Wireless World

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Auxiliaries to Television

THE setting-up of a national television service is not just a matter of deciding upon the best standards of transmission, of erecting suitably sited stations and then making available to would-be viewers a supply of receivers at prices they can afford. True, these things are of basic importance, and, as we have said in recent issues, *Wireless World* considers the foundations of a nation-wide service have been well and truly laid. But, however sound the foundations, a service cannot grow unless programmes are attractive and attainable at an economic cost. These matters are not our direct concern, but it is vitally important to us that the technical details of programme distribution should be developed to a high state of excellence. Economy in programme costs is as important as quality; television material is costly, and, at the present stage of development, the cost cannot be spread over a vast number of subscribers. It is reassuring that the B.B.C. is ready with equipment for serving the wider—and, presumably, increasingly more exacting—public for which it will soon have to cater.

Of these technical auxiliaries to the distribution of programmes, probably the most important are those for recording and subsequent retransmission on film. If we can go by the analogy of sound broadcasting, television will depend increasingly on the vision equivalent of sound recording, whereby films of current events can be made for use when required. The new "telefilm" recorders, described briefly in our January issue, fulfil this purpose. With the help of the ingenious and effective trick described as "spot wobble" (see page 84, this issue) the lines of the picture are made to disappear, and surprisingly little degradation of quality results from the combined processes of photographing from the end of a tube, subsequent scanning and then retransmitting the picture. New scanners also being installed will facilitate the handling of film, while elaborate apparatus has been installed for "dubbing" and other processes involved in preparing films

The "telefilm" apparatus just mentioned is, of course, for recording events picked up by the television camera. Ordinary sound-on-film news-reels, photographed direct from the scene, also have their place in programmes, but the normal speed of processing is often too slow for television, and so the B.B.C. is developing a method of recording on magnetic film the sound which accompanies the picture. This, it is claimed, will substantially reduce production time, and should help television to retain its outstanding advantage of speed in presenting "actualities." At the same time, sound quality should be improved.

Aerial Restrictions

MANY local authorities have banned the erection of television aerials on houses under their control, or else have imposed distinctly onerous restrictions. It would seem that in many cases this attitude has been due to ignorance, and we congratulate the Radio and Electronic Component Manufacturers' Federation on taking active steps to dispel ideas which would certainly be prejudicial to the rights and privileges of tenants.

The Federation has set up a panel of experts who are willing to advise housing and municipal organizations or any others concerned with the problems of television aerials. The panel will make recommendations for aerial installations which would provide adequate reception without unnecessary interference with the architectural appearance of the buildings concerned. Apart from æsthetic considerations, no doubt the panel will be able to give useful information as to the risk—or lack of risk—of damage to the building due to the fitting of a properly installed television aerial. It is good to hear that some councils who have been strongly opposed to television aerials have shown a much more tolerant attitude after discussions with the panel.

Simple Cathode-Ray Oscilloscope

Design for an Inexpensive Instrument "Without Frills"

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

OSCILLOSCOPE designs that have appeared in the technical press since the war have tended towards more and still more facilities and refinements, which of course is all very well in its way but rather discouraging to the amateur with modest means and requirements. So it seems that there may be room for details of a design which covers most ordinary needs simply and inexpensively.

Like most oscilloscopes, it comprises three departments:

(1) The cathode-ray tube itself, with its voltage supplies and controls for focusing, brightness, and shifts.

(2) A variable-frequency time-base generator, with synchronizing device.

(3) A deflection amplifier.

It is in (2) and (3) that there has been such lush growth in recent years. Demands for extreme linearity and such facilities as triggered "single-shot" and time-calibrated sweeps have resulted in elaborate multi-valve time-base circuits; and a wide-frequency-range amplifier must have low-resistance couplings, hence many stages—especially if push-pull is called for.

In the present design all the usual facilities as regards (1) are included. A single-valve amplifier gives a controllable gain of up to about 41 db (or ×110) at audio frequencies, and 26 db (or ×20) over a wider band. The tube can of course be used without amplification over a wide range of v.f. and r.f. The time base works at frequencies between 12 c/s and 40,000 c/s, so can be used for waveforms at least up to 500 kc/s. It departs perceptibly from perfect linearity, but if this is considered objectionable it could be overcome with the help of a sweep amplifier, similar to the above.

Principal Components

The tube specified is the VCR.138 because it is readily available at a very low price, it focuses excellently at low voltages, and has a nearly flat 3½in screen. The power supply consists of any ordinary 350-0-350V receiver transformer and two small Westinghouse rectifiers. Time base and amplifier each need a single valve. The rest consists entirely of resistors (fixed and variable) and capacitors, with three switches, a few terminals, and some sort of container.

Power Supply. The required transformer outputs are:

(*a*) 4 V, 1A for the c.r. tube heater, (*b*) 6.3V, 1.5A for the amplifier and time-base valve heaters, and (*c*) 700V for h.t. supplies (not more than 8 mA d.c.). An ordinary receiver transformer gives more than enough for all these, and, unless one wants to keep weight down to a minimum, will do in place of a special transformer. At such a reduced load it will give rather more than 700V r.m.s. between the end connections of the h.t. secondary, but the Westinghouse 16HT56 is rated up to 840. Assuming an actual 750V under load, the output across the reservoir capacitor is about + 850V. The maximum rated d.c. output for this rectifier (half-wave) is 8 mA, and the actual current lies between 5 and 6 mA.

The 36EHT25 rectifier supplies about − 950V 0.5 mA, of which about 900V is available as anode voltage for the c.r.t. If the transformer voltage is liable to exceed 740V it would be prudent to use the next larger rectifier, 36EHT30.

The winding used to supply the c.r.t. heater current should of course be sufficiently well insulated to stand 1000V peak to the earthed end of the h.t. secondary and 2000V to the other end.

Except that the reservoir capacitance (C_{20}) for the 16HT56 rectifier is rated at 1μF maximum, there is no objection to using larger smoothing capacitances than those specified.

C.R.T. Circuits. The VCR.138 tube (Mullard equivalent ECR.35) is rated at 1200V anode voltage (2500V max.). It gives good focusing and brightness at 750V, but is definitely poor at 500V. In the present design it receives about 900V, at which the peak-to-peak voltage required for 50 mm deflection is approximately 125V between the X plates and 60V (= 21V r.m.s.) between Y plates. Therefore as little as 1V r.m.s gives 2.5 mm Y-deflection.

The arrangements for controlling focus, brightness and X and Y shifts are entirely conventional. The wiring should be kept away from the 50 c/s h.t. connections, and a Mumetal screen for the tube is almost essential for preventing stray 50 c/s deflection.

Time-Base Generator. A gas-filled triode is used in the usual manner to discharge a selected capacitor at a frequency depending on the rate of charge and also on the grid bias. The following table will be a guide to the approximate frequency ranges obtained with the circuit shown, assuming the length of the time-base on the tube is adjusted to 50 mm:

As usual, the "length" and "frequency" controls are interdependent, but variations in length when the frequency control R_{23} is adjusted are

Capacitance, μF	Frequency, c/s
0.3	12–53
0.1	35–160
0.03	120–530
0.01	350–1,600
0.003	1,200–5,000
0.001	3,600–14,000
0.0003	13,000–40,000

minimized by means of R_{24}, which passes a compensating current through R_{25} (controlling the bias) when the current via R_{22} is reduced. The base length is less at the middle of the R_{23} frequency range than at the ends, but not seriously so.

When the time base is set to a normal working length—50 mm—the capacitor across V_2 charges to only about one-sixth of the available h.t., so it is linear enough for most purposes. The alternative would be either to use a series pentode (on the negative side of the EN31) in place of R_{23}, or—more conveniently—to restrict the amplitude still more by reducing R_{25}, and then amplify it. An amplifier similar to the Y-deflection amplifier would be suitable, and the rectifier would just stand the extra drain.

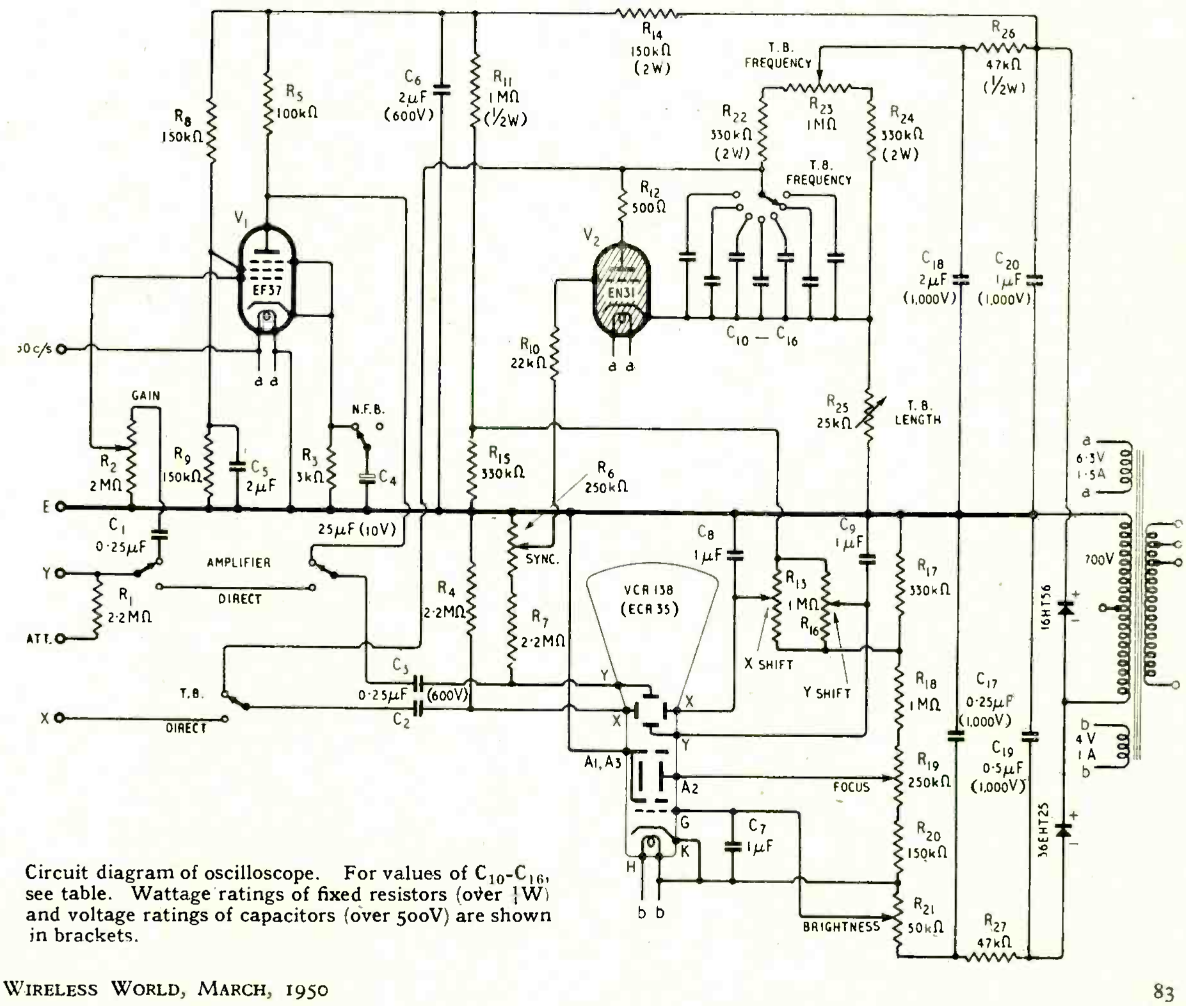
The synchronizing control, R_6, enables anything up to about 10 per cent of the Y-plate "work" voltage to be applied to the grid of V_2. This control performs very well; a fraction of its maximum is generally sufficient to lock the trace firmly to a signal of reasonably constant frequency.

Amplifier. By not attempting to extend the frequency range much above audio frequencies, one easily obtains a voltage amplification of 110–120 from a single stage. And since the peak-to-peak output voltage need seldom exceed 60V out of an available 500V h.t., there is very little distortion. That is with the bypass capacitor C_4 in circuit. When it is switched out, negative feedback reduces the gain to about 20, which affords a convenient step-adjustment of gain, and incidentally improves the uniformity of amplification. Over 20–20,000 c/s it is almost perfectly level, and a useful gain remains at some hundreds of kc/s, for v.f. tests, etc.

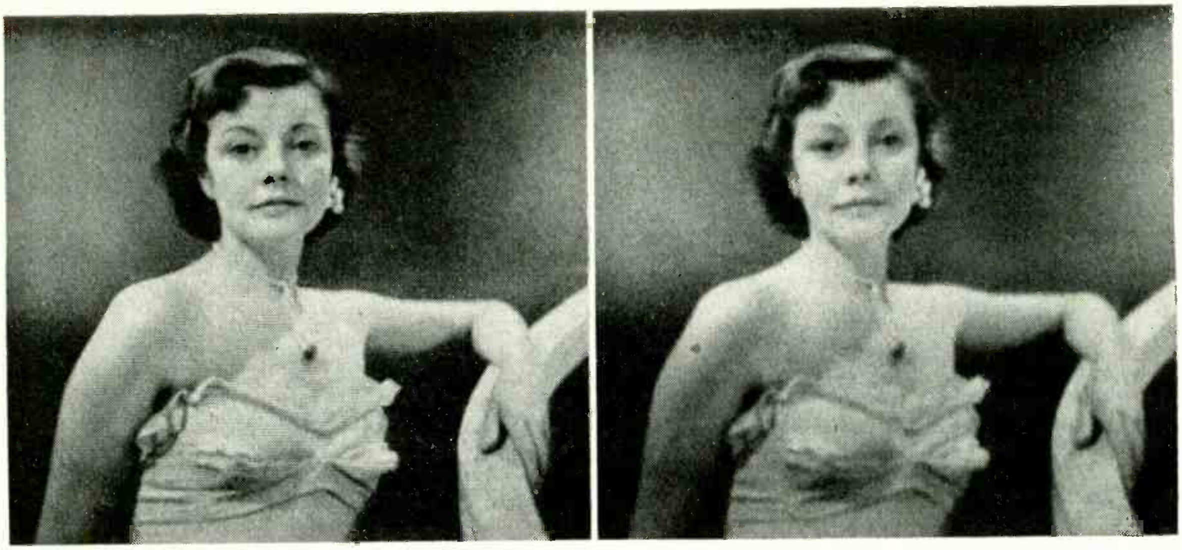
If the gain control R_2 is set low, its attenuation at high frequencies may be less than expected, due to bypassing by stray capacitance. A resistance R_1, which can be extended if desired, is included to bring voltages over 100 inside the "picture." The method of switching the amplifier is more convenient than separate terminals for Y-input, "with A" and "without A," but stray switch capacitance should be minimized by careful wiring.

General. No particulars of container and layout are given, because they can be arranged to suit convenience and requirements. Owing to the high resistance of the circuits associated with the c.r.t., the main thing in laying out and wiring the job is to avoid capacitance coupling from points of high alternating potential, especially the live end of the transformer h.t. winding. Reasonable care over this is rewarded by steady sharply-defined traces.

A useful feature is a terminal connection to the live end of the 6.3V winding, which gives 18V peak-to-peak 50 c/s for setting-up, frequency calibration, and many other purposes.



Circuit diagram of oscilloscope. For values of C_{10}-C_{16}, see table. Wattage ratings of fixed resistors (over ½W) and voltage ratings of capacitors (over 500V) are shown in brackets.



Elimination of lines by spot wobble is shown on the right : photographs taken with the new B.B.C. "telefilm" camera

Television Spot-Wobble

Simple Technique for Combating "Lininess" in the Raster

By R. W. HALLOWS, M.A. (Cantab), M.I.E.E.

EVERY viewer is familiar with the unpleasing effect known as "lininess" in the images on the screen of a television receiver. The proverb tells us that we can't cut our cake and have it: television reception, on the other hand, appears to show that if we use a technique which involves cutting the image into horizontal slices, we are bound to find that we have "had it" in the unpleasant impression produced by the dark lines which cross the screen from side to side. Experts hasten to assure us that if the lines are obvious enough to annoy us, we are sitting too close to the viewing screen. "Move away," they urge, "until the lines of which you complain are no longer sufficiently clear to call your attention to them; you then won't be conscious of them at all, and you will see the television image as it should be seen."

Although I have a respect amounting almost to veneration for the pundits of radio and television, no very deep processes of thought or observation are required to bring one to the conclusion that the offensive dark horizontal lines are part and parcel of the fine detail of the image shown on the television screen. Remove yourself far enough to lose the lines and don't you automatically lose also something of the sharpness of the picture? My vision is, admittedly, not normal now; I have not only to use glasses, but also to wear different glasses for distant work and for reading. For that reason I should hesitate to base any criticism of a television reception system on the evidence of my own eyes alone. I find, though, that those with normal vision with whom I discuss the subject hold opinions very like my own: moving far enough from the television screen to make the lines unnoticeable means, willy nilly, the acceptance of a not very sharp or detailed picture. Certainly there was no discrepancy in the views expressed by the owners of good, moderate and not-so-good eyes at a recent demonstration of spot-wobble television reception. All of us agreed that it was a joy to be able to sit near enough to the screen to see all the detail, and yet not to be worried by lininess in the image.

Having heard something of spot-wobble, and finding that it was in regular use in the B.B.C. Research Department, I asked whether one or two friends and myself might be allowed to sample its achievements. I have to thank Mr. S. N. Watson, of the B.B.C. Designs Department, for his ready co-operation and help. Spot-wobble (which, as its name suggests, means that the receiver scanning spot takes a wobbly, instead of a straight, course across the screen) can hardly be described as new, for the original patent was taken out in 1934 by a French company engaged in the manufacture of gas meters! Until fairly recently, though, it does not appear to have been exploited; and so far as I know, no use of it has yet been made in any domestic television receiver.

The instrument used for the demonstration was a receiver, very much of the *de luxe* order, specially made for the B.B.C. by Cinema-Television, Ltd., and containing a 20in c.r.t. I imagine that its cost would be in the neighbourhood of nine or ten times that of the ordinary domestic set—the tube alone runs, I believe, to something like £80! Apart from the size of the screen, striking features of this set are the sharpness of its focus and the perfection of the interlacing, clearly seen in its raster.

The first surprise was furnished by the position of the chairs in which we were asked to take our places. I did not actually measure the distance between them and the screen, but I am sure that it was not more than seven or eight feet. The reader will know that this is very much less than the optimum viewing distance laid down by the experts for the $17\frac{1}{2} \times 14$in picture shown. The lines should have been very much in evidence; and when the picture first appeared they were.

I was handed a small box connected by a length of twin flex to the receiver. "Cut the spot-wobble in or out as you like," I was told. "It's out now; but do that with the switch and it's in." I promptly did "that." The lines disappeared as completely as if some wizard had removed them with a magic duster. Handing the box to another of the party I put on my reading glasses, which focus at about 14in, and went close up to the screen. Looking right into it in this way one could still see no lines. One was conscious of what I may term a kind of small-scale turbulence of the picture elements, which was somewhat reminiscent of Brownian Movements. This activity is entirely invisible at over about 3ft to people with ordinary sight. The picture appears clear, detailed and with no dark lines.

Effect of Focusing

Thinking over the demonstration later on, I was led to wonder whether the full effectiveness of spot-wobble had not been due largely to the combination of a big screen and focusing arrangements so good that the spot was far smaller than that of the overall domestic television receiver. These points I mentioned to a friend who was going to see the apparatus later. A small screen-set was not available, but at his suggestion, definition was degraded by de-focusing until it was judged to be of average "domestic" quality. The improvement affected by spot-wobble was still definite and pleasing.

So much for the results of spot-wobble. The reader will now want to know just what it is and how it is done. In the familiar system of scanning the screen of the receiver c.r.t. the spot takes a straight-line course from left to right across the screen as it stipples in the image by its varying degrees of brightness from instant to instant. We speak of the television image as made up of blacks, whites and greys. Actually, there are probably few absolute whites or absolute blacks, the image being built up of an infinite variety of greys, ranging from extremely pale to extremely dark.

If we knew how to produce either a square-shaped scanning spot or a perfectly circular spot of unvarying diameter, no dark lines would appear on the screen to annoy us, for the diameter of the spot could be made always equal to the width of a line. Actually, the spot is only roughly circular in shape and its apparent diameter varies in practice quite considerably with the degree of brightness. On whites the spot has a very bright central portion, though its brilliance tails off towards the sides; it then appears to be larger than when it is dealing with medium, dark and very dark greys. The net result of all this is that the average diameter of a properly focused spot is a little less than the width of the slice of the image that it is painting in. At the top and bottom of the scanned line there are two narrow unactivated strips of the screen and, unless one views it at not less than a certain minimum distance, depending on its size, the image shows dark horizontal lines.

The better the focusing arrangements of a television receiver the smaller is the spot. This has two results. The first is improved definition; for the smallest element of an image that the spot can reproduce properly is one that is at least as large as itself. This is brought out in Fig. 1, from which it is seen that the brilliance of the spot at any instant corresponds to the *average* shade of the tiny portion of the image with which it is then dealing. As the figure shows, a spot large enough to fill the scanning line completely cannot reproduce the finest details of an image; an area consisting of tiny black and white elements is painted in as a grey patch. In many domestic receivers the focus is not very sharp, and there is consequently some loss of detail.

The second result of sharp focusing is to make the spot so small that, though it can cope with the finer details of the image, its diameter is less than that of the scanned strip. Hence, marked horizontal lines are produced on the screen, and to get rid of their effects the viewer must be so far away that he loses, perforce, much of the improved definition.

In other words, lininess is not so obvious as to be particularly offensive in the television receiver whose focus is not very sharp; but it becomes more and more marked as the focusing arrangements—and the definition—are improved in better designed instruments at higher prices. Third, although spot-wobble is of the utmost value when applied to high-quality receivers, it is not to be expected that it will produce an equally striking improvement in sets in which the spot-focus is not very sharp. Nevertheless a definite improvement is likely even in these.

The spot-wobble system is so utterly simple that one cannot refrain from wondering why it was not thought of and applied at the very inception of c.r.t. television. But it is the way of important inventions to be completely simple—and of people to kick themselves for not having thought of them.

What will happen if a small, rapid, up-and-down movement is superimposed on the lateral travel of the spot? Make the movements in the vertical sense sufficiently rapid and the amplitude of those movements so small as not to overlap seriously the

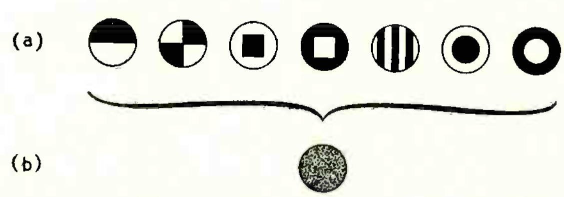


Fig 1. The scanning spot cannot deal adequately with any element of an image with an area less than its own. The spot, in fact, records on the screen elements representing the average illumination of areas of the same diameter as itself. Hence, the fine detail of each of the seven tiny areas seen at (a) is lost, and all of them appear on the screen as the small uniform medium-grey patch (b), the shade of which corresponds to the average brightness of each. The smaller the spot, due to good focusing, the better is detail brought out.

boundaries of one scanning line, then the wobbling spot will activate virtually the whole rectangular area of the screen corresponding to the line. To put it in another way, there will be what amounts to vertical elongation of the spot, and this, if correctly regulated, will annul the failure of the sharply focused spot to cover the full width of the scanned strips which, in the ordinary way, provides each line with dark borders and gives rise to lininess. The scanning element becomes a short vertical line instead of a spot and the gaps are filled without losing horizontal definition.

Additions to the Receiver

That, precisely, is what is done in spot-wobble. The effects are illustrated diagrammatically in Fig. 2. By using spot-wobble we scan, in effect, not with a roughly circular spot, but with an elongated spot. The essence of the spot-wobble system is to give the spot a vertical movement at a frequency approaching 1,000 ups and downs—let us call them cycles—per line. For our British 405-line, 25-image-per-second system this means a frequency of the order of 10 Mc/s. It would clearly not be feasible to apply this at the transmitter, the total modulation band-width of which is some 2.8 Mc/s. But there is no need for this. Spot-wobble is, in fact, essentially concerned with the receiver; and it is so simply produced that the additional cost need hardly exceed £1.

It might be done electrostatically by the use of two small deflector plates; but I was given to understand that magnetic methods are used in the instrument which we saw. The necessary additional circuits are shown in Fig. 3. They are given in block form partly because they are so simple and partly because the optimum component values for any particular television receiver must be found by experiment. The on-off switch is required because the receiver should be focused as sharply as possible with the wobbler out of circuit. That having been done, the switch is closed. To start with the control knob should be at the position giving minimum amplitude. Then the amplitude is gradually increased until the best balance is reached between welcome loss of lines and unwelcome loss of definition.

