Wireless World

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Television on Parade

THE Institution of Electrical Engineers is to be congratulated on the success of the recent Convention on "The British Contribution to Television." The object was to present the more recent developments against a background of the existing state of the art, and a good deal of time will be needed for digestion of the vast amount of information presented—much of it highly specialized. When all this is issued in permanent printed form, we shall have a most valuable source of information, not only on all aspects of broadcast transmission, distribution and reception, but on subsidiary applications of television techniques. Elsewhere in this issue we describe a few of the detail receiver developments that are of wide interest, and also attempt to present a general picture of the scope of the large number of papers that were presented.

Many who attended the Convention clearly did not expect to find that British television has already acquired an antiquity value. Foreign visitors—and some others—did not know that the Baird 30-line system was in use for some five years in the '30s, and a demonstration, crude as it seemed to modern eyes, was greeted with surprisingly warm and spontaneous applause. Indeed, speculation was even heard as to what might be done nowadays by applying modern electronic practice to such low-definition systems that call for no wider bandwidth than that of a good telephony channel.

But history played a relatively small part at the Convention, which, particularly in the discussions, was distinctly forward-looking. The "perfect" television picture is economically and technically no more practicable than the perfect newspaper illustration, but many of us left the Convention with the feeling that the British 405-line system represents the best compromise for the foreseeable future. But there was no complacency, and it was urged that the new science of Information Theory be invoked to help us to make use of channels of reasonable bandwidth and also to turn such aids as stereoscopy and colour to best account.

We agree with the various suggestions that a parting of the ways is due between broadcast television and other applications of the art. In non-broadcast applications the present high price of cameras is a serious obstacle. Many branches of science and industry cannot afford them, but, paradoxically, some others may well demand stereoscopy and colour before these refinements become economically practicable for broadcasting.

Restrictive Practices

THE I.E.E. Convention, in discussing non-broadcasting television, dealt with technical problems: we sometimes have misgivings that developments here may be restricted largely by administrative or political difficulties. The withholding of licences for cinemas is a case in point.

We take some encouragement in noting that the Postmaster-General has taken his courage in both hands in allowing special television transmissions to schools. The decision must have raised a host of administrative problems to which justice could be done only by a sea-lawyer. The schools transmissions, though admittedly very like broadcasting, can hardly fall into that category, either technically or according to the official definition of the International Radio Regulations. They are beamed to specified schools and are transmitted on a frequency allotted, we believe, to the B.B.C. for relay work—not for broadcasting. The complementary sound is distributed to the schools by wire—the antithesis of broadcasting.

If the schools transmissions are not, administratively speaking, broadcasting, into what category do they fall? But we must not pursue enquiries in this direction any farther, or we may find the B.B.C. really needs a licence for a fixed point-to-point communication service or something similar from which it is debarred by the terms of its Charter. As compared with the present experimental schools service, the licensing of cinema television, or of most other applications that can be envisaged, seems to be relatively simple administratively, and we are encouraged to think that official over-cautiousness will no longer be responsible for bringing promising developments to a halt.

Television Developments

A Selection from the I.E.E. Convention of Points Applicable to Receivers

IN a convention on television it is not to be expected that a great part of the material would be descriptive of new and startling developments. The material is likely to be much more of an historical nature and descriptive of present-day practice. As always, a convention tends to be a record of the present state of the art and, therefore, much of the material presented is already well known to those versed in the subject even when it has not been previously recorded in accessible form.

In all, 83 papers were presented at the recent I.E.E. Convention. The mere list of their titles and authors would occupy two pages of *Wireless World* and any attempt to summarize their contents is obviously impracticable. All that can be done, therefore, is to pick out some items of the widest interest and, very naturally, these fall mainly on the receiving side, simply because in the nature of things there are more people interested in receiving apparatus than in transmitting.

One development of very general interest was described in the paper by G. B. Townsend, "On Overcoming the Non-Interlacing of Television Receivers which are Accurately Synchronized." This paper refers to the common case in which perfect interlacing is secured during the fly-back but poor, or no, interlacing during the scan. The condition occurs not through timing errors so much as through amplitude errors. Successive cycles are slightly different in amplitude. The effect has been previously described[1] but a remedy for it is now proposed. The arrangement is shown in Fig. 1; V_1 is the normal discharge valve and R and C are the charging resistor and capacitor respectively. The additions to normal practice comprise the diode V_2 and the potential-divider R_1 R_2 with the large capacitance C_2.

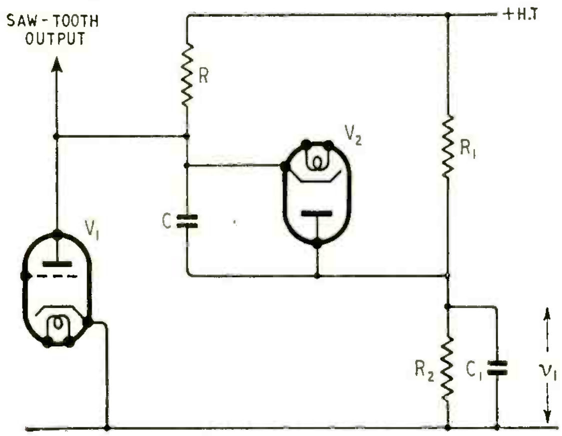


Fig. 1. The diode V_2 is added to a saw-tooth generator to improve interlacing.

During the scan V_1 and V_2 are both non-conductive and C charges through R in the usual way. The effective charging voltage is the h.t. supply less v_1 and the potential of the output terminal rises from a minimum substantially equal to v_1. On fly-back V_1 conducts to discharge C but V_2 remains non-conductive until the voltage across C has dropped to about 1 V, when it conducts and effectively joins the anode of V_1 to the voltage v_1 from the voltage divider. The diode ensures the termination of the fly-back at the same voltage level in every cycle and hence the start of the next scan from the same level.

Selenium Bias "Resistor"

A new use for metal rectifiers—as bias resistors—was described in the paper "The Applications of the Metal Rectifier in Television Receivers," by A. H. B. Walker. At a suitable operating point a selenium rectifier has a much lower a.c. resistance than d.c. resistance. The latter governs the bias voltage developed across it when it is in the cathode circuit of a valve but the a.c. resistance governs the amount of negative feedback. It is, therefore, possible to use cathode bias with much less degeneration than would be possible using an ordinary resistor. Its application is, of course, to cases where it is impracticable to use a cathode bypass capacitor and one example is the video stage of a television receiver, which may take the form sketched in Fig. 2. In a typical case the a.c. resistance may be only 70 Ω for a d.c. resistance of 295 Ω. The a.c. resistance varies considerably with current. Unless the signals are restricted, therefore, the feedback will vary with signal amplitude and give a non-linear response. This may, or may not, be disadvantageous, but it must be taken into account in the design.

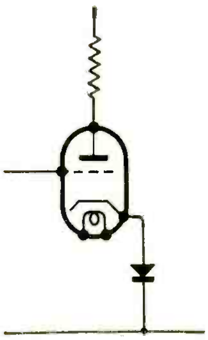


Fig. 2. Metal rectifier used as cathode-bias resistor.

The question of the proper intermediate frequency for television was discussed in the paper by D. H. Fisher, P. A. Segrave and A. J. Watts, "The Design

[1] "Interlacing", by W. T. Cocking, *Wireless World*, April 1947, p. 124. Editorial, *Wireless Engineer*, May 1951, p. 131.

of a Superheterodyne Receiver for Television." The conclusions reached are that the vision carrier frequency should be at 35 Mc/s and the sound at 38.5 Mc/s. In this connection it is interesting to recall that frequencies of 34 Mc/s and 37.5 Mc/s respectively were suggested three years ago as being the most suitable,[2] and there has recently been talk of using 34.5 Mc/s and 38 Mc/s.

This paper also describes three- and four-circuit filters for vision-channel i.f. couplings. With their aid very steep skirts to the response curve are obtained and it is possible to do without sound-channel rejectors. The discussion is eminently practical and is well illustrated by oscillograms showing the types of response obtained during alignment. The use of a wobbulator for alignment would appear to be essential with these circuits.

A typical arrangement is shown in Fig. 3. The first and last circuits L_1 and L_4 are tuned mainly by the valve capacitances, while the other pair L_2 and L_3 have capacitors C_1 and C_2; L_1 and L_2 are coupled by mutual inductance as are L_3 and L_4. A tapping on L_2 is connected to a coupling coil L_{3a}. It is important to avoid stray capacitance coupling and to arrange that the dust cores used for trimming do not appreciably alter the couplings.

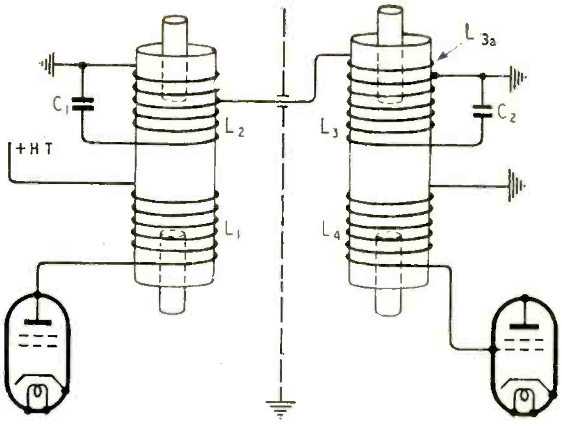


Fig. 3. Four-circuit bandpass filter.

Cathode-Ray Tubes

In the section dealing with valves one of the most interesting papers was one describing the development of an electrostatically-focused cathode-ray tube. Such tubes are not in essence new—at least one type was in use before the war—and there is a trend towards them in the U.S.A., largely in order to save the copper needed for an electromagnet or the cobalt required in a permanent magnet. Modern development in the electrostatically-focused tube is to retain magnetic deflection, to incorporate an ion trap, and to keep the potentials needed by the extra electrodes below 250 V so that they can be obtained from the receiver h.t. supply.

Work is being done on the development of a fixed-focus tube in which the focus electrode is joined to the cathode. With a 1st anode potential of 250 V, such a tube is feasible if operation of the final anode is at over 12 kV, but it seems that below 10 kV a focus control will be desirable.

Interference

The paper by A. J. Biggs and E. O. Holland on "The British Television Receiver" is noteworthy as giving a good account of the typical present-day British practice without excessive detail. A point of interest in the Appendix to it is the statement that double-sideband operation (e.g., double-sideband reception of Alexandra Palace) has been found superior to vestigial-sideband operation in fringe areas. Not only is noise less, as one would expect, but external interference gives rise to effects of shorter duration because of the greater bandwidth of the receiver.

A. J. Biggs and R. A. Mills presented a paper "The Performance of Television Receiver Installations in the Presence of Interference." The interference considered is that carried by the supply mains wiring of the house in which the receiver is installed. The paper describes an elaborate series of tests carried out with various television receivers under standard conditions. These tests showed that the use of twin aerial feeder tends to result in a higher level of interference than coaxial feeder as these feeders are at present used in average sets. In the worst sets tested, coaxial cable was 8 db better than twin and in the best sets 19 db better; however, the worst set with coaxial was 15 db worse than the best set with twin feeder.

It would be wrong to conclude from the tests that coaxial cable is, even on the average, inherently better than twin feeder. It is far less a matter of the cable used than of its termination and the relatively poor results obtained with many sets fitted with a twin feeder are due much more to the lack of a proper balance-to-unbalance transformer in the receiver than to the feeder itself. The large variations found with coaxial feeders are to be ascribed to the cable terminations. The bonding of the cable outer to the chassis is especially important and raises serious difficulty in transformerless sets where the chassis is live to the mains.

Cinema Equipment

In complete contradiction to the normal methods of synchronizing the receiver time-bases, the system which has been developed primarily for cinema television is extremely elaborate. Described in a paper by A. W. Keen, "A Precision Synchronizing System for Large-Screen Television Equipment," it is based on a form of fly-wheel circuit in which a multivibrator is kept in step with the line sync pulses by comparing the two signals in a phase discriminator and generating an error signal to control the multivibrator. A most unusual feature is that the frame scan is derived locally from the line waveforms and without any reference to the frame pulses in the received signal. Two things result from this. One is that the fly-wheel circuit is effective for the frame scan as well as for the line; the other is that it is possible to have an adjustable control of the precise timing of successive frames and, hence, of the interlace. As so far developed, the system seems much too elaborate for use in domestic receivers, but the paper is full of ideas, some of which might well find application to them.

[2] "Television Station Selection", by W. T. Cocking, *Wireless World*, July 1949, p. 242.

BRITISH TELEVISION TECHNIQUE

Papers Presented at the Recent I.E.E. Convention

THE Institution of Electrical Engineers has just done a very good thing for radio engineers in holding a Convention on what it modestly calls "The British Contribution to Television." Not only because the event has publicized the considerable British achievements in this field, but because it has brought into the light of day a large amount of technical information that would otherwise have remained in the dark recesses of filing cabinets and engineers' brains and been no use to anybody.

The Convention was held in London during the week beginning 28th April, and over a thousand delegates attended. Most of us, however, will have to be content with just reading the papers afterwards—not that there is any disadvantage in getting the information second-hand in this way, because at the Convention the authors only had time to give very brief summaries of their papers (which were prepared in advance), and the verbal discussions were necessarily somewhat sketchy compared to what they will be in the final printed form.

Over eighty papers were presented, in ten sessions. Each session centred around some particular aspect of television, and consisted of a survey paper followed by a number of more specialized supporting papers. In this way almost the whole field of television was covered, and there were very few omissions for such an ambitious scheme. Of course the papers were mainly concerned with present-day techniques, but one was devoted to the history of television development from the 19th century up to 1936. It only dealt with systems, however, and did not concern itself with the radio communication side.

Broadcasting and Reception

Television broadcasting stations and transmitters were surveyed very adequately, high-power transmitters being described in detail, and the old problem of whether to modulate at low level or at the output stage was brought up for discussion. Useful information was given on the design of transmitting aerials for common vision and sound working, and on suitable circuits for combining the two transmissions. There were expositions on wave propagation at television frequencies and the effect of the ionosphere, and an explanation was given of how sites for new transmitters are selected and tested.

There was a good deal of general information on the design of commercial receivers, with particular emphasis on receiving aerials, interference, interlacing, frame-scan circuits and deflector coils. A "preferred" range of valves for a.c./d.c. sets was suggested in one paper, while others showed how it was possible to make use of germanium and metal rectifiers in receiving circuits. More could have been included here, but then, of course, receiving technique is a very big subject.

Coming to the "glassware" used in television, the design, manufacture and life testing of cathode ray tubes were dealt with quite fully, and there was a description of a c.r.t. electrostatic focusing system. On valves there was a review of progress in the design and manufacture of receiving types from 1935 onwards, with some rather more specialized information on the development of reflex klystrons and coaxial-line oscillators for centimetre-wave radio links. Camera pick-up tubes and monoscopes were not forgotten.

The engineering aspects of programme production were surveyed very comprehensively, with discussion on the problems of studio lighting and the sound side. Design of cameras and associated equipment was also dealt with. Film came into the picture rather prominently with descriptions of film scanning and television recording equipment, and there was an interesting account of how the television camera can be used to advantage in film-making.

The business of conveying television signals from place to place was represented by descriptions of portable centimetre-wave radio links and a whole mass of information on coaxial cables and their associated equipment. There was also something on the system of television distribution by wire used at the moment for towns which are outside the service areas of transmitters.

Closed-Circuit Television

The array of non-broadcasting television applications in industry, commerce and scientific research was most impressive and pointed to the growing importance of this field. Full descriptions were given of a television system for demonstrating surgical operations and a flying-spot microscope. Certain aspects of large-screen projection television for cinemas were also included.

Most of the test apparatus described was for testing transmission channels, such as radio links and coaxial cables, for non-linearity, phase distortion and other forms of distortion.

Several papers gave a glimpse of possible future trends in television. The more fundamental and subjective aspects of colour television were reviewed, brief mentions were made of higher definition and stereoscopy, and there was a discussion on the possibility of compressing television signals to save bandwidth and ether space.

Single papers can be obtained from the I.E.E. at 1s 3d each, while a set for one session costs 8s, and the complete set for the whole Convention is £3 5s 3d; members can get them at lower prices. The papers will also be published in four special issues of the I.E.E. *Proceedings* (Part IIIA), with the discussions included.

Apart from the technical sessions, the Convention included a number of visits to firms and to B.B.C. and Post Office establishments. In the way of social functions there was an inaugural luncheon, a dinner and ball at the end, and a conversazione, given by the Radio Industry Council, at which manufacturers displayed a selection of their equipment.

Television Receiving Aerials

I—Characteristics of Simple Dipoles, Directional Systems and Requirements for Good Reception

By F. R. W. STRAFFORD,* M.I.E.E.

In preparing this article the author has made use of some of the information and diagrams in his paper "Receiving Aerials for British Television" which was read at the recent I.E.E. Television Convention, and is to be published as Paper No. 1287R in the *Proceedings of the Institution of Electrical Engineers,* Part 3A.

OUR knowledge of the dipole aerial for short-wave reception (or transmission) extends back for at least a quarter of a century. Eminent mathematical physicists have published numerous papers explaining why the exact mathematical theory is impossible which, at first sight, seems amazing having regard to the simple geometry of this elementary self-resonant collector (Fig. 1a).

Each physicist proceeds on the basis of acceptable compromises, and each deduces his impedance formulæ by the employment of independent, and sometimes ingenious, artifices. Their results agree very closely, but the dipole is analysed in every instance in idealized circumstances, in which it cannot be used! For example, a quarter-wave unipole is placed over an infinitely conducting and extending earth plane, or a half-wave dipole is placed at an infinite distance from the earth. In addition, no connection is made to the lower tip of the quarter-wave unipole, or between the two innermost tips of the half-wave version.

Hence, it is impossible to check the accuracy of any of these formulæ for the simple reason that it is necessary to bring the aerial near to an earth plane of finite conductivity and connect it to the measuring device by means of a suitable transmission line.

One can, in a practical way, make some realistic assumptions as to what is likely to happen. By virtue of its distributed L, C and R (Fig. 1b) the dipole is a very incompact tuned circuit possessing a low Q factor. It is well known that the Q of a normal lumped tuned circuit is reduced when it is brought into close proximity with other conducting objects, so there is every reason to suppose that the dipole should be similarly affected by the earth, and also by the connecting feeder if the latter is not balanced.

The vertical dipole possesses a considerable degree of symmetry which is largely destroyed when the feeder lies parallel to its lower element, but on practical and æsthetic grounds this is unavoidable.

Dipole Characteristics.—The term "dipole" will be used to describe the resonant half-wave dipole which, although precise, makes tedious repetition.

The radiation resistance referred to the centre terminals AB (Fig. 1a) is, theoretically, 72 ohms when the diameter, d, is infinitely small, but falls only slowly as the diameter is increased. For any dipole in the British television channels, diameters up to 1 in will introduce a negligible variation. The proximity of the feeder, and the effects of the earth and surrounding objects, have a far greater effect, with the result that the resistance will generally lie between 50 and 90 ohms.

Matching a Dipole to a Feeder.—A feeder in common use for television aerial installations is of coaxial

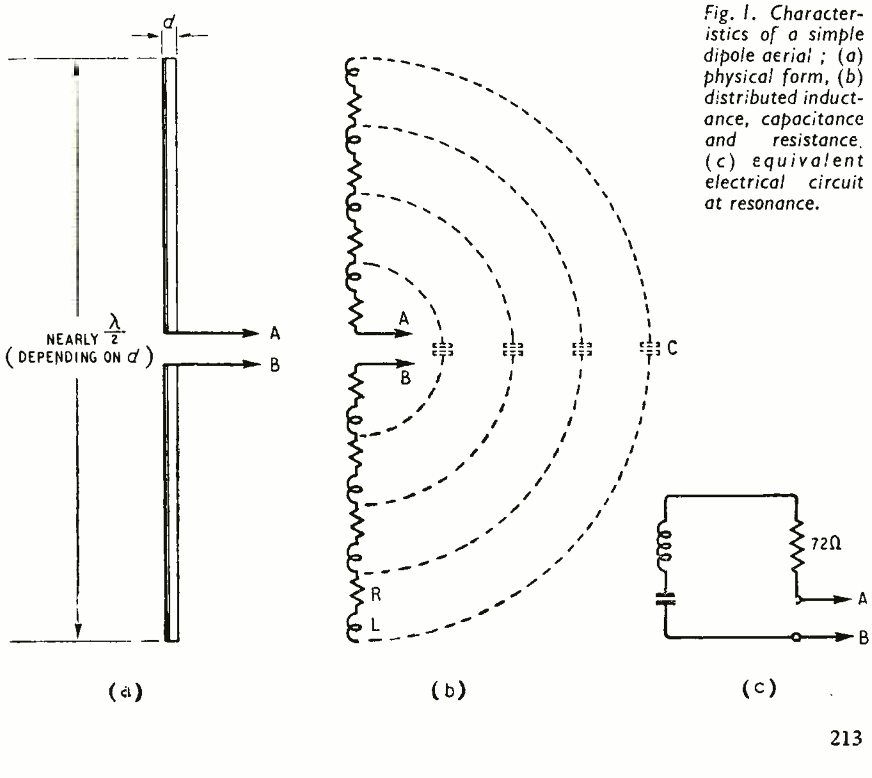


Fig. 1. Characteristics of a simple dipole aerial; (a) physical form, (b) distributed inductance, capacitance and resistance. (c) equivalent electrical circuit at resonance.

* Belling & Lee Ltd.

construction. A popular type employing a solid polythene dielectric has a loss of about 3.5 db per 100 ft, while a semi-air-spaced version possesses approximately half this loss and is usually employed for long runs, or where the signal is weak initially. Twin-balanced and shielded twin-balanced feeders are employed also.

If their route passes through local interference fields a high signal-to-noise ratio is obtainable with either type provided the coaxial feeder is joined to the aerial by an unbalance-to-balance section, and the twin feeder is connected to a carefully balanced input circuit at the receiver.

There is much misconception concerning the importance of impedance matching of television receiving aerials. This misconception probably arose from wartime experience of radar aerials. A single radar aerial usually performs both transmitting and receiving functions, but its electrical design is dictated by the more stringent requirements of transmission.

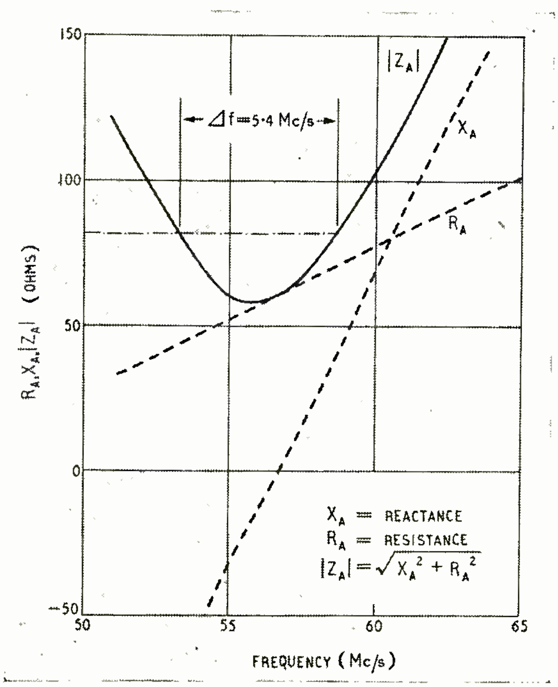
In high-power television transmitters the aerial design requires even greater care than is given to radar aerials. High-power transmitters cannot accept mismatched loads because of the dangers of voltage breakdown. There is an additional problem which involves very accurate matching at the aerial and the transmitter. On account of the length of the feeder (several hundred feet) and its very low attenuation losses, small mismatches at each end will result in multiple delayed images due to reflected waves along the feeder.

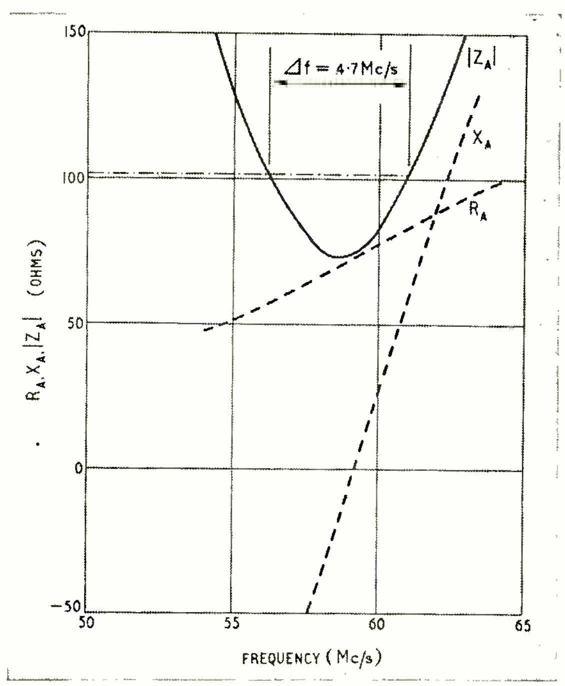
In the case of television receiving aerials, these problems do not arise. It is well known that maximum power transfer from a generator of finite resistance occurs when the load and generator resistances are equal. If a curve relating load power to mismatch ratio is plotted it will be apparent that there is considerable latitude. For example, a mismatch of 2 to 1 will cause a loss of only 0.4 db and a mismatch of 4 to 1 a loss of 2.0 db.

