Wireless World

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Broadcasting Monopoly

ALTHOUGH the B.B.C.'s charter does not expire until the end of next year, it seems highly probable that long before then the basic constitution of British broadcasting will be hotly discussed. The report of the Beveridge Committee, which will have an important influence on the ultimate fate of the B.B.C., will presumably add fuel to the fire. Broadcasting is now the "big business" side of radio, and nobody in any other branch is entirely unaffected by its prosperity or otherwise.

We imagine that few of our readers wish to see any violently disruptive changes, but equally, most of them will have ideas on how the fundamental control of broadcasting might be changed for the better. Much food for thought—and ammunition for discussion—on the organizational side of the matter is to be found in a new book, "British Broadcasting: A Study in Monopoly," by R. H. Coase,* and described as an historical study of the monopolistic organization of broadcasting in Great Britain. This is a severely factual study; the author comes to no conclusions, but implicit in the book is the underlying idea that he does not think the present monopoly is a good thing, or, perhaps more fairly stated, that he regards the case for monopoly as not proven.

Mr. Coase (and a good many other people) do not seem fully to realize that broadcasting—and, for that matter, all forms of radio communication—is to some extent a natural monopoly, just like the supply of water or gas. Broadcasting in the U.S.A. is generally cited as the antithesis of monopoly, but could one have a more perfect example of a local monopolist than the occupant of an exclusive channel? It is all a matter of degree; some frequency channels, such as those in the e.h.f. bands, constitute small and strictly local monopolies at all times, while the right to use other channels in the h.f. bands confers an almost world-wide monopoly at certain times. Broadcasting in a vast country like the U.S.A. can in the nature of things be organized on a less monopolistic basis than in a compact area like Great Britain. We can limit the monopoly of channel licensees by such artifices as reduction of transmitter power, directional aerials, or even time-sharing, but what is granted to them still remains a monopoly. Let us avoid catchwords, especially those with a political significance, in thinking of these matters.

This criticism is not intended to decry the great value of Mr. Coase's book, which has obviously been compiled with great care and is fully documented. The historical chapters constitute what is probably the most complete account yet published of the growth of our present system. The arguments produced for and against the monopoly are set out in detail, while the author's commentary in the last chapter will provoke thought and discussion. Wire broadcasting and foreign commercial broadcasting are treated at some length.

So much for Mr. Coase's excellent book, which shows how thoroughly the question of broadcasting reform has already been debated during almost a quarter of a century. Will any new proposals be brought forward before the B.B.C. Charter becomes due for renewal? Among the many suggestions made, some have been for a system intended to introduce competition in programmes, and to these *Wireless World* has always turned an attentive ear. A re-examination of such proposals after a long lapse of time gives the impression they lack an air of reality, but it may be that there is a new factor. If we do, in fact, want strongly competitive programmes, might not a licence to broadcast on e.h.f. be given to an entirely independent organization—or, for that matter, to a number of organizations? When the experimental transmitter at Wrotham has completed its tests, the vexed question of a.m. *versus* f.m. will be decided, and the time will be ripe for starting a national service on metre waves.

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* A London School of Economics publication, issued by Longmans, Green and Company, price 12s 6d.

Intermodulation Distortion

A Simplified Method of Measurement Not Requiring a Harmonic Analyser

By THOMAS RODDAM

DOES distortion really matter? How much distortion can we allow? These are regular topics of discussion in the high-fidelity audio world, but the discussion is nearly always limited to questions of harmonic distortion. It has always seemed to me to be very difficult to explain why the note of, say, a clarinet should be affected by a little on-linearity in the amplifier. After all, the reed mechanism which produces the note is not a linear device by any means, and the non-linearity is not closely controlled. Surely all that distortion can do is to make one clarinet sound like a different one, and so on through the orchestra. Except, of course, for the ocarina, which you can look up in Grove's "Dictionary of Music," and which produces a pure tone, and which will sound like a flute if you add harmonics. The piano is another special case, because of the compromises which are involved in the fixed temperament. In addition the piano, from our point of view, is not really a single instrument, because it can be, and usually is, used for producing more than one note at a time. The ordinary instrument, like the flute or the fiddle, however, produces enough harmonics for the odd 1 per cent more or less to be unimportant, and at first sight it would seem that those energetic gentlemen who go down to 0.1 per cent are carried away by the idea of linearity for linearity's sake.

It would be very pleasant if this were true: it isn't. The "member of the indigenous population of a tropical region in the concentration of fuel"—the nigger in the wood-pile—is intermodulation. In a nice old-fashioned amplifier, without feedback, the intermodulation and the harmonic distortion are related in a fairly simple way, so that either can be used as a measure of the goodness of an amplifier. Feedback makes the situation more complex, however, and the proper thing to do is to measure the intermodulation. First of all we shall see why intermodulation is a serious problem, why it makes an audio-frequency system have a "muddy" quality.

Nature of Intermodulation

For the purposes of this discussion we shall consider that we have two instruments, a double-bass and a flute, playing together with equal levels. The double-bass is booming away at 50 c/s, with its harmonics at 100 c/s, 150 c/s, 200 c/s and so on: in the diagram of Fig 1 the harmonics are shown up to 300 c/s. The amplitudes are chosen rather arbitrarily, and they suit the figure rather than the double-bass: I have not checked the actual distribution, and indeed I rather wish I had chosen the organ, to avoid argument. The flute has a fundamental of 1,000 c/s, and I have drawn harmonics up to the sixth.

When we listen with a not-too-good reproducing system to the sounds produced by this combination we shall observe that if either instrument plays by itself the effect is quite satisfactory: the sort of distortion assumed is 5–10 per cent. When both instruments are playing together, the flute takes on a harsh quality, losing the characteristic liquid tone. This harshness persists even if we put a filter in the loudspeaker leads, cutting off all frequencies below, say, 800 c/s, and thus eliminating all the sounds produced by the double-bass. A frequency analyser provides us with the reason: Fig 1 shows the sort of result we shall obtain. In addition to the expected frequencies, which are shown by the solid lines, we find a set of intermodulation products, shown by the dotted lines. These appear as a cluster of side-bands round each of the flute tones, and the most important group is that having frequencies $(1{,}000 \pm 50\,n)$c/s. In particular, the flute fundamental of 1,000 c/s is accompanied by 950 c/s and 1,050 c/s, corresponding to an amplitude modulation of the 1,000 c/s by the double-bass 50 c/s. This modulation gives a "dirty," thick tone; when we have an orchestra, the vast complex mass of intermodulation tones produces a complete confusion of the sound, so that the separate groups of instruments can no longer be distinguished.

The amount of intermodulation for a given non-linearity is not too difficult to calculate. It is, however, of particular interest to see what happens when we are using a lot of negative feedback. Up to the overload point the amplifier is then linear, for all practical purposes. The distortion is down in the 0.1 per cent region, and it is getting rather difficult to measure. As we increase the level above the overload point the distortion curve starts to rise quite sharply, and if we look at the output for a sinusoidal input we see something like the solid curve in Fig 2 (a). Most of the sine wave is reproduced perfectly, but the tips are chopped off by the overloading action. We cannot do anything about this by adding more feedback; in the overload region the output voltage is constant, while the input moves along the peak part of the curve. The *instantaneous* gain is therefore zero, so that the reduction of distortion by feedback, the factor $(1 + \mu\beta)$, is simply unity, no matter how big we make β.

Suppose that in Fig 2 (a) the frequency is 50 c/s, and that we add a relatively low level of about 500 c/s. In Fig 2 (b) we see the resulting waveform, and in this figure the level of the 500 c/s is about 12 db below that of the 50 c/s. The dotted part of the curve shows the signal which has been lost due to the overloading. We can get the same overall effect if we add to the undistorted signal the rather curious signal shown in Fig. 2 (c). This is the distortion signal, using distortion in its most general sense. The ear will perceive the two tones, 50 c/s and 500 c/s, and in addition the "buzz" shown in

Fig 2 (c), which consists of short bursts of 500 c/s every 1/100th of a second. This is then the intermodulation distortion.

One reason why we are sometimes led very much astray by ordinary harmonic distortion measurements is our habit of measuring at 400 c/s or 1,000 c/s. True, the harmonics of 400 c/s are easily heard, and it is a nice easy frequency for measurement purposes. At lower frequencies, however, new troubles arise in the amplifier, even before we add feedback. The output transformer distortion is roughly inversely proportional to frequency, so that at 40 c/s it is ten times as great as at 400 c/s. The screen decoupling circuits in pentode stages sometimes start to fall in efficiency, and this can produce distortion for reasons which are outside our present scope. It all adds up to this, though: the amplifier, before feedback is added, will produce more distortion at low frequencies.

With feedback there is a new trouble. Knowing that feedback improves the frequency response we may be tempted to cut the coupling capacitors and the transformer inductance; the gain without feedback may be much lower at the edges of the working band than in the middle. We do this at the top, too, using higher anode resistances than we should, and allowing stray capacitances to mount up to dangerous values. We put on our 20 db of feedback, in the middle of the band, and overlook the fact that at 40 c/s and 5,000 c/s the gain has fallen, say, 10 db and we only have 10 db of feedback. Distortion, instead of being reduced to one-tenth, is only reduced to one-third, and we have more distortion at 40 c/s anyway. But we have a good frequency response: we have good distortion figures at 400 c/s; and it still doesn't sound right. Perhaps we should measure the intermodulation.

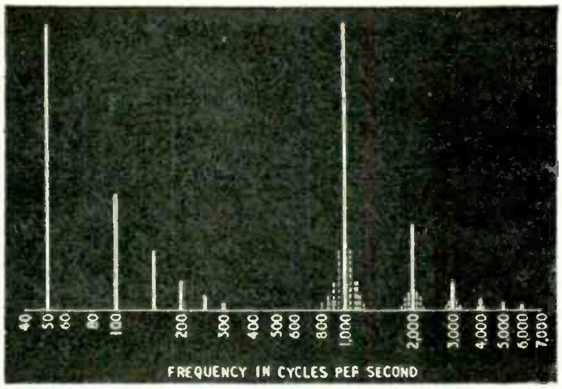


Fig. 1. Two musical instruments, producing fundamental frequencies 50c/s and 1,000c/s, and the harmonics of these frequencies, sound harsh because of the intermodulation products (shown dotted).

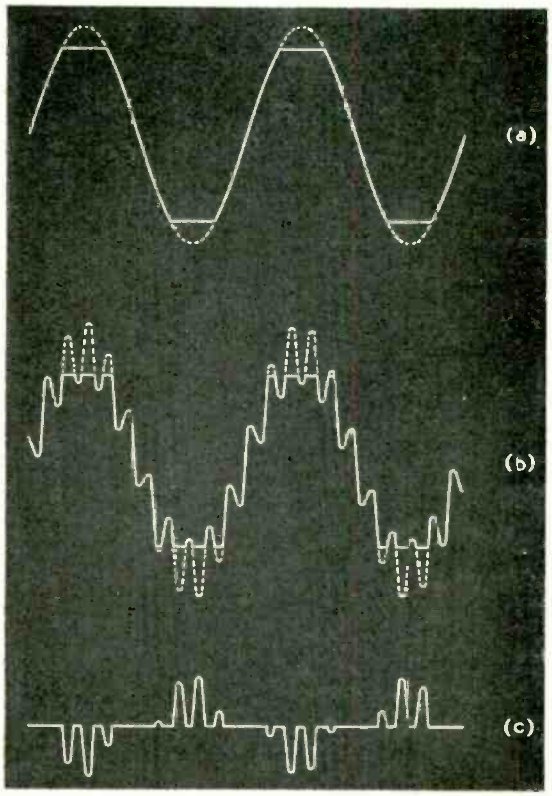
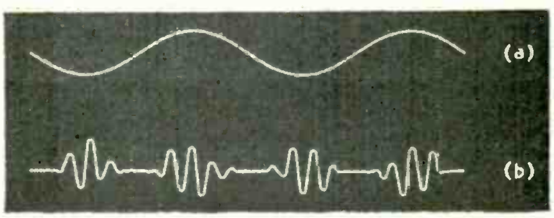


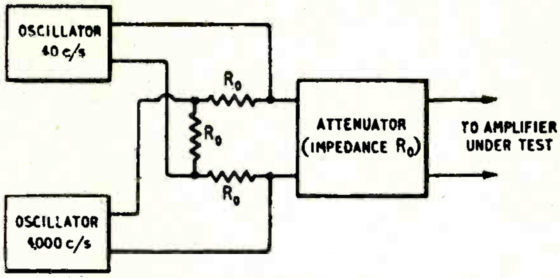
Fig. 2. When an amplifier is overloaded by a low frequency (a), the presence of a high frequency (b) results in a false signal which can be represented as (c)

Fig. 3. Approximate components into which the waveform shown in Fig 2(c) can be resolved.



Alternative Methods

The first and most obvious method of measurement is to use the selective valve voltmeter, or wave analyser, to measure the components shown in Fig. 1. Of course we shall only put in two pure tones, and fairly good values to choose are 40 c/s and 4,000 c/s, with the amplitude of the 40c/s either 12db or 20db above the level of the 4,000c/s. It is unfortunate that there is no generally agreed standard for this measurement but there is no generally agreed annoyance level either. When more people get down to this sort of test we shall have more knowledge of what is permissible. Anyway, using the wave analyser we can measure the amount of 3,960c/s, and of 4,040c/s, which should be the same, and take this as a measure of the intermodulation. The wave analyser is not a cheap instrument, and it is certainly not one which can be rigged up easily. In practice, too, I find it rather tedious to use. For intermodulation testing we can find a rather more convenient technique. Let us look again at Fig. 2(c). Rounding off the corners we see that it shows a waveform which is approximately the same as the sum of the two waveforms shown in Fig. 3. One, Fig. 3(a), is a term of the low-frequency component, possibly accompanied by some harmonics which will not concern us: the other, Fig. 3(c), is a term consisting of the high-frequency component modulated more than 100 per cent by the low-frequency component. If we call the two frequencies f_l and f_h, the intermodulation terms we shall try to measure are of frequencies $(f_h \pm nf_l)$ where n is 1, 2, 3, etc.



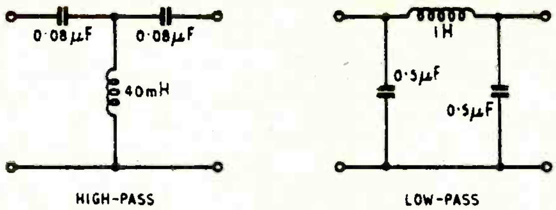
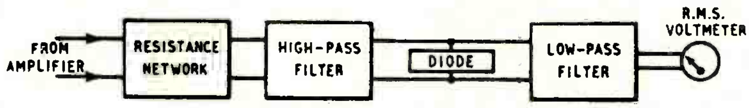


Fig. 6. Filter circuits for 1,000-ohm impedance.

Fig. 4. Resistance hybrid circuit for applying two oscillators with balanced output to a single amplifier.

Fig. 5 (right). Block diagram of intermodulation test set, output side.



We shall neglect $(mf_h \pm nf_1)$, the terms round the harmonics of f_h.

On the input side of the system we need, of course, two oscillators, one for the 40c/s and one for the 4,000c/s. We must combine the signals from these, and the safest thing to do is to use the circuit of Fig. 4. This makes use of what is called a resistance hybrid, which is a balanced bridge circuit. The oscillators must be provided with output transformers to prevent earths appearing in the wrong places, and as the two oscillators are connected to the two diagonals of the bridge there is no interaction between the oscillators. When the amplifier has a high input impedance the attenuator may be replaced by a potentiometer of resistance R_0, the tapping point going off to the grid. One point of the circuit may be earthed. No serious error will be caused if we use oscillators which produce 1-2 per cent harmonics, so that resistance-capacitance oscillators can be used without filters, and we have something to set against the cost of two oscillators instead of the one needed for harmonic measurement.

Output Circuit

The measuring side is rather more difficult. The amplifier output consists of the two fundamental terms, 40 c/s and 4,000 c/s, the harmonics of these, 80 c/s, 120 c/s, 160 c/s, etc., and 8,000 c/s, 12,000 c/s, etc., as well as the important intermodulation terms which we want to measure. First of all, let us get rid of the 40 c/s and its harmonics. By using a high-pass filter with a cut-off at 2,000 c/s we can be certain that a very simple filter will get rid of all traces of the 40 c/s: a rough calculation shows that a single section should produce 60db attenuation at 200 c/s and more than 100db at 40 c/s. The output of this filter consists of the 4,000 c/s, slightly modulated by the 40 c/s and its harmonics. We can treat this as a modulated signal from which we want to remove the modulation, the ordinary problem of the final detector in a receiver. A diode rectifies the 4,000 c/s carrier, and the modulation is extracted by means of a low-pass filter, which stops 4,000 c/s but allows harmonics of 40 c/s to pass. The output of this filter is made up of the intermodulation products.

Fig. 5 shows the general arrangement : the resistance network provides a good load for the amplifier under test, in case the output valve does not like working into the rather variable impedance presented by the filter. If used for power amplifiers, with an output level of some watts, there is no need to incorporate transformers, but the filters can be built with impedances of the order of 1,000 ohms. This gives a reasonable input to the diode, which can, however, by linearized by resistances or bias : it is not necessary to do this, because the actual modulation depth should be very low indeed. The final meter will probably need a single stage of amplification before it if a normal type of metal-rectifier meter is used. Measurements at lower levels demand that the high-pass filter should be followed by a step-up transformer, which will drive the diode reasonably hard.

The switching arrangements have not been shown in Fig. 5. The output meter should be connected so that it can be switched to read the amplifier output, and also the output level across the diode. This second measurement is mainly to take account of any transformer which we have included in the circuit. To determine the intermodulation we apply, at first separately, the 40 c/s and 4,000 c/s tones, using the output meter on the amplifier output to set the levels. Conveniently we can set the 4,000 c/s at 12db below the 40 c/s level. Then we read the level of 4,000 c/s appearing across the output of the high-pass filter, and the level of intermodulation products at the output of the low-pass filter. The ratio of these last two measurements, and the other two levels, define the behaviour of the amplifier.

It will be noted that there are no sharply-tuned circuits in this system, so that the same equipment can be used for tests at low frequencies up to about 100 c/s, and high frequencies down to 2,500 c/s.

The values of the filter elements for an impedance of 1,000 ohms are shown in Fig. 6. When other impedances are to be used, all inductances must be multiplied by R, the impedance in kilohms, and all capacitances divided by R. The filters are not very critical, because the frequencies to be stopped lie a long way from the pass band, and the frequencies to be passed are well away from the cut-off.

Listening Tests

Intermodulation measurements will provide a pretty rude shock to some high-quality enthusiasts. Expressing intermodulation distortion as the ratio of unwanted terms to the high-frequency (4,000 c/s), which is 12db down on a 400 c/s low frequency (not 40 c/s, which we have used) it is claimed that a trained observer cannot detect less than 10 per cent. This corresponds to something like 2-3 per cent of harmonic distortion. There is not a great deal of information about this, and my own guess is that 10 per cent is too much for good quality reproduction of orchestral music. What we need, however, is a thorough series of co-ordinated listening tests and measurements.

APPENDIX

The mathematics of the two kinds of distortion

Suppose that the relation between input and output voltage in an amplifier is expressed by the equation

$$v_0 = a\,v_1 + bv_1^2 + cv_1^3 \;. \;. \;.$$

where v_0 is the output voltage, and

v_1 is the input voltage.

For a single tone input

$$v_1 = A \sin \omega t$$

$$v_0 = A\,[a \sin \omega t + bA\sin^2\omega t + cA^2\sin^3\omega t + \ldots]$$

$$= A\,[a \sin \omega t + \tfrac{1}{2}bA\,(1 - \cos 2\omega t) + \tfrac{1}{4}\,cA^2\,(3 \sin \omega t - \sin 3\,\omega t) + \ldots]$$

We therefore have a second harmonic term $-\frac{bA}{2}\cos 2\omega t$

and a third harmonic term $\frac{cA^2}{4}\sin 3\omega t$

So long as cA^2 is not too large, the harmonic distortion is

second harmonic $\frac{bA}{2a} \,.\, 100\%$

third harmonic $\frac{cA^2}{4a} \,.\, 100\%$, and so on.

For two tones

$$v_1 = A \sin \omega_1 t + B \sin \omega_2 t$$

$$v_0 = a(A \sin \omega_1 t + B \sin \omega_2 t) + b\,(A \sin \omega_1 t + B \sin \omega_2 t)^2 + \ldots$$

$$= a\,(A \sin \omega_1 t + B \sin \omega_2 t) + A^2 b \sin^2 \omega_1 t + B^2 b \sin^2 \omega_2 t + 2ABb \sin \omega_1 t \sin \omega_2 t + \ldots$$

The last term can be written

$$2ABb \sin \omega_1 t \sin \omega_2 t = ABb\,[\cos\,(\omega_1 - \omega_2)t - \cos\,(\omega_1 + \omega_2)t]$$

This is the major intermodulation term in our discussion above, and defining the intermodulation as the ratio of this term to the amplitude of the higher frequency we can proceed, considering at first only one sideband. The ratio of the cos $(\omega_1 - \omega_2)t$ term to the fundamental is

$$ABb/aA = Bb/a.$$

The presence of two sidebands increases this figure by $\sqrt{2}$, because we must add on a root-mean-square basis. The total intermodulation distortion is therefore $(\sqrt{2}b/a)B$, compared with the figure of $(b/2a)A$ for the second-harmonic distortion. For second-order terms the intermodulation distortion is therefore 2.8 times the harmonic distortion. Higher-order terms can be computed, and it will be found that the ratio is greater: in practice values of about 3.5 to 4 are observed.

NEW BOOK

Elements of Sound Recording. By John G. Frayne and Halley Wolfe. Pp. 674 + xii; 483 illustrations. John Wiley & Sons, Inc., and Chapman & Hall, Ltd., 37, Essex Street, London, W.C.2. Price in U.K. £3 8s.

THIS book is based on a series of U.S. Government wartime training courses at the University of California. The authors, both of the Electrical Research Products Division of the Western Electric Company, have revised and expanded their material to produce this text-book.

Whilst bearing a resemblance to the 1938 volume "Motion Picture Sound Engineering," the scope of this new work is greater, and it collates a mass of useful information scattered throughout the literature on every aspect of sound recording and reproduction, although the concentration of attention on film recording and reproduction remains.

The first five chapters deal with fundamentals; e.g., sound waves and their perception, electrical, acoustical and mechanical analogues, thermionic valves and amplifiers. Chapters 6 to 10 cover network theory, including design data for attenuators, filters, equalizers, compressors and limiters.

The principles of disc recording and processing are treated in chapters 13 and 14, and chapter 29 deals with magnetic recording, both in theory and practice. Chapters 15 to 28 are devoted to clear expositions of variable-area and variable-density film recording, and the latest developments of these techniques, including noise-reduction methods. Two chapters discuss the important intermodulation test methods and flutter measurements, and an excellent chapter covers film processing. Film reproducing systems, both 35 mm and 16 mm, are described, with separate sections on loud-speaker arrays and studio/theatre acoustics. The last chapter discusses multi-channel reproduction and the problems and possibilities of stereophonic recording.

The treatment is not highly mathematical, and helpful numerical examples are included. Mathematical analyses have been restricted to cases where they are essential for a complete understanding of the subject.

Another most important part of this treatise is the bibliography at the end of each chapter, which enables the reader to explore the topics further.

This book is well printed and illustrated and is remarkably free from errors; it can be thorough recommended to the advanced student and professional sound technician. D. W. A.

Padding Inductor

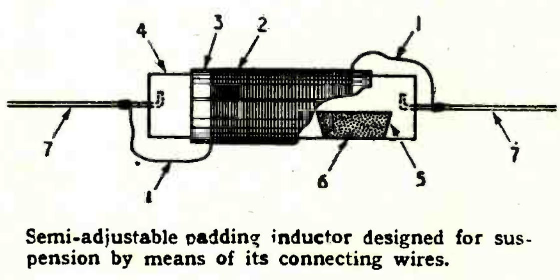
THE production of radio and similar apparatus having a neat and tidy appearance is facilitated if as many as possible of the smaller circuit components are mounted by suspending them by their own lead-in wires, either directly in the wiring or between spaced parallel bars of insulating material. Thus, it is of value to be able to extend the method which is used for supporting resistors and capacitors to small coils and chokes. A variable padding inductor which may be mounted in the manner described is shown in the accompanying sketch and described below.

The conductor (1) is wound into a coil (2) upon a sleeve (3) of insulating material. The sleeve is made so that it can slide on the former (4), which is recessed to receive a slug of magnetic material (6). The magnetic material may be of any shape and it may pass through the centre of the former instead of at the edge. It is only necessary that it should lie approximately at one end of the former. In the illustration, the magnetic slug completely fills the slot (5) and is keyed thereto by the sloping side walls.