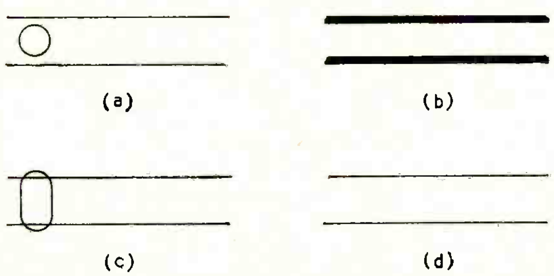


Fig. 2. The unwobbled "round" spot does not (a) quite fill the strip of the image which it scans. The result (b) is that each strip has narrow black borders and that the image is "liny." The better the focus, the smaller the spot and the better the definition—but the more pronounced also is the lininess. The wobbled spot (c) provides much the same effect as would the actual elongation of an unwobbled round spot. The scan slightly overlaps the edges of the strip and there are no unactivated portions of the screen; hence (d) the scanned strip is reproduced without the black borders, and the lininess disappears.

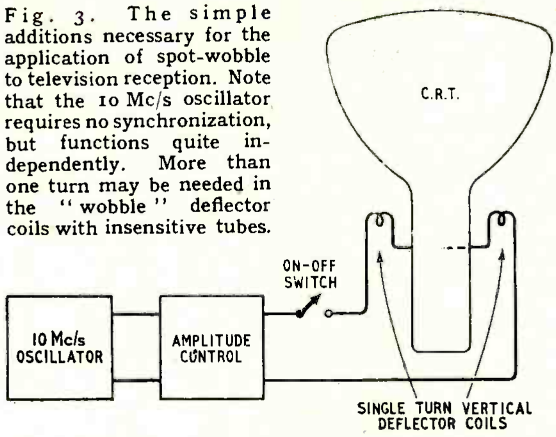


Fig. 3. The simple additions necessary for the application of spot-wobble to television reception. Note that the 10 Mc/s oscillator requires no synchronization, but functions quite independently. More than one turn may be needed in the "wobble" deflector coils with insensitive tubes.

For it must be admitted that spot-wobble results in a slight loss of vertical definition. When the proper adjustment of the amplitude is made the loss is very small indeed, and, as the vertical definition is rather better than the horizontal with existing systems, this is a matter of no real moment.

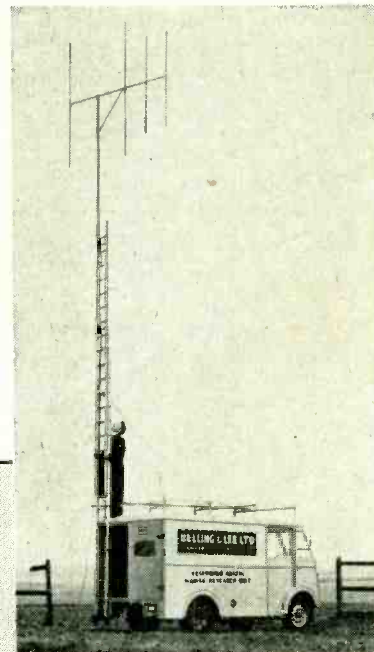
It is interesting to calculate the effects of a 10-Mc/s superimposed wobble on 405-line, 25-image-per-second reception. These can conveniently be based on a 10 × 8-inch image, for that is fast becoming the most popular size. Working in round figures, this frequency gives 1,000 wobbles per line. But the visible portion of the line is only 83.5 per cent of the whole; hence we have 835 up-and-down movements of the spot in 10 inches, or 83.5 in each inch of scanned line on the screen. The "wavelength" of the wobble in a 10 × 8-inch picture is thus 1/83.5 = 0.012in.

Since 377 "active" lines compose the screen image measuring 8in from top to bottom, the width of one line is 8/377, or 0.021in. As we have seen, the average diameter of the unwobbled spot is a little less than the width of one line. Let us call it 0.02in for the sake of argument. It will be seen that cutting in the spot-wobble circuit causes the scanning spot to describe very nearly two complete up-and-down movements as it travels a lateral distance equal to its own diameter.

It is open to question whether spot-wobble would work equally well with sequential scanning. Quite possibly the amplitude of the wobble, when adjusted to give the best results with interlaced scanning, would result in an undesirable overlap on "peak whites" (when the spot has its maximum diameter) in a sequential system. A smaller amplitude might be ineffective. But we do not seem likely to be concerned, at any rate in the near future, with any but interlaced systems; and with these, spot-wobble appears to supply the best means yet devised of making the even-numbered scanning lines adequately fill the gaps between those of odd number. It is interesting to speculate on the possible applications of spot-wobble to existing and future schemes for both colour television and stereoscopic television. Any system which permits a controlling frequency of 10 Mc/s or more to be applied to the scanning spot, quite independently of the transmitter bandwidth, or of the pass-band of the receiver's r.f. and i.f. circuits, is clearly worthy of serious attention by those now engaged in the research which will lead to the television of tomorrow.

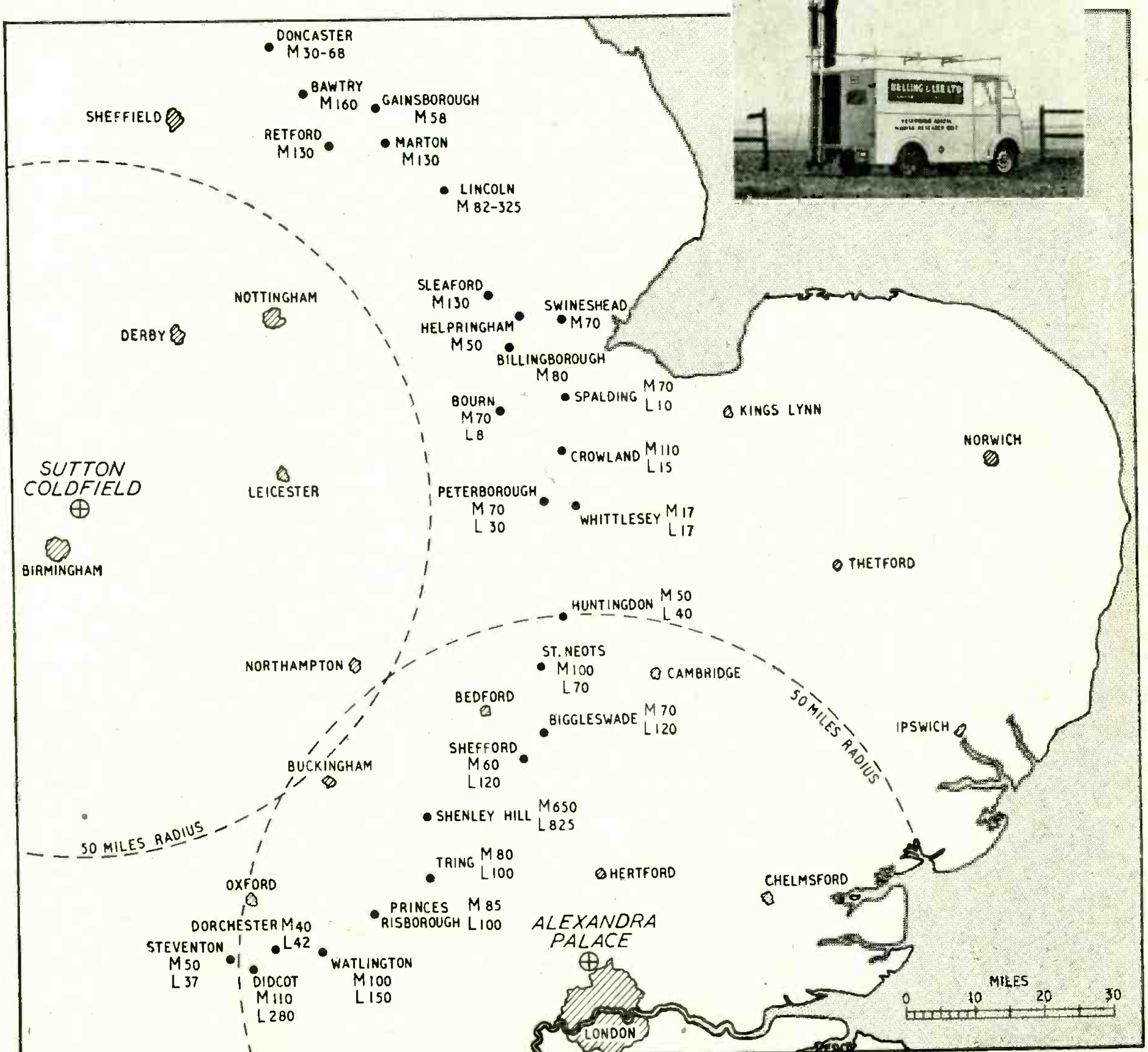
Fringe-Area Television

Map showing Midlands Station Field Strengths Outside the Recognized Service Area.



THIS map has been compiled from data gathered by Belling and Lee during the first part of a tour by a mobile field-strength measuring van (shown inset) on a radius of roughly 70 miles from Sutton Coldfield. Height of the 4-element receiving aerial array used for the measurements was 40ft above ground level. Vision signal strengths are shown in microvolts per metre for the Midlands station (M) and, where receivable, for London (L). At a few sites wide variations were met: these are indicated by minimum and maximum figures. At most sites a good picture was obtainable in the van from a representative commercial monitoring receiver fitted with a single-stage pre-amplifier when signal strength was 70 μV/m or over.

(*Data published by courtesy of Belling and Lee.*)



Wide Range R-C Bridge

A Simple Instrument for Resistance, Capacitance and Insulation Measurements

By **H. E. STYLES**, B.Sc.

IN these days of readily obtainable surplus radio components it is more than ever necessary to have a means of checking resistors and capacitors since these often bear no readily identifiable markings and may in any case be defective.

The use of an a.c. bridge for the measurement of resistance and capacitance will no doubt be familiar to most readers of this journal, as also will be the use of a neon "flasher" for insulation testing. The instrument to be described has been designed with a view to performing these three tests with a minimum of equipment. It has, moreover, a more open scale than many bridges, and can be operated from either a dry battery or a very simple mains unit, since its power consumption amounts only to about 0.1 mA at 200 V.

Bridge Circuits. The simplest a.c. bridge comprises the circuit of Fig. 1. In this an alternating potential is maintained across a potentiometer P, and an unknown resistance X is compared with a known resistance S by adjusting P until no sound is audible in the telephone receiver T. Under these conditions $X = \frac{B}{A}S$, where B and A are the resistance values of the two portions of the potentiometer at the balance point. Whatever the value of S, a given setting of the potentiometer always corresponds to a particular ratio between S and X and therefore a scale can be fitted to P to indicate this. It is evident that such a scale will extend from infinity at one extreme to zero at the other, the centre point corresponding to a ratio of unity. It follows that for ratios greater than unity the graduations must rapidly become very compressed.

The circuit can also be employed for comparison of capacitances, but if the same ratio scale is to be used it is necessary to interchange the position of the unknown and known components, since the bridge actually compares reactances which are, of course, inversely proportional to the capacitances.

Fig. 1. Simple bridge circuit.

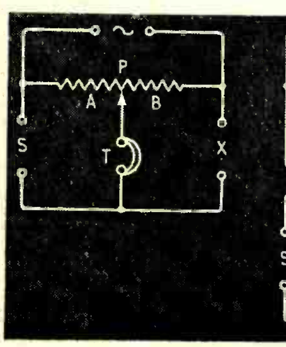


Fig. 2. Improved bridge circuit.

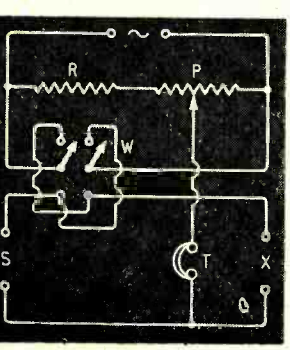
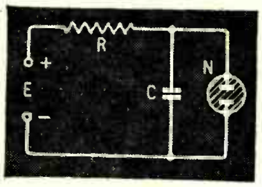


Fig. 3. Neon oscillator.



An improved circuit is shown in Fig. 2. In this a fixed resistance R is placed in series with the potentiometer P which must have a resistance slightly greater than R. A change-over switch W provides a means of interchanging S and X so that the bridge can always be balanced, regardless of whether S or X has the greater resistance. A ratio of unity, however, now corresponds to a potentiometer setting close to the extreme limit adjacent to R, and rotation of the potentiometer away from this position corresponds either to an increase or a decrease in ratio according to the position of switch W. Thus an almost complete rotation of the potentiometer now corresponds either to a range of ratios of from unity to zero or from unity to infinity so that the effective scale length is twice that of the circuit of Fig. 1. The potentiometer has to be provided with two scales, but this presents no difficulty since one is merely the reciprocal of the other. Which scale has to be used during any particular test is determined by the position of switch W, and, when testing capacitors, it is merely necessary to employ the scale opposite to that which would be used were resistances being compared.

A.C. Excitation. Various types of a.c. generators may be used for bridge excitation but, as will be seen later, the complexity of the test equipment and its versatility are considerably affected by the type of generator selected. Amongst possible sources of a.c. the following are commonly employed:—

1. *Electro-magnetic buzzers.* These are normally suitable for battery operation only, are somewhat difficult to maintain and required to be sound-proofed to obviate acoustic interference. Their frequency range is restricted and additional equipment must be provided for insulation testing.

2. *50-c/s a.c. mains.* This is far from an ideal source since neither the ear nor most telephone receivers are very responsive to a frequency of 50 c/s, whilst such a low frequency results in unduly high values of reactance when dealing with small capacitances. Hum pick-up from stray leakages may mask the null position, the frequency is fixed, and, obviously, such a source can only be used if a.c. mains are available. Added equipment is necessary for insulation tests.

3. *Valve oscillators.* These can be made to produce any desired frequency and can be mains or battery driven. Power consumption, however, may be relatively high owing to the necessity for cathode

heating and, in the case of mains-driven units, a fair amount of ancillary equipment is required. Additional equipment is required for insulation testing.

4. *The neon oscillator.* In the author's opinion this is the almost ideal a.c. source for simple bridge work. Very few components are needed and the oscillator can be operated from either batteries or mains (d.c. or a.c.). Power consumption is negligible, the frequency can be adjusted over a wide range, and, finally, the same components can be used for insulation testing. An extremely compact unit can be constructed if miniature neon tubes such as are employed in certain types of tuning indicators are used, but even with more normal tubes a compact assembly is possible since, in essence, the oscillator comprises only the three components shown in Fig. 3.

A "d.c." potential E charges the capacitor C through a high resistance R until the potential of C reaches the striking voltage of the neon tube N. At this stage capacitor C becomes partially discharged until its potential falls to the extinction voltage of N, when the cycle repeats itself. By suitable choice of values for E, R and C the repetition frequency can be varied from a few cycles per second to above the limit of audibility. With two of the values fixed, variation of the third gives a wide though not full range of control and applied voltage is a convenient choice of variable.

Insulation Testing. The circuit of Fig. 3 can be applied without alteration to the testing of the insulation of components such as capacitors, since, provided the combined leakage resistance of the neon tube, its holder and the shunt capacitor is sufficiently high, the capacitor can still be charged up to the striking voltage of the neon tube even though an extremely high resistance be inserted in series with the tube and the source of fixed potential. The striking frequency will, of course, decrease as the series resistance is increased, but with careful attention to the insulation of the oscillator it is easily possible to make it responsive to leakage resistances of 100 megohms or more. Owing to the small value of shunt capacitance required to produce a suitable frequency for bridge operation, the flashing of the neon tube is not so brilliant as is usual for "flash" testers, but this is no disadvantage since the occurrence of flashing is accompanied by the production of an audible signal in the telephone. In fact, in the author's instrument the neon tube is mounted behind the panel and its flashing is in any case not visible.

The objection might have been raised that a neon oscillator necessitates the use of somewhat high operating potentials, but this can now be seen to be invalid since if insulation tests are to be made it is obviously desirable to conduct these at a voltage reasonably similar to the working voltage of the components under test, and this is commonly of the order of 200 V.

Complete Test Circuit. The complete circuit of the test equipment is shown in Fig. 4. Apart from the inclusion of a means whereby any desired "standard" resistance or capacitance can be switched into circuit, it will be noted that two modifications to the previous circuits have been made. First, the relative positions of the telephone receiver and a.c. source have been interchanged. This has no effect upon the balance of the bridge but results in greater sensitivity when high resistances or low capacitances are being compared. Second, the neon oscillator is coupled to the bridge circuit by means of a step-down transformer. This serves the dual purpose of isolating the bridge and telephones from the power supply and also of helping to match the high impedance of the a.c. source to that of the bridge. The characteristics of the transformer are in no way critical and, since only a very small direct current is passed through the primary, a miniature a.f. component of 3:1 or high ratio is quite suitable.

Terminals Z are normally short-circuited and are employed only when insulation tests are being conducted. The selector switch SW for "standard" resistors, etc., is provided with an open-circuit position so that terminals S can be connected to any desired comparison component for special purposes.

With the change-over switch in position A the bridge covers ratios from unity to infinity, whilst in position B the ratios range from unity down to zero. For capacitance tests the switch positions are reversed.

Construction. The lay-out of the components is in no way critical and may be such as to give a maximum compactness with the particular articles available. Undue capacitive couplings between the wiring should, however, be avoided, and it is most important to ensure that the insulation of the oscillator components and terminals Z is as high as possible. A list of the components is given with Fig. 4.

In the author's instrument the "standard" com-

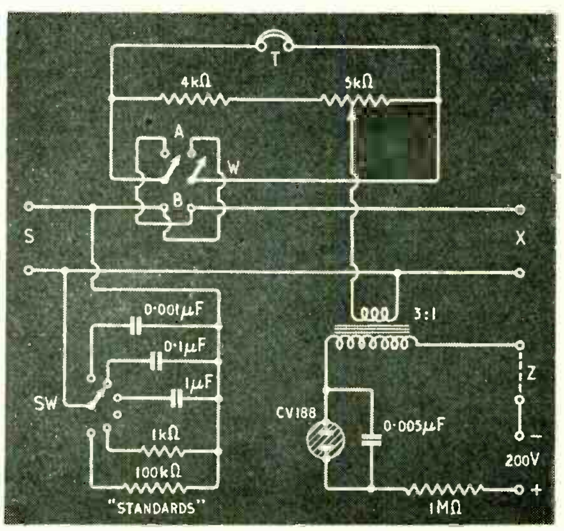


Fig. 4. Complete test circuit.

List of Components

Wire-wound linear law potentiometer, 5,000 Ω.
Fixed resistors—4,000 Ω, 1 watt, 1 MΩ, 1 watt.
D.P.D.T. switch (W).
Six-position S.P. wafer switch (SW)
High-impedance (4 kΩ) telephone receiver.
Telephone plug and jack (or terminals).
A.F. transformer—3:1 or higher ratio
Neon tube, type CV 188.
Fixed capacitor, 0.005 μF—preferably mica dielectric.
"Standard" components: Resistors, 1 kΩ and 100 kΩ. Capacitors 1 μF, 0.1 μF and 0.001 μF.
Terminals, panel, containing box and calibrated dial.

ponents and selector switch are mounted in the lid of the containing case, which is also provided with a compartment to house a single telephone earpiece and connecting leads. The rest of the components are mounted behind the panel of the bridge proper and the whole instrument is contained in a box measuring 8in × 7in × 4½in externally when closed.

The neon tube specified is actually a voltage stabilizer available as government surplus, but other tubes possessing reasonably similar characteristics can be employed, though minor adjustments to the series resistance and shunt capacitance values may be necessary to obtain a satisfactory oscillation frequency. The striking and extinction voltages of the tube should, however, be in the neighbourhood of 140 V and 100 V respectively.

Power Supply. No power supply has been incorporated in the test equipment, since many readers will already have available a suitable source of d.c. at about 250 V, whilst in other cases it may be desired to use batteries. The very simple circuit of Fig. 5 has been found to be quite adequate to provide the required supply from a.c. mains. The reservoir and smoothing capacitors may be of any capacitance above 1 μF, whilst the 1 megohm variable resistor functions as both a smoothing resistance and voltage controller. In view of the small current demanded, the rectifier could well be of the type employed for providing e.h.t. supplies in television receivers. The smoothing capacitor should, however, be non-electrolytic to obviate excessive voltage drop due to passage of leakage current through the smoothing resistance.

Preliminary Adjustments.—No difficulty should be experienced in getting the equipment to operate satisfactorily. Terminals S should be short-circuited as well as terminals Z and, with switch W in position B, the potentiometer turned to its extreme position farthest from its junction with the fixed resistor R. This ensures a maximum of unbalance and a strong signal in the telephone. A voltage of about 150 is then applied to the oscillator and slowly increased. Oscillation will be indicated by a ticking sound in the telephone which will increase in frequency as the voltage is increased until a suitable note is produced. If the voltage is raised too high the tube may glow steadily and oscillation cease and should this occur before a sufficiently high frequency is obtained the shunt capacitance must be reduced somewhat. It

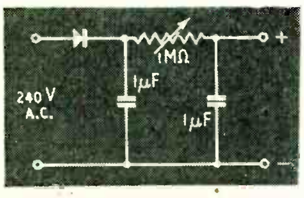


Fig. 5. A.C. power supply.

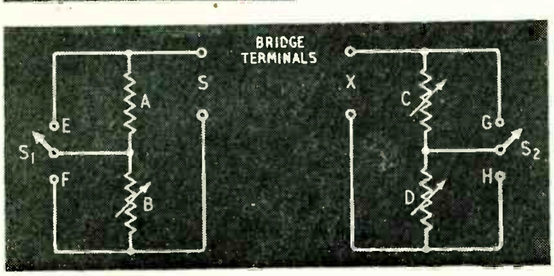


Fig. 6. Calibration circuit (Procedure 2).

will usually be found that at certain frequencies the telephone response peaks, on account of diaphragm resonances, and such a frequency should be employed for maximum sensitivity.

Having obtained satisfactory operation of the oscillator, terminals Z should be open-circuited. This should result in complete cessation of oscillation and if a slow ticking sound persists in the telephone it can be concluded that the insulation of the oscillator circuit is faulty. If so, appropriate steps should be taken to rectify the trouble; otherwise the leakage will be added to that of components undergoing insulation test.

Finally, if available, a high resistance of some 100 MΩ should be connected across terminals Z when a slow ticking sound will show that the leakage resistance across the tube shunt capacitance is sufficiently high to enable the instrument to detect insulation defects such that anything smaller can be ignored for all ordinary purposes. Should no oscillation occur under these conditions the resistance across terminals Z should be reduced until a slow tick is produced. This will indicate the limit of sensitivity of the insulation test and if this proves to be inadequate, attention must be paid to the insulation of the neon tube and its shunt capacitor.

Calibration.—It is, of course, necessary to calibrate the instrument in order to construct either a specially graduated dial giving ratio values direct or, if a uniformly graduated dial is used, a graph by means of which dial readings can be converted to ratio values. The former involves rather more work initially, but renders the bridge much more convenient to use and is well worth while.

Whichever method is adopted, however, the calibration procedure described below can be employed. This depends upon the fact that, apart from small irregularities at the extreme positions of rotation, a linear law potentiometer is such that a given angle of rotation corresponds to the same change in resistance whatever the initial position of the potentiometer contact. From this fact it can easily be established that if F be any bridge ratio value less than unity and Y the angle between the corresponding potentiometer position and that of unity ratio, then the relation between F and Y is given by the expression $Y = K\frac{1 - F}{1 + F}$ where K is a constant for any particular bridge. It follows that a graph of Y against $\frac{1 - F}{1 + F}$ will be a straight line and can therefore easily be drawn provided a few corresponding values of Y and F can be determined. Once such a graph has been prepared it can be employed to determine the angle of rotation required to give any desired bridge ratio, and the problem of calibration is thereby solved.

It is thus necessary only to determine a few fixed points on the bridge and this can be done by either of the two following procedures. If a direct-reading dial is to be constructed the potentiometer should be fitted with a temporary paper scale upon which positions can be marked, and this should first be provided with two diametrical lines at right angles so that the position of the scale centre can readily be located after a central hole has been cut for the potentiometer spindle. Whichever type of dial is used the position of maximum (or minimum) mechanical rotation of the potentiometer should be marked or noted so that

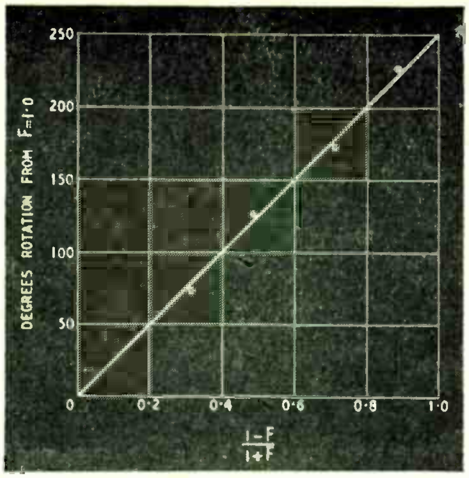


Fig. 7. Typical calibration graph.

if the dial is removed it can be replaced in the same position on the potentiometer.

Procedure 1. This is the simpler procedure but involves the use of resistors of accurately known values. Only a few such resistors are needed, however, and a suitable selection would be the following. 1 kΩ, 1kΩ, 3kΩ and 50kΩ.

With the bridge change-over switch in position B and the selector switch set so as to open circuit terminals S, the dial positions required to balance the following combinations of resistors should be determined.