The inherent attenuation losses of feeders encountered in the average receiving installation are generally greater than the losses which will arise from inaccurate matching. The average length of feeder installed in a suburban two-storeyed residence, where the aerial is erected on the chimney stack, is about 40 ft. A solid-dielectric feeder of the type described will introduce a loss of 1.5 db, so that little is to be gained by attempting to match an aerial with a resonant impedance of 40 ohms to a feeder of 80 ohms. Theoretically the gain would be 0.4 db, but a matching device may not be fully effective because of its own losses. When maximum aerial efficiency is required it is better to select feeders with lower losses than to attempt closer impedance matching.

Folded Dipoles.—The folded dipole may be regarded as a combination of a simple dipole and transmission line. The impedance at the points of connection is of the order of 300 ohms and the bandwidth is greater than that of the simple dipole. It will be seen later that the bandwidth of the simple dipole is more than adequate, so there seems to be little purpose in wasting precious raw material, bearing in mind that one folded dipole contains sufficient material to make *two* simple dipoles. The greater bandwidth of the folded dipole will introduce higher levels of adjacent channel interference, and in any event a transformer will be required to step down the feed impedance (300 ohms) to the conventional 80-ohm feeder.

It may be argued that the folded dipole serves a useful purpose when combined with parasitic elements as an array. It certainly raises the feed impedance and eliminates the need for a quarter-wave matching





Left: Fig. 2. Calculated impedance characteristics of a television channel-4 dipole made of ⅜-in. diameter tubing.
Right: Fig. 3. Calculated impedance characteristics of a channel-4 dipole made of No. 34 s.w.g. wire.

stub. But the matching stub can consist of a few feet of 40-50-ohm feeder and is cheaper than the additional elements required by the folded dipole. The foregoing evidence suggests that there is no case for it for British television of the present standard of definition.

On the other hand, the 819-line v.h.f. system operating from Paris and Lille requires folded dipoles, particularly for multi-element arrays, and such aerials are well in evidence among the growing number of installations to be seen on the Continent.

Multiple Images Due to Mismatching.—When the feeder is mismatched at each end, a series of evenly spaced "ghosts" of successively diminishing amplitude can occur, but it is very doubtful whether this arises in practice, for the following reasons. To be visible the ghost must be displaced beyond the normal visual circle of confusion. For example, assume that 60 ft of feeder is employed and that the dielectric is solid polythene; the first delayed image will arrive about 0.18 μsec after the original. For a 10-in picture width this corresponds to an image displacement of 1/50 in. The eye is not capable of resolving this into a second image, and at the worst it will merely cause a slight loss of definition at points of sharp contrast. In any case, to cause loss of definition in this way the strength of the reflected signal would have to be comparable with the original. The fraction of signal reflected by mismatch is given by $K=(Z_R-Z_0)/(Z_R+Z_0)$. On the assumption that the aerial and receiver impedance is 40 ohms, and the feeder impedance 80 ohms, the reflection coefficient calculated on this basis will be 0.33.

In the two traverses of the feeder (from receiver to aerial and return), the amplitude of the reflected signal will be one-ninth of the original. When converted to decibels, and added to 4 db, (the feeder loss), the overall attenuation of the ghost with respect to the original is 23 db. Ghosts may be produced artificially by splitting the output from a dipole and connecting one feeder direct to the receiver, while the other, a delay feeder, is connected to the receiver through a variable attenuator. The desired delay may be obtained by adjusting the length of the delay feeder. The amplitudes of the signals from the two feeders are at first equalized and attenuation is then introduced into the delay feeder until the ghost is removed. In a test of this kind it was observed that a displacement of about 0.1 in was necessary in order to resolve a ghost as a separate image, and that about 18 db in the attenuator removed it for any but the most discerning viewer. Attenuation of 24 db rendered the ghost indiscernible. The test was carried out on a commercial receiver of good performance.

To displace the image by 0.1 in the feeder length must be 300 ft. With a 2 to 1 mismatch at each termination, and normal feeder loss, the amplitude of the ghost will be 38 db below the original. It may be concluded that most installations will be free from ghosts arising from feeder reflections, and that if they are present it will generally be found that they are due to reflections from buildings, large structures, or hills in the vicinity.

Bandwidth of a Dipole.—In a lumped series-tuned circuit the bandwidth is defined as the total frequency band lying between the points at which the impedance is $\sqrt{2}$ times the minimum value. This is often referred to as the half-power bandwidth. There is no reason why the same definition should not apply to the dipole, although it might be better to refer to it

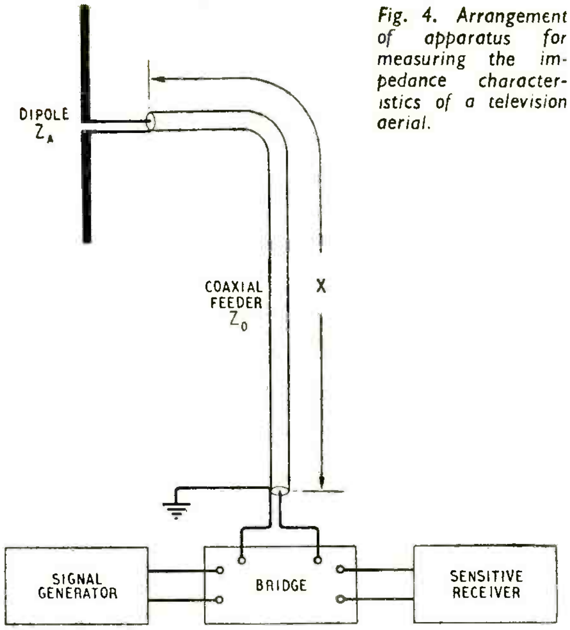


Fig. 4. Arrangement of apparatus for measuring the impedance characteristics of a television aerial.

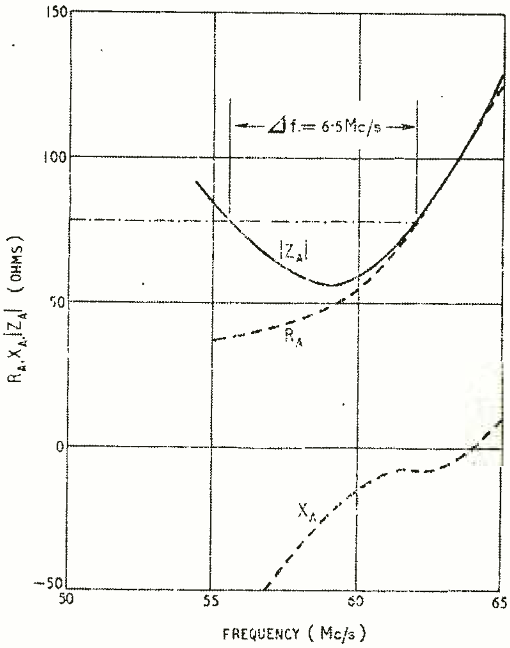
as the intrinsic bandwidth. The loaded bandwidth, which is obtained when the aerial is correctly terminated through a feeder by a resistive load, will be equal to twice the intrinsic bandwidth.

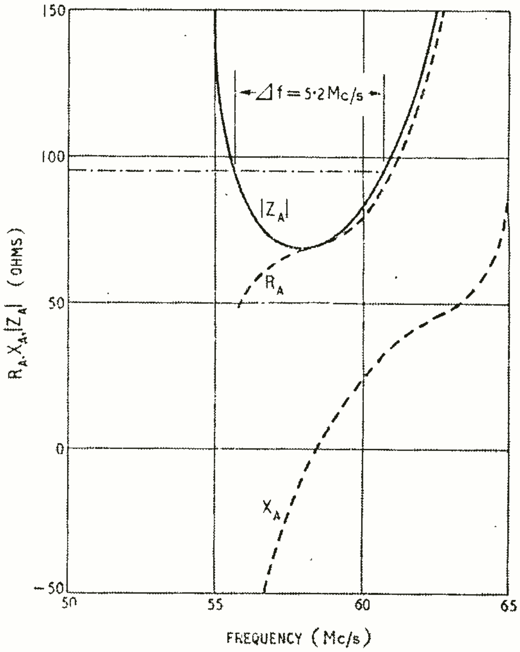
Formulæ developed by Schelkunoff[1] have been used to calculate the bandwidth of two dipoles. The first is constructed from 34 s.w.g. copper wire and can be regarded as a very thin-wire dipole. The other is constructed from ⅜-in tubing, and both dipoles are cut to resonate in channel 4 (Sutton Coldfield). The curves are shown in Figs. 2 and 3, from which it can be seen that the calculated intrinsic bandwidth of the thin dipole is 4.7 Mc/s and that of the ⅜-in dipole is 5.4 Mc/s. Hence, the loaded bandwidths are 9.4 and 10.8 Mc/s respectively. The loaded bandwidth of the thin-wire dipole is therefore far in excess of present requirements. It would be reasonable to enquire why fine wires are not employed commercially; such wires would have to be supported and the cost of the supports, including insulators for the remote ends, is greater than that of elements constructed from self-supporting tubes.

Measurement of Intrinsic Bandwidth.—There are several methods of measuring the intrinsic bandwidth of a television aerial and all of them have certain disadvantages. A cautious experimenter will encounter numerous and perplexing difficulties. The well-known slotted-line technique devised by Brückmann[2] is not practicable because of the length of precision line involved, which would be about 12 ft for channel 1. There is no doubt that a suitable line could be made, but it would require very careful design and involve extremely high manufacturing costs. One of the most reliable methods is to employ a high-frequency bridge, an example of which has been specially developed by the B.B.C. Research Department.[3]

The general arrangement is shown in Fig. 4 and it

[1] Schelkunoff, S.A. *Proc. I.R.E.*, 1941 V.29, p.493.
[2] Brückmann, H. *Hochfrequenztechnik*, 1938, V.51, p. 128.
[3] Calvert, R. *Electronic Engineering*, 1948, V.20, p.28.





Left : Fig. 5. Measured intrinsic impedance of a channel-4 dipole with $\frac{3}{8}$-in. diameter elements. Right : Fig. 6. Measured intrinsic impedance of a channel-4 dipole with No. 34 s.w.g. wire elements.

should be noted that the measurement of intrinsic impedance will include the effect of the coaxial feeder, and this must be removed mathematically. The procedure is laborious, but the calculations are considerably simplified by the use of the Smith[4] chart.

By this method the impedances of the $\frac{3}{8}$-in and 34-s.w.g. dipoles have been measured at a height of 23 ft. Figs. 5 and 6 depict these results and if compared with their theoretical counterparts (Figs. 2 and 3) it will be seen that the measured values of bandwidth exceed the theoretical by between 15 and 20 per cent. Fig. 7 shows the impedance moduli of the $\frac{3}{8}$-in dipole at three different heights. This slightly enhanced bandwidth is to be expected from the increased losses due to the proximity of the feeder and the earth, as pointed out earlier.

Directional Aerials.—It is often necessary to increase the signal energy supplied to the receiver, or reduce unwanted signals or noise arriving from directions other than that of the desired transmission. The addition of one or more correctly proportioned parasitic elements will assist in meeting this requirement.

The resolving power of a parasitic array of usable dimensions is very poor when compared with a reflecting telescope, which in most respects obeys the same laws governing television waves, since light is an electro-magnetic phenomenon.

To obtain a resolving power comparable with a simple 3-in reflecting telescope, a television channel-4 array would require a parabolic reflector some 450 miles in diameter!

The mathematical treatment of arrays containing a single parasitic element is very difficult and almost unmanageable for more than one. In any case, simplifying assumptions must be made which often provide an academic rather than an engineering solution. Hence, the development of directional aerials usually involves trial and error methods which may be laborious, and are largely affected by the weather. The apparatus shown in Fig. 8 was developed for reducing the time and effort involved in adjusting parasitic arrays. A frequency ten times that specified in the design is chosen and adjustable models of the aerial are constructed to a scale of one-tenth. The model is rotated slowly by means of a motor and is geared to a disc which carries a circular paper chart ruled in polar co-ordinates. The output from the model aerial is fed down the centre of the mast and applied to a terminating resistor of the disc type across which is connected a crystal rectifier circuit. The resultant d.c. output operates the servo-controlled pen which marks the directional response on the chart. The transmitting oscillator is a conventional tuned-line arrangement and care is taken to ensure that equal currents are supplied to the radiating dipole at each test frequency.

The radiator and model are placed about 14ft (seven wavelengths) apart on a concrete plinth about 6ft wide in which is embedded a close-mesh conducting mat, the purpose of which is to maintain constant ground plane conditions; early work indicating that this artificial earth was essential. During the initial experiments reflections introduced spurious responses and these were subsequently eliminated by locating the transmitting aerial within a corner reflector consisting of two brass sheets about 4ft high and 3ft in length set at 90 deg. The radiated power was increased as a result and the receiving rectifier then operated at a higher level, thus tending to linearize the output. It was necessary to control the rotating mechanism by a remote switch, otherwise the presence of a body near the apparatus gave rise to spurious responses.

Some very useful work has been carried out with

[4] Smith, P. H. *Electronics*, 1939, V.12, p.29.

this apparatus and the following conclusions are considered worth recording. Most of them confirm known theory: (a) A parasitic element whose length is shorter than the dipole acts as a director and must be spaced approximately 0.1 λ from the dipole to secure a maximum gain of about 5 db. (b) When a director is spaced approximately 0.05 λ from the dipole a high front-to-back ratio of about 26 db can be obtained, but this array is very sensitive to small dimensional changes and the feeder and supporting mast must not be in the plane of the elements. (c) If a director-type aerial is adjusted to provide maximum gain on a video-carrier frequency the gain falls considerably at the associated, and lower, audio-carrier frequency. (d) Arrays embodying closely spaced parasitic directors are very sensitive to spacing, and unless extremely rigid elements are employed considerable amplitude variation is observed in high winds producing picture brightness flutter of a very objectionable kind. (e) A parasitic element whose length is greater than the dipole acts as a reflector, i.e., reverses the directional response of the aerial. (f) When a parasitic reflector is employed the increase of gain with spacing is slow beyond 0.15 λ and attains its maximum value at about 0.25 λ. An aerial designed with 0.25-λ spacing is free from picture flutter. (g) A parasitic array designed for television reception must respond to both video and audio carrier frequencies; whilst it is usual to design for maximum performance on the video channel the design must not involve an appreciably lower gain on the audio channel. In the case of a two-element array a good compromise is effected by designing the dipole to resonate at the video carrier frequency, and the reflector at the audio carrier frequency, and spacing them one quarter of the arithmetic mean of the wavelength of the two carriers. (h) The two-element array specified in (g) will provide a forward gain of approximately 5.0 db and a front-to-back ratio of approximately 14 db. These measurements include the effect of the feeder which lies midway between the dipole and the parasitic element in the same plane. Previous workers have considered horizontal arrays in which the feeder and the supporting mast contribute little effect. The results obtained from vertical arrays must therefore differ appreciably from their horizontal counterparts.

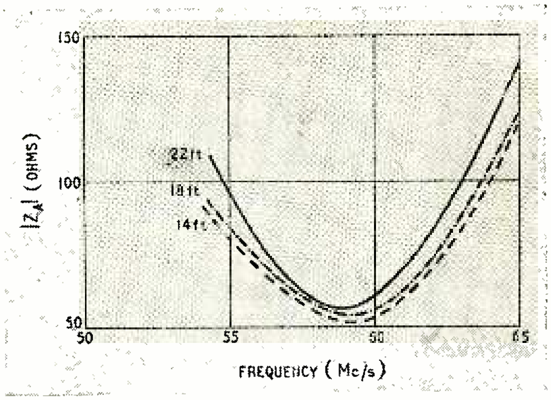


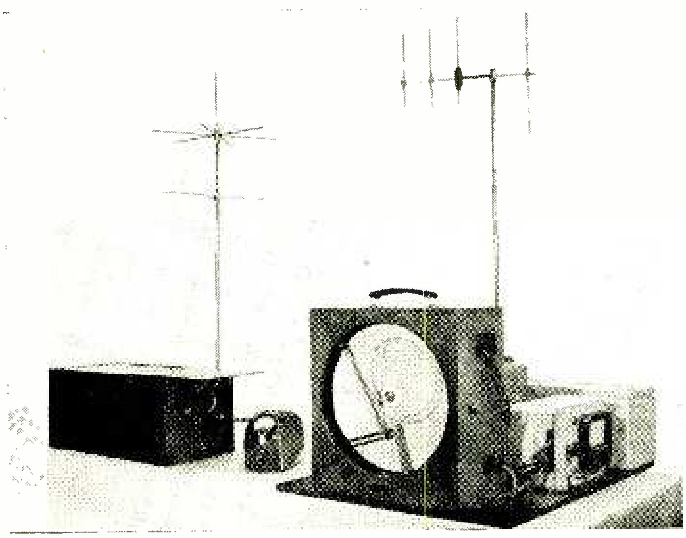
Fig. 7. Variation of intrinsic impedance of a dipole with $\frac{3}{8}$-in diameter elements at three different heights.

At the conclusion of the work on the miniature array a full-scale model may be constructed in such a way as to embody means for small adjustments to the element lengths and spacings above and below the optimum dimensions determined on the miniature model.

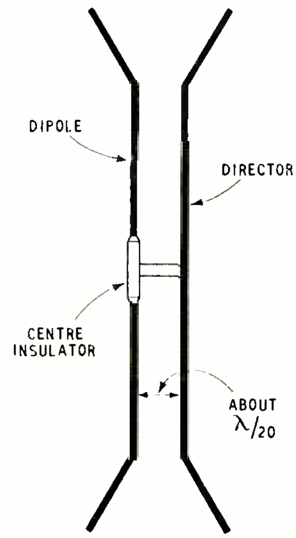
A useful variant of the H-type aerial is the well-known X which is, basically, an H with its waist "pinched." The spacing is substantially zero at the centre and $\sqrt{2} \times \frac{\lambda}{4}$ between the remote tips which gives it some hypothetical spacing determined by the current distribution and phases in the elements.

The X aerial possesses a somewhat higher front-to-back ratio than the conventional H, but achieves it at the expense of slightly reduced forward gain, loss of directional characteristics on the sound channel, and greater susceptibility to brightness modulation caused by reflections from flying aircraft. Any aerial whose collector elements subtend a horizontal component will increase aircraft modulation.

Another variant of the H consists of one in which the dipole and parasitic element are spaced approximately 1/20 of a wavelength apart. When the elements are suitably proportioned (the parasitic element being



Left: Fig. 8. Simple apparatus for measuring gain and directional response of scaled-down model arrays.



Right: Fig. 9. "Crooked-H" aerial giving high front-to-back ratio.

a director) back-to-front ratios as high as 30 db may be attained. To overcome the picture brightness flutter occasioned by oscillation of the remote tips these are bent as shown in Fig. 9.† Since most of the coupling between the dipole and its parasitic element takes place where currents are greatest (in and near the centre) the bending of the tips does not seriously reduce the front-to-back ratio. It is essential that the array be supported by a cranked mast, so that neither mast nor feeder lie between the dipole and director elements.

† Patents applied for.

For "fringe" reception, in field strengths of the order of 50 μV/m, a four-element array probably represents the largest structure that can be produced and erected economically when relating it to the initial cost of the receiver. The cost of manufacture and installation rise very rapidly when further elements are added. Such an array may comprise a reflector spaced about 0.25 λ behind the dipole, and two directors successively spaced 0.1 λ in front. The forward gain is approximately 9 db and the front-to-back ratio is about 24 db.

(To be concluded)

BOUNDARY-DISPLACEMENT MAGNETIC RECORDING

IN conventional magnetic recording systems the magnetization characteristic of the material is involved in the modulation process, and high-frequency "bias" must be applied to reduce non-linearity arising from this source to practicable limits.

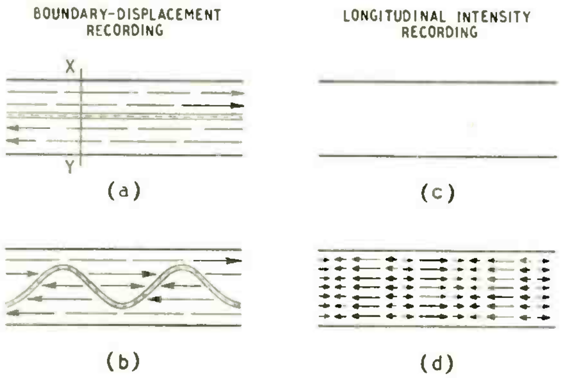


Fig. 1. Illustrating the difference between boundary-displacement recording (a) and (b) and conventional longitudinal intensity modulation (c) and (d).

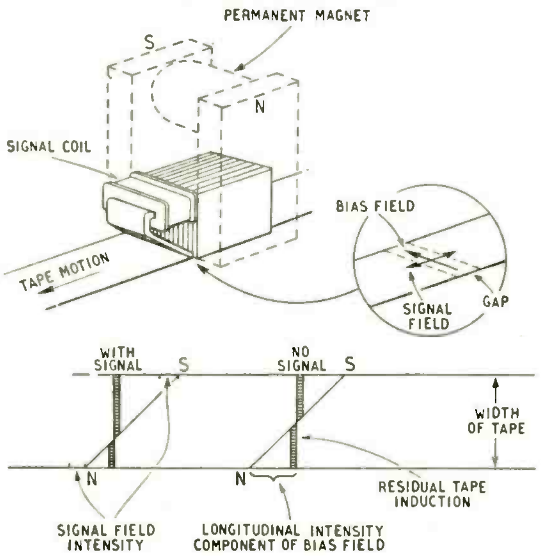


Fig. 2. Construction of recording head, and diagrammatic representation of combined bias and signal fields.

A method of recording in which the magnetic response of the material is not directly involved, is described by H. L. Daniels in the April, 1952, issue of *Electronics*. It is termed boundary-displacement recording, and can be used with standard commercial tapes. Although the fundamental magnetization is longitudinal, as in normal recording, the modulation is lateral and is obtained by displacement of the boundary between two zones of opposite magnetic polarity. These zones are uniformly magnetized to saturation, and the absolute intensity is immaterial, provided that it is equal on both sides of the tape. Fig. 1 (a) shows an unmodulated record with equal distances on each side of the central transition zone, while Fig. 1 (b) represents modulation by a sine wave. Magnetic conditions for equivalent states with conventional magnetic recording are indicated by Figs. 1 (c) and (d).

A normal playback head is used for reproducing boundary-displacement recording, and the gap may be represented by XY in Fig. 1 (a). It will be seen that in this case equal and opposite magnetomotive forces are applied to the magnetic circuit and the pick-up coil output will be zero. When the boundary is displaced from the centre line there will be an excess of one or other polarity and an equivalent voltage output will be produced. The system is analogous to variable-area recording on film.

For recording, a special type of head is used, in which a stack of thin laminations with non-magnetic separators forms a line of individual gaps, in the direction of motion of the tape, with a separate integral polepiece energised by the signal coil. Magnetic bias is applied transversely to the laminations by a permanent magnet and the interaction between this field and the signal field at right angles, varies the point at which the neutral flux crossover point intersects the line of the gap (Fig. 2).

It is evident that a high degree of accuracy in the width of the gap and the distribution of flux in the polepieces is necessary to ensure linearity of response to amplitude variations, and it is an open question whether the transfer of the onus from the magnetic material of the tape to the geometry of the recording head will prove of practical advantage for audio-frequency recording. So far the chief uses of the new principle have been in recording and measuring high-speed transients, and in this application the fact that the full energy-storing capacity of the material is employed, is of particular value.

LINE ELIMINATOR

"Spot Stretching" as an Alternative to Spot Wobbling

By G. N. PATCHETT,* Ph.D., B.Sc., A.M.I.E.E., M.I.R.E., A.M.Brit.I.R.E.

ONE annoying feature of television pictures is the presence of the lines, which are more pronounced on a receiver with good focusing than on one with a comparatively large spot. As the spot size is reduced the definition in the horizontal direction improves, so the spot is usually made as small as possible in order to give this definition. This "lininess" can be overcome by viewing the picture from such a distance that the lines are not visible, but in many cases this is more than the optimum distance and the horizontal definition is lost as the eye is no longer able to resolve the small detail in a horizontal direction.