The sleeve (3) carrying the coil is adjusted in position by sliding it along, in order to produce the required value of inductance, and it is then fixed to the former by an adhesive or by other means. The lead-in wires (7) and the magnetic material for the slug may be moulded into the coil former.

One great advantage of this arrangement is that the inductances may be accurately adjusted before they are fitted or they may, alternately, be adjusted *in situ*.

O. S. P.



Semi-adjustable padding inductor designed for suspension by means of its connecting wires.

Interference from Television Receivers

Some Experiments Show How Sound Broadcast Sets are Affected by the Line-Scanning Equipment

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

NOW that television receivers are being installed on an increasingly large scale, it is necessary to give them serious consideration as sources of interference with broadcast and other receivers. Complaints so far seem to have been few, but there is reason to expect that they might increase even more rapidly than the growth of television reception, unless precautions are taken.

The first step is to understand the nature of the interference. It consists of a series of carrier waves spaced at intervals of 10.125 kc/s, which strongly suggests that they are harmonics of the line-scan generator. That this is, in fact, the cause can easily be demonstrated by moving the "Line Hold" control, preferably when reception is cut off (so as to remove synchronizing signals). The frequency of the interference varies directly with the line frequency.

As one would expect, the interference is most noticeable on the long-wave band, but at close quarters it is detectable all over the medium-wave band, and even on short waves. The interfering harmonics being so closely spaced, one of them is bound to be within 5.063 kc/s of any frequency to which the receiver is tuned, and therefore liable to cause an audible beat note with all programmes. Whether or not it actually is audible depends only on the intensity of the interference relative to that of the signal.

For example, the 20th harmonic of 10.125 kc/s is 202.5 kc/s, which gives a 2.5-kc/s beat note with the 200-kc/s Droitwich transmitter of the B.B.C. This beat frequency (which is near the frequency of maximum hearing sensitivity) is unaffected by adjustment of the listening receiver, and remains constant so long as the 50-c/s mains are accurately on frequency and the line-scan generator in the television receiver is synchronized. Most listeners who regularly make use of Droitwich either receive a strong signal from it or are at present outside the television service areas, and in general it is only when an indoor aerial is installed fairly close to a neighbour's television receiver that the interference is strong enough to be noticeable. Over most of the present television areas the medium-wave local stations yield quite a strong signal even on the usual "bit of wire," and the line-scan harmonics are weaker than on long waves, so that they are still less likely to be noticeable. The evidence to be brought forward presently will lead to the conclusion that all except local stations are more than likely to be interfered with if a television receiver is located within a few yards of the aerial; and the absence of complaint goes to support the belief that there is very little distant-station listening, or that there are already so many heterodynes in the broadcast bands that a few dozen more excite little comment.

Preliminary Tests

Before bringing forward the experimental results, it may be as well to clarify the subject of interference fields, because much of the literature on the subject is misleading. In particular, interference is commonly described as "radiated," whereas in most cases, such as that now being considered, radiation is of negligible importance. Within a radius of $\lambda/2\pi$ from the source, induction fields predominate; and at 200 kc/s the distance $\lambda/2\pi$ works out at 240 metres, or about 260 yards. Even at 1,500 kc/s it is 35 yards. Experiment shows that perceptible interference from television receivers is well within these ranges, and it can therefore be regarded as due entirely to induction fields. Although, of course, an electric or a magnetic field is the same however it is propagated, the importance of making the foregoing distinction lies in the fact that a radiated field necessarily consists equally of magnetic and electric constituents, whereas induction fields can be mainly one or the other, or a mixture in any proportion. Therefore, when measuring the field strength at a distance from the source greater than a wavelength, the response of either a coil or a vertical aerial will (if properly carried out and calculated) give the same answer; but at close quarters the results picked up by a coil are no indication of the electric field strength.

The most likely part of a television receiver to set up an external magnetic field is the line deflection-coil unit. Ideally, the whole energy of the field is concentrated where it is required—across the neck of the c.r. tube—and the return path has zero reluctance. This ideal is, of course, unattainable, and in practice a considerable proportion of the total field energy is in the return path, and may spread far outside the coil, especially if no iron is provided. The iron yoke, which is normal practice to-day,* reduces the interference from this source, as well as increasing the power efficiency of the system; but as will be seen later it certainly does not eliminate the interference.

For sources of electric field one looks at those parts of the line-scan circuit at high voltage, especially if they are widely spaced. The systems that have recently been coming into general use for generating the anode voltage for the c.r. tube from the line fly-

* For details see W. T. Cocking, "Deflector Coil Characteristics," *Wireless World*, March 1950.

back circuit tend to increase the field on both counts; the voltage is stepped up to 5 kV or more, and there are more high-voltage parts tacked on to the line-scan circuit proper. Some of these are almost unavoidably spaced well away from the chassis and other low-potential parts, and they set up a strong external field.

In some preliminary tests to obtain a general idea of the extent of the interference, two television receivers were used. One, which will hereafter be denoted by T1, was a pre-war model with conventional thyratron time-base generators and rectified 50-c/s e.h.t. The other (T2) was a typical modern table model with flyback e.h.t. The broadcast receivers were: R1, a "fixed" table model with either indoor or outdoor aerial; and R2, a mains/battery portable. The location was on the edge of S.E. London.

It was first of all established that the interference was coming direct from the television sets themselves and not perceptibly via the mains or the coaxial aerial feeder. No appreciable difference resulted on changing over from battery to mains connection; and the interference increased rapidly as the television set was approached.

Quite clearly, too, T2 caused substantially more interference than T1. And whereas the whistles from T1 were pure, those from T2 were perceptibly modulated by a 50-c/s pulse; in fact, within a few feet this modulation was audible even without a carrier wave to act as beat oscillator.

Tuned to 200 kc/s (Droitwich), R2 emitted a whistle only when within about 5 ft of T1, but up to about 15 ft of T2. Reception of Droitwich on R1, used with a few feet of aerial wire hung up haphazardly, was interfered with practically anywhere in the house. Used with a good inverted-L type of outdoor aerial at the side of the house farthest from T2, interference was negligible.

On medium waves, there was no perceptible interference when tuned to either of the local stations (Brookmans Park at about 25 miles) with either receiver, unless the aerial was in the same room as T2. Most other stations were accompanied by a whistle, with the receiver anywhere in the house.

Interference in the region of 8 Mc/s was detected when the indoor aerial of R1 was brought within a few feet of T2.

Situation of Receivers

Since in flats and attached houses it is possible for a receiver to be within a few feet, or even inches, of a neighbour's television set, the likelihood of severe interference can certainly not be ignored. In most cases there should be no difficulty in overcoming the matter amicably and with little trouble by shifting one or both of the receivers, and taking particular care to keep the sound-broadcast aerial as far as possible from the television set. Present and prospective television transmitters are so sited that most of the receivers are likely to be installed in places where the Home and Light programmes are obtainable at over-riding strength without any elaborate anti-interference measures. It is in the exceptional circumstances where there are television receivers in places farthest from the nearest Home and Light stations, or where listeners want Third Programme or other relatively weak stations, that trouble is likely to arise If the listener can be persuaded to erect a proper outdoor aerial with screened downlead, most of it may be overcome. But the need for minimizing the interference at its source will obviously need attention.

Magnetic Interference Field

With a view to studying this side of it, some further experiments were carried out. An important factor is the rate at which the induction fields fall off as the distance from the source increases. Many of the books state that the strength of the induction field is inversely proportional to the square of the distance, without making it unmistakably clear that this applies only to certain particular kinds of source, such as isolated "current elements" (which, seeing that they have no return path, are of theoretical interest only), or approximately to those whose size is comparable with one wavelength. In the present case, however, the source of the magnetic field can be regarded as a coil with dimensions small compared with the distance at which the interference is detected and very small compared with λ. And the source of electric field can be regarded as two alternating opposite charges separated by a similar small dimension. On these assumptions, it can be shown that the field falls off inversely as the cube of the distance.

Experimental confirmation of this fact, as regards the magnetic field, was obtained by means of the apparatus indicated in Fig. 1, where L_1 is a screened coil as defined in the R.M.A. Receiver Testing Specification of 1936 for the purpose of setting up a standard magnetic field for testing receivers having frame aerials. It is provided with a screen to neutralize any external electric field. L_2 is a search coil, connected to a receiver provided with a beat oscillator, used for comparing the interference from the television receiver T2 with the known field from L_1.

Initially L_1 and L_2 were placed coaxially, and it was noted at the outset that turning L_2 about a vertical axis yielded a figure-8 response diagram, with clearly defined nulls when its axis was at right angles to that of L_1. With T2 as source, however, the polar diagram was a cardioid, owing to the fact that no special precautions were taken to exclude "vertical effect" (electric pick-up) in L_2. This comparison demonstrated the absence of electric field from L_1 and its presence around T2. A simple form of earthed screen round L_2 and its connecting leads eliminated response to the electric field from T2 and changed the cardioid into a figure-8. The screens around L_1 and L_2 were, of course, arranged so as to

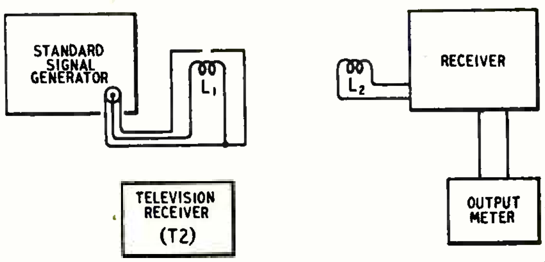


Fig. 1. Outline of apparatus used for measuring magnetic field strength in the neighbourhood of a television receiver. A comparison method is employed.

present no closed loops that could modify the magnetic field.

The signal voltage which had to be set up across L_1 in order to give a constant beat-frequency output from the receiver was plotted against distance (between centres of coils) over a range of about 50 to 85 cm, and on log paper the points marked out a straight line whose slope was 3.0, indicating the cube law to a surprising degree of accuracy considering that extreme precision was not attempted. The correction for the radius of L_1 (5 cm) was ignored; it would hardly be appreciable beyond about 25 cm. The experiment was repeated with both L_1 and L_2 turned through 90°, so that their axes were parallel, with nearly the same result.

These and all other quantitative tests were carried out at about 190 kc/s, corresponding to the 19th harmonic from T2.

With the axis of the search coil pointing towards the deflecting coils in T2, the response was a maximum from back and front of the set, almost zero from the sides, and moderate from top and bottom. Some comparative results at a distance of 2½ feet are shown in the following Table:—

Position of television receiver	Axis of search coil—		
	Horizontal and—		Vertical
	pointing towards source	parallel to source	
Back or front facing search coil.	12½–13 db	2 db	6 db
Side facing search coil.	–1 db	5½ db	4 db
On its side, with top or bottom facing search coil.	8 db	2½ db	0 db

Maximum response was obtained from the back, with the axis of the search coil inclined at about 30° to the horizontal. This is rather surprising, as from the design of the deflecting-coil system one would have expected the field to be vertical; and, of course, it would be advantageous for it to be so, as pick-up by frame aerials in the same horizontal plane would then be at a minimum.

Frame-aerial sets are not likely to be much used in close proximity to television sets, and in any case can easily be moved away from the most intense zone of interference, or orientated to cut it out; so the magnetic interference field is not likely to be a major nuisance. This is just as well, for a substantial reduction, beyond that obtained under the incentive of deflection power efficiency, would probably be troublesome and expensive to achieve. The deflection-coil system—possibly including the transformer—might have to be totally enclosed in mumetal or a thicker gauge of some other metal.

On the basis of measurements at a distance of about 2½ feet in the horizontal plane containing the deflection coils, and assuming the inverse-cube law, Fig. 2 shows the horizontal component of magnetic-field strength at the back of this particular television receiver. Sets using the core type of deflection coil would probably be slightly worse, and open (air-core) coils much worse.

The electric-field strength is not quite so easy to measure. Some idea was obtained by means of the simple apparatus shown in Fig. 3. The pick-up device was a vertical rod 3 feet high. C was adjusted so that the capacitance added to the receiver tuning coil was the same in both positions of the switch S. All except the aerial was more or less screened. The receiver was first tuned to give an audible beat note with the 19th harmonic from T2 picked up by the rod at a measured distance; then, with the switch moved to B, the unmodulated signal from the generator was adjusted to give the same output. The signal microvoltage required was then regarded as equal to that picked up by the rod.

Electric Interference Field

The main source of electric interference field was quite clearly the line-scan output valve and e.h.t. rectifier, with their high-potential connections; and by far the greatest intensity came from the back of the set. This was no doubt due to the layout of components in the set and to deliberate and fortuitous internal screening; the front, too, was largely screened by the graphite coating on the 12-in c.r. tube. Both electric and magnetic fields were thus strongest in the direction most likely to interfere with neighbours when the set is placed against a party wall—a point that designers should consider.

Measurements were taken at several distances along the line of maximum electric interference in the horizontal plane. Without knowing the effective height of the rod aerial one cannot convert these figures into field strength, but by calculation the effective height of such an aerial should be about half its actual height. On this assumption, the readings were used to give the electric-field-strength line shown dotted in Fig. 2. Although the readings appeared to be appreciably influenced by wires and other topographical features of the laboratory, the few data obtained conform reasonably well to the inverse-cube law; and the electric field at this frequency (192.375 kc/s) appears to be slightly stronger than the magnetic field.

It is reasonable to expect a good standard of broadcast reception on medium and long waves with field strengths down to 1 mV/m. Since it is generally accepted that for high-quality broadcast reception the strength of interference should be at least 40 db below that of the desired signal, it should not exceed 10 μV/m. On the basis of the results recorded in Fig. 2, the distance at which interference is reduced to this level is found to be about 40 feet, which agrees quite well with the listening tests and confirms the conclusion that a typical modern television receiver can cause objectionable interference to neighbours.

The set used had a considerable amount of internal screening around the sides, top and bottom which was obviously provided to reduce interference. The effect of removing this screening was tried and it was found to increase the field strength (measured at 7¾ feet distance) by a factor of 4.7. On the other hand, supplementing the screening by a very crude wire screen at the back reduced it to 0.36; and experiments with pieces of metal foil left little doubt that a further substantial reduction could be obtained by continuing the screening by means of such foil across the back, even without blocking the ventilation slots.

It may be of interest to consider the harmonic

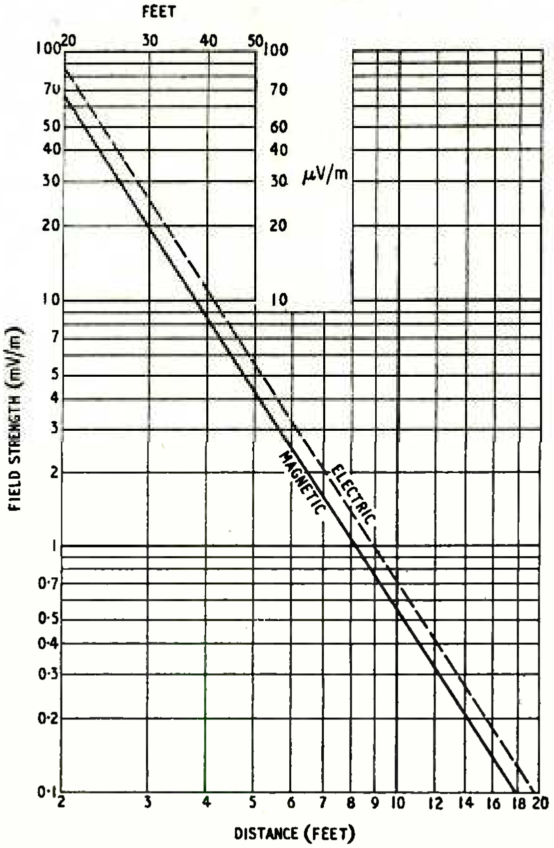


Fig. 2. The continuous line indicates the magnetic field, and the dotted line the electric field, from a typical television receiver, measured along the direction of maximum strength in the horizontal plane. For ease of comparison, magnetic field strength is given in terms of the equivalent radiated-field strength.

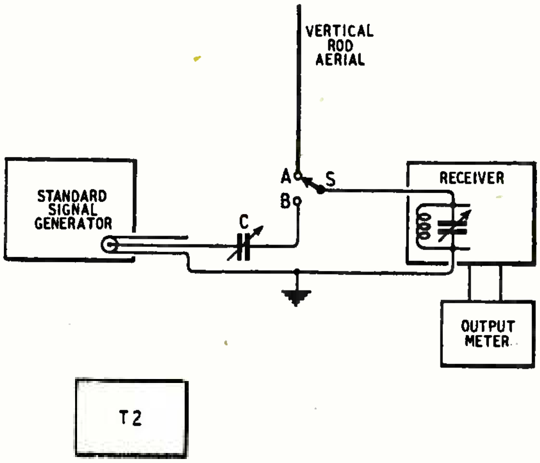


Fig. 3. Outline of apparatus used for measuring electric field strength in the vicinity of a television receiver.

structure of a perfect sawtooth waveform. The relative amplitude of the harmonics varies in two ways with the order of the harmonic, usually denoted by n. Basically it is proportional to $1/n^2$; but there is another factor, which can have any value from 0 to 1, being $\sin k\pi n$, where k is the fraction of the wave occupied by the forward stroke, namely, 0.84 in the line scan. There is not much point in computing it for the higher harmonics, because the results vary greatly with slight variations in k, and in any case the actual deflecting-current waveform, which is responsible for the magnetic interference field, is not ideal. The tendency is for the higher harmonics to be attenuated by series impedances and shunt admittances; on the other hand, particular harmonics are liable to be accentuated by resonance conditions in the circuits, or by flyback transients.

The electric field has, of course, the same waveform as the disturbing voltage, and this approximates to sinusoidal half-cycles during the flyback period, separated by relatively constant periods during the scanning strokes. The analysis of such a wave is extremely complex, but basically its harmonic amplitudes are proportional to $1/n$. At the higher frequencies, therefore, the strength of the electric interference may be expected to fall off less rapidly than the magnetic-field strength.

If the system of spot-wobble described by R W. Hallows* comes into use, it will introduce a further potential source of interference—the 10-Mc/s oscillator. This high frequency is radiated very readily, so care will have to be taken to screen the whole system adequately, including the deflection coils.

Summing up: The line-scanning system in television receivers is a source of both magnetic and electric interference fields. The magnetic field tends to be reduced by the present trend of design, but would probably be difficult to reduce much more; fortunately it chiefly affects portable receivers, which are in the minority and can be moved out of the interference. The electric field tends to be increased by the trend of design, and may be very serious; it does not, however, seem unduly costly or awkward to reduce it very substantially by simple screening, but the back should not be overlooked. When this has been done, the normal precautions for avoiding interference, by moving the aerial away from the affected zone, should in most cases clear the remaining trouble.

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

Guide to the Ionosphere

"SHORT-WAVE Radio and the Ionosphere" is a new edition of a book published by *Wireless World* six years ago under the title of "Radio Waves and the Ionosphere." The author, T. W. Bennington, has now produced what is to all intents and purposes a new book which will be of value to all who are in any way concerned with long-distance communication on wavelengths of, very roughly, 10 to 100 metres.

The physical processes in short-wave propagation are simply explained without mathematics. The practical aim is always kept in mind, and the author shows how available data can be applied to solving everyday problems of short-wave transmission and reception.

"Short-Wave Radio and the Ionosphere" is issued by our publishers, Iliffe and Sons Ltd., Dorset House, Stamford Street, London, S.E.1, at 10s 6d (postage 2d).

Re-Shuffling Europe's Frequencies

The Introduction of the Copenhagen Broadcasting Plan

ALTHOUGH the Plan for the re-allocation of frequencies to Europe's 350-odd broadcasting stations was agreed upon by 25 of the 32 countries who participated in the Copenhagen Broadcasting Conference in 1948, it was not certain even at the beginning of March that it would be implemented on the 15th. However, most of the difficulties had been overcome by the appointed day.

The two major difficulties were the clearing of the 1,500-1,605-kc/s band of marine services in order that the medium-wave broadcasting band could be extended and the provision of frequencies for services which were not catered for in the Plan—such as "Airmet." Whilst the latter is a purely domestic problem, the first is an international one.

Before dealing with the implementation of the Broadcasting Plan, we should, perhaps, consider the problem of frequency re-allocation in the wider field. It will be recalled that the Atlantic City Conference of 1947 allocated the frequencies between 10 kc/s and 10,500 Mc/s to services on a regional basis. It was then necessary for further conferences to be held between countries within each region or zone to distribute the available frequencies to their broadcasting stations, marine services, etc. Two conferences were held at Copenhagen in 1948; the one already referred to and the Maritime Mobile Radio Service Conference.

It has been suggested by some that it would have been preferable to leave the re-allocation of broadcast frequencies until such times as the international situation was more settled, thereby ensuring a greater degree of conformity. Some consider that the post-war situation was not untenable, so why not leave well alone? The truth is that in this country we were far better off than most other countries on the Continent—largely due to our geographical position. Moreover, the medium-wave broadcast band was extended (525-1,605 kc/s instead of 550-1,500 kc/s), so it was only reasonable to make full use of it. It is worth noting, in passing, that the 1934 Lucerne Plan, which but for the war would have been superseded by the Montreux Plan in March, 1940, was still adhered to by the large majority of stations at the end of hostilities. There have, of course, been considerable changes in the last two or three years.

Great Britain's Share

So far as this country is concerned the Copenhagen Plan, even when all the operational problems have been ironed out, does not provide for an improved broadcasting service, as there is a general lowering of the wavelengths allocated to us. In considering the general effect of the broadcasting plan, it must be remembered that since the introduction of the Lucerne Plan, countries which then had but a few low-power stations now operate many transmitters of considerably increased power. Not only did these have to be accommodated but provision had to be made for still further stations for some of the "backward" countries—in all some 70 new transmitters are allocated frequencies.

Some criticisms have been levelled against the Plan because we in this country have to share wavelengths with other countries. As Sir Noel Ashbridge recently pointed out, our geographical position—on the edge of the zone—makes it essential that we share with the countries most remote from us. The dropping of one of the Third Programme wavelengths below 200 metres has called forth considerable comment. It is estimated by the industry that some 75 per cent of the receivers in use will not tune down to this wavelength of 194 metres (1,546 kc/s). The 3,000,000 post-war receivers do, of course, cover this end of the band. We are not alone in this matter—nearly every country is allocated a frequency in this band. The Conference was not unmindful of the difficulties, and in allocating the Vatican City 1,529 kc/s added the rider that it could operate on 1,484 kc/s until such time as receivers covering the higher frequency were in more general use.

Broadcasting authorities are, in the main, keeping to the frequencies allocated to them, although in some countries there have been exchanges of frequencies between stations. Luxembourg has, in the past, used 232 kc/s, although it was allocated 1,249 kc/s under the Lucerne Plan. It is continuing to use this frequency with a power of 150 kW as well as its Copenhagen allocation of 1,439 kc/s with a power of only 1 kW. A transmitter with the full permitted power of 150 kW is planned to come into operation next January.

Policing the Ether

Unfortunately there is no international organization which has the authority to act as "policeman of the ether" to ensure that all stations are law abiding. The recently constituted European Broadcasting Union—although at the moment including 21 countries among its members—will not be able to act officially in this capacity, as the Copenhagen convention stipulates that the "expert" organization to "supervise its effective and regular implementation" must be nominated by at least 28 of the 33 countries invited to the Copenhagen conference. The new Union will, however, be able to make use of its checking station at Brussels to keep a watching brief on the situation.

At the time of going to press a deadlock had been reached over the question of a frequency for the meteorological station "Airmet" at Daventry. The G.P.O. has been unable to find a frequency for the service in the broadcasting bands—it has been operating on a "borrowed" frequency (245 kc/s) since its introduction—as no provision was made for it at Copenhagen. Kalundborg is now using 245 kc/s.

Services which previously operated in the band into which broadcasting has been extended (1,500 to 1,605 kc/s) are moving out. What is known in this country as the maritime "local services"—lighthouses and lightships—are moving from this band to the 1,850-1,865-kc/s band. The change will, however, have to be gradual owing to the difficulties of supplying new crystals for the stations.

The Copenhagen Maritime Convention provides for the transfer of the direction-finding frequency from 375 kc/s to 410 kc/s. The W.T. distress and calling frequency remains on 500 kc/s, but it is recommended that the radiotelephone distress frequency should be changed from 1,650 kc/s to 2,182 kc/s. This is unlikely to be introduced for some time. In conformity with the Maritime Convention, a number of the G.P.O. coast stations have changed their "mobile services" frequencies. The complete list is: Burnham, 476 kc/s; Cullercoats, 484; Land's End, 438 and 522; Niton, 464; Portpatrick, 472; Stonehaven, 458; Wick, 432; Humber, 441; N. Foreland, 418; Seaforth, 447; Jersey and Guernsey, 516.

