Wireless World

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Wireless in Westminster

WE should all feel flattered by the attention that our legislators have of recent months paid to radio, and to broadcasting in particular. But sometimes we could wish that more of them had taken the trouble to acquire the smattering of knowledge that seems essential before any application of our art can be rationally discussed. Summer Schools are much in vogue nowadays; would it be vain and fruitless to suggest an intensive course on "What a Young Politician Ought to Know"?

These thoughts may seem ungracious, coming so soon after the display of so much oratory, so much learning and wit; indeed, of so much sheer wisdom and sound common sense on the future of British broadcasting. But, unfortunately, all too many of the ideas and proposals of our political orators have been marred by failure to take into account some crucial and fundamental technical factor. Those of them who enjoy the advantage of having technical advisers ready to hand do not seem always to seek their guidance.

Too many inexact parallels have been drawn. To compare broadcasting with such mediums of communicating intelligence as the Press leads to very woolly arguments. Theoretically, the possible number of newspapers is unlimited, while the number of radio channels is in theory, and still more in practice, distinctly limited. That leads us straight to the thorny question of monopoly, which, at any rate in regard to the means for disseminating ideas, politicians of all colours agree is at least suspect, if not actually an evil thing. But all radio communication is inherently monopolistic. Presumably the word "monopoly" should, by its derivation, not be qualified, but we may be forgiven for saying that in fact every holder of any kind of transmitting licence enjoys a limited monopoly either of spectrum space, time, spatial coverage or a mixture of all three. The sturdiest individualist, if he knows anything about radio, will never press for complete freedom of the ether.

During the debate on the broadcasting White Paper in the House of Lords, one of the speakers tried most eloquently, but, judging by later speeches, rather unsuccessfully, to dispel the idea that the monopoly bogy could easily be laid by legislative action. But, so far as we can remember, the politicians' attention has never been directed to another sedulously fostered misunderstanding—the idea that competition between B.B.C. "regions" will lead to better programmes. How that can be we can never see. As things are, the broadcasting service is barely adequate for full national coverage and listeners hear only the stations of their own region. That being so, the various regions cannot effectively compete for the interest of those living outside their areas.

Finally, to point the moral, here is a story that for our present purpose at least ought to be true. A cryptic statement in Parliament was made nearly a year ago on a "new" system that should be considered before any decision was made on v.h.f. broadcasting. It is now rumoured that the mystery is solved; that the system in mind was in fact that described elsewhere in this issue under the title "New Kind of V.H.F. Propagation." Readers can themselves judge the applicability of this "system" to broadcasting!

Guardians of Our Jargon

A LETTER printed on another page reminds us that the B.B.C. is the guardian over something more than the tongue that Shakespeare spoke. The Corporation should exercise some sort of internal censorship over its use of the jargon appertaining to radio—its own medium of distribution. We share our correspondent's doubts over the need for (and precise meaning of) "pre-recorded." And other radio-linguistic crimes have been committed; we have heard talk of "broadcasting from taxis" when "radio-telephony" was meant. But happily the supreme contradiction in terms "broadcast to the B.B.C." (of a report received over a point-to-point channel) seems to have disappeared.

"Broadcasting" is a good word, coined in accordance with the best usage of figurative English. The B.B.C., in whose title the word appears, should be the last to lend themselves to its corruption.

Faulty Interlacing

Diagnosing the Trouble: How it can be Cured

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

IT is now universal practice to transmit an interlaced picture in order to reduce the transmitted bandwidth for a given number of lines. In theory it is quite an easy matter to design a receiver which will produce a correctly interlaced picture. Unfortunately in practice this is far from the case and, in the author's experience, there are few receivers which produce a really correctly interlaced picture. Many of the complaints concerning the "lininess" of a 405-line picture are due to incorrect interlace, or complete lack of interlace. In the latter case the picture becomes equivalent to a 202-line picture, but with rather poorer horizontal definition since each line is a combination of two slightly different lines, superimposed on each other. If the picture is correctly interlaced the two sets of lines (one set belonging to each frame) should fit between one another and be *equally* spaced. In order to obtain correct interlace the line time base and, in particular, the frame time base must be accurately synchronized to the line and frame synchronizing pulses respectively. There is a natural tendency for the frame time base to be synchronized by the line pulses, so that the frame flyback starts at the end of a line instead of half-way along it, as should be the case for odd frames. As a result of this one would expect that either a correctly interlaced picture would be obtained or else a picture showing complete lack of interlace. In practice this is not the case. Most sets which fail to interlace correctly do attempt to interlace, but the lines are not equally spaced. *Complete* lack of interlace does not seem to be common.

Before discussing the reasons for failure to interlace it is important to see the difference produced by a picture with correct interlace and one with only partial interlace. In Fig. 1(a) is drawn a set of lines corresponding to a correctly interlaced picture. The width of the line is about 70 per cent of the total space so that the dark portion between the lines is approximately 30 per cent of the line spacing. If the lines are now moved so they are approximately 20 per cent from equal spacing, Fig. 1(b) is obtained. The result is that one set of dark lines is now increased by 60 per cent, and, if these two figures are examined at a suitable distance, it will be found that the lines show up more distinctly in (b) than in (a). If the lines are moved so that they are approximately 30 per cent from equal spacing, two lines touch and Fig. 1(c) is obtained—the lines are now much more pronounced. If no interlace takes place the result is as shown in Fig. 1(d) which is vastly different from that of Fig. 1(a).

Fig. 2 shows the difference between a portion of a correctly interlaced raster (a) and one with no interlace (b), the only difference between the two photographs being a change of time base and synchronizing separator. These photographs were taken on a synchronized raster but with no modulation and the flyback is, therefore, clearly visible. The difference in the "lininess" of these two pictures is very obvious. Fig. 3 is another set of two photographs, (a) being a correctly interlaced picture and (b) a picture with a little or no interlace, the only difference in this case being a change in the frequency control of the time base. The photographs are a portion of the "picture" from a pattern generator. Not only does the interlaced picture show less line structure, but also gives the appearance of better *horizontal* definition.

In practice complete lack of interlace does not seem to be common but a "pairing" of the lines occurs. Fig. 4 shows the difference between a correctly interlaced picture at (a) and a "paired" or partially interlaced picture where the lines are unequally spaced as at (b). In this case the error in spacing is only about 20 per cent, but the difference in line structure is quite apparent. Not only is a "liny" picture produced, but the vertical definition is reduced.

Having now seen the importance of correct interlace, we will look at the problems involved. The synchronizing of the line time base from the line synchronizing pulses is comparatively easy and no more will be said about this. In order to obtain correct interlace the frame time base must be *accurately* synchronized to the frame synchronizing pulses. The only difference between line and frame synchronizing pulses is that of duration, the line pulses being 10 microseconds (taking round figures) and the frame syn-

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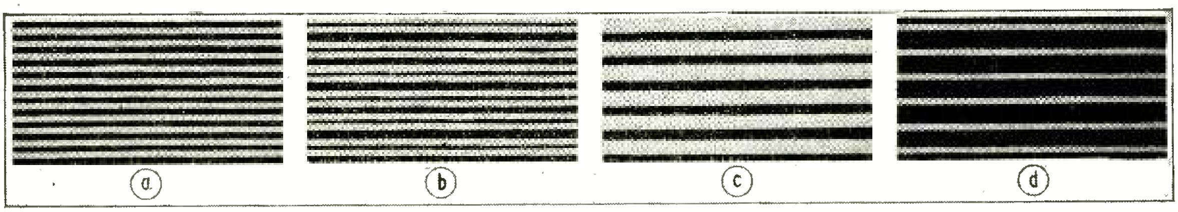
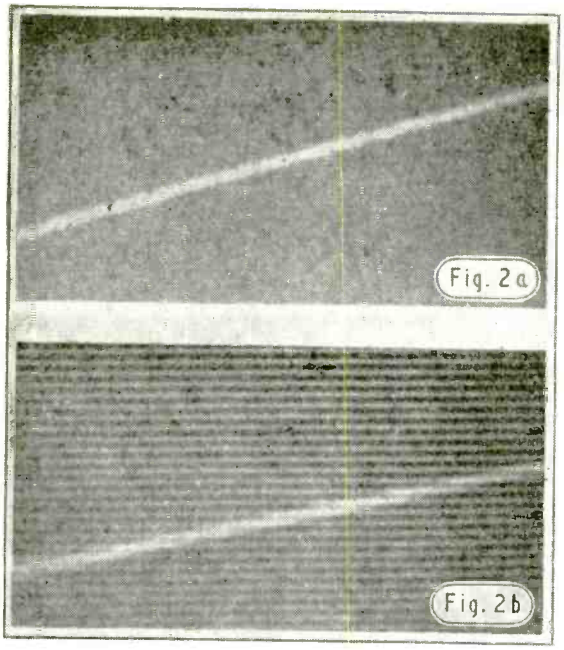
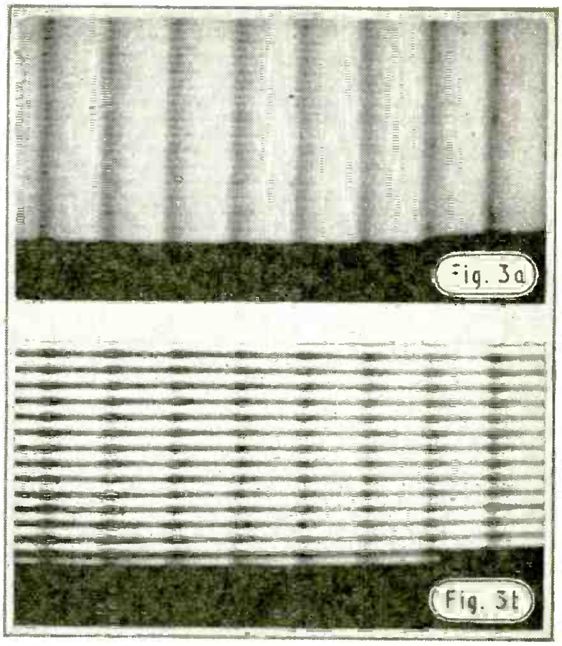
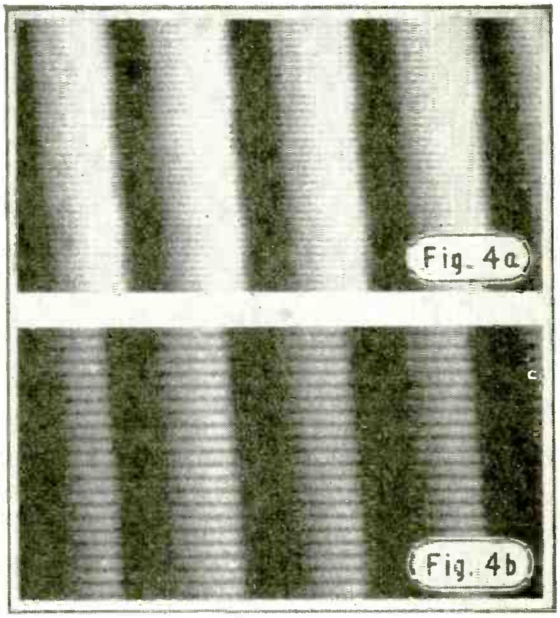


Fig. 1. Drawing showing the importance of correct interlace : (a) correct interlace ; (b) approximately 20% from correct interlace ; (c) approximately 30% from correct interlace ; (d) complete lack of interlace.







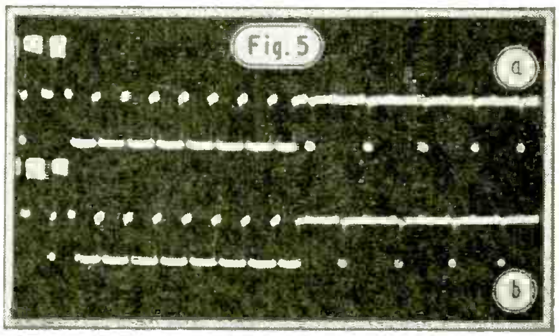


Fig. 2. Showing the effect of lack of interlace on a portion of an unmodulated raster : (a) correct interlace ; (b) no interlace.

Fig. 3. Showing the effect of lack of interlace on a portion of a test pattern : (a) correct interlace ; (b) no interlace.

Fig. 4. Showing the effect of partial interlace : (a) correct interlace ; (b) partial interlace (about 20% from correct interlace).

Fig. 5. Waveform during the frame synchronizing period : (a) even frames ; (b) odd frames.

chronizing pulses 40 microseconds. The frame synchronizing period of the signal transmitted by the B.B.C. consists of eight such frame pulses, extending over a period of four lines at the end of each frame. Since the picture is to be interlaced, the frame pulses on odd and even frames must be differently spaced, relative to the line synchronizing pulses, since the fly-back must occur after only half a line in the case of the odd frame.

A photograph showing the even (a) and odd (b) frame synchronizing periods is shown in Fig. 5, actually taken using a pattern generator producing synchronizing signals to B.B.C. standards. For correct interlace the frame time base must be synchronized to the start of the frame synchronizing pulses or with a *fixed* time delay from the start which must be identical on odd and even frames. It is the purpose of the frame synchronizing separator to produce a suitable triggering pulse related in the above way to the frame pulses. The first requirements of a frame synchronizing separator is, therefore, that it must produce a pulse with a fixed time delay to the start of the first frame pulse. In order that the synchronizing shall take place accurately it is desirable that the pulse should have a sharp leading edge. The reason for this is shown in Fig. 6. If the pulse has a sloping edge as shown in (a) then changes in a magnitude of the pulse, or in the triggering voltage of the time base, cause changes in the instant of triggering, and synchronizing is poor. If, on the other hand, the pulse has a sharp leading edge as shown in (b), changes in the magnitude of the pulse, or triggering voltage (within large limits), do not alter the instant of triggering.

It is often stated that so long as the time base is triggered correctly, by the sharp leading edge of the pulse, correct interlace will result. Further, it is said that if the brilliance is turned up, correct interlace may be checked by noting whether the flyback lines are correctly interlaced or by noting whether there are two flyback lines starting approximately half a line apart. This is totally incorrect. The frame time base may be correctly triggered and interlaced on flyback, but this does *not* guarantee that the scan will be correctly interlaced.

One convenient method of checking interlace is to feed the X and Y plates of a cathode-ray oscillograph from the two time bases and increase the frame deflection so that the lines are opened out and clearly visible. Fig. 7 shows a result obtained in this way, (a) being a nearly correctly interlaced picture and (b) a non-interlaced picture, as regards scan. It will be noted that in *both* cases two flyback lines can be seen starting approximately half a line apart and that the flyback is identical in both cases. This means that the flyback is correctly interlaced in both cases, while only (a) is correctly interlaced on scan.

In other words, interlacing on flyback does not ensure interlacing on scan and, of course, it is only the latter which is important. In most cases, but not all, the flyback is interlaced correctly and it is the scan where only partial interlace occurs. This means that some difference must occur between odd and even frames, at the end of flyback or at the start of the scan. The magnitude of the difference to cause incorrect interlace may be very small and therefore impossible to detect on a normal cathode ray oscillograph. Suppose that the interlace on scan is 20 per cent out, i.e., the scan of one frame is moved by one-fifth of half a line from its correct position, or one-fifth $\times 50 = 10$ microseconds. The time of one frame is 1/50th second, or 20,000 microseconds. Thus the percentage change to produce the above error in interlace is $10/20{,}000 \times 100$ per cent $= 0.05$ per cent, a very small amount. Before discussing the reasons for this lack of interlace on scan, two common synchronizing separator circuits will be examined.

Probably the most common frame synchronizing separator is the integrator circuit, consisting, in its simplest form, of a series resistor and shunt capacitor. During the pulses the capacitor charges through the resistor then discharges in the period between pulses. During the period of normal line pulses the space between the line pulses is nine times the period of the pulse, and hence the voltage across the capacitor is small since the charging time is small compared with the discharging time. During the frame-pulse period (see Fig. 5), the pulse time is four times the space between pulses, and the voltage across the capacitor rises because it is being charged for a longer period. In Fig. 8 (a) is shown the effect on even frames, and in (b) the effect on odd frames, both these oscillograms being taken on a special 25-c/s time base. In Fig. 8 (c) is the result when taken on a 50-c/s time base, which gives approximately the superposition of (a) and (b). (The time constant used for (c) is not quite the same as that for (a) and (b).) Three important things should be noted in connection with this frame pulse:—

(a) There is no sharp leading edge, the curvature of the leading edge depending on the time constant used in the integrating circuit.

(b) The start of the pulse is not identical in the case of odd and even frames. This is due to the fact that there is a different voltage across the capacitor at

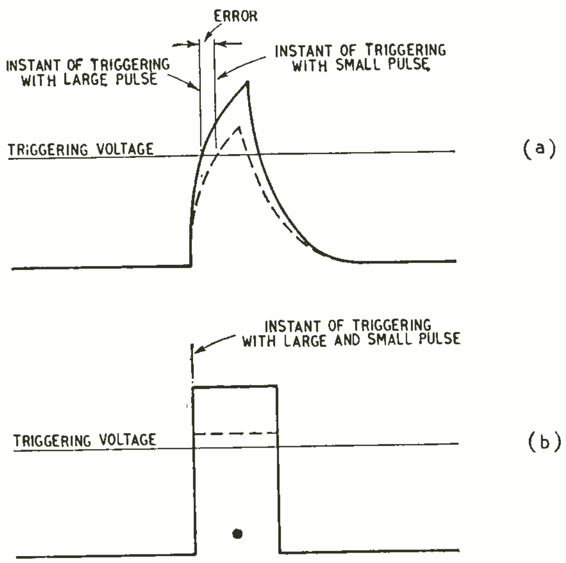
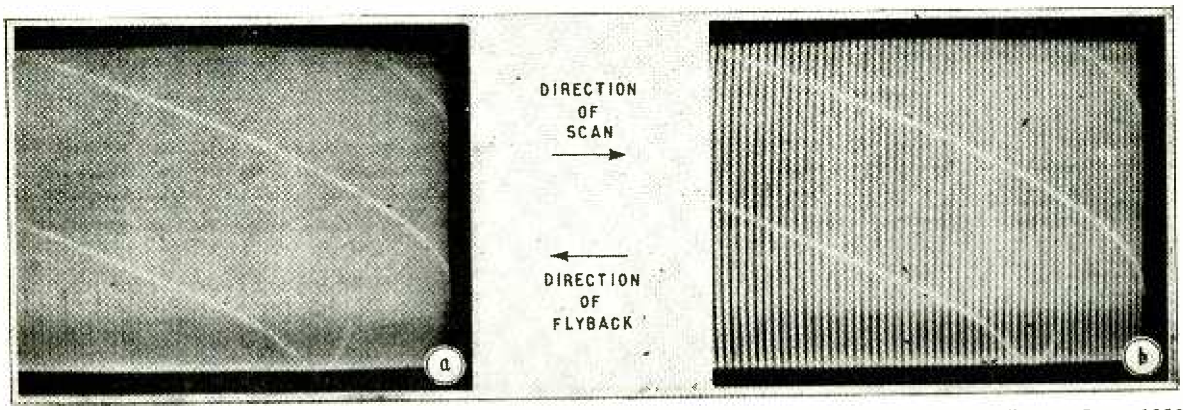


Fig. 6. Diagram showing the possible error caused by a sync pulse without a sharp leading edge.

Fig. 7. Photographs showing : (a) interlaced flyback and scan : (b) interlaced flyback and non-interlaced scan.



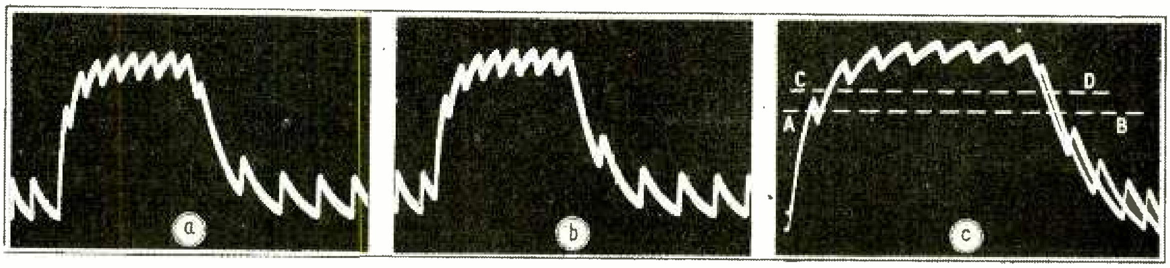
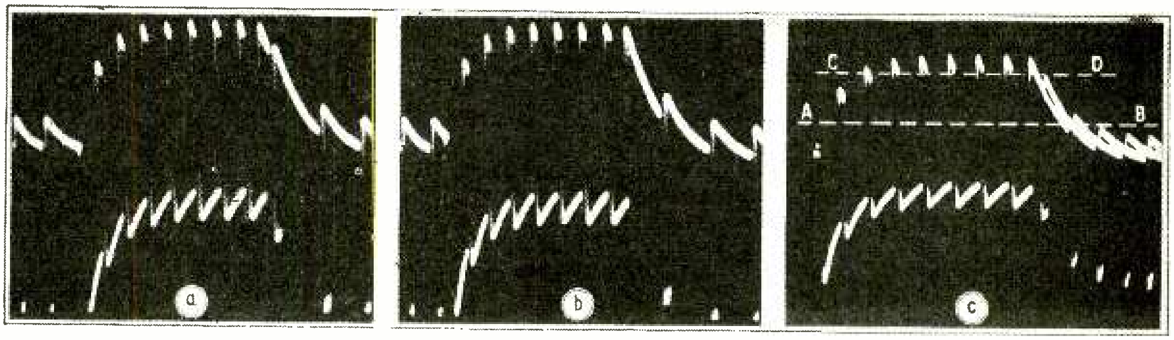


Fig. 8. Frame pulse produced by integrating circuit : (a) even frames ; (b) odd frames ; (c) even and odd frames (50-c/s time base).

Fig. 9. Frame pulse produced by differentiating circuit : (a) even frames ; (b) odd frames ; (c) even and odd frames (50-c/s time base).



the start of the frame pulses in the two cases. In the case of even frames (Figs. 5 (a) and 8 (a)), there is 90 microseconds between the last line pulse and first frame pulse, whereas on odd frames (Figs. 5 (b) and 8 (b)), there is only 40 microseconds. The difference in this starting level is easily seen on examination of Fig. 8. By suitable choice of component values and by suitable amplifying and limiting this error can be made very small.