Unless the diameter of the spot is equal to the full width of a "line," a small black bar is left between adjacent traces of the spot as shown in Fig. 1(a) and (b), and it is the width of this black bar that is important. It is usually smaller than the diameter of the spot and hence small changes in the diameter of the spot cause large changes in the width of the black bar. Taking a 12-in tube with a picture height of 8in, since there are 377 active lines the space occupied by a line is 8/377 = 0.021in, say 20 thousandths of an inch. If the spot is 14 thousandths wide then the black bar will only be 6 thousandths wide. If the spot is now reduced by twenty per cent to 11 thousandths, the width of the black bar is increased by fifty per cent to 9 thousandths and it becomes much more visible. In Fig 1(a) and (b) are shown two sets of lines drawn to these proportions, and it will be noticed that the lines are much more noticeable in (b). All this assumes perfect interlace, which does not appear to be commonly obtained in practice. If there is a certain amount of "pairing" of the lines the black bar is increased in width and the "lininess" is increased still more.

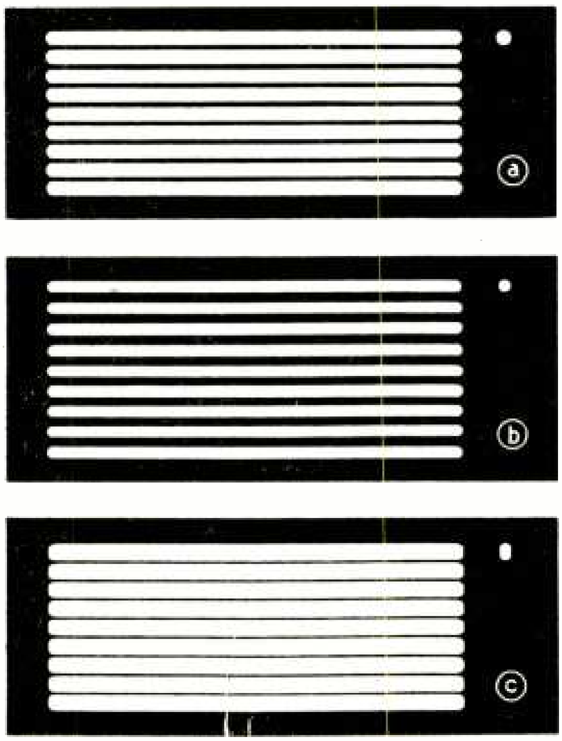
This "lininess" may be overcome if, instead of using a circular spot, the spot is made oblong in a vertical direction so that it just fills the space of one line. This is shown in Fig. 1(c) where the height of the spot is nearly equal to the width of a line; it will be noted that the lines are nearly invisible. If the width of the oblong spot is the same as the original diameter of the circular spot, the horizontal definition will remain the same or will be improved (see later).

One method of producing an oblong spot is by spot wobble† in which the spot is moved up and down at a frequency of the order of 10 Mc/s and so traces out a small vertical line. The method suggested by the author is not to move the spot up and down, but to focus it so that it is oblong instead of circular. This could be done by making the magnetic focusing coil so that it is not symmetrical about the centre of the tube and so only focuses in either a vertical or horizontal direction at one time—what is called astigmatism. But it is inconvenient to make the normal focusing arrangement unsymmetrical because of the difficulties of manufacture, and because no easy method would be available for adjusting the amount of asymmetry or removing it if not required. The author's idea is to place an auxiliary focus coil next to the normal focus coil or permanent magnet so that it assists or opposes the main focus system. The coil

* Bradford Technical College.

† *Wireless World*, March 1950, p. 84.

Fig. 1. Showing the effect of different spot sizes on visible line structure. In (a) and (b) the spot is circular while in (c) it is stretched to an oblong shape.



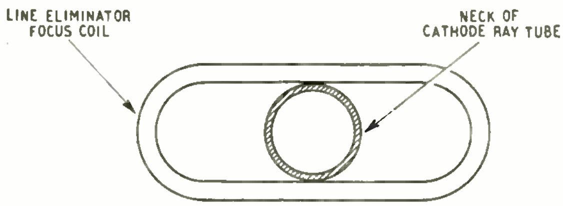


Fig. 2. Cross section showing the shape of the line eliminator focus coil in relation to the neck of the cathode ray tube.

is made oblong, as shown in Fig. 2, so that it has a greater effect in, say, the horizontal direction than in the vertical. If the current in the main focus coil is now adjusted it will be found that the spot comes to a focus as an oblong and not as a circular spot. In practice it has been found that the coil should not be horizontal or vertical but placed at about 45 deg, presumably because of the rotation of the electron beam as it travels through the focus coil. It is not certain whether this angle holds for all tubes, but the author has found it to be right for three tubes of different manufacture. Photographs of vertical and horizontal lines produced by the arrangement are shown in Fig. 3. Here the amount of alteration in spot shape is more than would be required in practice.

The best place to fit the coil is between the focus coil, or permanent magnet, and the deflector coils, as there is usually enough space there for a small coil of this shape. The number of ampere-turns required will depend to some extent on the tube and the exact position of the coil, but 50 ampere turns has been found to be more than sufficient. The coil can conveniently be placed in the h.t. line of the set with a variable resistor of 50 to 100 ohms in parallel, so that the magnitude of the "drawing out" can be controlled and cut out if required. The coil should be by-passed by a capacitor of, say, 50μF (12-volt working usually being sufficient), so that no alternating components pass through it. A coil of 250 turns carrying 200 mA has been used by the author.

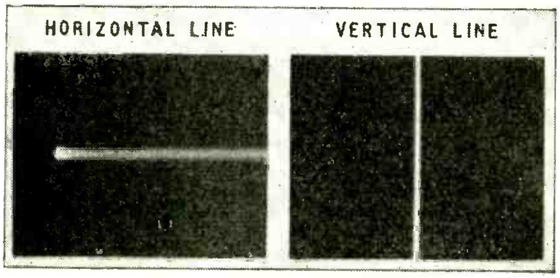
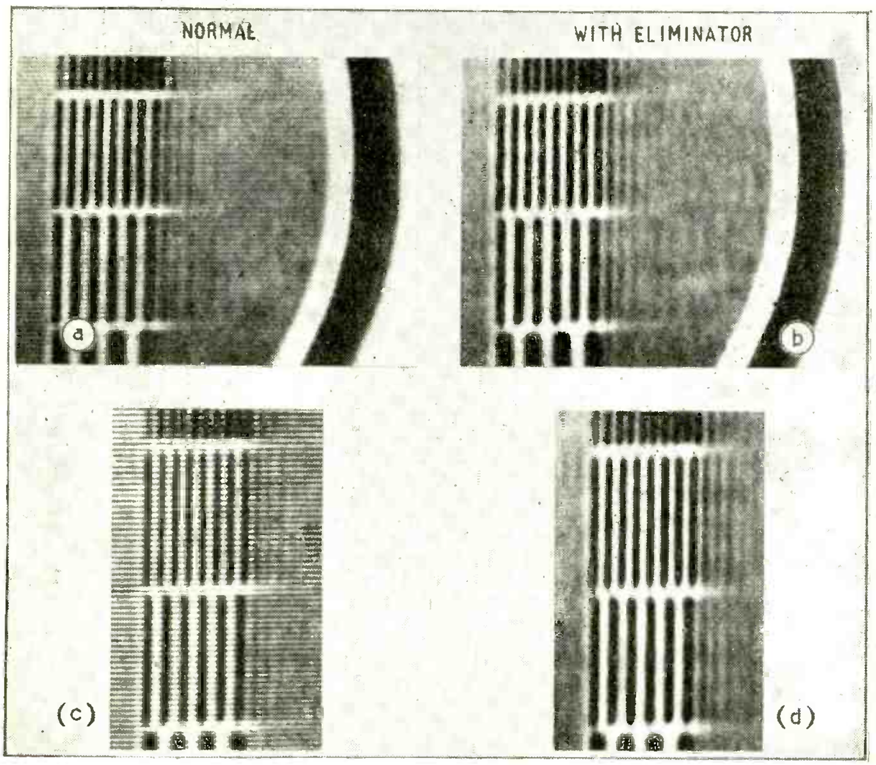


Fig. 3. Photographs of vertical and horizontal lines produced with the line eliminator in operation.

With the line eliminator in action, one must not focus on the lines (as is usual on a normal set) but on the horizontal definition. This is fairly easy on the B.B.C. Test Card C or on the tuning signal, but not as easy on an actual picture. One way is to focus on the lines with the line eliminator out of action and then increase the resistance in parallel with the coil until the lines just disappear. The setting is now nearly correct but not exactly so, as the coil does have some effect on the focus in a horizontal direction. The ideal way is to turn the deflector coils at right angles and then to focus on the lines with the line eliminator in action (when it will be found that the lines can be made as sharp as usual) and then turn the deflector coils back to normal without altering the focus. This is obviously not very practical where there is a focus control which can easily be moved, but it is quite feasible with permanent-magnet focus arrangements where the focus is set and not adjusted over long periods.

Some results taken on Test Card C are shown in Fig. 4; (a) and (b) being taken with normal picture size and (c) and (d) with the picture height increased about 50 per cent. Each pair is taken with exactly the same contrast and brilliance setting and the exposures were identical. The photographs were taken on a commercial receiver fitted with a 12-in tube operating near the centre of a city. Note that the horizontal definition is not impaired but is actually improved, the vertical bars being clearer in (b) and (d) than in (a) and (c). This can also be seen in Fig. 1, where the vertical edge is more distinct in (c) than in either (a) or (b).

Fig. 4. Photographs showing the effect of the line eliminator on B.B.C. Test Card C. In (a) and (b) the picture is of normal size while in (c) and (d) its height has been increased about fifty per cent.



The device also increases the contrast, as can be seen on Fig. 4. This is explained as follows: Suppose the normal spot is half the width of a line (and remains of constant diameter); in a black portion of the picture the whole area of the screen is black, but in a white portion only half the screen is white since the space between the lines is black and the area appears grey. When the line eliminator is in use the whole of the area is white in the white portion of the picture and, of course, the whole area is black in the black portion.

The vertical definition may not appear from the photograph to be as good. In theory, so long as the spot is uniform over its height and does not exceed the line width the vertical definition should not be different (see Fig. 1(c)), but in practice the spot is not quite uniform over its height (neither, of course, is a circular spot uniform over its diameter), and in these photographs the amount of line elimination has been increased so as to completely remove the line structure when viewed close up, and this, no doubt, causes some overlap of the white bars. In practice the amount of line elimination required is much smaller in order to make the lines quite invisible at, say, 3in away, and there is no point in increasing it farther. The amount that it is required to stretch the spot vertically is quite small, as can be seen in Fig. 1, the height of the spot in (c) being only 170 per cent of its width, i.e., the spot is only increased in height by 70 per cent. When the line eliminator is used so as to cut out the line structure at any normal viewing distance it is very doubtful whether there is any loss in vertical definition.

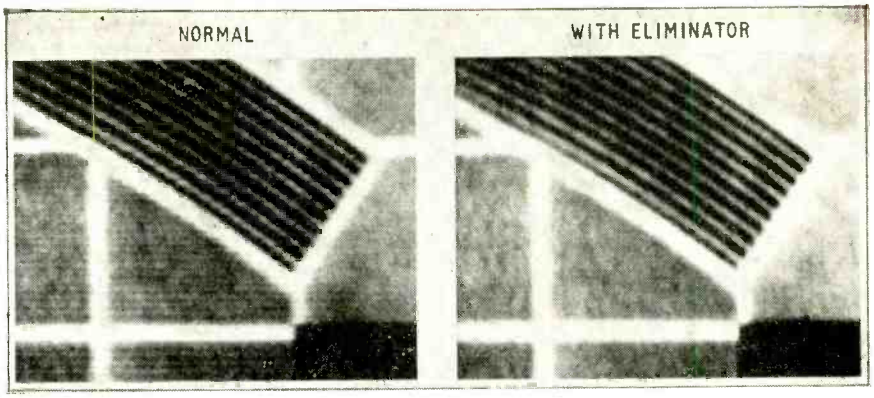


Fig. 5. Showing the effect of the line eliminator at the corners of B.B.C. Test Card C.

This scheme of line elimination has the advantage over spot wobble of being extremely simple and cheap. The total cost is only a few shillings and it can be fitted in a few minutes to most receivers. It also has the advantage that there is no possibility of interference from radiation, which appears to be a possibility with deflector coils operating at 10 Mc/s unless care is taken in the design. The device has been tried out on two commercial receivers of different manufacture and also on a receiver constructed by the author, and it has given equally good results on all of them. Most people who have seen the device in operation have stated a preference for the picture with the lines eliminated.

SUBMARINE TELEVISION

SINCE the successful use of television for the identification of the wreck of the submarine *Affray*, which had been located by acoustic means, considerable improvements have been made by the original manufacturers (Marconi's)*, and the Royal Naval Scientific Service has undertaken extensive trials with this and other equipment in an endeavour to evaluate the scope and limits of underwater television.

Demonstrations were given during the recent I.E.E. Convention of Marconi and Pye equipment, both of which are now being used experimentally by the Admiralty. A third type of camera—supplied by E.M.I.—is being used by the Scottish Marine Biological Association.

The cameras at first employed were modified versions of broadcasting equipment and, as such, are far more elaborate than is necessary for closed-circuit working. The increasing demand for simplified equipment for a wide range of industrial and research purposes will undoubtedly result in the production of more compact and simpler gear. The provision of the necessary watertight housing is not considered a formidable undertaking by the R.N.S.S., and two or three types of case have already been produced capable of withstanding water pressure up to 1,200 lb per square inch.

In a recently issued Admiralty Research Laboratory report, W. R. Stamp outlines not only the problems involved but the possible applications of underwater television. The direction of salvage work and the inspection of ships' hulls immediately spring to mind. Its main advantages in wreck survey are that it is capable of working at greater depths and for longer periods than a diver, even if an observation chamber is used; the findings are presented direct to those directing operations which facilitates manœuvring when using salvage grabs, etc., and, of course, there is no risk to life.

The study of marine life in its natural habitat and the use of television in oceanographic research are two further possible applications.

The latest camera, made by Pye, working in co-operation with the Admiralty, has a servo-operated, remotely-controlled focus system which, together with the remotely-controlled motor-operated four-lens turret, allows precise optical adjustment to be made at the control unit on board the deep-diving vessel. The vision signal is conveyed to a 14-in monitor tube at the control position.

One obvious advantage in the use of television is that a film record can be taken of the image received on the monitor, thus providing a permanent record of the investigation.

The camera is housed in a cylindrical case about 20in diameter and 30in long, to which is fitted a hood to carry the lighting. By increasing the diameter of the lens window in the housing to $5\frac{1}{2}$in it has been possible to use a $1\frac{3}{4}$-in focal length lens, which increases the angle of vision to some 40°.

* See May issue, p. 205.

NOISE

Concluded from page 202 of the previous issue.

2—Practical Effects

By "CATHODE RAY"

FIRST a quick recapitulation of last month's instalment. The only kind of noise being considered is that due to (1) the jostling of electrons in conductors (Johnson or thermal noise, which is there whether current is flowing or not), or (2) the granular nature of valve anode current (shot effect). Such noise sounds very much like gramophone "scratch" or escaping steam, and its power is distributed evenly over all frequencies—not just the audible ones. (1) is proportional to absolute temperature T (i.e., centigrade + 273), and is based on Boltzmann's constant $k = 1.38 \times 10^{-23}$. The noise power, within the frequency band B, generated in any resistance and passed on to an equal resistance connected in parallel, is kTB. Since the voltage of any generator that puts P watts into a matched load R is $2\sqrt{PR}$, the Johnson noise voltage E_N is $2\sqrt{kTBR}$. (2) is based on the amount of electricity in one electron, $e = 1.59 \times 10^{-19}$, and is proportional to the anode current, but the exact fluctuation component of current depends on various conditions and it is only for saturated diode conditions that there is a simple formula — $I_N = \sqrt{2eI_aB}$. With the resistances and bandwidths commonly used in amplifiers, E_N is usually between 1 and 10 microvolts, and the noise voltages due to passing I_N through a coupling resistance are of the same order or rather less. The shot noise of a valve is specified as the resistance which, at the input of a noiseless but otherwise similar valve, would give rise to the same noise.

Whether or not electron noise is important in any particular case depends on how much signal strength is available. If it is at least several millivolts, there is no need to worry about noise at all. But where, as in radar, the idea is to detect the smallest possible signal, noise is all-important, for it is what ultimately limits range.

Rescuing the Signal

The cause of the noise is universal and unstoppable, and every source of signal is bound to be a source of noise; so one can only arrange things to obtain the maximum signal/noise ratio in the circumstances. When that has been done, and still the signal is so weak that it is lost in noise, no further amplification can do any good. The limit has been reached. One obvious way of arranging things is to see that the bandwidth accepted by the amplifier is no more than is needed to bring in as much of the signal as is necessary. Then there are various devices for enabling radar and telegraph signals to be read even when they are weaker than noise. Pulse code modulation* is a dodge for improving telegraph signal/noise ratio. The "just-readable" standard is hardly acceptable for broadcasting, however! That is where the claims of frequency modulation come in.

Suppose now we study the noise situation in different types of set. A simple one to begin on is a microphone amplifier. The source of signals consists of the microphone, usually connected to the amplifier through a transformer. The transformer can be considered either as part of the microphone or part of the amplifier. I am going to include it with the microphone. Then, if the transformer is regarded as perfect, the resistance of the microphone can be multiplied by the square of the transformer ratio to give the resistance of an equivalent microphone directly connected to the amplifier, with no transformer (Fig. 1). Reactance rather complicates matters, so for the purpose of this elementary discussion we shall assume that the impedance of the microphone is all resistance. If the microphone resistance were 1kΩ, and the transformer ratio 1 : 6, the equivalent directly connected microphone would have a resistance of $1 \times 6^2 = 36$kΩ.

Another assumption we are going to make is that the input of the amplifier has an infinite impedance. If the first valve were a triode, its Miller effect would see that this condition was nowhere near fulfilled, but we suppose it to be a properly screened pentode. And, being an audio-frequency job, the amplifier is free from those v.h.f. effects that lower a valve's input impedance.

These two assumptions having been made, we know the r.m.s. noise voltage (or at least that part of it coming within the frequency band of the amplifier) at the input to the amplifier. It is $2\sqrt{kTBR}$. Suppose that B is 15,000 c/s, and R (the resistance of the microphone effective at the amplifier input) is 0.1MΩ. Then with T at its usual 290° the noise voltage would be just short of 5μV. If the requirement is for the weakest microphone signal to be, say, 40db above noise (i.e., 100 times its voltage) it must be at least 500μV. The microphone maker, if he knows his job, will have specified the strength of sound needed to produce a stated microvoltage, so we would know how strong the weakest sound would have to be at the microphone to ride above Johnson noise caused by the microphone resistance.

And here we see one reason why really high fidelity is difficult to achieve. To have a flat characteristic over the full audible frequency range, the microphone must be free from resonance over that whole range, which means that its diaphragm has to be small. Another reason for making it small is to ensure that parts of it are not hit simultaneously by opposite half-cycles of even the shortest (i.e., highest frequency) sound wave. All this means that the sensitivity is almost bound to be very low. Extending the frequency range from, say, 5,000 to 15,000 c/s brings in important but relatively very weak "signals"—the harmonics

* "Tens or Twos?" Sept., 1951.

that give clarity and faithfulness to the reproduction. But it also multiplies the noise power by 3. Another requirement for high fidelity is a full dynamic range—the system must deal with programmes having a very wide ratio of loudest to softest. All this being so, the weakest signal is very weak. So really high fidelity and at the same time freedom from noise is something to wonder at.

The fact that noise is equally powerful at all frequencies doesn't mean that it is equally loud. The loudness depends on the sensitiveness of one's ears, which is much less at low frequencies than at high. And since the frequencies above one or two thousands normally carry little of the power of the programme, cutting them down with a tone control reduces noise far more than signal, giving the impression that nearly all the noise is at that end. (Incidentally, this applies also to gramophone scratch, which although different from electron noise in origin gives the same sort of result.)

But we are getting rather off the point, which is to consider how the amplifier affects the signal/noise ratio. Thanks to our assumption that the signal source is connected straight to a first valve having infinite input impedance, no Johnson noise is introduced by the amplifier at its own input. And as we are pretty safe in assuming a gain of at least 10 times in the first stage (and probably much more), we can neglect any second-stage noise. That leaves only shot noise in the first valve to consider. As we know, it is not straightforwardly calculable like Johnson noise, so to make things as easy as possible for designers the valve makers specify the "equivalent noise resistance," which they denote by R_{eq}. But don't be misled by "resistance." It is as if the intensity of rainfall were measured in miles per hour, that being the speed of wind that would cause the same amount of rustling in the leaves. R_{eq} is no more a real resistance than rainfall is a wind. The reason for this roundabout approach is the difficulty of comparing the amounts of shot noise and Johnson noise in an amplifier if each is specified in its own terms. It is easy to compare them if shot noise is specified as the resistance between grid and cathode that would produce the same result by Johnson effect. In a low-noise pentode, R_{eq} is usually less than 2kΩ, so if the source resistance is at least 20kΩ one can reckon shot noise is unimportant. (Noise voltage at the grid being proportional to $\sqrt{R}$, and power being proportional to voltage-squared, noise power is proportional to resistance.) So any noise put out by this type of amplifier is almost entirely due to the resistance of the signal source; there is no excuse for the amplifier itself contributing anything worth mentioning.

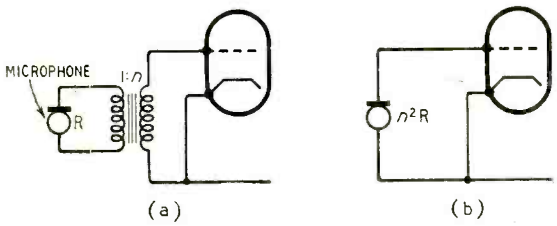


Fig. 1. For purposes of circuit calculation, a microphone or other signal source (a), having a resistance R connected to the amplifier by a perfect 1 : n transformer, is equivalent to a directly connected source (b) giving n times the signal voltage and having n^2 times as much resistance.

Next, we consider radio receivers. These may raise some queries about bandwidth. Broadcast receivers are designed to work on a bandwidth of twice the top audio frequency reproduced, in order to cover both sidebands of the transmitter. So they pick up twice as much noise as they would for the same audio band if they worked on the single sideband system used for radio telephone communication. Noise received along with both sidebands is transferred to the audio band by the detector. If the same transmitter power were concentrated into one sideband, and the receiver bandwidth halved accordingly, noise would be halved.

Noise from a Tuned Circuit

Up till now we have been assuming that the factor R in the basic noise formula—the resistance of the noise source—is the same at all frequencies, or at least all the frequencies accepted by the amplifier. But the input circuit of a receiver is normally a tuned circuit, and what is its resistance so far as noise is concerned? Is it the loss resistance, reckoned in series with the inductance and capacitance, and changing fairly slowly with frequency? Or is it the dynamic or equivalent parallel resistance, which is very high exactly at resonance and falls off sharply each side?

Actually it is the dynamic resistance that counts in the noise formula, so on a voltage reckoning this noise source itself has a limited bandwidth. But the bandwidth of a receiver sensitive enough for the noise to matter is practically certain to be much less than that of the first tuned circuit by itself, so there would be no need to worry about variation of dynamic resistance within it.

If one could vary the bandwidth of the receiver by a suitable variable-selectivity control, the effect on output noise of narrowing it would obviously be to reduce the noise, and at the same time alter its character. The alteration in character would not be conspicuous on a loudspeaker, but it was very prettily demonstrated by the receivers used at CH radar stations during the war, as the many R.A.F. and W.A.A.F. characters who operated them no doubt remember. The i.f. in these receivers was 2Mc/s, and there were three alternative bandwidths: "narrow" (50kc/s); "medium" (200kc/s); and "wide" (500kc/s). When the set was switched to "narrow," the noise that emerged from the i.f. amplifier was centred on 2Mc/s but included components 25kc/s above and below this. It could be regarded as a 2-Mc/s carrier wave modulated with complete irregularity at all frequencies up to 25kc/s. The detector converted the centre frequency to zero, and the noise voltages reaching the vertical deflector plates of the c.r. tube contained all frequencies up to 25kc/s. One half cycle of this highest frequency lasts for 20μsec. The time taken for a radar signal to go 1 mile and back again is 10.7μsec, so even the narrowest pulse of noise would occupy a width on the range scale equivalent to nearly 2 miles, or about one hundredth of the whole scale. Most of the noise structure, being lower in frequency, was still coarser, the general appearance being as in Fig. 2(a). (Because 25 pictures like this but all different in detail were superimposed per second, the noise actually looked more massed together than this, but all the outline were decidedly rounded.) With the switch at "medium" the noise frequencies ranged up to 4 times as great, so it looked much spikier ; and on " wide " there were noise frequencies up to 10 times the maximum on " narrow," so spikes could be less than 0.2 mile wide, making a typical picture more like Fig. 2(b) and the visible effect like very fine grass in a lively state of animation. The amplitude was not changed very much by bandwidth switching, because what the amplifier gained in bandwidth it lost in amplification.