A complete list of the Copenhagen broadcasting frequencies was given in our November, 1948, issue, and a reprint is available from our Publisher, price 7½d., including postage. The allocations are also given, together with the pre-Copenhagen frequencies, both numerically and geographically, in the fifth edition of our booklet, "Guide to Broadcasting Stations," price 1s 6d.

SHORT-WAVE CONDITIONS

February in Retrospect : Forecast for April

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

DURING February, the average daytime maximum usable frequency for these latitudes remained about the same as during January, instead of increasing, as had been expected. The reason for this may have been the decrease in sunspot activity which occurred during the month. The night-time m.u.f. was considerably higher than during January, and should now continue to increase towards mid-summer.

Daytime working frequencies remained relatively high, though slightly lower than during January. U.S.A. stations working on frequencies between 29 and 35 Mc/s represent the highest frequencies for transatlantic propagation during the month, whilst the 28-Mc/s band was usable on most undisturbed days. 10 Mc/s was about the highest regularly usable night-time frequency.

Despite the presence of a giant sunspot during the month the average sunspot activity decreased considerably.

Though some severe ionospheric storms occurred towards the end of the month, February was not, on the whole, a very disturbed month. The most disturbed periods were 2nd-3rd, 7th-8th, 20th-22nd and 23rd-25th. Eight Dellinger fadeouts were reported during the month, the most severe being at 0610 on 15th and at 1010 on 21st.

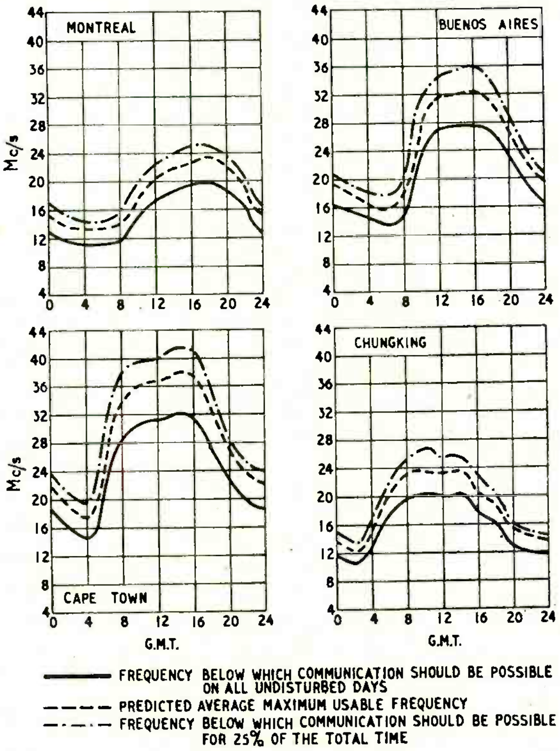
Forecast.—During April, daytime m.u.fs in these latitudes should undergo a considerable decrease, and this decrease should continue towards mid-summer. Night-time m.u.fs should continue to increase.

Daytime working frequencies should be considerably lower than during March on circuits running in east-west directions from this country, while on north-south circuits the decrease should be of a smaller order. It is unlikely that 28 Mc/s, for example, will be usable at any time over east-west circuits, though it should still be frequently usable to distant southerly points. At night, 11 Mc/s should remain usable the night through over most circuits. Daytime frequencies will, of course, remain operative for longer periods than during March.

Medium-distance communication is likely to be possible during the daytime on higher frequencies than during March, because of the fact that the E layer will control this type of transmission for several hours. Sporadic E transmission is not likely to be frequent.

A moderate amount of ionospheric disturbance is to be expected during April.

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



Unusual Ionospheric Storm

Effect of Giant Sunspot on 20th February

VERY early on 20th February a giant sunspot crossed the sun's central meridian and, presumably as a result of this occurrence, a severe ionospheric storm started during the evening of that day. Though this possessed the main characteristics usually associated with such storms, one or two of its effects were of a rather unusual nature.

It is generally thought that sunspots, when in an "active" state, emit a stream of corpuscles, and that some of these escape from the sun and travel out into space at a high velocity. The stream of corpuscles may be pictured as a conical-shaped jet, having the sunspot at its apex. The corpuscles are more likely to encounter the earth if they are shot out when the sunspot is near the sun's central meridian, as was the case on 20th February. On entering the earth's atmosphere they give rise to magnetic storms, ionospheric storms, auroral displays, and other phenomena.

The first sign of radio disturbance occurred at about 1745 G.M.T., when a peculiar "rumble" was noticed on the B.B.C. short-wave stations, and soon spread to European short-wave stations and then to more distant ones. This phenomenon, to which attention has previously been drawn[1], consists of a rhythmic beat, which causes a wavering note of low audio frequency to appear on the station under observation. It frequently is the first "radio" sign that an ionospheric storm is starting, and usually occurs only on stations which are within the skip zone of the observer. The exact mechanism of its occurrence is obscure.

By 1900 G.M.T. all the usual effects of an ionospheric storm were present, i.e., distant stations on the higher frequencies were weak or inaudible, rapid fading was present on lower ones and the F-layer measured critical frequencies soon became abnormally low. These effects persisted, in a greater or less degree, throughout the storm, which did not abate until early on 22nd February.

Reverting again to the evening of the 20th. At 1920 G.M.T. Leningrad v.h.f. station on 45.8 Mc/s and Stockholm on 41.934 Mc/s began to be strongly received in

[1] *Nature*, Vol. 157, p. 477, April 13th, 1946.

this country, and, incidentally, to cause some serious interference to the London television service. They continued to do so until after 2100 G.M.T. Meanwhile the Northern Lights had been observed in widespread parts of the country.

It has been observed, these many years past, that when ionospheric storms of such a severe type occur, the harmonics of northern European stations on very high frequencies are heard in this country, though this is the first time that interference to the television services has resulted. The phenomenon is almost certainly due to the production, by the action of the solar corpuscles, of the "auroral" type of Sporadic E. These highly ionised "clouds," lying within the E region somewhere to the northward, would become capable of propagating frequencies perhaps up to the order of 100 Mc/s. thus enabling v.h.f. stations to be heard far beyond their normal range.

A further unusual feature of this storm has been reported. At 2230 G.M.T. rapid fading was reported on the London Home Service. It is possible that this was caused by exceptional turbulences in the F layer, for a proportion of the energy being received, even at locations near the transmitter, might have been arriving by way of that layer.

T. W. B.

"High-Quality Reproduction"

Points from a Discourse before the British Sound Recording Association

IN a combined lecture-demonstration on February 24th, before the British Sound Recording Association, H. J. Leak gave his personal views on "High-Quality Reproduction—How to Achieve It."

Starting with a demonstration, he gave a comparison between the reproduction of a 5-piece orchestra in a neighbouring room through a high-quality microphone-amplifier-loudspeaker channel, and the same orchestra in the lecture hall a few moments later, playing the same music. After inviting the audience to discuss the results among themselves, Mr. Leak then proceeded to analyse the various elements of the circuit and to state his preferences where more than one solution presented itself.

On the subject of loudspeakers he thought that, with the possible exception of horn-loaded types, multiple units gave better results than single units for wide-range reproduction, and his preference was for direct radiators rather than horn-loading. Care was necessary in the choice of cross-over frequency and he was in favour of dividing filters of the constant-resistance type.

Many people were inclined to take amplifiers for granted, on the assumption that greater distortion was always to be found in the loudspeaker and other links in the chain. In Mr. Leak's opinion—and this was not challenged—the amplifier was always important, and small differences in non-linearity could be detected by ear in the presence of much larger distortions elsewhere.

Gramophone pickups should be designed to perform two equally important functions (1) faithful reproduction of the content of the record groove, and (2) preservation of the record and the stylus point. Small mass of moving parts was essential, and no more than the minimum downward pressure required for adequate tracing should be employed. Generally speaking, disc and stylus wear increased as the square of the weight on the point. The wear on sapphire styli was for this reason often excessive, and also because of poor selection of material and grinding. Tungsten carbide styli were also open to the objection that the surface often showed pitting as a result of imperfections in the sintering process by which they were formed. Diamond, on the other hand, was up to 200 times better than sapphire from the point of view of wear on itself, but just because of its hardness, special care in polishing was necessary if record wear was to be avoided. To get a good surface was a long and costly process, compared with which the cost of the diamond was negligible.

As regards the pickup movement, Mr. Leak's preference was for the moving-coil principle and for a coil of several turns rather than the single turn ribbon type, which he thought liable to hum pickup.

A top resonance in the pickup above 20 kc/s should be aimed at, and the l.f. resonance should be below 20 c/s. Large vertical compliance, as provided in many American designs, was liable to cause distortion owing to the translation of vertical into lateral movement. This had some bearing also on the problem of motor rumble.

Mr. Leak then played some records through his high-quality gear and contrasted the performance of records fresh from the press with those which had been played several hundred times.

Finally, a radio programme was reproduced and the effect of a sharply tuned whistle filter was demonstrated. In Mr. Leak's opinion a whistle filter was an essential part of any radio feeder unit.

A lively discussion followed in which the question of loudspeaker damping was one of the leading topics. It was generally agreed that it was not possible to have too much damping, but one speaker thought that there was little effect in reducing the electrical damping beyond a 10:1 ratio. For further improvement, control of the diaphragm itself by horn loading was essential.

In concluding the meeting, the chairman, Mr. W. S. Barrell, mentioned the importance of musical material in high-quality tests. When he himself wished to impress other people he played them Tchaikowski, but when judging other people's efforts he always insisted on Bartok!

"Williamson" Amplifier Booklet

SINCE it was first described in *Wireless World* in 1947, the "Williamson" amplifier has acquired a world-wide reputation for high-quality reproduction of records and radio programmes. Its 15-W power output is regarded as optimum for domestic use, while harmonic and intermodulation distortion is negligible.

All the information published on the amplifier, including subsequent modifications and additions in the way of auxiliary equipment (including pre-amplifiers, tone compensating circuits and a radio feeder unit) has now been collected into a booklet to be issued by our Publishers early in April at 3s 6d (postage 2d). The booklet gives, in effect, a complete specification for a general-purpose reproducer of a standard which will do more than justice to the best loudspeakers at present obtainable.

Murphy V150 Television Set

12-in Tube Table Model with Unusual Features

EVIDENCE that the design of television receivers is still far from being standardized is afforded by this set, for it has quite a number of unusual features in its circuit. It has, for instance, two signal-frequency stages and only one at intermediate frequency. Then the latter is reflexed to act also as a sync-pulse amplifier.

The circuit comprises basically a superheterodyne with two r.f. stages and a triode-hexode frequency-changer. The signal then splits into the sound and vision channels with one i.f. stage each. On the sound side this is followed by a diode detector, a diode noise limiter and a tetrode output stage. On vision the i.f. stage is followed by a diode detector and then by a v.f. stage with a diode noise limiter. Its output is fed to the grid of the c.r. tube with an RC coupling and a diode d.c. restorer.

An output is also taken from the cathode of the v.f. stage to a diode sync separator and thence back to the i.f. stage which, in addition to its main function, acts as a pulse amplifier.

It can do this without having to amplify two signals simultaneously as in the ordinary reflex arrangement, because the positive-going pulses applied to it from the sync separator occur when the i.f. input to it is zero and vice versa. This occurs because in the British television standards a sync pulse is transmitted by suppressing the carrier. The result is in this set that the i.f. valve handles the pulse output of the separator and the i.f. signal alternately in time sequence.

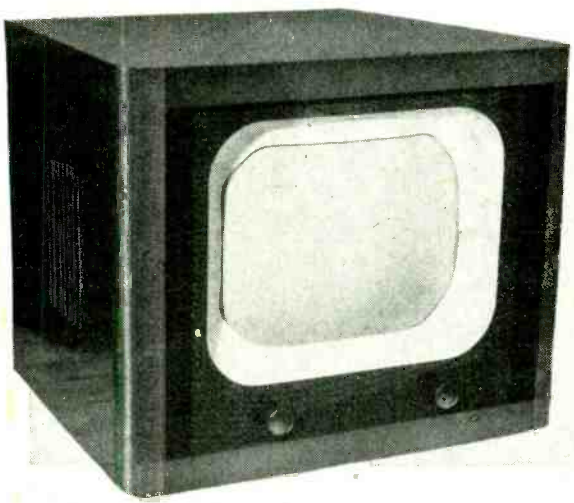
For the line time base a single-valve current generator is used, but for the frame there are two valves. One is a conventional blocking-oscillator voltage generator and the other a pentode output valve. E.H.T. is obtained from the line fly-back with the aid of a valve rectifier.

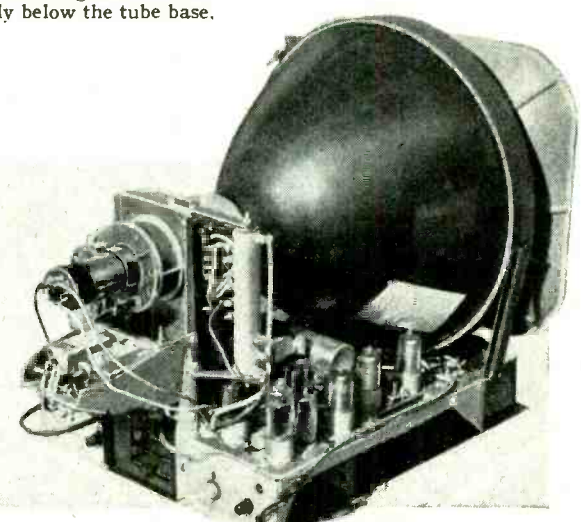
The power supply is obtained by the usual a.c./d.c. technique. The valve heaters are series connected and fed from the mains through a voltage-dropping resistor. A valve rectifier is used for the h.t. supply and acts as a half-wave rectifier. The set is, however, not suitable for d.c. supplies because the heater of the c.r. tube is fed through a transformer. The characteristics of a c.r. tube heater differ considerably from those of a valve, and it is not safe to connect it in series with the valves unless special precautions are taken. These often comprise the use of a thermistor and/or a thermal-delay switch to safeguard the tube heater. In this set the makers have preferred to use a small transformer and have accepted the consequent restriction of the set to a.c. supplies only.

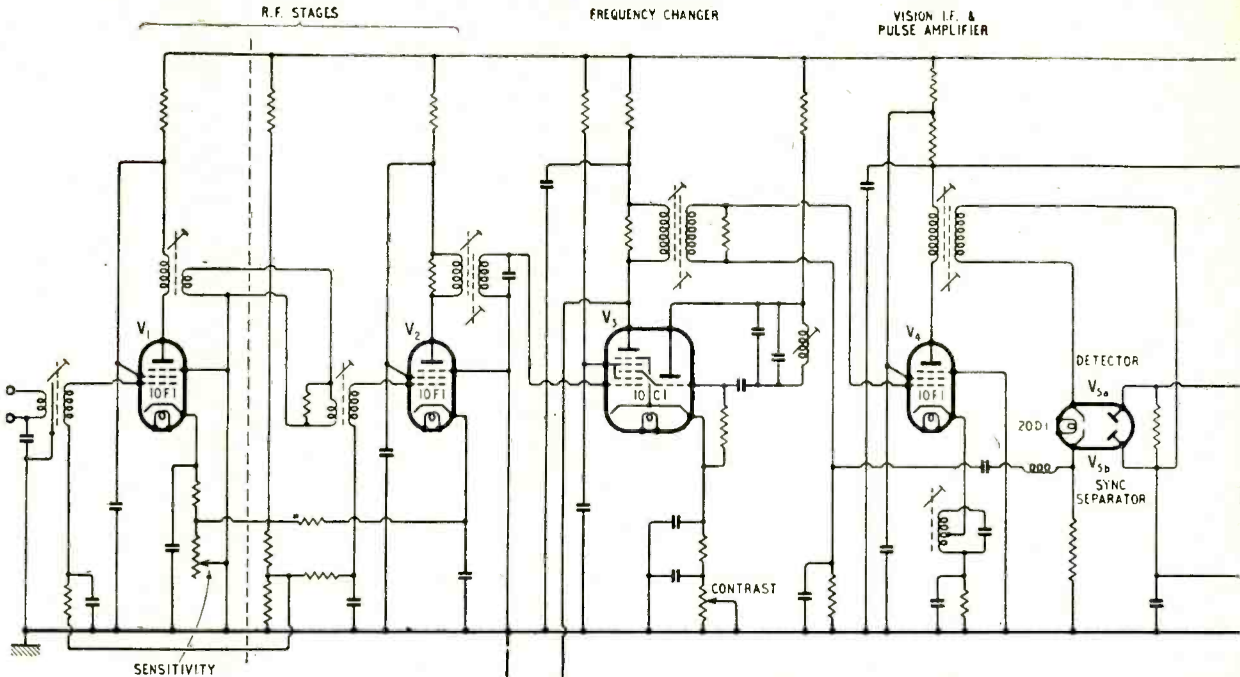
The tube is a 12-in type having a triode gun. It is mounted behind a safety glass panel and only two controls appear at the front. They are Contrast and Sound Volume, the on-off switch being combined with the latter.

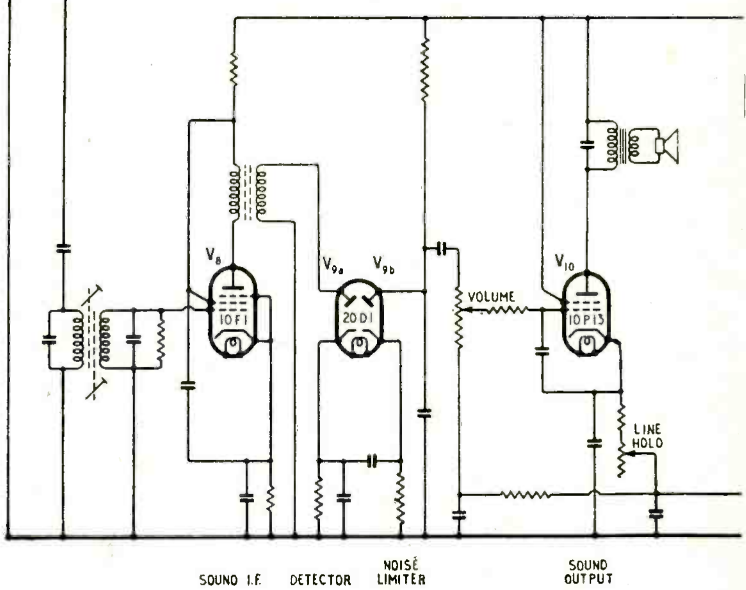
The other controls are at the rear. One is Brightness, and it is a knob-operated control. Frame Hold, Line Hold and Frame Amplitude (=Picture Height) are three sliding controls which can be locked in position by a turn of their knobs. The Vision Noise Limiter and Sensitivity Controls are screw-driver adjustable through holes in the back. Internally, there is a Frame Linearity Control and the perma-

Murphy V150 television set with 12-in tube and chassis view showing the r.f. side. The first r.f. stage is mounted as a sub-assembly immediately below the tube base.









nent magnet is adjustable by three screws for focus and picture centring. These internal controls are, of course, intended for adjustment by the dealer, not the user.

No continuous adjustment of picture width is provided, but a step control is arranged by means of a tapped deflector coil in conjunction with a series tapped choke.

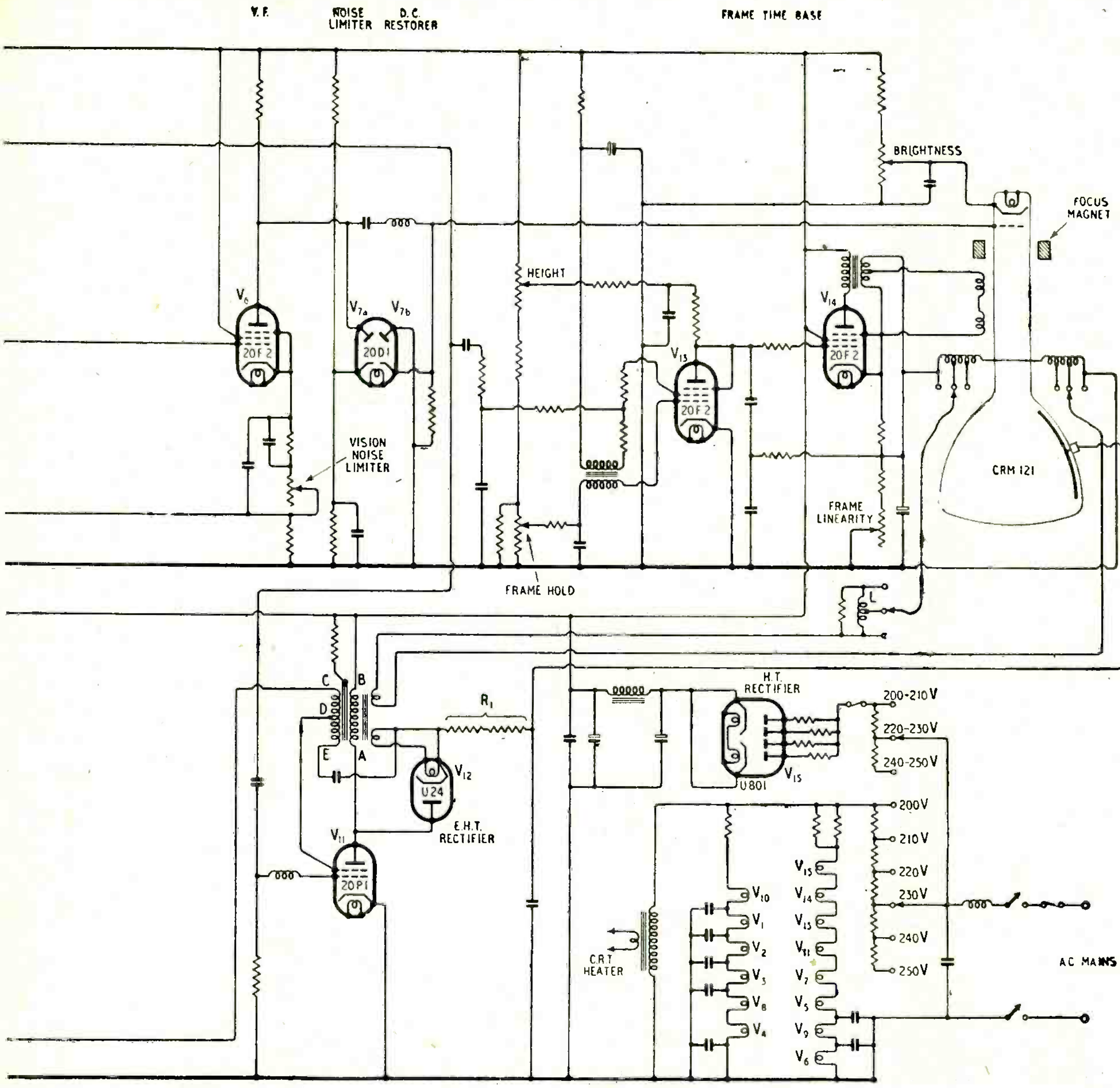
A wooden cabinet is used, the loudspeaker grille being on one side of it. With the exception of the loudspeaker, which is mounted on the cabinet, everything is contained on one chassis. The back is held on by six screws. The chassis is held by four screws under the cabinet, access to two of which necessitates the removal of a wooden batten held in place by three further screws. The chassis can then be drawn out, the loudspeaker leads are long enough for this to be done without unsoldering them.

The Frame Linearity, since it affects picture height as well as linearity, must be adjusted in conjunction with Frame Amplitude. The adjustment is very easy, however, and very good linearity is obtainable. The focus and picture centring adjustments are far from easy, for they are very interdependent. A good deal of experience is needed to obtain quickly a well-focused and properly positioned picture. However, the adjustments are stable and once the proper settings are found readjustment will probably be needed only at long intervals, for example when replacing the tube.

The Line Scan synchronizes well and locks rigidly. The frame scan does not lock nearly so solidly and the setting of the Frame Hold Control is more critical. The setting for good interlacing is very critical. The stability, however, is quite good, and once the control is properly set it should not need frequent readjustment.

The Sensitivity Control is a control of bias on the two r.f. stages and is pre-set by the dealer to suit the field strength existing in the district. The Contrast Control is a further gain control operating to vary the bias on the mixer. It is the panel control. It is somewhat unusual to have this as the main picture control with Brightness as a pre-set at the rear. The roles of these two controls are more commonly reversed.

The line-scan oscillator and e.h.t. circuits are unusual and interesting. A tetrode valve V_{11} is connected as an oscillator using the screen grid and anode as the operative electrodes, only the sync pulses being applied to the control grid. The anode winding is AB and the grid winding CD. The form is that of a Hartley oscillator but



Complete circuit diagram of the Murphy V 150, which contains many unconventional features (see text)

the constants are so chosen that there is a slow rise of current to form a substantially linear scan with a rapid fall for the fly-back.