Resistors in series across terminals S	Resistors in series across terminals X	Ratio F	Value of $\frac{1-F}{1+F}$
1 kΩ	1 kΩ	1.0	0
3 kΩ	1 kΩ, 1 kΩ	0.667	0.2
3 kΩ	1 kΩ	0.333	0.5
1 kΩ, 3 kΩ	1 kΩ	0.25	0.6
50 kΩ	1 kΩ, 1 kΩ, 3 kΩ	0.10	0.818
50 kΩ	1 kΩ, 1 kΩ	0.04	0.923
50 kΩ	1 kΩ	0.02	0.961

From the dial readings thus obtained, or from measurement by protractor, the angles of rotation from unit ratio position can be determined and these plotted against the corresponding values in the final column of the above table. The points thus plotted should lie on a straight line and the latter should be drawn so as to give the best possible fit.

Procedure 2. This method does not require the use of any accurately known values of resistance, but necessitates the use of a fixed resistor of about 1 kΩ, and variable resistors of about the following resistance values: 2 kΩ, 20 kΩ, and 20 kΩ. The two high-resistance components can with advantage be wired in series with 1-5 kΩ variable resistors to provide fine adjustment, but this is not absolutely essential. Two single-pole change-over switches are also required.

As before, the selector switch of the bridge is set to open-circuit terminals S, and the above resistors are conected to the bridge in the manner shown in Fig. 6 with B = 20 kΩ, C = 2 kΩ and D = 20 kΩ.

The first operation is to determine the position of the potentiometer corresponding to a ratio of unity. With switch S_1 in position F and switch S_2 in position H, resistor C is adjusted to a setting considered to approximate to a resistance of about 1 kΩ. The bridge is then balanced and its setting noted or marked on the scale. The bridge change-over switch W is then reversed when a signal will probably be received in the telephone, in which case the bridge is re-balanced and its new setting noted. The bridge is then set to a position midway between the two positions thus determined, and resistor C is adjusted until no signal is audible. The bridge change-over switch is again reversed, and if a faint signal appears a fresh balance position obtained. The bridge is set to midway between these two positions, as before, and resistor C again adjusted to give no signal. The change-over switch is again reversed and the foregoing procedure continued, if necessary, until the balance remains unchanged by reversal of the bridge change-over switch. When this is so, the resistance C must be equal to the resistance A and the bridge setting must therefore correspond to a ratio of unity. Note or mark this on the temporary scale.

Next move switch S_2 to position G and adjust resistor D until no signal is received, the bridge being left at the unity ratio setting. Resistors A, C and D must then all be equal. Switch S_2 is then opened so as to put resistors C and D in series and the bridge re-balanced with the change-over switch W in position A. This corresponds to a ratio of 2 : 1, or, bearing in mind that the two bridge scales are reciprocals of each other, to a ratio of 0.5 : 1.

The bridge change-over switch is then reversed and, with the bridge setting still at the 2 : 1 or 0.5 : 1 position, switch S_1 is moved to position E and resistor B is adjusted to give no signal. The resistance of B must then be twice that of C plus D or four times A, C or D. Switch S_2 is therefore moved to position G and the bridge re-balanced to give a setting corresponding to a ratio of 0.25 : 1.

Again reverse the bridge change-over switch and, without altering the bridge setting, adjust resistor D to no signal. D must then have a resistance sixteen times that of A and, by moving switch S_1 to position F, the bridge can be re-balanced to a setting corresponding to a ratio of 16 : 1 or 0.0625 : 1.

Next reset the bridge to the previously determined 4 : 1 position, move the bridge change-over switch to position B, and switch S_2 to position H. Adjust resistor C to balance the bridge and thus make its resistance equal to one-quarter of A. Move switch S_1 to position E and S_2 to position G. Set the bridge to its unity ratio position and adjust resistor B to give no signal. Its resistance must then equal that of D, which has already been made equal to sixteen times A. B, therefore, now has a resistance sixty-four times that of C and by moving switch S_2 from position G to H the bridge can be balanced to give the setting for a ratio of 0.0156:1 (1:64).

Ratio F	Value of $\frac{1-F}{1+F}$
1.0	0
0.5	0.333
0.25	0.600
0.0625	0.882
0.0156	0.969

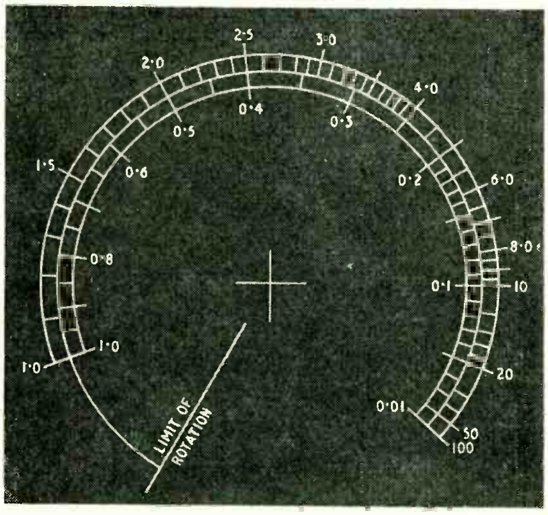
The foregoing procedure, which is much easier to perform than to describe, will have established the bridge settings for the ratios given in the table, and the corresponding angles of rotation from the unity position can therefore be determined and plotted against the values of $\frac{1-F}{1+F}$ as in the first method.

A graph such as that typified by Fig. 7 will thus have been prepared from which the angles corresponding to any values of $\frac{1-F}{1+F}$ can be ascertained. The Table below provides a ready means of converting bridge ratio values, F, to corresponding values of $\frac{1-F}{1+F}$ so that the graph can easily be used for the determination of angles corresponding to any desired values of F.

In the case of a uniformly graduated dial it will be necessary to construct additional graphs showing the ratio values plotted against dial readings, whilst a direct-reading scale can, of course, be constructed by marking in desired graduations with the aid of a protractor.

In both cases the scale readings for ratios above unity are determined by the position of the corresponding reciprocal value on the scale for ratios below unity. A typical direct-reading dial is illustrated in Fig. 8, the calibrations being extended as far as ratios of 0.01 or 100:1.

Fig. 8. Typical direct-reading ratio scales.



Comparison Standards.—To complete the instrument it is necessary to fit the standard components to the bridge selector switch. This demands the provision of at least one resistor and one capacitor of accurately known values, commercially available components of ±1 per cent tolerance being suitable. Given one component of known value of each type, other required standards may be selected, by means of bridge measurements, from available spares. The standards shown in the circuit diagram suffice to cover a resistance range of 10 Ω to 10 MΩ and a capacitance range of 10 pf to 100 μF, the highest range being somewhat lacking in precision, but very useful for checking electrolytic capacitors for which great accuracy is not needed.

Insulation Testing.—When it is desired to carry out insulation tests, the 1 kΩ standard resistance should be switched across terminals S, the change-over switch moved to position B and the bridge set to a ratio of 0:1 (i.e., fully rotated beyond the 0.01 ratio position). This ensures development of a loud out-of-balance signal.

Terminals Z are then open-circuited and the component to be tested is connected across them. If this has a fair capacitance it is probable that an initial burst of oscillation will be heard as the capacitance charges to the test voltage, but with components possessing first-rate insulation the oscillation will completely cease once charging has been completed. The continued occurrence of a few isolated clicks at a frequency such that they can be easily counted can be regarded as an indication that a leakage resistance of the order of some 100 megohms exists, a value sufficiently high to be ignored for all but the most exacting circuit conditions. With high-capacity components an irregular series of slow ticks may also result from fluctuations in the power supply voltage due to variations in the state of charge of the capacitance, but this effect is unlikely to be mistaken for a serious insulation defect.

If the rate of ticking is such that a low-frequency note is approached, the leakage resistance is of the order of tens of megohms and such components can only be regarded as possibly suitable for use under conditions when good insulation is unimportant. A musical note in any way approaching that of the normal bridge signal indicates very poor insulation.

The instrument can, of course, be used for any kind of insulation tests, such as the inter-winding insulation of transformers, but it is perhaps as well to point out that it cannot be used for checking the leakage of electrolytic capacitors, since this is always of considerable magnitude.

TABLE

Values of $\frac{1-F}{1+F}$ for ratios (F) of less than unity.

F	0	1	2	3	4	5	6	7	8	9
0.0	1.00	0.980	0.961	0.942	0.923	0.904	0.887	0.869	0.852	0.834
0.1	0.818	0.802	0.786	0.770	0.754	0.739	0.724	0.709	0.694	0.680
0.2	0.667	0.652	0.639	0.626	0.612	0.600	0.587	0.574	0.561	0.550
0.3	0.538	0.526	0.515	0.503	0.491	0.481	0.470	0.460	0.449	0.439
0.4	0.429	0.418	0.408	0.398	0.389	0.379	0.370	0.360	0.351	0.342
0.5	0.333	0.324	0.316	0.307	0.299	0.290	0.282	0.274	0.266	0.258
0.6	0.250	0.242	0.234	0.227	0.219	0.212	0.204	0.197	0.190	0.183
0.7	0.176	0.169	0.163	0.156	0.149	0.143	0.136	0.130	0.123	0.117
0.8	0.111	0.105	0.099	0.093	0.087	0.081	0.075	0.069	0.064	0.058
0.9	0.053	0.047	0.042	0.036	0.031	0.026	0.020	0.015	0.010	0.005

"Filters"—A Correction

The shunt arm impedance referred to in line 20, column 2 of page 27 in the January issue should be Z_2, and equation (1) on the same page should read:—

$$Z_0 = \sqrt{Z_1 Z_2} \cdot \sqrt{1 + \frac{Z_1}{4Z_2}}$$

Interference from Fluorescent Tubes

By "DIALLIST"

An Obscure Source of R.F. Radiation : Methods of Suppression

IN the January issue of *Wireless World* (p. 38) I made a brief mention of the interference with radio and television reception which may be caused by certain of the fluorescent tubes which are so widely used for lighting purposes nowadays in business premises and in homes. Realizing that the three short paragraphs referred to did little more than touch the fringe of a wide subject, I arranged, with the kind co-operation of Messrs. Belling & Lee, to spend a day in the firm's research department in order to go into the matter more thoroughly. It would obviously be of interest to others besides myself to know more about it. Every reader uses radio receivers of one kind or another and many have television sets as well; the use of fluorescent lighting is increasing rapidly; there is the Wireless Telegraphy Act of 1949, with its clauses prohibiting the use of interference-radiating apparatus . . .

One aspect of the question of the radiation of interference by gas-filled discharge tubes has received adequate treatment by Dr. E. B. Armstrong and Professor K. G. Emeleus of Queen's University, Belfast, in their paper on "The Generation of High-Frequency Oscillations by Hot-cathode Discharge Tubes Containing Gas at Low Pressure."* Their paper, however, is concerned mainly with low-pressure diodes and does not cover the fluorescent lighting tube, the behaviour of which shows important differences.

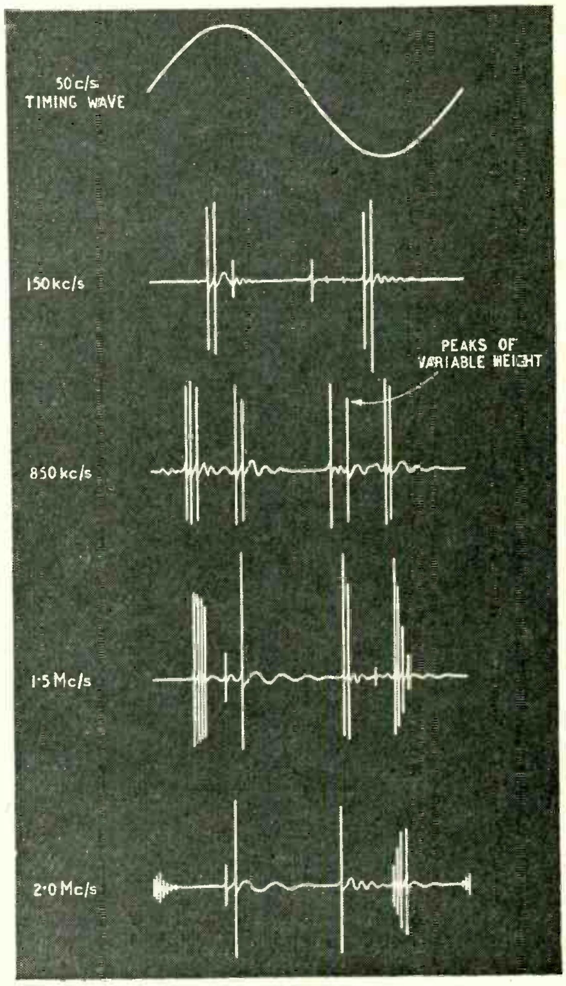
Outstanding amongst the observed facts about the behaviour of fluorescent tubes is that a small percentage of them generate interference with radio and television reception, the effects of which can fairly be described as devastating. The loudspeaker emits intolerable noise; across the screen of the television receiver there appear stationary white horizontal bars. If the receiver is close enough to such a fluorescent tube, the c.r.t. may be so over-driven that the horizontal bars are black instead of white.

The interference is generated by oscillation in the tube. This condition is not produced immediately the tube is switched on. It occurs from 5 to 15 minutes after switching on; and, once it has started, oscillation normally continues. It can be stopped as a rule by tapping the tube smartly. The interference then ceases for a time; but it always reappears, if the tube is one of those prone to oscillate, within 15 minutes.

When a tube is causing interference a noticeably bright spot can be seen on one of the heaters by looking through the narrow strip of clear glass near one or other of the ends. Rapping the tube sharply causes the bright spot and the interference to disappear simultaneously.

The interference is impulsive and the pulses are of very short duration; probably much less than a microsecond. For this reason no clean record may be obtainable on the screen of a cathode-ray oscillograph unless a suitably designed set-up is used. Fig. 1 shows interference waveforms on the screen of a c.r.o. connected across the telephones at the output of a receiver with a bandwidth of 8—10kc/s (6db down). The waveforms shown represent the modulation envelopes corresponding to large numbers of brief pulses. They are those obtained with the re-

Fig. 1. Typical fluorescent-light interference waveforms at various frequencies. C.R.O. connected across telephone terminals at output of measuring set with receiver bandwidth of 8-10 kc/s (6 db down).



* *Proc. I.E.E.*, Part III, No. 43. Sept., 1949; p. 390.

ceiver tuned to 150kc/s, 850kc/s, 1.5Mc/s and 2Mc/s.

The interference occurs at intervals over an enormously wide band of frequencies, extending from less than 100kc/s to well over 3,000Mc/s. Curiously enough, there is no harmonic relationship whatever between the frequencies at which it may be observed. If, for example, there is interference at 800kc/s, it may be absent at 1.6Mc/s, 2.4Mc/s or 3.2Mc/s.

Just how it is caused within the tube is still a matter that needs to be cleared up. There can be no doubt that its point of origin is the bright spot on the heater: if a search coil is moved over an interference-producing tube, the response of the c.r.o. increases as the coil nears the region of the bright spot and diminishes as it is moved away from it; but what exactly is taking place there?

The most plausible suggestion advanced up to now is that the oscillations causing interference are generated at a point (the bright spot, in the case of the fluorescent tube) where there is a small degree of flaking of the surface of the heater or cathode. This might occur with either a plain metal or an oxide-coated electrode. Between the body of the electrode

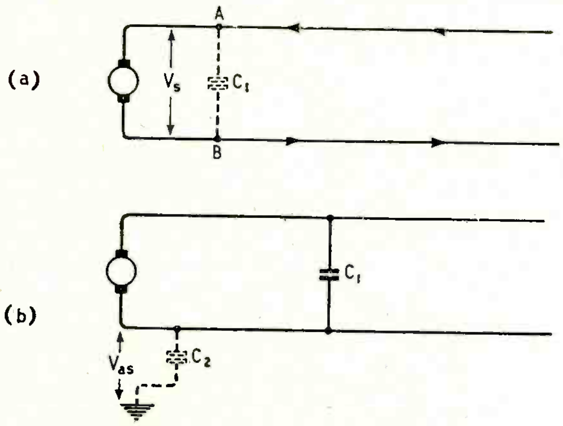
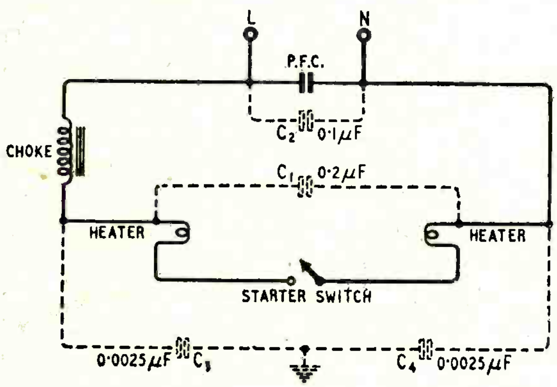


Fig. 2 (a). The symmetric component (V_s) of the generated interference consists of voltages nearly equal and of opposite sign in the two limbs of the circuit. The capacitor C_1 shorts out the interference. (b) Actually, the voltages are not quite equal in the two limbs. There is thus an asymmetric component V_{as} between the circuit, taken as a whole, and earth. This must also be shorted out by a capacitor such as C_2.

Fig. 3. Normal fluorescent type circuit (solid lines) fitted with suppressor circuit (broken lines).



and the flake something of the nature of an arc occurs. It is, again, possible that the flake itself is made to vibrate by the impact of the stream of electrons causing the arc. Inside the tube, it is suggested, there may occur bunchings of electrons, producing a kind of klystron effect. We are certainly concerned with oscillations of considerable amplitude, for Armstrong and Emeleus have shown that the interference radiated by diodes may amount to 1 per cent of the power dissipated at the anode. If this held good for fluorescent lighting tubes, an 80-watt tube could have an interference output of 0.8 watt!

From my own experience and that of others whom I have consulted I don't believe that the unwanted output of an interfering fluorescent tube is anything like so large. Nevertheless, its effect can be sufficient to ruin both radio and television reception.

Interference of many kinds, including that generated by offending fluorescent tubes, consists of two components: the symmetric and asymmetric. Let us take the case of the commutator motor, since this is simple to illustrate. As Fig. 2(a) indicates, the symmetric component of the generated interference appears as equal voltages of opposite sign in the two limbs of the circuit. Were the voltages *exactly* equal, even the vacuum-cleaner and the hair-drier would most likely cause little or no interference with radio or TV. What there was could, in any event, be removed by short-circuiting the voltage differences through the capacitor shown connected between points A and B.

In practice the voltages in the two limbs of the circuit are never precisely equal to one another. The difference between them gives rise to the asymmetric component (Fig. 2(b)), which appears as a voltage difference between the circuit taken as a whole and earth. The problem of suppression, then, becomes one of "shorting out" both the symmetric and the asymmetric voltage differences.

Fig. 3 indicates the way in which this is accomplished by the Belling and Lee suppressor for fluorescent tubes. The solid lines represent the normal components of the circuit and their connections. The additions made by the suppressor, when it has been connected to the circuit, are shown by broken lines.

In this case the two limbs of the circuit are themselves not symmetrical, for that which is (or most certainly should be!) connected to the phase wire contains a choke. For this reason C alone is not sufficient to short out the symmetrical interference component; it is also found necessary to increase the capacitance of the normal power factor capacitor by providing C_2 in parallel with it. Shorting out of the symmetric component thus takes place at both ends of the choke. C_3 and C_4 provide paths to earth from the circuit as a whole for the asymmetric component.

Even if a fluorescent tube does not suffer from "white-spot" trouble, it still radiates, if not suppressed, a small amount of interference owing to the asymmetry of its circuit. If only a single tube is in use, this interference may be so slight as to cause no noticeable effects; but when N tubes are served by the circuits of a building the total interference becomes $\sqrt{N}$ times as great as that from one tube. How effective is this system of suppression will be realized by any reader who visited the recent Exhibition at Olympia. Every one of the hundreds of tubes in use there was fitted with the suppressors described and there was no interference whatever from them with radio or television reception.

Deflector Coil Characteristics

1.—Efficiency in Television Scanning

By W. T. COCKING, M.I.E.E.

THE function of a deflector coil is to produce a more or less uniform magnetic field within the neck of the cathode-ray tube where it can act to deflect the electron beam. The establishment of this magnetic field demands the expenditure of energy, which is stored in the field while it persists. On the collapse of the field part of the energy is dissipated as heat, but part can be returned to the circuit and utilized.

The amount of energy needed depends on the field strength required and the volume of space which it occupies. A certain minimum energy is stored in the field within the glass walls of the c.r. tube and this can be taken as the minimum energy needed for deflection. In no practical case is it possible to produce a field within the tube without also producing one outside it, however, and this external field serves no useful purpose. The energy stored in it is, therefore, waste energy.

Other things, such as defocusing and raster distortion being equal, the most efficient deflector coil is the one which produces the least external field for a given internal field. The importance of minimizing external field may be realized when it is said that only rarely does a deflector coil produce less external than internal field and that it is common for the external field to be several times as great as the internal.

Coil Constants

The importance of deflector-coil efficiency has been greatly increased by the development of the a.c./d.c. television receiver. The h.t. voltage available in this type of set is quite low and it is expensive to obtain large scanning power by increasing the current. One line of attack has been to develop "economy" circuits in which the energy stored in the magnetic field is not all wasted as heat during the fly-back, but is partially recovered. Such circuits, however, demand additional components and an extra valve. They are not, therefore, cheap, although their use may be cheaper than the supply of a heavy current.

The fundamental point of attack should obviously be the deflector coil, for any improvement in its efficiency is immediately reflected in a reduction of scanning power. The simple pursuit of deflector-coil efficiency by itself is not sufficient, however. Not only must the coil remain satisfactory in producing a well-focused and undistorted raster, but its cost of manufacture must be acceptable.

The aim in producing a more efficient deflector coil is not to produce the most efficient coil possible, but to produce the cheapest television receiver. In general, a more efficient coil will mean a coil which is more difficult to make and, therefore, more expensive. It is of advantage only if its use enables a greater saving to be made in the rest of the equipment.

There are many possible ways of making deflector coils, and there is very little published information about their characteristics. One of the main aims of this article is to fill this gap in some degree by giving figures for the performance of the main types. There is no difficulty in measuring the performance of a deflector coil; the great practical difficulty of an investigation lies in the enormous amount of labour required to make the different forms of coil. It may need many hours of mechanical work to effect quite a small change in a design.

The deflector coil has inductance L and series resistance R. For a given deflection under given conditions a peak-to-peak current I is needed in the coil. The peak back-e.m.f. on the scan is

$$\frac{LI}{\tau_1}\left(1 + \frac{\tau_1 R}{2L}\right)$$

where τ_1 is the scan period, —84 μsec for the line scan of the 405-line transmissions. With L in millihenrys and R in ohms, this expression reduces to $11.9\,LI(1+0.042\ R/L)$ volts. The peak value of the volt-amperes is thus $11.9\,LI^2(1+0.042\ R/L)$.

For the frame scan τ_1 is 19 μsec and the peak back-e.m.f. becomes $0.0525\,LI\,(1+9.5\ R/L)$. It is better written $0.5\,RI\ (1+0.105\,L/R)$ and the volt-amperes as $0.5\,RI^2\,(1+0.105\,L/R)$.

In practice, R/L usually lies within the limits 0.5 and 2 and is generally around 1 to 1.5. With an error of less than 10 per cent, therefore, the factors in brackets can be taken as unity and the line scan volt-amperes are approximately $11.9\,LI^2$ and the frame $0.5\,RI^2$.

The figure for LI^2 is indicative of the energy needed to establish the magnetic field; and the smaller the figure obtained the more efficient is a deflector coil. Since resistance losses are usually unimportant at line frequency the LI^2 figure is a convenient indication of the merit of a coil. At frame frequency, however, the opposite condition exists and the resistance losses greatly exceed the field energy. The figure for RI^2 is in this case a measure of the power needed for deflection; the LI^2 figure is still useful, however, for it is indicative of the merit of a coil in producing useful field. Consequently, it is often desirable to consider RI^2 as the product $LI^2 \times R/L$.

While at line frequency efficiency can be improved only by reducing LI^2, at frame frequency it can be increased by reducing either LI^2 or R/L. In fact, it may sometimes happen that an alteration which decreases the field efficiency enables the resistance/inductance ratio to be so much reduced that the total efficiency is improved.

It is, therefore, necessary to consider the line and frame coils to a large extent separately. Nearly everything that is said about the efficiency of line-scan coils applies also to the field efficiency of frame-scan coils but not necessarily to their total efficiency. It is to be noted also that while the RI^2 figure is indicative of the inherent efficiency of a frame-scan coil, it is not always a true measure of the merit of a coil when considered in conjunction with the circuit which feeds it. There are cases where circuit economy may require a deflector coil which does not have the lowest attainable RI^2 figure.

At first the question of field efficiency only will be considered. All inductance figures quoted are in millihenrys and currents are in amperes. The energy in the magnetic field in joules is, therefore, 0.0005 times the LI^2 figure; and, at a scanning frequency of 10.125 kc/s, the power in watts is 5.0625 LI^2, assuming that the energy is all dissipated in resistance during the fly-back. In all cases, the current is the peak-to-peak amplitude of saw-tooth current needed to give a deflection of $7\frac{1}{2}$ in measured across the curved face of a Mullard MW14-c tube operating at 5 kV.