At long and medium-wave broadcasting frequencies there is generally so much noise of other kinds—atmospherics, electrical equipment noise, and radio interference—that electron noise is seldom heard above the tumult. A possible exception might be a highly sensitive set with a very small aerial—say a small frame aerial loosely coupled to the first tuned circuit. In such a case the incoming signal might be so feeble that the set gain would have to be brought up to the point where it would reveal Johnson noise of the input circuit. But generally speaking it is only at the higher frequencies that electron noise is a major problem. Radar is the outstanding example of noise-limited communication ; but v.h.f. radio is also affected.

We saw that in the microphone amplifier, likely values being assumed, the amplifier itself did not contribute a significant part of the noise. It all came from the signal source. That is the best possible situation ; the standard or ideal condition with which all others are compared. Assuming, as we did, that the input impedance of the amplifier was infinite, increasing the step-up transformer ratio would increase the signal voltage in the same proportion. But it would also increase the square root of the source resistance—and hence the noise voltage—in the same proportion. So, provided that the transformer ratio was high enough to make the source resistance much greater than the equivalent noise resistance of the first valve (so ensuring that the amplifier noise was negligible), there would be no point in raising the ratio further. The signal/noise ratio would not be appreciably affected. But if, for example, a 1-kΩ microphone were connected straight to an amplifier whose first valve had an R_{eq} of 2kΩ, the result would be to multiply the noise/signal ratio by 3, compared with the ideal noiseless amplifier. This condition is stated compactly by saying that the *noise factor* is 3. It means that the result of amplifier noise is to make the noise 3 times as bad as in the ideal case where the signal source is the sole noise generator. In an ideal amplifier or receiver the noise factor (which is usually denoted by N) would be 1.

There are various slightly different definitions of noise factor (in America, " noise figure "), but I am not proposing to go into these. Perhaps the simplest way to reckon it is as :

$$N = 1 + \frac{\text{noise power generated by receiver (referred to the input terminals)}}{\text{noise power at input terminals due to signal source.}}$$

Try checking the factors in the examples (1 and 3) by this.

When the first stage amplifies largely, it is the only one that need be considered as a noise generator. Otherwise, the second and perhaps even third stage will contribute appreciably. So clearly the first requirement for low noise factor is a reasonable gain

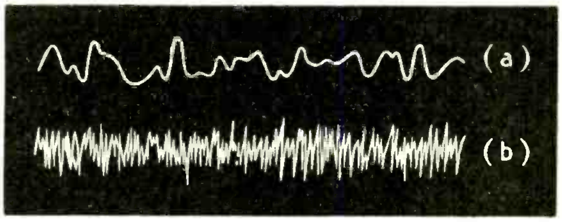


Fig. 2. Appearance of noise on a c.r. tube trace when the amplifier has a (a) narrow (b) wide bandwidth.

from the first stage—say at least × 3 in voltage. While there is no difficulty about this up to perhaps 100Mc/s, it becomes rather a problem at higher frequencies.

The next thing is to see that the first valve introduces as little noise as possible. This is judged by comparing its R_{eq} with the source resistance, both being referred to the same point—the input terminals—as we have already been doing. Some readers may prefer to do the thing a little more mathematically. The noise voltage due to a resistance R is, as we know, $2\sqrt{kTBR}$. As we shall be having rather a lot of this $2\sqrt{kTB}$ thing, let us denote it by K for short, so that we can write the noise voltage as just $K\sqrt{R}$. Now look at Fig. 3(a), where the signal source is represented by the circuit to the left of the dotted line. R is its resistance, E_s the open-circuit signal voltage, and $K\sqrt{R}$ the open-circuit noise voltage. These are all the essentials. For the reasons I explained there is no need to show R_{eq} as a resistance ; the essential thing is its noise voltage, $K\sqrt{R_{eq}}$, which is equivalent (so far as the valve output is concerned) to the shot effect inside the valve. The signal/noise voltage ratio of what is coming from the signal source is clearly $E_s/K\sqrt{R}$, but to be able to add different lots together we must reckon in power*, and on that basis we have to square the voltages, making the signal/noise power ratio E_s^2/K^2R. The signal noise ratio of what comes out of the valve (and—since we are neglecting noise from later stages—out of the amplifier as a whole) is worsened by R_{eq}, being $E_s^2/K^2(R + R_{eq})$. The noise factor N, which is the worsening factor, must be the ratio of these two signal/noise ratios : $E_s^2/K^2R \div E_s^2/K^2(R + R_{eq})$, which simplifies to $(R + R_{eq})/R$, or $1 + R_{eq}/R$, in agreement with our general definition of N.

If a 1 : *n* step-up transformer is used, the corresponding representation is Fig. 3(b), where we see that the signal voltage is *n* times greater ; the source noise voltage is also *n* times greater ; so the source signal/noise ratio is unchanged. But N is changed from $1 + R_{eq}/R$ to $1 + R_{eq}/n^2R$. So if R_{eq} is substantial compared with R, the step-up considerably improves matters ; but if not, not. Try a few values and see. In our microphone amplifier there was no foreseeable reason why n^2R should not be made far greater than R_{eq}, so bringing N down nearly to the ideal 1.

But the radio receiver, being as we suppose highly sensitive, is almost certain to have at least one frequency changer. The mere process of shifting the incoming r.f. band to a different (usually lower) r.f. called the i.f. does not in itself necessarily increase

* " Total Power," March 1952.

noise. But if the designer were to say to himself that it was so much easier to amplify at i.f. than at a very high r.f. that he would do all his pre-detector amplifying at i.f., it would mean that the first stage was the frequency changer. For various reasons a frequency changer generates considerably more noise than a straight amplifying stage. There is the oscillator to make a contribution. Then a frequency-changer valve such as a hexode has a lot of electrodes to cause partition noise. But the most serious thing is that the conversion conductance is at best only about one-third of the mutual conductance. What this means is that for a given r.f. signal input the i.f. output voltage from a frequency changer is at most about one-third of the r.f. output of a similar valve used as a straight amplifier. But the noise generated is at least as much, so the net effect is a serious drop in signal/noise ratio, or rise in noise factor.

The answer is to use at least one stage of r.f. amplification before the frequency changer, provided it can be coaxed into amplifying usefully. But when one gets into thousands of Mc/s—and for most people considerably less than that!—all coaxing fails, and (except for the new travelling-wave tube) there is nothing for it but to use the quietest frequency changer that can be got. This problem was acute during the last war when microwave radar was introduced; the solution was the crystal diode, which was the ancient crystal detector brought up to date.

Return of the Triode

At the same time the frequency at which r.f. amplifiers could be made to work was pushed considerably up. It is perhaps rather puzzling to find that triodes are used. One was taught that a triode was useless for amplifying even moderately high frequencies because of feedback from anode to grid, causing oscillation. So it seems paradoxical to find them being used to extend the range of useful r.f. amplification into the hundreds of Mc/s. The reason they are preferred is that the fewness of electrodes causes them to be quieter than multi-electrode valves. And the reason they can be used is the earthed-grid technique. Instead of the usual type of connection, Fig. 4(a), the input leads are reversed (b). The earthed grid acts as a screen between the input (cathode) and output (anode). This scheme would not succeed at ordinary broadcasting frequencies, because the amplification is very poor by pentode standards, and the input impedance is very low. But at the frequencies in question it would be low anyway, and one is thankful for a gain of even 2 or 3, provided that valve noise is small.

If, with Fig. 3 still in mind, you are wondering why there is such a fuss about the first valve, seeing that we swamped its shot noise by using a sufficiently high step-up ratio n, the answer is that while Fig. 3 may be a fair enough representation of an a.f. amplifier, with its supposedly infinite input impedance, it certainly will not do at very high r.f., where the input resistance is quite low owing to electron transit-time and other effects. At 100Mc/s it is only a few thousand ohms at best, and may actually be less than R_{eq}. Moreover, it is necessary to have some sort of input tuning circuit, and its dynamic resistance comes in parallel with the valve input resistance. So the simplest equivalent circuit that can be used is Fig. 5, in which R_i is the input resistance of the valve and the input circuit lumped together; and of course it gives rise to its own noise voltage $K\sqrt{R_i}$. The signal voltage reaching the valve is no longer nE_s, but $nE_sR_i/(n^2R + R_i)$; and the maximum for a given E_s and R_i is obtained by making $n^2R = R_i$. This is done by adjusting the step-up ratio n. If R_i is lower than R, n would have to be less than 1, so it would be a step-down.

It is quite straightforward to apply the general

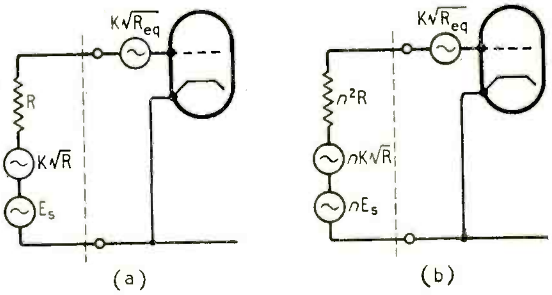


Fig. 3. In these equivalent circuits the signal source is represented by the generators (signal and noise) to the left of the dotted line, and the shot noise in the valve by the generator $K\sqrt{R_{eq}}$ (R_{eq} being the "equivalent noise resistance" of the valve). (b) is the same as (a) except that a 1 : n transformer is used between source and amplifier.

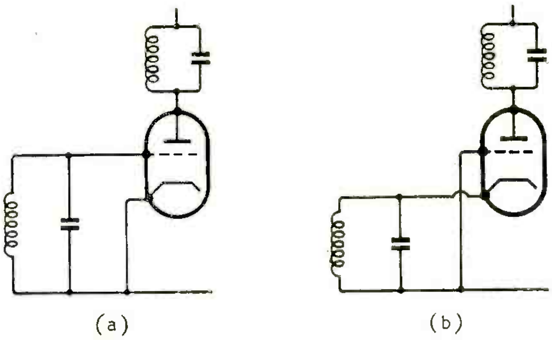


Fig. 4. At very high frequencies the input resistance of a valve is quite low, and it is advantageous to change from the conventional connections (a) to the earthed-grid scheme (b). (In practice the tuning circuits are altered too, but here they are drawn the same as in (a) in order to emphasize the difference in valve connection.)

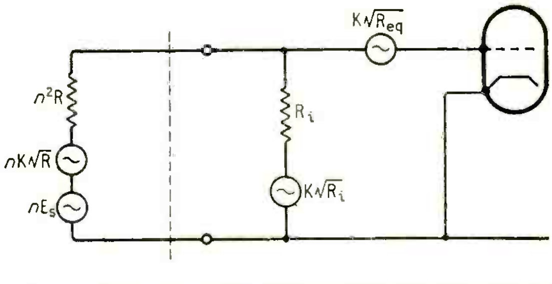


Fig. 5. Elaboration of Fig. 3(b) to include the effect of input circuit resistance (both inside and outside the valve), represented by R_i, with its own noise generator $K\sqrt{R_i}$.

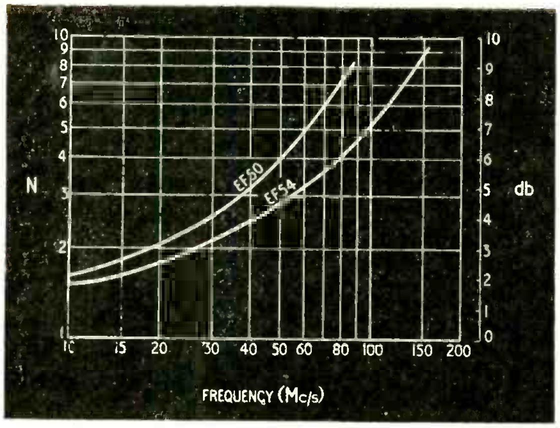


Fig. 6. Examples of how the lowest possible noise factor (N) rises with frequency, showing the result of improvements in the design of the EF50, embodied in the EF54. All depends on the first valve in the set.

formula for noise factor to this equivalent circuit, and the result is

$$N = 1 + \frac{n^2R}{R_i} + R_{eq}\frac{(n^2R + R_i)^2}{n^2RR_i^2}$$

Although this formula may look rather formidable, it shows up the situation quite clearly. First, suppose the valve itself is noiseless: $R_{eq} = 0$, so the last term goes out and leaves $1 + n^2R/R_i$. If the input resistance of the valve is infinite (as we assumed with the microphone amplifier), the second term goes out too and we are left with N = 1, meaning a perfectly noiseless amplifier. Next, still with $R_{eq} = 0$, adjust n to make $n^2R = R_i$ to get maximum signal into the amplifier. Now N = 2. Reducing n, making the input coupling a step-down ratio if necessary, mismatches the load and reduces the signal strength, but also reduces N, so improves the signal/noise ratio. With a truly noiseless valve, we could in this way get as near the ideal N = 1 as one wished; but in practice R_{eq} puts a limit to it, for if n^2R is made very much smaller than R_i the last term reduces to approximately R_{eq}/n^2R; which shows that the more n is reduced the greater this term becomes, and the worse the noise factor.

So we find that if the step-up ratio n is made very large the second term becomes large; if it is made very small the third term becomes large; in either case the noise factor rises. For every given R_i and R_{eq} there is a best n that gives lowest N. So we see (1) that the coupling of the aerial or other signal source to the receiver is important; (2) that matching the aerial impedance to the receiver, though it may give the strongest signal, does not give the lowest noise factor; and (3) that when the input resistance R_i falls (as it does rapidly at frequencies above 30Mc/s) it spoils one's chances of reducing the effect of valve noise (R_{eq}) by increasing n. So, as the frequency rises, N is bound to rise too; and that is why the electron noise problem is so serious in v.h.f. and radar. Fig. 6 shows two examples of how the best obtainable noise factor rises with frequency. The higher the frequency, the more important it is to choose a first valve (or crystal) with as low a noise resistance as possible. At the same time, as we have noted, its gain should be high enough to make the noise contribution of later stages negligible in comparison.

In practice one can't calculate N accurately, and it is necessary to measure it. The simplest method is to use as one's signal generator a "noise diode"—a diode valve used under the conditions that do allow of reasonably accurate calculation from the formula repeated at the beginning of this article. L. A. Moxon has covered this subject in the Jan., 1947, issue; and some of the radio instrument makers produce suitable apparatus.

A final point—the fact that a set has a satisfactory noise factor doesn't guarantee a good signal/noise ratio. The definition of N shows that it could be brought as near the ideal 1 as one liked by loading the signal source up with resistance. But since that would degrade the signal/noise ratio more than it improved N the last state would be worse than the first. So R, as well as N, should be reduced to a minimum.

TELEVISION EYESTRAIN

Results of Enquiry by Opticians

TO what extent is television affecting the nation's eyesight? In an endeavour to answer this question the Association of Optical Practitioners submitted a questionnaire to a representative sample of opticians in the service areas of Alexandra Palace, Sutton Coldfield and Holme Moss. The results of this investigation, which is the first of its kind to be undertaken in this country, were embodied in a report submitted to an optical congress at Bournemouth in April.

It would appear, from an analysis of the replies to the questionnaire, that up to one half of the country's viewers may associate symptoms of eyestrain with the use of television. The lecturer, J. L. H. Moss, stressed, however, that a person who is not an avid reader or cinema enthusiast may have a minor visual defect which does not inconvenience him in his normal occupation. Then, having acquired a television set, he spends hours concentrating on a small screen. His eyes become tired and he finds he needs spectacles, as he probably would have done had he suddenly developed a keen interest in books or films. Television did not cause the trouble, it drew attention to a small existing visual error which needed correction.

Television has introduced new visual problems and, "in the interests of comfort in viewing," the Association of Optical Practitioners has issued a pamphlet drawing attention to seven simple rules to ensure viewing without eyestrain. These include the injunction to view in a reasonably illuminated room (it is inadvisable to look at television in a darkened room). The ideal viewing position is directly in front of the screen at a distance of approximately eight times the diameter of the tube and looking slightly down.

Two of the seven rules draw attention to the need for correct adjustment of the set. Incidentally it would appear from an analysis of the replies to the questionnaire that probably 65 per cent of viewers are operating their sets under conditions which could be improved if more attention were paid to lighting, viewing distance and the correct adjustment of the brightness control.

It is interesting to note that the findings of this investigation confirm the results of similar research undertaken in America.

LETTERS TO THE EDITOR

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

Colour Coding

I STRONGLY disagree with "Diallist" when he writes desiring resistors to be marked with figures instead of colour coded (p. 206, May *Wireless World*). Colour coding enables a resistor to be quickly located and its value easily read even if it is more than half buried by wires and other components in a set. Again, colour coding makes it easy to spot the required value among a whole box full of resistors. I do, however, think the "spot" colour should always be a band, first, because there is much less chance of it being rubbed off, and secondly, because it cannot be hidden by being under the resistor as can happen with a spot. For the same reason, if figures *must* be used, they should be repeated in a spiral right round the resistor.

Regarding the wattage rating, this can usually be seen by the size of the component, but if it is thought necessary, it is *this* that could be marked on in figures, since one need only know the wattage when selecting the resistor for the job.

Surely any experimenter worthy of the name should find little difficulty in mastering the standard colour code when it is to his advantage to do so.

Totland Bay, I.o.W. R. V. GOODE.

I MUST differ from "Diallist" on colour coding (your May issue).

Whilst admitting that a number on a piece of paper is quicker to read than a set of colours, these conditions do not obtain in radio work. Having worked on a number of continental receivers where colour coding is seldom used, I know the time wasted in pushing components about to read the value of a "submerged" resistor and if you keep your resistors in trays or boxes in decade steps you will know how quick it is to find a particular value by colour, but how hard it used to be in pre-coding days.

Then, too, when servicing a set where a circuit diagram is available, the particular section one is interested in can be found immediately by the distinctive colouring of the resistors associated with that circuit—far quicker than were there sets of numerals.

No, Sir; while admitting the many small disadvantages of the present coding, I cannot agree that reverting to figure marking would be helpful—or even sane, with the increasing complexity of equipment.

Beckenham, Kent. P. G. SKANE.

Hot Stylus Technique

IN reply to D. W. Aldous's letter (April issue), I should like to make the following points.

My main reason for winding the coil immediately above the sapphire on the shank, in preference to the shank itself, is simplicity. It is far easier to wind a dozen or so turns of 44 s.w.g. wire on the shank than it is on the small length of sapphire that is usually available between the shank and the tip. Further, due to the inherent tendency of the swarf to ride up the flat of the cutter, which is even more in evidence when the cutter is heated, there is far greater danger of the swarf coming into contact with the coil and volatilizing.

These advantages, I consider, outweigh the disadvantages that more heat must be applied to overcome that lost by conduction away from the tip by the shank, and that the moving parts of the cutter head must be capable of dissipating the slight increase of heat without affecting any thermosensitive compliance.

D. W. Aldous states that "currents of the order of 0.4 to 0.5 A may be employed," but gives no indication of the resistance of the coil he uses, which might vary from 0.5 to 35 Ω, depending on whether he uses copper or resistance wire. What is of importance is the watts dissipated in the coil, and about 0.75 watt appears to be the optimum; any appreciable increase on this figure is merely dangerous, due to the liability of the swarf to ignite. A plot of surface noise against power input to a coil taken on a $33\frac{1}{3}$-r.p.m. disc at 5in diameter, with a 10-micron bevel, shows a rapid fall of surface noise as the power is increased up to 0.5 watt, and then a flattening out as the curve becomes asymptotic to a figure determined by rumble and other mechanical noises. An improvement of some 20 db can result.

In order to effect an improvemnent on the upper frequency response the bevel may be reduced to about 5 microns with hot stylus without depreciation of surface noise.

M. C. PHILIP.

Northwood, Middlesex.

I SHOULD like to add a little more information, gathered from experiments made by my company, on the subject of hot stylus technique.

As we all know, the highest possible quality obtainable on disc is achieved by using a sharp edge stylus on wax. For obvious reasons this is not practicable except where a reasonable number of copies are required to warrant the cost of processing, hence the acetate disc.

Acetate offers considerably more resistance to the stylus, and even when using a cutter head with plenty of "punch," the groove when cut with a sharp stylus is noisy and grey in appearance. The best method we have found to overcome this is to dull the cutting edge in such a way as to produce a minute radius (0.00015in) along the entire working edges of the sapphire, which would normally be sharp. A stylus of this type, when set into the cutter head with care, produces a bright and silent cut with a very good top frequency response, but the average commercial recording studio simply cannot spare the time usually required to fiddle about adjusting the angle of cut; added to which is the cost of expensive discs used up during this process of getting the cut right.

The negative bevel (Capps') American patent, which is used almost universally to-day, produces a clean, bright cut with a minimum of adjustment, but with a reduced top response.

The hot stylus which is intended to combat this condition, that is to produce a clean, quiet cut with a good top response, does do this, but it also introduces a noticeable element of distortion. By cutting at very slow speed with a microscope rigged up immediately behind the cutter head it is possible to observe the freshly cut groove which has been warmed by the sapphire at the moment of contact slowly creeping back to an altered position on cooling; in other words, the groove actually changes its shape after having been cut. However, in spite of this defect, hot stylus is at present the most practical method of direct disc recording, in so far as it does achieve the best possible results with a minimum of trouble to the recording machine operator.

Concerning the origins of this method of recording, I believe that a resistance-heated stylus was tried out in this country by L. Stroud as far back as 1930.

E. R. WALLWORK.

Colton & Co. (Lapidaries), Ltd.,
London, S.W.19.

HEATING the stylus is only one way of warming the recording medium, and sounds rather crude to me unless radius compensation is applied to ensure uniformity of heat transfer at all linear groove speeds.

I have vivid recollections, as a small boy (*circa* 1912), of helping my father to make direct-*cylinder* recordings with an Edison-Bell phonograph. As No. 2 on the machine, my job was to hold a hot flat iron an inch or two from the surface of the wax; my reward was a sound cuff when I allowed the iron to lag instead of lead the soundbox.

HENRY MORGAN.

Hindhead, Surrey.

Picture Quality

WITH reference to the suggestion of C.E.S.R. in your May issue, concerning a type of "frame displacement" at 12.5 times per second, I would like to mention of my own experience of this device. In 1946-47 I and some colleagues were experimenting with "cross scanning sequences"; that is, one frame vertical, next frame horizontal, with the lines in the opposite sense. During this period we actually put into practice the scheme suggested by C.E.S.R. and the result was this. Although one can synthesize triple interlace with this device, the additional low frequency (12.5 c/s) component gives rise to excessive eye strain, and this can be minimized by ensuring that only pure square wave forms are used to shift the frame mean position. But even here the presence of such a low frequency component cannot be eliminated, and can only extend the very short viewing period without eye strain. With reference to the extra brightness available suggested by C.E.S.R., it is surely not the same as in spot wobble; for one thing, the mean length traced out by the spot is not increased as in spot wobble where the spot traverses a larger area for a given "line." HENRI THOMAS PICHAL.

Westcliff-on-Sea, Essex.

"Standardizing Television I.F."

THE letter from the Secretary of B.R.E.M.A. in your April issue is very good in its own way. The choice of the i.f. will do something towards freeing television from interference by other services, but it is to be hoped that this alone is not the best to be expected, as it is not sufficient.

Any amateur with a 150-watt transmitter on 14 Mc/s knows only too well that, even when he has eradicated harmonics, sets in his vicinity will be swamped by his fundamental signal, which is about *sixty per cent* off tune at the receiver. To talk, as some dealers do, of amateur "interference" under these conditions, is almost impertinence. "Receiver incompetence" would be a better term.

The amateur, to remain on friendly terms with his neighbours, usually provides a high-pass filter. The mere fact that it so often succeeds proves that the trouble is not usually due to illegal radiation on his part. One wonders what happens when commercial and Services transmitters cause interference. Do *they* have to accept responsibility for wide-open r.f. or mixer stages in television receivers?

The onus should be on the receiver designer to clear the trouble by the inclusion of a cheap and simple high-pass filter, cutting off at about 35 Mc/s. For the "high i.f." adherents this would be an i.f. rejector. For the "low i.f." supporters it would be the cure for second-channel interference. For the transmitting amateur it would be merely justice.