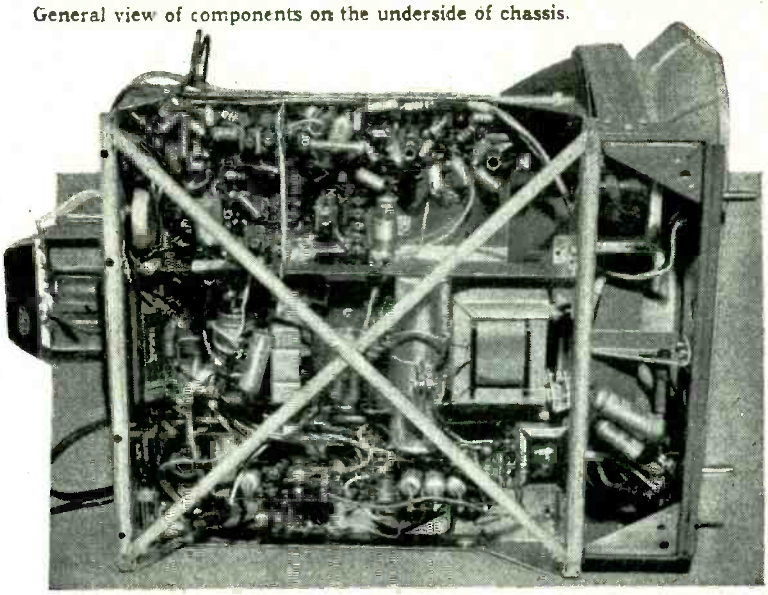
The deflector coils are tapped to form a picture-width control. A tapped coil L in series enables the total inductance on the transformer to be maintained constant for, as turns are reduced on the deflector coil, more turns can be introduced in the loading coil and vice versa. The free-running frequency of the time base is dependent on this total inductance and can be adjusted without much effect on picture width by adjusting the loading-coil turns only.

On fly-back, there is the usual positive pulse on the valve anode at A. There is also a negative pulse on the screen grid at D. This last is stepped up at E by the transformer action and the total voltage AE is applied through the rectifier V_{12} to C_1, which becomes charged nearly to the peak value. During the following scan stroke V_{12} is non-conductive and E is near earth potential, so that C_1 discharges through R_1 to provide the tube current and keep C_2 charged. In this way an e.h.t. supply of about 6 kV is obtained.

A peculiarity of the circuit is that the screen of the line-scan oscillator is fed from the cathode of the sound output stage V_{10}. This valve is really used as a screen-feed resistor, its cathode resistor forming the Line-Hold Control, and the purpose of this arrangement is to minimize the effect of mains-voltage variations on the frequency of the time-base. As the mean screen potential is close to earth nearly the full h.t. supply voltage appears across this stabilizing valve, and it can also be used for the output stage of the sound receiver.

The reflex arrangements are quite simple. The picture signal required at the detector output is negative-going and the sync pulses positive. The signal developed on the cathode of the v.f. stage is the same and is applied to the sync diode V5b which conducts only on the sync pulses. Its output of positive-going pulses is applied through a filter to the i.f. grid circuit. The output of the stage is developed across a resistor in the anode circuit and applied through a differentiator to the line time base and through an integrator to the frame time base.

General view of components on the underside of chassis.



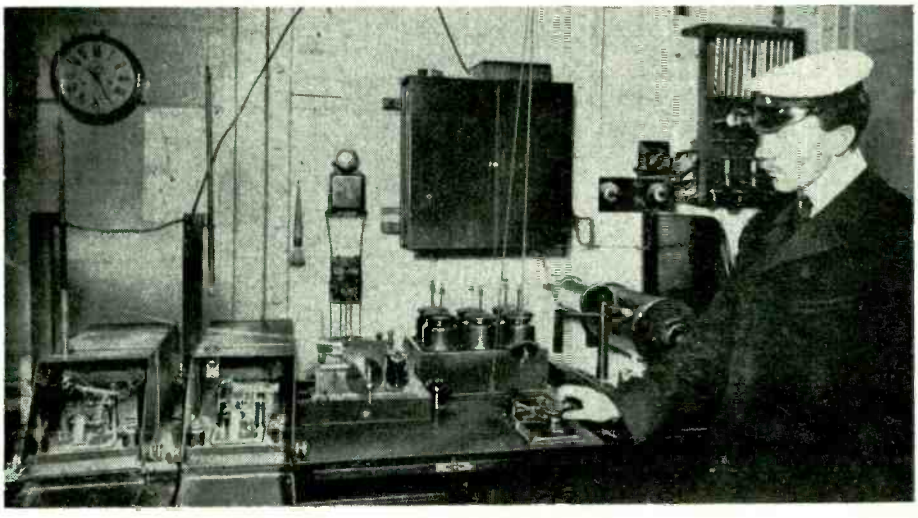
On test, the receiver gave a very satisfactory performance, the picture being bright and stable. The brightness is adequate for daylight viewing but naturally the best results are secured when the room lighting is at a minimum. The controls are, on the whole, easy to adjust, and stable enough for readjustment to be rather a rare occurrence. As already mentioned, the frame-hold control is very critical for good interlacing, and it is unlikely that the man-in-the-street will be able to set it properly. Once set, however, the interlace seems to hold well over long periods. The picture detail is good and the noise limiters function well. The wooden cabinet is 16¼-in high by 16⅝-in deep, plus a 3-in extension at the rear covering the tube base. The width is greater at the front than at the rear, being 18⅞in, as compared with 17⅜in. The set costs £54 including purchase tax, and is made by Murphy Radio, Welwyn Garden City, Herts.

MARINE RADIO JUBILEE

FIFTY years ago no British merchant ship was equipped with radio. When a ship left port she was lost sight of until she reached her first port of call. This continued until, on April 25, 1900, Marconi's Wireless Telegraph Co. formed a separate company—the Marconi International Marine Communication Co.—to cater for the radio needs of shipping.

The first ocean-going British merchant ship to be fitted with Marconi wireless telegraphy apparatus for everyday use was the *Lake Champlain*, in 1901. The installation, similar to that shown in the photograph, included a 10-in induction coil—working off a 12-volt accumulator, a coherer receiver and a morse inker. The operator on the first voyage recalled some of the incidents in an article in *Wireless World* some years later.

High-lights in the progress of marine radio—the first d.f. installation (1912) and the first marine radiotelephone (1920) —are recalled at the M.I.M.C. exhibition, about which details are given elsewhere in this issue, and in the book "Wireless at Sea—The First Fifty Years" (15s), by H. E Hancock, published by the company to mark the Jubilee.



EDWARDIAN MARINE RADIO: A Marconi installation fitted in a liner in 1904. The cord-and-pulley device, actuated from a lever on the manipulating key base, was for changing the aerial from transmitter to receiver.

Standard Frequency Transmissions

National and International Problems in Establishing a Service

By A. GRAHAM THOMSON

THE need for an international service of standard frequency transmissions is becoming increasingly evident and its possibility has been brought considerably nearer by the experimental service from the Rugby station, which was started on February 1st this year (see p. 99 of March issue).

It may be recalled that the National Physical Laboratory used to transmit a very small programme of standard frequencies. With its larger resources the U.S. National Bureau of Standards was able to give more frequent transmissions; moreover, the development of its service was not interrupted by the war and its station, WWV, in Washington now transmits standard frequencies continuously. The National Physical Laboratory, on the other hand, was obliged to discontinue its standard frequency transmissions when war broke out.

After the war the need for resuming this service was established by a committee under the chairmanship of Dr. R. L. Smith-Rose. Rather than set up a large transmitting station at Teddington, the General Post Office was asked to assume technical responsibility for the transmissions. The frequencies used by the Rugby transmitter for the experimental service are 60 kc/s and 5 and 10 Mc/s.

The essential requirements of a standard-frequency service are that the transmission should be steady, constant, and capable of being measured with extreme accuracy. Since the transmitting and receiving stations may be situated in different countries there must be world-wide agreement on standards.

World Coverage

At the international conference held in Atlantic City in 1947 it was agreed that certain frequencies be reserved for standard frequency transmissions, namely 2.5, 5, 10, 15, 20 and 25 Mc/s. The American service is operating continuously on all these frequencies and its transmissions are available as a standard of reference to anyone who can receive them, the accuracy being guaranteed to one part in 10 million. At a conservative estimate this service covers an area extending for not more than 2,000 miles round Washington. To supplement this service an experimental station is being operated by the Bureau on the Island of Maui, Hawaii. It operates on 5, 10 and 15 Mc/s with the call WWVH.

Although Washington's signals can often be received in Britain, its reception is not always satisfactory, so that British establishments cannot rely on this service.

The new British service was introduced after consultation with various Commonwealth countries, notably Australia, New Zealand, Canada and South Africa, and discussions took place on the possibility of setting up a network of standard frequency transmitting stations throughout the world. The British service is intended to cover the whole of Western Europe and North Africa, as well as a large section of the Atlantic Ocean where it is required for the calibration of ships' receivers and transmitters. It is expected that South Africa and Australia will each establish similar services in due course, though no up-to-date information is available as to the progress of their plans.

It will be recalled that, as an interim measure, in 1948 the Department of Scientific and Industrial Research issued a list of B.B.C. and Post Office stations which in the normal course work on frequencies which are known and kept very constant. (See *Wireless World*, September, 1948, p. 322.)

Mutual Interference

Since only six channels have been made available for the transmission of standard frequencies, countries operating services of this nature will often be transmitting on the same frequencies. Should two or more stations be transmitting simultaneously, listeners would probably be unable to identify the service which they were receiving, and a certain amount of mutual interference might also result. It might therefore become necessary at a future date to draw up an international time-sharing plan.

To ascertain whether any serious difficulties of this nature were likely to be encountered, the National Physical Laboratory agreed with the American Bureau of Standards that an attempt should be made to find out to what extent the transmissions from Rugby on 5 and 10 Mc/s interfered with the Washington services on the same frequencies. For example, in the middle of the Atlantic, half-way between Rugby and Washington, the signals might be approximately equal in strength. It has to be discovered whether this will cause any confusion to ships' receiving stations. For international exchange purposes the National Physical Laboratory will measure Washington's signals at Teddington, so that they can be directly compared with those transmitted from Rugby.

The measurement of frequencies can now be undertaken with an accuracy even greater than that which astronomers have achieved in the measurement of time. The method adopted consists in timing the beat resulting from the comparison, for example, of a frequency of a million cycles per second with another of one million and one cycles per second, the resulting beat being 1 c/s. This beat can be counted and measured very accurately, thus giving the difference to one part in a million without any complicated calculations.

In practice, the operator wishing to measure a frequency sets up his receiver, compares the frequency of the signal received with that of a local standard which is known very accurately, and measures the resulting beat.

Broadcasting in America

Will Television Oust "Sound"? : AM/FM Controversy : Programme Problems

FROM AN AMERICAN CORRESPONDENT

A TYPICAL comment of the average American family owning a television set is: "We never turn on our radio in the evenings any more—only sometimes during the day when there are no television programmes." How many such families are there? Industry sources estimate that at the end of last year 3,100,000 American families owned TV sets; 2.5 million of the sets having been sold in 1949. It is estimated that during this year sales will be 3.8 million. By 1954 it is anticipated that 19,100,000—or 42 per cent—American families will have television sets.

Only a few years ago television was a novelty; now its programmes reach 57 cities and serve many of the most concentrated markets in the U.S. Television, therefore, is already a serious threat to other forms of mass entertainment.

Sound broadcasting is losing its audience, especially during the evening when the biggest shows are on the air on both radio and TV. A few big national advertisers put their big programmes on sound and vision networks simultaneously. Some are considering the abandonment of radio in favour of television. The prevailing view in the industry and in the Government is that television will supplant radio as the dominant broadcasting medium within five years. Hundreds of the 2,800 or more broadcasting stations now operating in the United States are expected to go off the air within three years.

How Did This Condition Arise?

The pat answer is that the public is fed up with radio and has seized upon TV as having more appeal. To understand this, it must be realized that to the American public not "vested interest" is sacred. The moment it has served its purpose it will be discarded, and something new built up to take its place.

For many years, American radio has failed to build up any important new programme ideas, or develop any important new talent. The blame for this must be shared by both the networks and advertisers. Networks were reluctant to spend large sums over a long period of time to build up audiences for new programmes or talent. Similarly, advertising sponsors, when they buy a show or some outstanding talent, want an established audience—just like the guaranteed circulation of a publication. The net result is that the same big-name artists and the same type of show are featured year after year.

It looked for a time as if FM might save sound broadcasting. During the war, FM transmitter manufacturers bombarded AM stations with a high-pressure sales drive to "order your FM transmitter *now* and be first with FM after the war." Many AM stations fell for the argument, but defensively.

After the war, FM stations blossomed fast. Then the receiver manufacturers had to be persuaded—reluctantly—to produce FM and/or AM-FM receivers. For a time, the public caught on, and it looked as if FM might go places. This had AM stations and networks worried, for it was splitting their audience. They wanted to duplicate their programmes on both AM and FM. The musicians union said no. So the programmes for FM stations had to be provided separately—mostly with good music on transcriptions, a refreshing change.

A few regional FM networks, linked by coaxial cable and/or short-wave relays, made their appearance. It was then possible for FM listeners to realize the inherent quality of FM when live orchestras broadcast over the FM networks. But all this ended abruptly when the musicians' union lifted its ban on duplication. Immediately, FM stations began carrying the regular network programmes, which sounded no better over FM than they did over AM.

In any case, few receivers were capable of reproducing the full range of quality of which FM is capable. Few were equipped with automatic frequency control; so tuning an FM set was in most cases difficult to begin with, and then it had to be fiddled with as drift set in. The interference-free feature of FM carried little weight. There is little interference in the primary service area of an AM station. So public interest in FM died overnight. At a recent I.R.E. meeting in Syracuse, N.Y., the figures in the table were given which tell the story.

However, all is not well with TV broadcasters. Costs are terrific. It costs around $500,000, on the average, to build a television station—about five times the cost of the average radio station. Then programmes cost several times as much as radio shows. The average half-hour TV network show, to reach the still relatively small TV audience, costs an advertising sponsor as much as $14,000. Television networks also are expensive. A network as big as the present broadcasting networks would cost an estimated ten million dollars a year in rentals.

Receiver Sales—Dollar Volume Percentage.

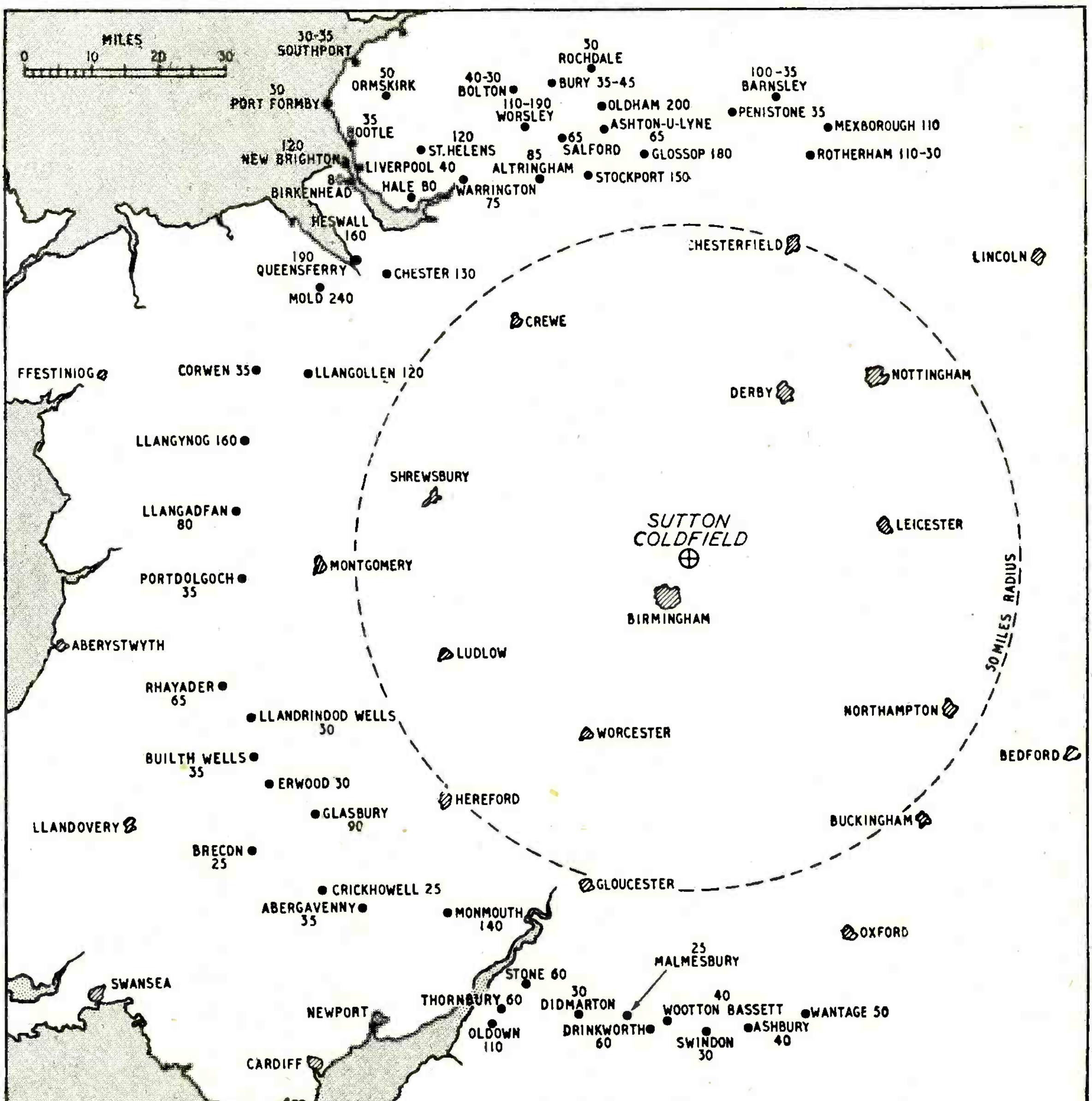
	1947	1948	1949
TV	8%	35%	80%
AM	76%	46%	12%
FM	16%	19%	8%

These high costs mean that the great majority of television broadcasters are incurring heavy losses. This brings up the question as to whether it will ever be possible to provide television facilities outside the big metropolitan areas. There are vast areas in the United States with very low population density, yet these people are clamouring to be served, and, in anticipation of TV, are not buying new broadcast receivers. But if television, like "sound" broadcasting, is to be supported wholly by advertising, the rates may be too high for the medium to be employed in any but concentrated market areas.

Fringe-Area Television *(Continued)*

More Measurements of Field Strength from Sutton Coldfield

THIS map presents data collected by Belling and Lee, Ltd., on the second half of a survey carried out on a radius of roughly 70 miles from the Midlands station at Sutton Coldfield. Readings obtained with a mobile field-strength measuring van on the first half of its tour were given in our last issue. Height of the four-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. 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. As might be expected, the greatest variations in strength shown on this map are in the hilly country of Wales. Remarkably good signals were recorded at Chester and in the surrounding area.



WORLD OF WIRELESS

International S-W Broadcasting ◆ Set-Makers' Report ◆ New European Union ◆ Television Frequencies

High-Frequency Broadcasting

ON April 1 the International High-Frequency Broadcasting Conference, which has the formidable task of allocating frequencies (between 3.5 and 27.5 Mc/s) to the world's short-wave broadcasting stations, opens in Florence. This country's delegation will include representatives from the G.P.O., B.B.C., and the Foreign Office.

Although the bands available for high-frequency broadcasting were allocated at the Atlantic City Conference in 1947, it remains for a plan to be drawn up allocating the available frequencies within those bands to the countries using, or desirous of using, short-wave broadcasting.

It was realized that the claims for channels—many times greater than the number available—could only be met by some stations using the same frequency on a time-sharing basis and others, suitably disposed geographically, sharing frequencies. A further point to be considered was that the usefulness of some frequencies depended on the sun-spot cycle.

At a conference held in Mexico from October, 1948 to April, 1949, and attended by representatives of 64 countries, a "basic plan" was drawn up for one phase of a sun-spot cycle on a time-sharing and channel-sharing principle. From this plan has been prepared, by a specially appointed Technical Plan Committee, a number of what are called derivative plans. These have been submitted to all countries participating in the conference for comment, and it is to consider these plans and comments that the Florence conference has been called.

It is interesting to note, in view of the forthcoming short-wave broadcasting conference, that the B.B.C. has advised the association that it intends to make the fullest possible use of the 21-26 Mc/s band, and has recommended that receivers intended for export should cover this in addition to the lower bands down to 3.5 Mc/s.

Various technical problems relating to standards for sound equipment have been examined during the year. One of them relates to the need for a method of making accurate and comparable acoustic measurements at a reasonable cost without resorting to the use of an expensive damped room or the free air method. Experiments on the use of acoustic ducts for testing loudspeaker units and microphones show that a degree of accuracy approaching that of a properly designed acoustically damped room are possible.

B.R.E.M.A. Report

WHILST a good deal of the 55-page report of the British Radio Equipment Manufacturers' Association is domestic, in that it concerns only the members of the association, there are a number of points of general interest.

In the section outlining the more important matters dealt with by the Technical Committee, reference is made to the problems involved in selecting preferred vision and sound i.f.s for television receivers in order to get the best results from the B.B.C. 5-channel scheme.

European Broadcasting

THE Torquay conference, attended by representatives of broadcasting organizations of 23 countries, saw the birth of the European Broadcasting Union and the demise of the International Broadcasting Union (U.I.R.) founded in 1925. The new Union includes among its members the broadcasting organizations of all the Western European countries and those of Egypt, Greece, Morocco and Tunis, Lebanon, Syria, Turkey and Yugoslavia.

Since 1946 there have been two international broadcasting organizations in Europe, neither of which had sufficient backing to act as the continent's mouthpiece in broadcasting matters. With the withdrawal of eleven countries from the International Broadcasting Organization (O.I.R.) last November, it has moved its headquarters from Brussels to Prague.

The wavelength checking station at Brussels, which was set up by the U.I.R. and taken over by the O.I.R. after the war, will come under the control of the new Union.

Television Topics

IT is understood that a decision has been made on the allocation of frequencies to the next two television transmitters to be completed. The North of England station at Holme Moss will operate on channel 2—vision 51.75 Mc/s, sound 48.25 Mc/s—and the Scottish transmitter at Larkhill on channel 3—vision 56.75 Mc/s, sound 53.25 Mc/s.

The change in picture aspect ratio from 5:4 to 4:3 announced in our last issue will be introduced by the B.B.C. on April 3rd. B R.E.M.A.

National Show

ALTHOUGH the Radio Industry Council had tentatively booked Olympia for a period in June in 1951-53 for the National Radio Exhibition, it has been decided that an autumn show is preferable. As it was impossible to secure a later date at Olympia, it has been decided to hold the shows at Earls Court in September.

The past sixteen radio shows (1926-39, 1947 and 1949) have been held at Olympia. The next exhibition, of course, will be at Castle Bromwich, Birmingham, from September 6 to 16, plans for which are

THE FIRST PRESIDENT of the European Broadcasting Union, Sir Ian Jacob, Director of Overseas Services, B.B.C. (centre), with, left to right, Sir Noel Ashbridge, F. C. McLean, H. Bishop and R. D. Marriott, B.B.C. delegates to the Torquay conference.

now well advanced. Provision is made for 122 stands, a television studio and a communal television demonstration room. Individual demonstrations of television will be permitted on the stands, but there will not be a radio-frequency distribution system for broadcast receivers as was used at Radiolympia last year.

Physical Society's Show

ADMISSION to the annual exhibition of scientific instruments and apparatus organized by the Physical Society—which is being held at the Imperial College, South Kensington, from March 31 to April 5—is by ticket, valid for a specified session (either morning or afternoon) available from the Society, 1, Lowther Gardens, London, S.W.7.

Among the papers to be given during the exhibition are "Colour Vision and Colour Television," by Dr. W. D. Wright, at 6.15 p.m. on April 3.

R.E.C.M.F. Exhibition

THE seventh exhibition, of components, valves, materials and test gear, organized by the Radio and Electronic Component Manufacturers' Federation, opens at Grosvenor House, Park Lane, London, W.1, on April 17th. Admission to the show, which will be open from 10 to 6 for three days, is restricted to holders of invitation cards issued by the R.E.C.M.F., 22, Surrey Street, London, W.C.2. There will be 103 exhibitors.

Television by Relay

THE first television relay service for an area, as distinct from blocks of flats, is being installed in Gloucester by Link Sound and Vision, Ltd., formed jointly by Pye and Murphy for the provision of such services in "fringe areas" of television stations.

The system comprises a master receiving station picking up programmes from Sutton Coldfield and redistributing them by wire to subscribers, who will also have the choice of four sound programmes. The charge—including the licence fee—is 7s 6d a week.