The whole matter of deflector-coil design resolves itself into obtaining the smallest LI^2 figure compatible with a satisfactory mechanical construction and negligible defocusing and raster distortion. The attainment of a low LI^2 figure is essentially a matter of avoiding waste field.

The simplest form of deflector coil is the air-core type, but it is of limited utility because of its poor efficiency. It necessarily produces a very large external field. The efficiency can be at least doubled by the use of an iron circuit. This increases the inductance, which is undesirable, but reduces the current so much more that the net result is an improvement. With some iron-circuit types the addition of copper screens enables the increase of inductance due to the iron to be partially offset and a further improvement can be made. It is to be noted that such screens are effective only at line frequency, not at frame.

There are two basic forms of iron circuit, which will be designated the iron-ring and iron-core types. The iron-ring is usually a stack of laminations which fits around the centre part of the coils which are themselves much the same as in air-core types. An air-core assembly (line-coils only) is shown at (a) in Fig. 1 and with an iron-ring at (b). The rectangular stack forming the "ring" is often rectangular outside and circular inside. The iron-core type is shown at (c). The core is a stack of circular laminations and the winding is around the iron circuit itself. The laminations need not be circular; indeed, rectangular are more frequently used, as shown at (d).

The iron-ring and iron-core types are so different in their construction that it is very important to realize that inside the window of the iron circuit they are identical. The main deflecting field is produced inside the iron circuit by the straight wires

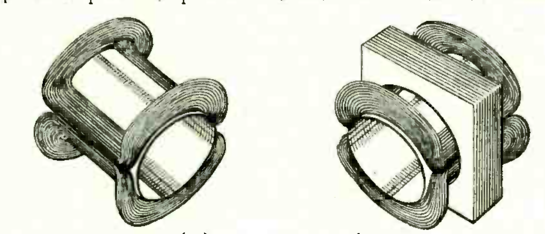


Fig. 1

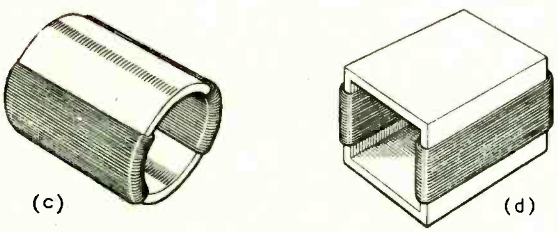
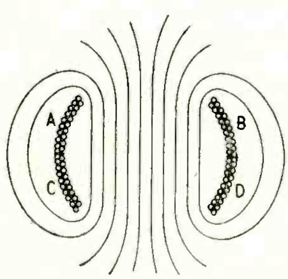
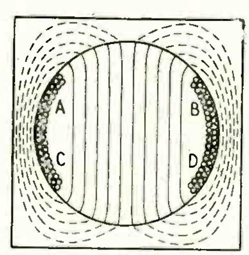


Fig. 1. The pair of bent-up end coils forming an air-core deflector coil for the line scan is shown at (a) and the same coils with an "iron"-ring at (b). An iron-core coil with the windings around a stack of circular laminations is illustrated at (c) and with square laminations at (d).

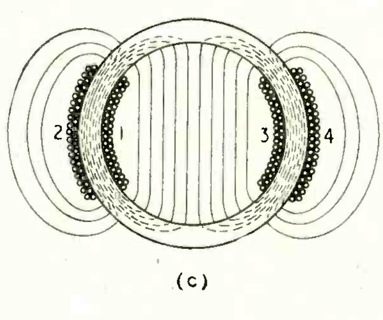


(a)

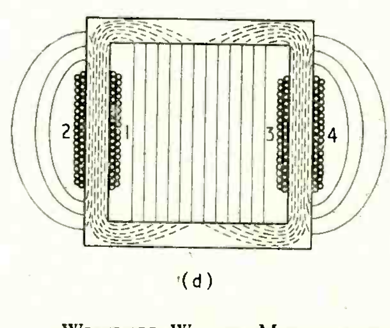
Fig. 2



(b)



(c)



(d)

Fig. 2. Cross-sections through the centres of the coils of Fig. 1 are shown here together with an indication of the magnetic fields. Reference letters are the same as in Fig. 1.

which lie between the iron and the neck of the tube.

In all the coils of Fig. 1 parts of the whole coils are formed by sets of wires which lie alongside the neck of the c.r. tube. Cross sections through the centres of the various assemblies are shown in Fig. 2. In the air-core coil (a) the sets of wires A and B form the go and return paths for current in the upper coil of Fig. 1 (a), while C and D are the go and return paths for the lower coil. If the current flows upwards out of the paper in A it does so also in C, and flows downwards into the paper in B and D. The end connections between A and B and between C and D are made through the bent-up end wires passing outside the neck of the tube.

In an iron-ring coil, Fig. 2 (b), the coils are identical but the field external to the coil is substantially confined to the iron ring. It requires so much less energy to establish a field in iron than in air that the energy needed for the return field in the iron is negligibly small compared with that needed for the field in the air gap closed by the iron. The waste external field of the centre part of the air-core coil is virtually eliminated by the iron ring.

In the iron-core coil of Fig. 2 (c) the internal conditions are identical with those of the iron-ring coil (b). The windings of one coil are 1 and 2 and of the other they are 3 and 4. The wires of 1 are identical with A and C of Fig. 2 (b) and the wires of 3 are identical with B and D. If current flows upwards in 1 and 4 it flows downwards in 2 and 3.

External and End Fields

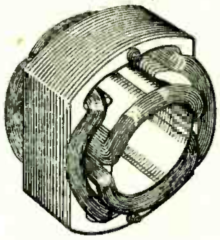
Internally there is no difference at all between the iron-ring and iron-core types. Externally there is quite a big difference, for the iron-core coil produces a large external field. This can, however, be greatly reduced by a close-fitting external metal shield in which eddy currents produce an opposing magnetic field. At line frequency such a shield can double the efficiency of a coil, but at frame frequency it is ineffective.

The iron-ring coil does not produce this external field, but instead it produces end fields quite different from those of the core type. In coils with an iron circuit, the waste field is largely produced by the connections between the side wires [A, B, C, D of Fig. 2 (b) and 1, 3 of Fig. 2 (c)]. These connections are 2 and 4 of Fig. 2 (c) but are the bent-up ends of the ring type.

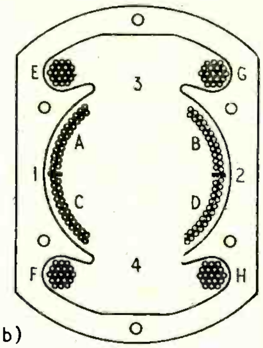
In both core and ring types the field produced by the end connections of the side wires is waste. Unless the deflector coil is unusually short the length of wire involved in these end connections is greater for a core-type coil than for a ring type; in addition, the wire of these end connections is usually nearer the iron of the core than in a bent-up end coil. As a result, a core-type coil is usually less efficient than a ring type. At line frequency external copper screens are usually more effective in reducing inductance with the core-type of coil but, even so, the ring-type is still the more efficient.

The writer has not carried out measurements on very short deflector coils (coils with a length of under, say, 1 in as compared with the usual $1\frac{1}{2}$-2 in) but it is not improbable that the core-type of coil would then be relatively much better, for it would have the shorter end connections of the two. However, the reduction of length would in itself so reduce the efficiency that such short coils would never be used unless some special requirement made them otherwise necessary.

Fig. 3. (a) Assembly in which the pole-pieces of the frame deflector act as an iron-ring for the line; Sketch (b) represents a section through the assembly.



(a)



(b)

The most widely used deflector coil for television is the iron-ring type and the core-type is comparatively rare. A hybrid version, in which the iron acts as a ring for the line coils and as a core for the frame coils, is more common but its use is not nearly as widespread as the ring type. A slotted-ring type is also sometimes used, but again only rarely. This is like the ring-type described but the stack of laminations has longitudinal slots on its internal face and the wires of the coils lie within the slots. The object is to increase the efficiency by bringing the iron nearer to the neck of the tube.

Still another form of deflector coil has iron pole pieces for the frame deflection. It is sketched in Fig. 3, the complete assembly at (a) and a section through it at (b). The line coils are of the ordinary bent-up end type, the sections through the internal wires being A, B, C and D. The iron poles 1 and 2 form part of an iron ring which is not complete, but is gapped at 3 and 4. The frame coils are E, F, G and H, and are wound around the poles, the magnetic path being completed by the external part of the laminations.

This type of assembly has been used for television but, as far as the writer can trace, there is not a single example of it now to be found. The most probable reason is that it is more expensive.

There is still one other general form—the tandem type. Here the line and frame structures are quite independent and mounted in tandem so that the electron beam passes first through one (usually the line) and then through the other. The main advantage is the very low degree of coupling which need exist between the two deflection assemblies and it is normally used only when the coils are fed directly from self-oscillating current generators. With these coupling between the line and frame generators can seriously affect the performance, but with more normal circuits, embodying amplifiers between the sawtooth generators and the deflector coils, coupling is relatively unimportant.

Because the line deflector can be designed without having to consider frame requirements, the line-scan efficiency of the tandem type can be higher than in the usual combined assembly. The frame efficiency is usually very poor, however, and it is usually more difficult to secure freedom from defocusing.

(To be continued)

SHORT-WAVE CONDITIONS

January in Retrospect : Forecast for March

By T. W. BENNINGTON (*Engineering Division, B.B.C.*)

DURING January the average day-time maximum usable frequency for these latitudes was considerably lower than during December, whilst the average night-time m.u.f. increased slightly, as compared with the previous month. The reason for these variations is not very obvious, since there was little change in the sunspot activity.

Day-time working frequencies remained relatively high, though the highest frequencies actually propagated seemed to decrease as the month progressed. During the first week American police transmissions on 38-40 Mc/s were frequently received in this country, but by the last week 30 Mc/s appeared to be the highest frequency being generally propagated over this path. The 28-Mc/s band was usable on undisturbed days over most circuits. The highest night-time working frequencies *regularly* usable were of the order of 8 Mc/s.

Sunspot activity was, on the average, slightly higher during the previous month.

January was another relatively quiet month, and only one ionospheric storm of the severe type appears to have occurred, on 24th-25th. Storms of minor intensity took place on 7th, 14th-15th, 20th-21st, and 30th-31st. A severe Dellinger fadeout occurred at 1105 on 20th, but no others have yet been reported.

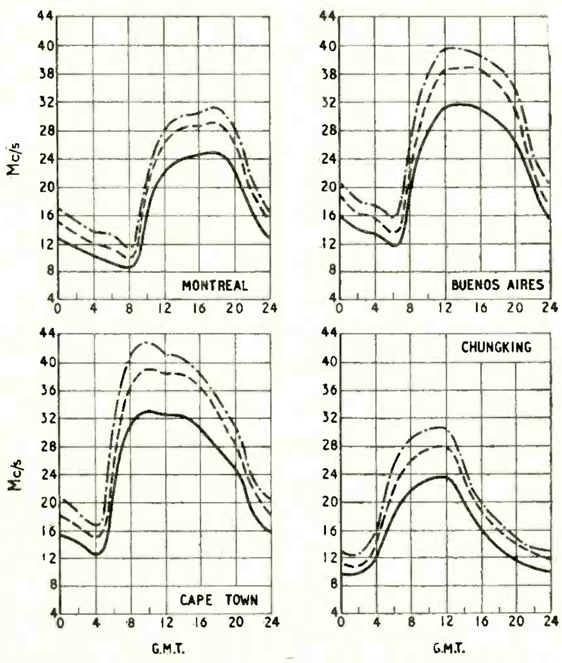
Forecast.—During March there should be a decrease in the day-time m.u.fs. in these latitudes, and a considerable increase in those for night-time.

Day-time working frequencies over nearly all circuits should, therefore, be somewhat lower than during February, and frequencies like 28 Mc/s should become less frequently usable over east-west paths. Over north-south paths, however, they should still be *regularly* usable. Day-time frequencies should remain operative for considerably longer periods than during February, due to the lengthening hours of daylight in the northern hemisphere. At night, 11 Mc/s should remain usable over most paths till after midnight, and 9 Mc/s should be the lowest frequency really necessary at any time of night.

Over medium distances the E layer may control transmission for an hour or two around noon, but Sporadic E transmission is not likely to be frequent.

March is often a bad month for ionospheric storms, and some periods of severe disturbance should be expected.

The curves indicate the highest frequencies likely to be usable over four long distance circuits from this country during the month.



——— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS
– – – – PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY
–·–·– FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

NEW BOOK

High-Frequency Heating. By L. Hartshorn, D.Sc., A.M.I.E.E., A.R.C.S., D.I.C. Pp. 237; figs. 102. Allen & Unwin, 40, Museum St., London, W.C.1. Price 21s.

IT is lately the fashion for technical books to be written with a cold impersonal style intended to imply efficiency. It is a welcome change to read a book written in narrative prose, particularly one in which the prose is well packed with meaning. This no doubt arises from the book having been based on lectures; it is unfortunate that this foundation has led to a rather unevenly detailed treatment of the subject. For instance, the generation of radio-frequency power for heating purposes is not just a very simple aspect of radio transmitter design, but a new subject full of its own pitfalls; but this book says all too little about it. Perhaps the title of the book is misleading: most of the books on r.f. heating deal with the theory and design of oscillators in as much detail as they deal with their use; this book is less ambitious.

For it is on r.f. heating applications that the book is most attractive. Whether the author has had personal experience of every single job that he writes about or whether he has skillfully abstracted some of it from the varied and copious bibliography is hard to tell; but he provides authoritative information on a variety of r.f. heating applications ranging from stock examples such as hardening steel tools to unexpected ones such as drying cabbage leaves, and on each subject he provides in a condensed and palatable form all that a worker in these fields needs to know before he can safely start collecting experience of his own. Practical details and enough of the underlying theory are given so that the reader can appraise the orders of magnitude involved in the various uses of r.f. heating: it should be a help in avoiding the waste of time which occurs in trying to apply r.f. heating in cases where it is quantitatively or qualitatively unsuitable.

To anyone interested in "application" work this book is whole-heartedly recommended. To anyone interested in packing readable facts into a small space this book should serve as an object lesson.

A. H. C.

WORLD OF WIRELESS

Standard Frequency Service ✦ Television News ✦ Europe's Wavelengths ✦ National Radio Show ✦ French Television

U.K. Standard Frequencies

AS a result of investigations carried out by a committee under the chairmanship of Dr. R. L. Smith-Rose (Director of Radio Research, D.S.I.R.), a daily experimental service of standard frequency transmissions was inaugurated on February 1st. The G.P.O. has assumed technical responsibility for the transmissions which will be radiated from the Rugby station using the call sign MSF.

The frequencies to be used are 60 kc/s, 5 Mc/s and 10 Mc/s, with a power of 10 kW. The transmissions on 60 kc/s should be received throughout the United Kingdom and Western Europe. Those on 5 and 10 Mc/s form part of an international plan designed to give reliable world coverage on one or other of the six frequencies (2.5, 5, 10, 15, 20, 25 Mc/s) which have been allocated to standard frequency services. The transmissions on these frequencies from the U.S.A. National Bureau of Standards' station WWV are not always satisfactorily received in this country and farther east. It is hoped to learn from the new experimental service to what extent reception in the European area is improved and also to what extent the usefulness of both the U.S.A. and U.K. transmissions may be impaired by mutual interference.

The frequencies, which are to be maintained within two parts in one hundred million of the nominal values, will be monitored at the National Physical Laboratory, and all enquiries or comments concerning the transmissions should be addressed to the Director, National Physical Laboratory, Teddington, Middlesex. Information about reception conditions and any interference with the U.S.A. transmissions, which may be experienced, will be particularly useful.

The present schedule (G.M.T.) is 0544-0615 on 5 Mc/s; 0629-0700 on 10 Mc/s and 1029-1045 on 60 kc/s. The first minute of each transmission period is devoted to the call sign in slow morse and a speech announcement. Then the following fifteen-minute cycle is repeated: carrier modulated with 1,000 c/s for five minutes; the carrier unmodulated for nine minutes and the call sign and announcement for one minute.

Television Progress

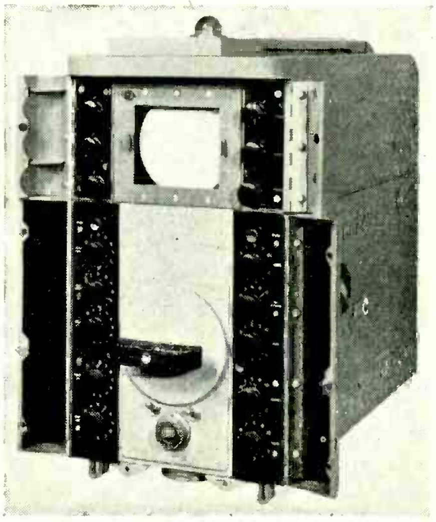
AS referred to elsewhere in this issue, the B.B.C. recently had a "house-warming party" for the five new studios at Lime Grove, Shepherd's Bush, the first of which it is hoped to bring into service in a few months.

Considerable progress is being made in the plans for erecting the remaining two stations to complete the chain of five high-power transmitters. An order has been placed with E.M.I. for the two 50-kW vision transmitters and with Standards for the associated 12-kW sound transmitters for these stations which will be erected in Scotland and the Bristol Channel area. For the Scottish station the B.B.C. is seeking a site at Kirk of Shotts near Harthill, which is almost mid-way between Edinburgh and Glasgow. Tests are in progress in South Wales and North Somerset for the other station.

Work has already begun on the Holme Moss station which is to be equipped with Marconi sound and vision transmitters.

Five new image orthicon cameras are being purchased from Marconi's. This type of camera has already been used by the B.B.C., particularly on outside broacasts—one of the first being the Oxford-Cambridge boat race last year.

The B.B.C. intends shortly to change the picture aspect ratio from the present 5:4 to 4:3 to bring it into line with cinema and foreign television standards. This change will merely involve slight readjustment of receiver height and width controls.



CONTROLS and electronic view finder on the Marconi image-orthicon camera as used by the B.B.C. It has a four-lens turret which is controlled from the rear of the camera.

Frequency Re-Shuffle

AT the time of going to press there is still considerable doubt as to the possibility of implementing the Copenhagen frequency plan for Europe's broadcasting stations on the date originally given—March 15th.

It will be recalled that the European medium-wave broadcasting band was extended and will in future be from 525-1,605 kc/s instead of from 550-1,500 kc/s. This extension of the band has, therefore, necessitated the re-allocation of frequencies to other services using the contiguous bands. For instance, the 1,650 kc/s marine distress and calling frequency is being altered to 2,182 kc/s.

No provision was made at Copenhagen for the Airmet transmissions at present radiated on 245 kc/s which in the Plan is allocated to Kalundborg.

Complete details of the Plan were given in the November, 1948, issue of *Wireless World*, and are available from our Publishers as a reprint, price 7½d, including postage. The fifth edition of our booklet, "Guide to Broadcasting Stations" (price 1s 6d), which gives operating details of some 1,300 s.w. stations of the world and of Europe's long- and medium-wave stations, also lists the Copenhagen frequencies.

Broadcasting Committee

IN addition to the oral evidence given by the B.B.C., the G.P.O. and such organizations as the Radio Industry Council and the Listeners' Association before the Broadcasting Committee, it has received written evidence from such bodies as the British Sound Recording Association, the Radio and Television Retailers' Association, the Relay Services Association and the Television Action Committee.

Among the personalities who have

given individual evidence are Sir Robert Watson-Watt and Sir James Shelley—until recently Director of Broadcasting in New Zealand.

A number of concerns who regularly sponsored programmes from Continental stations before the war have given evidence.

"National", not "Midlands", Exhibition

PREVIOUSLY announced as a Midlands radio exhibition, the show planned to be held at Castle Bromwich from September 6th to 16th has been enlarged in scope, and will now be known as the 17th National Radio Exhibition. The previous sixteen national radio shows have been held in London.

Its scope will be similar to last year's Radiolympia and, although it is being organized by the Radio Industry Council on behalf of the British Radio Equipment Manufacturers' Association, participation will not be limited to its members.

Physical Society's Show

THE annual exhibition of scientific instruments and apparatus, organized by the Physical Society, will be held for a longer period—including a Saturday— this year. Admission to the exhibition, which will be held at the Imperial College, South Kensington, from March 31st to April 5th, will be by ticket, valid for a specified session, available from Fellows of the Society, exhibitors and learned societies.

The exhibition will be open each morning from 10 a.m. to 1 p.m., and each afternoon from 2 p.m. until 9 p.m., except on the first and fifth, when it will close at 5 p.m.

The catalogue of the exhibits of the universities, Government departments and manufacturers taking part, will be available from the Society at 1, Lowther Gardens, London, S.W.7, price 6s.

High-quality Recording

AT the invitation of the president, W. S. Barrell, members of the British Sound Recording Association were invited to a musical evening at the E.M.I. Studios, on January 14th, and were able to enjoy, under acoustically ideal conditions, a varied programme of disc and magnetic recordings exemplifying the present high standard of the art.

The demonstration was outstanding not only for the excellence of the musical performances, but also for the remarkably low background noise and intermodulation distortion; and from the large attendance, it was obvious that the idea of an entire evening devoted to critical listening found favour as a diversion from the more usual lectures, in which demonstrations form a subsidiary and often tantalizing part.

French Television

IN response to requests from several readers, we give below the times (G.M.T.) of transmissions from the medium-definition (455-line) Paris television station. The vision carrier frequency is 46 Mc/s and the sound carrier 42 Mc/s; the powers are 30 kW and 5 kW respectively.

1000-1100.—Sunday.
1145-1220.—Tuesday to Saturday.
1630-1730.—Wednesday and Thursday.
1630-1800.—Saturday and Sunday.
2000-2200.—Daily.

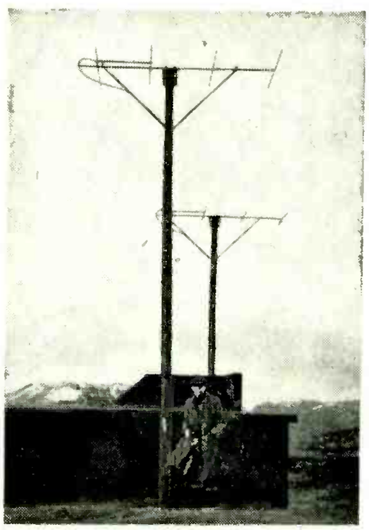
Programmes from the new 819-line transmitter—radiated from the Eiffel Tower on 185.25 Mc/s (vision) and 174.1 Mc/s (sound)—are broadcast from 1330 to 1530 from Tuesday to Friday.

B.B.C. Labour-Saving

IN order to lower its engineering staff costs, the B.B.C. has introduced two labour-saving ideas into the sound broadcasting system; unattended low-power transmitters and automatic quality-checking monitors.

The present unattended transmitters, which are remotely controlled and have duplicate sets of equipment, have proved as reliable in operation as attended transmitters; whilst in the future, even greater reliability may be obtained by the use of transmitters with multiple units working in parallel.

Automatic monitoring of a programme is achieved by comparison with another source of the same programme whose quality has been checked by a human monitor, any discrepancies being arranged to sound an alarm. By the end of 1950, this system is expected to release 26 men from the Home Service alone.



AERIAL ARRAYS on Torshavn, one of the Faroe Islands, erected for the inter-island V.H.F. radiotelephone system installed by Marconi's.

PERSONALITIES

Lord Burghley, who is chairman of A. C. Cossor, Ltd., and this year's president of the Radio Industries Club, is leading the industrial mission to Pakistan, which is being sent at the invitation of the Pakistan Government.

Sir Robert Watson-Watt, whose nomination as vice-president of the American Institute of Radio Engineers was announced in September, has now been elected to serve for 1950.

Prof. Arthur Porter, M.Sc., Ph.D., who went to the Military College of Science at Shrivenham, Wilts, as the first occupant of the chair of instrument technology, has been appointed director of research in the Canadian branch of Ferranti's. During the war he worked in various Government research establishments, including the Radar Research and Development Establishment.

C. Holt Smith, B.Sc., has been appointed Professor of Instrument Technology at the Military College of Science in succession to Professor Porter. He was at the Royal Aircraft Establishment, Farnborough, from 1926 to 1930, when he went to the B.B.C. Research Department for eight years. In 1938 he returned to Government service and since then has held various technical administrative positions in research establishments, including R.A.E. and T.R.E. His work has been largely associated with radio and radar navigational aids for aircraft.

V. M. Roberts, B.Sc., who is manager of the Electronic and Sound Sales Department of B.T.H. and also director of Multi-Broadcast (Engineering), Ltd., has been elected chairman of the Council of the Radio Communication and Electronic Engineering Association for this year. **K. S. Davies,** general manager of the Electronics Division of Murphy, is the new vice-chairman.

Derrick Murdoch has resigned from the position of joint general sales manager of the Truvox Engineering Co. to undertake export research on behalf of manufacturers. He is visiting the United States in March and enquiries from radio manufacturers should be sent to 46, Daver Court, Manor Street, Chelsea, London, S.W.3.

C. G. Allen (G8IG), a director of McMichael Radio, Ltd., has been awarded the Rotab Cup by the Radio Society of Great Britain. It is awarded annually to the amateur who, in the opinion of the R.S.G.B. Council, has made outstanding long-distance transmissions during the year.