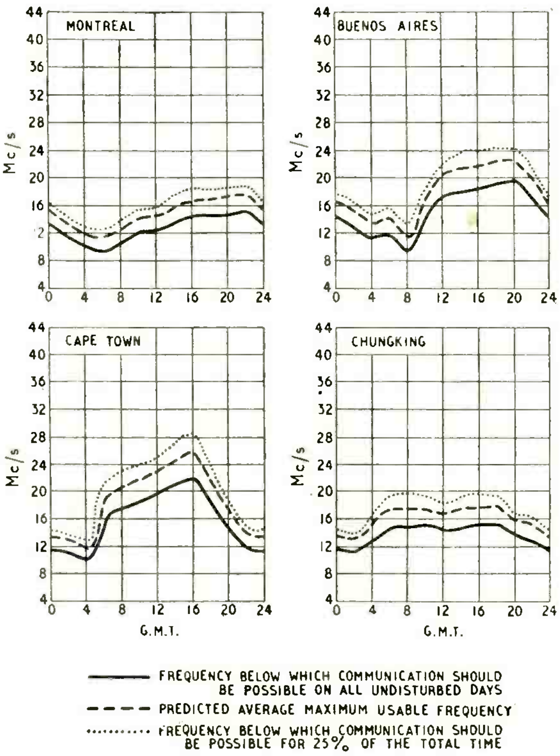
Worksop, Notts. H. S. CHADWICK, G8ON.

Short-wave Conditions

Predictions for June

THE full-line curves given here indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during June.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.



WORLD OF WIRELESS

Allocating Europe's Television Frequencies ♦ A.M./F.M.: Present Position ♦ Marine Navigational Beacons

European V.H.F.

THE conference of representatives of all countries in the European Broadcasting Area to discuss the question of v.h.f. broadcasting in Europe meets in Stockholm on 28th May. The main matter on the agenda is the allocation of frequencies for television and sound broadcasting in the bands 41-68, 87.5-100 and 174-216 Mc/s.

Although these bands were allocated at the Atlantic City Conference (1947) to European broadcasting, there were provisos permitting the use of sections of them for other services. We in this country, for instance, may use 66.5-68 and 95-100 Mc/s for mobile services, 85-90 for maritime radio-navigation, 94.5-95 for meteorological aids; 174-200 for fixed service; and 200-216 for aeronautical radio-navigation.

The British delegation to the conference which is scheduled to last a month numbers about ten—mainly B.B.C. and G.P.O. representatives.

Marine A.M. or F.M.?

IT will be recalled that the question was raised in the House last July regarding the request from the United States for the U.K. to reconsider its decision to use a.m. for single-channel v.h.f. maritime radio services. Incidentally, a.m. has also been adopted by a number of European and Commonwealth countries. The former P.M.G. (Mr. Ness Edwards) stated in July that he would stand by this country's decision in any international discussion.

Efforts have been made in various quarters to find a solution to this problem and *Wireless World* understands the Post Office hopes to have further discussions with other countries fairly soon and that it will continue to advocate the use of a.m.

During a recent visit to the United States, John Brinkley of Pye's, had an opportunity of discussing the a.m.-f.m. question with officials of the F.C.C. and the Port of New York Authority, when Pye a.m. equipment was successfully demonstrated. Apparently America has not committed herself so deeply as this country, and there are as yet very few v.h.f. radio-telephony harbour installations.

Show News

WHEN the ten-day Manchester radio show closed on May 3rd, a total of 100,793 people had seen the exhibits of the 39 manufacturers and eight other exhibitors. Twenty-eight of the manufacturers demonstrated television receivers in the communal viewing avenue, and in all there were about 160 television sets being demonstrated in the exhibition.

A proposal had been made to hold a show in Glasgow later this year, but the R.I. Council has decided against this in view of the Government's decision to reduce production for the home market.

At the recent ballot for stands at the National Radio Show (Earls Court, August 26th—September 6th) space was allocated to about 90 exhibitors.

It has been decided to hold next year's components exhibition at Grosvenor House, London, W.1, from April 14th-16th.

Welsh Television Opening

WENVOE, the last of the high-power television transmitters to be built, is expected to be ready for operation, using the standby equipment (5-kW vision and 2-kW sound), on 15th August. The official opening, by the Postmaster-General, Earl De La Warr, will be preceded by test transmissions.

The 50-kW main vision transmitter for the Wenvoe station is being manufactured by E.M.I. and the 12-kW sound transmitter by Standard Telephones and Cables. The station will operate in channel five (63.25 Mc/s sound, 66.75 Mc/s vision).

Radio Beacons

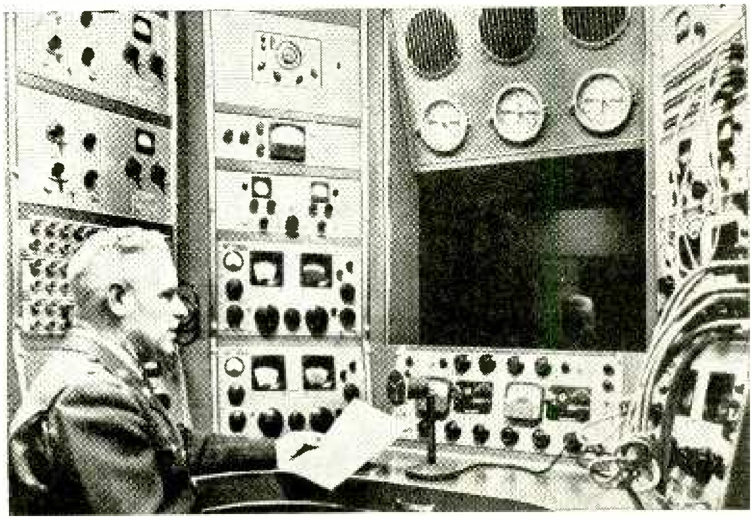
NEW equipment to comply with regulations laid down at the conference for the reorganization of maritime radio beacons (Paris, April, 1951) is to be supplied by Marconi's for over forty lighthouses and light vessels round the coasts of Great Britain. The new 20-watt medium-frequency navigational beacons, ordered by Trinity House, provide fully automatic operation with duplicate equipment to avoid a stoppage in the service.

Under the new plan, which comes into operation in August, 1953, the beacons are arranged in groups of two, three and six stations. The transmissions from the stations in the groups will take place alternately over a 6-minute cycle so that a vessel will be able to "fix" its position very rapidly and accurately by the intersection of a number of cross bearings.

Engineer's Jubilee

THE distinction of being the first engineer to spend fifty years in the wireless industry is claimed by Raymond D. Bangay, who, having joined the Marconi Company on 15th May, 1902, is still in the company's employ. In 1902 he went to America and for five years helped with the erection of stations, including the first U.S. coastal station.

In 1921 he was appointed chief of designs and in 1925 technical repre-



PRESIDENTIAL COMMUNICATIONS.—The array of controls at the console of the radio installation on the U.S. Presidential train gives some idea of the diversity of facilities available. They include radio-telephony, facsimile and teleprinting.

sentative abroad. He has held his present post—Foreign Manager—since 1935.

Wireless World is particularly interested in this jubilee for R. D. Bangay was the author of the first wireless text book, "The Elementary Principles of Wireless Telegraphy"—published by *W.W.*

PERSONALITIES

H.R.H. The Duke of Edinburgh has accepted the invitation of the Radio Industry Council to be the Guest of Honour at its second annual dinner at the Savoy Hotel on November 25th.

Lord Burghley, K.C.M.G., who is chairman of Cossor's, has accepted the invitation of the Radio Industry Council to become its president. He succeeds Mr. Oliver Lyttelton, who relinquished the presidency, which he had held since 1947, on taking office as Secretary of State for the Colonies.

Sir Robert Watson-Watt, C.B., F.R.S., who recently opened a Montreal branch of his company, Sir Robert Watson-Watt & Partners, has been appointed adviser on radar and electronics to the Canadian Defence Research Board. As the new post is a part-time one, Sir Robert will retain his advisory posts in this country.

Frank C. Connelly, Ph.D., A.M.I.E.E., has relinquished his post as head of Murphy's Electrical Design Dept. to become managing director of Acoustic Products, Ltd., a subsidiary of Murphy Radio. During most of his eighteen

DR. F. C. CONNELLY

years at Welwyn Garden City he has been associated with the electrical design of equipment. In 1950 Dr. Connelly produced a comprehensive work, "Transformers—Their Principles and Design for Light Electrical Engineers." He has done considerable work on safety precautions in receivers, and contributed an article on this subject in our January, 1951, issue.

Dr. Lee de Forest, pioneer of the three-electrode valve, was recently honoured by the American radio industry on the 50th anniversary of his entry into wireless.

D. P. Taylor, M.B.E., A.M.I.E.E., who had been with the Ministry of Civil Aviation since 1946, has relinquished the post of Senior Signals Officer in charge of telecommunications training to join the International Civil Aviation Organization. For three months he will be at the I.C.A.O. headquarters in Montreal and will then go on a two-year "technical assistance mission" to another country as civil aviation telecommunications adviser. Mr. Taylor was a Marine radio officer prior to joining the B.B.C. in 1935 as a maintenance engineer on high-power transmitters. During the war he was Technical Signals Officer, R.A.F. After his term of duty with I.C.A.O. he will return to M.C.A.

OUR AUTHORS

R. Brewer, who contributes the article "Valve Life Testing" in this issue, joined the Research Laboratories of the General Electric Co. in 1937 as a member of the Illuminating Engineering Dept. After considerable wartime experience with the production of experimental valves for radar and similar purposes, he was put in charge of the Valve Life-Testing Dept. in 1943.

G. N. Patchett, author of the article on interlacing on page 219, became Head of the Electrical Engineering Dept. of Bradford Technical College in May, where he has held various academic posts since 1940 when he joined the staff of the college to teach Servicemen radio. His own academic training was received at the college, where he graduated B.Sc. (electrical engineering). In 1946 he received the Ph.D of London University. He is an associate member of both the I.E.E. and the Brit. I.R.E.

F. R. W. Strafford, author of the article "Television Receiving Aerials," the first part of which appears in this issue, entered the radio industry in 1922 and commenced research work with Kolster-Brandes in 1928. He has undertaken research and development work with various companies and is now technical manager of Belling & Lee, Ltd. Mr. Strafford gained corporate membership of the I.E.E. by a thesis on the super-regenerative detector and has written and lectured extensively, particularly on aerials and radio-interference problems.

B.B.C. APPOINTMENTS

F. Axon, who joined the B.B.C. in 1941 as a member of the Overseas and Ionosphere Section of the Overseas and Engineering Information Department, becoming head of the section in 1949 and head of the department in 1951, has been appointed senior supt. engineer, external services. He has represented the B.B.C. at several international conferences, including Rapallo, Geneva and Mexico City.

F. Williams, B.Sc.(Hons.), M.I.E.E., who becomes senior supt. engineer, home broadcasting, has been with the Corporation since 1925. He has been engineer-in-charge at several stations and from 1943 to 1949 was asst. supt. engineer, studios. He has been supt. engineer, studios, since 1950.

H. G. Whiting, A.M.I.E.E., has relinquished his post as engineer-in-charge of the Sutton Coldfield transmitting station, which he has held since 1949, to become assist. E.-in-C. (Television), Birmingham. He joined the B.B.C. in 1932 at the Daventry station as a maintenance engineer, and four years later transferred to the London television station as vision equipment engineer and senior maintenance engineer, development. He returned to Alexandra Palace in 1946 as senior maintenance engineer, studios, having served as senior maintenance engineer at the Rampisham short-wave station during the war.

R. D. BANGAY
(See "Engineer's Jubilee")

R. C. Harman, A.M.I.E.E., who succeeds Mr. Whiting at Sutton Coldfield, joined the Corporation in 1935. He has been on the maintenance staff at Daventry and Alexandra Palace and has been asst. E.-in-C. at Sutton Coldfield since 1949.

H. W. Baker, A.M.I.E.E., who is appointed supt. engineer, television studios, joined the staff at Alexandra Palace in 1936 after ten years' service at various transmitting stations. During the war he was E.-in-C. at Lisnagarvey and Ottringham and returned to Alexandra Palace in 1945.

T. H. Bridgewater, M.I.E.E., who has been E.-in-C. television O.Bs since 1946, becomes supt. engineer, television outside broadcasts. With the exception of the war years, when he served as a signals officer in the R.A.F., he has been associated with television. He joined the Corporation in 1932 on the introduction of the 30-line service.

H. Walker, O.B.E., A.M.I.E.E., is appointed head of technical operations in the television service. Since 1950 he has been E.-in-C. of the London television station, to which he was transferred from the Newcastle broadcasting station in 1936.

M. H. Hall, who has been with the B.B.C. for 25 years, becomes E.-in-C. television studios. He has been maintenance engineer at both broadcasting and television stations and since 1950 E.-in-C. at the Lime Grove studios.

W. D. Richardson, who succeeds Mr. Bridgewater as E.-in-C. television O.Bs, went to Brookmans Park as asst. maintenance engineer in 1930. With the exception of the war years, when he was in the Station Design and Installation Dept., he has been in television. Since 1947 he has been asst. E.-in-C. television O.B.s.

IN BRIEF

Sir Edward Appleton, speaking of the British development of television at the Silver Jubilee Dinner of the Television Society: "Even the full possibilities of the present system have not yet been fully exploited, especially on the camera side. Let us concentrate on getting the best out of what we have. It seems that we were wiser than we knew in starting the 405-line system, for it turns out to be about the best compromise of fidelity, simplicity, and economy which could have been devised for home viewing. Anything more complex as regards the number of picture lines would have exposed us to the law of diminishing returns."

Receiving Licences.—The number of television licences in the U.K. increased by about 71,000 during March, bringing the total at the end of the month to 1,457,000. The increase during the first three months of the year was nearly 276,000. There were approximately 12,665,000 receiving licences (both sound and vision) current in Great Britain and Northern Ireland at the end of March.

Marconi's Birthday, April 25th, was the date ultimately chosen for the erection by the London County Council of the commemorative plaque on 71, Hereford Road, Paddington, recording that "Guglielmo Marconi (1874-1937), the pioneer of wireless communication, lived here in 1896-1897."

Baird's Birthplace, in Helensburgh, Dumbartonshire, now has a bronze plaque affixed to the wall recording that he was born there on August 30th, 1888.

Uruguayan Television Study.—The technical director of the Uruguayan broadcasting service, Senor Dante Tartaglia, has spent two months in this country (under the British Council's bursary scheme) studying British television. During his stay he spent a month with the B.B.C. and subsequently visited the factories and research establishments of a number of manufacturers. Senor Tartaglia is Professor at the Technical University of Uruguay.

Help Needed.—The Liberian Government is seeking the help of short-wave listeners in this country to assist in a survey of the coverage of the broadcasting station ELBC at Monrovia, which transmits on 6.025Mc/s daily from 15.15 to 23.15 G.M.T. Further details are available from the Liberian Government Public Relations Officer (6) at 20, Hereford Road, London, W.5.

"Physics and Sound Reproduction" is the title of the paper to be given by our contributor, D. T. N. Williamson, of Ferranti, Edinburgh, during the fourth conference on industrial physics (arranged by the Institute of Physics) to be held in the Royal Technical College, Glasgow, from June 24th to 28th. Details of the conference and the associated exhibition are available from the Institute of Physics, 47, Belgrave Square, London, W.1. The closing date for registration was May 15th, but applications from *W.W.* readers will be considered whilst there is room. Mr. Williamson's address will be given at 7.15 on June 25th.

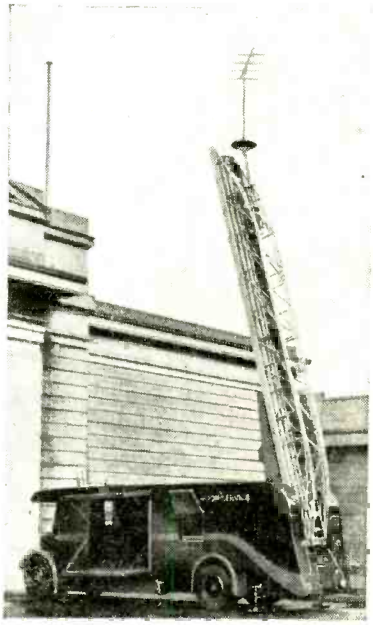
Radio Officers' Union.—H. Moore has been elected chairman of the Radio Officers' Union for the second year. He has been on the marine staff of Marconi's since 1920. The new vice-chairman of the Union is G. W. Cussans, who is a Deputy Flight Radio Officer with the British Overseas Airways Corporation. Prior to 1936 he was a sea-going radio officer with Marconi's.

Radar Association.—At the recent annual general meeting of the Association, Air Vice-Marshall D. C. T. Bennett was elected president. Grp. Capt. W. Proctor Wilson, Head of the B.B.C. Research Dept., has become a vice-president.

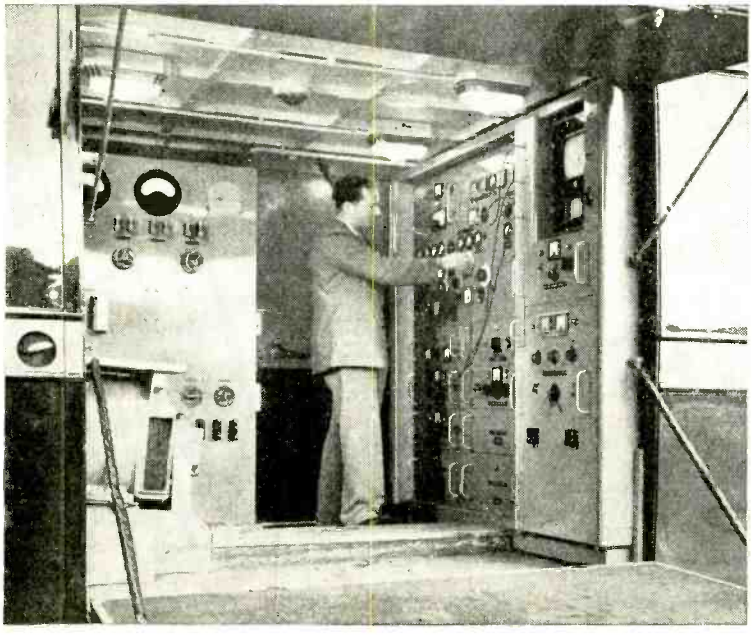
Wireless Dinner Club.—At the 29th annual general meeting and dinner of the British Wireless Dinner Club (founded by wireless officers of the 1914-18 war), at which Sir John Cockcroft, C.B., F.R.S., was the principal guest, Admiral A. J. L. Murray, C.B., was elected president in succession to G. M. Wright, C.B.E. The new vice-president is Air Vice-Marshal C. W. Nutting, C.B.E.

Models Show.—Originally planned for August, "The Model Engineer" exhibition will be held at the New Horticultural Hall, Westminster, from October 20th to 29th. The radio-control of models will again be a feature of this exhibition, which is to be opened by H.R.H. the Duke of Edinburgh.

Electronic Films.—The first film to be taken using the electronic system, developed by High-Definition Films, Ltd., in co-operation with Pye and cinema interests, was shown during the I.E.E. convention at which a paper on the system was presented by Norman Collins (chairman and managing director of the company) and T. C. Macnamara (technical director).



SCHOOL TELEVISION. The pilot scheme for school television was opened for four weeks on 5th May. Using an O.B. transmitter similar to this one, the programme is radiated with a peak white power of 340 watts in the 184-200 Mc/s band on a 40° beam to six schools in N. London. Frequency converters, provided by the B.B.C., reduce the frequency to that of Kirk o' Shotts enabling standard receivers (lent by manufacturers) to be used. Sound is conveyed by G.P.O. line.



Brit. I.R.E. in India.—As a result of the recently concluded visit of the general secretary of the British Institution of Radio Engineers (G. D. Clifford) to India, Sections of the Institution have been established in Delhi, Calcutta, Madras and Bangalore—a Section was already in existence in Bombay.

Mechanical Handling in various forms is employed in radio factories and we therefore bring to the attention of production engineers in the industry the forthcoming exhibition at Olympia from June 4th to 14th. During the exhibition, organized by *Mechanical Handling*, a convention will be held at which one of the papers covers the subject of electronics in materials handling. Tickets for admission to the exhibition are obtainable from the organizers, *Mechanical Handling*, Dorset House, Stamford Street, London, S.E.1. Separate tickets are required for the convention; these are obtainable on the day at the exhibition.

Amateur Show.—The R.S.G.B. has booked space at the Royal Hotel, London, W.C.1, for the week ending November 29th for its annual amateur radio exhibition.

A.R.R.L. Handbook.—The R.S.G.B. asks us to point out that it now has a stock of the 1952 edition of the A.R.R.L. Handbook so that copies can be supplied by return of post, price 31s post free.

Policing the Ether.—Plans have been approved by the European Broadcasting Union for the construction of a new Checking Station at Jurbise, near Mons, Belgium, in place of the present centre in the suburbs of Brussels. The change has been necessitated by the development of the previously rural district.

E.M.I. Scholarships.—The next four-year course in electronic engineering under the E.M.I. scholarship scheme, inaugurated in 1950, will begin at E.M.I. Institutes, 10, Pembridge Square, London, W.2, on October 14th. Applications for inclusion in the scheme, which provides for two six-month periods in the laboratories and workshops of the E.M.I. Engineering Development Co. during the course, must be made by August 29th. A descriptive brochure is obtainable from the Principal.

Digital Computing. — A Summer School in programme design for automatic digital computing machines will be held in the University Mathematical Laboratory, Cambridge, from September 16th to 26th. The course will give a basic training in the mathematical use of machines, dealing with the processes employed and their embodiment in programmes which specify the operation in detail. A syllabus may be obtained from G. F. Hickson, M.A., secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge.

Electronics Course.—The fourth eight-week full-time course in electronics and electrical engineering for students with little or no knowledge of electronics, opens at the South-East London Technical College, Lewisham Way, S.E.4, on October 6th. Particulars of the course, for which the fee for students residing in the L.C.C. area is £6 13s 4d, are obtainable from C. W. Robson, Head of the Electrical Engineering Dept. at the College.

Plastics Progress.—A collection of papers, based on the lectures and discussions at the 1951 British Plastics Convention, has been issued under the title "Plastics Progress" by our contemporary *British Plastics* which sponsored the exhibition and convention. Recent developments in the technology of plastics and their applications to various industries are dealt with in this fifty-shilling book.

Testing Varnishes.—A proposal to test impregnating varnishes by means of a standard test coil has been investigated by the Electrical Research Association and is endorsed as a more realistic method of simulating practical conditions than tests on isolated films. A detailed report is contained in publication A/T124, obtainable (price 21s) from the Association at Thorncroft Manor, Dorking Road, Leatherhead, Surrey.

Performance Specification for an automatic keying device for use in merchant ships has been issued by the Post Office. This specification, which is one of the series "Radio for Merchant Ships," is published by H.M.S.O., price 4d.

Correction to "Winds in the Ionosphere," page 188 of May issue. The last sentence of the penultimate paragraph should read: "In the *summer* the wind direction is principally towards the east and in the *winter* months generally south-westerly."

Pye's are lending the two-way radio-telephone equipment for installation in the sailplanes to be used by the British gliding team competing in the World Gliding Championships to be held in Spain this month. The lightweight equipment will enable the pilots to keep in constant touch with their attendant cars.

Microgroove Records are to be made by E.M.I. for distribution in this country. As promised in 1950, the company has given the trade six months' notice of its intention to introduce "records of speeds other than the standard 78 r.p.m." in October.

E.M.I. Sales & Service have appointed W. H. Perkins, O.B.E., M.Sc., lately Director of Education for Warwickshire, as their Educational Adviser in succession to A. C. Cameron, M.C., M.A., who has resigned on medical advice. Mr. Perkins' office is at the Gramophone Co., Ltd., 363, Oxford Street, W.1. (Tel.: Mayfair 1240.)

Decca Radar, Ltd., have formed a new division of the company—Radar Applications Division—which will be concerned principally with the study of marine radar and harbour radar and associated systems, and the planning of installations. R. F. Hansford, late of the Admiralty Signal and Radar Establishment and Sperry Gyroscope Co., has joined Decca to take charge of the new division.

"Design from Britain," the exhibition recently held in Oslo under the auspices of the British Council and the Council of Industrial Design, to boost the prestige of British consumer goods, includes the Pye PE39 short- and medium-wave export receiver.

BUSINESS NOTES

Digital Computor, similar to that installed last July in the Manchester University, has been built by Ferranti for the National Research Council of Canada and will be installed in the University of Toronto. A brief description of the computor, which uses only 3,500 valves compared with the 20,000 employed in ENIAC, was given in our August, 1951, issue.

Ace Radio's new chief engineer is S. F. Wiercinski, who joined the company's laboratory staff in August last year. He was previously assistant to the chief engineer at Rees Mace (Marine), Ltd. Ivor Troostwyk, the managing director of Ace Overseas, Ltd., sole export distributors of Ace products, is on a three months' business tour of the Far and Middle East.