(c) The end of the pulse is very different for odd and even frames, due to the differences which occur at the end of the frame pulse periods (see Fig. 5). Although this has nothing to do with the triggering of the time base it is important as regards interlace, as will be shown later.

These differences are not present when the circuit is used on American television signals since a series of equalizing pulses is transmitted before and after the frame synchronizing pulses.

Another fairly common circuit is the differentiating circuit. Here a change in the position of the pulses relative to the zero line takes place, due to the different d.c. components of the line and frame synchronizing pulses. When the pulses are passed through a differentiating circuit having a suitable time constant (say 40 microseconds), results as shown in Fig. 9 are obtained. In these figures negative-going synchronizing pulses are fed to the differentiating circuit in order to obtain a positive output pulse. Fig. 9 (a) is for even frames and (b) for odd frames, both these being taken on a 25-c/s time base, while (c) is the approximate superposition of the two given by a 50-c/s time base. Before this output can be used to synchronize a frame time base it is usually necessary to remove the line pulses by a suitable limiting circuit, cutting off below, say, the line AB. It will be noted that in this case:—

(a) A sharp leading edge is produced which is much better for precise triggering of the time base.

(b) There is a difference between the height of the pulses on odd and even frames (due to the different voltages at the start of the pulses). This must occur since the voltage obtained in this case (which is that across the resistor) and that obtained by the integrator circuit (which is the voltage across the capacitor) must add up to the input pulses. This slight difference may be important in some cases.

(c) Again, the trailing edge is quite different on odd and even frames, and may cause failure to interlace on scan, as will be shown later.

It was noticed that when both of these circuits were used correct interlace did not occur unless the time base frequency control was adjusted very carefully, and it was therefore decided to see if a reason for this failure to interlace could be determined. There are many types of time base circuit and an even greater number of variations, and, therefore, the following investigation was limited to the popular blocking oscillator circuit and a thyraton time base circuit. A commercial pattern generator was used, giving true B.B.C. sync signals. The method of checking whether the time base actually interlaced was as follows:

The time base under test was fed with a frame synchronizing pulse from the synchronizing separator and the output from the time base fed to the X plates of a cathode ray oscillograph. The Y plates were fed with the video waveform from the pattern generator. With the oscillograph used, the X deflection could be expanded so that the video waveform could be opened out, and from the appearance of the resulting trace, it was quite easy to tell whether the time base was correctly interlaced or not.

The first thing was to determine whether the time bases would interlace correctly if they were fed with ideal synchronizing pulses, which are identical on odd and even frames. Such a synchronizing pulse was obtained from the pattern generator and consisted of a square pulse, four lines long (corresponding to the eight half-line frame synchronizing pulses). The circuit of the blocking oscillator used on these tests is shown in Fig. 10, and is fairly conventional. With the time base synchronized by these ideal pulses (either positive on the grid or negative on the anode) it was found impossible to get the time base to interlace incorrectly. Either the time base interlaced correctly or it pulled completely out of step. The magnitude of the synchronizing pulses used was 10-20 volts, but the value was found not to be important. The same time base was now fed off a differentiating type synchronizing separator, followed by a triode limiting circuit so as to eliminate the line pulses, i.e., to cut off all below a line such as AB on Fig. 9. The resultant frame pulses, being negative (due to phase reversal in the limiter), were fed to the anode of the time base. It was now found that it was possible to obtain accurate interlace, but the setting of the limiter and frequency control of the time base were very critical. It was found possible to obtain nearly any degree of interlace, from complete interlace to complete lack of interlace, by variation of the limiter-setting (or amplitude of the pulses fed to it), the h.t. supply and the frequency setting of the time base. When adjusted to obtain incorrect interlace the circuit appeared reasonably stable, the actual degree of interlace remaining nearly constant.

It was now necessary to find out why this occurs. In order to do this it is necessary to examine the flyback of the time base on a 50-c/s time base accurately synchronized to the pattern generator. A special Sanatron time base was used in which the start of the trace (not flyback) was triggered by a 50-c/s synchronizing pulse from the pattern generator. The speed of the trace of the time base could be varied so that any portion of the flyback, or scan, could be examined. It was soon found that lack of interlace could occur in a number of ways depending on the frequency and limiter settings.

(1) Lack of interlace could result from the fact that the time base was triggered by different pulses on odd and even frames. It will be seen from Fig. 9 that the positive pulses (produced by the spaces between the frame synchronizing pulses) are not exactly the same height on odd and even frames. This is caused by the difference in the time between the last line pulse and the first frame pulse in the two frames. The flyback in this case is shown in Fig. 11 (a) where two distinct flybacks (50 microseconds apart) are shown, resulting in two different traces. (The two traces are difficult to distinguish because of the small difference.) From this it would appear that complete lack of interlace should result. This is not generally the case, owing to partial cancellation of the incorrect flyback times by the second cause of incorrect interlace described below. The author has found it possible to get a time base so that there was no interlace on flyback and yet correct interlace on scan.

(2) Partial interlace may result from the differences at the end of the frame pulse. This is shown in Fig. 11 (b). In this case the Y deflection has been approximately doubled so that only the end of the flyback is visible. It will be noted that only one flyback occurs, indicating correct triggering of the time base, but at the end of the frame pulse two traces are produced causing two different waveforms, or scans, on odd and even frames. The "notches" in the waveform are caused by the pulses from the differentiating circuit, and it is these which cause the differences in the start of the scan in the two cases. The effect on the anode waveform of the blocking oscillator is shown in Fig. 11 (c) where again two distinct traces are produced, one for odd and one for even frames. The blocking oscillator valve actually only conducts for about four pulses (two lines), after which the blocking oscillator transformer is forced into damped oscillation by the synchronizing pulses. Fig. 11 (d) shows the result when correct interlace was obtained by careful adjustment of the limiter (increasing the limiting) so that the differences at the end of the pulse are largely removed, such as above a line CD of Fig. 9 (c). The setting was critical, however, and not likely to be of much use in practice.

(3) Another way in which interlace can fail is shown in oscillogram 11 (e) of the end of the flyback. It would appear that the slight differences in the two sets of pulses cause the valve to cease conducting at different instants, producing two distinct scans. All the above oscillograms are to the same X scale.

(In the concluding instalment an improved sync separator will be described)

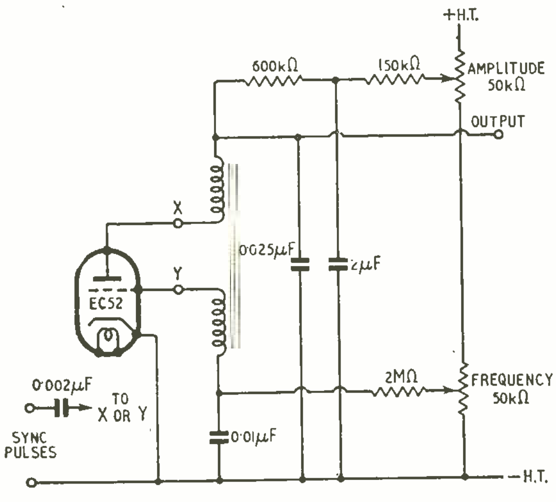
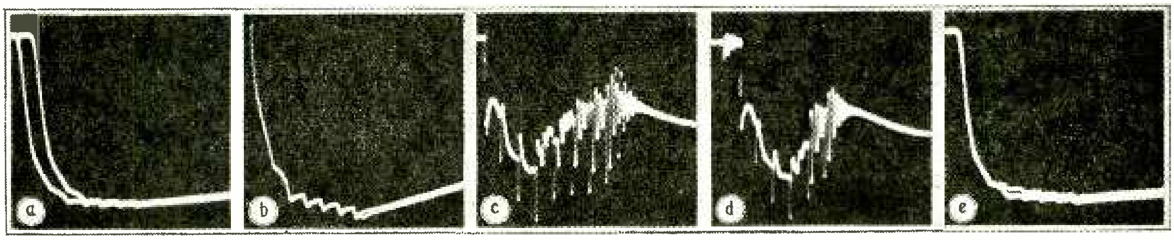


Fig. 10. Circuit of blocking-oscillator time base.

Fig. 11. Oscillograms during flyback of blocking oscillator: (a) and (b) output voltage; (c) and (d) anode voltage; (e) output voltage.



EQUIPMENT FOR

SOUND REPRODUCTION

New Products Shown at the Recent B.S.R.A. and A.P.A.E. Exhibitions

Disc Recorders.—A new studio recorder (Type CB/S) has been introduced by the M.S.S. Recording Company. It is similar to the Type CBE/2 but is for 78 r.p.m. only, and will accommodate discs from 5in to 17¼in in diameter. The turntable is driven by a synchronous motor through a gearbox and the traverse mechanism can be arranged to cut from an inside or outside start.

In the latest "Connoiseur" recorder (A. R. Sugden & Co.) the usual type of solid rubber friction drive has been replaced by a floating belt with jockey pulley which ensures a greatly increased contact area both on the drive spindle and on the turntable rim. Speeds are selected by means of interchangeable spindle heads.

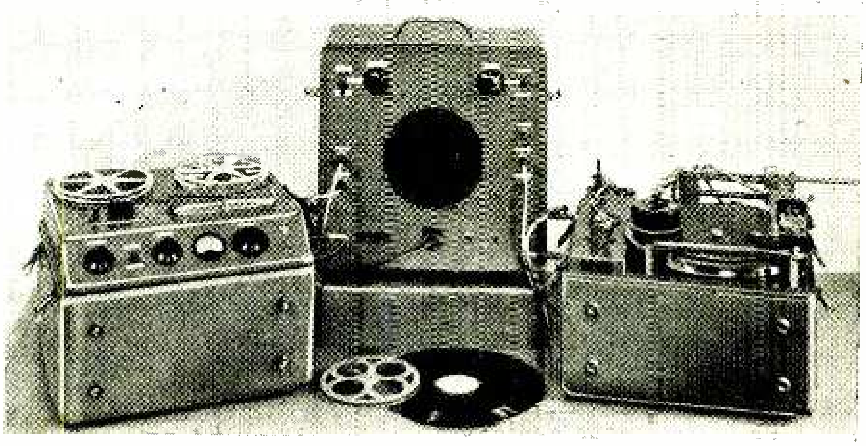
The prototype of a recording machine of advanced design which has arrived at the production stage was shown in action by Decca. The cutter is of the moving-coil type and has a frequency range of 30-15,000 c/s with built-in and metered facilities for heating the cutting stylus. The traverse mechanism instead of being coupled mechanically to the turntable drive, is driven separately by a "velodyne" motor in which the speed is primarily controlled by feedback from a directly coupled tachometer generator. Overriding controls are provided to set the pitch of the groove or to give a fast run-in (or run-out), and the speed is indicated electrically by a meter calibrated directly in grooves per inch. The beauty of this system is that automatic variable pitch recording is possible, say, when dubbing from tape, by utilizing an advance playback head, spaced the equivalent of two grooves to be recorded, to open out or compress the groove pitch, through the medium of a long time constant circuit in anticipation of the signal from the main playback head. All controls of the machine are electrical, by switch or push-button, and include selection of turntable speed (33⅓, 45 or 78 r.p.m.) and offsetting of the top of the turntable for cutting eccentric run-off grooves.

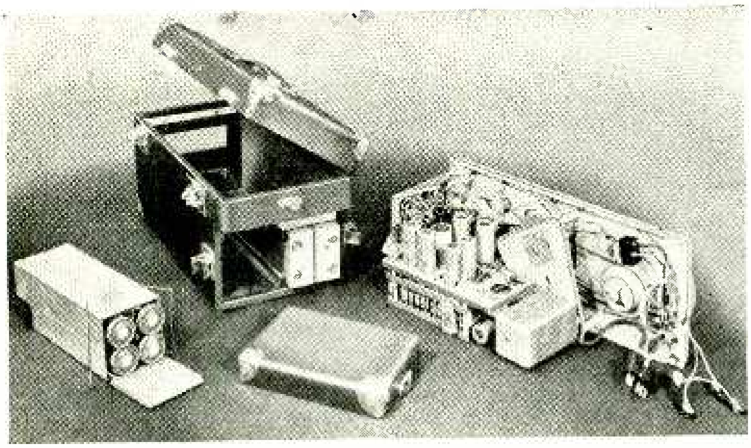
Magnetic Recorders.—An alternative version of the M.S.S. tape recorder is now available in the Type PMR/2 in which the recording machine is separate from the power amplifier and loudspeaker unit. Three heads are fitted and a separate replay amplifier enables the recorded sound to be sampled and compared with the incoming quality. The complete equipment is designed for 600-Ω line connection in addition to 30-Ω microphone input and high-impedance output to a disc recorder cutterhead. The power available for playback or transcription is 10 W.

British Ferrograph were showing their basic "Tape Deck" and a range of complete recorders including the Type "YD," for tropical conditions, in a welded aluminium case. A voice-operated relay unit for use with this amplifier is designed to effect economies where long intervals may occur between the items of information to be recorded.

Wirek (Electronics) have developed a wire recorder for use in aircraft as a test pilot's log. Measuring

Decca disc recorder, with facilities for servo-controlled automatic variable groove spacing, and (below) transcription from tape to disc by the new M.S.S. Type PMR/2 tape recorder used in conjunction with the Type CLED disc recorder.





E.M.I. portable tape recorder, Model L/2 with chassis and motor battery cassette removed from the carrying case.

"RD Minor" amplifier for 33⅓ and 78-r.p.m. records (Rogers Developments).

12in × 6in × 5½in and weighing only 9½lb, this recorder is designed to function under the most arduous conditions of test flying. The power consumption is 0.75 A from the aircraft 25-28-V supply and it gives an hour's recording time with a wire speed of 30 in/sec. The same firm also makes portable tape recorders, of which there are two types, the "Reporter" with a running time of 7-8 minutes from each wind of a spring-motor drive, and the "Personal," with a battery-driven motor, giving 15 minutes on each 5-in tape spool.

E.M.I. Factories were showing for the first time a lightweight battery-operated tape recorder (Type L/2) in which the tape motor is driven by ten U2 cells in parallel, giving a total run of 1½ hours. Three versions are available with tape speeds of 15, 7½ or 3¾ in/sec and frequency responses (within ± 2 db) of 50-10,000 c/s, 50-7,000 c/s and 50-3,000 c/s respectively. Recording times per 600-ft spool are 7½, 15 and 30 minutes respectively. In addition to the recording head a replay head is fitted for headphone monitoring of the tape during recording, or replay through a loudspeaker. Manual re-winding is effected by a handle operating through the lid, which is closed during operation. Windows are provided for viewing the volume level meter and the amount of tape on each spool. The complete recorder measures 14in × 7in × 8in. and weighs 14½lb.

An unusual feature of the "Reflectograph" tape recorder shown by B.K. Partners is the continuously variable tape speed (2 to 8 in/sec) which enables material of awkward length to be recorded on standard tape spools.

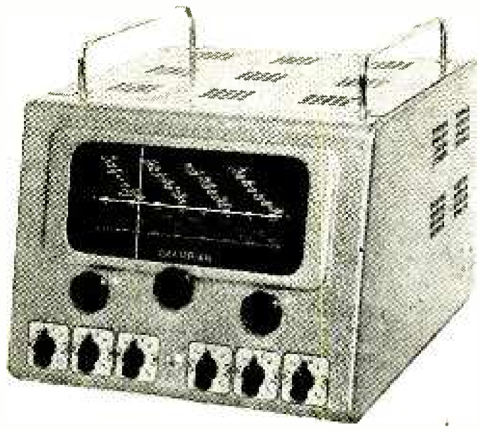
The type C/S pulse-synchronized tape recorder developed by Leevers-Rich for film work was shown in improved form and its exceptionally low background noise was demonstrated. This firm was also showing a simple but effective bulk eraser (Model ER31) for spools up to 7in diameter. The spool as a whole is subjected to a high-intensity 50-c/s field and removed to a distance before the current is switched off. The method is particularly effective in cleaning high-coercivity tapes from the residual effects of over-modulation and general background noise.

"Scotch Boy" recording tape made by the Minnesota Mining and Manufacturing Company is now available in 300-ft lengths on 3⅝in spools and also in 2,400-ft lengths on the latest N.A.B. type of double-sided professional spool; these are in addition to the wide range of existing standard lengths. Other developments are the production of 35-mm film stock, coated for the full width between the perforations, and also a special splicing tape for editing tape recordings.

Amplifiers, Pre-amplifiers and Feeder Units.—An effective demonstration was given by H. J. Leak & Company of the response of their production model TL/12 amplifier to square-wave inputs, not only in the comparatively easy mid-frequencies but also at 50 and 5,000 c/s. As far as we know this is the first time that a commercial amplifier has been publicly submitted to this searching test of frequency and phase response. A new pre-amplifier, the "Vari-Slope," has been developed to replace the RC/PA/U pre-amplifier. As the name implies, the new unit incorporates a low-pass filter with continuously variable rate of cut-off above the "turnover" frequency, which can be switched for 5, 7 or 9 kc/s. The range of variation of slope is from 5 to 50 db/octave and is achieved by a twin-T resistance-capacitance network with variable feedback.

Rogers Developments were showing a wide range of well-finished amplifiers, including the "Williamson." A recent addition is the "RD Minor" gramophone amplifier with independent tone controls, in addition to basic compensation for 33⅓ and 78-r.p.m. recordings. Full output of 3½ watts with less than 0.5 per cent distortion is obtained with 50 mV input from 33⅓ and 80 mV from 78-r.p.m. records. The response is level within ± 1 db from 40 to 20,000 c/s. Among new auxiliary equipment shown by this firm were noted a range of low-pass "scratch filters" for connection between pickup and amplifier input, and a variable-selectivity superhet radio unit with alternative bandwidths of 23, 15 and 8 kc/s, and a cathode-follower, voltage-doubler A.V.C. circuit designed to avoid asymmetrical loading.

Pre-tuned variable-selectivity superhet units made by Goodsell were shown by B. K. Partners. These are available with or without an r.f. stage before the frequency changer. The range of Goodsell pre-amplifiers includes one (Type PFA) which was made originally for the American market and is now generally available, with switch-selected correction characteristics for the following recording characteristics: RCA (45 r.p.m.), Columbia, NAB, British standard 78 r.p.m. and Decca FFRR. Low-pass filter circuits



Grampian Type 511 30-watt receiver/amplifier.

cutting off at 5, 7, 10 and 13 kc/s are available in addition to normal bass and treble tone controls, and input sockets are provided for high and low impedance pickups and two radio circuits.

The importance of accurate conformity to designed response characteristics was emphasized by the Acoustical Manufacuring Co., who demonstrated factory test equipment used in checking their production tone control units against a standard. Cumulative errors which might affect the normal linear response are thus eliminated. A prototype f.m. tuner unit designed to match other auxiliary units associated with the Acoustical Q.U.A.D. amplifier was also shown.

Among the tuner units shown by the Lowther Manufacturing Company were noted a pre-set tuner for the amplitude-modulated Wrotham transmissions and a series of pre-set tuners for each television sound channel.

For public address and sound distribution work a number of new and redesigned amplifiers were shown for the first time. Among those designed for operation from a.c. mains were noted the G.E.C. Type BCS2410 10-watt amplifier built to a tropical specification and using two KT61 output valves in Class AB1. A new 30-watt receiver-amplifier (Type 511) by Grampion incorporates a superhet with r.f. stage covering medium and long waves, and includes a monitor loudspeaker. Compact enclosed-rack industrial amplifier equipments for works sound distribution were shown by Birmingham Sound Reproducers, Whiteley Electrical, Trix and the Magneta Time Company, the latter firm having produced a two-unit model for hospitals similar in specification to their Type S11 sectional amplifier assemblies.

A new portable version of the Whiteley Electrical 50-watt amplifier made its debut, and Trix were showing a very interesting 25-watt amplifier (Model U885) suitable for d.c. as well as a.c. mains operation. A total number of nine miniature valves are used with four in parallel push-pull in the output stage.

Several examples of portable amplifiers for alternative operation from batteries or a.c. mains were shown. In the B.S.R. Type BM40 30-watt model an interesting feature is the output level indicator signal lamp, while in their Type AV15 for battery operation only, a battery economy switch is fitted to cut out the vibrator unit, while keeping the valve heaters in circuit during standby periods. A similar feature is incorporated in the new Grampian Type 524 15-watt a.c./battery amplifier.

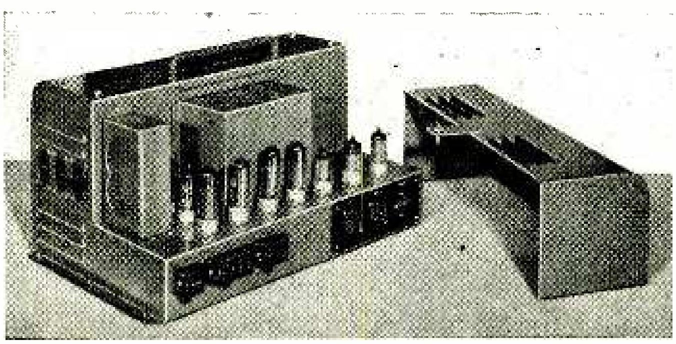
Two interesting pieces of auxiliary equipment were shown by the Magneta Time Company. One was a coin-operated extension loudspeaker unit for hotel sound distribution systems, and the other a signal-operated switch unit designed to meet Air Ministry requirements by automatically shutting down relayed music, etc., in clubs and other auxiliary buildings on airfields when high-priority messages are relayed through the official sound distribution system.

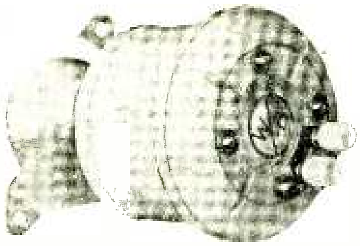
One of the most fundamental recent discoveries in sound distribution is the Haas effect, which exploits the ear's property of appearing to select the direction of the first of a series of sounds arriving at different times from a given source. Pamphonic Reproducers were showing complete rack-mounted equipment for delayed sound reinforcement utilizing this principle and similar to that recently installed in St. Paul's Cathedral.