PERSONALITIES

Col. A. H. Read, O.B.E., has been appointed Director of Overseas Telecommunications (G.P.O.) in succession to H. Townsend who recently retired on his appointment as Assistant General Secretary of the International Telecommunication Union. Col. Read was G.P.O. Deputy Inspector of Wireless Telegraphy for fifteen years and Inspector for three years.

H. B. Rantzen, head of the Engineering Designs Department, B.B.C., has been appointed Director of Telecommunications Services with the United Nations. He is to take up his new duties in New York at the end of March after 20 years with the B.B.C.

John B. McMillan, M.A., B.Sc., who has been with E.M.I. Institutes since January, 1947, has been appointed to the new position of Director of College Studies with the Institute. Prior to joining E.M.I. he was with the R.A.F. Education Branch, where he specialized in teaching radio and radar.

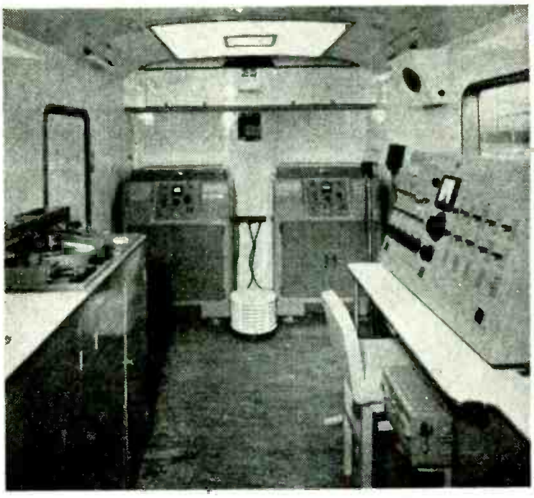
P. T. V. Page, B.Sc., has been appointed Director of Postal Studies with E.M.I. Institutes. He was for some time lecturer in electrical engineering at the Military College of Science, Bury, and subsequently became Officer Commanding, Heavy A.A. Workshop, R.E.M.E. (Canadian First Army) and later Technical Staff Officer on the German Control Commission.

H. G. Menage has left R. A. Rothermel, Ltd., and has joined the technical staff of E. Shipton & Co., Ltd., of Northwood Hills, Middlesex, where he is specializing in research and development work on Rochelle crystals.

E. R. A. Milne has joined the staff of Fielden (Electronics), Ltd., as sales manager and will operate from their new works at Paston Road, Wythenshawe, Manchester. He was previously northern area technical representative for the Everett Edgcumbe Co.

C. T. Nuttall, who for the past four years has been sales engineer in the Radio Division of T.C.C., has been appointed technical sales manager of British Mechanical Productions, Ltd., and the General Accessories Co., Ltd., who, respectively, manufacture and market Clix components. Prior to joining T.C.C. he was with the Gramophone Company.

B. A. Pettit, who has been with the British Radio Equipment Manufacturers' Association for about four years as a technical assistant, has joined Plessey's as technical representative in their sales organization.



INTERIOR of Radio Luxembourg's new mobile recording van supplied by E.M.I. The two magnetic-tape recorders are in the centre ; left, is the disc recorder and play-back desk ; and, right, the engineer's control panel.

IN BRIEF

South African Television.—Marconi's and Cinema Television are joining forces to present a television demonstration to visitors to the Rand Agricultural Show to be held in Johannesburg from April 1st to 10th. The demonstration, which is being organized in co-operation with the South African Broadcasting Corporation, will include projection television using a full-size cinema screen as well as reception on domestic Bush receivers.

A record monthly increase of 45,800 television licences in the United Kingdom was reached in January. This brought the total to 285,500 at the end of the month. There was a decrease of 17,400 in the number of "sound" licences in force. The total number of sound and vision licences was 12,209,700.

Exports.—Figures issued by the Board of Trade reveal that the number of domestic receivers exported last year was 295,036 compared with 308,224 and 406,508 in 1948 and 1947 respectively. The only countries to which the export of sets increased were South Africa, India, Malaya and Egypt. There was a reduction in the number of valves and cathode-ray tubes exported—5,197,831 compared with 5,623,637 the previous year. The 1947 figure, however, was 4,447,167. The value of transmitting equipment exported increased from £2,720,156 in 1948 to £3,150,656 last year. The 1947 figure was £1,441,962.

National Field Day.—The R.S.G.B. is organizing a National Field Day for the 24 hours from 1600 G.M.T. on June 3rd. Stations will operate in the 1.8, 3.5, 7 or 14Mc/s bands. The rules for the contest are given in the February issue of the *R.S.G.B. Bulletin*.

Electronic Control of industrial equipment will be covered by the paper on "Control of Electric Power and Sequence Flow in Material Handling," by J. O. Knowles, M.A., to be given during the convention which is to be held concurrently with the second Mechanical Handling Exhibition at Olympia from June 6th to 17th. The exhibition and convention are being organized by our associate journal *Mechanical Handling*.

Dutch Television.—It is understood that the experimental television transmissions which have been continuing for some months from the Philips station on 567 lines are in future to be radiated on 625 lines. A correspondent informs us that about 90 per cent of the 400-odd receivers in use in the Netherlands are amateur constructed.

Navigation.—An exhibition entitled "Navigation Through The Ages," prepared by the British Council in conjunction with the Institute of Navigation, opened in Oslo on March 15th. The exhibition, which closes on April 4th, includes photographs and diagrams of the Liverpool Harbour radar, a complete ship-borne radar installation and other radio-navigational aids.

McMichael Radio are exhibiting a 12-valve radiogramophone on the motor yacht *Northwind* which, with a display of British products on board, is leaving on March 30th for a three-month goodwill trade mission to some twelve Mediterranean ports including Tangier, Cyprus, Athens, Alexandria and Haifa.

Marconi Marine Jubilee.—A series of events has been arranged by the Marconi International Marine Communication Co. to mark the 50th anniversary of its formation—April 25th, 1900. An exhibition is being held at the Baltic Exchange, London, E.C., until April 4th. Admission is by invitation cards which have been supplied to shipping interests, societies and many manufacturers. The development of Marine wireless is depicted by replicas of ships' radio cabins for each decade from 1900. A luncheon for Marconi veterans has been arranged for April 1st.

Foire de Paris.—Some thirty of the 225 French radio manufacturers exhibiting at the Paris international trade fair (May 13th-29th) will be showing 819-line television receivers.

American Television Stations totalled 112 at the end of January. The pictorial list of tuning signals of 77 U.S. television stations recently published in *Radio-Electronics*, to which we referred in our February issue, was a little misleading. We commented on the fact that about 50% were purely pictorial giving no facility for receiver adjustment. We are informed that all U.S. stations transmit standard test patterns as well as a pictorial identification signal. The published list included a selection of both.

Argentina.—Two 100-kW medium-wave broadcasting transmitters have been ordered by the Argentine Government from Marconi's for installation at Gral Pacheco, some 15 miles from Buenos Aires.

Norway's most northerly broadcasting station at Vadso, Finnmark, which was destroyed during the German occupation, has been rebuilt and a 20-kW transmitter has been installed by Standard Telephones and Cables for the Norwegian broadcasting authorities. Since the end of the war a temporary 1-kW transmitter has been operating on 347 kc/s. The new transmitter is operating on 701 kc/s under the Copenhagen plan. Owing to its situation within the Arctic Circle, special attention had to be given to the thermal insulation of the building and the air from the valve-cooling plant is used to heat the building.

Tenders for the supply of a quantity of telecommunications equipment are being sought by the Greek Ministry of Posts, Telegraphs and Telephones. Among the purely radio items are:—equipment for radio links to the U.S.A. and the U.K. and for inter-island multichannel radio networks. The specification can be inspected at the Commercial Relations and Exports Department, Board of Trade, Room 1080, Thames House North, Millbank, London, S.W.1 (Reference CRE(IB)43996/50). Closing date for tenders is April 25th.

Decca Radar.—To enable demonstrations of equipment to be given and to provide instructional facilities for ships' officers, the Decca Navigator Co. has installed Decca ship's radar equipment on the Woodside Landing Stage, Birkenhead. The chairman of the company recently stated that it was proposed to form a separate company to handle the radar equipment.

Pickup Repairs.—We understand that Martin Slater Radio, 42, Broadwick Street, London, W.1, have stocks of spares and replacement parts for "Lexington" moving-coil pickups, and are in a position to undertake repairs.

"View Master" Pre-amplifier."—A constructional chart for an r.f. unit for addition to the "View Master" television receiver is now issued at 1s 1d by post from the office of the sponsors at 10, Norfolk Street, London, W.C.2.

R.F. Heating.—The correct title of L. Hartshorn's book reviewed on page 98 of our last month's issue is "Radio Frequency Heating." This error is particularly to be regretted, as "High Frequency Heating," the title incorrectly attributed to the book, is a needlessly vague and ambiguous description, all too widely used, that is deplored by *Wireless World*.

R.C.A.—The office of R.C.A. Photophone, which is an associate company of the Radio Corporation of America, has been transferred from 43, Berkeley Square, London, W.1, to 36, Woodstock Grove, Shepherd's Bush, London, W.12 (Tel.: Shepherd's Bush 1200). Information on R.C.A. radio equipment and valves is obtainable from this address.

Hazlehurst Designs, Ltd., have moved from 186, Brompton Road, London, S.W.3, to 34, Pottery Lane, London, W.11 (Tel.: Park 6955).

Aeradio.—The address of International Aeradio, Ltd., is 40 Park Street, London, W.1, and not Parker Street as stated last month.

MEETINGS

Institution of Electrical Engineers

Radio Section.—"A Review of Some Television Pick-up Tubes," by J. D. McGee, M.Sc., Ph.D., and "The Design of a Television Camera Channel for Use with the C.P.S. Emitron," by E. L. C. White, M.A., Ph.D., and M. G. Harker, B.Sc. (Eng.) on April 12th.

Discussion on "The Relation Between Production, Operation and Maintenance of Service Radio Equipment," opened by D. H. Hughes on April 24th.

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

Cambridge Radio Group. — "The Structure, Electrical Properties and Applications of the Barium-Titanate Class of Ceramic Materials," by Prof. Willis Jackson, D.Sc., D.Phil., at 8.15 on April 18th, at the Cavendish Laboratory.

North - Eastern Radio Group.—"Radar Automatic Tracking," by F. J. V. Ritson, B.Sc., at 6.15, on April 3rd, at King's College, Newcastle-on-Tyne.

Scottish Centre.—Faraday lecture on "Radar," by R. A. Smith, M.A., Ph.D., at 7.0 on April 18th, at the Royal Technical College, Glasgow.

South Midland Radio Group.—"Energy Conversion Devices for Electrical and Electronic Measurement of Non-Electrical Quantities," by J. C. Finlay, at 6.0 on April 27th, at the James Watt Memorial Institute, Great Charles Street, Birmingham.

British Institution of Radio Engineers

London.—"U.H.F. Propagation and Characteristics," by D. W. Heightman, at 6.30 on April 20th, at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

West Midlands Section. — "Intermodulation Analysis," by C. R. Amey at 7.0 on April 26th, at the Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.

Scottish Section.—"Electrical Measurements," by F. M. Bruce, M.Sc., Ph.D., at 6.45 on April 6th, at the Institution of Engineers and Shipbuilders, Glasgow. (Joint meeting with the Institute of Physics.)

Television Society

London Meeting. — "Television Transmission over Telephone Lines," by T. Kilvington, B.Sc. (Eng.), at 7.0 on April 14th, at the Cinema Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2.

Leicester Centre. — "Large Screen Television Projection Unit," lecture and demonstration by member of staff of Mullard's at 7.0 on April 5th, in Room 104, at the College of Art and Technology, Leicester.

Institution of Electronics

North-West Branch.—"Cathode-Ray Tubes for Television," by J. A. Darbyshire, M.Sc., Ph.D., at 6.30 on April 18th, in the Reynolds Hall, College of Technology, Manchester.

British Sound Recording Association

London. — "Practical Microgroove Recording and Reproduction," by A. R. Sugden and R. W. Lowden, at 7.0 on April 21st, at the Royal Society of Arts, John Adam Street, London, W.C.2.

Society of Relay Engineers

"Radio Communication at Very-High Frequencies," by J. R. Brinkley (Pye, Ltd.), at 2.30 on April 25th, at the Royal Society of Arts, John Adam Street, London, W.C.2, preceded by the 6th annual general meeting of the Society at 11.30, in the Conference Room, Aldwych House, Aldwych, London, W.C.2.

Guild of Radio Service Engineers

Edinburgh Branch.—"Radio Valve Development," by C. H. Gardner (Mullard Electronic Products) at 7.30 on April 20th, at Unity House, 4 Hillside Crescent, Edinburgh.

Radio Society of Great Britain

London.—"Radio Interference Suppressors," by H. Andrews, B.Sc., at 6.30, on March 31st.

"Mobile V.H.F. Equipment," by J. R. Brinkley (Pye, Ltd.), at 6.30 on April 28th.

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

Hull Electronic Engineering Society

"Distortion," by W. S. Milner, M.Eng., at 7.30 on March 31st.

"Electronic Servo-Control for Industry," by S. H. Dale (G.E.C.), at 7.30 on April 14th.

Both meetings of the Society will be held at the Electricity Showrooms, Ferensway, Hull.

Iron-Cored Inductance

Before Using Read Instructions (if Any) on the Label

By "CATHODE RAY"

IF you are very precise you will of course object to the title. I know that inductance is only what is called a concept, and can no more be iron-cored than can a production target or the equator. The full title (to which the Editor would object) is "The Meaning of the Term 'Inductance' (or, more strictly, 'Self-Inductance') as Applied to Inductors with Ferromagnetic Cores." For example, when a certain iron-cored coil is said to have an inductance of 20 henrys, what is meant? And if the purchaser measures it and finds it to be 10 henrys, ought he to have his money back?

First, a quick "recap" on the meaning of inductance in general. When a current flows in any circuit it sets up a magnetic field. A coil (or inductor) is just a piece of circuit so arranged that the magnetic field is much more concentrated than it would be if the wire were stretched out straight; but what is said here about coils applies in some degree to every part of a circuit. The magnetic field causes so-called magnetic flux—much more of it where the space is filled with iron than where it is air or other non-magnetic materials.

If the current varies, the amount of flux varies. A circuit linked with a varying magnetic flux has an e.m.f. induced in it. So, when the current in a circuit varies, the variation sets up an e.m.f. in it. And this e.m.f. invariably acts in the direction tending to oppose the current variation that caused it. Circuits in which a relatively large e.m.f. is induced by current changing at a given rate are said to have a large inductance. Obviously such circuits need a correspondingly large e.m.f. to be applied to them to force the current to change at that rate; in other words, they show a strong preference for the current to stay as it is. The number of volts induced in a circuit when the current in it is varying at the rate of one ampere per second is said to be its inductance in henrys. (If it were due to current varying in *another* circuit, it would be distinguished by calling it the *mutual* inductance between the two circuits.)

The point I want to focus attention on is that the induced e.m.f. is caused by the variation of magnetic flux, and only indirectly by the current. In fact, the e.m.f. would be induced just the same if the flux variation were produced by waving a permanent magnet about, with no current at all. (Come-off-it Charlie will of course point out that permanent magnetism is believed to be due to molecular movements of electrons, which should be reckoned as electric currents; but we need not follow that red herring.) If the flux were in exact proportion to the current, as it is in circuits where iron (etc.) is kept well away, there would not be the same point in distinguishing between flux variation and current variation. It is because iron "multiplies" the magnetic flux, and the multiplying factor (or permeability, μ) itself varies, that complications arise in the meaning of the word "inductance."

They are rather similar to the complications that arise in the meaning of "resistance" when that word is applied to rectifiers and valves and other circuit parts in which the current is not always exactly proportional to the voltage. But unfortunately inductance is more complicated still. However, it may be instructive to begin with resistance.

Fig. 1 is a typical current-voltage graph of an ordinary resistor—a straight line passing through the origin. So the resistance, V/I, is always the same whatever values of V and corresponding I on the graph are used for calculating it. The resistance is constant and the graph is described as linear.

Fig. 2 is a typical anode-current—anode-voltage graph of a valve, and is markedly non-linear. Its resistance, reckoned as V_a/I_a, obviously depends very largely on the particular point selected on the graph. At point A, V_a and I_a are 10 V and 5 mA respectively, so the resistance is 2,000Ω; at B, they are 100 V and 10 mA, so the resistance is 10,000Ω. Neither of these values is what is wanted for judging the effectiveness of the valve for signal handling. If the signal causes V_a to vary 10 V above and below point B, I_a varies only 0.01 mA above and below the same point, and on this basis the resistance is 1,000,000Ω. As we all know, resistance in this sense—the "a.c." resistance

Fig. 1. Graph of an ordinary linear resistance.

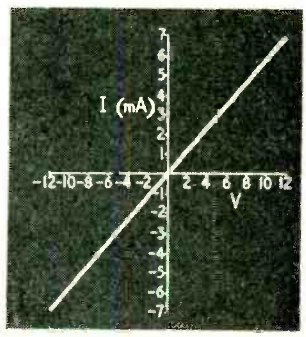
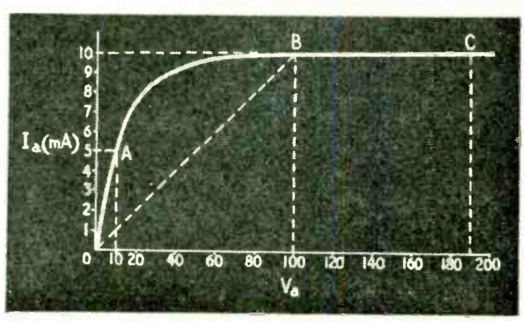


Fig. 2. Graph of non-linear resistance (V_a/I_a curve of a typical pentode).



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—is represented by the slope of such a graph turned on its side. From such a viewpoint the slope at B is very steep, indicating the high resistance we have just calculated; whereas the more gradual slope of a line drawn from B to O represents the "d.c." resistance, 10,000Ω.

An important point about the a.c. resistance is that it depends on the assumption that the portion of graph swept over by the signal voltage is straight. If the graph is in fact curved at the point concerned, the calculation only makes sense by supposing that the signal voltage is infinitesimal. (As a matter of fact, one *can* give a meaning to resistance as applied to a non-linear circuit element, by using the familiar formula

$$\text{watts} = \frac{(\text{volts})^2}{\text{ohms}}$$

or, in tidier form, $R = V^2/P$, where V is the r.m.s. voltage and P the power in watts; but it involves the waveform of V and the impedance of the rest of the circuit and leads to incredible difficulties in calculation.)

For instance, if the peak signal amplitude from point B happened to be 90 V, so as to involve the portion of graph stretching from A to C, it would be very difficult to say what the a.c. resistance of the valve was. It would *not* be correct to calculate it from the slope of the straight line joining A to C; that is to say, by dividing 180 by 5.1.

And that is just the sort of difficulty one is up against with iron-cored coils.

The Make-up of Inductance

Let us first see how the inductance of a linear (air-core) coil is made up, for comparison with Fig. 1. Inductance is defined in terms of the back-voltage induced when the current is changing at the rate of one ampere per second, though as we have noted it is the rate at which the magnetic flux linked with the circuit is changing that is really responsible. Current is only brought into it because in practice it is more likely to be measurable than the number of flux linkages it sets up. But seeing that just now we are trying to get at the roots of the affair we must not overlook any of the middlemen in the transaction.

Magnetic flux—the total flux, not its density—is often reckoned in lines (also called maxwells), but the up-to-date unit consists of 100 million (10^8) lines,

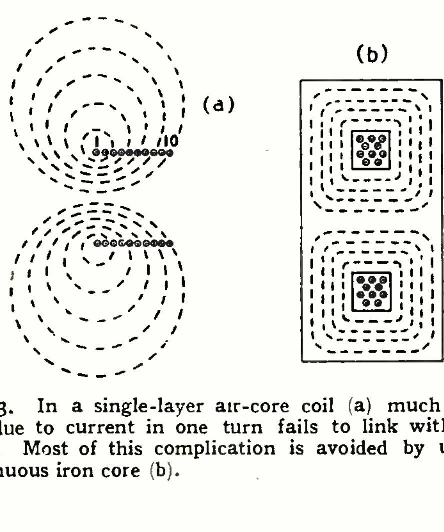


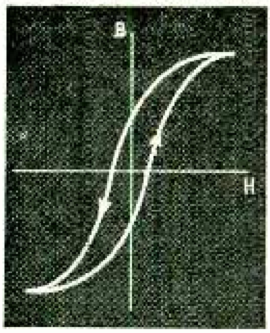
Fig. 3. In a single-layer air-core coil (a) much of the flux due to current in one turn fails to link with other turns. Most of this complication is avoided by using a continuous iron core (b).

and is called the weber. The advantage of the weber is that it belongs to the same practical system of units as volts and amps and henrys, so that one gets the very easy rule that changing the flux linked with one turn of wire at the rate of one weber per second induces an e.m.f. of one volt. If 100 turns are linked with the same flux, each turn has one volt induced in it, giving a total for the whole coil of 100 volts; just as if the coil consisted of one turn with the flux linking it changing at the rate of 100 webers per second. That is why it is flux-*linkages* that must be counted, and is one reason why a high inductance results from using many turns. The other reason is that more turns give more flux for a given current—and current is the basis for reckoning inductance. So if the one weber of flux were produced by one amp flowing through one turn, the inductance of the turn would be one henry; one hundred turns carrying the same current would cause 100 webers of flux, and assuming all of it linked all the turns there would be 10,000 flux linkages per amp and so the inductance of the coil would be 10,000 henrys.

These are not very likely figures in practice, but they are easy ones for making clear why inductance is proportional to the *square* of the number of turns. Another thing that is not quite practical about this example is the assumption that all the flux links every turn in the coil. In Fig. 3 (a), which is supposed to be a cross-section of a single-layer coil, a few of the imaginary flux lines due to the current in turn 1 have been dotted in, and it is clear that only a small proportion of them link turn 10. The inductance of a coil like this would be a good deal less than turns-squared times the inductance of one turn. It could be brought nearer to it by winding the turns closer together, and much nearer still by providing an easy path for the flux by giving the coil an iron core, as in Fig. 3 (b). The rise of inductance due to more complete flux linkage would of course be in addition to the very large increase likely to be obtained by the flux-multiplying effect, or permeability, of the iron core.

Just as the calculation or measurement of resistance in its simple or Ohm's-Law sense depends on the current through it being strictly proportional to the voltage, as in Fig. 1, so our definition of inductance assumes that the flux is strictly proportional to the current. And so it is, except when core materials having permeabilities substantially greater than 1 are used. These materials—principally iron, but also various alloys—are distinguished by the name "ferromagnetic." Corresponding to the graph needed to show the relationship between current and voltage in a circuit element where it is non-linear (e.g., Fig 2) is the B-H graph of a ferromagnetic material. B is the flux density, which (sticking to the same system of units) is given in webers per square metre cross-section of flux path; and H is the magnetizing force, in ampere-turns per metre length of flux path. The permeability, μ, is simply B/H. The only snag about using these units is when it comes to permeability, the figure for vacuum (and nearly the same for all except ferromagnetic materials) being $4\pi/10^7$, instead of 1 as in the older system of units. In practice one works most of the time in *relative* permeabilities, which are the same as the old permeabilities. It is only in the actual equation $\mu = B/H$ that the awkward figure has to be used in order to keep the units right.

Now although valve curves display a great variety



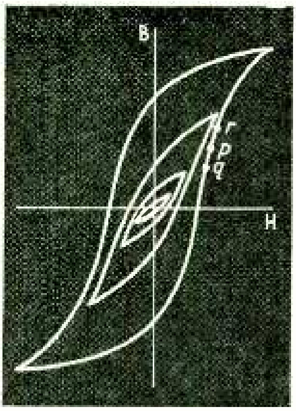


Fig. 4. Typical B,H curve for iron, using a.c. of a fixed amplitude.

Fig. 5. (Right) Each value of a.c. amplitude gives a different B/H loop.

of non-linearity, at least they are normally the same coming and going. If one plotted the curve in Fig. 2 by increasing V_a and noting the corresponding values of I_a, the result should be the same as if one had started from the top and worked down to zero. If it were not so, it would be a sign that either something had been wrong with the valve at the start, or it had been made wrong by applying excessive voltages or currents. But unfortunately the B-H plots always depend on whether the magnetism is going up or coming down. In other words, B (and therefore μ) depends not only on the value of H now but also on what it was before.

I say "unfortunately," in connection with inductance; of course it is very fortunate in other ways because it makes permanent magnets possible. They depend on the fact that when H has been raised to a suitably large value there is still a good deal of B left after H has been brought back to zero.

If one starts with a completely unmagnetized core (B=o), and begins to pass current through the coil (increasing H), the B increases in a manner not unlike the current in a pentode valve (Fig. 2). But when H is reduced again, the downcoming curve is to the left of the upgoing one. After the core has been taken through a number of complete cycles of equal positive and negative H, the upgoing and downcoming parts of the curve are the same every time (Fig. 4). That certainly simplifies matters a bit; but to cover other maximum values of H it is necessary to draw a whole series of these loops, as in Fig. 5. Obviously just knowing the value of H is not nearly enough to fix the value of B. With H=o (magnetizing current cut off), B might be anything between a large positive and a large negative flux density.