International Aeradio's operations manager, G. R. Scott-Farnie, during his recent 16,000-mile tour of the company's stations in the Far East, arranged for I.A.L. to provide air traffic control facilities for the Sarawak Government at Sibu airport. L. M. Layzell, who has joined the staff of I.A.L. from the flight operations department of the Royal Dutch Airlines (K.L.M.), was in the Signals Branch of the R.A.F. on radar during the 1939-45 war.

Falkland Islands, with a population of some 2,000 on the hundred or more small islands south-east of South America, is being equipped with a new 5-kW medium-wave broadcasting transmitter. This Marconi installation at Port Stanley replaces the 45-watt transmitter erected in 1942.

Switzerland's first television station, which is expected to start transmitting very shortly, will use Pye cameras. Five stations are planned for Switzerland—at Zurich, Berne, Geneva, Lausanne and Lugano—which will operate on the standards approved by C.C.I.R., i.e., 625 lines and negative modulation.

Five hundred loudspeakers, grouped in 80 circuits and fed from four 500-watt amplifiers, have been installed by G.E.C. in the tobacco factory of John Player & Sons, Nottingham. In addition, a 60-watt amplifier installed in works in another part of the town is linked by G.P.O. line to the main installation from which it is remotely controlled.

Marconi Marine Installations.—Among the vessels recently equipped with Marconi Marine communication gear and radio navigational aids are the new twin-screw passenger and car-carrying ship *Lord Warden*, to be used by the British Railways between Dover and Boulogne, the 18,400-ton tanker *Eva Peron* and seven trawlers being built in the Hull area. The company has also equipped twenty-nine of the thirty-one vessels comprising Pakistan's merchant fleet. The twenty-fifth ship of the Royal Mail Lines' fleet to be equipped with Marconi Marine radio-communication and navigational aids is the *Ebro*, a 5,500-ton single-screw cargo vessel. The new 10,000-ton cargo steamer *Romney*, of the Lamport & Holt line, is also fitted with Marconi gear.

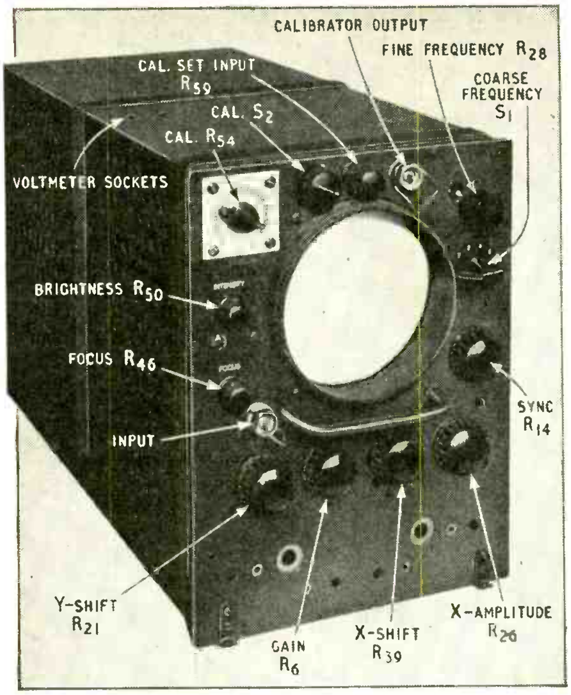
Radio Resistor Co., Ltd., of 50, Abbey Gardens, London, N.W.8, have been appointed sole distributors in the U.K. of the electronic components—including high-stability resistors and fixed capacitors—manufactured by Rosenthal Isolatoren of Bavaria.

A consignment of Pye 100-watt v.h.f. transmitters and associated receivers, 15-watt mobile and fixed transmitter-receivers and marine radio-telephone sets was recently shipped to East Pakistan for the police force in Dacca.

British Relay Wireless, Ltd., has appointed as commercial manager of the B.R.W. Group of Companies Barry King, who, during the past seven years, has successively occupied the positions of chief internal engineer and chief planning engineer.

Business Radio v.h.f. equipment has been supplied by Marconi's for ten Swedish tugs. They are fitted with Type H16 transmitter-receivers.

C.R.T. Service. — Standard Telephones and Cables' depots at 5, Oldbury Road, Blackheath, Birmingham, and 87, McAlpine Street, Glasgow, C.3, are now able to exchange "over the counter," defective Brimar television tubes still under guarantee.



General view of the oscilloscope. The voltmeter for the calibrator plugs into sockets which are accessible through holes in the top of the case.

TELEVISION OSCILLOSCOPE

Simple Design With 5-in Cathode-Ray Tube

By W. TUSTING

AN oscilloscope is used in television mainly for the examination of the waveforms produced by receiver time bases and for checking the operation of sync-separator circuits. The lowest and highest repetition frequencies are 50 c/s and 10.125 kc/s. These frequencies are neither particularly low nor particularly high and, at first sight, there would seem to be no great difficulty in building amplifiers or other circuits to handle them without distortion.

However, it is in their amplifiers and control circuits that so many simple oscilloscopes fail when used in television. For so many years the main occupation of wireless people has been with sound broadcasting that the requirements of sound are often carried over unconsciously into other spheres without proper examination. The simple oscilloscope may well have an amplifier response which is flat within 0.5 db from 50 c/s to 10 kc/s. This appears to be quite adequate for television purposes, but it is not. Such an amplifier is quite useless and grossly distorts television waveforms.

It is, in fact, not very helpful to think in terms of frequency when discussing non-sinusoidal waves and it is much better to think in terms of sags and rise times. Neither of these is very familiar and it is consequently necessary to define their meanings. The sag is related to the amplitude and phase responses at low frequencies, whereas the rise time is related to these responses at high frequencies. Usually they can be considered quite independently of each other.

The dotted rectangle in Fig. 1 (a) represents a rectangular pulse of duration τ. If this is applied as an input signal to an amplifier the resulting output voltage is likely to be of the form shown by the solid line. At the end of the pulse the output voltage sags below the level at the start of the pulse. There is an overshoot equal to the sag and a long trail after that.

The sag is thus the amount by which the output at the end of a pulse falls below the value at the beginning, the ideal pulse being a flat-topped one. In passing, it may be said that a negative sag is possible, but unusual; it means a waveform like that of Fig. 1 (b), where the output rises during the pulse.

The sag is produced mainly by the low-frequency phase characteristic of a circuit but it is usually easier to forget this aspect and to consider it from the point of view of the step response. As an example, the typical RC-coupling of Fig. 2 may be considered. If the grid voltage of the valve is suddenly changed from

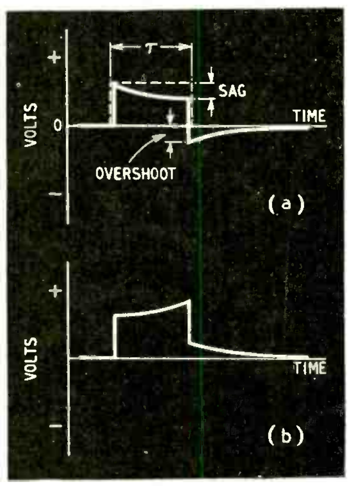


Fig. 1. With an input rectangular wave, shown dotted in (a), the output normally tends to the form shown by the solid line. The fall during the pulse is known as the sag. A rise during the pulse (b) is possible with some circuits but is unusual.

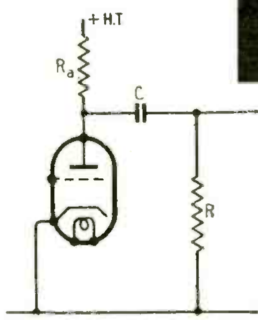
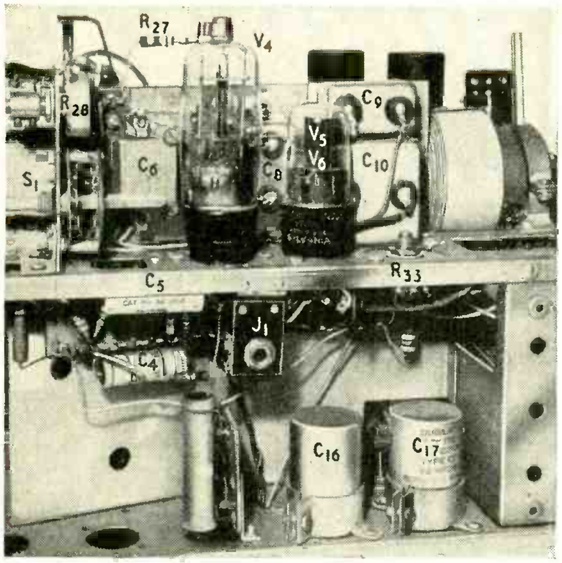


Fig. 2. Typical RC coupling in which the amount of sag depends on the time constant CR.



The time-base is mounted on the upper deck alongside the c.r. tube.

one value to another the anode current changes also and with it the anode voltage. This change is communicated through C, since a capacitor cannot change its charge instantly, and appears across R in its entirety. A voltage across R, however, calls for a current in it and the current demands that C should change its charge. Although the anode voltage of the valve may stay constant at its new value the voltage across R gradually falls; as C, by charging or discharging, provides the current, the current gradually falls and eventually becomes zero. The voltage across R is then also zero and the change of voltage appears fully across C.

Following the initial change of voltage, the voltage across R falls off exponentially from its initial value. The difference between the initial value, when zero time has elapsed after the change of grid voltage, and the value at any later time is the sag at that time. For the circuit of Fig. 2, the sag is given by the very simple expression

$$\text{Sag} = t/\text{RC}$$

with t in seconds, R in megohms and C in microfarads. This is an approximate relation which is accurate enough for sags up to about 0.2.

Fig. 3. The effect of the high-frequency characteristic of an amplifier is to affect the edges of a pulse. The ideal pulse (dotted) is transformed to the shape of the solid line pulse.

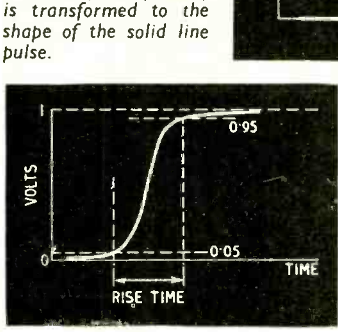


Fig. 4. The rise time of an amplifier is usually defined as the time required for the output to change from 5 per cent to 95 per cent of its final value when an ideal pulse is applied at the input.

As an example, common values for C and R are 0.1 μF and 1 MΩ where a good low-frequency response is needed. The frequency response at 50 c/s is 0.9995, which seems good enough for anyone. A rectangular pulse repeated 50 times a second has a duration of 0.02 sec, very nearly, if the interval between successive pulses is small. The sag during such a pulse is 0.02/0.1 = 0.2 so that the output falls by 20% by the end of the pulse. This is gross distortion.

Now let us consider the rise time. This affects the "vertical" edges of the pulse and converts a pulse of the form shown dotted in Fig. 3 into one like the solid line. It often happens that the output rises very slowly at the start and end of the rising part of a pulse, somewhat as shown in Fig. 4. It is then difficult to specify the rise time precisely. To avoid this difficulty the convention has grown up of taking the rise time as the time required to change from 5% to 95% of the final value.

After this digression we are in a position to consider what is needed in an oscilloscope for television. The waveforms of longest period occur in the frame time base and, as the frame fly-back time does not exceed 1.5 msec, the long part of a saw-tooth lasts for 18.5 msec. This is near enough to 20 msec to use the round figure. During this time the sag must be negligible if the picture on the tube face is to be undistorted.

The question now is, "What is negligible?" Suppose we use a 5-in tube and normally have a trace 4 in ≈ 10 cm high. Suppose the spot diameter is 1 mm. It is unlikely that we could detect a sag which did not exceed the spot diameter, which means a sag of 1/100 = 0.01. Because of the curved face of the normal tube and other tube distortion this is probably an unnecessarily small figure and it would not be unreasonable to allow a sag five times as great, or 0.05.

The highest repetition frequency is 10.125 kc/s, but the rise time of the leading edge of a sync pulse does not exceed about 0.2 μsec. To obtain this, the oscilloscope response must be at least as good as that of a television set; the 3-db frequency response should extend to about 3 Mc/s! However, without using an expanded trace or its equivalent, one cannot observe such short rise times.

If the time base provides a sweep at 10.125 kc/s so that one line of the television signal is displayed as a trace 10 cm long the duration of the trace is about 100 μsec and we shall be able to detect no change shorter than about 1 μsec. We can content ourselves, therefore, with a rise time of 1 μsec, which means a frequency response to around 0.6 Mc/s only.

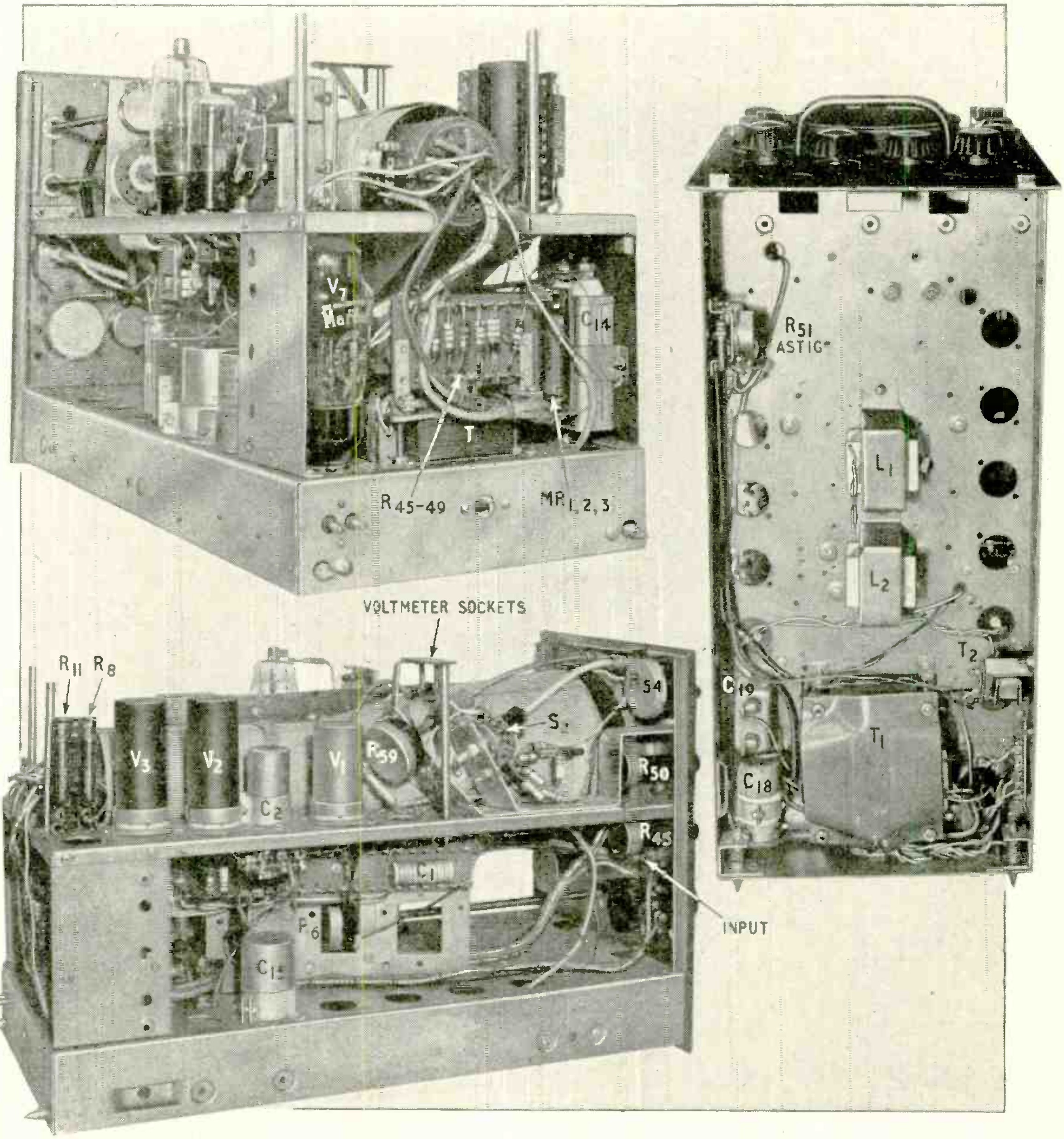
The cost, size and weight of an oscilloscope all rise rapidly as the rise time of its amplifier is reduced. Coupling resistors must be reduced in value to increase the rise time. This reduces stage gain and makes more stages necessary which, in turn, makes it more difficult to keep the sag small. In addition, the current taken by the output valves, at least, must be proportionately increased in order to secure the necessary output with lower-value resistors. This means bigger valves and a bigger power supply.

A typical oscilloscope tube needs a signal input of the order of 300 V p-p applied in push-pull, so that the amplifier must have a pair of output valves delivering about 150 V each. The change of anode current in each valve must be 150 divided by the value of the coupling resistor. If this is 5 kΩ, the current is 30 mA. For good linearity the mean anode current must be appreciably greater than one-half of this and so must be around 20 mA per valve. The circuit capacitance is unlikely to be less than 20 pF. With a 5-kΩ resistance the time constant is 0.1 μsec. This gives a rise time of 0.3 μsec for the one stage. To obtain a rise time of 0.3 μsec in the output stage thus demands a mean current consumption of 40 mA.

This could be reduced appreciably by using compensated couplings, but they add to the complexity and demand careful proportioning if overshoot is to be avoided.

The smallest signal which it is likely that one will want to observe is that existing at the detector of a television receiver, and this is unlikely to be less than 1 volt p-p. A total Y-amplifier gain of around 300 times is, therefore, sufficient and a two-stage amplifier will probably suffice. The largest signal to be viewed will not usually be more than 250 V p-p and so a gain control with a range of 250 : 1 is needed.

On the time-base side, it is desirable to be able to have from one to three cycles of a repetitive waveform visible. In television, three cycles are usually required in order to see one cycle in its entirety, because the "spikes" in television waveforms are usually at the ends of cycles and it is these spikes that govern the synchronizing of the oscilloscope time base. If only one cycle is shown, part is lost in the fly-back. If two



In these photographs the general layout of components can clearly be seen. The rectifier and e.h.t. equipment can be seen under the back of the tube (top left) while some of the power-supply parts are beneath the chassis (right). The signal amplifier and the calibrator are on the upper deck alongside the tube (bottom left).

are shown, one complete cycle is visible but its start and end are not always clearly defined.

This makes the required range of time-base recurrence frequencies 50/3 c/s to 10.125 kc/s, and the time-base linearity should certainly not depart from perfection by more than 5%.

It is necessary to have shift controls so that the trace can be moved to any required position on the screen of the tube. It is very desirable that these controls should be almost instantaneous in their action, for it is very irritating to find that after altering one of them the trace drifts slowly across the screen. A common practice is to use RC coupling to the deflector plates of the tube and to obtain the shift voltages from potentiometers in the e.h.t. supply. If the time constants of the couplings are made large enough for an adequately small sag on a 20-msec pulse, then slow-acting shift controls are inevitable because the shift voltage necessarily requires that the mean charge on the capacitors be altered. To obtain quick-acting controls it is necessary to use direct coupling to the deflector plates and to apply the shift via the amplifier.

There are, of course, many ways in which the requirements for television can be met and the description which follows of an oscilloscope which the writer has made for this purpose illustrates one solution to the problem. In its mechanical form, the oscilloscope was based on a piece of surplus equipment, the American Loran Indicator Unit, Type AN/APN4, but only because the chassis and case were convenient for the purpose. No use whatever was made of any existing circuitry and the whole chassis was completely stripped as a start. Some of the components were used, mainly capacitors and resistors, and the tube, a Type 5CP1.

The precise layout of the components was dictated to some extent by the form of the chassis and so no useful purpose would be served by giving measurements. It is unlikely that there are many of these Units now available; the writer's was bought several years ago. A British equivalent to the 5CP1 tube is the Mullard DG 13-2, but the design is, in general, not restricted to this tube type and any form of oscilloscope tube can be employed without any great modification being required.

The main peculiarity of the 5CP1 and DG 13-2 tubes lies in having a post-deflection accelerating electrode so that up to 4 kV can be used to obtain a very bright trace with a deflection sensitivity much the same as that of a normal 2-kV tube. No use is made of this and the electrode is operated at about 2 kV being, in fact, connected to the final anode, for the brightness at this voltage is amply sufficient.

(To be concluded)

Measuring High Resistance

The Guard Ring Technique for Eliminating Surface Leakage Errors

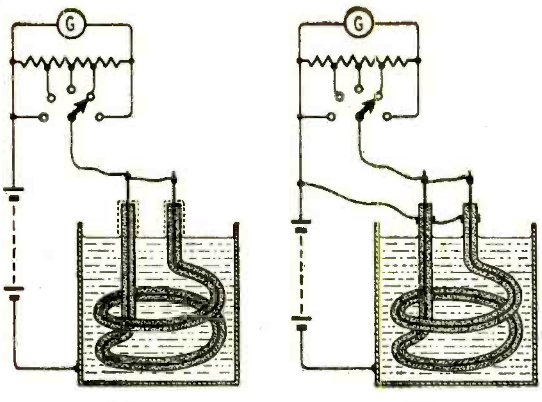
By M. G. SCROGGIE, B.Sc., M.I.E.E.

SEVERAL readers have written to enquire where they can find information on the guard ring technique mentioned in connection with the valve voltmeter described in the January issue (p. 18). It is in most of the textbooks on electrical measurements, but not usually in literature dealing with radio applications, so a few notes may be helpful.

The object of a guard ring is to confine a resistance measurement to the path required to be measured. There is usually no need for special precautions with low and medium resistances, because parallel leakage paths can be neglected. But with very high resistances, such as insulation, one has to consider exactly what it is one is measuring. This problem arose in the last century, when it began to be necessary to measure the insulation resistance of cables. One electrode for making contact with the insulation was, of course, ready made—the inner conductor. If it was an armoured cable the outer covering could be used as the other electrode; if not, the sample was immersed in salt water to make good contact with the outer surface of the insulation. In either case the sample was connected in series with a high-voltage battery and a sensitive galvanometer. Obviously, the galvanometer had to be shorted out while the battery was being connected, for the sample was in effect a capacitor, and the momentary charging current would usually be vastly greater than the leakage current through the insulation. The galvanometer was provided with a variable shunt, and unshunted cautiously.

With this straightforward arrangement, shown in Fig. 1(a), the galvanometer would read not only the current passing through the cable insulation but also some going over its surface at the ends of the cable where the connection was made. This leakage path, shown dotted, would naturally be quite short, and the current passing that way might well be a considerable proportion of the whole, invalidating the measurement.

Since these two paths are permanently in parallel with one another, it might seem difficult to measure the current through one of them only. But the solution is very simple: a wire is tied round the cable insulation as near the ends as possible, forming a "guard ring," which is connected straight to the galvanometer side of the battery, as shown in Fig. 1(b). Surface leakage current between this guard ring and the water does not pass through the galvanometer; and there is no battery to drive any current through the galvanometer via the leakage path between guard ring and inner conductor. This leakage path forms a shunt to the galvanometer, but normally its resistance would be far too high to affect the reading appreciably. So the only current driven by the battery



(a) (b)

Fig. 1. Without special precautions (a), the measurement of high resistances such as cable insulation is subject to error due to parallel leakage paths, shown dotted. Provision of a guard connection (b) excludes this source of error.

through the galvanometer is what flows through the cable insulation, and everything is as it should be.

Fig. 2 shows the principle more generally. R denotes any high resistance to be measured, and R_L is any unavoidable leakage. Some of R_L may belong to the thing being measured (such as surface leakage at the ends of a cable), and some of it may be inside the resistance-measuring apparatus itself. If no precautions were taken (a) the measurement would be unreliable. So the apparatus, whether set up as required from separate units or permanently wired up in a box, ought to be provided with a guard system as shown dotted (b). The high-potential terminal (from the galvanometer's points of view), 2 in Fig. 2(b), is surrounded by a guard ring; and a third terminal, 3, is provided for connecting to any external guard ring that may be necessary. If any earthing is to be done, this would be the terminal for it, as it would keep the galvanometer at earth potential.

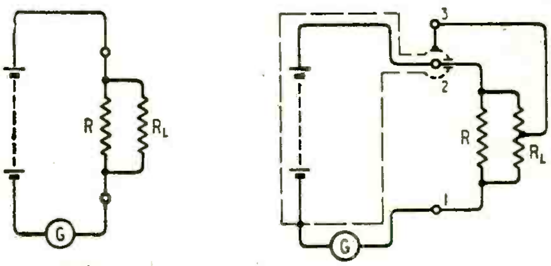
Looking at Fig. 2(b) one can scarcely help thinking of the dotted guard as a screen. From the purely d.c. point of view this is hardly correct, because air is such a good insulator that leakage through it can generally be neglected, even for insulation measurements; so it is only around solid insulation that a guard is needed. But in practice one finds that it is an advantage for the guard to be in the form of a continuous screen, because with very high resistances, of the order of millions of megohms, capacitive effects are a nuisance unless screening is provided. Even moving the hands about near the apparatus varies the electric field pattern and causes small charging currents to pass through the indicator.