IN BRIEF

Licences.—An increase of 33,000 television licences was recorded during December. The number of television licences current at the end of the year was 239,700—an increase of 146,900 during the year. The total number of licences—both sound and vision—on December 31st was 12,181,300 compared with 11,456,800 a year ago.

E.H.F. Television. — Experimental transmissions of television in the 529-

535-Mc/s band have begun from the U.S. National Broadcasting Company's station, near Bridgeport, Conn. The 1-kW station, KC2XAK, is to re-transmit the regular programmes from WNBT(TV) and special receivers are being installed at selected homes within an area of 25 miles for field tests.

Another Transmitter, replacing the emergency station erected in Liverpool in 1940 and since the end of the war used to radiate the Third Programme, has been brought into use by the B.B.C. The new station, which is in Birkenhead, comprises a 1-kW transmitter feeding a "T" aerial supported by two 126-ft tubular steel masts. The transmitter, which operates on 1,474 kc/s, is remotely controlled from Broadcasting House, Manchester. A second transmitter will later be installed as a standby.

R.C.E.E.A. Report.—The annual report of the Radio Communication and Electronic Engineering Association records that communications gear, broadcasting transmitters, navigational aids and industrial electronics to the value of £3.25 million was exported in the first nine months of last year. The Association, which is one of the four constituent bodies of the Radio Industry Council, has prepared a simple 10-colour wiring code which is to be published and recommended to members for use in professional communication and electronic equipment.

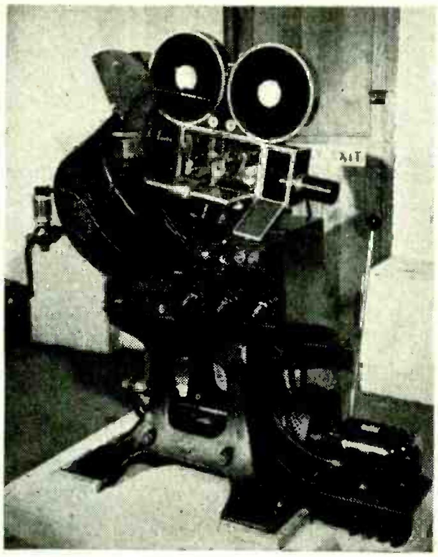
Radio Facilities at the airfields in 110 countries are given in the Aerad Flight Guide issued by International Aeradio, Ltd. It also includes details of lighting and runways and general airport information. It is issued on a subscription basis, which includes the weekly amendment sheets, from 40, Parker Street, London, W.1.

Cathedral Acoustics.—A permanent sound reinforcement system has been installed by Philips Electrical in Canterbury Cathedral, with seventeen microphones and over a hundred loudspeakers, each individually adjusted to optimum level in order to overcome difficulties arising from the 8½-second reverberation time. The system is completely automatic and the number and arrangement of loudspeakers in use is controlled by the switching of individual microphones.

B.I. Callenders.—The Chester branch office of B.I. Callender's Cables is now at 1, Stanley Street, Watergate Street, Chester (Tel.: Chester 396). The company's Cambridge office has also moved. The new address is 61A, Regent Street, Cambridge (Tel.: Cambridge 56318).

Canadian Television.—The transmitters for Canada's first two television stations, to be installed in Montreal and Toronto, are being built by the Canadian associates of two American companies—General Electric Co. and R.C.A. The stations will be operated by the Canadian Broadcasting Corporation.

Marconi Booklets.—Two brochures dealing with Marconi's training facilities have been issued by the company One, entitled "Marconi College," deals, as its title implies, with the facilities for post-graduate training in radio engineering which is available to those joining the company and also to nominees of associated companies and clients throughout the world. The other—"Marconi Training"—deals with the company's apprenticeship schemes. The booklets are issued from the Education Department, Marconi College, Arbour Lane, Chelmsford.



TELE-FILM RECORDING. One of the cameras recently installed at Alexandra Palace for recording televised events for re-transmission, to which reference is made in the Editorial. A "still" is reproduced on page 84.

Portuguese East Africa.—The British Consulate-General in Lourenco Marques reports that A. G. Simons, Ltd., P.O. Box 363, Lourenco Marques, is interested in securing agencies for British domestic and car receivers.

Import Restrictions on certain products of member countries of the Organization for European Economic Co-operation or their overseas territories have been lifted by Portugal. Among the items listed are transmitting equipment and loudspeakers.

I.E.E. and the Engineers' Guild.—The Council of the Institution of Electrical Engineers made the following announcement regarding the propriety of corporate members of the Institution becoming members of the Engineers' Guild. "The Council wish to remind those concerned that the Institution is not permitted under its Charter to deal with matters of remuneration or conditions of service. A corporate member in his personal capacity is free to decide for himself whether he joins the Guild."

B.I.F.—The 29th British Industries Fair will be held simultaneously at Olympia and Earls Court, London, and at Castle Bromwich, Birmingham, from May 8th to 19th.

G.R.S.E.—Since preparing the note on the Guild of Radio Service Engineers, which appeared on page 58 of our last issue, we have been advised that the registered office of the Guild has again been changed; it is now at Bank Chambers, 6, Station Road, Clacton-on-Sea, Essex (Tel.: Clacton 1549). The new assistant general secretary is G. M. Tedder.

A Radio Relay Record was created by Cable and Wireless when transmitting a photograph of the arrival at Auckland, New Zealand, of the South African Empire Games team on January 23rd. Transmitted from Wellington, the photograph was automatically relayed (not re-transmitted) at Sydney, Melbourne and London for reception in Cape Town, an unbroken journey of some 18,400 miles.

British Overseas Mart.—Under this name an organization has been set up in the United States to market British-made goods. At its headquarters at 1775, Broadway, New York, 19, is a permanent exhibition where British products can be displayed and demonstrated. Among the firms whose products have already been handled by the sponsors, William Carduner and Harry Spinrad, are Multicore Solders and Garrard Engineering. Mr. Carduner is visiting this country in February.

Institute of Physics.—A new monthly journal, *British Journal of Applied Physics*, has been published by the Institute of Physics, the annual subscription for which is £3 (U.S.A. $8.50). Whilst the Institute's other publication, *Journal of Scientific Instruments*, will be devoted to scientific instruments and apparatus, the new journal will deal with new applications of physics and developments of those already known.

All-India Radio has completed another station in its chain of transmitters to provide a broadcasting service to the principal linguistic areas. The station is at Dharwar, Bombay, and radiates Kannada programmes on 640 kc/s.

"Television" is the name of a new technical monthly journal published in France in association with the well-known *Toute la Radio*. Both journals are under the direction of E. Aisberg.

Educational Tours.—Formed for the purpose of providing facilities for engineers and technicians to visit engineering establishments abroad, the Engineers' Educational Travel Club, Ltd., has arranged tours to Scandinavia, Belgium, France and Italy this year. Particulars of membership are available from the Secretary, 35, St. George's Square, London, S.W.1.

R.S.G.B. Officers.—At the recent annual general meeting of the Incorporated Radio Society of Great Britain, W. A. Scarr, M.A. (G2WS), was elected president, and F. Charman, B.E.M. (G6CJ), acting vice-president.

Murphy Television Courses.—Fourteen television training courses, each lasting twelve days, have been planned by Murphy's for their dealers and servicemen for the period March to October. Particulars are obtainable from the Murphy Television School, Welwyn Garden City, Herts.

F.B.I. Register.—The 1949/50 edition of the F.B.I. Register of British Manufacturers, which is produced for the Federation of British Industries, jointly by Kelly's Directories and our Publishers, is now available. It lists nearly 6,000 firms and their products. The main sections of this 807-page directory, which costs 42s, include lists of trade marks, trade names, addresses, and products and services provided by the manufacturers.

VHF Radiotelephone equipment has been supplied by the G.E.C. to the fleet of dredgers which operate from the Preston, Lancs, dock and work continuously in the River Ribble from Mondays to Saturdays keeping the channel navigable. Single-unit transmitter-receivers are used, working in the 160-Mc/s band. Two-frequency simplex is employed in which the called and calling stations operate on separate frequencies and speak one at a time.

"View Master" Receiver.—An envelope of constructional plans for a Midlands version of the "View Master" television receiver, described in its original form in our issue of December, 1948, has now been issued. The envelope is obtainable from wireless dealers for 5s, or from George Over, Ltd., Market Place, Rugby, for 5s 6d by post.

CLUB NEWS

Birmingham.—At the meeting of the Slade Radio Society on March 3rd, a member of the staff of Premier Radio will describe the construction of a television set using the VCR97 tube. On March 31st a talk on "The Application of Electronic Techniques to Industrial Problems" will be given by a member of British Electronic Products, Ltd. Meetings of the society are held at 7.45 at the Parochial Hall, Broomfield Road, Erdington. Sec.: C. N. Smart, 100 Woolmore Road, Erdington, Birmingham, 23.

Birmingham.—Meetings of the Midland Amateur Radio Society are held at 6.45 on the third Tuesday of each month at the Imperial Hotel, Birmingham. Sec.: W. J. Butler, 32, Pilkington Avenue, Sutton Coldfield, Warwick.

Cleckheaton.—Three meetings of the Spen Valley Radio and Television Society will be held in March. On the 1st B. Marsden will speak on "Microgroove Recording and Quality Amplifiers" and on March 15th H. Reeder (R. N. Fitton) on "Television." The title of the talk to be given by W. T. E. Isaacs (Mains Radiograms, Ltd.), on March 29th has not yet been announced. Meetings are held at 7.30 at the Temperance Hall, Cleckheaton. Sec.: N. Pride, 100 Raikes Lane, Birstall, Nr. Leeds, Yorks.

Coventry.—At the meeting of the Coventry Amateur Radio Society on February 27th, which will be held at the B.T.H. Social Club, Holyhead Road, Coventry, at 7.30, L. Chapman will speak on "Diecasting in Radio Equipment." At the meeting on March 13th F. A. Noakes will speak on "This QSL Business!" Sec.: K. G. Lines, (G3FOH), 142 Shorncliffe Road, Coventry, Warwick.

Sunderland.—Class "C" amplifiers will be dealt with by K. V. Draycott (G2BOI) at the meeting of the Sunderland Radio Society (G3CSR) on March 8th. The fourth of the series of lectures on valve manufacture by members of the staff of the Edison Swan Electric Co., will be given on March 22nd. The subject is "Assembly" and the speaker H. Pattinson. Meetings are held at 8 p.m. at Prospect House, Prospect Row, Sunderland. Sec.: C. A. Chester, 38 Westfield Grove, High Barnes, Sunderland.

MEETINGS

Institution of Electrical Engineers

Radio Section. — Discussion on "Mobile Radio Power-Packs" opened by Air Comdre. R. L. Phillips, C.B.E., on February 27th.

"The Fundamental Limitations of Second-Harmonic Type of Magnetic Modulator as Applied to the Amplification of Small D.C. Signals," by Prof. F. C. Williams, O.B.E., D.Sc., D.Phil., and S. W. Noble; and "A New Theory of the Magnetic Amplifier," by A. G. Milnes, M.Sc. (Eng.), on March 7th.

"The Structure, Electrical Properties and Applications of the Barium-Titanate Class of Ceramic Materials," by Prof. Willis Jackson, D.Sc., D.Phil., on March 15th.

"The Operation and Maintenance of Television Outside-Broadcast Equipment," by T. H. Bridgewater, on March 27th.

Informal Meeting. — Discussion on "The Place of High-Frequency Heating in Industry," opened by C. E. Eadon-Clarke.

The above meetings will be held at 5.30 at the I.E.E., Savoy Place, London, W.C.2.

Cambridge Radio Group.—"A Survey of the Possible Applications of Ferrites," by K. E. Latimer, Ph.D., and H. B. MacDonald, B.E., on February 28th.

"The Acoustics of Studios and Auditoria," by W. Allen, on March 21st.

Both Cambridge meetings will be held at 6.0 at the Cambridgeshire Technical College.

Mersey and North Wales Centre.—Faraday lecture on "Radar," by R. A. Smith, M.A., Ph.D., at 6.45, on March 22nd, at the Philharmonic Hall, Hope Street, Liverpool.

North-Eastern Radio Group.—"Experiences Over Fifty Years," by E. Fawssett, on March 6th.

"The B.B.C. Short-Wave Transmitting Station at Skelton," by S. A. Williams, on March 20th.

Both North-Eastern Group meetings will be held at 6.15 at King's College, Newcastle-on-Tyne.

North Midland Centre.—Faraday lecture on "Radar," by R. A. Smith, M.A., Ph.D., at 7.0, on March 6th, at the Town Hall, Leeds.

"The Motor Uniselector and the Technique of Its Application in Telecommunication," by W. H. Grinsted, M.B.E., at 6.30 on March 14th, at the Yorkshire Electricity Board Offices, 1, Whitehall Road, Leeds.

North-Western Radio Group.—"The Electrical Breakdown Strength of Air at Ultra-High Frequencies," by J. A. Pim, B.Sc. (Eng.), Ph.D., at 6.30 on March 29th, at the Engineers' Club, Albert Square, Manchester.

Scottish Centre. — "Some Electromagnetic Problems," by Prof. G. W. O. Howe, D.Sc., LL.D., at 7.0 on March 1st, at the Heriot-Watt College, Edinburgh.

South Midland Radio Group.—"Magnetic Amplifiers," by A. G. Milnes, M.Sc. (Eng.) at 6.0 on February 27th, at the James Watt Memorial Institute, Great Charles Street, Birmingham.

"Some Electromagnetic Problems," by Prof. G. W. O. Howe, D.Sc., LL.D., at 7.15 on March 15th, at Warwick House Restaurant, Belle Vue Terrace, Great Malvern.

"A Storage System for Use with Binary Digital Computing Machines," by Prof. F. C. Williams, O.B.E., D.Sc., D.Phil., and T. Kilburn, M.A., Ph.D., at 6.0 on March 27th, at the James Watt Memorial Institute, Great Charles Street, Birmingham.

Rugby Sub-Centre.—"Some Electromagnetic Problems," by Prof. G. W. O. Howe, D.Sc., LL.D., at 6.30 on March 14th, at the Electricity Showrooms, High Street, Rugby.

London Students' Section.—"The Electronic Performance of Simple Mathematical Processes," by R. C. Orford, B.Sc. (Eng.), at 7.0 on March 13th, at the I.E.E., Savoy Place, London, W.C.2.

Television Society

Constructors' Group. — "Interlaced Pattern Generator," by F. Cox (Sobell Industries) at 7.0 on March 9th, at the Cinema Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

Leicester Centre.—Lecture by member of research staff of Ultra Electric at 7.0 on March 1st.

"Construction and Use of Wobbulators for Alignment of Television Receivers," by R. H. Hibberd, B.Sc (B.T.H.) at 7.0 on March 22nd.

Both Leicester Centre meetings will be held in Room 104, The College of Art and Technology, Leicester.

British Institution of Radio Engineers

London Section.—"Travelling Wave Tubes," by R. L. Kompfner, Dipl. Eng., at 6.30 on March 3rd, at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1. (Meeting postponed from February 23rd.)

"High Performance Television Monitors," by J. E. Jacob, B.Sc. (Eng.), at 6.30 on March 23rd at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

West Midlands Section. — "Electronics and the Brain," by H. W. Shipton, at 7.0 on March 1st, at the Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton. (Meeting postponed from February 23rd.)

"Radio Interference with Broadcast Reception," by A. A. Devey, at 7.0 on March 22nd at the Wolverhampton and Staffordshire Technical College, Wolverhampton.

North-Eastern Section.—"Electrical Breakdown of Gases at Ultra-High Frequencies," by W. A. Prowse, B.Sc., Ph.D., at 6.0 on March 15th, at Neville Hall, Westgate Road, Newcastle-on-Tyne.

Scottish Section.—"The Limitations of the Loudspeaker," by P. J. Walker, at 6.45 on March 2nd, at the Heriot-Watt College, Edinburgh.

South Midlands Section. — "Electronics and the Brain," by H. W. Shipton, at 7.0 on March 30th, at the Coventry Technical College.

British Sound Recording Association

"Microphones and Balance Technique," by F. W. Alexander, Ph.D., at 7.0 on March 24th, at the Royal Society of Arts, John Adam Street, London, W.C.2.

Institution of Electronics

North-West Branch.—"Improvements in Large-Screen Television," by T. M. C. Lance (Cinema Television) at 6.30 on March 10th, at the Gas Showrooms, The Town Hall, Manchester.

"CATHODE RAY"

COMES DOWN TO EARTH

—And Explains Some of the Finer Points of the Radio Valve

THE extent to which I have drifted from my original simplicity has been strikingly brought home to me by seeing several of my recent articles actually mentioned in that stratospheric-brow journal, *Wireless Engineer*. No doubt the toddlers who, in pre-war days, grappled with my attempt to explain the difference between resistive and reactive ohms in terms of a game of blow-football, have now reached the age at which "Filters" (in two parts) is easy meat. But if I were to continue in phase with them while they advanced into the mathematical intricacies of non-linear networks, I would lose touch with readers who need help in understanding the learned mandarins who write the rest of *Wireless World*. In short, it is time for the flyback.

This introduction is merely to warn sophisticated readers not to continue in the hope of finding subtleties buried under the common or garden title above. It is going to be strictly elementary.

What use is the earth? What use, that is to say, apart from supporting life? The question must often have leapt into the more innocent public's mind when the earth wire became detached and the radio kept on playing pretty much as before. (The less innocent, of course, reply "Earth? I don't use it, old man," or perhaps just smile pityingly, as though one had called their attention to a "No Smoking" notice. And when they buy an electric appliance with a three-wire flex, they attach a two-pin plug to the most likely looking pair and hope for the best.)

Saving Aerial Wire

Is earthing, then, a practice of the ignorant or conscientious or pedantic few, and scorned by the rest as "just one of those regulations"? And do the rest always get away with their indifference to it?

The argument is likely to be rather confused unless we disentangle the various uses to which the earth is put. In pre-wireless days it was used as an inexpensive electrical conductor, saving the cost of a return wire in a telegraph system (Fig. 1). Although most soils are poor conductors compared with copper, the earth makes up for that by its considerably fatter gauge—provided that one makes the contact plates sufficiently large.

When wireless came along, the uninitiated thought they understood how one half of the connection between stations was established, for there was the same earthing as in Fig. 1; but they were completely baffled by how the other half went through the air. If Marconi's system had used a dipole or microwave aerial, without any earth connection, people would not have been misled by this apparent resemblance to Fig. 1. As things were, the buried-plate earth was an important feature of his system, but for quite different reasons. He used it as the lower half of a vertical aerial, or one plate of an opened-out capacitor. If he, and the person to whom he was signalling, had been floating in space, they would have been

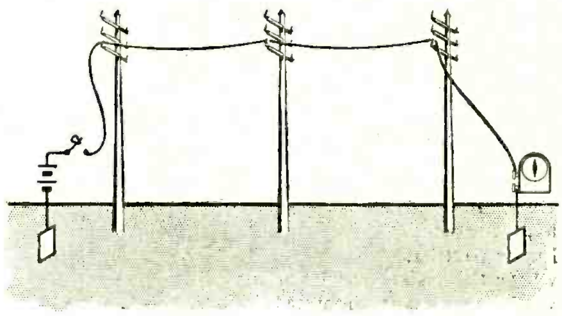


Fig. 1. Nineteenth-century use of "earths" to save telegraph wire.

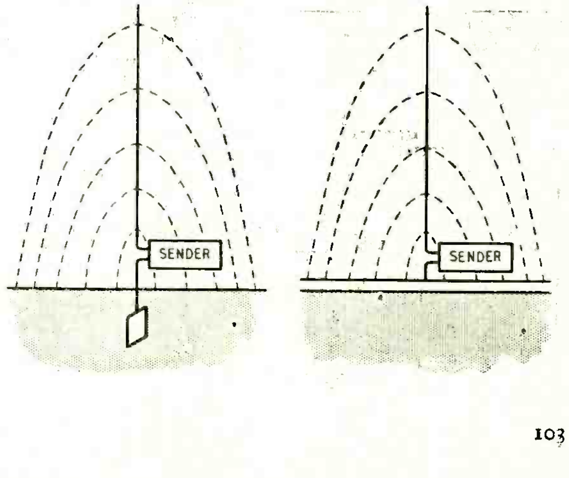
obliged to use aerials more or less like the present television dipoles. An outstretched electric field, such as is necessary for radiating wireless waves, cannot be produced unless there are *two* bodies between which to produce it. The dimensions of these bodies are preferably not too far short of a quarter of the length of wave to be radiated. So for medium and long waves the best length of aerial is long enough to make one welcome the opportunity of using the earth as one of the bodies, leaving only the other to be provided.

This stage in history, which is still with us, can be represented by Fig. 2, with a few of the imaginary lines of electric force drawn in between aerial and earth.

If you lay a large mirror on the floor to represent the earth, and stand a walking stick or something on it to represent an aerial, what you will see is this "aerial" and (apparently) another one exactly the

Fig. 2. (Left) Twentieth-century use of earth to save aerial wire.

Fig. 3. (Right) For long-wave stations, the natural earth is usually false economy, so an artificial earth or "earth screen" is used.



same, pointing downwards below the surface of the "earth." Since light waves and wireless waves are exactly the same except for wavelength, this is a real working model illustrating the fact that, by virtue of its reflecting powers, the earth is equivalent to a mirror image of the aerial. (The reason why one can't actually see the image, except when the wireless station happens to be afloat on calm water, is that light consists of such extremely short waves that they are scattered by all except very smooth surfaces.)

Like most cheap substitutes, this half-aerial is not quite as good as the genuine article. If the earth were made of pure copper, or at any rate surfaced with it, there would be little to complain of (in this particular respect). Sea water is good enough for practical purposes, and there would even be something to be said for a perfect insulator (which, like a sheet of unsilvered glass, gives a partial reflection). But ordinary soil is neither; it acts as a resistance load, absorbing valuable radio-frequency power. This loss is particularly serious at very-long-wave stations, where the resistance of the aerial proper can be made very low. So at such stations it is customary to lay down an "earth screen" of copper wires or netting, Fig. 3, close to the surface of the ground (above or below).

Protection from Lightning

An artificial earth something like this was also used for the comparatively short waves of radar stations during the earlier years of the war. It was not for providing a low-loss half-aerial (for self-contained dipole aerials were used), but to ensure regularity of reflection where the earth itself was not quite level. The importance of this, especially in radar, is that the strongest radiation from the station rises at the angle where the radiation direct from the aerial and the radiation reflected from the surrounding earth (natural or artificial) are in phase.

All these things apply at the receiving end too. If so, then, how is it that it seems to make so little difference whether we earth or not?

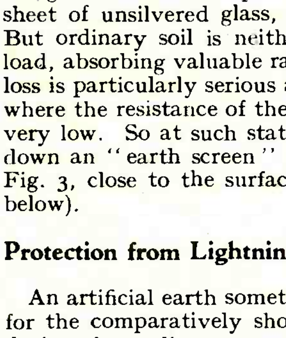
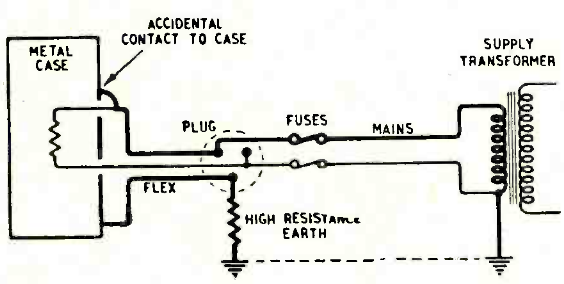


Fig. 4. An earth arranged like this gives some protection against lightning, which may find it easier to cross the air-gap than to go through the receiver.

Fig. 5. (Below) Earthing domestic appliances protects the user against shock due to faulty insulation, but only if the resistance of the connection is low enough to make the fuse blow promptly.



Part of the answer lies in the fact that even the cheapest receivers are generally four-valve superhets, capable, with a good aerial-earth system, of receiving distant or weak stations; yet most listeners rarely, if ever, use them for anything beyond the powerful locals. So there is a vast amount of reserve, and all that happens when the earth wire is removed is that the a.g.c. brings this reserve into action and so keeps the volume nearly the same as before. This increased amplification is likely to bring in some noise as well; but that is a different story.

Taking history another step forward, we come to television. For reasons which have often been explained, it is organized on wavelengths which make the best length of aerial only a few feet long. So if the system in Fig. 2 were adopted, the whole of the aerial would inevitably be within a few feet of the earth. On most sites this would mean that it would be coyly hiding behind all sorts of obstructions which short waves find it difficult to get round or over. Fortunately the economy motive is reduced in proportion to the wavelength, so it is no great hardship to provide both halves of the aerial, which can then be mounted as high as practicable, free from all obligation to the earth. Is the earth therefore quite unnecessary? And if so, why are television receiving systems earthed?