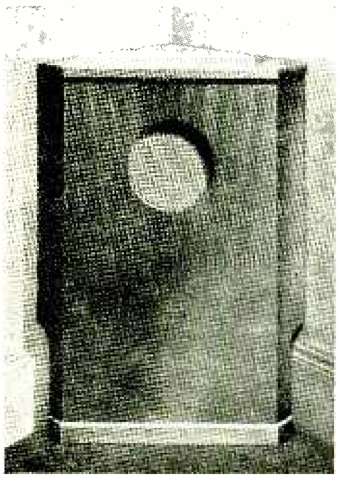
Loudspeakers.—A new miniature re-entrant horn unit has been introduced by Truvox and is to be known as the "Minor Reflex." It is rated to handle 3 watts and is intended to fill in the corners of awkward distribution schemes or for general use in small spaces where directional properties and/or high efficiency are desirable. The recently introduced Type T52 pressure unit by Goodmans is a neat workmanlike design with an economical centre-pole magnet system giving light weight and small external field. The rear diaphragm assembly can be changed without detaching the unit from the horn. The Grampian SP1 pressure-unit is now available in a weatherproof housing which encloses the matching transformer.

An offshoot, so to speak, of the Whiteley Electrical "Duplex" loudspeaker is the new "tweeter" horn

Trix Model U885 a.c./d.c. amplifier with 25-W output, and (right) Truvox 3-watt re-entrant "Minor Reflex" loudspeaker







Top left: Whiteley Electrical Radio "tweeter" loudspeaker.

Above: G.E.C. Type BCS2372 studio ribbon microphone.

Left: Wharfedale "Golden/CSB" sand-filled corner panel loudspeaker.

unit which is now supplied separately with, of course, a re-designed magnet system.

Two new corner loudspeakers for high-quality reproduction were noted, the Wharfedale "Golden/CSB Corner Panel" with non-resonant sand-filled front, and the Rogers Developments "RD" Corner Reproducer," using a folded and tapered air column, with the driving unit located to neutralize the principal air column resonances.

That loudspeakers need not necessarily be housed to look like scientific instruments was demonstrated by the cabinets shown by Sali. These are designed primarily with an eye to *décor*, but not at the expense of technical soundness. The laminated moulded material used in their construction exhibits self-damping properties, and the enclosed volumes are adequate ($6\frac{1}{2}$ cu ft in the "Standard" and $8\frac{1}{2}$ cu ft in the "Major" model). They can be used either as an enclosed or as a vented baffle.

It is interesting to learn that the Pamphonic "line source" loudspeakers used in the St. Paul's sound reinforcement scheme, which give a flat horizontal radiation pattern, are to be sold separately for use in applications other than the delayed sound system.

Pickups and Microphones.—Decca were showing the prototype of a new pickup with miniature armature giving a top resonance of 14-15 kc/s when used on plastic long-playing records. Both "Decca" and "Connoisseur" (Sugden) pickups are now available with long tone arms for use with large-diameter transcription discs.

A new ribbon microphone for studio use has been developed by G.E.C. with a response claimed to be level within ± 1 db between 200 c/s and 14 kc/s and within ± 2.5 db between 50 c/s and 200 c/s. A variety of fittings for cable suspension, desk or stand mounting are available.

In conclusion, mention should be made of the demonstration arranged by Reslo to give further proof, if such were needed, of the ruggedness of their 2-micron-thick microphone ribbon. Visitors were invited to use the microphone as a short circuit for a small dry cell and to observe the complete recovery and re-alignment of the ribbon after having been bowed out by what looked a good half inch from the polepieces!

MANUFACTURERS' LITERATURE

"C" Type Cores for hermetically-sealed and open-type transformers and chokes; technical details and curves in a leaflet from The English Electric Co., Ltd., East Lancashire Road, Liverpool, 10.

Sound Reproducing Equipment hire charges listed on a leaflet from Alexander Black, Ltd., 34, Marlborough Grove, London, S.E.1.

Electric Gramophone console with three-speed record changer and 4-watt amplifier; specification from The Trix Electrical Co., Ltd., 1-5, Maple Place, Tottenham Court Road, London, W.1.

Gas Discharge Tubes for discharging high voltages induced in telephone wires; descriptive brochure from The Edison Swan Electric Co., Ltd., 155, Charing Cross Road, London, W.C.2.

"Rediffusion," an illustrated booklet explaining the distribution of sound and television broadcast programmes by wire, from Broadcast Relay Service, Ltd., Carlton House, Lower Regent Street, London, S.W.1.

Five-channel Tunable Television; leaflets describing H.M.V. 12-in console and table-model "Highlight" receivers, from The Gramophone Company, Ltd., Hayes, Middlesex.

Insulating Material; a booklet on Mycalex giving physical properties, forms in which it is available, hints on machining and other information useful to designers. From the Mycalex Company, Ltd., Ashcroft Road, Cirencester, Glos.

Silver-zinc Light-weight Accumulators described in a brochure from Venner Accumulators, Ltd., Kingston By-pass, New Malden, Surrey.

Anti-vibration Clips for securing pipes and cables; a leaflet giving sizes available, from Howard Clayton-Wright, Ltd., Wellesbourne, Warwickshire.

Mail Order Catalogue of radio, electrical and mechanical equipment, from John Farmer, 194, Harborne Park Road, Harborne, Birmingham 17.

Low-voltage Soldering Iron (2.5-6.3V), for operation from mains or battery, described in a leaflet from Scope Laboratories, 417, Keilor Road, Essendon, Melbourne W.5, Australia.

Resistance Wires and tapes and **Molybdenum** rods, wires and tapes; a booklet of technical data from the Vactite Wire Company, Ltd., 24, Queen Anne's Gate, Westminster, London, S.W.1.

Turnover Crystal Pick-up head; description with a specification from Birmingham Sound Reproducers, Ltd., Claremont Works, Old Hill, Staffs. Also a leaflet describing a three-speed **Automatic Record Changer** for playing 12in, 10in and 7in records intermixed.

REACTANCE SKETCHES

—*How They Help Us to Visualize the Action of Circuits*

By "CATHODE RAY"

SKETCHES, in this connection, are not what you might think. They are graphs, of a kind. But the name really is quite appropriate. My dictionary explains a sketch as "a picture rapidly executed and intended to give general features or chief characteristics." If a drawing were made carefully and exactly to scale, it would hardly, except in a mood of excessive modesty, be described as a sketch. And a graph is not a sketch if it has been accurately plotted point by point. When it is only required to show the "general features or chief characteristics," a graph need not be plotted—it can be sketched. For instance, Fig. 1(a) is a sketch of the equation $y = ax^2$. Although not plotted to numerical scales, it shows such general features as the absence of negative values of y, symmetry of the graph about the y axis, and the steadily increasing slope of the curve with increasing x (+ or −). A slight elaboration (b) could be sketched to show how the appearance varies with the "parameter" a.

What I am proposing to do is show how sketching graphs of reactance can help one to visualize the action of certain kinds of circuits, especially tuning circuits and filters. This has already been shown, notably by W. L. Everitt in his book "Communication Engineering," first published 20 years ago; but I suspect that there are still a good many people who would find reactance sketches helpful who haven't come across them. When one is confronted with a rather complicated tuning circuit it is useful to be able to sketch its frequency characteristic. Or to devise a circuit to tune in a certain frequency and tune out certain others. Probably not everybody realizes that simply "tapping down" a tuning coil, as in Fig. 2, not only causes a step-up or step-down transformer effect but gives the tuner two simultaneous resonances—one an acceptor and the other a rejector.

The simplest subject to "sit" for our sketching is Fig. 3(a)—a single inductance. Its reactance, X, as we all know, is $2\pi f$L. Of this, f, the frequency, is the variable part. The 2πL has the status of a in Fig. 1—it doesn't alter the characteristic shape of the graph, but only its slope. 2π is a constant and L is a parameter—something that is also constant for a particular graph, but whose value can be altered to suit the occasion. The essential fact is that X is directly proportional to f. So the graph is a sloping straight line, passing through the origin 0 (Fig. 3(b)). If you have even the slightest shade of doubt about this, it will be worth while actually plotting a sample graph. Choose any value you like for L and calculate the values of X for, say 50, 100, 200, 300, 500, 800 and 1,000 c/s (or kc/s if you prefer) to give a corresponding number of points. Then plot another graph for a different value of L. It is better to do this than to carry around ideas that are woolly just because they have never been put to the test.

To sketch the reactance of a single inductance, then, one just draws a straight line sloping up to the right from 0. An optional extra is the arrow showing that the steepness of the slope increases with the inductance. The slope might have been downward, had it not been agreed to call inductive reactance positive. This distinguishes it from capacitive reactance, which is conventionally regarded as negative. The formula for capacitance, $X = -1/2\pi f C$, shows that the reactance varies *inversely* with frequency (and capacitance). X being negative, its graph must be wholly below the

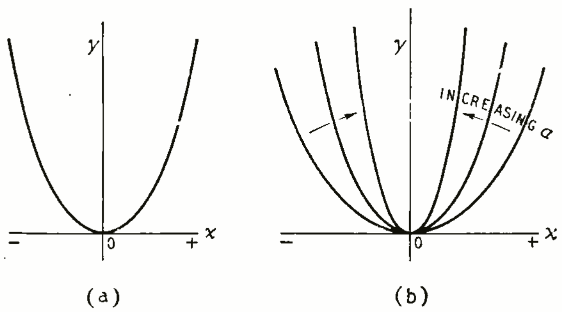


Fig. 1. This is an example of graph sketching—the equation $y=ax^2$. But you don't have to understand it in order to follow this article.

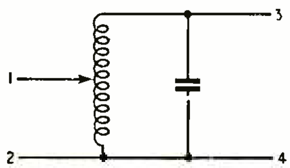


Fig. 2. Tapping down the coil not only gives a step-up effect from left to right but also brings in an acceptor resonance in addition to the rejector resonance. This is revealed by sketching, as in Fig. 9.

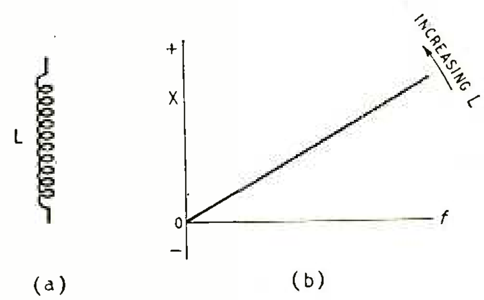


Fig. 3. The simplest reactance sketch (b) and its subject (a). It shows how the reactance (X) of L varies with frequency (f).

horizontal axis. But its shape (Fig. 4(b)) is not so easy to predict without actual plotting. However high the frequency, the reactance never quite reaches zero, so the curve gets closer and closer to the horizontal axis but never touches it. And at zero frequency the reactance is infinitely great (negatively), so the curve gets closer and closer to the vertical axis but never touches it.

This kind of curve, incidentally, is called a rectangular hyperbola ; but for purposes of reactance sketching there is no need to know that. However, in case anybody doesn't see the significance of the rectangular part of it (for the curve itself is admittedly far from rectangular), I will just point out that if you multiply both sides of the equation by f you rearrange it into $fX = -1/2\pi C$; that is to say, the two variables multiplied together are equal to a constant. If you take any point on the graph, say A in Fig. 5, the two variables are represented by the distances to the axes, Af_a and AX_a ; so the product (result of multiplying together) the two variables is represented by the area of the shaded rectangle A f_a 0 X_a. This area, then, represents the constant $1/2\pi C$. And, since it is constant, the area must be the same for every point on the graph. The same, for example, as the area Bf_b0X_b or Cf_c0X_c. The larger C is, the smaller is $1/2\pi C$, so the smaller the area, and the closer the curve to the axes, as indicated by the arrow in Fig. 4(b).

Combining the Elements

Having made sure of the two kinds of " brick " from which all reactance sketches are built, we can try a simple combination of the two kinds, Fig. 6(a). The total reactance of two reactances in series is their sum (result of adding together). So to get the graph one just adds together the distances representing the values of the separate reactances at each frequency. In Fig. 6(b) the separate reactance sketches are repeated in dotted line. At very low frequencies, X_L is small, so there is not much to add to X_C, which is away down near minus infinity. But as the frequency rises, adding X_L to X_C makes it less negative at an increasing rate, until a frequency is reached (marked f_a) where X_L and X_C are equal and opposite, so their sum is zero. At still higher frequencies, X_L increasingly prevails, until at very high frequencies the X curve nearly (but never quite) coincides with the X_L curve.

I need hardly explain how this represents the phenomenon of series or acceptor resonance, in which the total reactance disappears at a particular frequency depending on the values of L and C. But you may be interested to notice how shifting the X_L and X_C curves as directed by the arrows in Figs. 3 and 4 brings out the familiar fact that increasing L and/or C lowers the resonant frequency, and vice versa. It is also worth noting that at frequencies below resonance the total reactance is capacitive and (at any one frequency) the LC combination is equivalent to a single capacitance, which, since the X curve is closer in to 0 than the X_c curve, must be a larger capacitance than C. And of course all vice versa for frequencies above resonance.

This may be the right place to point out the chief limitation of reactance sketches—they don't take any account of resistance. Actually, if you are good at visualizing in three dimensions, you can imagine the graph as a plan view of a three-dimensional arrangement in which the R axis stands out perpendicular to the paper, and the X curve is just the plan view of an impedance (Z) curve floating above the paper at a distance representing the series resistance. Provided that R is small compared with either of the reactances at resonance (i.e., Q is large), it is only near resonance that it has much influence on affairs.

Obviously the opposite number to L and C in series is L and C in parallel. In theory it is just as simple, but the fact that most people are more accustomed to think in reactances than susceptances makes it more complicated because one has to translate reactances into susceptances and then (having performed the addition) back again into reactances. Any grievance we may feel against the parallel circuit for causing all this extra work is of course just as undeserved as the grievance Englishmen have against the French for insisting on speaking their own language. There is nothing inherently more difficult about speaking French ; in fact most Frenchmen find it easier than speaking English. Nor is thinking in susceptances any more difficult than thinking in reactances ; the processes are exactly similar. Yet so many people who are familiar with reactance haven't a clue to susceptance. I hope, however, that this is not true of my readers (if any), because I have emphasized the importance of being bilingual in this matter*, and only a month or two ago† returned to the subject, explaining the exact analogy between reactance and series circuits on the one hand, and susceptance and parallel circuits on the other ; and the similar analogy between L and C. So for Fig. 7(a) it should be enough

* " Admittance," January 1949.
† " Duals," April 1952.

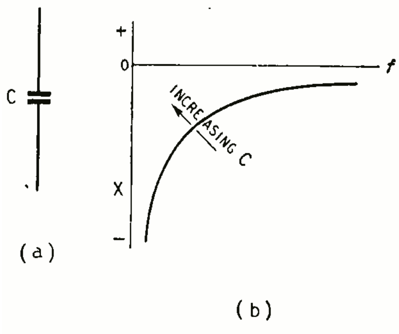


Fig. 4. *Reactance sketch for C. Since X is negative, the graph is below the horizontal axis.*

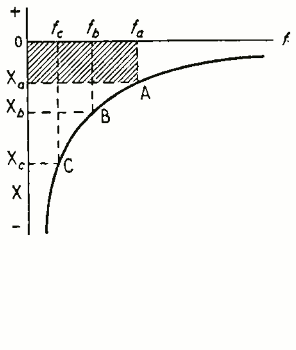


Fig. 5. *Explaining the peculiarities of the Fig. 4(b) curve.*

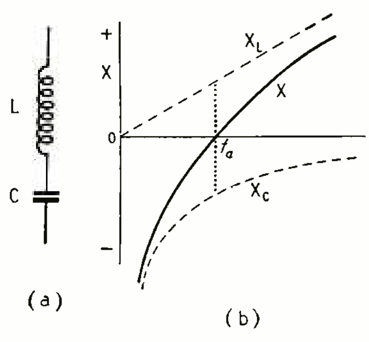


Fig. 6. *Reactance sketch of the simple series resonant circuit, or acceptor.*

for me to say "Apply the principle of duality to Fig. 6".

I feel however that this might not be well received by new readers (if any), or by old ones who have forgotten; so with unfailing generosity will proceed as if susceptances were an unfamiliar tongue, to be translated into from reactance with toil and sweat, and back again into reactance as soon as possible.

It is really just an extension of what one does when finding the total resistance of two or more resistances in parallel. Denoting the total by R and the separate ones by R_1, R_2, etc., we have the usual rather uncouth formula

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

If we turn it upside down it becomes

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

This is much more sensible, because we can see that a total something is the result of simply adding together a number of somethings, just as we do with resistances in series. The only difference is that the somethings are not resistances but one-upon-resistances. By calling these conductances and denoting them by G we exactly match the procedure for resistances in series:

$$G = G_1 + G_2 + \ldots$$

It is the same with reactances. By calling one-upon-reactance susceptance and denoting it by B we get, for a circuit consisting of B_1, B_2, etc., in parallel:

$$B = B_1 + B_2 + \ldots$$

Applying this to Fig. 7(a) in particular, we have the total susceptance $B = B_C + B_L$. The simple straightforward sketching procedure for susceptance-speaking personnel is the same as for Fig. 6 except that B_C takes the place of X_L and B_L the place of X_C (Fig. 7(b)). Those who are just learning susceptance may want to start from the terra firma of Figs. 3 and 4, with reactance sketches. As I explained in "Duals," inductive susceptance is not just the reciprocal ("one-upon-") inductive reactance; its sign is changed too. (That can be blamed on the subtle influence of "j," but there are other ways of explaining it.) So $B_L = -1/X_L = -1/2\pi fL$, and $B_C = 2\pi fC$. Comparison of Figs. 7(b) and 6(b) shows that this fits. If we start with Fig. 3(b), its reciprocal means that we must make it very large where X is small, and very small where X is large, giving a curve like Fig. 4(b), but in the positive half. Reversing the sign makes it exactly like Fig. 4(b). Doing the same for X_C yields the B_C curve—exactly the same as X_L. So now we have got as far as the dotted curves in Fig. 7(b). Being susceptances, they can be added together, just like X_L and X_C in Fig. 6(b), to give the B curve. Here f_r is the frequency of parallel or rejector resonance, where the susceptance of the parallel circuit as a whole is zero, and its reactance therefore infinitely large. The "third man" this time, sticking out of the paper, is conductance, and in a sharp tuning circuit it is relatively small, meaning that the equivalent parallel resistance ("dynamic resistance") is relatively large.

Unless all this is already very familiar, it would be a good thing to ponder over Fig. 7 a little, comparing and contrasting it with Fig. 6. If you are susceptance-minded you will probably be content with Fig. 7 as it is, but if not you may want to see a translation of

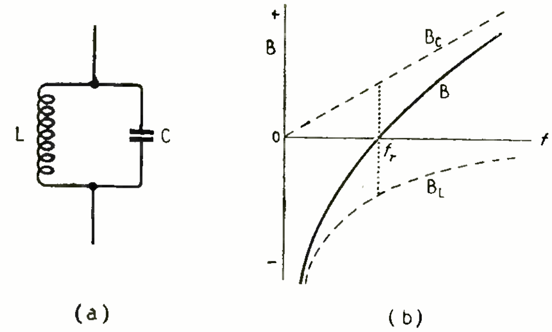


Fig. 7. *Susceptance sketch of the simple parallel resonant circuit or rejector.*

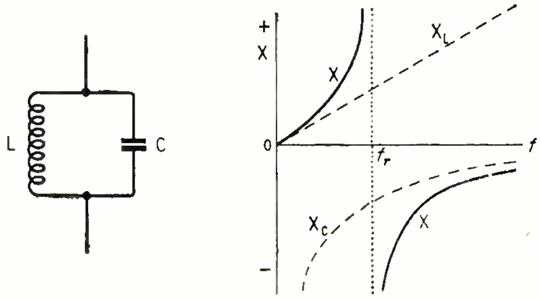


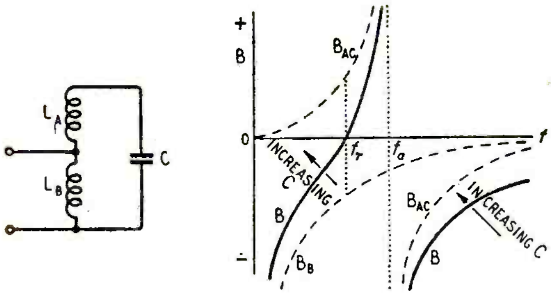
Fig. 8. *Fig. 7 "translated" into reactance.*

it into reactance. This will be needed anyway if we want to find the result of connecting Fig. 7(a) in series with anything. Well, we just reverse the procedure for getting susceptance curves from reactance curves, substituting a large +X for a small −B, and so on. Fig. 8 is the reactance sketch corresponding to B in Fig. 7. Compare and contrast it with Fig. 6(b).

Where the Resonances Come

Having allowed time for all this to be fitted into one's other knowledge of tuned circuits, and for the beautiful symmetry of the reactance-susceptance edifice to be admired, I must point out one feature that might be overlooked. It is the fact that all the X and B curves, separately or in combination (resistance being neglected), slope upwards to the right. Now an acceptor resonance is represented by the reactance curve crossing the zero line, as at f_a in Fig. 6(b). So it is clear that no circuit, however complicated, can have another series resonance at some other frequency, unless there is a rejector resonance at an intermediate frequency. For if the curve has already crossed the line on its upward slope, the only way it can cross it again without sloping downward is to do the Indian rope trick as in Fig. 8, disappearing into celestial infinity and returning from the infernal regions; and this phenomenon is the sign of a parallel resonance. In the same way, there can be no two parallel resonances without a series resonance in between. So the total number of resonances of one kind cannot be more than one more or less than the number of the other kind (I hope that doesn't sound too much of a brain-twister).

But we shall have to press on if I am to demonstrate any of the more interesting applications of reactance-susceptance sketching. Let us tackle Fig. 2, which is



(a) (b)

Fig. 9. Detailed working-out (b) of the circuit (a) introduced in Fig. 2, on the assumption that there is no coupling between L_A and L_B.

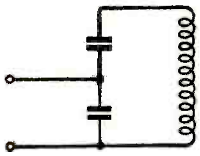


Fig. 10. This circuit, otherwise similar to Fig. 9(a) gives an acceptor resonance at a lower frequency than the rejector.