Most of us, electronically minded and shallow-pocketed as we are, do not go in for the super-sensitive galvanometers beloved of the classical electricians. Apart from anything else, we are stricken by the thought of what would happen in the kind of set-up just described if the insulation were to break down. So we rig up a valve voltmeter circuit, possibly with a cheap Government-surplus milliammeter as the indicator. Actually, as emphasized in the valve-voltmeter article previously mentioned, the valve has to be carefully selected for type, and perhaps individually; and it must be operated with low heater and anode voltages and minimum anode current. But even if one goes the length of buying a relatively expensive electrometer valve it is cheaper and far less hazardous than a galvanometer.

The usual circuit begins something like Fig. 3, where the terminal numbering is the same as before. 500V is the standard for general insulation resistance measuring. Terminal 1 and the range switch must, of course, be very highly insulated. Supposing the highest range resistance is 10,000MΩ, then an indication of 0.5V is obtained through one million megohms. It is important that the test voltage be very thoroughly stabilized, especially when measuring the resistance of capacitors.

But it is not the intention just now to give details of the measuring equipment. The present subject is the guard-ring technique and would be incomplete without some reference to the testing of insulation samples for volume and surface resistivity.

In the classical method the sample is floated on mercury, and upper electrodes (inner and outer) are also formed of mercury. But since mercury is unpleasant stuff to have around (the vapour from a mere drop of it inside an instrument case causes all the soldering to disintegrate), and necessitates rather special brass-work to hold it into the prescribed shapes on the top of the sample, the British Standard tests allow one the alternative of painting electrodes on to the sample with graphite. Volume resistivity is determined by measuring the resistance between circular electrodes on each face of the sample. If R_v is the resistance, ρ_v (the resistivity) is $R_v\ A/t$, where A is the area of



(a) (b)

Fig. 2. Here the resistance to be measured is denoted by R and undesired leakage paths by R_L. (b) shows a complete guard system.

Right: Fig. 3. How a guard ring can be applied when the measuring instrument is a valve voltmeter.

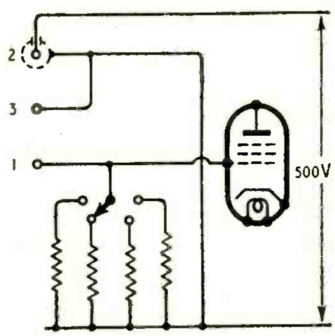


Fig. 4. Standard connections for measuring volume resistivity of a sample of material. The numbering applies to both Figs. 2 and 3.

Fig. 5. Connections for measuring surface resistivity.

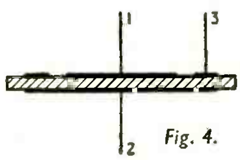


Fig. 4.

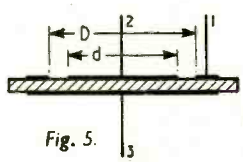


Fig. 5.

each (or the smaller) electrode, and t the thickness of the sample, in centimetres or metres, according to whether one is a follower of the c.g.s. or m.k.s. system of units. To exclude the effect of surface leakage via the edges, a guard ring is painted around the upper electrode; and the connections are as in Fig. 4. The test voltage exists between 1 and 2, but there is negligible voltage between 1 and 3 to cause leakage current over the surface. The sample should not be thicker than necessary, or there will be error due to the area of conduction spreading.

Surface resistivity is more a measure of the weather than of the material, for it varies at least a hundred times as fast as the relative humidity of the atmosphere; but where this is accurately controlled there may be some sense in making the measurement. The problem is to measure the leakage path across the surface while excluding so far as possible conduction through the volume of the material. To do this, the sample is connected as in Fig. 5. Here the test voltage exists across the surface between 1 and 2, but not round the edges or through the material between 1 and 3. If R_s is the measured resistance, ρ_s is $2\pi R_s/\log_e (D/d)$. To exclude volume conduction, the difference between D and d ought to be not less than six times the thickness of the material; but even so, it is normally small enough for one to use the approximation $\pi R_s(D+d)/(D-d)$ without serious error. It makes no difference what units the distances D and d are measured in (so long as the same units are used for both).

It must be remembered that the resistivity of insulators and semi-conductors varies not only with atmospheric moisture but also with temperature and test voltage. Checking the insulators and materials around one's laboratory is likely to be a real eye-opener. It is possible to find that an insulator used to keep connections from contact with the wood base may actually conduct more readily than the wood! And the desirability of keeping apparatus warm and dry can be strikingly demonstrated, even in the temperate climate of Great Britain.

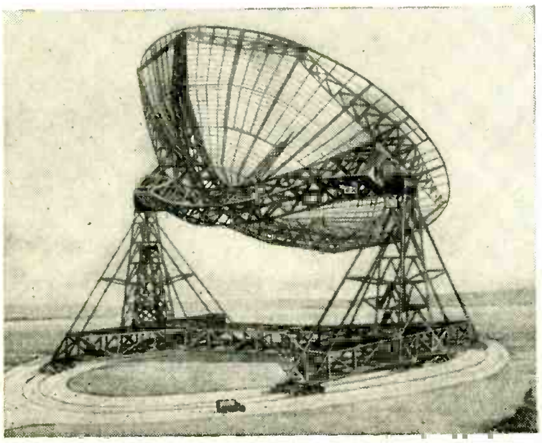
Giant Radio Telescope

250-ft Steerable Paraboloid for Exploring the Radio Cosmos

NOT long after the establishment of a Chair of Radio Astronomy at Manchester University comes the news that a giant radio telescope (the biggest in the world) is being built for the University at its radio astronomy experimental station at Jodrell Bank, Cheshire. It will cost somewhere in the region of £336,000, half of which is to be paid by the Nuffield Foundation and the other half by the Department of Scientific and Industrial Research.

Jodrell Bank already has quite a large paraboloidal radio telescope (220 ft), but as this is fixed to the ground the beam can only explore the small strip of sky across which it is swept by the rotation of the Earth. Thus the radio astronomers may have to wait perhaps all the year round for the beam to get to the particular section of sky in which they are interested. The new radio telescope will avoid all this, for the paraboloid will be mounted so that it can be swung through a complete circle in both azimuth and elevation to steer the beam in any direction required. The steering is to be done by an extremely complex automatic remote control system, which will bring the beam to fixed positions, make it follow the course of a radio star, or produce a kind of scanning "raster" across an area of sky. The speed of movement of the beam will be continuously variable from 2 degrees per hour to 36 degrees per minute.

Drawing of the new steerable radio telescope as it will appear when completed. A motor lorry is in the foreground.



Considering the enormous size of the paraboloid, this steering facility will be something of an engineering achievement. The platform on which the structure rotates will be 310ft across, and when the beam is directed horizontally the top rim of the paraboloid will be 300 ft from the ground. Trafalgar Square, London, would just about accommodate the base of the telescope, but Lord Nelson on the top of his 175-ft column would be put somewhat in the shade!

The great size of the paraboloid is necessary partly to achieve high gain (for the incoming signals are extremely weak), and partly to give a narrow pencil beam (about 2° wide) capable of separating radio stars very close together. Signals from these radio stars are like noise in character and cover an extremely wide range of frequencies, but only those with wavelengths between about 3 centimetres and 30 metres can actually get through to us because of absorption in the atmosphere at one end of the band and the blocking effect of the ionosphere at the other. The radio telescope will be able to look through this "window" on a band of wavelengths between 1 and 10 metres.

When the telescope is completed it will be applied first to the study of radio stars, in our own galaxy, the Milky Way, and in other galaxies. Later it will be used as a radar aerial for exploring the moon and some of the nearer planets.

VALVE LIFE TESTING

Standard Equipment Adaptable to Various Types

By R. BREWER *

IT may not be generally realized that manufacturers of radio valves conduct extensive and regular life tests on samples of their products. This is done to determine the service which the ultimate users may expect to receive from the valves, and to obtain accurate information regarding the way in which valve characteristics as a whole change throughout life. Information of this kind is very difficult to obtain during the actual use of the valves since, in most of their applications, they are just one of the many circuit elements needed to convey a radio signal. Unless valves are examined as a circuit element, independently of the circuits in which they are used, it is impossible to obtain that information concerning them which is essential for improving their life performance.

When equipment is running normally, few users are prepared to check all their valves periodically merely in order to gauge how their characteristics are changing. It is only when a fault occurs that the valves are checked. Generally the length of time which the valve has been working, its operating conditions throughout the time, and the possible association of the valve fault with the failure of other components, are all factors either altogether unknown or only roughly estimated.

Fig. 1. Receiving valve life-test bays.

Factors of this kind considerably influence the life of a valve, but because they are usually imperfectly known the potential evidence from valve failures in use is seldom fully available to the manufacturers.

Valve makers rely upon their own life tests to obtain information about valve behaviour in use, great care being taken to ensure that this information is as reliable as possible. There must be no doubt that a valve which fails on test has become defective and has not failed as a result of an equipment fault or a deviation in operating conditions. Life-test evidence which is suspect, or which the production engineer feels he cannot use with confidence, is valueless. This requirement for the results obtained to be of the utmost reliability is that which most strongly influences the design of all radio valve life-testing equipment. It is essential for the equipment to possess an order of reliability better than that of the valves under test.

From the safety aspect also, equipment reliability is of great importance. Life-testing time is reduced to a minimum by operating the plant 24 hours a day and seven days a week, and designing it to require the least possible amount of supervision. Fire hazards, in particular, have to be reduced to a negligible minimum by sound equipment design. The way in which these various factors have been taken into account can best be illustrated by reference to the new installation at the G.E.C. Research Laboratories at Wembley, where life tests on Marconi and Osram valves are conducted.

Receiving valves are tested in double-sided racks as shown in Fig. 1. Completely independent bays of equipment are mounted back-to-back on each frame, providing a total capacity for 96 valves on approximately 2 sq ft of floor space. Power supplies are carried over busbars running along the tops of the racks and the incoming supplies are converted to potentials appropriate to the valve electrodes by equipment housed in the two lower panels. Heater supplies

* Research staff of the M.-O Valve Company at the G.E.C. Research Laboratories, Wembley.

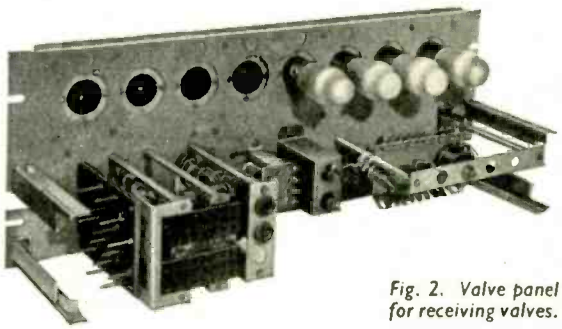


Fig. 2. Valve panel for receiving valves.

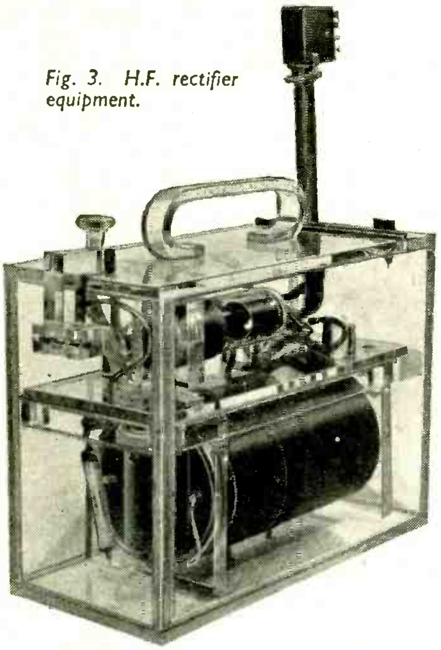
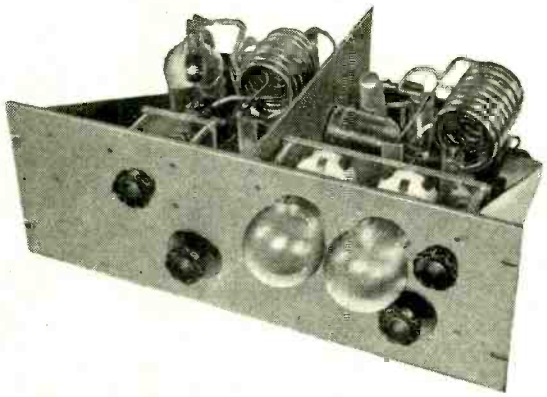


Fig. 3. H.F. rectifier equipment.

Below: Fig. 4. Transmitting valve panel.



are derived from a 240-V 50-c/s regulated motor-alternator set which is used for life-test purposes only.

The front of each bay is fitted with a heater transformer which supplies all the valves on the bay. Anode, screen, heater-cathode and other d.c. supplies are provided by motor-generator sets, potentiometers on each bay being used to produce the required electrode potentials.

The valves on test are placed in the six panels which occupy the main central area of each bay. The valve panel, shown in Fig. 2, is the "heart" of the system. It is specially designed so that it is capable of running most types of receiving valves with a minimum of conversion. Although a valve manufacturer may market perhaps 200 types of receiving valves, only a small proportion of these types are in manufacture at any one time. Nearly every type of valve requires life-test equipment which differs in some way from that needed by other types. If, therefore, equipment were to be available to cover the whole range of types produced, the larger part of the total life-test facilities would always be idle. This problem is met by mounting the valve holders and their immediate wiring in a removable sub-panel and making the permanent supply and control wiring adequate for all needs. Conversion from one type of valve to another thus necessitates only the exchange of the sub-panel.

Immediately above the upper row of valves in Fig. 1 are seen two panels which house the bay switching and fault-indicating equipment. Coloured lamps on each bay denote the incidence of a blown fuse or the occurrence of a heater-to-cathode short circuit. The heater-cathode fault lamp is operated by a relay, the coil of which is in series with the supply which maintains the heater-cathode potential difference. When a heater-cathode breakdown occurs in any valve on the bay, current flows through the relay and a limiting resistor, and the fault lamp lights. Since this indication may have been caused by a fault in any one of the 48 valves running on the bay, the next stage is to isolate the defective valve without having to remove more than a minimum number of the remaining 47 valves. This is done by fitting a press switch in the line carrying the total cathode current of each valve panel. Operation of this switch on the appropriate valve panel breaks the relay coil circuit and extinguishes the fault lamp, thus limiting the search to within eight valves. These are removed in turn until the defective one is found.

The life-test equipment described has proved to be extremely adaptable in testing a wide variety of valve types under many different operating conditions. In addition the amount of maintenance work needed by the installation in over three years' continuous use has been extremely small. Further, the equipment has easily fulfilled the life-test requirements of many new types of valve that were not in existence when it was first designed.

Testing Rectifiers

Rectifiers are tested in panels accommodating four valves, each of which has its own h.t. transformer, capacitor and resistor elements which form the load. A single transformer supplies heater power for all the valves on a bay. By this means precise control of heater voltage is effected without the necessity of a large number of individual adjustments.

The high-frequency type of rectifiers used in television receivers are life tested in the equipment shown in Fig. 3. A Perspex box houses the valve on test, its h.t. transformer, load resistor and capacitor. All components are immersed in oil to avoid possible deterioration of the test equipment, and to ensure absolute safety for the operators. The filaments of the rectifiers are heated by a 1.4-V 50-c/s supply which is more convenient for routine measurement and control than h.f. power. The latter, which is derived from a valve oscillator associated with each box unit, is used for the anode supply.

Transmitting valves are run in typical oscillatory circuits, the precise running conditions being determined by the specification of each valve and the service for which it is intended. Some of the test conditions for transmitting valves involve the use of a considerable amount of auxiliary equipment. This factor plays a large part in the design of this class of life-test unit since it is essential that the life-test report for each valve shall refer to the valve alone, and should be independent, as far as possible, of changes in the associated equipment.

The wide range of frequencies for which the smaller types of transmitting valves are used makes it difficult to standardize the design of their life-test equipment. Circuit techniques change markedly with frequency, and the diversity of valve power dissipations and cooling methods means that each type of transmitting valve requires its own specially designed piece of life-test gear. A further consideration is that of the operators' safety. The higher voltages and powers involved in testing transmitting valves make it necessary to use automatic protection devices which prevent access to all dangerous parts of the equipment until the power has been switched off. By constructing all test sets on standard panels 19in wide, however, and mounting them in a standardized form of h.t. safety enclosure, a satisfactory degree of unification has been achieved.

Fig. 4 shows a typical life-test panel in which a small transmitting pentode is tested as an amplifier in the Class C condition at a frequency of 25 Mc/s. The valve on test, its oscillatory circuits and driving valve are mounted on the platform at the back of the panel, the controls and load lamps appearing on the front of the panel.

The test panels are housed in bays built to form h.t. enclosures similar to that illustrated in Fig. 5. The valve panels are mounted on the sides of the enclosure. The safety gate is placed in the front partition and is flanked on either side by the control panels of the power units which are permanently housed inside. The whole equipment operates from a 240-V 50-c/s regulated supply, the gate switch preventing the power units from working until the gate is closed. The valve test equipment extends from the top of the framework to within about 2ft of the floor, the power rectifier units occupying the remainder of the space.

To prevent the free radiation of r.f. energy, the whole of the transmitting valve life-test equipment is installed in a screened room, formed by enclosing a layer of copper mesh in walls, floor and ceiling during construction. Each h.t. enclosure derives its a.c. power from a special transformer and filter unit which stops r.f. power from life-test sets reaching the mains.

It may be noted that for life-test purposes high-power audio frequency valves are tested in the same manner as transmitting valves owing to the similarity of their voltage and power demands. These valves are tested at a fixed audio frequency, the output being absorbed by a dummy load.

Checking Operating Conditions

An instrument trolley is used for setting or checking the operating conditions of valves on life test—a routine which is carried out daily. Apart from economic considerations, the trolley system is preferred to built-in meters on account of the much greater ease with which instrument checks may be made. All valve life-test evidence ultimately depends upon instrument measurements, so it is important to maintain the required standard of accuracy of the instruments in order to get reliable information.

In addition to the instrument trolley checking, the operating conditions of receiving valves during life test can be automatically checked by a specially developed "routiner." This instrument draws the attention of the operator to the small number of circuits needing adjustment, thus cutting out the alternative and much more lengthy process of tracing the faulty circuits.

The essential unit in the "routiner" is a precision relay which operates on either a.c. or d.c., and is capable of completing an alarm circuit when the voltage across the relay coil changes from a reference figure by more than 1 per cent. The instrument is fitted with two contacts on either side of the moving armature, the latter being held in the mean position

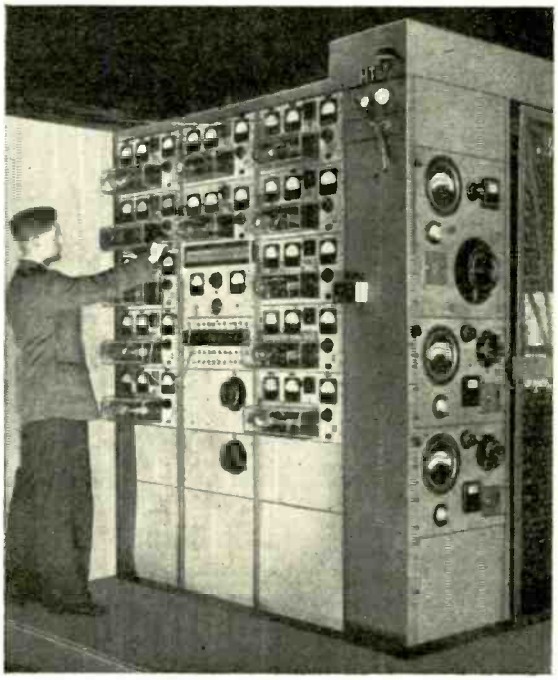
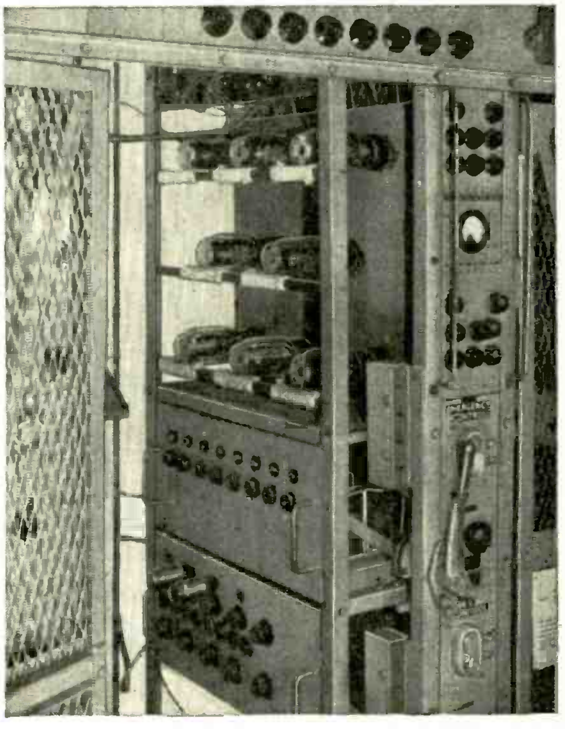


Fig. 5. H.T. enclosure for transmitting-valve life tests.

Fig. 6. High-power audio output valve equipment.



by a potential difference of 10 volts across the coil terminals. If 10 volts can be derived from each bay circuit to be tested, when the circuit is correctly adjusted, a change in any circuit of more than 1 per cent will cause the relay to operate and an alarm lamp to light. The relay is connected in turn to the test circuits by means of a two-motion selector switch, a capacity of 500 test lines being available.

Arrangements can be made for changing the sensitivity of the "routiner" when testing different groups of lines. This enables variations of up to 10 per cent (instead of the normal 1 per cent) to occur before an alarm is shown. These wider variations are naturally only allowed on those electrode supplies which affect the life of a valve less critically.

The "routiner" is used principally for testing heater voltages, h.t. electrode voltages, rectified load current, and the occurrence of broken filaments in battery-type valves. Controls available include manually operated keys for stepping the switch to any desired circuit, and a retest key. The latter enables the operator to repeat the test on any circuit which has stopped the "routiner" if a transient fault is suspected. The "routiner" can be set to run a single cycle, or to work continuously until a fault is found.

To simulate typical operating conditions, receiving valves are switched on and off throughout their life test. The switching impulses originate in timers on a central switching bay, a uniselector distribution unit being used to switch all the life-test bays in succession. This arrangement avoids the surges on supply lines which would otherwise occur if the full life-test load were switched simultaneously. A typical switching programme is to run valves continuously for the twelve day-time hours followed by a five-minute off period in each of the twelve night hours. Day-time switching would interfere with the work of placing valves on the test racks and making the necessary measurements.

The valve life-test installations which have been described handle approximately 6,000 valves of all types each year. The work of the group responsible for life-testing valves can be regarded as falling into two distinct categories. One section is employed in making measurements, analysing results and preparing information for reports, while another section is responsible for the design, installation and maintenance of the equipment, together with the development of new life-testing techniques. While routine tests on standard products are proceeding continuously, a large part of the work is concerned with testing valves of an experimental nature. The work of the group therefore contributes towards the fundamental research carried out on valves and associated topics. Valve makers are continuously concerned with improving the design, manufacture and performance of their products, and the life-test report is the best indication of the results of their endeavours.

MANUFACTURERS' LITERATURE

Interference Suppression capacitors and filter units for incorporation in electrical equipment, catalogued in an illustrated folder from the Dubilier Condenser Co., Ltd., Ducon Works, Victoria Road, North Acton, London, W.3.

Negative Feedback Amplifiers and pre-amplifiers with tone control; their design and application in equipment for high-quality reproduction, with particular reference to the Leak "Point One" series. An informative and well produced booklet, including a comprehensive bibliography, from H. J. Leak and Co., Ltd., Brunel Road, Westway Factory Estate, London, W.3.

Television Components suitable for use with wide-angle c.r.t.s; informative and well-produced catalogue available to manufacturers from The Plessey Co., Ltd., Ilford, Essex. Also a catalogue of **Loudspeakers.**

Spot Wobbler unit for television receivers; brief description on a leaflet from Aren (Radio and Television), Ltd., High Street, Guildford, Surrey. Similar leaflet describing their 8-12kV r.f. **E.H.T. Unit.**

Capacitors by T.C.C. Technical bulletins on the following: miniature moulded silvered mica; "Cathodray" high voltage; "Picopack" miniature electrolytics; "Plimoseal" finish for stacked mica and silvered mica; "Lectroflash" electrolytics for electronic flash photography; electrolytics for high-temperature working. From The Telegraph Condenser Co., Ltd., North Acton, London, W.3.