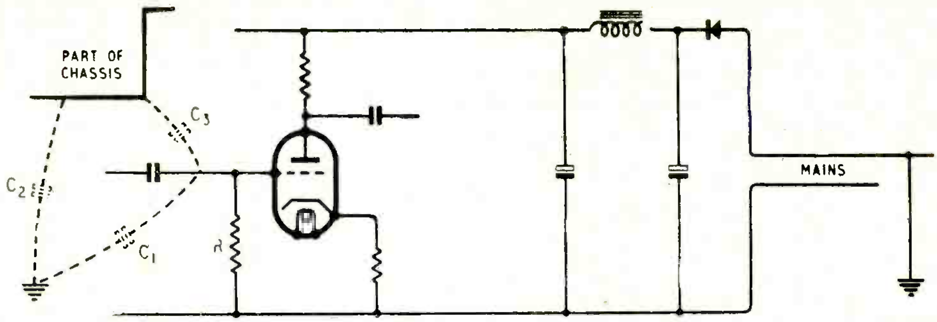
These questions bring in some of the other uses of the earth. One of them is protection against lightning. Although some lightning flashes take place between two clouds, many are from cloud to earth, and if the most convenient spot to strike happens to be a high-sited aerial (television or otherwise) and that aerial leads into a *cul de sac* in the form of the receiver, it may be just too bad for the receiver. But if there is a comparatively straightforward by-pass to earth (even if it includes a short air-gap) the receiver will be reasonably safe. The heavy momentary currents in lightning set up dangerously large potentials across even small inductances, such as bends or loops in the aerial or lead-in wires, but have little difficulty in bridging short gaps. So an arrangement like Fig. 4 is usually quite good. Something of the kind, in conjunction with fuses in the branch, is used to protect telephones, as I discovered the other day after a thunderstorm. The earthing switches that used to be recommended have the disadvantage that there may not be anyone to work them when a thunderstorm comes on; or, if there is, the lightning might happen to strike while his hand was on the switch. Although the lightning risk is admittedly very small, it is better to be on the safe side.

Earthing the Receiver

A considerably greater risk is electric shock. Quite a number of people are killed every year by it; and even if you aren't killed it can be unpleasant. Probably the commonest danger is caused by the live side of the mains making accidental contact with the metal parts of an electric appliance, such as a kettle, iron, or lamp. When this happens (often due to frayed flex), and the metalwork is not earthed, it is all ready to hand out shocks. But if it is earthed —and that is the reason for the third wire—the fault causes a fuse to blow and investigations to be made.

To be a real protection, the earthing must have a low resistance. If not, we get the state of affairs shown in Fig 5, in which a fault current flows as

Fig. 6. From this one can work out why, in a.c./d.c. sets, the chassis must be made potentially "live" in order to avoid excessive hum.



indicated by the heavy line, but the earth resistance limits it so that the fuse either doesn't blow at all, or there is an appreciable delay, during which the case is fully live. An earthing rod stuck into the dry soil under the eaves is not good enough. Photographic evidence has been adduced to show that even the flower-pot earth is not a mere comedian's fable!

A radio set is less likely than most domestic electrical appliances to be a danger when its metalwork comes in contact with the mains, because it is generally covered up by a cabinet. This is just as well, with a.c./d.c. sets at least, because in most of them the chassis is deliberately connected to the mains. Seeing that from the safety point of view this can hardly be considered ideal, there must be a strong reason for doing it. This reason is that otherwise it is extremely difficult to avoid an intolerable amount of hum.

To understand why, consider the audio-amplifying part of the set—say the triode part of the double-diode-triode in most models—together with the mains connection (Fig. 6). Suppose for the moment that there is no surrounding metalwork. There will, therefore, inevitably be some stray capacitance, C_1, between the grid of the valve and earth. But if the side of the mains connected to the rectifier happens to be the one that is earthed, the whole mains voltage (assuming it is an a.c. supply) will come across C_1 and R in series. Since R is normally of the megohm order, and a small fraction of a volt across it is enough to cause hum, C_1 does not have to be exceptionally large to give trouble.

The answer to this, you may say, is to reverse the mains plug so as to bring the earthed side to cathode. Certainly, for a.c.; but what about d.c.? One is then obliged to connect so that the rectifier side is positive, and about half the d.c. mains have the positive earthed. So there is no getting away from it. While it is true that pure d.c. can't cause hum, d.c. mains invariably have a ripple which, though less in voltage than the d.c. itself, is comparatively high in frequency and therefore the more able to infiltrate via C_1. It is also far more audible than 50 c/s.

Suppose, next, that in order to cut out C_1 the usual metal chassis and screening are used, and to avoid connecting it to the mains, it is left floating, as shown in Fig. 6. It will almost certainly make matters worse, for it will have a considerable stray capacitance to earth (C_2) and also (compared with C_1) to grid. C_1 is therefore merely replaced by C_2 and C_3 in series. Earthing the screens increases the total stray still further, by short-circuiting C_2.

So to ensure freedom from hum on all mains, one is obliged to stick to the usual practice of joining the negative side of the receiver circuit to chassis. And if the set is to work on d.c. mains this inevitably means connecting it direct to the mains, so there is a fifty-fifty chance of the chassis receiving full mains voltage.

The radio manufacturer who believes in keeping his customers alive to buy from him again, not only takes care to cover up all the metalwork—not forgetting the grub-screws on the control spindles—but also arranges matters so that one cannot get at it without unplugging the mains. For the same purpose, he insulates the aerial and earth terminals from the rest of the set, using either inductive coupling or capacitances not large enough to deliver a devastating shock.

Why Not a "Mains Earth"?

Obviously an earthable chassis is a surer and more convenient safety measure; and except for sets which may have to be used on d.c. there is no difficulty in arranging it, because the mains can be isolated by means of the usual transformer. Fig. 6, with the negative side of the valve circuits at alternating potential, is just an unfortunate abnormality. Normal practice is to earth the negative. Although a floating chassis would not then introduce hum by its stray capacitance to earth, as in Fig. 6, it would probably do so by its stray capacitance to the mains or other alternating potentials. So to be effective against electric fields, a screen must be tied down to an appropriate potential, preferably earth. This is no doubt what "Free Grid" had in mind when, some years ago, he investigated complaints of electrostatic interference arising from the stroking of cats by old ladies. His conclusion, it may be remembered, was that the only complete cure was to permanently earth the cats.

The desirability of earthing having now been established, the reader who is still reluctant to dig deep holes in the moist subsoil, or even to run a wire from a rising water main, may point out that (as shown in Fig. 5) one side of the mains is itself soundly earthed, so why not earth the set simply by connecting it to the earthed mains lead (the "neutral") as in Fig. 7?

One reason for not doing so would become only too clear if the set were plugged in the wrong way round! Among other reasons, the length of wire between the receiver and the earth connection at the supply end generally picks up an unpleasant assortment of electrical noises created by the neighbours' appliances. (Your own, of course, will all be noise-free or thoroughly "suppressed"!). Using this wire as an earth connection, you have these noise voltages right in the aerial-earth system, where they can make the maximum nuisances of themselves (Fig. 7). Moreover, any anti-noise filters the set may contain depend on direct earthing for their effectiveness. The advice to make the earth lead short is, after all, well-founded, and is *not* fulfilled by relying on a "mains earth." Incidentally, you are forbidden to earth the neutral at your end.

Stray Capacitances

One of the first things that have to be understood before making accurate measurements of capacitance is that it has no precise meaning unless the capacitor (or a surrounding screen) is earthed. Suppose C represents the capacitance between the terminals of a low-value standard capacitor (Fig. 8(a)). That might seem to be all one need know. But the plates, terminals and connections have some capacitance to the surroundings (which for simplicity we shall assume are all earthed). These capacitances are represented by C_1 and C_2. Being in series across C, they add to it. So one cannot just get C by itself. Even if the values of C_1 and C_2 can be found, they are upset whenever you (an earthed body) move nearer or farther away, or the capacitor is shifted.

Either C_1 *or* C_2 can be got rid of by earthing one of the terminals; but as it is unlikely that C_1 and C_2 are exactly equal, the value of the capacitor will depend on which terminal is earthed. The way out of the difficulty is to put the capacitor inside a metal screen, so that the only stray capacitance (C_5 in Fig. 8(b)) is to the screen and is therefore unaffected by what goes on outside. The stray capacitance of the screen to earth is then eliminated by earthing it, and the total capacitance is $C + C_5$.

Stray capacitances affect the a.c. values of resistors and inductors, too; so an important use of earthing in lab. work is to make these values definite. The same applies to potentials. If a piece of apparatus is floating (i.e., not earthed), the potential of any part of it is indefinite, depending on stray leakages and other chance effects. The potential of earth is reckoned as zero, so by earthing the apparatus somewhere all its potentials are made definite.

One sometimes comes across the expression "earthy." This is not, as might be supposed, a quotation from the Burial Service (even when read over "Free Grid's" aunts' cats), but a convenient way of describing terminals or other points in a circuit which may not actually be connected to earth but which normally have little or no alternating potential. Of the two input or output terminals of an amplifier, one is generally connected to h.t. – and would be regarded as "earthy," in contrast to the terminal connected to grid or anode.

Summing up the uses of earthing, then, we have: supplying the lower half of an aerial; controlling the angle of radiation or reception; protecting from lightning and electric shock; excluding hum and other noise; regularizing circuit values and potentials.

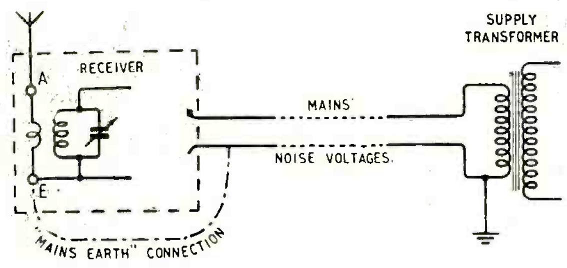
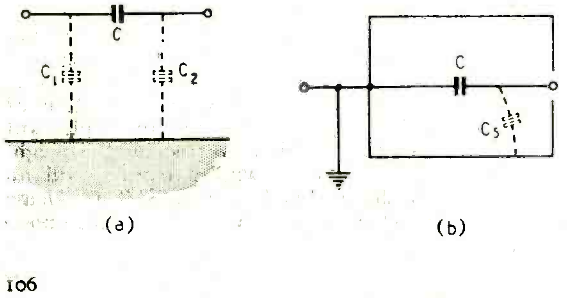


Fig. 7. One reason why it is not a good idea to rely on the mains as an earth.

Fig. 8. (a) The exact capacitance of an unscreened capacitor is indefinite, owing to the "strays," C_1 and C_2. (b) For exact measurements, the capacitor should be screened and earthed.



PUBLISHED REPORT

Naturalness in Speech Reinforcement Systems

SOME recent German research work has been concerned with the effect on the naturalness of speech sounds of a reinforcing signal following the original sounds within a few milliseconds. This work has been carried out by Herr H. Haas under the direction of Professor E. Meyer, University of Göttingen, and has given two main results which are summarized as follows.

First, if the reinforcing signal from a secondary source (e.g., loudspeakers) reaches the listener at least five milliseconds after the sound from the primary source (e.g., the actual speaker), then all of the sound appears to be coming from the primary source. This effect continues even if the secondary source is 10 decibels greater than the primary source, and is almost independent of the positions of the primary and secondary sources.

Secondly, if the time difference between the primary and secondary sounds reaching the listener is increased, a stage will of course be reached where the secondary sound is heard as a distinct echo. But before this occurs the secondary sound will have begun to have a bad effect on the naturalness of the speech sounds. The critical time differences have been investigated as a function of the relative intensities of the primary and secondary sources. For instance if the secondary sound is 10 decibels greater than the primary sound then the maximum permissible time difference before the naturalness is affected is about 25 milliseconds.

As these German results are of obvious importance in the design of speech reinforcement systems, and as this work would not normally be published, the Department of Scientific and Industrial Research has had the paper translated. Copies of the translation may be obtained, free of charge, by interested organisations and firms on written application to The Director, Building Research Station, Garston, Watford, Herts.

Solving Parallel Problems

Unconventional Formula Suitable for Quick Mental Calculations

By D. A. POLLOCK (*Engineering Division B.B.C.*)

MOST of us who are concerned with radio in its many and varied aspects have occasion to use Ohm's law, and early in our acquaintance with this law we discovered that when using resistances in series the value was easy to find. We just added their respective values. When we came to putting resistances in parallel we found that it was a different matter. There was a formula :—

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \text{ etc.}$$

Some of us do not carry around slide-rules for working out reciprocals and the rule of thumb routine is apt to be tedious. There was an alternative formula for two resistances in parallel :—

$$R = \frac{R_1 \times R_2}{R_1 + R_2}$$

This is the accepted formula at present in general use, and unless the values of R_1 and R_2 are fairly simple figures it still requires either the slide-rule or pencil and paper.

Now when we parallel two resistances, we know at once that the combined value will be lower than that of either single resistance. Let us start from the most elementary values and observe their relationships. To find the combined value R when we parallel R_1 of $1\,\Omega$ with R_2 of $2\,\Omega$; using the conventional formula we find that the answer is $2/3\,\Omega$, which is $1/3\,\Omega$ lower in value than R_1. So far there is nothing significant except that we note that a new figure, 3, appears in the answer which is related to 2 and 1. Let R_1 be $1\,\Omega$ and R_2 be $10\,\Omega$. Then R is $0.909\,\Omega$. R_1 was 1/10th of the value of R_2, but R is not 1/10th lower in value than R_1 but 1/11th, i.e., R_1 minus (R_1 divided by 10 plus 1). Now add some noughts to the figures and let us see if this relationship still holds good. Let R_1 be $1{,}000\,\Omega$ and R_2 be $10{,}000\,\Omega$. Then R is $909\,\Omega$, still 1/11th lower than R_1.

Take some different figures : let R_1 be $56\,\Omega$, and R_2 be $280\,\Omega$ (five times greater), then R is $46.6\,\Omega$, which is 1/6th lower than R_1. What is happening is that the combined value is following a relationship which is in proportion to the " ratio " of the resistance values, with the distinction that there is always figure 1 added; so all we need to do is to look at the values of R_1 and R_2, mentally assess the ratio of R_2/R_1, and add 1. Divide R_1 by this figure and subtract the result from R_1 to get the answer for R.

For example : find the parallel value R when R_1 is $33\,\Omega$ and R_2 is $66\,\Omega$. The ratio R_2/R_1 is $66/33 = 2/1$. Add 1, which gives the divisor 3. Then $R = 33 - 33/3 = 33 - 11 = 22\,\Omega$. This method can be stated in the formula :—

$$R = R_1 - \frac{R_1}{\frac{R_2}{R_1} + 1}$$

which can be shown to be the equivalent of the usual formula.

Having shown that resistances in parallel follow a " law " related to the ratio of their values, a further simplification can be introduced, namely :—

$$R = \frac{R_2}{\frac{R_2}{R_1} + 1}$$

which, again, can be shown to be the equivalent of the usual formula.

We need only look on R_2/R_1 as a simple ratio to get sufficient accuracy for most practical requirements. Even where the experienced designer of radio circuitry wants accuracy with speed it will surely be agreed that this unconventional formula has advantages over the generally accepted one.

To take an example, let R_1 be $8{,}000\,\Omega$ and R_2 be $24{,}000\,\Omega$. Then substituting values, the parallel value will be :—

$$R = \frac{24{,}000}{\frac{24{,}000}{8{,}000} + 1} = \frac{24{,}000}{3 + 1} = 6{,}000\,\Omega$$

Reversing the values of R_1 and R_2 :—

$$R = \frac{8{,}000}{\frac{8{,}000}{24{,}000} + 1} = \frac{8{,}000}{\frac{1}{3} + 1} = 8{,}000 \div \frac{4}{3} = 6{,}000\,\Omega$$

The formula applies equally to impedances whereever phase angle is not involved. Where Z is resistive :

$$Z = \frac{Z_2}{\frac{Z_2}{Z_1} + 1}$$

which is a useful formula for the quick calculation of parallel loads. Similarly for parallel inductances :—

$$L = \frac{L_2}{\frac{L_2}{L_1} + 1}$$

Parallel capacitances are simply added together as are series resistances, but we can adapt the formula for capacitances in series :—

$$C = \frac{C_2}{\frac{C_2}{C_1} + 1}$$

Simple examples have, of course, been chosen for convenience in demonstrating the general principle. The formula is easy to memorize, and speed in using it will soon come with practice. Finally, here is a useful application of the " ratio " idea which needs no formula to express it. We have a resistance (or a load) of $55\,\Omega$ and we want to bring it down to $50\,\Omega$. Let R be $50\,\Omega$ and R_1 be $55\,\Omega$ and R_2 be the parallel value required. Visualize R_1 split into its two parts (R_1 minus R) and R. Then ($R_1 - R$) is to R, as R_1 is to R_2. That is, 5 : 50 as 55 : R_2. Almost at a glance R_2 is $550\,\Omega$.

Electronic Circuitry

Selections from a Designer's Notebook

By J. McG. SOWERBY (Cinema-Television, Ltd.)

STABLE C.R.O. TIME-BASE

A LINEAR time-base is commonly employed in cathode-ray oscilloscopes, and to meet varying requirements its frequency is usually made variable over a wide range. The controls which effect this variation may be calibrated if the time-base is sufficiently stable, and this facility is very useful for giving a rapid guide to the time scale of the waveform under observation. The terms in which the controls are calibrated will depend on how the oscilloscope is to be used; it is often convenient to calibrate the controls in terms of frequency, rather than time, if sine waves and similar repetitive signals are to be viewed and the time-base is of the continuously repeating type. On the other hand, if a triggered or single-stroke time-base is used, only calibration in terms of time is practicable or directly useful. With a continuously repeating time-base calibrated in terms of frequency, the rise and fall of singularities in the waveform to be observed are easily timed because the interval taken by one complete sweep of the time-base is merely the reciprocal of the calibrated frequency (within the tolerances mentioned later).

If a condenser-charging (or discharging) type of time-base is to be calibrated, several awkward problems arise, most of which derive from the fact that simple time-bases are, as a rule, inherently unstable devices. For example, although it is not a difficult matter to control the charging current in a time-base with fair accuracy, it is much more difficult to be certain that the amplitude of the saw-tooth will remain constant with ageing valves and components, and when replacements are made. Because the amplitude of the saw-tooth waveform is inversely proportional to the frequency of the saw-tooth for a given charging current, it is necessary (as can be seen from the full line and dotted saw-tooth waveforms of Fig. 2 (a)) to regulate the amplitude of the saw-tooth in some way if the controls are to be calibrated in terms of frequency. Again, the fly-back time must either be negligible or a constant fraction of the time occupied by the forward sweep, or calibration at one end of the frequency scale will not hold at the other.

The aforementioned requirements are fairly well met in the following circuit, in which the frequency controls may be calibrated with a fair degree of accuracy. The principle[1] adopted in this circuit is that of artificially constraining the amplitude of a time-base within fixed and predetermined limits, so that the resultant amplitude of saw-tooth waveform is less than that which would otherwise be obtained. The limits of the constraint imposed are defined by direct potentials, so that they may be controlled by a relatively stable device such as a gas discharge stabilizer tube.

Fig. 1 is a block diagram showing how the circuit is arranged. The output from the saw-tooth generator is fed into two comparator circuits FB_i and FB_s, and when the amplitude of the saw-tooth approaches equality with the potential E_i the fly-back is forcibly initiated. The fly-back proceeds in the usual way until the output amplitude approaches equality with E_s, and at this instant the fly-back is forcibly suppressed and the sweep begins again. Thus the amplitude of the saw-tooth is constrained to be nearly $(E_s - E_i)$.

Fig. 3 shows one arrangement of the circuit which, although probably not the simplest, is easy to follow because the various functions are separated into blocks corresponding to Fig. 1. The components R, C, V_1 and V_2 form a normal Puckle time-base[2], the output saw-tooth being obtained at the cathode of V_1 as is usual. As C charges through R, to form the sweep part of the waveform, the potential of the grid of V_3(b) is taken steadily negative until it approaches that of V_3(a)—which is E_i. V_3(a) now begins to conduct (having so far been held at cut-off by the cathode current of V_3(b) through the common cathode load) and in doing so it applies a negative-

[1] British Patent No. 624,022.

[2] "Time Bases," by O. S. Puckle. 1st Ed., p. 30.

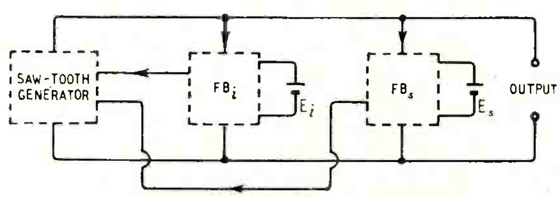


Fig. 1. Block diagram of the circuit, showing how the upper and lower limits of constraint, E_i and E_s, are applied by two separate comparators, FB_i and FB_s.

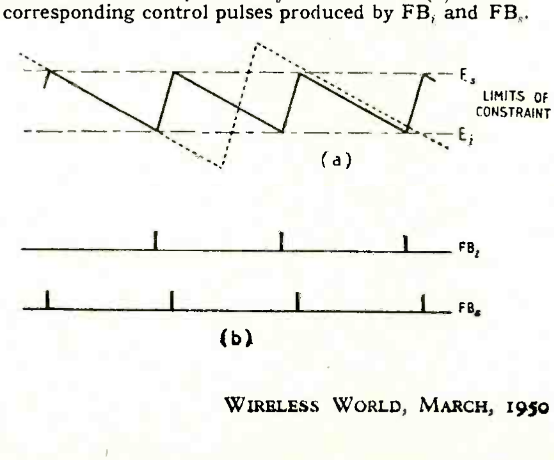


Fig. 2. At (a) is shown the output saw-tooth (full line), and the output (dotted) that would be obtained in the absence of the FB_i and FB_s circuits. At (b) are the corresponding control pulses produced by FB_i and FB_s.

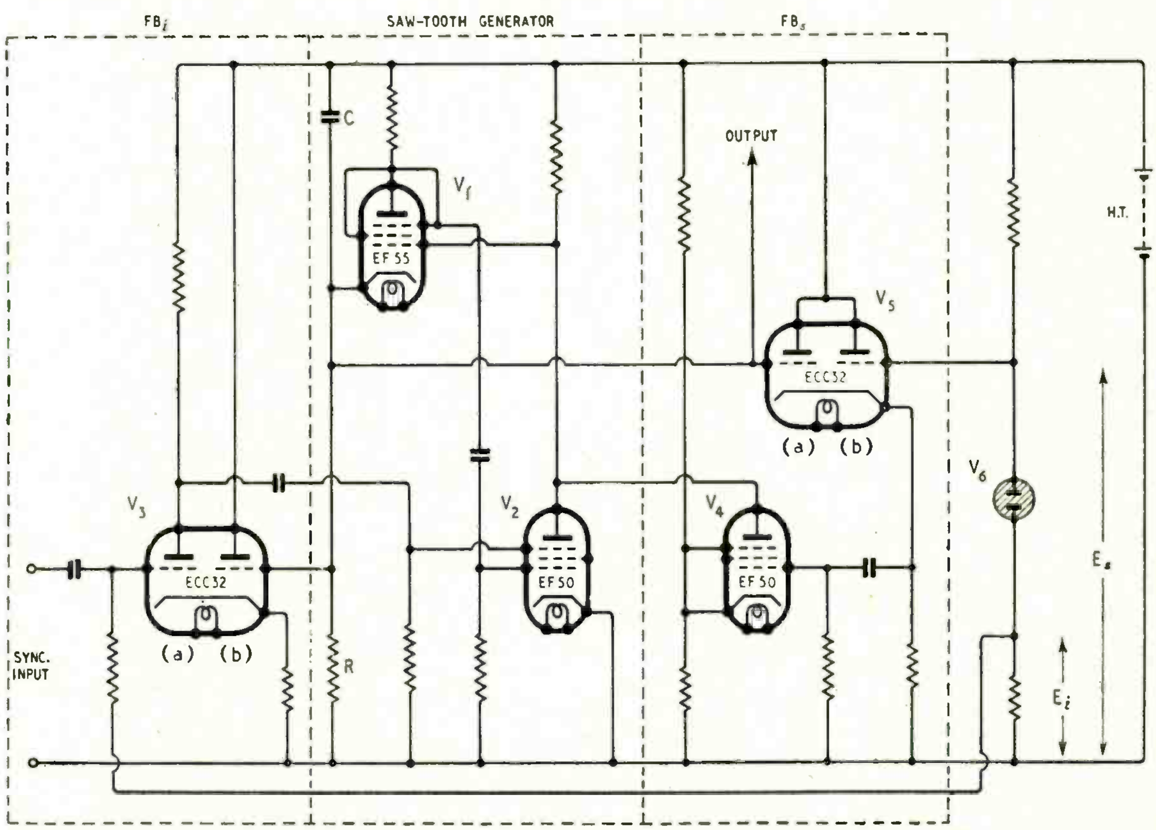
going amplified saw-tooth to the suppressor grid of V_2. As a result the anode potential of V_2 rises, so that V_1 begins to conduct. Note that for this to be possible, the standing anode potential of V_2 must be less than E_i. As soon as V_1 is sufficiently conducting, V_2 is cut off at its control grid in the usual manner of a Puckle time-base, and since the grid of V_1 is returned to the h.t. line the impedance of V_1 falls to a very low value. This allows C to discharge very quickly, and the cathode potential of V_1 moves rapidly positive, taking with it the grid of V_3(b). The anode of V_3(a) now goes positive (owing to increased current through the common cathode resistor) and so the negative pulse on the suppressor grid of V_2 collapses; but this is of no importance, since V_2 is held at cut-off by the potential applied to its control grid by the time the collapse takes place.

