if it were tuned between two stations, it was a matter of speculation which one would pull it into resonance. But, evidently, one of its designers must be in the U.S.A., as the same broad principle has been applied to something else which can, I think, best be described as an electronic juke box. All you have to do is to whistle or hum a tune at the device and it at once orchestrates and amplifies it and so fills the air with its cacophony.

Where it resembles the woman's receiver is that it takes account of the fact that, just as women can't tune a set correctly, few men can whistle or hum a tune in a manner which does not inspire murderous thoughts in the musically minded. I well recollect, many years ago, inspiring such feelings in one who was normally of a gracious and kindly disposition, as I was, so he said, usually a semi-tone flat. This new make-your-own-music device, as it has been called in some quarters, corrects the flatness or other musical outrage of the whistler or hummer and turns his feeble efforts into a full-throated melody which Caruso himself might envy.

Watts in a Name

MUCH as I like correct nomenclature, I cannot altogether support the protest of a correspondent in a recent issue against the use of the words wattage and amperage as synonyms for power and current respectively. I myself greatly prefer the word "faradage" to the new-fangled "capacitance" which has come into use of late years. Electrical engineers talk glibly enough of a "wattless current"; they do not speak of a "powerless current" which would, I suppose, be the more pedantically accurate term.

No doubt it was a wattless current that the Lord Chief Justice had in mind when, summing-up in a recent case, he told the jury that it was the duty of the Electricity Board to supply the public with "power and current"; at any rate, I cannot see what else he could have meant, although I certainly did not know previously that it was a legal obligation of the Board to supply it.

Radiæsthesia

THERE was a time when *Wireless World* took a pride in the fact that it was a journal "covering every wireless interest" and boldly carried this proud slogan on the cover of every issue. In those days I should have had to look no farther for information on any radio subject no matter how seemingly trifling and insignificant.

To-day, however, although I feel sure that the old spirit of wireless catholicism still hovers over the Editorial desk, the ramparts of radio have become so far flung that quite important matters are, of necessity, denied a hearing. It is for this reason, I think, that we have not had a single authoritative article on the subject of radiæsthesia. Even "Cathode Ray" who, month by month, guides our faltering footsteps up the forbidding slopes of Mount Parnassus, has not turned his all-revealing beam on the subject.

Now many of you will probably ask "what is radiæsthesia?" I must confess that I should very much like to know myself. I have just been wading through a Belgian monthly publication which calls itself *La Radiesthesie Pour Tous*, and in its sub-title informs me that it deals with "Teleradiesthesie" as well. The fact that I am not much the wiser is not necessarily an indication that my knowledge of French does not extend beyond the limits of "Your beer no bon, Mademoiselle"; for no matter how perfect his knowledge of English, a chance visitor from Mars, who had never heard of wireless, would not find a clear definition of it if he picked up an odd copy of *W.W.*

It has been suggested to me that, among other things, radiæsthesia embraces water divining. If that be so, I am entitled to call myself a radiæsthetist, for I have exceptional sensitivity as a dowser. In fact, I have suffered considerable embarrassment at times when seated among my fellow guests at one of those cultural uplift parties given in Chelsea, as my umbrella, which has a hazelwood shaft, often shows signs of violent agitation when the Third Programme is switched on and even turns inside out if the programme be exceptionally "wet."

So far as I can gather, radiæsthesia is a blend of personal d.f. and psychometry in which slotted aerials, such as the B.B.C. uses for f.m., are employed side by side with Kallenberg's Pendulum, used of yore by Madame Estelle and others to determine the sex of unhatched eggs and suchlike things.

To sum up I extend an invitation to any student of this esoteric subject to give a succinct definition of it and a brief account of its *modus operandi.* Provided that it is treated seriously and in a knowledgeable manner, the Editor will, I know, give it the same publicity as he did to a letter during the war which showed how the sun-spots foretold Hitler's downfall.

Unusually wet.