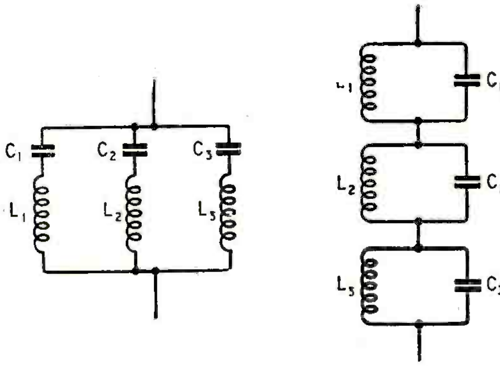
one step farther on in complexity. Between terminals 3-4 it is obviously a rejector circuit. If the coil were wound on a suitable closed iron core and worked at lowish frequency, one could fairly assume that all parts of it were closely coupled together. That being so, it would still be a rejector circuit between 1-2, the only difference being a lower input impedance, and a step-up in voltage from 1-2 to 3-4. But a tapped r.f. coil, even if wound on an iron core, does not work like this, because only a proportion of the whole inductance can be reckoned as completely coupled. To deal with a partly coupled tapped coil is too much just at this stage, but some clue to its behaviour can be gained by going to extremes and assuming that the two parts of the coil have no coupling to one another at all. They are in effect separate coils, which in Fig. 9(a) are distinguished as A and B. So what we have between the terminals is an *acceptor* circuit (L_A and C) in parallel with L_B. Now we know what the reactance curves of these two separate items look like—Fig. 6(b) and Fig. 3(b) respectively. But since they are in parallel we shall have to work in susceptances. We already have a susceptance curve that will do for L_B—B_L in Fig. 7(b)—but no susceptance curve for an acceptor circuit. However, the merest smattering of dualism should lead one to decide that it would be the same as the X curve for a rejector circuit, as in Fig. 8. And so it is. In Fig. 9(b) the susceptance curves for L_B (B_B) and L_A C (B_{AC}) have been dotted in; and adding them together gives the full-line curve (B) for the whole circuit between the terminals.

By now we ought to be susceptance-minded enough to resist the urge to translate this B curve into an X curve. When we see the B curve crossing the f axis, with Fig. 7 still in mind there should be no difficulty in murmuring "Ah, yes—parallel resonance!" and marking the spot "f_r" for "rejector." So when the next trick is Indian rope, there is only one answer left—series resonance, marked "f_a" for "acceptor." In this circuit arrangement, then, the acceptor resonance is at a higher frequency than the rejector. By now we may be getting so dualistic that we can't wait to scribble down the circuit that would give an acceptor frequency *lower* than the rejector; yes! it is Fig. 10. Try checking it with a susceptance sketch.

This is an example of arranging a circuit to fit a requirement—say to tune in a certain station and at the same time tune out strong interference on another frequency. Fig. 9(a) or 10 could be connected in series with the aerial as a wave-trap and the component values chosen or adjusted to make the whole thing have infinite susceptance (zero reactance) at the wanted frequency and zero susceptance at the interference frequency.

I hope that if you are taking an interest in this at all (as you must be to be still here) you are taking time to work out how the sketches are affected by increasing or reducing L and C values. In fact, quite a lot of this

Fig. 11. When two or more tuned circuits are connected together, but without intercoupling, their resonant frequencies are the same as when they are separate.



(a) (b)

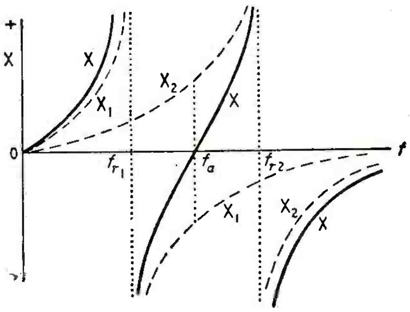


Fig. 12. This reactance sketch, of the first two tuned circuits in Fig. 11(b), shows the truth of the fixed resonant frequency principle.

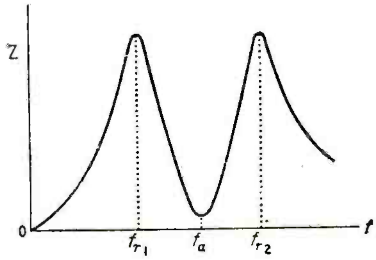


Fig. 13. Impedance sketch corresponding to Fig. 12, after allowing for a normal admixture of resistance.

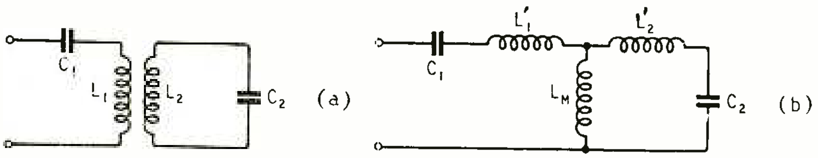


Fig. 14. *To bring (a) within the scope of the sketching technique, it should be replaced by its equivalent, (b).*

subject will have to be done as homework if I am to prevent it from spilling over into next month's issue. For example, see if you agree with me about the "increasing C" arrows in Fig. 9; if so, you might try putting in arrows for "increasing LA" and "increasing LB."

If one is to make practical use of tuning circuits with multiple resonances, an important thing is to know where the resonances occur (in frequency). With a single tuned circuit it can be calculated from $f_a = 1/2\pi\sqrt{LC}$. But in a multiple circuit is one resonant frequency affected by tuning to another?

In Fig. 9(a), the series resonant frequency (f_a) is determined by LA and C, and adjusting either of these obviously also affects the parallel resonant frequency with LB (f_r). But adjusting LB doesn't affect f_a, because at that frequency the reactance of the LA C branch is zero, and nothing that is connected in parallel with zero can affect it in the slightest. (Always provided that there is no appreciable coupling between LA and LB). So one would first set LA C to f_a; then, that having been settled, LB could be adjusted to the desired f_r without fear of upsetting the previous tuning. The same would apply to Fig. 10.

But if one has two or any number of complete tuned circuits as in Fig. 11, having no coupling between one another, each can be tuned quite independently. Take the first two rejector circuits in Fig. 11(b). Looking at Fig. 8 to remind ourselves of the characteristic shape of the reactance curve for a rejector circuit, we dot in the curves for these two, assuming that they resonate at different frequencies, f_{r1} and f_{r2}. As the two rejectors are in series, we get the reactance curve for the whole by adding those for the parts, as in full line (Fig. 12). Adding X_2 to X_1 however does not shift the position of f_{r1}, because at that frequency X_1 is already infinite.

In the same way, adding X_1 to X_2 shifts X_2—except where it is infinite, i.e., at f_{r2}. Between f_{r1} and f_{r2} the X curve is compelled to cross the f axis, giving an acceptor resonance f_a. This is because between f_{r1} and f_{r2} X_1 and X_2 are of opposite sign, and at one position (f_a) also equal in magnitude, making their sum zero. Looking at the circuit itself, we remember that below the resonant frequency the reactance of a rejector circuit is inductive, and above it is capacitive; so between f_{r1} and f_{r2} L_2 C_2 must be inductive and L_1 C_1 capacitive, and therefore capable of series resonance.

The effect of the little unavoidable resistance in tuned circuits is to convert "infinite" into "very high" and "zero" into "very low." Allowing for this, we can sketch a graph of *impedance* against frequency (Fig. 13). As this is only the *magnitude* of the impedance, there is no question of + and −.

If a little more homework is desired at this stage, it can suitably be indulged in by sketching the susceptance curves for Fig. 11(a). They should correspond to Fig. 12, and prove that the resonant frequencies of the separate acceptor circuits are independent of one another, and that there is a rejector resonance between each pair of them.

Then, if there is a desire to pursue the subject farther, I suggest studying circuits in which there is some degree of inductive coupling. Fig. 14 shows the technique for bringing them within the scope of what we have done already. L_1 and L_2, partly coupled, are replaced by L'_1 and L'_2, completely uncoupled, and L_m common to both and therefore completely coupled. This (Fig. 14(b)) is simply Fig. 6(a) added to Fig. 9(a). To make sure that you have got the hang of this subject, try sketching its reactance curve, assuming $C_1 L'_1 = C_2 L'_2$. I shall give you my version next month as a check.

Farther on still, this sketching business can be used to illuminate filters. I have no space to enlarge on this, but refer readers to Everitt's book, chapter VI. This explains a simple method of using reactance sketching to show the ranges of frequency over which filters pass and attenuate. It might be a good follow-up to my articles on filters (Jan. and Feb. 1950).

ENCROACHING TRANSMITTERS

COMPLAINTS have lately been rife among amateur transmitters that unauthorized stations are encroaching on the frequency bands allocated internationally for their use. These complaints are carried a stage further in the May issue of the *R.S.G.B. Bulletin*, where D. P. L. May (G2BB) enters specific objections against two distinct types of offenders, stated to be mainly of Eastern European origin: these are stations sending normal commercial traffic by high-speed telegraphy and nets of stations using amateur call signs but adopting military procedure.

Mr. May's letter continues:—

Since our authorities are powerless to prevent this misuse of bands allocated to us by international agreement, it seems to me that it is up to the amateur to take what action he can to show his disapproval.

Many amateurs are under the impression that it is useless to transmit on frequencies used by these stations, on the assumption that the offending transmitter is of high power, and therefore his own signal will be swamped. In practice I find that these intruders are just as susceptible to interference as is the long-suffering amateur station.

In one case recently a foreign "net" was working in the 20-metre band, using "BK" operation. I found that I could break-in on this net, and, having established this, I asked for "repeats" *and got them*! After a short time I found that I was virtually controlling the net, and it occurred to me that I might add further to their embarrassment. Accordingly I came up with "QRT" repeated several times. Very much to my amusement the whole gang promptly closed down!

I suggest that we may help to clear the "rubbish" off our bands by:—

(i) Seeking out frequencies occupied by the unwanted transmissions and using these frequencies for our transmissions from time to time; not being discouraged by unanswered CQ calls.

(ii) Making any tests or local contacts upon a frequency occupied by one of these "pirates."

(iii) Bringing this line of attack to the attention of overseas amateurs.

Our bands are crowded, even in the absence of commercial transmissions. Our present practice of moving into the gaps between the "pirate" transmissions is aggravating this trouble.

I feel that concerted action along the above lines will at least discourage the spread of this menace to our hobby.

Television Receiving Aerials

2—Problems Involved in Measurement, in Siting and in Construction

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

IN the first part of this article we dealt with the characteristics of simple dipole and multi-element television receiving aerials. In this, the concluding part, some of the problems involved in making measurements on these aerials are discussed together with some aspects of indoor aerials and the often neglected subject of mechanical design of outdoor aerials.

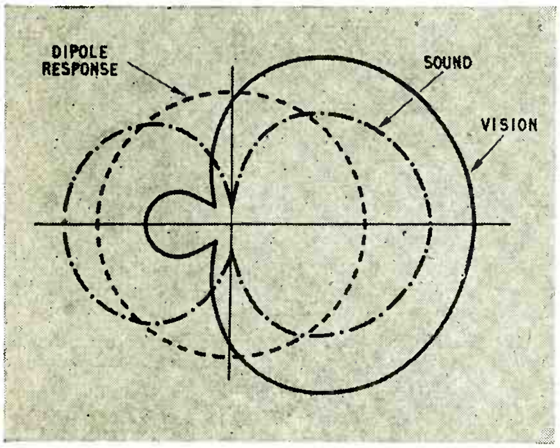


Fig. 10. Directional response of a typical λ/4-spaced 2-element aerial at a height of 30 ft compared with that of a dipole (broken-line curve).

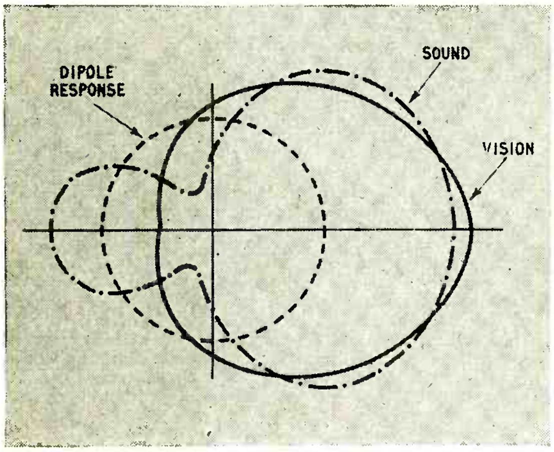


Fig. 11. Directional response of a typical 4-element array at a height of 30 ft compared with that of a dipole (broken-line curve).

Measurement of Gain and Directional Response.—Arrays are usually erected at heights between 30 and 100ft, and are nearly always surrounded by other structures. When comparing the properties of two arrays it is essential to select an open site free from elevated structures, and to choose a representative height such as 30-40ft. It must be ascertained, first, that the source of transmission does not produce any standing waves over the area chosen for the measurements, and that the initial plane of polarization is maintained; a preliminary survey with a dipole will provide this information. Figs. 10 and 11 are typical of the relative gain and directional response of a two- and a four-element array compared with a dipole. They indicate the extent to which gain and front-to-back ratios may be improved by the addition of parasitic elements, but they cannot indicate those properties when the aerials are installed on a site which is not free from proximity effects. Maximum gain and front-to-back ratio can only be achieved by adjustment during installation, but in practice this is too costly.

Bandwidth of Arrays.—No reliable information seems to have been published on the terminal impedance or bandwidths of parasitic television arrays. Accessible papers indicate lower values than for a dipole, but they generally deal with optimum single-frequency conditions for maximum gain or front-to-back ratio and the feeder is removed from the plane of the elements.

Measurements made by the bridge previously described do not indicate a narrowed response, or a low mid-band impedance, when a four-element array is designed as a compromise for both vision and sound and includes the proximity effect of the feeder. Fig. 12 shows an example of a set of measurements. The array is probably behaving as a bandpass filter.

The terminal-impedance characteristic of an array is not the only criterion of its frequency selectivity. As the number of elements is increased the directional response becomes very sensitive to small deviations from the design frequency. It is possible to devise an array which would have maximum response at say 45 Mc/s but would be at a minimum at 47 Mc/s. Such an array would attenuate the upper side bands of the London vision transmission to the detriment of the picture definition, although the terminal impedance characteristics might be flat over this range. If a four-element array is used in an adequate field-strength, and is rotated to a bearing approaching that of its *minimum* response to the video carrier, some loss of definition will be observed. Normally the beam in the direction of the transmitter is

*Belling & Lee, Ltd.

sufficiently blunt to make the effect inappreciable when the array is slightly off bearing, but the effect does not appear to be appreciated generally.

Viewing tests confirm that the loaded bandwidth of a four-element array is adequate for full definition, though the frequency band transmitted by the B.B.C. may not always provide the most acceptable picture. Installers of receivers in "fringe" areas will testify to the advantages to be obtained by tuning the i.f. circuits more sharply in order to minimize interference and receiver noise. Full use of the transmitted bandwidth can be made with advantage to the viewer only when interference of all kinds is negligible.

Indoor Aerials.—In areas enjoying high signal strength satisfactory reception can be obtained with any piece of wire as an aerial if the site is reasonably free from electrical interference. However, a resonant dipole shortened somewhat to allow for the increased proximity effects of walls is usually more effective than a random length of wire. Aerials of this kind all suffer from a common defect. Movement of persons in the room, or in an adjacent room, disturb the standing-wave signal pattern and cause picture brightness flutter. A position relatively free from this defect may be found by experiment and so the indoor aerial has become popular where signals are strong.

Siting Problems.—In most cases the problem of siting a receiving aerial reduces to one of finding the most convenient point of installation consistent with adequate field strength and a feeder of minimum length. The only circumstances in which an advantage may be gained by incurring greater feeder length is when the aerial can be removed from a local field of interference so that the signal-to-noise ratio may be improved. In the presence of surrounding buildings raising an aerial will sometimes *decrease* the received energy. This effect is due to standing waves and, when present, a small lateral or vertical shift of the aerial will often assist in reducing c.w. interference and ghosts. The screening effect of a building may often be used to reduce interference, particularly from the ignition systems of vehicles. For example, a viewer dwelling on the side of a busy thoroughfare might be better served by an aerial at a height of about 15ft at the end of the back-garden.

Ghosts from Structures and Hills.—Single or multiple ghosts due to reflections from hills or elevated structures may constitute a serious problem. Successful reduction may often be achieved by the use of a 2-element array in cases where the reflection is from a single hill or structure behind, or at the side of, the receiving site. More stubborn cases may require the use of a 4-element array. It is indeed fortunate that the troublesome reflections are confined within a semicircle *behind* the receiving site. The energy of reflections forward, and to the side, of the site is of much lower intensity.

A serious problem will exist when the intensity of the direct signal is lower than that of the reflected. Viewers on the lee-side of a valley will receive a small proportion of direct signal by diffraction, the greater proportion arriving by paths from reflecting surfaces on the opposite side. These conditions are known to occur within a few miles of the Holme Moss transmitter. Receivers well within the average service area may have to be regarded as outside it if local contours lower the intensity of the direct signal in this way. Where such vicinities are densely populated a relay system or low powered transmitter, or reradiator, may provide the only satisfactory solution. This problem has already been discussed in *Wireless World*[5].

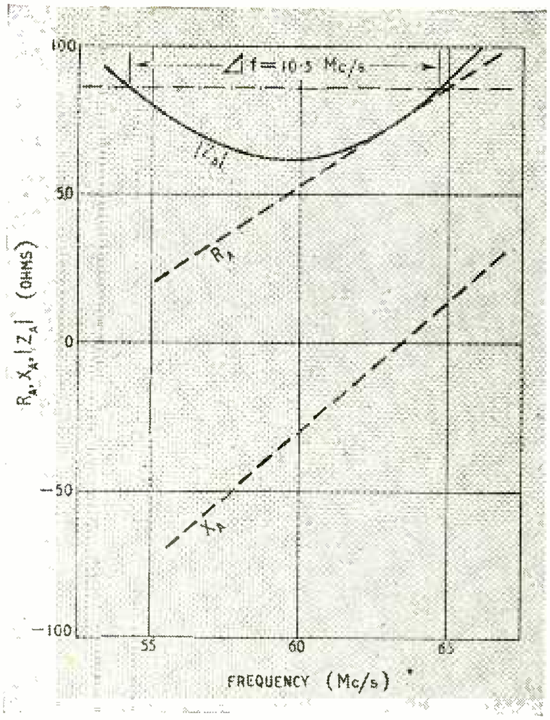


Fig. 12. Measured intrinsic impedance of a 4-element array.

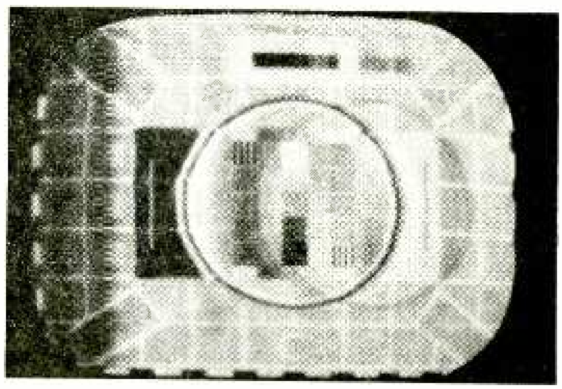


Fig. 13. Typical ghost due to distant hills.

It should be observed that a reflection occuring on a white picture element may be delayed so that it coincides with, and cancels, a black line-synchronising pulse. In this case the receiver time-base fires indeterminately and produces "tearing" of the picture. Under certain conditions synchronism may be established, alternatively, by the direct and reflected waves in a random manner depending upon the black and white picture distribution. Fig. 13 shows a typical ghost due to distant hills while Fig. 14 shows loss of synchronism due to a ghost which is not apparent as a displaced image.

The trouble is likely to become widespread when the Scottish and Welsh transmitters are in operation,

[5]Hutton, J. A.; March 1952, p. 84.

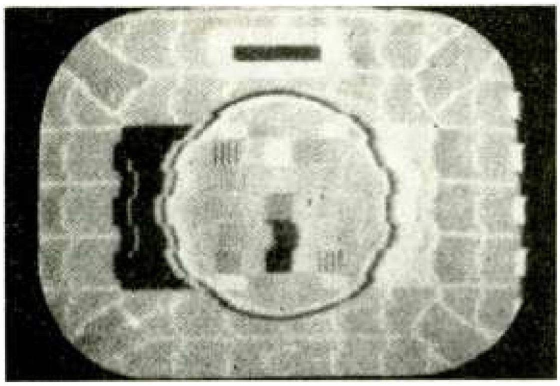


Fig. 14. Loss of synchronism due to ghost which, however, is not apparent as an image.

because the service areas appear to include a number of unfavourably placed valleys.

It has been found that a considerable reduction of the ghosting effect may be obtained, not only by turning the aerial in the normal way, but by tilting it away from the source of the reflections, and sometimes by skewing the aerial slightly to one side or the other.

The position of the aerial is also extremely important and it has been found that moving an aerial a few feet is sufficient to remove or partially remove ghosts in some instances. The same techniques apply when loss of synchronism, as distinct from ghosts, is the only evidence that the phenomenon is occurring.

Mechanical Design.—A television aerial must be capable of withstanding continuous atmospheric exposure for several years without overhaul. There must be no inherent weaknesses in the design which would cause fracture or permanent distortion when the aerial is subjected to gusts of 80 miles per hour, which occur frequently in exposed coastal parts of the British Isles. So far as electrical requirements permit the aerial should be neat in appearance, light, and capable of erection without difficulty.

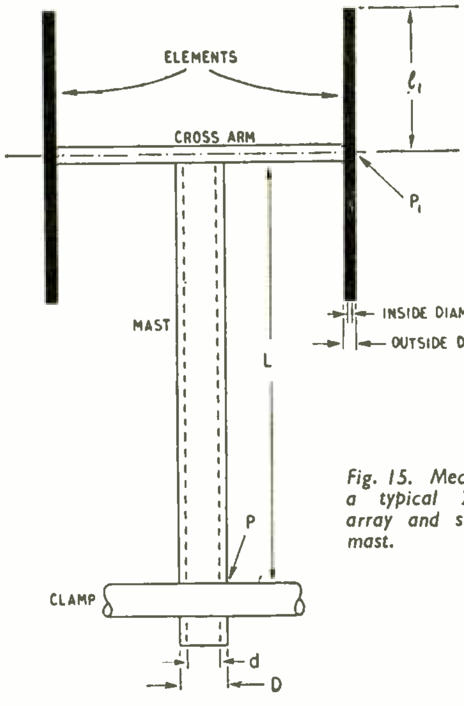


Fig. 15. Mechanics of a typical 2-element array and supporting mast.