Consol Navigational Aid; booklet for prospective users, containing general description and operational data, from The Marconi International Marine Communication Co., Ltd., Marconi House, Chelmsford.

Multi-outlet Television Pre-amplifiers described briefly on a leaflet from Rainbow Radio Manufacturing Co., Ltd., Mincing Lane, Blackburn.

Unit Television Aerial; standard components that can be put together in various ways to form different kinds of arrays, described in leaflets from Ladybird AMI, 27, Whitcomb Street, London, W.C.2.

Magnetic Recording Tape; descriptive leaflet and price list from the Minnesota Mining and Manufacturing Co., Ltd., 167, Strand, London, W.C.2.

Neon Tester for one-pole tests on a.c. or d.c. mains; a leaflet from Grafton, Kersten & Co., Ltd., 77, South Audley Street, London, W.1.

NEWS FROM THE CLUBS

Birmingham.—"Practical Accelerators and their Electronics" is the title of the talk to be given by J. Y. Freeman, of Birmingham University, to members of the Slade Radio Society on June 6. The following meeting (20th) will consist of a direction-finding test with instruction for beginners. At midnight on June 28/29 the club will be participating in the d.f. test being organized in connection with the Midland Amateur Radio Society's "Field Week-end." The club meets on alternate Fridays at 7.45 in the Parochial Hall, Broomfield Road, Erdington. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Brighton.—The lecture at the meeting of the Brighton & District Radio Club on June 24 will be given by F. E. Lane of the Tungsram Valve Co. Meetings are held every Tuesday at 7.30 at the Eagle Inn, 125, Gloucester Road, Brighton. Sec.: R. T. Parsons, 14, Carlyle Avenue, Brighton, 7.

Coventry.—A talk on "C.W." will be given by L. Gardener, G5GR, (chairman) to members of the Coventry Amateur Radio Society on June 9. The club meets on alternate Mondays at 7.30 at the Y.W.C.A., Queen's Road, Coventry. Sec.: K. G. Lines, 142, Shorncliffe Road, Coventry.

Southend and District Radio Society has undertaken to erect and man a transmitter and provide associated equipment for the Scouts' Jamboree at Belchamps, Hockley, Essex, from August 9-16. Sec.: G. Chapman, Bell Hotel, 20, Leigh Hill, Leigh-on-Sea, Essex.

FURTHER NOTES ON

THORN NEEDLES

A Quantitative Contribution to an Old Controversy

By S. KELLY*

SOME months ago, my interest in thorn-type styli was re-awakened by an article written by Mr. Pollock.[1] It had always been my opinion (confirmed by a series of experiments several years ago) that thorn styli suffered from two serious faults: (a) the high-frequency response was considerably reduced relative to a semi-permanent stylus, say, of sapphire or diamond, and (b) the thorn stylus required sharpening at frequent intervals and under some circumstances would not last one side of a 12in record.

At the time these experiments were performed, the pickups experimented with were what were then termed " lightweight." They required a tracking pressure of 25 gm, and had an upper resonance of round about 14 kc/s, and a low frequency of 20 c/s.

Mr. Pollock's article shook me out of my complacency—especially as the facts could not be reconciled—a stylus tip of approximately 0.001in diameter should not trace satisfactorily a record groove of considerably greater dimensions, and the high-frequency cut-off should be considerable; but as the results claimed were purely subjective a quantitative investigation was decided upon.

Stylus Dimensions

A moving-coil pickup supplied by Mr. Pollock was used for the tests, and to establish a common point two frequency response curves were taken, using sapphire styli. The styli were 0.29in long and 0.21in long, respectively (for convenience called the "long" and the "short" sapphires). The sapphires used were checked for radii and found to be 0.0025in ±0.00005in. The polish and general finish, viewed under a Beck binocular microscope with a magnification of ×87, was good. The thorns, which were obtained from Mr. Pollock, were also checked: as received, and after playing the first and both sides of Decca K2069 "Danse Macabre." One of the sapphire styli was used for comparison, and the dimensions of the thorn as received agree with the photo-micrographs of the December, 1950 issue of *Wireless World*.

The response of the pickup using the sapphire styli is shown in Fig. 1. The response agrees well with accepted theory, and it is seen that the upper resonance, using the "short" sapphire, is above 20 kc/s, and the maximum variation from an ideal curve is of the order of 3 or 4 db. The "long" stylus gives a resonance at 16.5 kc/s.

The sapphire styli were then replaced by thorn styli of three different lengths: 0.39in ("long"), 0.31in ("medium"), and 0.21 ("short"), and the frequency response of the pickup is shown in Fig. 2. Here it will be seen that, as expected, the resonant frequency is considerably reduced, and with the "long" stylus comes at about 7.5 kc/s, which is too low for its effect to pass unnoticed. The amplitude of the resonance is also considerable, the "long" stylus showing a peak of almost 20 db, and the shorter styli giving reduced amplitude of the peaks, which is to be expected.

Cantilever Mounting

Fig. 3 shows the response of thorn styli 0.062in long, cemented in the end of a cantilever stylus. The tracking weight of the unit was adjusted to 10 gm, and the

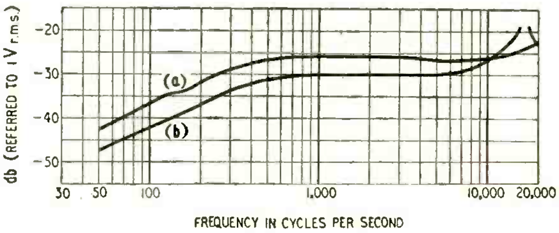


Fig. 1. Frequency response curves of moving-coil pickup (a) with "short" stylus (0.21in) and (b) with "long" stylus (0.29in).

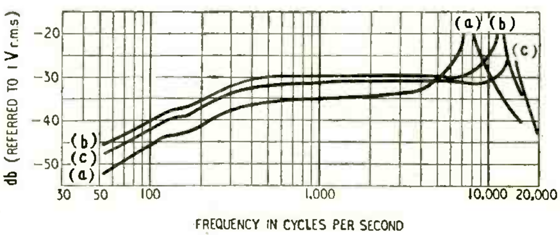


Fig. 2. Frequency response of the same pickup with three thorn styli, (a) "long" (0.39in), (b) "medium" (0.31in.) (c) "short" (0.21in).

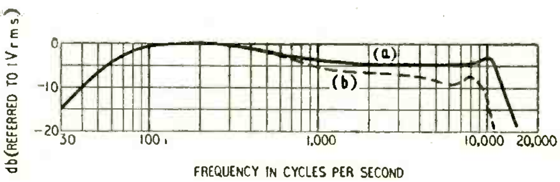


Fig. 3. Response of cantilever crystal pickup (a) with normal short sapphire stylus (b) with thorn stylus, 0.062in long, cemented in place of the sapphire.

* Cosmocord, Ltd.

[1] *Wireless World*, December, 1950.

maximum life obtained was seven sides of "Danse Macabre." The moment of inertia at the stylus tip using the thorn styli was within 10 per cent of that using the sapphire.

The E.M.I. JG 449 test record, used for the response measurements, is a spot frequency disc and it is possible that minor wiggles may have passed unnoticed; the deviation from the ideal response at about 150 c/s in the curves of Fig. 2 was not investigated and no comments are offered, as it is not thought to be relevant to the present discussion.

It was found that reliable readings with newly pointed thorns could not be taken because the shape is such that intimate contact with the groove walls is not obtained until the point is worn to a chisel point.

The above measurements were made on a pickup connected to a valve voltmeter through a correctly loaded matching transformer. The tracking weight was adjusted to 10 gm, and the results recorded after one complete run on the JG 449 with the "long" and "medium" styli and after the fourth run with the "short" stylus. The stylus was visually checked under the microscope before and after each run, and it was confirmed that consistently repeatable results were not obtained until the thorn had achieved a wedge-shaped profile.

The pickup was then checked on the E.M.I. intermodulation test record JH 139 on side 400-4,000 c/s.[2] It was only checked with the "long" and "short" styli and the mean of the response corresponding to 10 per cent intermodulation distortion was reached at a level, referred to a groove velocity of 1 cm/sec, of 12.5 db on the "long" stylus and 20.5 db on the "short" stylus. The pickups were then given subjective tests, being connected to a correctly equalized amplifier-speaker system. The "Danse Macabre" was used as a test record, and it was found that the surface noise was not unduly coloured using the "long" stylus, but the violin tones were extremely harsh, even when the treble was cut 10 db at 10 kc/s. With the "medium" and "short" styli, the violin tone showed progressive improvement, but was not clean.

Using the "long" sapphire stylus, the surface noise had a marked high-frequency coloration, and the violin tone was comparable with the results obtained with the "short" thorn. With the "short" sapphire, the surface noise had no discernible coloration and sounded truly "white"; the violin tone here was very clean and on other audio tests gave the best results.

No tests were made on long-playing records.

Playing Time

The maximum playing time which could be obtained before marked deterioration of quality was apparent was between three and seven sides of a 12in record. It cannot be ascertained whether this was due to minute differences in stylus shape and the included angle, or variations in the stylus material.

The experiments confirmed the generally accepted view that thorn styli for use with low mechanical impedance pickups can give a reasonably extended frequency response, but at a cost of changing the stylus frequently and the tedium of re-sharpening.

Wear tests on records were not attempted in this experiment, but on the previous experiment with a 25-gm pickup, and replacing the stylus after every side, wear was apparent after approximately 200 sides had been played, using the second side of "Danse Macabre" as the test record.

In conclusion, I would like to thank Mr. Turville for his help in these experiments.

[2] For a detailed discussion of intermodulation testing of pickups the reader is referred to an article in the July, 1951, issue of *Wireless World*.

At the Editor's invitation the following comments on Mr. Kelly's findings have been contributed by Mr. A. M. Pollock, author of the original article in the Dec., 1950, issue.

I AM very appreciative of the trouble Mr. Kelly has gone to in following up with laboratory experiments the ideas I expressed on the merits of thorn styli in suitable modern pickups.

I have not myself been able to obtain quite as severe peaks, but this may be because I use a gliding-tone test record whereas Mr. Kelly's curves were plotted from points taken under steady-state conditions.

A point of some value illustrated by the curves is, I think, the fact that the vibrating system has to be considered as a whole when discussing the performance of a pickup. This should, of course, be obvious enough, but a variation in resonant frequency *of the same pickup* from 7.5 kc/s to over 20 kc/s may be rather more than many would have expected. Also it is of interest to note that an apparently small change in the length of a sapphire stylus from 0.21in to 0.29in alters a very desirable characteristic into one with marked high-frequency coloration and, as Mr. Kelly says, noticeable harshness in the reproduction of music.

The tests suggest that, for the best results, the thorn should be reasonably short and users can no doubt meet this requirement by keeping new thorns of the maximum length for their older or lower quality recordings where some top cut may be necessary anyway. Also there seems to be room for experiment by individual users in the acuteness of the point to give the best compromise between acceptable life and good groove fit.

I think it not unfair to suggest that Mr. Kelly's results bear out my general proposition regarding the possibilities of thorns under favourable conditions. One has still to remember the great variations in quality of commercial records and, as I have said before, these variations tend, in my experience, to swamp the smaller differences between thorn and sapphire reproduction at domestic sound levels in similar grades of pickup.

Finally, as a matter of record, I should perhaps mention that the output characteristic given in my letter published in the April, 1951, issue was taken with a different pickup from the one used by Mr. Kelly. The latter was an improved model with much lighter coil.

A. M. POLLOCK.

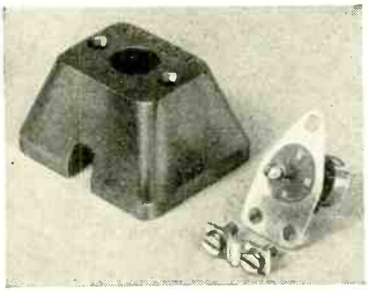
Manufacturers' Products

New Equipment and Accessories for Radio and Electronics

Coaxial Outlet Box

A WELL-DESIGNED television coaxial outlet box (for terminating the incoming aerial feeder) has recently been introduced by Wolsey Television Ltd. of 75, Gresham Road, Brixton, S.W.9. It consists of three parts and is contrived so that the cable can be connected and clamped down without bending and straining the inner conductor. The socket is of standard dimensions, with outer contact surfaces cadmium-plated and inner surfaces silver-plated, and has a polythene dielectric. The strongly made cover is ⅞in deep, has a bronze-type finish, and is provided with two screw holes for fixing down to woodwork.

The firm has also introduced a new coaxial plug of simple design which

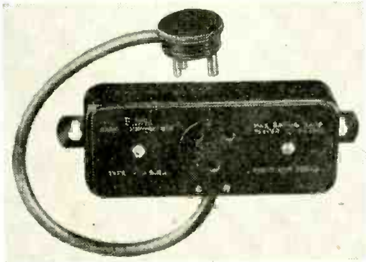


Component parts of the Wolsey television coaxial outlet box.

can be used with any standard socket and with any cable between 0.165in and 0.24in in diameter. The cable is clamped by sprung claws which are forced into the metal braiding when the outer case of the plug is pushed on.

All-wave Interference Suppressor

A NEW mains interference suppressor produced by E.M.I. is claimed to be equally effective at all frequencies from 150kc/s to 30Mc/s (between 10 and 2,000 metres) and is suitable for use with any radio receiver or electrical appliance operating on 100-250 volts a.c. or d.c. and



E.M.I. mains interference suppressor.

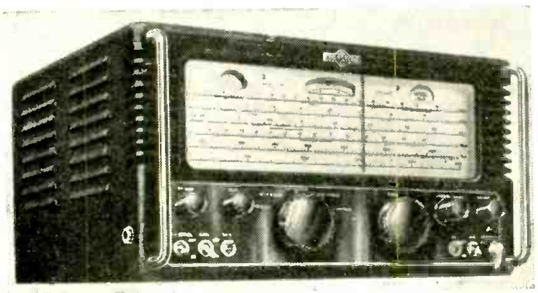
drawing up to 5 amps. It is housed in a moulded case designed to permit simple fixing to a skirting board. A mains plug and socket are fitted for easy connection between the receiver or appliance and the supply point. The suppressor is available from the Dealers' Service Development Division of E.M.I. Sales & Service Ltd., Blyth Road, Hayes, Middlesex, at £2 9s 6d.

Communications Receiver

QUITE a number of improvements have been made to the 15-valve Eddystone 680 communications receiver (reviewed in our September 1949 issue) and in its new guise it is known as the Model 680X. The main change is in the frontal appearance, the small rectangular scale opening now being replaced by one extending right across the cabinet.

A few small changes have been made also in the circuit; for example a small resistor is included in each r.f. grid, presumably for anti-parasitic purposes, although nothing of this nature was met with in the set we tested. There has been a rearrangement of the headphone circuit and the signal is now taken from the anode of the output valve feeding the phase inverter. A capacitance-resistance network is used and the insertion of the headphone plug in its jack automatically disconnects the loudspeaker.

The makers are Stratton and Co., Ltd., Eddystone Works, Alvechurch Road, West Heath, Birmingham, 31, and the price is £106.



Eddystone 15-valve communications receiver, Model 680X.

RANDOM RADIATIONS

By "DIALLIST"

We Sink Our Differences: But Our Syncs Differ

APART FROM THE FACT that it uses more scanning lines, there is one rather interesting difference, which you may or may not have noticed, between the French 819-line system and both the United States 525-line and our 405-line systems. This is in the method of frame synchronization. At the end of each frame the B.B.C. transmits a series of eight broad (40 μsec) pulses which collectively form the frame sync signal. In the French 819-line transmissions there is only one 20-μsec frame sync pulse. Under our system a complete image of two interlaced frames is built up in this way: immediately after line 405 of the preceding image come the eight sync pulses, of 40 μsec each, at 10 μsec intervals. Thus the eight pulses and the eight intervals occupy 400 μsec, or the time equivalent of four scanning lines with their sync pulses. Then, after 10 lines of "blacks" and line sync pulses frame No. 1 starts at line 15. It is brought to an end at line 202½ by the next series of frame sync pulses and "blacks" and the second frame starts at line 216½.

The French System

In the 819-line system the duration of a line plus the 2.5-μsec line sync pulse is approximately 50 μsec. Immediately after line 819 of the preceding image come 3½ lines of "blacks," then the 20-μsec frame pulse followed by 37 lines of blacks. Frame No. 1 starts at line 42 and ends at line 409½. After a similar 41-line series of "blacks" containing a single frame sync pulse, frame No. 2 starts at line 450½. The line sync pulses are, of course, kept going during each inter-frame blackout. After disentangling the circuit diagram of an 819-line receiver, I gather that this system makes it rather more difficult than does ours to obtain effective synchronization at the receiving end. Even the line sync pulses are passed through an amplifier before being applied to the line oscillator.

The Resistor Problem

ONE OR TWO READERS seem to have misunderstood the nature of my grouse about fixed resistors. "Surely," writes one of them, a South African doctor, "nobody would think of putting such a component into a piece of electronic apparatus without first verifying its value." I agree. But I was not complaining of any failure on the part of new resistors to show their marked values within the tolerance limits of their classes. What was—and still is—biting me is this kind of thing. In a particular circuit you need a resistor of round about 20,000 ohms. You pick one of adequate power rating, allowing what should be an ample factor of safety. Its actual value turns out to be, say, 21,500 ohms both before and after you solder it into place. Sometime later faulty working develops and the cause is eventually traced to that resistor, which now shows an enormously different value. Greater reliability in resistors would, I am convinced, mean far less trouble in radio, television and other electronic gear.

Queer Goings On

WRITING FROM A VILLAGE a little south of Okehampton in Devon, a puzzled correspondent reports that ever since the B.B.C's temporary caravan transmitter got to work near Barnstaple in early March, he has suffered from severe *daylight* fading. Previously he had enjoyed a satisfactory service from Start Point, though one would imagine that the field strength of this station cannot be very great in his part of the world, which lies right in the wireless shadow of the 1,800-ft Cawsand Beacon. The village is almost on a straight line joining Start Point and Fremington, where the 250-watt temporary station is working. The two ground-wave signals must be interacting somehow—possibly owing to reflections of one or both from one of the Tors. Have other mid-Devon readers had similar experiences? Is it some kind of ground-wave variety of the Luxembourg effect?

A Ticklish Job

NEEDING A MIDGET a.f. transformer for a gadget that I was engaged in making, I looked through the bits and pieces drawer to see if it could provide anything suitable. Yes; there was the very thing I wanted. But my joy was short-lived; for, though the primary passed its tests with full marks, the secondary was "dis." The protective paper covering was carefully removed, disclosing an outer layer consisting of what looked like about a million turns of cobweb-fine enamelled wire. I was just going to drop the thing into the wastepaper basket, so hopeless seemed the idea of locating—to say nothing of mending—the break, when something prompted me to take a look at it with a strong magnifying glass. My luck was in, for I found two little "whiskers" sticking out near the middle of the layer. It might not, of course, be the only break; still, a repair was worth trying.

Something Attempted

With the help of a pair of tweezers, one end was gently coaxed until about $\frac{3}{4}$in of it was free. Then, the other end was similarly treated until a whole turn of it had been unwound. This latter having been cut to a suitable length, the two ends were bared by the careful use of rouge paper and twisted together, a strip of waxed paper being placed under the joint. To my no small joy, the secondary now proved to be continuous. The joint was successfully soldered with the aid of the new 5-cored Multicore and a miniature iron. Finally, everything was made shipshape and secure by winding on a layer of insulating tape.

Telephone and Wireless Set

YOU MAY REMEMBER the queer instances I described recently of the interaction which has on occasions taken place between my telephone and the domestic broadcast receiver. In case you don't, what happens is that very occasionally when someone is using the telephone, which is in another room, the conversation is clearly and fairly strongly reproduced by the loudspeaker of the set. An engineer, who was many years ago in the department of the G.P.O. which deals with complaints of interference, tells me that he has known many such cases. The cause is invariably the presence of a non-linear resistance in some part of the telephone circuit. The microphone itself might be responsible, but I believe that a special capacitor is now fitted to prevent this. The most probable culprit is a bad joint—or rather an imperfect joint, which just once in a way becomes bad owing to the effects of weather, temperature or vibration. The rectified telephone signal is usually passed to the wireless set either by re-radiation from the telephone wires and pickup by the radio aerial, or *via* a common impedance in the telephone and wireless earth connections. I am glad to have this explanation, for the phenomenon is so rare and so transient in my own house that I have never been able to investigate it properly. The long-suffering G.P.O. engineers would have to take up residence to be sure of hearing a repeat performance!

UNBIASED | By FREE GRID

Divorce Wanted

THE modern domestic wireless set is such a reliable and trouble-free instrument that I have long since given up "rolling my own" except for experimental and other special purposes. But whenever I buy a new set I always resent having to pay for something which I don't want and never use. I refer, of course, to the loudspeaker, which is built into the set.

I have no quarrel with such an instrument *per se*. It is usually of excellent design and sometimes of peerless performance, but I dislike it churning out Chopin close against my ear and I think that designers should arrange a divorce between set and loudspeaker. I could, of course, solve the problem by putting the set at the far side of the room but I should then run the risk of tripping over the cat every time I desired to change from Charlie Chester to Chamber music. If you look at the position of the wireless receiver in the average home it is usually where mine is, namely, by the fireside where I can get at the controls comfortably from my armchair.

The remedy I adopted long ago was to buy a good extension loudspeaker and place it at the other side of the room, and I think that if more people realized how much this improved the pleasure of listening they would do likewise. But having done it they would probably curse me soundly and accuse me of getting a handsome rake-off from the extension loudspeaker manufacturers, for it cannot be denied that the noxious noises belched forth by many extension loudspeakers to-day is a travesty of what the inbuilt loudspeaker gives.

The reason is that too often we find a first-class set harnessed to an equally first-class extension loudspeaker and forming as ill-matched a pair as sometimes appears before the local vicar to be united in what A. P. Herbert has called "holy deadlock." In the case of an incompatible set and loudspeaker, it is, of course, ill-matched ohms that form the "cause, or just impediment," and the remedy is aptly summed up in the phrase *caveat emptor*. I am no Agag and will not, therefore, venture to give any opinion on the cause and cure of matrimonial mismatching.

Am I a Pirate?

THE P.M.G. has for a long time been making a praiseworthy effort to call wireless pirates to repentance by a high-pressure display of posters. It is quite obvious, however, that new blood has been injected into this anti-pirate campaign as we have had quite a crop of novel and ingenious posters recently. They are not designed to strike terror into the hearts of the timid nor to appeal to the hardened malefactor but to give information to the genuinely, if stupidly, ignorant.

Broadcasting has been with us for so long that everybody must be aware that a licence for a broadcast receiver is necessary, but the fact that television and car radios are not covered by the ordinary licence

has not been publicized nearly enough. Therefore, I welcome the poster which tells me that there are three types of licence, namely, a sound-only licence for £1, a television licence for £2, which also covers sound, and a car-radio sound licence for £1.

While reading this the other day, with all the soul-satisfying smugness of self-righteousness, I was suddenly assailed by a horrible doubt as to whether I was, after all, numbered among the goats and not the sheep, for installed in my car—"within the meaning of the act"—I have a television set. I installed this and a telescopic aerial for use when I desire to view some important event which is being televised when I am away from home.

Frankly, I do not think I am within the law. As an ordinary sound-only licence does not cover car-radio it is logical to suppose that my ordinary domestic television licence does not cover my car television. It is also certain my £1 car-radio licence does not cover car television; the poster makes it quite clear that it is for sound only.

Although there appears to be no

licence obtainable to put me on the right side of the law, my conscience will not let me sleep well o'nights until I get this point settled.

The Telepædicator

OF the many adjuncts to the wireless set, such as pickups and playing desks which have appeared during the last quarter of a century, there is one which is still in use but has never shown any dramatic technical improvement since it first appeared over twenty years ago.

I mean the baby-alarm which consists of a microphone placed over a child's cot and connected to the receiver downstairs in such a manner that when the baby bawls for nourishment, clean pyjamas, or just out of pure cussedness, its caterwaulings are superimposed on the radio programme.

This telepædicator, as I feel sure the Yanks must call it, was first described in the Readers' Problems section of *W.W.* in the knob-twiddling twenties and was very little different from the one I saw at a recent National exhibition at Olympia. There was little difference between it and the original. I ventured to point out to one of the sylphlike sirens on the stand that there had been but little change in design in twenty years or more, but far from being disconcerted she somewhat tartly, but very rightly, pointed out that there had been little change in the design of babies over this period. It is many years since I visited Queen Charlotte's Natarium but I suppose the 1952 models coming off its assembly lines are indistinguishable from the old 1927 models.