However, what we are concerned with just now is the bearing of all this on inductance. Seeing that H is in ampere-turns per metre we can say that it is directly proportional to the current. So varying the current at, say I amperes per second varies H at a definite knowable rate. The trouble is that the corresponding rate of B variation depends on whereabouts on the B-H loop H is varying. Although B-H curves have as much variety of shape as valve curves, they are all more or less curved; so one is up against the same difficulty in determining the inductance as in determining the resistance of a valve. More difficulty, in fact, because with valve curves there is at least a definite I_a corresponding to each V_a (other things being constant). As with valve curves, the only reasonably calculable condition is when the range of variation is confined to a part of the curves that is tolerably straight. Looking at Fig. 5 (which is fairly typical) the prospect might not seem very bright. With even the smallest H variation, the graph opens out into a loop. Nor must it be supposed that by starting at a point such as *p* one could work up and down between *q* and *r*, as one could on a valve curve. The B-H curve would open out into a little local loop, which would slope less steeply than the line *qr*.

On the other hand, it is not as bad as it may look, because until the range of H is made so large as to cause the loops to bend over noticeably (due to "saturation"), they are roughly elliptical in shape. Now if you start with a sine-wave input, as in Fig. 6, and trace the output corresponding to it, via an elliptical characteristic curve, you will find that the output waveform is quite undistorted, just as if the characteristic had been perfectly linear, the only effect of the opening-out being to shift its phase. In so far as B-H loops resemble ellipses, then, they do not distort the waveform; the effect is to shift the phase of the induced voltage in such a way as to introduce resistance into the circuit as well as inductance. In any case, the sort of iron chosen for use in chokes, transformers, and other components in which the inductance matters, generally has a very thin loop; so the "up-and-down" effect is not always so pronounced as in Fig. 5.

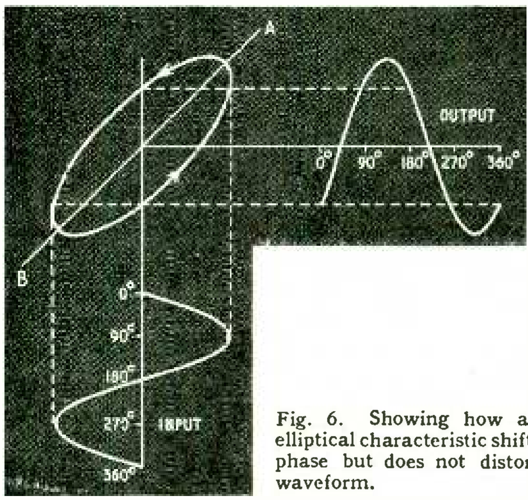


Fig. 6. Showing how an elliptical characteristic shifts phase but does not distort waveform.

Complications

In Fig. 6 the amplitude of the output is the same as would be obtained from that input if the characteristic had been a straight line (AB) having the same slope as the ellipse. In the same way, the inductance can be reckoned from the B-H curve by taking account of the slope of the loop. This is all right so long as the shape of the loop is not too unlike an ellipse; but when it bends over at the ends the waveform of the induced voltage is no longer the same as that of the current. What this means in practice is that if the a.c. passed through an iron-cored coil is so large as to saturate the core at the current peaks, there will be distortion. Not only so, but (as we found with the resistance of a non-linear component) it becomes a very difficult matter to say what the inductance is; impossible, if one doesn't have details of the rest of the circuit. For one thing, the amplitudes of the harmonics resulting from the distortion depend on the impedance of the whole circuit to the harmonic frequencies. The straight line joining the tips of the loop is not necessarily a good approximation. So, for what remains, we shall be assuming that the loops are reasonably elliptical.

Calculating the inductance of an iron-cored coil is a complicated enough matter, even when one can make this assumption, because the cross-sectional area of the core is unlikely to remain the same throughout, and it is very difficult to decide how much flux passes through the surrounding air ("leakage flux"), and the smallest air-gap in the flux path may need more magnetizing force than the whole of the iron part. So the following example is of purely theoretical interest, merely to link up the information given in the B-H curve with the definition of inductance.

Suppose a coil has 500 turns and carries a peak current of 25 mA, and the size of the core is such that the average length of the flux lines is 10 inches (say 0.25 metre) and its cross-section is 1.5 square inches (say 0.001 square metre). Then the number of ampere-turns is $0.025 \times 500 = 12.5$; and H, the ampere-turns per metre, $12.5/0.25 = 50$. The B-H curve shows, say, that the B corresponding to this peak H is 0.2 weber per square metre. So the total flux is $0.2 \times 0.001 = 0.0002$ weber. The flux linkages or flux-turns therefore amount to $0.0002 \times 500 = 0.1$, set up by 0.025 amp. If this current were changing at the rate of 1 ampere per second the flux linkages would change at $0.1/0.025 = 4$ weber-turns per second; so the inductance is 4 henrys.

If the peak current were much higher, so that the B-H curve bent over towards saturation, the slope of the curve would be less, B would not go up in the same proportion, and the inductance would be less. If it were not for this non-linearity, there would be no need to know the current in order to calculate the inductance. But with an iron core the inductance at first increases as the alternating current is increased from a very small value; but soon it starts to decrease, and falls off continuously as the current rises towards saturation values. And while this is happening the inductance not only falls off but becomes rather indefinite, depending on waveform and circuit conditions. If you try to measure it, you get different answers according to the method employed. So it is no use claiming that the accuracy is 0.1%, even if you have a very nice bridge!

One more aspect of the matter remains. I mentioned that the effective slope of the B-H curve with H varying between the limits marked out by the points *qr* in Fig. 5 is not what it might seem to be from the diagram. What does happen is shown in Fig. 7. If d.c. is passed through the coil so as to magnetize the core with a force equal to H_1, B will rise by some such curve as that shown, to *p*. If now a small a.c. is superimposed, the core will work round a little loop *qr*, having a slope considerably less than that of the main curve at *p*. In other words, the a.c. inductance is less than one would expect.

If now the d.c. is increased, the main curve tends to flatten out, and the little loop does so too. Increasing the d.c. reduces the a.c. inductance. With a given d.c., the a.c. inductance also depends to some extent on the amplitude of the a.c., for reasons already considered. And for reasons not considered, the inductance falls off if the frequency is made very high. So the isolated statement that the inductance of an iron-cored coil is, say, 20 henrys, doesn't mean very much. And it is quite pointless to attempt to measure it with extreme accuracy, unless all the conditions are very precisely known and specified.

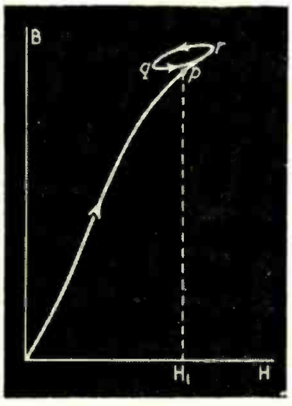


Fig. 7. Graph corresponding to the magnetization of iron by d.c. plus a relatively small a.c.

French Scientific Instruments

Electronics at the Science Museum Exhibition

WITH the object of stimulating closer relations between scientific workers in Britain and France, an exhibition of French scientific instruments was held at the Science Museum from 9th to 26th February last. The exhibition was representative of all branches of physical measurement and included a wide range of electronic instruments.

The Centre Nationale de la Recherce Scientifique showed an interesting four-channel electronic switch for the simultaneous display on a cathode-ray tube of coincident phenomena, e.g., measurement of vibration at several points in a structure, sound intensity measurements in rooms, encelphalography, etc. The four voltages are chopped at 34 kc/s and sample pulses are selected with phase differences of 90 degrees from the four arms of a Maxwell bridge each with its associated amplifier. The audio-frequency range available is 0-6,000 c/s. Also shown on this stand were a cathode-ray recording phase-meter and a single-valve RC generator for low frequencies (0-30 c/s).

Sensitive direct-reading instruments for measuring magnetic fields were included in the exhibit of the Office National d'Etudes et de Recherches Aéronautiques. The primary of a small transformer with high-permeability core material is supplied with sinusoidal current of audio frequency. In the presence of a superimposed unidirectional field, the output contains even harmonics, the strength of which is proportional to the field. The second harmonic is filtered, rectified and applied to a pointer meter calibrated in millioersteds. In one instrument there are five ranges of 0 to 10 up to 0 to 1,000 millioersteds, and compensation is provided for ambient fields of the order of magnitude of the earth's magnetic field. Another instrument is designed to explore remanent magnetism in ferromagnetic structures and has a centre zero indicating the direction as well as the strength of the field.

The Commissariat a l'Energie Atomique showed a wide range of stabilized high-voltage supplies, low-noise amplifiers, pulse scalers and counters and radiation monitors.

Deflector Coil Characteristics

2. *Characteristics of Line Coils*

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

As an indication of the order of magnitude of the LI^2 figures to be expected of deflector coils Table 1 shows figures for a number of coils designed for radar use. They have been collected from various sources and reduced to the form of expression adopted in this article. They are not strictly indicative of the relative merits of the different type of deflector coil, for the coils are of varying physical dimensions; in particular, there is considerable variation in their lengths and inside diameters.

Table 1

Coil	LI^2 (mH, A^2)	R/L (Ω, mH)	RI^2 (mH, A^2)
1. Air core	2.7	4.2	11.3
2. Air core	3.4	1.8	6.12
3. Air core	5.2	1.5	7.8
4. Circular iron core	2.1	1.2	2.52
5. Ditto, with external screen ...	1.35	—	—
6. Circular iron ring	1.9	2.1	4
7. Slotted circular iron ring ...	1.1	1.6	1.76
8. Square iron core...	3	1.2	3.6
9. Square iron core...	4.6	0.39	1.8

The LI^2 figures vary from 1.1 for a ring-type iron-circuit built of slotted laminations to 5.2 for an air-core coil. To supplement these figures and give them some practical meaning, the ring-type coil used in the *Wireless World* Television Receiver has $LI^2 = 2.6$. In addition, the smallest LI^2 theoretically possible is about 0.5. Table 1 shows that a figure of 1.1 is a practical possibility. One can hardly expect to be able to approach the theoretical minimum very closely but a figure around 0.75 might not be impossible.

The importance of this may be judged when it is said that the power input to the output stage of the *Wireless World* Television Receiver is 45 W (94 mA at 480 V). A reduction of LI^2 from 2.6 to 1.1 would reduce this to 18.3 W, assuming the valve efficiency to be unaltered, which is not necessarily true. An LI^2 figure of 0.75 would mean a power input of only 13 W. These figures include transformer losses and might be further reduced by improvement in this component.

Theoretical considerations indicate that to improve efficiency it is necessary to shorten the end connections as much as possible and to minimize the internal dimensions of the iron ring. Very little information is available about the extent to which efficiency is affected by changes in the dimensions, however, and in order to gather some information about this the writer carried out a series of experiments.

A set of bent-up end coils was made in which the side wires each occupied 45° around the circumference of a circle, so that the eight sides of the two line and two frame coils filled the circumference. The outside diameter was made 42 mm so that tests could be made with a standard iron "ring" lamination. The coils were assembled around a very thin-walled paper tube of 36-mm inside diameter. This represents the minimum practical diameter. The overall length of the assembly was 53 mm and the length inside the bent-up ends of the frame coils was 32 mm. The ends themselves were made of minimum length, the inside wires of the line coils lying directly on the assembly tube. The ends of the frame coils were necessarily longer for they had to pass over the side wires of the line coils.

The coils were wound to shape in a special former,

Table 2

Measured characteristics of bent-up end coils at line frequency with various iron rings.

Ring	L (mH)	LI^2 (mH, A^2)	R/L (Ω, mH)	RI^2 (Ω, A^2)
1. None (i.e., air core)	6.1	2.1	2.69	5.65
2. 1-in stack of 0.014-in laminations: 42-mm internal diameter	9.1	1.06	1.8	1.91
3. As 2, but one-half the laminations removed and the rest spaced in 5 groups to 1in	8.9	1.14	1.84	2.1
4. Three flat strips $2\frac{3}{4}$in by 15/16in bent round and overlapped	7.8	1.34	2.1	2.81
5. Single layer No. 24 galvanized-iron wire $1\frac{1}{4}$-in long ...	7.1	1.55	2.31	3.58
6. Stack of L-laminations in 7 groups spaced 1/16 in to 1 in total length, forming square window of 42-mm side	8.1	1.11	2.02	2.25
7. As 6, but 54-mm side	7.3	1.26	2.3	2.9
8. As 6, but rectangular window 42×68 mm:				
(a) long side horizontal	8.0	1.24	2.05	2.54
(b) short side horizontal	7.2	1.47	2.27	3.33

the wire size being changed twice in the line coils and once in the frame to obtain a grading of the turns density and a more uniform field. The line coils had 180 turns each and the frame 200.

The results obtained with the line coils of this assembly are given in Table 2. With no iron, ring 1, the LI^2 figure is 2.1. This is considerably better than the air-core coils of Table 1 and is to be attributed to the smaller dimensions of this coil.

The addition of a 1-in stack of laminations with a circular hole of 42-mm diameter, ring 2, brings LI^2 down to 1.05, a very big improvement. About one-half of the laminations were now removed and the remainder stacked in five groups which were spaced out to occupy the same total length as the full coil, ring 3. This increased LI^2 to 1.14, a reduction of efficiency of about 7%. These laminations, incidentally, were of unknown vintage; they were reputed to be Rhometal.

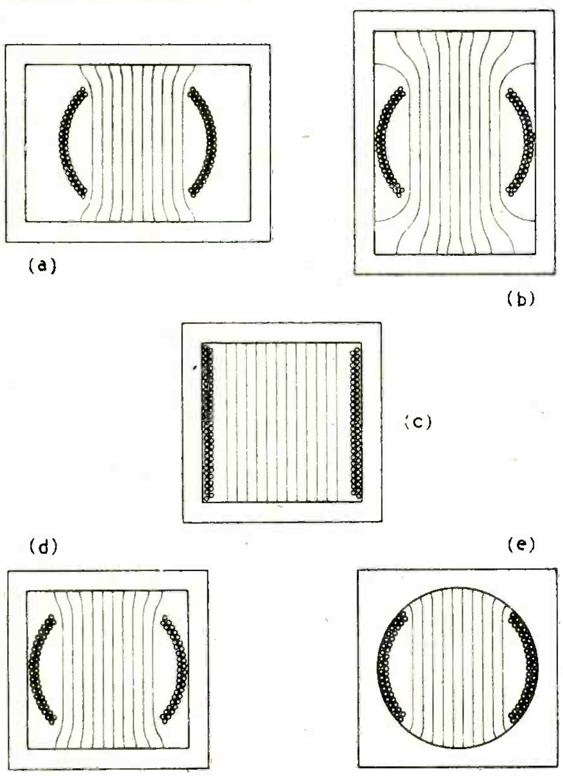


Fig. 4. Magnetic field within various forms of iron circuit.

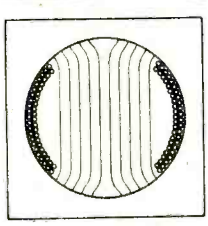


Fig. 5. Actual form of field in iron-ring assembly.

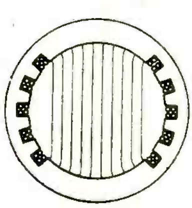


Fig. 6. Section through an iron-ring deflector coil using slotted circular laminations.

A ring was next made by cutting three flat strips from some transformer laminations, bending them into semi-circles and placing them overlapping around the coil assembly as a ring, ring 4. Each strip measured $2\frac{3}{4}$in by $\frac{3}{16}$in. This iron ring gave $LI^2 =$ 1.34. It is not nearly as good as the proper ring, but very much better than nothing. A winding of No. 24 galvanized iron wire was tried, ring 5, and this gave a figure of 1.55.

The conclusions to be drawn from these experiments are that while a full stack of proper laminations gives the best results the amount of iron used is by no means critical and that if the highest possible efficiency is not necessary very considerable liberties can be taken with the iron circuit. The use of spaced laminations to reduce the quantity of iron is in particular, permissible. Unless it is important to reduce the amount of iron in order to save weight, however, it may not be worth while to do so for the arrangements for spacing the laminations may well be more costly than the laminations saved. We have, however, established the fact that it is permissible on efficiency grounds to space the laminations, and this is important, because in some forms of iron circuit it may permit standard laminations to be used or an iron circuit to be fabricated from overlapping strips.

Effect of Window Size

The next step in the experiments was to try the effect of varying the window size. A "ring" with a square window of 42-mm side was built from L laminations assembled in seven spaced groups to a total length of 1 in, ring 6. This had a window area of $4/\pi = 1.27$ times that of the circular window. Rather surprisingly this gave an LI^2 figure of 1.11, slightly better than with the comparable circular window, ring 3. It would not be wise to conclude from this that the square window is better than the round, however, for the difference is small and may be accounted for by experimental error and by differences in the grades of iron. Suitable laminations in the same grade of iron were not available. All that one can safely conclude is that there is not much difference between square and circular windows of the same side and diameter respectively.

A similar ring with a 54-mm side to the window, ring 7, gave $LI^2 = 1.26$. These figures tend to show that LI^2 varies as the square root of the length of side of a square window (fourth root of window area), but not enough figures are available to warrant the statement as a general law.

The experiment was next tried of using a rectangular ring 42 mm by 68 mm. With the long side horizontal, ring 8 (a), this gave $LI^2 = 1.24$ but with it vertical, ring 8 (b), it gave $LI^2 = 1.47$. This conclusively proves that it is not the area of the window which matters but the position of the iron in relation to the winding and tube. The fact that LI^2 varies when the rectangular ring is rotated about the coil assembly shows that the magnetic field does not fill the window uniformly.

Now the magnetic lines of force are closed loops surrounding the current-carrying wires and their paths are partly in air and partly in iron. They tend always to take the path of lowest reluctance. In view of this one would expect the field distributions to be of the forms sketched in Fig. 4. Such distributions are in accordance with the facts already noted. The field outside the side wires lies mainly in the iron and the large air space between the wires and the iron side limbs in (a) does not reduce efficiency appreciably because there is little magnetic field within it.

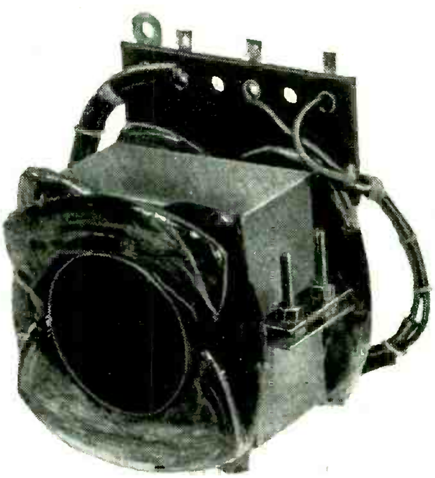
When there is a large space between the wires (b) and the upper and lower limbs of the iron, however, the efficiency suffers considerably because this space is filled with magnetic field. A square iron circuit with the windings disposed as in (c) is particularly inefficient because the whole of the window area must be filled by the field. This arrangement is sometimes used with core-type structures because it is relatively easy to construct.

The reason for the small difference in efficiency between circular and square rings of the same diameter and side now appears plain. They are shown at (d) and (e) and in the latter the circular opening is superimposed dotted. It is plain that in the region of the field there is very little difference between the two.

However, the field distributions shown in Fig. 4, although plausible, are not accurate. A further experimental fact disagrees with them. This is that large air gaps between the two halves of the ring just where the field appears to enter the iron have very little effect !

A deflector coil was measured with a 1-in stack of Silcor IV laminations giving a 42-mm ring and and LI^2 figure of 1.15 was obtained, the inductance being 11.9 mH. The two halves of the stack were then separated to give a ½-in gap between the two sets of laminations. With the field distributions of Fig. 4 one would expect LI^2 to rise considerably. However, it increased to 1.19 only while L dropped to 11 mH. The region immediately over and below the centre cannot, therefore, be carrying appreciable field.

This result is a surprising one and it was confirmed by some measurements with a different winding and a different lamination. These were special laminations forming a 42-mm ring, but having material cut away so that the gap did not entail moving the iron away from the coil at the sides. The air gaps were actually ¾ in with these and LI^2 turned out at 0.94. This must not be taken to indicate that the gap



Complete deflector-coil assembly comprising two pairs of bent-up end coils with iron-ring.

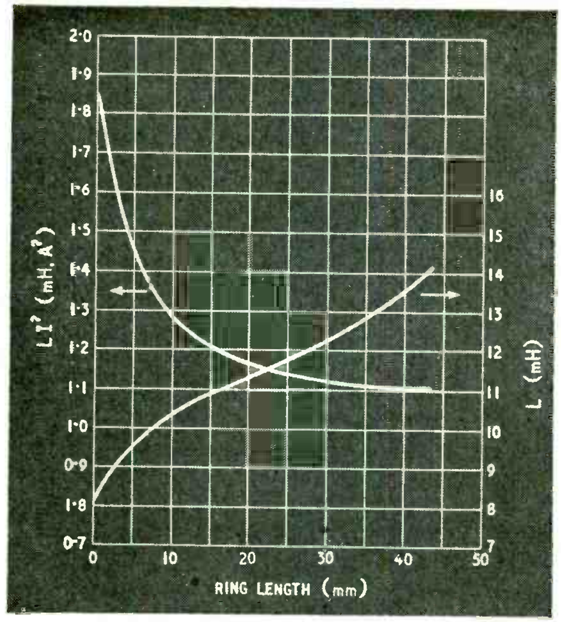


Fig. 7. These curves show the effect of varying the length of an iron-ring on a bent-up end type coil.

improves the efficiency, for the winding was a different one and each side-limb occupied some 60° instead of 45° only. This coil will be referred to in more detail later.

In view of this the field must crowd together round the edges of the wires somewhat in the manner sketched in Fig. 5. An attempt was made to confirm this with iron-filing patterns but it proved very difficult to secure satisfactory patterns because of the very confined space in which they were needed. Diagrams inside the coil assembly could easily be secured and indicated no serious curvature over this important region.

One other form of iron ring deserves mention. This is one built from slotted circular laminations, of the form shown in Fig. 6. It reduces the space inside the iron to a minimum for the inside diameter of the iron can be made only just sufficient to clear the tube neck and the windings placed in the slots in the iron.

Owing to the difficulty of obtaining such laminations the writer has carried out no experiments with them. Some figures culled from other sources are given in Table 1, however. On theoretical grounds the improvement in efficiency through their use is unlikely to exceed about 20%. If the whole window were filled with field the improvement could be 36%, but it is not, and there is some waste flux in the slots, so that the maximum gain from a slotted lamination is probably 20%. In view of this, and taking into account the difficulty of obtaining them (and their probable high cost, for their production is obviously very wasteful of material) and the fact that they make the self-capacitance of the winding very high, their use is not considered to be worthwhile. They will not be further treated here.

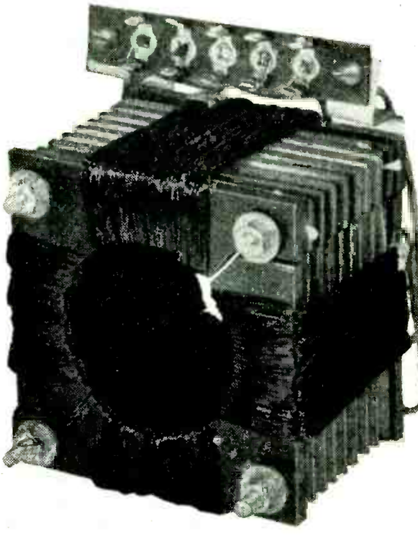
So far, no mention has been made of the effect of the length of the iron ring. The stack length used in the previous experiments was 1 in (ring 2, Table 2) and this is the length usually adopted for this type of iron circuit. No great increase was possible with the particular coil assembly used for the various rings of Table 2 because of the bent-up ends of the frame coils. A new pair of line coils was constructed, therefore, this time by an actual bending process. The turn distribution was much the same but the total turns were greater and the ends were rather longer and thinner. The laminations used had the same 42-mm internal hole, but were this time of Silcor IV and 0.02-in thick.

The curves of Fig. 7 show the way in which L and LI^2 vary with the length of the ring; LI^2 continually decreases as the ring is lengthened but only very little beyond a certain point. As the ring length increases from zero, LI^2 decreases very rapidly at first but after about 1 in only very slowly. Increasing the length from 1 in (25.4 mm) to 1.71 in (43.5 mm) changes LI^2 from 1.14 to 1.11. It is clear from this that the usual 1-in stack of laminations is about right; any longer stack gives no worthwhile improvement.