The elements of pre-war aerials were usually constructed from brass tubing. This material possesses moderately good corrosion resistance, but is at present scarce and expensive. Since the war steel or light alloys have been used. Steel possesses better tensile properties than light alloys but needs protective treatment, particularly when installed in industrial areas where the atmosphere is polluted with acid gases. Heat-treated aluminium alloys have now almost superseded steel. The base material, aluminium, is alloyed with small quantities of magnesium and silicon. The alloy is fully heat-treated and has a minimum 1 per cent proof-stress of 15 tons per square-inch. Circular section tubing is invariably employed for the elements on account of its ease of manufacture. Because these elements are vertically disposed the bending stresses at the point of attachment to the cross-arm P_1 (Fig. 15) will depend upon the wind velocity. At 80 m.p.h. the pressure on the effective projected area of a cylinder is 4.96×10^{-5} tons/sq/in.

The bending stress at the fulcrum (P_1) is :—

$$S_{P1} = \frac{4.96 \times 10^{-5} l_1^2 D_1^2}{0.196 (D_1^4 - d_1^4)} \text{ tons/sq/in}$$

This must be less than the proof-stress for the material in the ratio of the factor of safety, which is a matter for the makers' discretion.

The dipole inner tips are enclosed in an insulator which protects the feeder connections from corrosion. Because the impedance between the inner tips of the elements is not greater than 100 ohms the electrical qualities of the insulator are unimportant. Calculations, based upon the power factor and dielectric constant of the lowest grade of thermo-setting plastic, will confirm this. The effect of a solid block of ice across the inner tips of the element has been studied; measurements at 45 Mc/s indicate shunt resistances of the order of 30,000 ohms, which is negligible. The effect of a film of water over the insulator has also been investigated and found to produce negligible shunting effect.

In order to satisfy certain mechanical requirements some of the component parts of the aerial structure (e.g. bolts, nuts and clamps) may be made from dissimilar metals, and the contact potentials arising from galvanic action will promote corrosion under damp conditions; the metals should be selected, or suitably electro-plated with other metals, so that the resultant contact potentials do not exceed 0.25 V. In the installed position the contour of the structure, particularly at points of high stress, must not present any hollows which could trap rain and thereby accelerate corrosion. Slotting, notching, or dimpling at stressed points is undesirable as this leads to crystallization, and ultimate fatigue of the metal.

Well-seasoned Canadian Douglas fir is suitable material for masts; Scotch fir is a good alternative but the timber shortage has led to the general adoption of light alloys in their place.

The effect of a metal mast on the gain and directional response of an aerial does not appear to differ appreciably from that of a wooden mast due to the feeder, which lies close to the axis of the mast in either case. The stresses at the fulcrum of the mast P

(Fig. 15) may be determined at a wind velocity of 80 m.p.h., from :—

$$S_P = \frac{5.17 \times 10^{-4} LD \left(A_1 + \frac{A_2}{2}\right)}{(D^4 - d^4)} \text{ tons/sq/in}$$

where the multiplier

$$5.17 \times 10^{-4} = \frac{4.96 \times 10^{-5}}{\pi/32}$$

and A_1 = Projected area of array in sq in.
A_2 = Projected area of mast in sq in.

Attaching the Aerial to a Building.—The aerial assembly is often mounted on a wall, and a suitable bracket and flange are required so that the attachment may be made by coach or rag bolts. An aerial so installed constitutes a landlord's fixture and in common law cannot be removed by the outgoing tenant. More often the aerial is attached to a chimney stack by clamps, secured by a wire lashing tensioned round the stack. This method has been used for many years by the British Post Office for attaching telephone line insulators to buildings, and apart from its simplicity and reliability it does not constitute a landlord's fixture when applied to television aerials. The stranded lashing wire should be of 7/16 or 7/18 s.w.g. heavily galvanized, high tensile steel (100 tons/sq/in).

Audible Humming of an Aerial.—The low frequency hum (about 60 to 100 c/s) observed when steady light breezes cause an alloy aerial to vibrate (and the interior of a chimney stack to amplify the hum by resonance), is very objectionable. The frequency of the hum, which is due to turbulance and causes the well-known " singing " of telephone wires, is given by :

$$f = \frac{3.26v}{d}$$

where v is the wind velocity in miles per hour, and d is the element diameter in inches.

The element diameter of typical aerials is of the order of ½ in, so that a steady breeze of 10 miles per hour will generate an eddy frequency of about 65 c/s. Masts are usually of the order of 2 in diameter, so that the wind velocity would have to be very high before the eddy frequency attributable to them attained an audible pitch. The effect has not been observed on masts, possibly because the wind velocity at gale levels is insufficiently uniform to produce it. The turbulent frequency of the elements may not be audible unless it coincides with a principal flexural resonance of an element, and it is a coincidence that the mechanical properties of light alloys, and the dimensions necessitated by electrical and mechanical requirements, provide the conditions for flexural resonance at the most likely turbulent frequency, i.e. 60-80 c/s. Because of the different mechanical properties of steel the phenomenon does not occur when this is used.

The trouble may be cured by introducing some form of mechanical damping.

21-Mc/s BAND-PASS CONVERTER

Modifying the 10-metre Model for Reception on 14 Metres

THE recent announcement that as from July 1st United Kingdom amateurs can operate in the 21-Mc/s band (14 metres) comes as welcome and timely news since it follows so soon after a similar concession granted to United States amateurs. U.K. amateurs are at present restricted to the use of telegraphy and to 200 kc/s only, the actual band being 21 to 21.2 Mc/s.

The converter described here for use in this band is identical to the 10-metre band-pass converter described a year or two ago in *Wireless World*.[1] In fact the only difference between the new model and the 10-metre one is in the signal-frequency coils. In the original circuit, redrawn here in Fig 1, these are marked T_1 and T_2. The circuit damping resistors, R_1, R_4 and R_6, are retained at 10 kΩ.

Although the requirement is for a coverage of 21 to 21.2 Mc/s only, as it is relatively easy to obtain a 1-Mc/s bandwidth, advantage is taken to give a coverage of 21 to 22 Mc/s, and so take in the whole of the adjacent 13-metre broadcast band as well.

As in the previous model, the intermediate frequency is 6 Mc/s (50 metres) and the unit is intended primarily for use with the popular R1155 communications receiver, but it can be used equally well with any receiver having a short-wave range covering 50 metres. In this case the resistor R_{14} in the h.t. negative lead can be omitted.

[1]Band-pass Converters, *Wireless World*, October 1950.

Propagation conditions being not particularly favourable for long-distance 10-metre communications just now the existing converter was altered for the new 14-metre band by replacing the three signal-frequency coils L_2, L_3 and L_4 but using the original 10-metre oscillator coil. Having made the coils, and they are simple and quite straightforward, the replacement can be effected in about half an hour, including realignment of the circuits.

Like those of the 10-metre model, the 14-metre

Coils	Former Size	Wire Gauge	Turns	Winding Length
	in in			
T_1 { L_1	$\frac{3}{8} \times 1\frac{1}{2}$	No. 26 EN	8	0.2 in
T_1 { L_2		No. 26 EN	25	0.5 in
T_2 { L_3	$\frac{3}{8} \times 2\frac{1}{4}$	No. 26 EN	25	0.5 in
T_2 { L_4		No. 26 EN	24	0.5 in
L_7	$\frac{3}{8} \times 1\frac{1}{4}$	No. 26 EN	13	Spaced in 0.5 in
		or		
		No. 24 EN	13	closewound
T_3 { L_5	$\frac{1}{2} \times 1\frac{3}{4}$	No. 26 EN	48	1 in
T_3 { L_6		No. 26 EN	5	Overwound earthy end

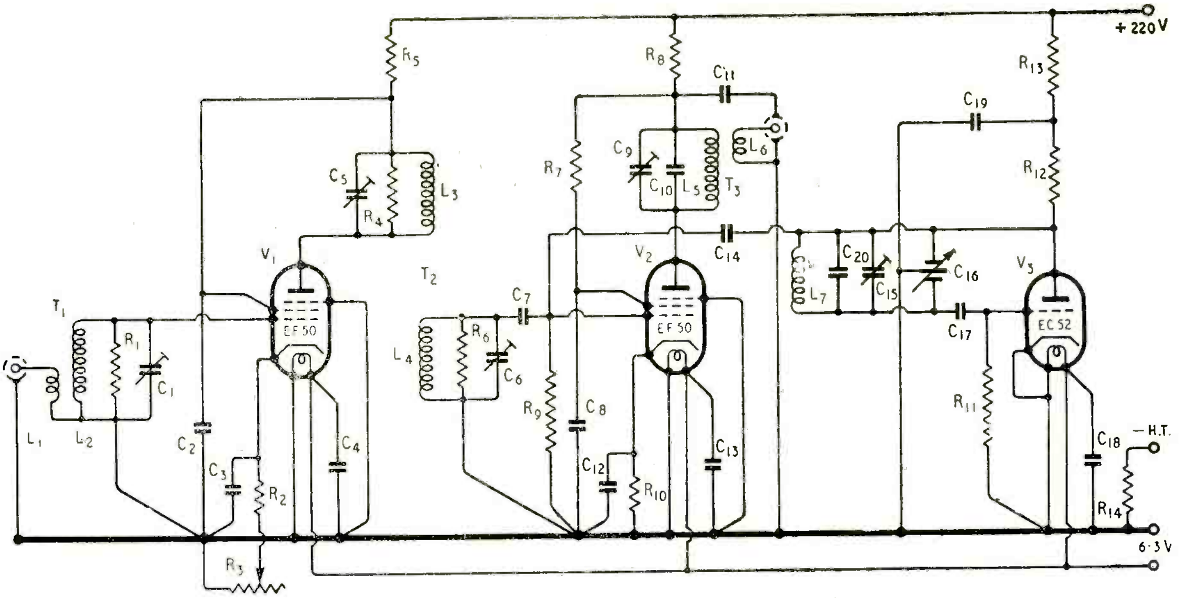


Fig. 1. Circuit of the original 10-metre converter is used also for the 14-m model except for an additional capacitor, C20, joined across L_7. Components are as follows: C_1, C_5, C_6 = 10 pF (max); C_2, C_3, C_4, C_{18}, C_{19} = 0.001 μF; C_7, C_{17} = 22 pF; C_8, C_{11}, C_{12}, C_{13} = 0.01 μF; C_9 = 30 pF (max); C_{10} = 100 pF; C_{14} = 5 pF; C_{15} = 30 pF (max); C_{20} = 10 pF; C_{16} = 8 + 8 pF (butterfly); all 350 V working. R_1, R_4, R_6 = 10 kΩ; R_2 = 150 Ω; R_3 = 10 kΩ (var); R_5, R_8, R_{13}, R_{14} = 2.2 kΩ; R_7 = 68 kΩ; R_9 = 2.2 MΩ; R_{10} = 470 Ω; R_{11}, R_{12} = 33 kΩ; all ½ W except R_{12} which is 1 W.

coils are wound on ⅜-in diameter formers. In view of the difficulty experienced in obtaining the bakelized paper tube used hitherto, a substitute was sought and found in ⅜-in hardwood dowel rods obtainable from most ironmongers or hardware stores.

After cutting the formers to the required size they are thoroughly dried in an oven and then given a coat of shellac varnish. Thick varnish should not be used, and it is actually better to soak them in a diluted varnish rather than apply it with a brush as the thin varnish penetrated deeper into the wood. When dry they can be wound in accordance with the data in the coil table. They are then given another coat of diluted shellac varnish and set aside to dry and harden. Coils made in this manner have proved quite satisfactory on a number of occasions and help to solve one of the main difficulties of present-day home construction: namely, finding suitable quantities of raw materials.

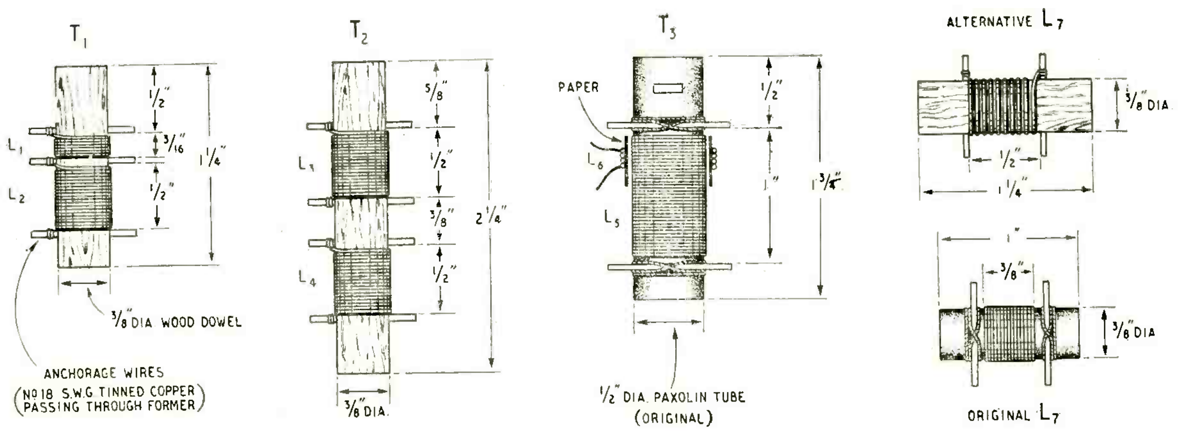
The ends of the windings can be anchored to short lengths of No. 18 s.w.g. tinned copper wire secured to the wooden formers by binding with thread as illustrated in the drawings of the 10-metre coils or by drilling slightly undersized holes through the wooden former and drive in the wire studs. Details of the new coils are given in Fig 2, where is included also the original 6-Mc/s i.f. transformer T_3.

Alignment of the converter is effected by tuning the input circuit L_2 C_1 to 21.4 Mc/s, the first band-pass circuit L_3 C_5 to 21.6 Mc/s and the second band-pass circuit L_4 C_6 to 21.2 Mc/s.

In order to enable one gauge of wire to be used for all coils an alternative winding for L_7 is given in Fig 2.

H. B. D.

Fig. 2. Details of the 14-metre coils T_1 and T_2 and of the alternative oscillator coil L_7. Included also is the original i.f. transformer T_3 and the original oscillator coil.



LETTERS TO THE EDITOR

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

Frequency Response Measurements

THE useful contribution of S. Kelly and A. M. Pollock on thorn styli last month raises, as a side issue, an interesting discrepancy between the results plotted from fixed-frequency, point-to-point measurements and those obtained with a gliding tone record.

The test signal used with automatic curve tracers coupled to beat-frequency oscillators or gliding tone discs, which sweep through the audio-"frequency" range in a matter of minutes (in some cases, even seconds), is really one long transient. To append a scale marked "Frequency in cycles per second" to curves obtained with such apparatus, seems to me to be the height of optimism. How can the concept of frequency, which is essentially repetitive, be applied to a vibration emanating from a system whose parameters are changing continuously with time? Or are we supposed to believe that there is such a thing as "instantaneous frequency"? If so, it must change even during the period of each cycle of the wave, which can never be sinusoidal.

Hindhead, Surrey. HENRY MORGAN.

Aerial Ambiguities

WHENEVER I hear people talking about the "beam" of a directional receiving aerial, I feel inclined to ask "A beam of what?" A contributor to your June issue, for example, refers to the "beam" of a radio telescope, thereby leading the uninitiated to think of a radio telescope as some kind of device that directs energy like a searchlight. In the same way, aerial experts often talk about the "radiator" of a paraboloidal receiving aerial, or about the parabolic reflector being "illuminated" by the "radiator." We know that these wizards suffer from the occupational disease of always having their heads in the ether and couldn't care less whether an aerial is used for transmitting or receiving, but such ambiguous terminology makes things very difficult for poor plodders like me who like to keep their feet on the ground.

London, S.W.4. JAMES FRANKLIN.

Ionosphere and Weather

THOSE interested in "Winds in the Ionosphere" (your May issue) may not know that Amundsen, in the journal of his voyage to the North Pole, makes the very interesting and remarkable observation that by the speed and direction of motion of certain streamers in the Aurora Borealis he was able to predict the strength and direction of the winds on the earth's surface likely to be encountered a few days later.

Whether or not there is a movement of air in the ionosphere, it is abundantly certain that the movement of the ionised layers is interlocked with terrestrial weather phenomena.

The development of the big anti-cyclones which frequently cover a large area of Europe is always preceded by abnormal ionospheric activity. I have kept observations on this particular "warning" for 25 years and have never known—rare though it be—the long, slow swing on my meter fail to produce its welcome fine-weather system.

London, S.W.16. B. S. T. WALLACE.

Complaints Box

MAY I get a couple of complaints off my chest? Now that the ether is a mad jumble of interference, why are the set manufacturers content to do nothing about it? Why don't they leave the lush South, and set up their development departments in large interference-infested towns like this? Banks of rejectors cost money, but could be worth while.

Then there are volume controls. I have needed four new ones for my "sound" receiver and one for my television set inside two years. The squash-plate type seemed promising, but has now taken a back seat. The only bright idea appears to be the German one of using a globule of mercury for making contact with the carbon track.

Rugby. J. W. SHILVOK.

"Pre-recorded"

I WISH you would bring your influence to bear on the B.B.C. to explain a recently introduced monstrosity: the expression "pre-recorded" as applied to a programme. Pre-when? A "post-recorded" transmission should be worth while hearing! On second thoughts, though, perhaps the Corporation is leaving the door open for the time when they may be able to pick up and record a transmission that has been echoing for years through the vastness of outer space.

Seriously, the B.B.C. should give some thought to choice of a proper form of words for announcements of this kind. "This programme was recorded" is lacking in precision; for all we know, it may have been a "live" transmission that had been recorded for later reproduction.

Norwich. R. P. TRUMAN.

Marking Resistors

IN your May issue "Diallist" brought up an interesting point with regard to the colour codes on resistances, and asks why it has become so firmly established. I have often wondered why myself, and although his suggestions on marking the resistances are very good I would like to point out that decimal points are easily obliterated. I would suggest that a 100,000-ohm resistor be marked 100k, which would make it very much easier to read. Incidentally, I know of one Italian firm who mark their resistors and do not use the colour code. I can assure you that this makes for very much quicker work.

The one great drawback in marking resistors (and this applies to resistors marked with dots instead of bands as well), is that it is very difficult to identify them when wired in a circuit, *unless* the marking is in such a position that the value can be easily read off. Assuring that resistors are wired in a circuit with the value easily displayed will, again, increase production time. Of course, this would not apply to the case where all components are mounted on a common tag-board.

In view of the above, I think that the coding of resistors by means of colour bands seems to be the best method. The ideal case would be to mark the resistors by means of coloured bands as well as numerically, but I suppose that this would be asking too much.

Livingstone, N. Rhodesia. R. KRUMMECK.

Electronic Noughts and Crosses

I RECENTLY built a machine for playing Tick-tack-toe (noughts and crosses) and I am sure that others have done so also. I would welcome correspondence with all individuals who have built such devices or who know of such and their makers or published material on the same.

5430, 35th St., E. M. McCORMICK.
W. Riverside, California, U.S.A.

WORLD OF WIRELESS

Decimetre Television in America ◆ Amateur Frequency Changes ◆ International Television ◆ Awards to Authors

U.S. Television

BY assigning 70 channels in the 470-890-Mc/s band to television, the Federal Communications Commission has been able to lift the ban on the building of stations which it imposed in 1948. There are at present 108 stations in America operating in the 12 channels in the bands between 54 and 216 Mc/s but eventually the F.C.C. plans to allow for 2,053 transmitters of which 242 will be non-commercial educational stations.

According to our contemporary, *Electronics*, there were 506 applications for building stations outstanding in February this year.

14 *and* 21 *Mc/s*

AS from July 1st amateur transmission in the band 14.35-14.40 Mc/s will cease and, in place, amateurs in the U.K. will initially be permitted to use 21.0-21.2 Mc/s, which it is expected will ultimately be extended to 21.45 Mc/s. Transmissions will temporarily be restricted to telegraphy (A1).

This announcement by the G.P.O. followed a similar statement by the American and Canadian authorities introducing the 21.0-21.45-Mc/s band as from May 1st. The 14-Mc/s band was withdrawn in N. America on April 1st.

It has been recommended to the International Amateur Radio Union that the first 150 kc/s of the new band be used for telegraphy and the remainder for both 'phone and W/T.

In the States a new interference problem arises for, according to *QST*, the industry chose—in the face of opposition from the American Radio Relay League—21.25-21.9 Mc/s as the sound channel i.f. for television sets.

Anglo-French Television

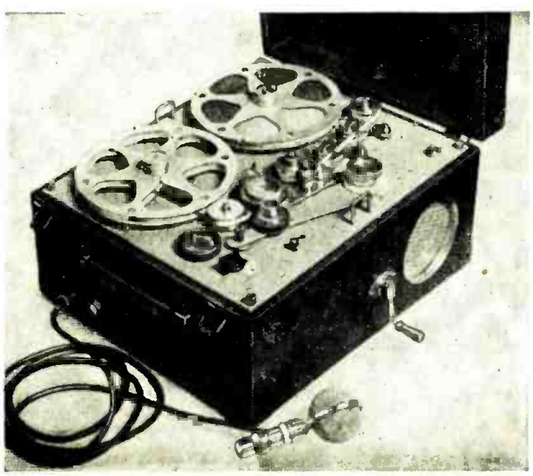
FOR the first time in the history of television, the same programmes will be broadcast from 8th to 14th July simultaneously in two countries using different standards. The B.B.C. and Radiodiffusion et Télévision Françaises are combining forces for the interchange of programmes between London and Paris.

The major problem has been to convert 819-line pictures to 405 lines and vice-versa, but, by the introduction of spot-wobble, it has been possible to remove the line structure thus allowing the resulting picture from one country to be re-scanned from the end of a monitor tube for re-transmission.

Technical Writing Premiums

THE first awards under the Radio Industry Council's scheme for encouraging technical writers will, it is hoped, be made in time for presentation of cheques at the National Radio Show. According to the scheme (see *Wireless World*, January, 1952) premiums of 25 guineas each, up to an average of six per year, are offered.

The interim awards are to be made for articles published in the first six months of this year. Authors of articles, or editors of journals in which they are published, are invited to submit them for consideration not later than July 7th to the Radio Industry Council, 59, Russell Square, London, W.C.1. Full particulars of the competition may be had from that address.



WINNING EXHIBIT in the 1952 competition for the President's Trophy for apparatus made by members of the B.S.R.A. in their amateur capacity ; the battery-operated portable tape recorder made by C. L. Appleby.

Birthday Honours

AMONG the first Birthday Honours conferred by the Queen were the C.B.E. on W. J. Richards, chief supt., Telecommunications Research Establishment; and Dr. R. L. Smith-Rose, director of radio research, D.S.I.R.