The time-base is now well into its fly-back mode, and as a result, the grid potential of V_5(a) now moves rapidly in a positive sense. Eventually the grid potential of V_5(a) approaches that of V_5(b), and V_5(a) begins to conduct. In consequence the common cathode potential of V_5 begins to go positive, taking with it the grid of V_4, which has hitherto been cut off by the bleeder current through its cathode resistor. As soon as V_4 conducts sufficiently, the common (V_2, V_4) anode potential falls and V_1 is cut off, so that the fly-back mode is forcibly suppressed. The resultant onset of the negative-going sweep soon produces a collapse of the pulse at the grid of V_4, but this is unimportant because the cessation of the fly-back allows V_2 to conduct again and this is, of itself, sufficient to hold V_1 at cut-off and to allow the sweep to proceed. The sweep continues until the grid potential of V_3(b) again approaches that of V_3(a) and the cycle of operations is complete.

It will be realized that the fly-back is forcibly initiated and suppressed at instants when the amplitude of the saw-tooth approaches equality with the potentials of E_i and E_s respectively, as shown in Fig. 2. In Fig. 3 the difference between these potentials is maintained constant by the gas discharge stabilizer V_6. Owing to the relatively large loop amplifications of the FB_i and FB_s circuits, the amplitude of the saw-tooth is closely controlled, and with all ordinary variations to be expected in components, excepting R and C, the repetition frequency changes very little. Normally a linear sweep is required, so that a negative feedback type of constant current charging device (e.g., a cathode follower[3]) is usually substituted for R in Fig. 3. This is much preferable to the more usual pentode, because the current can then be controlled with considerable accuracy. The condenser C—or more usually a succession of condensers to give the required frequency range—must be a stable component; good quality paper condensers have been successfully used for the low frequencies and silvered mica for the high. With such precautions, the frequency controls of the time-base can be calibrated in the confidence that the calibra-

[3] "Electronic Circuitry," Oct., 1949, p. 395.

Fig. 3. Circuit of the stable time-base, with dotted compartments corresponding to the block diagram in Fig. 1.



tion will remain unchanged over considerable periods of time. The main "active" component on which the operating frequency depends is the stabilizer V_8, and a good choice here would be the 85A1.

The time-base may be synchronized by applying a suitable proportion of the waveform under observation to the grid of V_3(a) or to the grid of V_3(b). In the latter case the synchronizing waveform either shortens or prolongs the fly-back time, so that this method is only really suitable when the synchronizing waveform has sharp leading or trailing edges. It is generally much more convenient to synchronize at the grid of V_3(a), and then the onset of the fly-back is either delayed or accelerated. This method is indicated in Fig. 3 by the connections shown.

In most simple time-bases it will be noticed that the onset and cessation of the fly-back is not very rapid compared with the intervening part. In the present time-base the fly-back can be made exceptionally rapid because of the additional loop amplification provided by the FB_i and FB_s circuits at the critical "turn-over" points. An additional factor making for a short fly-back time is the fact that it is easy to arrange for the anode potential of V_1 always to be sufficient to enable a large discharge current to be drawn. In fact, it has been found practicable to calibrate the frequency controls on the assumption of zero fly-back time for a 3:1 range between 5 and 15 c/s, and between 15 and 50 c/s; and to adjust C in steps to yield frequency ranges up to 50 to 150 kc/s, with an error nowhere exceeding four per cent. At frequencies above 150 kc/s (or thereabouts, depending on the exact circuit) the stray capacitances begin to exert sufficient influence to render the calibration increasingly inaccurate. Using the valve types shown, a maximum frequency of about 250 kc/s could be obtained with C provided merely by the stray and inter-electrode capacitance, with a charging current of 3 mA, and a saw-tooth amplitude of about 100 volts.

In use the waveform to be observed is applied to the deflection plates of a c.r.t. and to the synchronizing terminals of the time-base. The sync. control is then adjusted to apply the weakest of locking to the time-base, after which the frequency controls are adjusted until a poorly locked trace is seen, and finally the sync. control is advanced until the lock becomes satisfactory. The frequency of the time-base can now be read from the calibrated controls, and the frequency or timing of the waveform under investigation deduced. If the time-base proper is followed by an amplifier of variable gain, the amplitude of the visible sweep on the c.r.t. can be made variable without affecting the frequency calibration. This facility is sometimes useful when it is desired to study a small part of the waveform under investigation.

Finally, it is perhaps worth noting that stable time-bases of this type have been in laboratory use for nearly three years now, and on the whole have proved very useful.

AMERICAN INSULARITY

By O. S. PUCKLE, M.I.E.E.

PROFESSOR MACLAURIN, of the Massachusetts Institute of Technology, has written a most interesting book, "Invention and Innovation in the Radio Industry." It is, however, unfortunate that a large part of the book suffers very greatly from the same fault as that which appears in many American technical writings. I refer to the fact that some American writers appear to play up American achievements at the expense of their scientific and technical colleagues in other parts of the world. A reader of this book who is unfamiliar with the true state of affairs would undoubtedly receive the impression that Europe had contributed nothing to the radio industry since about 1910. This is simply not true.

In dealing with the early days Professor Maclaurin has been eminently fair and reasonable. Why, then, does he find it necessary to write in so biased a manner about later happenings? One can only assume that his reading of the later happenings has been solely from American magazines and technical journals, which also suffer from this defect. These journals are read in Europe because the Americans have done, and are doing, much to help the radio industry, but they have certainly not done everything. I should add that the most important American scientific journals do not indulge in this practice.

In the field of inventions outside America, the following facts and inventions deserve a place:—

(1) Professor Sir Ambrose Fleming's work on the valve is made to appear unimportant, whereas it is the basis on which the whole of the radio industry is built.

(2) Great Britain produced the first successful high-definition television service in the world and the quality of the results obtained in this country are considerably better than those obtained anywhere else, not excluding America.

(3) Great Britain first developed radar and is certainly not lagging behind America at the present day.

(4) The wartime work of A. D. Blumlein and F. C. Williams on circuitry in this country deserves notice since it is of the greatest possible importance, and the same may be said of the work of Randall, Boot and Megaw on the high-power magnetron, which at once made centimetric radar practicable.

I could enumerate many other examples, but these will suffice.

It is to be hoped that, in future, American writers will be rather less insular in their outlook and more willing to credit the foreigner with a certain amount of inventive abilty. European engineers have a great deal of admiration for the work being done in America and they do their best to give them credit for all they have done when writing books or technical articles.

With the proviso stated above, I should like to say that, in my opinion, this book is of the very greatest interest and well worth reading. There is no doubt that Professor Maclaurin has done a useful job in publishing this book and I would like to suggest that he could do even better by immediately writing a second edition in which, to European eyes, the bias is less noticeable.

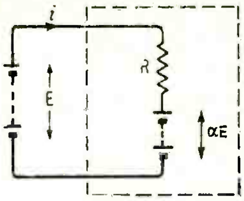


Fig. 1. This circuit is used to illustrate the calculation of resistance.

Negative Feedback

Its Effect on Input Impedance and Distortion

By E. GRIFFITHS, Grad.I.E.E.
(Engineering Division, B.B.C.)

READERS of *Wireless World* will be familiar by now with the use of negative feedback to modify amplifier gain and distortion characteristics. Articles have also been published on the effect of negative feedback on output impedance, but very little has been written about the modification of input impedance by negative feedback, although it has been mentioned in passing by several authors. In this article the spotlight will be concentrated on the way in which negative feedback can be used to change the input impedance of an amplifier.

First, however, it is necessary to clear our minds of the idea that resistance as measured in ohms always indicates the presence of a physical component of that value. We are so used to handling resistors marked or colour-coded in ohms that it is easy to forget that resistance is a ratio of two in-phase quantities, voltage and current, and that the input impedance of a circuit is defined as the ratio of the voltage across the input terminals to the current flowing into the terminals. As an example, consider a mysterious black box with two terminals. If a p.d. of 2 V across the terminals causes a current of 1 A to flow, the obvious conclusion is that there is a 2-Ω resistor connected between the terminals, but this does not necessarily follow. There might be a 1-Ω resistor inside the box with a 1-V battery opposing the applied e.m.f., or on the other hand, it could be a 3-Ω resistor in series with a 1-V battery aiding the applied e.m.f. If different applied voltages were tried we might conclude that there was a non-ohmic resistor inside the box, because the applied e.m.f., divided by the current flowing, would not be a constant. After a while, however, suspicion might be aroused and a voltmeter connected across the input terminals would give the answer to the problem. Suppose, however, there was a gremlin inside the box who adjusted the internal e.m..f so that it was always proportional to the applied e.m.f. Where would we be then? The voltmeter test would show nothing, but it is obvious that the input resistance would not be equal to the value of the physical resistance inside the box.

Using the symbols shown in Fig. 1 we can calculate the input resistance as follows:

Net voltage acting round circuit

$= E - \alpha E$

$= E(1 - \alpha)$

hence

$i = E(1 - \alpha)/R$

so that, input resistance

$= E/i = R/(1 - \alpha)$

which is greater than R.

On the other hand, if the gremlin suddenly reversed the polarity of the internal e.m.f., the input resistance would fall to $R/(1 + \alpha)$.

After this slight digression we can now return to the object of this article and consider how the input impedance of an amplifier can be increased or decreased, depending on the method of connection of the feedback voltage.

With series-connected feedback the source voltage, grid voltage and feedback voltage are in series round the circuit. Fig. 2 shows the simplified circuit for an input stage with valve gain A, connected to a source of internal resistance R_1 and open-circuit output voltage e'. Assuming a grid-cathode voltage of e_g is developed across the grid resistor R_2, the output voltage will be Ae_g and, if the feedback voltage is fed back via a circuit of gain β', the feedback voltage will be $A\beta' e_g$. (It will be seen later why β' is used in preference to the usual symbol β).

By definition, the input impedance $Z_i = e/i$ and

$e = iR_2 + A\beta' e_g$

but

$e_g = iR_2$

$\therefore e = iR_2 + A\beta' iR_2$

whence

$$Z = e/i = R_2(1 + A\beta') \quad \ldots \quad (1)$$

and shows that the input impedance has been increased by the use of series-connected feedback.

Parallel-connected feedback is obtained when the three voltages in which we are interested are connected in parallel, as shown in Fig. 3. The feedback voltage is aiding the input voltage and the grid-circuit current is therefore increased—the input

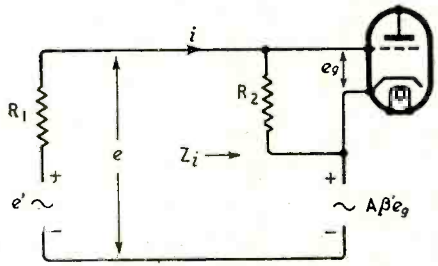
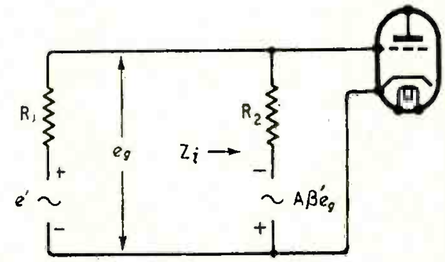


Fig. 2. (left) Showing the simplified circuit of a series-connected feedback stage.

Fig. 3. (right) Illustrating the basic parallel-connected feedback stage.



impedance is thus reduced by the application of the feedback voltage.

With this circuit the input voltage is equal to the grid voltage, so that the input impedance is given by:

$Z_i = e_g/i$

and

$e_g = iR_2 - A\beta' e_g$

from which, with a little mathematical juggling, we find:

$$Z_i = R_2/(1 + A\beta') \quad \ldots \quad (2)$$

Modern high gain a.f. amplifiers normally use a r.f. pentode for the first stage, and with such valves the maximum recommended value of grid resistor is usually of the order of 0.5 MΩ. When a crystal microphone or pickup is used, it may be desirable to use a much higher input impedance than this, and a series-connected feedback stage may then be used as a half-way house between a conventional valve stage and a cathode follower.

As an example, consider the requirement of a 5-MΩ input impedance when the grid resistor is 0.5 MΩ. The increase in input impedance required is 10 times and reference to equation (1) shows that the required value of $A\beta'$ is 9. Assuming a grid to anode gain of 200 is available, calculation shows that β' is 9/200. Fig. 4 then gives the circuit to be used. The load resistance for the valve (R) is that of the anode feed resistance R_2 and the following grid resistance R_3 in

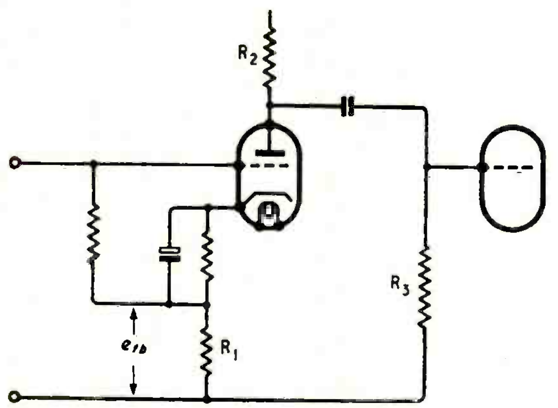
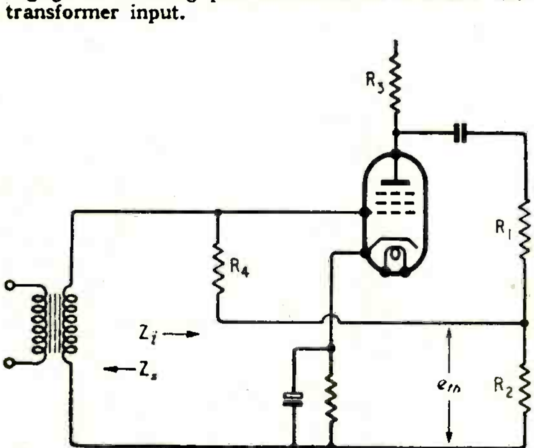


Fig. 4. Cathode feedback is one example of the series-connected type.

Fig. 5. Illustrating parallel-connected feedback with transformer input.



parallel and a typical value is 100 kΩ. β' is the ratio of the feedback resistance to the load resistance, and since this must have a value of 9/200, the correct value for the feedback resistance R_1 is 4,500 ohms.

Parellel-connected feedback may be used to give feedback without loss of gain, provided that the comparison is made on the basis of two amplifiers doing the same job. By this, it is meant that the comparison is between two amplifiers having the same input impedance, rather than the same amplifier with and without feedback.

Fig. 5 shows an example of parallel-connected feedback. In this circuit the value of the grid resistance is not limited by the maker's recommended value, since there is a low resistance d.c. path between grid and cathode provided by the input transformer. If the resistance R_4 is made 5 MΩ and the impedance on the secondary of the input transformer is to be 0.5 MΩ, reference to equation (2) shows that $A\beta'$ must be 9 and hence, with a grid to anode gain of 200, β' is 9/200. Assuming a value for R_1+R_2 of 0.3 MΩ we have:

$$\frac{R_2}{R_1+R_2} = \frac{9}{200}$$

and hence, $R_2 = 13,500$ ohms.

The Feedback Factor

It is now necessary to distinguish between β and β'. In this article, β' has been defined as the ratio of the fed-back voltage to the output voltage. β is, however, defined by the fact that $A\beta e_g$ is the feedback voltage effective between grid and cathode. This distinction is made clear by reference to Fig. 6

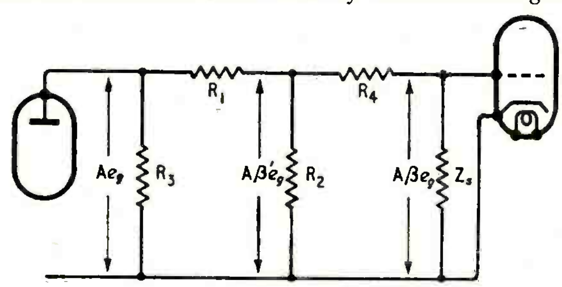
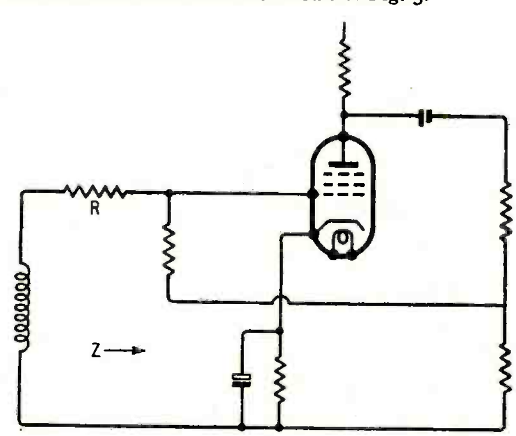


Fig. 6. This diagram is used to show the distinction between distortion reduction and gain reduction factors.

Fig. 7. This arrangement enables distortion to be reduced more than with the circuit of Fig. 5.



which is equivalent to Fig. 5 when only the feedback path is considered. The distortion-reduction factor when negative feedback is applied to a single-stage amplifier is $1/(1+A\beta)$, but the value of β' must not be substituted in this formula, since it is not the voltage $A\beta' e_g$ which is effective between grid and cathode, but $A\beta e_g$. As an example, considering the circuit shown in Fig. 5 again, we know that the resistance R_4 is 5 MΩ and β' is 9/200, and assuming that $Z_s = Z_i = 500{,}000$ ohms, and remembering that R_2 is small:

$$\beta = \frac{Z_s}{R_4 + R_s}\,\beta' = \frac{0.5}{5.5}\,\beta' = \frac{1}{11}\,\beta' = \frac{9}{11 \times 200}$$

The distortion-reduction factor with this circuit is therefore:

$$\frac{1}{1+A\beta} = \frac{1}{1 + \frac{200 \times 9}{11 \times 200}} \approx \frac{1}{2}$$

This circuit can therefore be used to give nearly 50% decrease in distortion without loss of gain as compared with an amplifier without feedback and with the same input resistance. The greater the change in input impedance with feedback, the nearer the distortion-reduction factor approaches a half.

This particular change in harmonic distortion is, of course, only obtained with amplifiers in which a high input impedance is reduced to the same value as the source impedance by the use of parallel-connected feedback. When the source impedance is high compared with the input impedance obtained by applying feedback the distortion will be reduced by more than 50%, because β more nearly approaches β'. The converse also applies.

When a greater reduction in distortion is required it can be obtained by using the circuit of Fig. 7. This circuit may be developed from that of Fig. 5 in the following manner. If β' is increased the value of the impedance Z will fall. The input impedance may be restored to its original value by adding the resistance R, the effective feedback factor then becomes larger, so that the distortion is reduced still more. On the other hand, the series resistance R and the apparent impedance Z, together, form a voltage-dividing network, so that the gain is reduced by the factor $Z/(R+Z)$. When cathode injection of the feedback voltage is used, the gain is reduced by the same factor as the distortion (for a given output) but when parallel-connected feedback is used the required reduction is distortion can be obtained with only about half the loss in gain that is given by the more conventional circuit.

Gain Stabilization

One advantage of negative feedback is that the overall gain is stabilized in spite of reasonable variations in valve parameters. When parallel-connected feedback is used, an easily visualized explanation for this exists. If the grid to anode gain falls, the input impedance rises and with the simple circuit shown in Fig. 5 a bigger proportion of the source voltage appears between grid and cathode. With the circuit of Fig. 7 the loss ratio of the voltage-dividing network falls, owing to the rise in the value of Z, but in this case the variation in amplifier input impedance is less, because of the padding effect of the series resistance R.

OPERATING TROLLEY-BUS POINTS

Remote Control from Driver's Cab by Induction Link

SINCE the introduction of trolley-buses in London, one of the main operational difficulties has been the changing of points on the overhead track at junctions and turning places. At present, this has to be done either by the conductor, who leaves the bus to operate a switch at the side of the road, or, in the case of a busy junction, by a man permanently on the site. To overcome the many obvious disadvantages of this procedure, a device has now been developed by Wayne Kerr for the London Transport Executive, to enable the trolley-bus driver himself to change the points by pressing a button in his cab.

It is an induced-current system, comprising a one-valve oscillator and transmitting loop on the trolley-bus, and a corresponding pick-up loop and receiver mounted on the overhead track wires. The driver switches on the oscillator as he approaches the junction, then as soon as the transmitting loop on the roof of the trolley-bus passes underneath the pick-up loop, a current is induced from one into the other. This is rectified in the receiver, and the resulting d.c. operates a sensitive relay which, in turn, closes the electrical circuits of the existing point-changing mechanism. To switch on the oscillator, the driver presses a push-button which actuates a thermal relay to give a 30-second time delay; this enables him to put the system into operation some way in advance of the junction, and so leaves his hands free for driving for the rest of the time. A signal is painted on one of the roadside pillars to tell him exactly when to press the button.

Since the transmitter radiates at a frequency of 70 kc/s (somewhere in the region of 4,000 metres) it is not likely to cause interference with reception on the long-wave band. In any case, the power radiated has been deliberately kept low in order to limit the range of the system to a few feet, so that the receiver will not be triggered by more than one transmitter at a time. The oscillator valve dissipates about 12 watts in its anode, and the tank circuit is matched to an 80-ohm coaxial line which feeds power into the transmitting loop. Heater current for the valve is obtained directly from the 24 V supply in the trolley-bus, and h.t. from the same source by means of a synchronous vibrator.

Perhaps the most interesting part of the equipment is the receiver. This consists of little more than a 5-mA Westinghouse bridge rectifier housed in a small container, which is suspended, together with the pick-up loop, on the overhead track wires. The d.c. output of the rectifier is wired across to a roadside pillar and into a weather-proof box, which contains the sensitive relay already mentioned and a heavier relay for switching the point-changing mechanism. The pick-up loop is arranged in a rectangle, 16ft × 5ft, and consists of one turn of 3-core electric light cable, with the cores connected to form three turns.

Reports from the London Transport Executive indicate that the first installation, at a road junction in Croydon, has proved very reliable and simple to operate, and four trolley-buses have, so far, been equipped with transmitters.

UNBIASED

By FREE GRID

Quicunque Vult

MOST of you have, I suppose, heard the story of the youthful and impecunious curate whose wife unexpectedly presented him with twins when he had budgeted for only one child. With a grim and determined expression on his face he promptly named them Alpha and Omega. To the unlettered masses such names may appear to be meaningless and to have no bearing on the matter, but *W.W.* readers and other *alumni* of Robert Raikes will have no difficulty in recalling the succinct definitions of "the first and the last" given to these two letters in the Apocalypse.

I cannot help feeling that the + and − signs with which we continue to label our cells and the d.c. parts of our radio circuits are equally as meaningless to non-*W.W.* readers. Many a listener whose electrical education hasn't advanced greatly since the last century probably imagines that one sort of electricity comes out of one battery terminal and another out of the other. A more technically advanced citizen would speedily point out, with all the dialectical skill of a well-fee'd lawyer, that there was only one kind of electricity, which, like the cornet music in the once-popular song, "goes round and round." We could pardon him for thinking that there was an excess of electrons at the + terminal and a deficiency at the − terminal so that the battery tried to adjust itself around the external circuit in the seemingly commonsense way.

But all *W.W.* readers will know on the authority of "Cathode Ray" and myself (15th December and 3rd November, 1938) that electrons dwell in Looking-Glass land like the friends of Alice and therefore go the wrong way round like a woman driver negotiating a traffic roundabout. "Lesser breeds without the law," gorged by a surfeit of "Explaining-The-Atom" articles which are dished out daily nowadays, and bewildered by much talk of protons, positrons and neutrons, in addition to electrons, might well be forgiven for postulating a four- or *n*-times fluid theory.

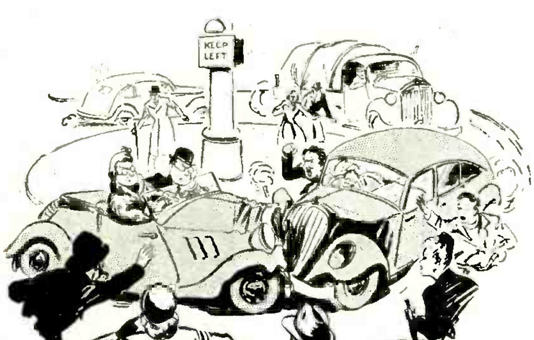
Surely the best way of settling all this business is to cease using the misleading + and − signs and to leave such symbols to the nuclear physicist if he wants them. The obvious name for the so-called negative terminal of a cell is cathode terminal, the anode being the so-called positive. In this way we should avoid the hopeless befogging of the lay mind that exists at present and bring things into line with the nomenclature used in the field of the valve and the c.r. tube.

"Cathode Ray" may care to support my plea, although I always fancy he regards me as a bit of an Arian, and he may, therefore, denounce my ideas with Athanasian thunder.

The Cloven Hoof

THE *Journal of the Franklin Institute* contains, as one would expect, much of value to electrical and radio engineers. A recent issue also contains something suggestive of Berchtesgarten rather than Philadelphia. An Editorial scribe demands with totalitarian abruptness that the scientist be subject to the authority of no man, but that he be allowed to carry out his heart's desire, namely, research work, untrammelled by such sordid things as money, and the restrictions which the lack of it forces upon him.