The inductance curve gives a clue to the reason for this. As the ring length is increased from zero the inductance rises rapidly at first and then more slowly. When the ring exceeds about 25 mm, however, the inductance starts to rise more rapidly again.

When the ring is fairly short its main effects are to reduce the external field and increase the useful internal field while it also increases the inductance of the side wires of the coil. As it is lengthened it becomes effective over an increasing length of the coil. However, when the length exceeds a certain figure the ends of the ring begin to approach the bent-up ends of the coil and to increase their effective inductance. The field produced by these ends is mainly external to the c.r. tube and has no useful effect; the increase of the end inductance with increasing core length is thus detrimental. It so happens that the increase of efficiency from the side wires is rather the greater; otherwise, the LI^2 curve would turn up for long rings and show a definite optimum value. However, the two effects nearly cancel one another and a long ring is of no practical advantage.

The effect of ring material is not great. A 1-in. stack of 0.014-in laminations of unknown material gives $LI^2 = 1.06$ (coil 2, Table 2). The same windings with a 1-in stack of 0.02-in Silcor IV laminations gives $LI^2 = 1.16$.



Core-type deflector-coil with external screens removed.

Core-type Assemblies

So far only ring-type iron circuits have been considered. The iron-core types are important because they offer some constructional advantages; in particular, the windings are very simple. Certain measurements were, therefore, carried out to determine their efficiency.

An experimental core-type assembly with a square window of 42.8-mm side was constructed. The laminations were L-shaped cut to size from transformer U stampings.

They were assembled in groups of three, separated by larger L-shaped paxolin spacers of $\frac{1}{8}$-in thickness. The spacers carried five shallow slots on all four edges so that when wound the wire just cleared the laminations on the one hand and just did not fill the slots on the other.

The fabrication of these spacers proved very laborious, but the method would be very suitable for production since they could be simple mouldings. The whole assembly was made in two L-shaped halves which were placed together after winding. The laminations were not interleaved but had butt joints at two diagonally opposite corners. Incidentally, this was found to cause serious raster distortion. An exceedingly good butt joint is needed to reduce the distortion to within tolerable limits.

The overall length of this coil assembly was 2.01-in and the core length 1.75 in. The core-type coil can inherently have a longer core than the ring type for the outside wires of the line and frame coils are quite separate and do not cross each other as they do with the bent-up end coils of the ring-type iron circuit. The frame and line windings can be of the same length.

On test this coil had an LI^2 value of 3.1, which compares very unfavourably with the ring-type. Indeed, it is worse than an air-core bent-up coil. This low efficiency occurs partly because the windings are close to the iron rather than the neck of the tube and so the whole of the window is filled by the field. It also occurs because the end connections to the side wires pass close to the iron around its ends and outside. The field produced by these connections is waste just as the field produced by the bent-up ends of the ring-type is waste. The length of wire involved in these outer wires of the core-type coils is greater than that needed for bent-up ends in a ring type and it is much closer to the iron. The waste field produced is, therefore, much greater in a core-type assembly than in a ring-type.

However, at line frequency it is possible greatly to reduce the waste field of a core-type coil by using a closely-fitting copper screen. This is not effective at frame frequency, for the action depends on eddy currents and is consequently frequency sensitive. The addition of a closely-fitting copper screen to the four external sides of the coil described above reduced LI^2 from 3.1 to 2.2.

This change was almost entirely one of inductance, which dropped from 9.4 mH to 6.6 mH, the current changing from 0.57 A to 0.58 A only. As one would expect, the screen has very little effect on the field active for deflection, but greatly reduces the waste external field.

The addition of copper and plates was then tried. The one at the rear had a 1½-in centre hole and the one at the front a 2-in hole to clear the tube. They were mounted as closely as possible to the end wires where the wire comes out from the inside of the core and passes over the end plate to turn outside the core.

These screens brought LI^2 down to 1.81 and the inductance to 5.05 mH. The current rose to 0.6 A. This indicates that the end screens do, in fact, cut off some useful field, but they reduce the waste field much more.

The effect of the full screening is to reduce LI^2 from 3.1 to 1.81. It would actually have been possible to have reduced LI^2 still further, for the screens used did not fit as closely to the wire as they might have done and their whole action depends on very tight coupling between screens and wires.

The reduction of inductance by the screens is accompanied by a considerable increase in the effective resistance of the coil. This may be important if any large inductance reduction is obtained for it may result in the energy lost in the resistance being no longer negligible compared with the energy stored in the magnetic field.

A few further experiments were carried out with this type of coil. The same core was retained and the arrangement of the external wires was much the same. Inside, however, instead of placing the wires close to the iron they were placed near the tube. The aim was to make the internal wires occupy as nearly as possible the same position as in a bent-up end coil with an iron ring. The difference between this coil and the bent-up end coil with the 42-mm side square-iron ring described earlier, was thus a slightly longer iron-stack, a 42.8-mm window and the different end connections.

Unscreened, this coil gave $LI^2 = 3.19$. This compares with 3.1 for the original winding. The gain obtained by placing the wire near the tube is thus more than offset by the increased length of the end connections. With copper end and outer screens LI^2 dropped to 1.85,—again slightly worse than with the wire near the core.

We thus conclude that although it is preferable to place the wire near the tube when using a square-iron ring, it is better to place it near the iron when using a square-iron core. The difference in the latter case is negligibly small and within the limits of experimental error. However, the coil is usually much easier to wind when it is near the iron so that this is the preferred alternative.

Circular Cores

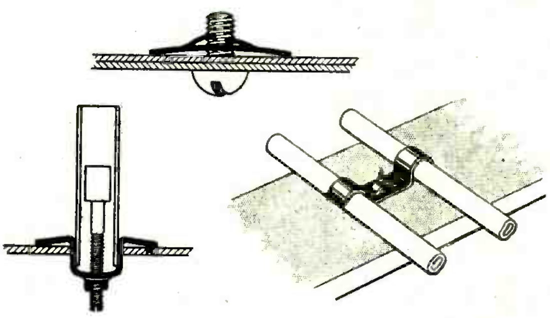
No iron-core type which the writer has made has proved nearly as efficient as an iron-ring type. It should be noted, however, that no experiments were carried out using a circular core. Such a core would undoubtedly be more efficient than a square one for it would enable the internal wires to be placed next to the c.r. tube neck without lengthening the end connections. Coil 7 of Table 1 indicates that such a core can give a deflector coil of the same order of efficiency as the ring type. The chief objection to a circular core is the practical difficulty of winding. Unless very few turns are employed it is essential to use a toroidal-winding machine.

Core-type coils with external screening also have one practical disadvantage; the inductance, and hence the efficiency, depends on the coupling between the winding and the screen. In manufacture it is likely that close tolerances would have to be set on the physical dimensions of both if considerable variations between completed assemblies were not to occur.

The general conclusions are thus that for the line scan "bent-up end" type coils with an iron ring should be used. The iron ring should be a stack of laminations but it need not be a solid stack; very little is lost by using only 50% of a full stack if the remainder is spaced out to occupy the space of a full stack. A circular window is better than a square one, but only very slightly, and a gap in the ring reduces the efficiency negligibly.

(To be concluded)

New Fixing Technique



A selection of clamps and fittings embodying the Spire speed nut principle, having various radio applications.

THE Spire "speed nut" is a relatively new development and, unlike the ordinary threaded nut, does not have to be tightened with any great amount of force as its holding power, and resistance to vibration, are dependent solely upon spring tension.

Simple spring shapes affording a vibration-proof lock provide speedy and effective assembly of sheet metal parts and for securing glass or plastics to metal or non-metal surfaces. Since only moderate pressure is needed, the risk of damage to fragile parts is very small indeed.

The Spire nut bears no resemblance to the orthodox threaded variety as it is a thin, flat strip of springy steel with a slight curvature and having a centre hole with two wings, one a shade longer than the other. Being a self-locking affair, neither spring washer, locknut or the equivalent is needed. Another feature is the speed with which these nuts can be assembled, as the tension is not critical for secure fixing.

The very nature of the device lends itself to many variations in design, and the locking portion can be made integral with some larger fitting, such as a cable or tubular capacitor clip (single or double). Coil former supports embodying a Spire nut for the threaded shank of a dust iron core are available also, and one style is illustrated.

These are essentially manufacturers' parts, and various styles can be made to meet special production requirements. The makers are Simmonds Aerocessories, Ltd., Treforest, Glamorgan, Wales.

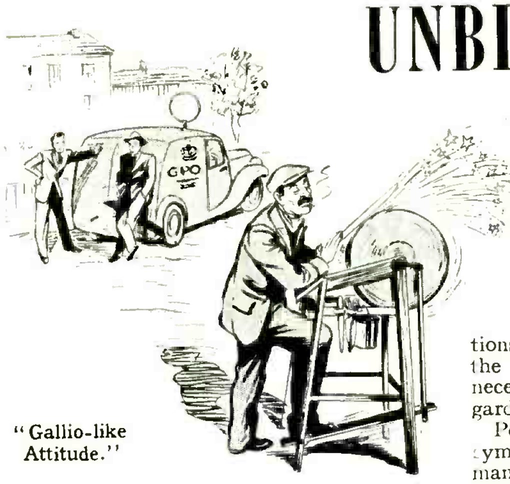
"Preferred-Value Attenuators"

Correction to Diagrams

We regret that owing to a printer's error, Fig. 1 and Fig. 4 in this article (p. 71, February) have become interchanged. The caption "Fig. 1" refers, of course, to the diagram on page 72, whilst the caption "Fig. 4" refers to the diagram on page 71.

UNBIASED

By FREE GRID



"Gallio-like Attitude."

Fiat Justitia

MANY people grumble at the wireless licence fee paid to the G.P.O. and question whether they get the moneysworth to which they think the fee entitles them. The trouble is, of course, that, like the dog owner, they are entitled to nothing in return for their licence fee and get nothing. Some people think that the wireless licence fee is a special levy instituted in 1922 for the upkeep of the B.B.C. It is nothing of the kind, as many of us old hands know full well, as we have paid it since the palmy days of Edward VII. We made bitter protests at the passing of the first Wireless Telegraphy Act, which made it necessary for us to seek official permission to do something we had been doing without let or hindrance since Queen Victoria's time.

The licence has never even entitled us to the services of the Post Office in detecting interference. This has merely been an act of grace on the P.M.G.'s part, done without any sordid profit motive. Perhaps it is because wireless licence receipts didn't depend directly on the P.M.G.'s success or otherwise in detecting and checking interference that he and his young men have adopted such a Gallio-like attitude towards the whole question. Gallio, for the benefit of those of you who, as Mr. Churchill once remarked in the House, had the misfortune to be "educated" at Eton, was the first man to be pilloried for adopting the "couldn't-care-less" attitude.

A reader living near the leafy glades where Henry VIII's halberdiers assured him interference-free reception of Queen Elizabeth's mother, has written, so the Editor tells me, complaining of the P.M.G.'s attitude in this matter. The Editor, being a truthful man, has admitted that the Post Office attitude to interference leaves a nasty taste in the mouth, but at the same time has pointed out that the anti-interference clauses in the 1949 Act are inoperative and nowt can be done about owt until the committee to advise the P.M.G. has been appointed. It is on the recommendations of this committee that the P.M.G. will make the necessary regulations regarding interference.

Personally, I have little sympathy with those who manufacture or use "unsilenced" apparatus, but I must confess to feeling the same lack of sympathy with those radio users who permit an over-loud loudspeaker to cause acoustic discomfort to other listeners and to non-listeners.

Acoustic interference from an over-loud loudspeaker is, in my opinion, covered by the Act, since such interference must necessarily arise from electro-magnetic causes, just as the acoustic interference brought about in a listener's loudspeaker or television screen by a neighbour's vacuum-cleaner arises from electro-magnetic causes in it.

Eatanswill 1950

THE last General Election showed up clearly the power of P.A. to add to the growing impersonal mechanization of our lives. The next Election, which newspapers with Birnam Wood-Dunsinane equivocation, tell us will come sooner rather than later, will undoubtedly show it up more clearly still unless I can be given time to organize an anti-P.A. party and to equip my candidates with the necessary personal P.A. apparatus to silence all opposition.

The wireless set in the home can be quickly switched off if you feel that a political speaker's remarks are causing a dangerous rise of blood pressure, but we are all helpless against the P.A. van bowling and bawling along our streets. It is even useless determining not to vote for the side which makes, what the greatest of our poets calls, "this horrid din that doth offend our ears," for it would mean not voting at all, since all parties use this offensive street weapon.

Even the political meetings in the market places of our ancient country towns are no longer the personal man-to-man affairs they used to be when candidates kissed all the babies, washed and unwashed, and their mothers, too, in cases where the Dickensian reply was "Barkis is willin'." To-day, in this mechanized age, trained troupes of glamorous female osculators, hired from a theatrical agency, kiss the fathers instead, while the candidate protects himself from homely hecklers by sheltering behind a barrage of loudspeakers and a missile-proof "windscreen" fitted with an electrically driven egg wiper. Even in the meeting halls the heckler's lone voice stands no chance against the mechanical mouthings from the platform.

One remedy would be for each member of the public to be provided with a compact pack P.A. outfit of the type once used by guides in the Fatherland, which I illustrated in these columns some years ago and again reproduce. But it is essential that it be far more compact than this, so that it can become everybody's *vade mecum*.

I am glad to say that I have produced a successful prototype by adopting and adapting the miniature technique used in the modern hearing aid. The biggest problem was the loudspeaker, but even this has been solved by making the horn collapsible and constructing it on the lines of my ancient gamp. The metal ribs provide an excellent "umbrella" aerial for drawing on the B.B.C.'s military band music to reinforce my heckling.

But providing the public with personal P.A. to bark back at the perambulating political P.A. vans

Personal P.A.

would only result in a mad P.A. "armaments race," whereas by equipping my party with pocket P.A., we ought to be able to blast our way to Westminster and place an anti-Political P.A. Act on the Statute Book. Even if Birnam Wood be come to Dunsinane before these words appear, there will be other elections, and we must adopt the motto evolved for the Boy Scouts—"Be Prepared."

Manufacturers' Products

New Equipment and Accessories for Radio and Electronics

Volume Level Meter

THE characteristics of this instrument, which is now in production by Taylor Electrical Instruments, 419-424, Montrose Avenue, Slough, Bucks, are in conformity with standards established in America and elsewhere for programme level indicators.

Essentially the instrument is an a.c. voltmeter of the rectifier type designed to give a zero reference level equivalent to 1 milliwatt when connected in series with 3,600 ohms across a 600-ohm line. "VU's" are then virtually db referred to 1mW with the additional qualification that the readings are taken on programme material rather than with a steady sine-wave input, and that

Taylor Instruments' "VU" meter.

the ballistic constants of the meter movement conform to the following standards: *Speed*—When full-scale voltage is applied the pointer must reach 99 per cent of full scale deflection in between 270 and 330 milliseconds. *Damping*—When full scale voltage is applied the overswing is between 1 and $1\frac{1}{2}$ per cent.

The scale is calibrated in "VU" and percentage, and positive readings above zero are marked in red. The price is £5 10s.

Coaxial Cable Connector

TO meet the need for a simple and reliable connector for coaxial cables carrying an appreciable amount of radio-frequency power, the Plessey Company, Vicarage Lane, Ilford, Essex, has added a new concentric plug and socket to their existing Breeze range. It is available in sizes to accommodate Uniradio 4 and 39 cables that figure in much of the high-frequency equipment used by the Services and by some makes of industrial r.f. apparatus.

The new connector will carry up to 19 A and withstand voltages of 2.5 kV in one case and 3 kV in the other. It comprises a panel member and cable fitting, the latter being available for straight or right-angle connection. Casings are made of die-cast aluminium, and the insulation is high-quality polythene.

Television Accessories

EKCO television receivers are provided with means for the ready attachment of either a pre-amplifier (for areas of low field strength) or an attenuator (for areas of very high field strength). This takes the form of a slide on the back of the cabinet to take either amplifier or attenuator and a socket on the receiver chassis for the power supply to the amplifier.

An amplifier measures $3\frac{1}{2}$in × 3in × $2\frac{1}{4}$in and costs £2. It is available in two types, LGA108 for London and LGA1108 for Birmingham. An attenuator suitable for either transmission costs 7s and measures 9/10in × $1\frac{3}{8}$in × $1\frac{3}{8}$in. The makers are E. K. Cole, Ltd., Southend-on-Sea.

Versatile Radio-telephone

THE PTR6 radio-telephone set made by the Plessey Company, Vicarage Lane, Ilford, Essex, is intended for use in motor cars and on motor cycles. It employs amplitude modulation and operates on a single crystal-controlled frequency in the band 67 to 100 Mc/s.

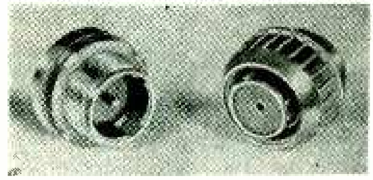
In the case of motor cycle installations, the equipment is divided into two units of approximately equal weight which are mounted behind the saddle and on either side of the rear wheel. The short vertical aerial can be assembled on an extension of the rear number plate support. When fitted in a car, everything is housed in a single container.

The receiver is an eleven-valve superheterodyne, and special attention has been given to the a.g.c. system and to the noise limiter; the one to ensure even signal strength under all conditions and the other to keep out extraneous noise.

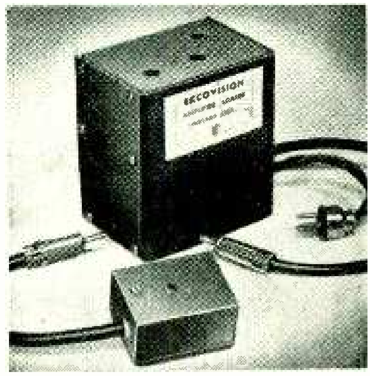
Five valves are used in the transmitter, which is crystal controlled; it gives from 6 to 7 watts r.f. output to the aerial. The modulation amplifier can be switched to feed a "loud hailer" type of speaker when this facility is needed.

A feature of this equipment is that it enables selective calling of any one or all of ninety mobile or fixed installations to be effected from a fixed installation, but not from a mobile. The mobile units can receive the calling signals, and either aural or visual indicators can be employed.

During stand-by operation the power consumption is 23 watts only, and power units for 6, 12 or 24 volts d.c. and 200 to 250 volts a.c. are available.



Plessey Breeze concentric plug and socket with polythene insulation.



Ekco pre-amplifier and attenuator.

Mobile model PTR6 v.h.f. radio-telephone, which embodies a selective calling system, made by Plessey.

Electric Solderguns

WOLF ELECTRIC TOOLS, Pioneer Works, Hanger Lane, Ealing, London, W.5, have produced a range of electric soldering irons. Two patterns are made: an orthodox type and one with a continuous feed of solder to the copper bit.

These irons reach the operating temperature very quickly; the average time to reach a temperature sufficient to melt 60/40 solder is about $3\frac{1}{2}$ minutes.

Despite the quick heating, the design of the element is such that overheating cannot occur, so that the tool may be left unused for quite long periods without the copper bit scaling and burning away.

The design feature that prevents overheating of the copper bit also restricts the general rise in temperature, so that the life of the heater element is correspondingly prolonged. Conservation of heat also leads to economy in consumption, which becomes quite appreciable in the larger industrial sizes.

In addition to studying the electrical qualities of the tool, the makers have also considered ease of handling, and, as the illustration shows, the grip is of the off-straight kind and shaped to fit the hand.

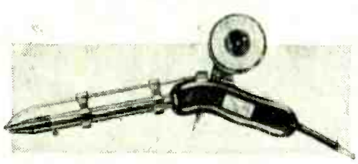
Wolf soldering irons and solderguns are made for voltages of 25 to 250 and in sizes ranging from 60 to 200 watts. A 60-watt automatic feed soldergun costs £2 10s, while a plain soldering iron of the same wattage costs 19s 6d.

Crocodile Clips

No fewer than eighteen different varieties of crocodile clips are now made by A. F. Bulgin and Co., Bye Pass Road, Barking, Essex. A few are illustrated here, three being of the kind that find application in radio test rooms and research laboratories and also in the amateur's den, while the remaining two have been designed for battery charging.

The small sizes are rated at 5 amps, while the larger models will carry up to 25 amps. Among the former is one with special jaws, serrated teeth on one and plain tongue-shaped for the other. This has been produced especially for gripping very fine wires. One of the larger models has curved serrated jaws for securing a firm grip on the round lugs of car batteries.

Many varieties of finish are employed; for example, copper plate, cadmium plate, nickel plate and lead plate on a steel body, or natural brass and nickel-plated brass. The steel body varieties in the small 5-A size cost $4\frac{1}{2}$d each (6d for cadmium plate) and the brass type 6d and $7\frac{1}{2}$d each. Large 25-A battery clips with red, black or white identity inserts in the thumb-grip cost $10\frac{1}{2}$d and 1s each, according to type.



Wolf soldergun with drum of resin-cored solder fixed on the hand grip and (right) Mullard valve volt-ohm meter type E7555 with an r.f. probe.

Samples of Bulgin crocodile clips.

Valve Volt-ohm Meter

Recently introduced by Mullard Electronic Products, Century House, Shaftesbury Avenue, London, W.C.2, is a valve volt-ohm meter with the type number E7555, covering a wide range of voltages and frequencies and having very high input resistances on all ranges. A feature of interest is the inclusion of a position on the selector switch for reversing the input to the meter on the d.c. ranges, thus obviating the need to change over the actual connections when taking measurements on circuits where voltage may change sign.

Six ranges are provided for d.c. voltages covering full-scale readings of 3, 10, 30, 100, 300 and 1,000. A multiplier can be inserted on the last two ranges by a press-switch which extends their f.s. readings to 3 kV and 10 kV respectively.

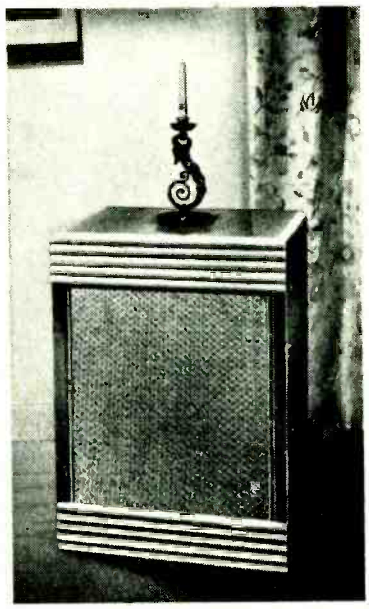
Up to 100 V the input resistance is 15 MΩ, from 300 to 1,000 V it is 10 MΩ and from 3 kV to 10 kV it rises to 100 MΩ.

Measurements of a.c. and a.f. voltage up to 10 kc/s is effected by direct connection to the instrument, and the range covered is 0 to 10 kV. A probe unit containing a diode is provided for r.f. measurements up to 30 Mc/s, and the range is 0-100 V.

Resistance can be measured also, and six ranges together cover 0 to 2 MΩ. The meter is a.c. operated, and costs £45.

Loudspeaker Cabinets

Designed to combine acoustic efficiency with good appearance, the "Ventex" range of cabinets made by C. T. Chapman (Reproducers), of Riley Street, Chelsea, London, S.W.10, are matched to the low-frequency characteristics of the loudspeaker units with which they will be used. Type 1255 is designed for the Goodmans Axiom 12 or 22, with bass resonance at 55 c/s and extends the frequency response down to 30 c/s with an average power handling capacity of 15 or 20 watts, depending on the type of unit. In the Type 1275 cabinet the characteristics of the Goodmans T2 unit with a bass resonance of 75 c/s are taken as the basis for design.



"Ventex" cabinet for Goodmans 12-inch loudspeakers.

The dimensions of the Type 1255 are $31\frac{1}{2}$in x $22\frac{1}{2}$in x $15\frac{3}{4}$in, and of the Type 1275, $25\frac{1}{2}$in x 21in x $14\frac{1}{2}$in. The foundation cabinet work is of heavy reinforced construction and alternative polished veneer finishes of walnut, sycamore, mahogany, etc., are available. The price is £15 10s, including packing, but not carriage.

LETTERS TO THE EDITOR

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

Output Impedance Control

I MUST thank Mr. Thomasson for his immediate proof of my statement that the mention of damping factor will always provoke correspondence. His discussion of the mechanism is no doubt correct, though personally I prefer to regard the problem as one of designing a filter network: perhaps I may replace the "swinging door" analogy by a swinging urchin on a swinging gate.

The power figures given have puzzled me. If I am listening at a level of 50 mW, with this power representing the level of a line-up tone at 40% modulation, the peak level cannot exceed about 300 mW for 100% modulation. We obviously cannot resolve our difference in your correspondence columns.