The following become M.B.E.s:—F. G. Diver, chief engineer, McMichael Radio; E. Garthwaite, chief engineer, Marconi Instruments; and F. W. Jones, engineer-in-charge of machine shop, Mullard Radio Valve Co., Mitcham.

F. H. Gilbert, overseer, Admiralty Shore Wireless Service, receives the British Empire Medal.

Increased Exports

FIGURES based on Customs and Excise returns for the first three months of the year, reveal that the value of the components exported was the highest of any section of the industry — £2,412,000, which is nearly 37 per cent of the total of £6,558,000.

The exports of transmitters, communications equipment and navigational aids totalled £1,725,000 (26 per cent), receivers £1,320,000 (20 per cent), valves £967,000 (15 per cent) and unclassified equipment £134,000 (2 per cent.)

If exports continue at the volume recorded for the first three months of the year, the year's figure will exceed £26,000,000. The figures quoted do not take into account indirect exports of equipment installed in ships and aircraft or components used in electrical apparatus other than radio and electronic equipment.

Amateur Recordings

THE question of the recording and re-radiation of amateur transmissions has been raised by the R.S.G.B. The Society states it has been advised that the G.P.O. raises no objection to the recording of transmissions which fall within the scope of the P.M.G.'s licence.

It is pointed out, however, that if it is intended to re-transmit the recordings, the call sign of the original station must be deleted and, too, that the re-transmission must be for the originator of the message.

PERSONALITIES

Brigadier E. J. H. Moppett, M.I.E.E., who has just completed his tour of duty as Chief Inspector, Electrical and Mechanical Equipment, Ministry of

Supply, has voluntarily retired after 29 years' service in Royal Signals, to join the Pye Group of Companies. He will be a director of Pye Telecommunications, Ltd. Brigadier Moppett is very well known in the radio industry through his three tours with I.E.M.E. since 1940, when he first joined this Inspectorate as the original Inspector of Radiolocation. At the beginning of the war he left the Army School of Signals, where he was Chief Radio Instructor, to join Lord Gort's staff as Wireless Staff Officer. During the D-day period he was in the War Office communication system.

Dr. R. L. SMITH-ROSE
(See "Birthday Honours")

Donald G. Fink has resigned the editorship of our New York contemporary, *Electronics*, to join the Philco Corp. as co-director of research-operations. He joined the editorial staff of *Electronics* after graduating with the B.Sc. from the Massachusetts Institute of Technology in 1933. During the war he obtained leave of absence to become a member of the Radiation Laboratory at M.I.T. and subsequently headed the loran division.

John H. Jupe, A.M.I.E.E., who has occasionally contributed to *Wireless World*, has resigned from his post as Press Officer to the General Electric Co. to take up an appointment in the Technical Information Division of Marconi's at Chelmsford.

Jack Sykes, M.I.E.E., M.Brit.I.R.E., who has been Divisional Telecommunications Officer at the South-West Division H.Q. of the Ministry of Civil Aviation since 1948, has been appointed Senior Signals Officer (Telecommunications Training) in succession to D. P. Taylor, whose appointment to I.C.A.O. was announced last month. Mr. Sykes joined the Ministry in 1935 as an examiner. He is succeeded at the S.W. Division by **A. C. Knowling,** O.B.E., who, until recently, was for five years in charge of civil aviation telecommunications in the British Zone of Germany.

Hugo Gernsback, editor of our American contemporary, *Radio-Electronics*, is visiting Europe and will be in this country from July 2nd-8th.

L. F. Sinfield, author of the article on square-wave generators (p. 285), who is now working on the development of industrial electronic equipment and instruments, spent most of his career in the R.A.F. on radio and radar. After instructing on airborne radar gear at the R.A.F. Radio Schools (7 and 8) and at the Bomber Command Radar School, he spent several years on the development of airborne radar equipment and radar counter-measures before leaving the Service in 1947.

IN BRIEF

Receiving Licences current in the U.K. at the end of April totalled 12,646,000, including 1,487,000 for television and 132,871 for car radio. The month's increase in television licences was approx. 30,000.

Telecommunications Standards.—The first meeting of the recently formed Telecommunications Industries Standards Committee was held at the British Standards Institution on May 15th. The R.I.C. and its four constituent bodies (B.R.E.M.A., R.E.C.M.F., R.C.E.E.A., and B.V.A.), together with the Ministries of Supply and Civil Aviation, G.P.O., D.S.I.R., British Electricity Authority, British Electrical & Allied Manufacturers' Association and the Telecommunication Engineering and Manufacturing Association, are represented on the committee, of which O. W. Humphreys, director of the G.E.C. Research Laboratories, is chairman.

Membership of the Radio Section of the I.E.E. is the largest of any of the four specialized sections of the Institution—4,768. The total membership of the Institution is given in the recently issued annual report for 1951-52 as 37,253.

Marine Scholarships.—To provide financial assistance to intending radio officers, the Marconi Marine Co. has introduced a scholarship scheme. Fifty scholarships will be awarded this year and these have been allocated to fifteen private wireless training colleges in the U.K. The Company will meet two-thirds of the tuition fees for the training of successful applicants, who must be nominated by the principals of the colleges.

MOUNTED on a telescopic hydraulic mast, the scanner on this mobile Decca radar demonstration unit can be readily raised for operational purposes and stowed below the roof line when on the road. The vehicle enables demonstrations to be given to shipping interests "on their doorsteps."

Information Theory.—The symposium announced in the April issue (p. 149) is to be held at the I.E.E. during the week commencing September 22nd. The tentative programme includes over forty papers grouped under the following subject headings: General Theory; Modulation Systems; Smoothing, Filtering and Feedback; Speech and Music; Television and Facsimile.

Instruments Show.—The second British Instrument Industries Exhibition is planned to be held at Olympia from June 30th to July 11th next year.

B.S.R.A. Officers.—The new president of the British Sound Recording Association is H. Davies, who is in charge of the recording section of the B.B.C. Designs Dept. The 1952-53 vice-presidents are M. J. L. Pulling, at one time supt. engineer (recording) and now senior supt. engineer (television), B.B.C., and N. Leevers, of Leevers, Rich & Co., Ltd. R. W. Lowden continues as honorary secretary.

A.P.A.E.—At the annual general meeting of the Association of Public Address Engineers on May 29th, A. E. Buchan, of Aberdeen, was elected president. This year's vice-presidents are A. M. Middleton (Post Office Radio Branch), L. W. Murkham (Reslosound), C. W. Clarabut, of Bedford, who is also chairman, and Alex. J. Walker, who also continues as honorary secretary. The vice-chairman is A. Apps, of Canterbury.

Kinematography and Television.—To provide for a closer co-operation between technicians in kinematography and television, the British Kinematograph Society has inaugurated a Television Division, particulars of which are obtainable from the Secretary, B.K.S., 164, Shaftesbury Avenue, London, W.C.2.

German Show of radio and television equipment will be held in Dusseldorf from August 22nd to 31st.

Radio Industries Club's twenty-first anniversary was celebrated with a special luncheon on May 20th at which Lord Brabazon, the new president, was in the chair. The Club's new chairman is Owen Pawsey (editor, *Electrical & Radio Trading*) and the vice-chairman H. A. Curtis (director, Radio & Television Retailers' Association). In the Club's annual report it is recorded that the membership has increased by 38, the total now being 750.

Radio Ball.—The Radio Industries Ball will again be held at Grosvenor House, Park Lane, London, W.1, on the first Friday of the Earls Court Show—August 29th.

B.S.R.A., Manchester.—The general meeting of the Manchester Centre of B.S.R.A. will be held at 7.30 on June 30th in the Engineers' Club, Albert Square, Manchester.

Electronic Control of cranes, both by radio and television, were demonstrated at the recent Mechanical Handling Exhibition organized by *Mechanical Handling* at Olympia.

Antiference, Ltd., provided the aerials for the reception by the six selected North London schools of the 200-Mc/s experimental B.B.C. television transmissions to schools. A new factory and sales office of Antiference (Canada), Ltd., is being opened in Toronto this month. Norman M. Best, managing director of the parent company, was accompanied on his visit to Canada by R. M. Henderson, who is remaining in Toronto as general manager.

Metropolitan-Vickers announce that Walter Symes has resigned from the Board and from the position of works manager at Trafford Park to become manufacturing consultant with Associated Electrical Industries. His place on the Board, and as works manager, is being filled by Arthur C. Main, who has been with the company since 1925. They were both concerned with the production of radar gear during the war.

British Standards.—A complete list of the 1,800 British Standards current at March 31st, with a brief description of the subject matter of each, is given in the B.S.I. Year Book for 1952. Obtainable from the British Standards Institution, 24, Victoria Street, Westminster, London, S.W.1, it costs 7s 6d.

"Electrical Who's Who."—The second edition of this directory of men and women in prominent positions in the electrical industry, compiled by *Electrical Review*, is now available, price 12s 6d (postage 1s 3d). About a thousand names have been added during the revision.

"Elettra II," the research and demonstration yacht of the Marconi Marine Co., is being used, in company with the training ship *Wendorian*, for the residential nautical course "How do I go to Sea?" which is sponsored by the Ministry of Labour.

Partridge Transformers.—We are asked by the manufacturers to state that the prices which they gave in their advertisement on p. 101 of the June issue were by an oversight incorrect and that the price of the potted type should be £7 5s and of the de luxe type £6 16s 6d.

Fifty years of manufacturing at the Rugby works of B.T.H. was celebrated on May 2nd by a luncheon attended by representatives of industry and civic life in the town.

Cossor's Technical Service Dept. has moved to 445-447, Holloway Road, London, N.7 (Tel.: Archway 6281). W. F. Poole is in charge of the Department.

Multicore's Ersin Flux, hitherto available only as a core in solder, is now obtainable in liquid form in gallon cans.

Trevor-Johnstone Co., assemblers and distributors in this country of the Belgian Dictorel magnetic dictating machine (see our May, 1951, issue), have moved their head office to 14, Berkeley Street, London, W.1. The development and service departments are remaining at 169-174, Sloane Street, London, S.W.1.

BUSINESS NOTES

Standby Transmitters.—The B.B.C. has ordered two more 5-kW transmitters and two associated 2-kW sound installations from Marconi's. One installation is to be used as a standby at Sutton Coldfield and the other is for future use elsewhere. The company supplied the standby equipment at Holme Moss, Kirk o' Shotts (where it is initially being used for the service) and Wenvoe.

J. B. Hyde & Co., manufacturers of the E-Z wire stripper, advise us that Buck & Hickman, Ltd., of 2-6, Whitechapel Road, London, E.1, have been appointed sole distributors of the Hyde bench and foot-operated strippers in addition to the E-Z.

Emitron Television, Ltd., has supplied a new 16mm film scanner to the B.B.C. which supplements the 35mm equipment previously installed. It has a magnetic head (for the reproduction of tape recordings) as well as the normal optical sound head and it can handle either married or single picture and sound films.

A.P.A.E. ANNUAL EXHIBITION

SEVENTEEN exhibitors took the available stands at this year's "P.A." exhibition held in London on May 29th and organized by the Association of Public Address Engineers.

An innovation this year was the Ideas Competition which gave scope for members and their technical staffs to display their ingenuity in devising short cuts in testing and installation work. Nineteen entries were received and the eight prizes were allotted as follows: 1st, 6th and 8th to A. Curtis (Antone Company) for a design for an intercomm. set, a modulation-operated light indicator for remote loudspeakers, and a tubular scaffold pole bracket; 2nd and 3rd, to S. Lewis (Theydon Bois) for gramophone mixer and test units; 4th, to Warren Radio (Luton) for a tape reproducing mechanism; 5th and 7th to L. Yates (National Sound Reproducers) for a horn loudspeaker attachment and a cable-laying device.

The Institution of Post Office Electrical Engineers (Junior Section, Radio Group) also arranged an exhibit of instrument-making by their members, which gave encouraging promise of the ability of the rising generation.

A new scheme for training apprentices, approved at the annual general meeting, should go far to ensure the high technical standards fostered by the Association. Candidates will be required to serve a three-year term with an Association member, and to pass theoretical and practical examinations, before being granted a certificate of competence.

Some of the more recent commercial products exhibited are described elsewhere in this issue.

New Kind of V.H.F. Propagation

American Experiments on Long-distance Transmission

REPORTS have recently appeared in the British lay Press of a new kind of propagation at very high frequencies, in which it was stated that as a result of an experiment made in America transmission over long distances had been proved possible. Technical details of the American experiment have now been given in a Report* of the U.S. National Bureau of Standards.

The range of a v.h.f. transmitter has hitherto been considered to be that of the distance of the radio horizon (somewhat beyond the optical horizon), this range being normally somewhat enhanced by the presence beyond the radio horizon of a diffracted wave. At times it is further considerably enhanced by refraction, reflection or scattering from various forms of tropospheric irregularity, but such transmission is unpredictable and unreliable. Propagation to long distances by way of the ionosphere has not been thought possible on v.h.f. because—except at certain times for the lower of the v.h.f.s only—the ionization of the layers never reaches a value such as is necessary for the complete refraction of such high frequencies, and the waves are therefore not returned to earth, but penetrate the ionosphere altogether.

Scattering from Ionosphere

The American Report tells us that the experiment was conducted over a path 1,245 km (774 miles) long, the transmitter being at Cedar Rapids, Iowa, and the receiver at Sterling, Virginia. The frequency used was 49.8 Mc/s, and since no mention is made of any form of modulation the type of emission was presumably continuous wave. A power of 23 kW was fed to a rhombic transmitting aerial with a main lobe whose maximum was at an elevation angle of seven degrees. With such a high-gain aerial the effective radiated power in the direction of the receiver would be very high.

Signals were received at all times of day and night and, during the course of the experiment (which has lasted for many months) there was never any failure in reception due to propagation effects. The waves arrived at the receiver after travelling by way of the lower part of the ionosphere, the receiver signal power consisting of energy which was "scattered" downwards from that region. No refraction process was involved, the energy scattered downwards towards the receiver being but a small proportion of that incident on the layer.

There was rapid fading on the received signal, which was accompanied at all times of day by random heterodyne whistles caused by meteors, and coincident with the occurrence of such a whistle there was often an abrupt increase in signal strength, due, no doubt, to reflection of energy from the ionized meteor trail. It seems, in fact, that meteors make an important contribution to the mean signal level.

The received signal was automatically recorded, and from the records the hourly average of signal level was obtained and a field strength graph plotted giving the hourly median values for a particular month. It would appear from this graph that the received signal strength was, having regard to the high radiated power, very low, and not to be compared with what would be obtained over such a distance from a wave returned from the ionosphere by the normal refractive process. The mechanism of propagation is, in fact, shown to be that of scattering from irregularities in the electronic distribution (attributable to turbulences) which permanently exist in the lower part of the ionosphere, and it would not be expected in these circumstances that the signal strength would be other than low in relation to the power radiated. But the experiment is important in proving that such a new type of propagation is possible.

The field strength graph for April, 1951, shows that the received field strength was at its maximum around midday, that there was a pronounced minimum near 2000 hours Local Time (LT), a steady increase throughout the night and a tendency for a second maximum near 0600 LT. The authors of the Report think, therefore, that the ionization in the region which is responsible for the return of the radio energy may result from two causes. First, there is the sun's ultra-violet radiation, which would be at a maximum at midday, and would account for the main maximum in the field strength. Then the ionization produced by meteors would be at a maximum at about 0600 LT and at a minimum at about 1800 LT, which would account for further features in the field strength graph. The relative importance of these two causes would vary according to season, and their combined effects, when superimposed, are considered to account for many features in the observed monthly trends.

Increases in Signal Strength

Some most important effects were noted during ionospheric storms and during Dellinger fadeouts. At times when severe ionospheric storms were in progress the signal strength showed some enhancement, and during moderate ones it remained normal. From observations made during 24 Dellinger fadeouts, it was noted that during 17 of these there was an increase in signal strength of from 3 to 6 db, and during the other 7 signal strength remained normal. There was never any decrease in field strength during these occurrences, and, furthermore, the background noise was observed to diminish when they took place.

As is well known, Dellinger fadeouts are due to the abnormally enhanced ultra-violet radiation from solar flares, which causes an abnormally increased ionization in the absorbing region of the ionosphere —supposed to be the D layer and possibly also the lower part of the E—at a height of about 100 km (60

* "A New Kind of Radio Propagation at Very High Frequencies Observable Over Long Distances" by D. K. Bailey, R. Bateman, L. V. Berkner, H. G. Booker, G. F. Montgomery, E. M. Purcell, W. W. Salisbury and J. B. Wiesner.

miles). This abnormal increase in ionization results in the complete absorption—and hence the fadeout—of the ordinary h.f. waves, which have to pass through this region before undergoing refraction at a higher level. The fact that the field strength in the American experiment does not show any reduction, but rather an enhancement, at these times suggests that the signals are returned from a region near or just below that where the heavy absorption of ordinary h.f. waves occurs—in fact, from the lower part of the E layer and perhaps even from below the D layer.

Polarization measurements at the receiver indicated that the horizontal polarization of the transmitted waves was preserved, which is not so for a wave refracted in the ionosphere in the normal way.

Maximum Range

This interesting experiment has thus shown that the range of a v.h.f. transmitter cannot truly be said to be limited to the distance of travel of the ground or tropospheric waves, but that the return of a certain amount of energy from the ionosphere to greater distances is possible. The geometry of the transmission path would indicate that the range for one-hop transmission would be limited to about 2,000 km (1,250 miles) by the earth's curvature, and it is understood that the transmissions have been widely received by radio amateurs within that distance of the transmitter. An attempt to receive the signals at a distance slightly greater than this resulted in reception only being obtained when Sporadic E was present.

The partial dependence of the scattering medium upon meteor activity is also interesting, and this would seem to support the view long held by Sir Edward Appleton and certain other British scientists that a considerable part of the E layer ionization—and particularly its "residual" night-time ionization—is largely due to the effects of meteors.

As to the possible uses of the system, there would appear to be several, mainly in the nature of point-to-point communication. It appears, however, that multi-hop transmission would call for the expenditure of enormous power at the transmitter, even if it were then accomplished, and this would seem to limit the uses of the system somewhat severely.

T. W. B.

RADIO RESEARCH AT THE N.P.L.

THE versatility of the National Physical Laboratory and its capacity for carrying through short and long term research programmes with equal thoroughness was well exemplified by the radio exhibits shown at the recent "Open Day."

For many years the Radio Division has studied propagation at metre and centimetre wavelengths in the lower atmosphere, and this tropospheric research is now bearing fruit in the production of reliable data upon which the siting and frequency allocation of television stations can be planned. Recent emphasis on turbulence scattering has been investigated and a statistical analysis of the results has shown that it is of secondary importance to reflection from temperature inversions in giving rise to anomalous field strengths at distances of the order of 200 km.

The cathode-ray direction finder for atmospherics, with which the N.P.L. has been long associated, has been further improved, and in place of verbal co-ordination between observers at different stations in registering particular flashes it is now possible to use an automatic audio "pip," which is triggered by flashes above a pre-determined threshold. A quiescent period of 7 seconds is arranged to follow each synchronizing signal to enable observers to write down the bearing. Suspected bearing errors at some of the Meterological Office stations have been investigated with a mobile direction finder, and have been traced in one instance to a buried cable and in another to tilting of the polarization of the field by neighbouring hills.

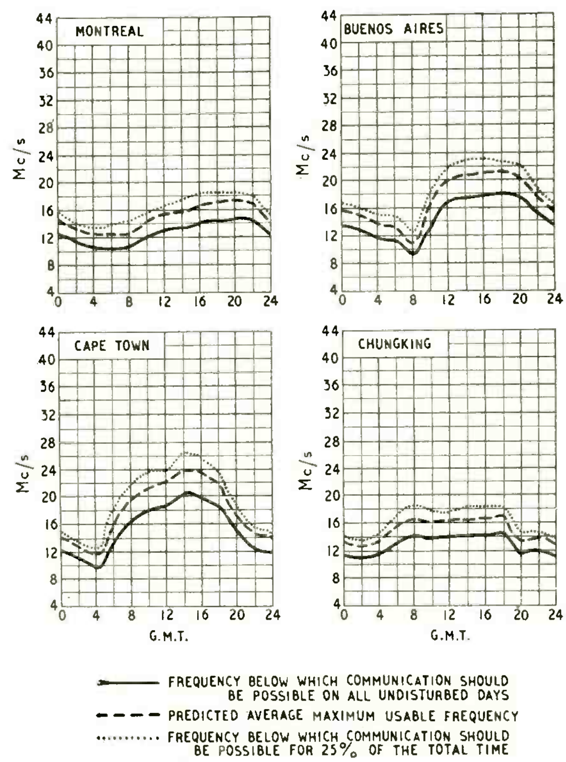
Among test and measuring methods demonstrated by the Electricity Division were noted a low-noise system of calibrating signal generators, employing the "synchrodyne" principle, and the investigation of stability in permanent magnets by means of the current required in a search coil working in the field across a standardized gap to balance the force of gravity on a known weight.

Short-wave Conditions

Predictions for July

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

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



Series Mode Crystal Oscillators

Circuit for Low-activity Crystals

By H. B. DENT

WHEN used for frequency control of valve oscillators quartz resonators generally take the form of thin discs or plates assembled between two metal electrodes. For certain special purposes the resonator is fashioned in the form of a rod and very occasionally as an annular ring.

Employed in this way it is convenient to depict the quartz crystal as comprising inductance, capacitance and resistance arranged as shown in Fig. 1. Apart from the capacitance C_H, which is produced by the holder or method of mounting the crystal, the other quantities are essentially fictitious, as neither the inductance L, nor the capacitance C_x, nor the resistance R have existence as we like to visualise them, and they can be neither separated nor can access be had to them individually.

These quantities may be regarded as the electrical equivalents of the mass, resilience and frictional loss of the crystal when in a state of vibration, or oscillation. The crystal is tantamount to a mechanical vibrator having a strongly marked fundamental frequency, and at this frequency vibration once started can be maintained with very little external power, but at any other period of oscillation very considerable power is required to start and to maintain it.