Here let me interpose that this sort of world is the one I've always wanted for myself, and so have you, too, if you are honest with yourselves; in brief, a worryless world. But, unfortunately, the curse laid upon Adam—and I'm not referring to Eve—still holds good, and we can't expect the community to keep us while we let our ego fulfil itself.



The Wrong Way Round.

Now it doesn't at all surprise me that the writer goes on to attack Hitler and St. Paul, among other figures who have been prominent in the world's history. Some scientists always attack Adolf because, I suppose, in his heyday he achieved a goodly measure of success in applied psychology, so far as the German people were concerned, although he had no book learning in the matter. To a scientist, lack of book learning is one of the unforgivable sins. It doesn't take a very long memory to recall the frowns bestowed on young Marconi who, although not claiming to be a scientific savant, managed to bridge the Atlantic in 1901 without ever having heard of the Heaviside layer.

The Curse of Adam.

If a scientist holds the technocratic and therefore virtually totalitarian views which the Franklin *Journal* writer voices, then there is an even greater sin than lack of book learning, and that is for an aggressor to see the error of his ways and join the opposite camp. Those of you who have rather more accurate knowledge of St. Paul than to imagine that he built the Cathedral on Ludgate Hill, will recollect that this is exactly what the man of Tarsus did. Few people have persecuted a religious community with more fervour than he did, and it is not surprising, therefore, that when he suddenly abandoned his old ways he incurred the undying hatred of his former fellow-aggressors.

Since that day his memory has always been to the aggressor, potential or actual, a sharper and more piercing "thorn in the flesh" than that from which he himself suffered. If the opinions of the Franklin *Journal* writer be any criterion, it is clear that the passing of the ages has not blunted it by one decibel or whatever be the unit of acuity.

LETTERS TO THE EDITOR

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

"A.C./D.C.-Battery Power Supplies"

THE article by L. Miller in your January issue contains several serious errors, presumably caused through lack of knowledge of the characteristics of the battery valves concerned.

In his third paragraph, Mr. Miller refers to ". . . 1.5V and 3.0V valves . . ." In fact, the rating is 1.4 and 2.8 volts both in England and America. This rating is, however, only used when the valves are run from a dry cell of the Leclanche type, whose discharge characteristic shows a progressive fall in voltage during life. When the valves are run from a constant voltage source, as is the case when mains-operated, it is desirable to maintain the filament voltage at 1.25 volts, 46 mA, in order to combine a long life with adequate performance.

The supply voltage, therefore, for a set of four valves, when mains operated, would be 6.25 volts (3 × 1.25 and 1 × 2.5) and not 7.5 volts as stated by Mr. Miller. If continuous operation at the higher voltage is attempted, an unnecessarily short life will be experienced.

The suggestion that a 50L6 be used is still applicable if the correct operating current for the battery valves is employed, by increasing the grid bias voltage by means of a cathode resistor.

The circuit shown in Fig. 3 is unlikely to be satisfactory, since the screen voltage is presumably left connected to the battery output pentode when the mains valve is in use, although the anode voltage is disconnected. Furthermore, the signal voltage is still applied to the control grid.

G. R. WOODVILLE.
The M.O. Valve Co.,
London, W.6.

IN view of some of the remarks in L. Miller's article in the January issue, we feel that we should draw your attention to our published operational recommendations for the use of "1.4-volt" valves, the relevant sections of which are:—

"(1) *Dry Battery Operation.* Valves with 1.4-volt filaments are designed to be operated from a dry-cell battery with a rated terminal voltage of 1.5 V. In no circumstances should the voltage across any 1.4-volt section of filament exceed 1.6 V. If these valves are operated with their filaments in series from dry batteries with a higher terminal voltage, shunting resistors may be required to ensure the correct voltage across individual 1.4-volt filaments.

(2) *Accumulator or Mains Operation.* When valves with 1.4-volt filaments are operated from an accumulator or from a mains supply unit, the voltage drop across each 1.4-volt section of filament of valves with rated filament current should have a nominal value of 1.3 V and should be maintained between 1.25 V and 1.4 V at normal line voltage, that is to say at voltages equivalent to 2 volts per cell for accumulators or to nominal line voltage for supply mains. If the filaments are operated in series, shunting resistors may be required to ensure the correct voltage across individual 1.4-volts filaments."

Although in paragraph (1) a rated *terminal voltage* of 1.5 V per cell is quoted, it must be borne in mind that the average potential per cell during most of its useful life is approximately 1.3 V.

From paragraph (2) it is apparent that the filament voltage should not be adjusted to a nominal value of 1.5 V when the filaments are operated from a mains supply.

The shunting resistors referred to in the final sentence are necessitated by the fact that the anode current of each valve flows through the filaments of all valves nearer the negative end of the filament chain, and the cumulative anode current near the negative end of the chain is sufficient to overload the filaments.

The upper and lower limits for the filament voltage (1.4 V and 1.25 V) are specified to permit correct l.t. adjustment with the minimum number of input tappings on the mains transformer, and also to permit convenient values of shunting resistors to be employed.

It must also be understood that the rated filament current of 50 mA occurs only at a filament voltage of 1.4 V; at 1.3 V the filament current is less, a typical value being 47 mA.

The method of operation described by Mr. Miller in which the filament chain of the battery valves is in the cathode return of a mains output valve, cannot be recommended as satisfactory for use in large-scale receiver manufacture. Normal deviations of the characteristics of the mains output valve from those used in the design of the circuit, and possible variation in the operating conditions during life, might easily result in the filaments of the battery valves being run at a voltage outside the recommended limits. Furthermore in the event of the mains valve passing an abnormally high current, the filaments of some or all of the battery valves would be destroyed.

If, however, there are experimenters who wish to investigate these circuits, may we draw attention to the Mullard UL41 valve? The heater current of the UL41 is only 0.1 A compared with 0.15 A for the 50L6, and it requires a heater voltage of 45. The half-wave rectifier in the Mullard range suitable for use with the UL41 is the UY41, with a heater current of 0.1 A and a heater voltage of 31.

H. P. WHITE.

Mullard Electronic Products,
London, W.C.2.

Stereophonic Broadcasting

A NOTE in your January issue states that "it is understood" that the f.m. transmitter at Wrotham has now been accepted by the B.B.C., and we may therefore deduce that at some future, unspecified date official transmissions will begin.

It is typical, however, of the Corporation's obscurantism in engineering policy matters that we should have to rely on such meagre information on the progress of a fundamental development. Listeners with some technical awareness will not have forgotten the occasion of the change of site of the Third Programme transmitter which, virtually unannounced, caused great inconvenience in much of the London area; nor will they have failed to observe, more recently, the unheralded jugglery with transmitter powers. It is high time that the Corporation recognized its obligation to the technically informed public, for the rapid progress of broadcasting has depended, to a considerable extent, on the active participation of this body in the transitional and formative phases.

I do not believe, however, that the B.B.C. is past praying for; it could easily reverse this baleful trend and restore its position as an enlightened body in the technical as well as the cultural spheres. It might begin, for instance, by sending out binaural transmissions from Wrotham, radiating one channel from the f.m. and the other from the a.m. transmitter. In this way the listeners could judge for themselves the efficacy, or otherwise, of a stereophonic system. Let me attempt to counter, in advance, possible objections which might be raised to this proposal.

(a) Cost. The binaural system could be used on, say, certain selected orchestral programmes originating in the London area; in this way the line costs could be kept to a minimum. The studio costs would be small, and I do not doubt for a moment that the necessary enthusiasm exists in all grades of the B.B.C. engineering staff to carry out such an experiment.

(b) The restricted appeal of such a system. A large number of professional and amateur radio engineers would no doubt welcome such a trial. We might note that Writtle had a restricted appeal in 1920.

(c) Diversion of effort and facilities. The juxtaposition of your January note with another suggests that powerful commercial interests may oppose further expenditure on the f.m./a.m. project. The B.B.C. has usually, in the past, sets its heart against wrong-headed parochialism, however well intentioned, and it can safely be trusted to resist the influence of newer pressure groups.

E. JEFFERY.

Arborfield, Berks.

Television on 25c/s Mains

WITH the extension of the television service to the Midlands area, the existence of a number of pockets of 25-c/s mains will undoubtedly lead to the temptation to use television receivers designed primarily for frequencies of 40 to 60 c/s.

Each individual design of equipment involves certain problems and, in many cases, the addition of several hundred microfarads to the existing smoothing capacitor, whilst yielding a tolerable performance, is not without hazard.

May I suggest that in each case the receiver manufacturer be consulted in advance to ensure that dependable information regarding the modifications required is obtained and carried out, to reduce this hazard to a minimum?

O. G. COX.

A. H. Hunt, London, S.W.18.

Dark Television Screens?

AS the black portions of a television image are due to the non-illumination of the screen by the scanning beam, the depth of "blackness" is determined by any extraneous light which falls on the screen. Hence if the screen itself were initially dark instead of "off-white" as at present, considerable improvement in contrast should be experienced when viewing in lighted rooms or in daylight.

It would be interesting to know if it is technically possible to manufacture tubes with dark-coloured screen materials.

A minor advantage would be a more pleasing appearance to the receiver when it is not in use, as the white screen has a very "naked" look.

With regard to title captions, lists of artists, etc., used during television programmes, the general practice seems to be black lettering on a light background. Would it not be preferable to use white lettering on a dark background? This would be more restful to the eye, would prolong tube screen life and would reduce the power used by the transmitter.

If black lettering on a light ground is more practicable on the actual caption card, a "negative" could easily be produced electronically.

ALAN HUMPHREYS.

London, N.4.

"Output Impedance Control"

WHILE it is true that excessive resistive damping applied to a loudspeaker can cause loss of transients, Mr. Roddam (your February issue) is surely at fault in stating this in connection with the effective damping produced by feedback. A low resistance connected across the loudspeaker could produce this effect, but feedback damping works in a different way.

With negative voltage feedback, the amplifier input is the difference between the applied signal and the voltage across the loudspeaker. As the latter is largely dependent on the cone velocity, the feedback tends to make the velocity proportional to the applied voltage.

With no input signal, the feedback loop damps the motion of the cone, since any movement will apply a voltage to the input of the amplifier so that the output stage exerts power to stop the movement. The application of an input signal jerks the cone into motion, the force applied being proportional to the discrepancy between the actual cone velocity and the correct velocity. Increasing the feedback increases the excess power applied, and reduces the discrepancy.

The "swinging door" analogy fails, because in that case the damping is applied continuously in relation to a fixed point. In the feedback amplifier the damping is applied in relation to the instantaneous input signal voltage. Transients are improved by the application of excess power on the leading edge and at the peak, while the cone is brought to rest quickly after the transient has ended.

The excess power required must be available, and it may be that this is the source of Mr. Roddam's loss of transients. Taking the output level he quotes, 50 mW, an undamped amplifier will need about 5 watts peak output to deal with transient peaks. With feedback applied, the normal peak margin of 20db must be increased by 5-6db with the average loudspeaker, giving a total power of 20 watts.

It is interesting to note that the extra margin required with a cheap loudspeaker may be as much as 10db, while some of the best types require only 3-4db. These figures apply to a feedback loop giving AB ≑ 25. Lesser degrees of feedback require less extra power.

If sufficient reserve power is available, the heaviest possible feedback gives the best result. The practical limit is imposed by stability requirements, and here again Mr. Roddam makes a queer statement. He says that if the feedback is taken too far the amplifier will oscillate, but this effect can be detected by ear. Not if the oscillation is in the supersonic range, as it may well be. Many experimenters have condemned negative feedback because it introduces supersonic oscillations, the only audible effect being a reduction in power output capacity.

The scheme for feeding a varying number of speakers from the output of a heavily damped amplifier must also be questioned. The load impedance will vary, and the matching will suffer. A better system is to use suitable load resistors which are substituted for loudspeakers not in use. The load then remains constant, and so does the power supplied to each listening point.

Lastly, the condition under which a feedback amplifier has a gain of 1/B (more correctly −1/B) is that AB is large, not that A alone is large.

Having dealt cavalierly with some of his minor points, I would like to make some amends by congratulating Mr. Roddam on the circuit which forms his main theme. It is good to see something simple and efficient in these days of inefficient complexity.

DONALD W. THOMASSON.
E.A.R.L. Services, Exeter.

Interference from Televisors

ONCE again I write to you concerning a type of interference which is widespread in the London area, though I have read no comments on it. I refer to the severe interference propagated by certain types of televisor.

The interference is manifest by a raw a.c. tone comprising a mixture of 10-kc/s and 50-c/s frequencies together with other mush. This note is imposed upon any strong carrier received by a radio receiver situated within 100 yards or so of the offending vision receiver.

The number of cases I have personally encountered during the past few months lead me to believe that this interference is rapidly increasing. Apparently the a.c./d.c. types of televisor are the main culprits.

Beyond doubt, local televisors are often responsible for complaints of loud hum in broadcast receivers. When testing the vision units for this fault it is in most cases necessary to make sure television transmissions are on, otherwise the interference is at a low level.

In most cases a partial cure can be effected by placing a capacitor across the main input terminals of the video set. However, it transpires that the capacitance is critical. Too much capacitance often increases the radiation.

R. M. STAUNTON-LAMBERT.
London, N.W.6.

"T-Match Television Aerial"

REFERRING to the article by B. Mayson in your January issue, we are interested, as manufacturers of aluminium alloys, in the material of which the aerial was made. We presume from the context that the alloy used by the author was Duralumin B. This alloy, which is the strongest of the Duralumin series, contains copper, and we would not regard it as specially suited for the construction of a television aerial. We are, in fact, supplying very large quantities of Duralumin H, a strong heat-treatable aluminium alloy not containing copper, for the manufacture of such components, and this alloy has been found to have a strength and corrosion resistance entirely adequate for the service. Aerials made in Duralumin H do not need protection by painting.

We do not normally recommend that, in those cases where aluminium alloys are to be protected by painting, paints containing lead compounds should be used; as in the event of the lead pigment becoming reduced, some harmful effect on the alloy might ensue.

May we add that as the word "Duralumin" is the registered trade mark of this Company, it should be spelt with a capital letter D and not with a small letter.

C. SMITH.
James Booth & Company,
Birmingham, 7.

RANDOM RADIATIONS

By "DIALLIST"

European Television Standards

Though Britain and France are the only European countries with regular television services, it is likely that a good many others will enter the field before very long. Everyone realizes the desirability of having a common standard, but it is not easy to find one that is acceptable to all; in fact, the only thing now common to all schemes is the number of frames per second! There's, fortunately, no choice about that, since the mains periodicity in almost all European countries is 50 c/s. A meeting was held in London in January at which the matter of definition standards was discussed by representatives of the five Brussels Treaty countries, Belgium, the Netherlands, France, Luxembourg and Britain. No agreement was then reached, but another meeting will be taking place in Paris by the time this appears in print and it is by no means impossible that these five countries, at any rate, will come to satisfactory terms.

Medium and High Definition

It can't be denied that the difficulties are very great indeed. We cannot possibly change our number of lines, for cast-iron guarantees have been given by the Government that it will be maintained for some years. Few people, except ourselves, regard 405 lines as adequate for the medium-definition service with which most countries will make a start. The standard that seems to be coming most into favour outside the five countries mentioned is 625 lines. Very good results are obtainable with this number of lines, but the modulation bandwidth required is too large for the majority of existing and projected coaxial cables to do justice to long-distance international relays. My forecast is that agreement will not be reached about the number of lines used in medium-definition services. But these, after all, are only a preliminary stage. The television of the future will be the thousand-odd line type and it should be possible to agree on a common standard for this, since no country is yet irretrievably committed to any particular number of lines.

Multum in Parvo

A very neat little multi-range measuring instrument has been sent to me by a French friend. This is the Model 450 of the well-known Annecy firm, Metrix. Though its dimensions are only $5\frac{1}{2} \times 4 \times 1\frac{1}{2}$ inches it does quite a remarkable number of things—and does them well. Its ranges, 18 in number, are: 1.5, 15 and 150 mA, 1.5A, 15, 150, 300 and 750 V—on both a.c. and d.c.—10,000 ohms and 1 MΩ. The basic instrument is a moving-coil milliammeter with a full-scale deflection at 0.5 A and on all voltage ranges the resistance is 2,000 ohms per volt. The $3\frac{1}{2}$-inch dial has clearly divided scales and an anti-parallax mirror. The makers claim an accuracy better than ±1.5 per cent on all ranges and tests made against sub-standard instruments bear this out. On the 150-V ranges, for example, the greatest error was under 0.5 per cent with d.c. and 1.3 per cent on a.c.

The Range Question

My only criticism of the instrument is one with which by no means every reader will agree. It concerns the actual ranges chosen and I suppose we all have our own ideas about what we like in that way. If I'd had the designing of an instrument with four voltage and four current ranges for a.c. and d.c., I think I should have chosen 3, 30, 300 and 900 volts and for current 3, 30, 300 mA and 3 amps. Then I would have preferred the resistance ranges to be 100,000 ohms and 10 megohms. With those ranges you can make nearly every test on radio receiving gear that can be made with a current-operated instrument. In the old days one never built a set without ruefully wishing later on that it contained just one more valve; nowadays I can't handle a multi-range meter for long without yearning for one more range. There isn't room on this little Metrix for the extra socket that would be needed; but perhaps the makers may produce a slightly larger version sometime. If they do, I'd like to see a 0-500 micro-amp range, making use of the basic milliammeter without any shunt. Should I be satisfied then? I should probably soon discover another that I wanted.

Simple but Useful

Talking of meters, there's one type very useful for certain jobs which can be made up without much trouble from the bits and pieces that most of us have in drawers and cupboards. This is a simple form of slide-back valve voltmeter which will measure r.f. and a.f. voltages. Ingredients: a valve, a milliammeter, a d.c. voltmeter, a potentiometer, two 0.1 μF (or thereabouts) capacitors and a resistor of about 2 MΩ. The choice of the first four components will depend upon the magnitude of the voltages that you want to measure. One of the input terminals is connected to the cathode; the other is connected via one of the capacitors to the grid. Put the resistor between the grid and the slider of the potentiometer, the fixed portion of the potentiometer being connected across a grid biasing battery—the e.m.f. of which again depends on the sort of voltage to be measured. The voltmeter goes between the slider and g.b.+ and is shunted by the second capacitor. The milliammeter is arranged so as to measure the anode current. The principle is simply that the valve is biased back to begin with by moving the potentiometer slider until the anode current is zero. The voltmeter reading is now noted as V_1. Next the alternating or oscillating voltage to be measured is applied to the input terminals and the slider of the potentiometer is once more adjusted to make the anode current *nil*. Read the voltmeter again and you have V_2. The *peak* applied voltage is $V_2 - V_1$. To obtain the r.m.s. voltage, if you require it, multiply by 0.707. Thus if $V_2 - V_1$ came to such an obliging—and most unlikely!—figure as 14.14, you would see at once that the applied voltage had an r.m.s. value of 10.

Elbow Room

As it happened, I wasn't able to go to the sort of housewarming party that the B.B.C. gave to inaugurate the new television studios at Lime Grove, Hammersmith, which were bought from the J.

Arthur Rank organization. Next day, though, I met a friend who had been there. He seemed still to be slightly dazed by the vastness of the buildings. "They have bought five great *cathedrals*," he explained. In comparison with the rather cramped accommodation at Alexandra Palace the five new studios certainly are enormous. One of them has a floor area over twice as large as that of the whole studio space at A.P. Between them the five studios at Lime Grove measure some 28,100 square feet, or nearly two-thirds of an acre. The purchase was a wise one, for television plays and so on need many more rehearsals than those for sound broadcasting. Now several rehearsals will be able to go on at once and still leave a studio available for actual broadcasts. The B.B.C. is certainly doing everything it can to help television along. Would that its style were not so cramped by present-day economic obstacles in the way of buying new transmitters and erecting buildings.

MANUFACTURERS' LITERATURE

BULLETIN No. 85, dealing with "Araldite" casting resin, from Aero Research, Ltd. Duxford, Cambridge.

Comprehensive lists of magnetic relays from Jack Davis, 30 Percy Street, London, W.1.

Illustrated leaflets describing radio-frequency heaters Types RFH/1 and EH10A, and waveform monitor, Type 3794, from E.M.I. Factories Ltd., Hayes, Middlesex.

Selected list of test and measuring instruments supplied by F. Livingston Hogg, 77 Wood Vale, Muswell Hill, London, N.10.

Bulletin B601C, "Phonic Motor Timing Devices," from Muirhead and Co., Beckenham, Kent.

Catalogue of "Reosound" chassis, components and accessories, from the Reosound Engineering and Electrical Company, Coleshill Road, Sutton Coldfield, Warwickshire.

Technical specification, including response curve, of the "Concentric Dual" loudspeaker, from Sound Rentals, Canterbury Grove, London, S.E.27.

New pamphlet of "Telcon" cables for car radio, anti-static and television aerials, and microphones, from the Telegraph Construction and Maintenance Company, 22 Old Broad Street, London, E.C.2.

Retail list of radio components from M. Watts and Co., 8 Baker Street, Weybridge, Surrey.

Manufacturers' Products

New Equipment and Accessories for Radio and Electronics

Ignition Interference Suppressors

TO combat interference with television, car radio and any form of mobile radio on petrol-engined vehicles, A. F. Bulgin and Company, Bye Pass Road, Barking, Essex, have introduced a suppressor incorporating a wire-wound resistance element for inserting in the ignition system. It is intended to fit into the centre contact of the distributor and both screw-in and plug-in types are available. The resistor is totally encased in a slightly flexible polythene moulding which is virtually impervious to moisture and oil.

In the samples examined, the resistor measured 15kΩ and should therefore have negligible effect on the behaviour of the engine. The screw-in fitting is known as the P445 and the plug-in as the P444; each costs 1s 6d.

Disc Seal Triode

AN addition to the Mullard range of e.h.f. valves is a new disc seal triode, the type ME1003. It is indirectly heated and operates at 6.3 V, 1.0 A, and the maximum anode voltage is 500. It will tolerate a peak anode current of 500 mA, with a normal maximum of 200 mA. The maximum anode dissipation with convection cooling is 25 W.

This valve is intended to be used in common grid type circuits in which the anode is "earthy" and in a concentric line oscillator or power amplifier. In a circuit of this kind the power output is approximately 6 watts at 1,500 Mc/s (20 cm), rising to 20 watts at 430 Mc/s (70 cm). The limit of operation is about 13 cm.

The makers are Mullard Electronic Products, Century House, Shaftesbury Avenue, London, W.C.2.

Cabinet Loudspeakers

A SERIES of loudspeakers mounted in acoustically matched vented cabinets has been developed recently by "Phase-In" Speakers, 99, Ash Bank, Bucknall, Stoke-on-Trent. A special feature is the provision of vertical plywood strips in front of the loudspeaker aperture to diffuse the h.f. beam horizontally.

The "Junior" model is supplied with the Wharfedale "Golden" or the type W10/CSB unit at £13 13s or £16 16s and measures 30in × 15in × 12in. In the "Senior" model the width is increased to 17in and the driving units supplied are the Barker 148A, Goodmans Axiom 12 or 22, or the Wharfedale W12/CS, the prices being £28 7s, £21, £25 4s and £19 19s respectively. Finally there is the "Twin" model containing the Wharfedale W10/CSB and W12/CS units with a cross-over network centred on 1,000 c/s. This loudspeaker costs £30 9s and is housed in a cabinet measuring 36in × 18in × 14in. All models have a nominal input impedance of 15 ohms.

Electronic Instruments' Model 25 laboratory valve voltmeter. The meter scale length is six inches and an anti-parallax mirror is provided.

Precision Valve Voltmeter

DESIGNED to give a performance comparable with that of British Standard Specification BS89:1937 for first-grade moving-coil meters, the Model 26 laboratory valve voltmeter made by Electronic Instruments, 17, Paradise Road, Richmond, Surrey, has an accuracy better than ±1 per cent of full scale on all but the two lowest a.c. ranges (where the maximum error does not exceed 2½ per cent), and a stability of 0.7 per cent on d.c. and 0.8 per cent on a.c. ranges over a 24-hour period after warming-up.

Two double-stage d.c. amplifiers are coupled back-to-back to form a balanced bridge network and heavy negative feedback is applied over the whole system; individual range adjustment is effected by incremental variation of feedback. The power supply, which is derived from a.c. mains is stabilized by a constant-voltage transformer. Power consumption is 30 watts.

For high-frequency measurements a probe is provided and is housed in a compartment with a curved hinged flap. Terminals are also provided for low-frequency work, but when these are used the input capacitance is increased from 6 to 30pF.

There are six ranges for both a.c. and d.c. with full-scale readings of 1, 2½, 10, 25, 100 and 250 volts; resistances between 500Ω and 500MΩ can also be read in four overlapping ranges. The price is £88.

(Left) Bulgin car ignition suppressors to combat interference to television and to radio reception on vehicles.

(Bottom left) Mullard disc seal e.h.f. triode type ME1003, for use up to about 2,300 Mc/s (13 cm).

(Below) Junior and Twin "Phase-In" loudspeakers.