The onset of oscillations can be detected by ear: at first the oscillation occurs only at peaks (maxima *or* minima) of low frequencies, and resembles the "buzz effect"; under steady state conditions the measured distortion may be as low as 1%. At higher oscillation levels there is severe peak chopping. It is true that the oscillations are observed only because of the degradation of quality, the frequency being usually 40-80 kc/s.

The requirement for a gain of $|1/B|$ (the minus sign is just a nuisance), is that AB should be large: I do not know whether the B dropped out after the manuscript stage or whether I meant to write "A must be large compared with 1/B," the form which is most nearly related to the idea used in choosing A.

The plan of feeding a number of loads from a single amplifier is quite satisfactory provided that the generator impedance is low enough and the valve sees the optimum impedance at full load. Since the article was written a three-stage amplifier has been constructed, feeding 40 points at 50 mW each. The individual load resistances are 600 ohms, and each is fed through a 600-ohm resistance. The total power with all loads connected is 4 watts, and the output transformer is designed to give optimum loading with 30 ohms connected to the line. The amplifier generator impedance is 0.1 ohm. No clicks are observed when loads are connected, and any disturbance injected at one outlet is attenuated 80 db to the others. The only way to specify such amplifiers is to say that they will give an output of E volts (11 in this particular case) with a maximum power output of W watts (4 in the 3-stage amplifier). To scale down the impedances for the direct connection of loudspeakers would clearly be difficult: the wiring alone would make the achievement of a few milliohms impossible.

Finally, Sir, may I thank Mr. Thomasson for his kind conclusion. *O si sic omnes.*

THOMAS RODDAM.

IN the first paragraph of the article by Thomas Roddam in the February 1950 issue, there appears a statement which seems to me to indicate that the author cannot have thought very clearly about the theory of loudspeaker damping and transient response.

He says that if a loudspeaker has too much electro-mechanical damping then "transients are lost completely." Analogies are made between the behaviour of a loudspeaker diaphragm and the behaviour of swing doors and galvanometers. The conclusions about the amount of damping desirable, which are drawn from these analogies, would be correct only if a loudspeaker diaphragm were very stiffly suspended, and if the aim were to make the diaphragm *displacement* follow faithfully the amplifier output waveform. This may be the aim in the case of high-quality headphones, which work into a very small volume of air, i.e. the ear-cavity, but the situation is quite different in the case of a loudspeaker, as may be seen by considering the behaviour of an idealized loudspeaker.

The ideal moving-coil driving system would have a coil wound of wire of zero resistance and would be fed from an amplifier of zero output impedance. The self-inductance of the coil, when held stationary, would also be zero; it can in practice be made quite small by having a field magnet powerful enough to saturate the pole-pieces and so reduce their a.c. permeability to a very low value. Under these conditions the coil velocity would, at all instants, have to be such as to generate a motional back-e.m.f. just equal to the amplifier output voltage. The waveform of the coil *velocity* would then be exactly the same as that of the amplifier output voltage, and this would of course apply to transients as well as to sustained notes.

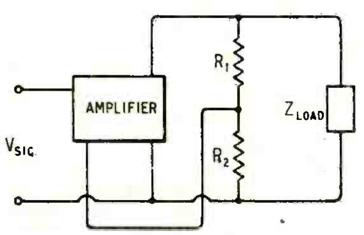
To complete this concept of an

ideal loudspeaker, the coil would be attached to a light, but perfectly rigid, diaphragm, working into a large exponential horn. The horn would present the same resistive acoustic impedance to the diaphragm at all frequencies, so that the frequency response of the loudspeaker would be level, and the transient response perfect.

Mr. Voigt has tried very hard to make loudspeakers which approach as close as possible to this ideal, and the excellent fidelity obtainable from a Voigt speaker, under really favourable conditions, does, I think, provide a good practical demonstration that the above basic principles are correct; in particular, it may be remarked that the transient response, when fed from an amplifier of low output impedance, is quite outstandingly good.

These arguments do, I think, show that it is not, in general, correct to suppose that a loudspeaker gives the best transient response when the amplifier output impedance is adjusted to give critical damping; and further, that with a properly designed speaker, the best results, particularly as regards transient response, are obtained when the electro-mechanical damping is very high.

It is, however, quite likely that some commercial loudspeakers will sound best when the damping is reduced, but for quite different



$R_1 + R_2 \gg Z_{LOAD}$

AND $\frac{R_2}{R_1 + R_2} = \beta$

reasons. For example, if a loudspeaker is deficient in extreme bass, an easy way to compensate this (not really a very elegant way) is to feed it from a high-impedance source, thereby allowing the bass resonance to have more effect. The rising top response produced may be corrected by a simple top-cut tone control. It is also possible for some fairly high-frequency diaphragm resonances to be more prominent when a very "rigid" drive is applied to the diaphragm by the speech coil, and in a loudspeaker in which there is a bad resonance of this type, more pleasant results may again be obtained when the amplifier output impedance is fairly high.

With regard to the circuit used for providing a variable output impedance, I think its main virtue is its ability to give negative values of output impedance. If I am not mistaken, the voltage across the loudspeaker, with a constant signal input, is proportional to $Z_{load}/(Z_{out} + Z_{load})$ in which Z_{out} is varied by means of R_4. Hence, as far as variation of gain with output impedance is concerned, the result is the *same* as it would be if we had a zero-impedance amplifier and put a variable resistance between this and the loudspeaker; the special circuit described can, however, produce an effect equivalent to making this variable resistance negative. My derivation of the above result is as follows.

In the accompanying diagram the amplifier in the box has internal positive feedback, as in Fig. 3 of the article under discussion, and has a high-impedance output (pentode). Its gain, expressed as a mutual conductance, is G which is variable by the positive feedback.

$$\frac{V_{load}}{V_{sig}} = \frac{GZ_{load}}{1 + GZ_{load}\beta}$$

$$Z_{out} = \frac{1}{\beta G}, \therefore G = \frac{1}{\beta Z_{out}}$$

Hence

$$\frac{V_{load}}{V_{sig}} = \frac{Z_{load}/\beta Z_{out}}{1 + Z_{load}/Z_{out}} = \frac{1}{\beta}\cdot\frac{Z_{load}}{Z_{out} + Z_{load}}$$

It may possibly be of some interest to mention that we have a stabilized power-supply at T.R.E. in which variable positive feedback is applied to the stabilizing amplifier, with the result that the output impedance of the power-pack may be adjusted to positive zero or negative values.

PETER J. BAXANDALL.
Malvern.

I MUST protest against the statement of your contributor Thomas Roddam, in the February issue of *Wireless World*, that an overdamped loudspeaker will have a poor transient response. On the contrary, provided the damping is electromagnetic, and is mainly due to the speaker being fed from a low source impedance, the greater the damping the better the transient response.

That this is so may be seen from the following reasoning. The driving force on the voice coil is proportional to the current passing through it, which will be given by the difference between the source e.m.f. and the motional e.m.f., divided by the total electrical impedance of the source plus voice coil. If this impedance is very small, then the driving force will be practically infinite unless the motional e.m.f. is equal and opposite to the source e.m.f. at all times. Under these conditions, the motional e.m.f. must follow the source e.m.f. and so the velocity of the voice coil will be proportional to the source e.m.f. Thus all frequencies will be well reproduced, until the mechanical impedance of the cone system becomes so large that the current needed to drive it produces appreciable voltage drop in the coil and source. This is clearly the condition for good transient response, although the cone will be practically "blocked" as far as external mechanical forces are concerned.

Mathematically these statements may be proved as follows:—

The driving force F_M in the coil is equal to Bli, where B is the flux density, l the length of the coil and i the current passing through it.

$$\therefore Bli = Z_M\dot{\xi}$$

where Z_M is the mechanical impedance of the coil and cone assembly and ξ the displacement.

The back e.m.f. will be

$$Bl\dot{\xi} = \frac{B^2l^2}{Z_M}\cdot i$$

Therefore the total electrical impedance looking into the coil is $Z_B + \frac{B^2l^2}{Z_M}$, where Z_B is the blocked impedance of the coil.

If Z_S is the source impedance, we have

$$i = \frac{E\epsilon^{j\omega t}}{Z_S + Z_B + \frac{B^2l^2}{Z_M}}$$

and

$$F_M = \frac{BlE\epsilon^{j\omega t}}{Z_S + Z_B + \frac{B^2l^2}{Z_M}} = Z_M\dot{\xi}$$

Therefore

$$\dot{\xi} = \frac{BlE\epsilon^{j\omega t}}{B^2l^2 + Z_M(Z_S + Z_B)}$$

If $g(\omega)$ is the Fourier transform of an applied transient voltage, then we have

$$\dot{\xi} = \frac{1}{2\pi}\int_{-\infty}^{\infty}\frac{Blg(\omega)\epsilon^{-j\omega t}\,d\omega}{B^2l^2 + Z_M(Z_S + Z_B)}$$

If $Z_M(Z_S + Z_B) \ll 1$, then

$$\dot{\xi} = \frac{1}{2\pi Bl}\int_{-\infty}^{\infty} g(\omega)\epsilon^{-j\omega t}\,d\omega$$

and is therefore proportional to the applied transient voltage. Otherwise the integrand will have poles at the zeros of Z_M and of $Z_S + Z_B$, and resonances at these frequencies will be produced.

Kenton, HOWARD PURSEY.
Middlesex.

THOMAS RODDAM, in his article in your February issue, gives the expression for the output impedance of multi-stage amplifier as

$$\left[\frac{r_a}{1 + A\beta}\right]\sqrt{n}$$

where n is the output transformer ratio (which way is n as a matter of interest?). This expression is based on a popular canard that the output or source impedance at the primary of the output transformer is $\frac{r_a}{1+A\beta}$; the true value for the multi-stage case is, however, $\frac{r_a}{1+A_1\mu\beta}$.

A_1 is the gain from the point of injection of the feedback voltage to the grid of the output stage.

μ is the amplification factor of the output valve.

r_a is the a.c. resistance of the output valve.

β is the feedback ratio.

In the case of a high-impedance output valve, the error involved in using the author's expression can be quite considerable. Even granting the author's expression, the output impedance as seen at the secondary would be

$$\left[\frac{r_a}{1+A\beta}\right]\Big/n^2 \quad \text{not} \quad \left[\frac{r_a}{1+A\beta}\right]\sqrt{n}$$

The true expression for output impedance at the secondary becomes, therefore,

$$\left[\frac{r_a}{1+A_1\mu\beta}\right]\frac{1}{n^2}$$

(it has been assumed that the transformer ratio is $n:1$).

Arborfield. E. JEFFERY.

I FEEL sure that most quality enthusiasts like myself can offer nothing but our appreciation and praise for the article on "Output Impedance Control" by Thomas Roddam which appears in your February issue.

Mr. Roddam, in his closing paragraph seemed to be interested in the application of his circuit to the well-known Williamson amplifier. He goes so far as to suggest how it may be done, subject to obvious precautions. It would be simple enough to split R_{10} and R_{22} in the Williamson amplifier so that R_{10} is substituted for R_1 and R_{22}, for R_3, but this method almost destroys the self balance of V_5 and V_6, and the self balance of V_3 and V_4 is totally destroyed. This being so, V_3 and V_4, also V_5 and V_6 must match to within 3% or less, because upon application of positive feedback the mismatch is made prominent. The arm (R_3, R_4, R_1) with the greater gain, giving the higher feedback voltage, thus has command of the negative loop already in existence. The whole method fails in this case, for the above reasons, and also that the response curve is lost, because of the positive loop gain falling at upper frequencies, although the negative loop tends to correct this. The loss of self-balance is the most important drawback. HENRI J. PICHAL.

Southend-on-Sea.

Dark Television Screens?

I WAS interested to read the letter from Alan Humphreys in the March issue of *Wireless World* on the subject of dark-screen cathode-ray tubes. Some time ago I took out a provisional patent incorporating this idea, but I would point out that though it is possible by this means to considerably increase the contrast on the screen when viewed in daylight, it is not easy to produce a fluorescent material with a dark ground which will still transmit the light from activated portions with negligible attenuation.

The light produced on the screen is largely generated in the surface layers of the crystals at the back of the screen, and any darkening of the background, as seen from the front, must therefore intercept and attenuate the transmitted light.

In the case of cathode-ray tubes having a screen which fluoresces as a colour, as distinct from the white fluorescence normally required for television, a considerable improvement can be achieved by treating the crystals with a dye of the same colour as the fluorescence; the attenuation is then small, but the background is relatively dark. Screens which glow with a white fluorescence present a much more difficult problem and really require naturally dark crystals in a very thin layer. I know of no suitable material for this purpose.

The use of F centres in crystal lattice structure should not be overlooked as a possible method of achieving the desired result. The skiatron projection system was, of course, a method in which this property was used.

R. C. JENNISON.

Manchester, 13.

Ultrasupersonics

I NOTICE a growing tendency to apply the term "ultrasonic" to vibrations with frequencies above the upper limit of audibility. *Ultra*, meaning beyond, could apply equally well to frequencies below the lower limit of audibility (e.g., those associated with the passage of a group of meteorological secondary depressions).

"*Super*sonic" (meaning above) is in danger of being lost by default to the aerodynamicists, who apply it consistently and with every right to speeds above the speed of propagation of sound in air.

In the early stages of the development of the art of producing vibrations of extra-high frequency and large amplitude, with which I had some connection (*circa*, 1917), it never occurred to us to talk of anything but "supersonics," and I fail to see now why we should abandon a perfectly good word, just because the flying types have "muscled in."

As an indication of the sort of mess we shall get into if we don't make a stand, consider this definition from a well-known American textbook: "Ultrasonic is a term used to designate any sound above the audible frequency range. Supersonic is a term used to designate any very intense sound regardless of frequency."

What is "very intense," or, for that matter, "*sound* above the audible frequency range?"

HENRY MORGAN.
Hindhead, Surrey.

Stereophonic Broadcasting: B.B.C.'s Reply

IN your March issue, Major Jeffery takes us to task for not keeping listeners sufficiently informed on our engineering policy and developments. I hope there are not many of your readers who think this, because we always give as much information as we can as soon as it can be given. But when changes or new developments are of an experimental nature we must take care that we do not mislead listeners.

The change of location of the Third Programme transmitter serving the London area was announced in the Press three days before it took place. In addition, microphone announcements were made in both the Third and Home Service programmes before the change was made.

There has been no secret about the new v.h.f. station at Wrotham. As far back as March, 1948, we announced the location of this station which has been built for experimental frequency modulated and amplitude modulated transmissions. Now that the construction of the station has been completed, we shall shortly issue a statement concerning test transmissions.

We do not propose to radiate binaural transmissions from Wrotham. We first studied this system of transmission before the war and made some experimental transmissions both by radio and over short-distance wire circuits. The idea is an interesting one, but the advantages are doubtful and the objections are overwhelming. As far as I am aware, there is not now and never has been a regular service of binaural broadcasting in any part of the world. The system requires that the programme chain must be duplicated from the studio right through the low-frequency and high-frequency chain to the aerial. Moreover, there must be duplication of receiving equipment at the listeners' end. The cost would be very high and double the number of carrier frequencies would be required for transmission. It is no exaggeration to say that, in all the wave-bands now used or projected for sound broadcasting, it would be quite impossible to find sufficient channels to enable this to be done.

Finally, there is no doubt that such a system would interest only a relatively small number of listeners, and for this reason, if for no other, it is doubtful whether we should be justified in spending so much money to give a specialized service to so few people.

H. BISHOP,
Chief Engineer, B.B.C.

"Industrial High Frequency Electric Power"

IT was disappointing to find, in his review of my recent book (February 1950 issue), that A. H. C.'s principal criticisms appear to arise from considering certain statements without their context. Statements which he rightly condemned as incorrect when applied to high-frequency oscillators actually refer to Class A resistance-loaded amplifiers. I think this is made sufficiently clear in the text (pp. 110-113). I think it is also fair criticism to say that A. H. C. gave his readers little indication of what the book is about. E. MAY.
Erdington, Birmingham.

"Solving Parallel Problems"

MENTAL arithmetic is easy if one is using one's own mental processes, but may be more difficult if other people's are being followed. To my mind there is a simpler approach to the calculation of the combined resistance of resistors in parallel than that outlined by D. A. Pollock in your March issue.

Any resistance R is equivalent to *n* resistances in parallel, each having the value *n*R. Thus, to quote Mr. Pollock's first example of 1Ω in parallel with 2Ω, 1Ω is equivalent to two parallel resistances of 2Ω each. The whole then becomes three 2Ω resistances in parallel, and the resultant is one-third of any individual one; i.e., $\frac{1}{3} \times 2 = \frac{2}{3}\Omega$.

Mr. Pollock's third example of 24,000Ω and 8,000Ω may also be worked out:—

$$\frac{1}{R} = \frac{1}{24{,}000} + \frac{1}{8{,}000}$$
$$= \frac{1}{24{,}000} + \left(\frac{1}{24{,}000} + \frac{1}{24{,}000} + \frac{1}{24{,}000}\right)$$
$$= \frac{4}{24{,}000} = \frac{1}{6{,}000}$$

Therefore, R = 6,000Ω.

In addition, three or more parallel resistances can be manipulated simply, provided a convenient lowest common multiple can be found.

Consider 10Ω, 20Ω and 30Ω in parallel. The lowest common multiple is easily seen to be 60, and each resistance must therefore be considered as a number of parallel resistances of 60Ω. Their numbers are, at a glance, seen to be 6, 3 and 2, totalling 11. The resultant resistance is thus 60/11 = 5.45Ω.

London, S.E.11. R. PARFITT.

CLUB NEWS

Southend.—The contest for the new Pocock cup and other trophies competed for by members of the Southend and District Radio Society (G5QK) will take place on March 31st. Sec.: J. H. Barrance, M.B.E. (G3BUJ), 49, Swanage Road, Southend-on-Sea, Essex.

Sunderland.—The fifth talk in the series on valve manufacture which is being given by members of the staff of the Edison Swan Electric Co. to the

Sunderland Radio Society will deal with sealing, exhausting, ageing, etc. It will be given by J. Finney at 7.30 on April 19th at Prospect House, Prospect Row, Sunderland. Sec.: C. A. Chester, 38, Westfield Grove, High Barnes, Sunderland, Co. Durham.

Wadebridge.—The West of England Amateur Radio Club is holding a short-wave listening contest in the 20- and 80-metre bands from 1800 on April 8th to 2100 on April 9th. Sec.: C. Richards, W.E.A.R.C., St. Issey, Wadebridge, Cornwall.

Warrington.—Meetings of the Warrington and District Radio Society (G3CKR) are held on the first and third Mondays of each month at 7.30 at the Sea Cadet Headquarters, Wilderspool Causeway. Sec.: J. Speakman, Davyhulme Cottage, Dark Lane, Whitley, Nr. Warrington, Lancs.

Watford.—Members of the Watford and District Radio and Television Society conduct a hospital service which includes the maintenance of the radio equipment in the Watford Peace Memorial Hospital. Meetings of the club are held at 7.30 on the first and third Tuesdays of each month at The Cookery Nook, The Parade, Watford. Sec.: R. W. Bailey (G2QB), 32, Cassiobury Drive, Watford, Herts.

Manufacturers' Literature

ILLUSTRATED leaflets describing the DAC10 mains portable and RG11 radiogramophone, from Bush Radio, Power Road, London, W.4.

Supplementary list "Brand New Components, 1950," from A. F. Bulgin & Co., Bye Pass Road, Barking, Essex.

Leaflet describing the "Grampus" all-square welding vice for building angle framework, from C. Caspar & Co., 146-7, Grosvenor Road, London, S.W.1.

Leaflet No. 7, describing the Type SP10 slow-speed oscilloscope (0.1 to 50 c/s) for medical and industrial research, from A. E. Cawkell, 7, Victory Arcade, The Broadway, Southall, Middlesex.

Technical descriptions of "Cintel" Type 2000/5 stabilized e.h.t. power packs; R.C. oscillator and automatic-frequency monitor; and microsecond counter chronometer, from Cinema Television, Worsley Bridge Road, Lower Sydenham, London, S.E.26.

Leaflet describing "Elac" permanent-magnet focus units, from Electro Acoustic Industries, Broad Lane, Tottenham, London, N.15.

Illustrated leaflet (V5/TT/50) giving details of Ferranti television tubes, from Ferranti, Ltd., Hollinwood, Lancs.

List of transmitters and receivers for the radio amateur, from Radiocraft, Ltd., 25, Beardall Street, Westow Hill, London, S.E.19.

Leaflet giving detailed specification of the Eddystone "750" communications receiver, from Stratton & Co., Alvechurch Road, West Heath, Birmingham, 31.

RANDOM RADIATIONS

By "DIALLIST"

Are Americans Insular?

THE NOTE on American insularity in last month's *W.W.* may have surprised readers who don't see much of U.S.A. publications; to those who see a good many of them it seemed just the kind of tactful statement that may do something to improve the present unsatisfactory position. I don't believe that American editors and writers wilfully belittle the great things in radio, radar and television that have originated and continue to originate here, in France, and in other European countries. What I think many of them do is, consciously or unconsciously, to play up to the desire of their readers to see their own land first in everything. By so doing they render these readers a disservice, for many of them remain woefully ignorant of important advances in various branches of electronics and telecommunications that are made in other countries. The average American owner of a television receiver does not, for example, realize two things of some importance regarding the relative merits and demerits of television in the U.K. and U.S.

The TV Aspect

The first of these is that the B.B.C.'s technique is immeasurably superior to that behind the bulk of U.S.A. television transmissions: I have never yet met an educated American who did not at once volunteer an opinion on these lines after seeing our television. In these notes I have quoted more than once extracts from American publications which show that they tolerate standards of linearity which would keep the B.B.C.'s telephone exchange busy with the complaints of irate viewers if they obtained here even for an evening or two. The second is that a television receiver of comparable screen size costs a good deal less here than it does in the States. I've often wondered why this should be so and I just don't know the full answer, though, of course, they have to cope with variable tuning. The American home market is probably ten times as big as ours and their valves are very much less expensive. But it is our manufacturers who have found out how to provide the public with the moderately priced receiver.

And Radar

I am completely flabbergasted by some of the post-war American articles on the subject of radar. One of these began: "There was nothing new about the magnetron . . ." True enough; but the *cavity* magnetron was revolutionary—and the article never so much as mentioned Boot or Randall! Another article led off with the astonishing statement: "It is not generally realized that at the beginning of the war the German radar was much superior to the British." Not, we were told, until America showed how things should be done was the position retrieved! Yet another article told its readers that until America came into the war and produced I.F.F. the British had no means of telling whether a "target" on the radar screen was friendly or hostile! Well, I was regularly using I.F.F. day and night from quite early days of hostilities and I know that our people invented not only the system, but also the name, which is, of course, short for Identification Friend or Foe. It's a pity that any country should give the appearance of trying to steal the applause in matters of science. Theoretical or applied science, like music and other forms of art, is international and should know no frontiers.

Radierlscortia?

So, for at any rate four years including 1950, there won't be a Radiolympia. This year's show is to be held at Birmingham in September and for the three following autumns Earls Court has been chosen. A good site, I think, for it's easy to get to it from any part of London. I think it's a good idea to hold the radio show at Birmingham this year, for the town, apart from its own big population, is far more easily and more cheaply accessible than London to a great number of people living in the Midlands and the West. Thank goodness, the proposal (quite strongly supported by some sections of the radio industry) to hold the national radio show in June instead of September was not adopted. The surest way of making the radio exhibition a sickening flop would be to hold it in the hottest, finest and traditionally most glorious outdoor month in the British calendar.

Women and Wireless

"FREE GRID" and others have remarked not once but many times on the general inability of the allegedly gentler sex to tune a radio receiver by ear. To me it is one of the profounder mysteries of nature that a woman with a genuine love of music can listen spellbound to the rendering of an Albert Hall concert by a set that is anything up to a couple of kilocycles off tune. Mrs. Diallist, for example, can never have enough music, whilst I can endure only small and infrequent doses of anything that is not simple, cheerful and what Americans might call easy on the ear. Yet, whenever I go into the room where the broadcast receiver lives and find her listening to a musical transmission that she has herself tuned in I dash to the control knobs almost in one bound. My unmusical ears are offended by the lopped sidebands and instantly rebel against a cacophony which their musical opposite numbers were accepting as euphony.

The More it Grows

AS MORE stations come into operation the popularity of television as a form of home entertainment should increase far more rapidly than would be expected from the number of people that each transmitter adds to those within receiving range. Here's the reason. Every station will be connected to London by a two-way link; it will therefore be possible to transmit to and relay from London events taking place in any television area. There is no doubt that "actuality" broadcasts are those making the strongest appeal to viewers. So far, these are limited to events in the London area; but it will soon be possible to tap the Midlands. Later will come the North of England, Scotland and the West. When television can show the whole country the Grand National, the Waterloo Cup, a rugger match at Murrayfield or Cardiff, soccer at a large selection of grounds, a meet of the Devon and Somerset at Dunkery Beacon, and things of that kind, its appeal will become irresistible.