Ignoring the resistance R in Fig. 1, L, C_x and C_H form a circuit tuned by a parallel capacitance comprising C_H and C_x in series. As C_x is always very small, only a fraction of a pF, and C_H is some hundred times larger, quite large changes in C_H can be made without affecting appreciably the resultant value of C_H and C_x in series. Consequently variations in C_H, and in any shunt capacitance connected across the points A and B, have very little effect on the resonant frequency of the crystal. The only way in which any appreciable change can be brought about in the fundamental frequency is by mechanical means, such as by grinding away some of the surface to make it thinner. This will *increase* its fundamental frequency. A sufficient change in frequency to enable a crystal oscillator to be frequency modulated is possible, however, with special circuits and F.M.Q. is one example of this.[1]

Measurements made to determine the effective values of L, C_x, C_H and R in Fig. 1 for some typical quartz crystals are to be found in the literature on the subject[2], and a few of the more interesting figures are given here.

The type of cut, or particular part of the mother crystal from which the resonator plate is taken, determines these values. For example, an AT-cut plate of 3,000 kc/s fundamental frequency was found to have equivalent values as follows :— $C_x = 0.022$ pF, $C_H = 8$ pF, $R = 30$ ohms and $L = 0.127$ H, thus giving an equivalent Q of 120,000. For another, with a fundamental frequency of 6,300 kc/s, the corresponding values are : $C_x = 0.0059$ pF, $C_H = 5$ pF, $R = 30$, $L = 0.108$ H and $Q = 390,000$.

With some low frequency crystals of the order of 100 kc/s, equivalent inductances of 20 H to 30 H can be obtained and with Q values of 150,000 to 280,000. An Essen-type ring crystal, as a matter of interest, produced the fantastically high Q value of over one million. It was for 100 kc/s and the equivalent inductance was 50 H.

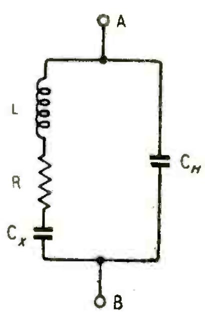
Frequency Control

It is because of their exceptionally high Q values that quartz crystals exert such a stabilizing effect on the frequency of oscillating circuits.

Not only do they hold the frequency constant despite variations in the associated circuit values, but as the resonant frequency is governed by the physical dimensions of the crystal they can be ground for a particular frequency and will hold this frequency almost indefinitely after the initial ageing period.

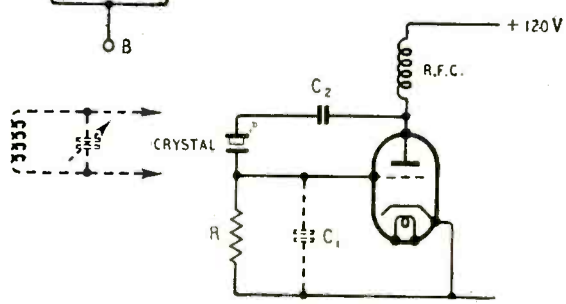
Quartz crystals are affected to some extent by changes in temperature, but in many crystals this can be kept to within 0.03 per cent or so for low-frequency crystals of the order of 10 kc/s to 50 kc/s and to within 0.1 per cent or better for high-frequency crystals over a moderate range of temperatures. But if there are likely to be very wide changes in ambient temperature and a high accuracy is required the crystal must be mounted in a temperature-controlled oven.

In the majority of circuits where a quartz crystal is used for controlling the frequency of oscillation the



Left : Fig. 1. The equivalent electrical circuit of a typical quartz crystal vibrator.

Below : Fig. 2. Pierce crystal controlled oscillator. If the crystal is replaced by the tuned circuit shown dotted it becomes the familiar Colpitts.



[1] "F.M.Q." By W. S. Mortley. *Wireless World*, October 1951, pp. 399–403.
[2] "Quartz Vibrators." By P. Vigoureux and C. F. Booth, Table 12.

crystal takes the place of a tuned circuit and behaves as a parallel tuned resonant circuit; the Pierce oscillator shown in Fig. 2 is a case in point. To appreciate this it is only necessary to replace the crystal by a tuned circuit as shown dotted, and it will be recognised as one of the Colpitts family.

Triodes or pentodes, or pentodes used as triodes, function equally well as crystal oscillators, and there is little to choose between them as oscillators at low power, but the pentode scores when the oscillator is operated at any appreciable power as by a suitable choice of circuit, the r.f. current flowing through the crystal, and hence the power in this circuit, can be kept reasonably low. If too much r.f. power is put into the crystal its amplitude of vibration increases and eventually becomes large enough to shatter the crystal. The inclusion of a small flash lamp bulb (60- to 100-mA type) in series with the crystal, as shown in Fig. 3, enables the actual r.f. current through the crystal to be monitored. With most crystals a moderate glow is permissible.

In Fig. 3 the crystal is used in a tuned-grid—tuned-anode circuit, and it may sometimes be necessary with pentodes to include a small capacitance—3 to 5 pF should be ample—between the grid and anode as shown dotted. With a triode the additional capacitance should not be required.

The grid resistor R_1 provides grid bias (from the grid current) for the valve, as without it the anode and screen currents are likely to be excessively high. But as from 10,000 to 50,000 ohms only will serve for this purpose, an r.f. choke is sometimes included as well to raise the impedance in shunt with the crystal to a reasonably high level. In very low-power oscillators R_1 can often be made a half megohm or so, then the r.f. choke can be omitted.

Many variations of these two basic circuits are in general use, and with few exceptions the crystal behaves as a parallel tuned circuit, so that they might be described as parallel-mode crystal oscillators in order to distinguish them from circuits in which the crystal is employed as a series tuned circuit, or as a very low impedance at the resonant frequency, i.e., series-mode crystal oscillators.

Looked at from the points A and B in Fig. 1, L and C_x form a series circuit resonating at a frequency fixed by their respective values, and this frequency is very close to that of the alternative resonance using the shunt capacitance C_H in series with C_x to tune the "coil" L.

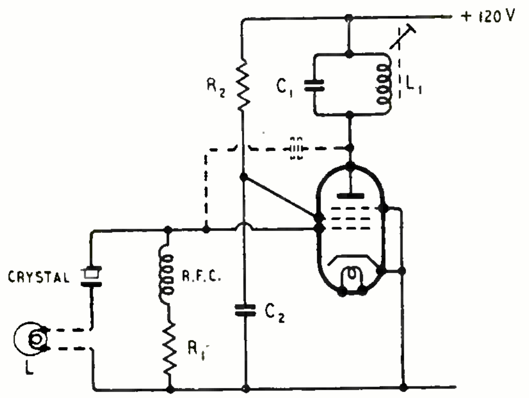


Fig. 3. In this circuit the quartz crystal behaves as a high impedance tuned-grid circuit. A capacitor joined between anode and grid (shown dotted) may be necessary in some cases.

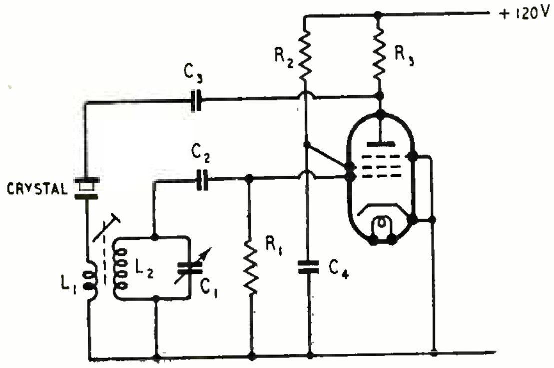


Fig. 4. A circuit in which the series resonance of the quartz crystal is used to produce oscillation.

Alternative Circuits

The fact that different ways of using a crystal to control an oscillator are possible can often be a distinct advantage as, if for one reason or another the crystal will not function as a high impedance element in one of the orthodox circuits based on Figs. 2 and 3, then it might be possible to get it to perform the desired function in one of the lesser-known circuits based on the crystal's series-resonance characteristics.

The series-resonance mode of operation can be a little tricky at times, especially with high-frequency crystals, owing to the presence and shunting effect of the capacitance formed by the crystal electrodes and holder. However, there is not much likelihood of running into difficulty over this with crystals of lowish frequency, say 950 kc/s and lower. With much higher frequency crystals it may be an advantage to balance out the holder's capacitance and neutralized or bridge circuits have been employed quite successfully for this purpose.[3]

The need to seek and explore the series mode of operation was brought about by the desire to utilize some of the odd-frequency quartz crystals that have been reasonably plentiful in the disposal markets. They were to be used for calibrating various r.f. oscillators for the home laboratory, and while the actual frequency of the crystals was unimportant, it was necessary for the exact frequency to be known to within close limits, and as the Services were very particular in this respect they seemed to fill the requirements admirably. If the seals on the holder are intact it is safe to assume it contains the original crystal.

Some appeared to be not quite so active as could be desired, and would not function satisfactorily in the more orthodox circuits. One that has proved very satisfactory is that shown in Fig. 4, which is nothing more than the familiar reaction coil oscillator with the crystal included in the reaction coil circuit.

At its resonant frequency the effective resistance of a 950-kc/s crystal used in this circuit was found to be about 2,000 ohms. The reaction coil was accordingly adjusted to produce oscillation at the crystal frequency,

[3] "Series Resonant Crystal Oscillators." By F. Butler. *Wireless Engineer*, June 1946, pp. 157-160

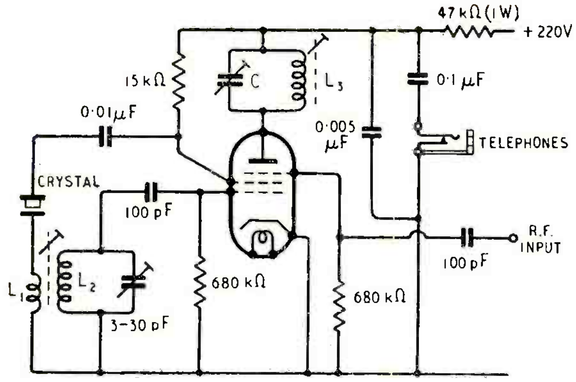


Fig. 5. A single r.f. pentode used as a crystal oscillator, harmonic generator and beat-note detector. The anode circuit C, L_3 is tuned to a harmonic of the crystal.

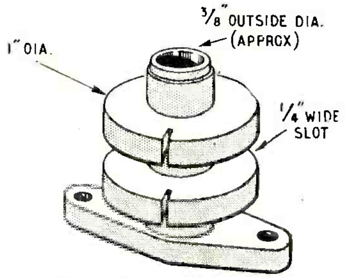


Fig. 6. Coils wound on a former of this construction are suitable for use in medium-frequency crystal oscillators (1,000 kc/s).

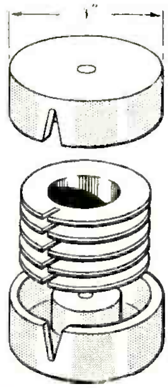


Fig. 7. For comparatively low-frequency crystals (500 kc/s) a pot-type core as shown here provides a more compact coil.

but to be too weakly coupled to produce oscillation with any appreciably higher value of series resistance. Actually the adjustment is not critical with most crystals, but it might prove a little awkward with crystals mounted in a metal case. So far this type has not been tried in the circuit.

The requirement of the circuit (fairly weak reaction coil coupling) results in only low-power oscillators being practical without recourse to neutralization, but for calibration work low power is adequate.

Perhaps the simplest way of adjusting the reaction coupling is to so proportion the turns of L_1, Fig. 4, that oscillation occurs only with L_2, C_1 tuned to the crystal frequency and with any appreciable mistuning oscillation ceases.

With a valve such as the Brimar 6BA6 suitable values for this circuit, using a 950-kc/s crystal, are: R_1 = 470 kΩ, R_2 = 47 kΩ, R_3 = 5-10 kΩ, C_1 = 3-30 pF, C_2 = 100 pF, C_3 = 0.01 μF, L_2 = 850 μH. A coil of this inductance can be made reasonably compact if constructed as shown in Fig. 6. For this a bakelite former of about ⅜in outside diameter and 1in long is used. Fixed to it by Seccotine or other suitable adhesive are two 1-in diameter discs cut from 1/16-in bakelite sheet and forming a single slot ¼ in wide. L_2 is wound on first and has 190 turns of No. 30 s.w.g. enamelled copper wire; layer winding is not essential, but it should be reasonably even. Two or three turns of "Cellophane" tape cut to the right width serve as insulation, and then 36 turns of the same gauge wire are put on for L_1.

In the prototype oscillator C_1 is variable, but it could well be fixed at about 20–25 pF and the core in L_1, L_2 adjusted for tuning. Otherwise the core is fixed with about equal amounts projecting each side of the coil. This may not be a very efficient coil, but it has proved quite satisfactory for a number of crystals of about the same frequency and obtained from different sources.

This standard of frequency, and others like it, have been used for calibrating various test oscillators for use in the home laboratory, using harmonics up to the fiftieth or more. At times when calibrating oscillators it has been found an advantage to select and accentuate a particular harmonic to act as a band marker. This is done by rearranging the circuit so that the control grid, g_1, and the screen grid, g_2, of an r.f. pentode function as a triode oscillator, and a circuit tuned to the required harmonic is connected in the anode of the valve, as shown in Fig. 5.

Usually some form of beat-note detector is required when calibrating oscillators, and this is embodied in the circuit by using the suppressor grid as a mixer for external signals. The valve is a Brimar 6BA6.

The circuit values mentioned are generally satisfactory for crystals of 1,000 kc/s or so, but with crystals of appreciably lower frequency (for example 500 kc/s) it will be necessary to increase the size of the grid tuning capacitor to about 100 pF, otherwise the inductance required to tune the grid circuit becomes unduly large. At such frequencies coils wound on pot-type cores, of the type shown in Fig. 7, give better results and are far more compact.

With the type of coil former shown in Fig. 6 the dust-iron core increases the inductance by 1.8 to 2 times, whereas with the pot-type of Fig. 7 the inductance is increased 3.5 to 4 times. These figures can be taken as a guide for calculating coil inductances for various crystals, the coil being regarded as a multi-layer coil with dimensions fixed by the overall space taken by the winding. The appropriate abac in the *Wireless World* "Radio Data Charts" will give the inductance of an air-cored coil of the dimensions used.

This value should be about half the required inductance for coils wound on the open core of Fig. 6 and one quarter for coils with the pot-type core of Fig. 7.

MARINE RADIO

SOME 700 more British cargo vessels will compulsorily have to carry radio gear when the International Convention for the Safety of Life at Sea comes into force on November 19th. This Convention provides, among other things, for the fitting of W/T or R/T gear in all cargo ships between 500 and 1,600 gross tons (the previous minimum tonnage).

Provision is also made in the Convention for all ships over 1,600 g.t. to carry d.f. gear when engaged on international voyages, and to maintain a continuous watch on the distress frequency either by operator or auto-alarm. Signatories to the Convention may defer the fitting of d.f. gear in ships between 1,600 and 5,000 tons for two years.

Drawn up at a conference, attended by delegates from thirty countries, in 1948, the Convention provided that the regulations should come into force one year after fifteen countries (seven of which had not less than one million gross tons of shipping) had ratified their acceptance of the Convention—sixteen have now accepted.

UNIPOLE TELEVISION AERIAL

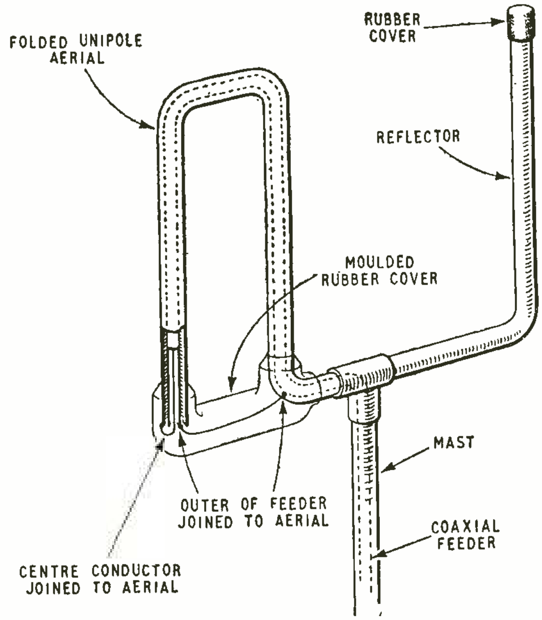
Inexpensive Design for Use in Areas of High Field Strength

IN areas of high field strength it may often be desirable to employ a television aerial having high directivity rather than high gain, as its selective properties can be utilized for rejection of interfering signals and undesirable reflections.

A new type of aerial developed for this purpose by E.M.I. Engineering Development takes the form of a unipole with a reflector and, in the interests of mechanical strength, cheapness and ease of erection, it is made from one piece of tubing. The use of a unipole reduces the amount of metal by about 20 per cent and the consequent reduction in weight enables the fixing arrangements to be lighter and cheaper. Since the aerial is made in one piece, mechanical joints are eliminated and insulators are unnecessary.

The drawing shows the form of construction adopted. The aerial is folded in order to raise the impedance from about 15 ohms to about 60 ohms, and thus achieve a satisfactory impedance match to a standard feeder. The feeder may be fed through a part of the aerial and supporting mast as shown, or it can be joined externally to the same points on the aerial.

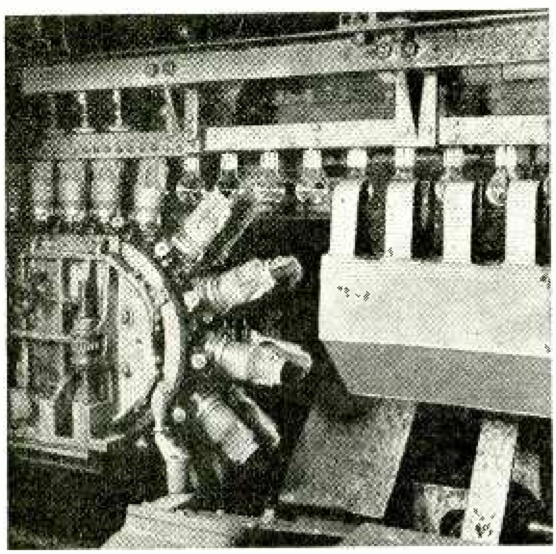
The centre conductor of the feeder is joined to the extremity of the folded portion of the aerial and the outer conductor to a point near the centre where it is bent to form the horizontal bar. A rubber or plastic covering is fixed as shown to the folded part of the unipole in order to prevent the ingress of moisture. The end of the tube remote from the folded unipole is bent upwards to form a reflector and this end of the tube is closed also with a rubber bung or cover.



Constructional details of the new E.M.I. unipole television aerial for use in areas of high field strength.

The total length of the tubing is approximately one wavelength when the aerial and reflector sections are separated by one-quarter wavelength, but this will be reduced if the spacing between the two parts is less than one-quarter wavelength.

MASS-PRODUCING VALVE BULBS



The completed glass bulbs (for electric lamps) leaving the split moulds, which are returning on their belt.

GLASS envelopes for valves or electric lamps can be blown at the rate of a million per day by a new type of machine installed at the Haworth factory of Glass Bulbs, Ltd., near Doncaster. At the "input" end of the machine a controlled stream of molten glass from the furnace flows down between two rollers and emerges as a continuous ribbon with bumps in it, like the ribbon of caps in a boy's toy pistol. This ribbon is carried along on a belt of metal plates and eventually meets a continuous chain of blow-heads which descend on it from above.

Each blow-head presses into a bump on the ribbon and gives a puff of compressed air, which blows the glass into a rough bulb through a hole in the metal plate. The roughly-formed bulbs hanging below the plates are then met by split moulds of the required valve shape, which rise up from below on a moving belt and close round them from both sides. The moulds begin to rotate and at the same time the air pressure from the blow-heads increases, so that the rough bulbs are moulded to their final shape.

Eventually the moulds open again (see picture) and the completed envelopes are cooled by air jets and tapped off the ribbon by a hammer, finally being tipped on to a conveyor belt and passed through an annealing oven to the packing department.

V.H.F. Broadcasting

Lessons to be Learned from American Experience

By J. R. BRINKLEY*

IT is paradoxical that while Britain is apparently about to embark on v.h.f. broadcastings, in America where frequency-modulated v.h.f. broadcasting has been in existence for fifteen years many people are wondering whether it can survive much longer. In the belief that the facts about U.S. f.m. broadcasting are not well known in this country, the following report, based on a survey carried out during a two months' visit to the U.S.A. earlier this year, has been compiled.

According to production figures for the first few months of this year—15 years after the establishment of the first f.m. stations—only five per cent of all sound receivers and only 2 per cent of all television sets now being manufactured in the States incorporate f.m. sound broadcasting.

An indication of its importance in the eyes of the American public is obtained from the fact that three times as many midget receivers and seven times as many car radios are sold as f.m. models.

One of the largest radio receiver manufacturers stated that about 5 per cent of his sets had an f.m. range while the biggest and most "loyal" f.m. manufacturer stated that about 12 per cent of his output incorporated f.m. Many manufacturers have dropped f.m. altogether.

Receiver Prices

While a.m. table receivers retail at from $12 to $40, the cheapest f.m. model sells at $55 and a table model f.m. set may be priced as high as $90 dollars.

If similar circuits were adopted by British manufacturers the typical table model now costing £15 would cost £30 with f.m., plus tax in both cases.

In spite of the fact that the cost of receivers has undoubtedly been an important factor in inhibiting the sales of f.m. receivers in the U.S., efforts to produce really cheap sets have been unsuccessful.

Super-regenerative receivers and converters of the types now being tried out in Germany have disappeared from the American market entirely. Manufacturers who still market f.m. sets in the States have come to the conclusion that they must have high sensitivity, good limiting, low drift and low distortion, even if these features make the receiver expensive.

At the peak period there were 800 f.m. stations, now there are some 600 licensed compared with 2,300 a.m. transmitters. Moreover, many existing f.m. operators have applied to the F.C.C. asking to be allowed to reduce their hours of operation.

Of the 600 stations in existence, only 65 operate independently; the others being affiliated to a.m. stations and merely duplicating the a.m. programme. Of the independent stations only six claim to have shown a profit in 1951. Twenty-one stations were closed down in the year 1950/51 alone.

No separate figures are available for the affiliated stations but most of these seem to represent a "holding down the channel" operation. The comment of the station manager of WHAM, Rochester, was typical. He stated that if his a.m. outlet broke down he would be inundated with telephone complaints within a half-minute. The f.m. outlet carrying the same programme could fail for half an hour and no one would seem to mind, and no calls would be received.

It is interesting to note in passing that television is so far showing little sign of ousting sound broadcasting in the U.S. It is merely changing its character and the listening habits of the public. In television-developed areas a.m. revenue was down by only 2 per cent in 1951 while in areas not covered by television a.m. revenue was up by 10 per cent.

Public Reaction

Frequency modulation does, of course, make a limited appeal to certain minorities and for special purposes such as:—

(a) High quality enthusiasts.

(b) Rural listeners in those areas where night-time reception of a.m. is bad.

(c) The smalltown local station listener whose a.m. station closes down at night.

(d) Foreign language and educational broadcasts to minority groups in metropolitan areas.

(e) Specialized broadcasting such as providing background music for restaurants.

None of these functions constitutes a primary public service and few have any commercial attraction. Frequency modulation in the U.S. is at best a gap-filler for the a.m. services. It has met with no success when trying merely to do a little better what the a.m. stations do already. Such success as it has had, has been in tackling those specialized fields which the a.m. stations neglect. It is largely in the hope that these special functions may grow to flourish that f.m. is warding off the threat of extinction.

One is led to conclude that, in the U.S.A. at least, f.m. receivers are much too expensive in relation to what they offer the public in terms of improved reception or alternative programmes. In the eyes of the American public the f.m. band is probably worth about as much as the inclusion of a short-wave band is to a British listener.

Whilst one gained the impression that the problem would have been substantially easier and the position healthier if amplitude modulation had been chosen, the overall impression is that any form of v.h.f. sound broadcasting has a difficult furrow to plough.

So far as Britain is concerned there is reason to fear that v.h.f. broadcasting may suffer a similar or a worse fate, especially if we stumble into it without benefiting from the American experience.

It is certainly incumbent upon those who promote it to advance logical reason why it may be expected to fare better.

* Pye Telecommunications Ltd.

By W. TUSTING

TELEVISION

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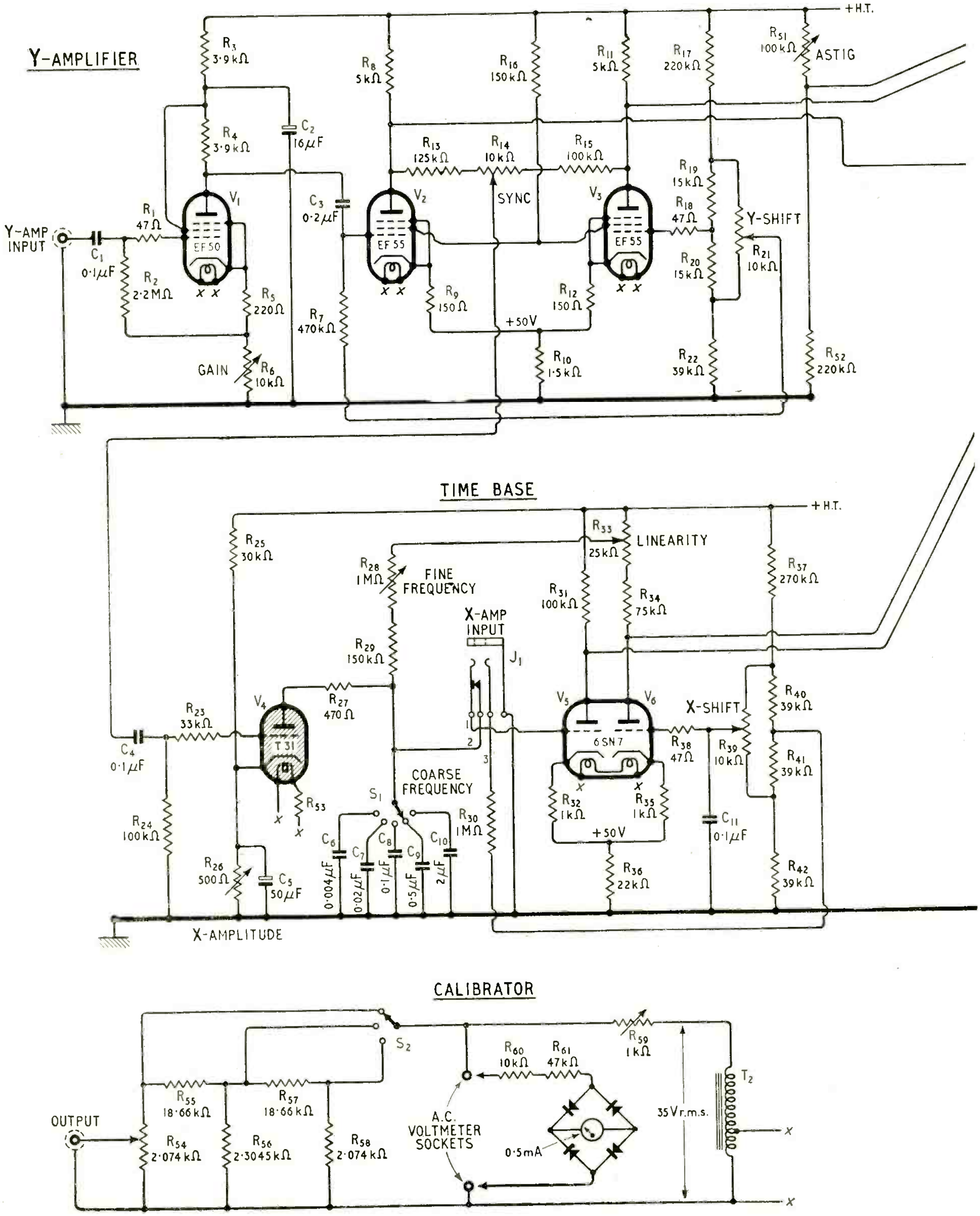


OSCILLOSCOPE

Layout of the Components

of the previous issue

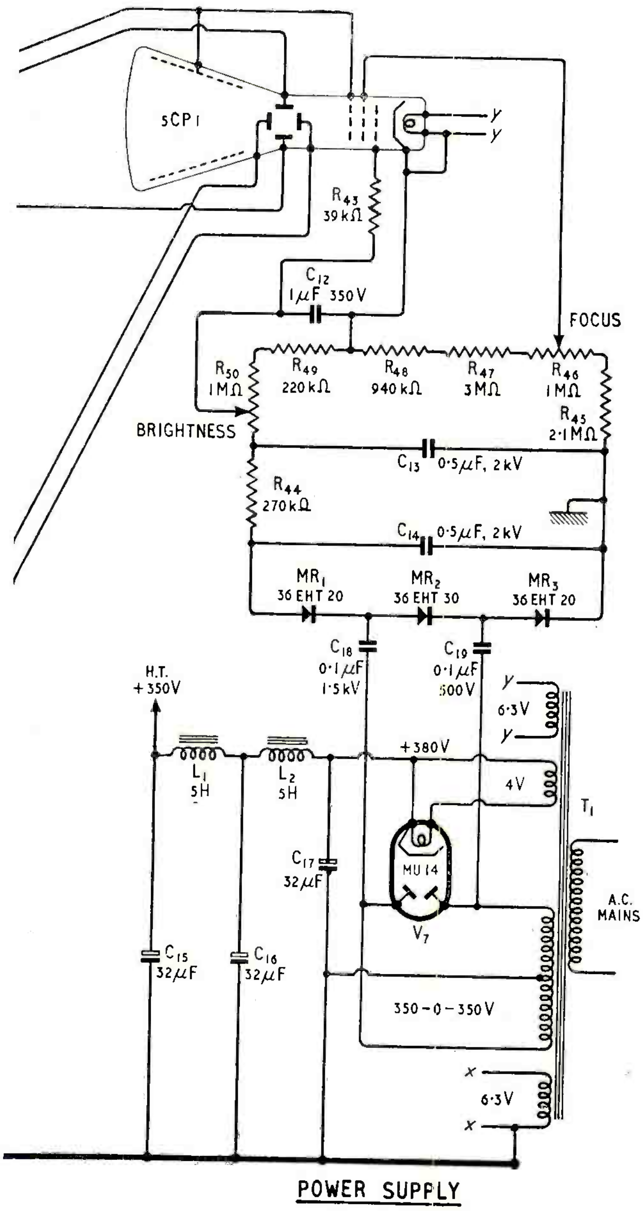


Fig. 5. Complete circuit of the oscilloscope. The time base is direct-coupled throughout and the Y-amplifier is directly coupled to the tube. The e.h.t. supply comes from the 350-V winding of the transformer through a voltage-multiplying rectifier.

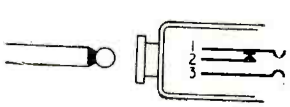


Fig. 6. Arrangement of jack J_1. The two main springs are arranged to contact the ball of the plug simultaneously.

THE complete circuit diagram of the oscilloscope is shown in Fig. 5 and it comprises four sections, the Y-amplifier, the time base, the power supply and the calibrator. The amplifier has two stages, of which the second is a pair of valves cathode-coupled to operate in push-pull. The gain control is a variable resistance R_6 in the cathode circuit of the first valve, and it operates by varying the negative feedback in this stage. Some initial feedback is provided by the bias resistor R_5 which appreciably increases the linearity of the stage.

The input time constant C_1R_2 is only 0.22 second and represents a compromise between the requirements of a low sag and a quick recovery from shocks. When the gain is reduced, the effective value of the time constant is increased considerably, with a consequent reduction of sag, by the negative feedback action.

The coupling to the second stage is by C_3R_7 of time constant 0.094 sec. Here, however, compensation is provided by the anode time constant R_4C_2 and the sag in this coupling is extremely small for waveforms up to 20 msec in duration. Beyond this point all couplings are direct.

The output valves have low-value individual cathode resistors R_9 and R_{12} to provide some feedback to improve the linearity. The two valves are coupled by R_{10} and their outputs in opposite phase are developed across R_8 and R_{11}, the anodes being connected directly to the Y plates of the c.r. tube. A resistance network R_{13}, R_{14}, R_{15} is connected between the two anodes so that a small part of the output can be tapped off in either phase to lock the time base.

If V_2 and V_3 gave precisely equal outputs R_{13} and R_{15} would be required to be of equal value and there would then be no output from R_{14} when its slider was set at its mid-point. However, with this form of push-pull, the output of the second valve is less than that of the first and so R_{15} must be less than R_{13} to bring the zero to the mid-point. Because of resistor tolerances, it may be necessary to adjust the value of R_{13} or R_{15} experimentally. The normal resistor tolerances for R_{13} and R_{15} are greater than the total value of R_{14}.

With a sine-wave signal the time base should lock in equally well with R_{14} fully rotated either way and it should not lock at all with it at a point near the middle of its travel. If it is found that it locks at all settings, but that the degree of lock varies from one end to the other, then the resistor connected to the end of R_{14} at which the lock is the harder should be increased. The change of resistance value needed may be considerable, for it is possible to have R_{13} 25 kΩ high and R_{15} 20 kΩ low; to correct for this, as much as 40 kΩ would have to be added to R_{15}.

This difficulty could be overcome by using a centre-tapped potentiometer for R_{14} and connecting its tapping to +h.t. However, the arrangement shown enables a standard component to be used.

The layout should be chosen to give very short direct leads for all grid and anode connections. The output valves should, therefore, be mounted near the tube base. The leads to R_8 and R_{11} should also be short and this will usually mean mounting the potentiometers close to the valves and operating them through extension rods. If, as a result of this, the input lead to V_1 is long, it should be screened. It may be mentioned that it is possible to fabricate a short length of low-capacitance screened lead by using a piece of large-diameter braiding from a normal cable, inserting grommets in the ends and a piece of thin wire for the actual lead.

The control R_{51} is for reducing astigmatism in the tube. The mean potential of the Y plates is the mean potential of the anodes of V_1 and V_2. The final anode potential of the tube should be at about, but not necessarily precisely, the same potential. The anode is taken to the junction of R_{51} and R_{52}, and R_{51} is adjusted in conjunction with the focus control for the best focus. If R_{51} is wrongly adjusted, it may be found that there are two settings of the focus control, one giving apparently good focus on a horizontal line and the other on a vertical line. R_{15} is adjusted so that these two settings as nearly as possible coincide.

Perfection is not to be expected, for the mean potential of the X plates also has an effect and should also be adjustable. This is not easily arranged, however, and the result is that the focus is not simultaneously perfect in the two directions. The effect is small, however, and normally negligible.

Time Base

The time base is about the simplest that could be devised and has direct coupling throughout. A gas triode saw-tooth generator is used with a double triode as a cathode-coupled push-pull output stage. The linearity is limited only by the linearity of the amplifier itself, for positive feedback is used to keep the charging current of the saw-tooth generator constant.

In operation, the charging capacitor $C_6 - C_{10}$, is discharged by the gas triode V_4 to some potential near earth. V_4 then becomes non-conductive. The capacitor charges through R_{28} and R_{29} from the h.t. supply at a rate dependent on the value of capacitance and the value of R_{28}. As it does so, it carries with it the grid of V_5, and the anode voltage of V_5 falls to provide the negative-going half of the output. The cathode voltage of V_5 and V_6 rises also and so the grid-cathode voltage of V_6 changes negatively and the current in V_6 falls, making its anode voltage rise to form the positive-going part of the output. At a certain point on the anode load of V_6 the change of potential is precisely equal to the change of grid potential of V_5. In other words, between these points there is unity gain and no phase shift. There is, however, a constant difference of potential and a resistance connected between the two must draw constant current. This resistance is the charging resistance R_{28} and R_{29}.

As the grid potential of V_5 rises with the increase of voltage across $C_6 - C_{10}$ consequent upon the flow of charging current, the "top" end of R_{28} rises equally in potential, and the charging current is constant. Therefore, the saw-tooth rises linearly.

The proper point on the load of V_6 must be found, of course. The load comprises R_{34} and R_{33}. The charging resistance is returned to the slider of R_{33} and this is adjusted for a linear saw-tooth. This is easily done if a television set is available. If the input lead of the Y amplifier is placed near the set, it will usually pick up enough signal from the line time base to give a vertical deflection of perhaps ½ inch. The time base should be adjusted to run at about 1,000 c/s so that about ten pips appear along the trace. Then R_{33} is adjusted so that these pips are equally spaced.

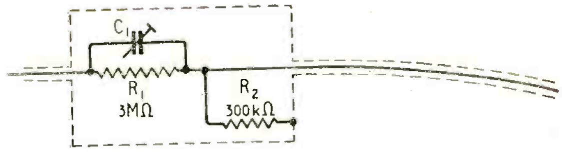


Fig. 7. Detail of input attenuator designed to give a reduction if required of about 10 : 1.

The adjustment holds for all capacitance values in C_6-C_{10} with one proviso—that all the capacitors have negligible leakage. If it is found that on one range the trace becomes non-linear then, almost certainly, the capacitor on that range has excessive leakage.

As in the case of the Y amplifier, independent cathode resistors R_{32} and R_{35} are used to improve the linearity and the X-shift is taken from a potential divider across the h.t. supply. It is possible that some adjustment of resistor values may be needed here, especially if a different gas triode is used. With the time base operating normally to give about 4-5 inches of trace and R_{39} at the centre of its travel, R_{42} should be chosen to centre the trace.

One fact about the time base will seem peculiar at first and results from the direct coupling used throughout. If the X-amplitude is adjusted, the left-hand end of the trace remains fixed in position and it is the right-hand end that varies. This occurs because to whatever voltage C_6-C_{10} is charged, it is always discharged by V_4 to substantially the same level and, as the amplifier is directly coupled throughout, the position of the spot on the screen is directly related to the grid voltage of V_5.

The gas triode used is one that the writer had by him and is hardly a current type. It is a 4-V valve, hence the heater resistance R_{53} of 1.53 Ω to drop 2.3 V at 1.5 A. If a more modern valve, with a 6.3-V heater is used, it is, of course, unnecessary.

Power Supply Equipment

The power supply comprises a 350-0-350 V transformer with an indirectly heated rectifier V_7, a two-stage smoothing circuit comprising L_1 and L_2 of 5 H each and three 32-μF capacitors C_{15}-C_{17}. The chokes used are of unusually low inductance because it was desired that they should be physically small and of low d.c. resistance. There is no objection at all to the use of higher values.

The transformer must be very carefully placed with respect to the tube if serious interference from its magnetic field is not to be found. It is desirable to mount it behind the tube, but this could not be done in the writer's model without making a new case for the oscilloscope. To reduce the hum to a satisfactory level it was found necessary to wind the transformer astatically and to use a mu-metal screen on the tube. The writer's experiments on this aspect of the oscilloscope have been described in an earlier article[1].

The e.h.t. supply is derived from a voltage-multiplying rectifier and 2 kV is obtained. The main reservoir capacitor is C_{14} and smoothing is effected by R_{44} and C_{13}. Although R_{47} and R_{45} are shown as single resistors on the diagram they actually comprise

[1] "Oscilloscope Hum," by W. Tusting, *Wireless World*, December 1951, p. 507.

about four resistors apiece in series. This is done to keep the voltage on each at a low level, for when the voltage on a carbon resistor continuously exceeds about 500 V it is liable to deteriorate quickly.

The capacitor C_{12} can itself be of low voltage rating but must, as a whole, be insulated for 2 kV from the chassis. The resistor R_{13} is included so that a signal can be fed to the grid for brightness modulation if required. If so fed it must be through a capacitor of low leakage and 2 kV rating. No use has so far been made of this. Because of the high impedance of the e.h.t. supply, the heater winding for the c.r. tube must be very well insulated.

A jack is included in the time-base unit so that the saw-tooth generator can be disconnected from the amplifier and another signal fed in. This facility is provided mainly for use with a wobbulator so that a special time-base signal can be provided. It is, however, useful for other purposes.

The jack is of non-standard form and was fabricated from two normal ones. The arrangement is shown in Fig. 6. The normal jack had the frame as shown contacting the body of the plug and one contact for the ball, also the break contact. A second main contact was taken from another jack and fitted to the other side so that the ball contacts the two simultaneously.

With the plug removed, 1 and 2 are in contact and the time base is joined to the amplifier. With the plug inserted the connection between 1 and 2 is broken and the ball of the jack contacts 1 and 3, thus connecting the input to the grid of V_5 and to the grid leak R_{30}. A capacitor is inserted in series with the cable at the other end. The body of the jack is earthed and so earths the screen on the cable.

There are other ways of doing this, of course, but this happened to be the simplest for the writer.

The Y amplifier is built on a chassis level with the tube on one side of it and the time base on a similar chassis on the other side. The power supply is under the back end of the tube. A great deal of space has been left vacant towards the front of the lower chassis. This was done deliberately to leave room for additional equipment should it prove necessary.

The input cable is a major difficulty with all oscilloscopes. It is desirable to have it some 4-5 ft in length, but it should be of negligible capacitance. It must be a coaxial cable to avoid serious hum pick-up. If a connector is fitted to the panel one can make up a number of input cables for different purposes. The writer mostly uses a length of 70-ohm coaxial cable with a capacitance of 22 pF per foot. This means that the input capacitance is around 100 pF.

However, this capacitance is not very important in time bases. In a line time base, it is chiefly the current waveforms that one wants to inspect. To see them it is, in any case, necessary to break the circuit and insert a resistance. For example, the deflector-coil current is vetted by inserting a 10-ohm resistor in series with it and connecting the oscilloscope across this. The cable capacitance is then unimportant. In the frame time base the cable capacitance is not large enough to have much effect.

Then, in general, where the time-base impedance is high the voltage is high also and probably too great to be controlled by the gain control. An input attenuator is then necessary and can be arranged to reduce the capacitance loading. The writer made one to the circuit of Fig. 7, the components being fitted in to an old electrolytic-capacitor can at the end of the cable remote from the oscilloscope. The resistors are chosen to give an attenuation of 10 times approximately and C_1 is adjusted, when viewing a sharp pulse developed on a low resistance source, so that the waveform of the pulse is the same with or without the attenuator. If C_1 is too large the pulse will have overshoot, if it is too small the corners will be rounded, a value of about 10 pF is needed. On the input side of the attenuator only a few inches of cable should be used and the input capacitance is then reduced to some 10-20 pF.

The calibrator section of the oscilloscope has already been described.[2] A small auto-transformer T_2 is used to provide 35 V r.m.s. from the heater line, and its output is applied to an attenuator through R_{59}. This resistor enables the input to the attenuator to be adjusted precisely with the aid of the rectifier-type voltmeter. The output is continuously adjustable by R_{54} and S_2 from 50 V p-p to 0.05 V p-p; R_{54} is provided with a calibrated scale and so is direct reading.

In use, the deflection corresponding to a given signal is noted, the Y-amplifier input is transferred to the calibrator and R_{54} and S_2 are adjusted so that the same deflection is obtained. The peak-to-peak voltage can then be read off.

[2] "Oscilloscope Calibrator," by W. Tusting, *Wireless World*, August 1951, p. 310.

REPRINTS OF ARTICLES

CONSIDERABLE interest having been created by the design for a simple inexpensive f.m. set for the 90-Mc/s band (by J. G. Spencer of the B.B.C. Research Department) which appeared in our November and December, 1951, issues, a reprint has been prepared and is now available from our Publisher, price 1s (by post 1s 1½d). The modifications given in the May, 1952, issue for fitting an X79 frequency changer in place of the obsolescent X81 are also included in the reprint.

A reprint has also been prepared of the article by J. F. O. Vaughan (December, 1951) describing a pre-tuned radio feeder unit with gramophone pre-amplifier. Price 9d (by post 10½d).

This announcement affords an opportunity for us to list the other *Wireless World* articles, of which reprints are still available. The price in parentheses includes postage.

Cathode-Ray Oscilloscope. General-purpose instrument with a three-valve time base, single-valve amplifier and two-valve wobbulator. By S. A. Knight (December, 1948). 6d (7½d).

General-Purpose Oscilloscope. Modifying an ex-Government radar unit. By J. F. O. Vaughan (May, 1948). 9d (10½d).

Receiver Alignment Equipment. Composite reprint: Simple Cathode-Ray Oscilloscope (March, 1950) and Design for a Wobbulator (October, 1950). By M. G. Scroggie. 9d (10½d).

Communications Receiving Equipment. Composite reprint including: Modifying the R1155 (July, 1946); Band-Pass Converters (October, 1950); More about Band-Pass Converters (February, 1951). 1s (1s 1½d).

Quality Superheterodyne. Design for a nine-valve receiver. By S. A. Knight (December, 1947). 6d (7½d).

Sensitive T.R.F. Receiver. Three-valve circuit embodying automatic gain control. By S. W. Amos and G. G. Johnstone (October and November, 1951). 1s (1s 1½d).

Midget A.C. Mains Receiver. Two-valve medium-wave portable. By S. W. Amos (March, 1949). 6d (7½d).

Midget Three-Valve A.C. Mains Receiver. Long- and medium-wave t.r.f. set. By S. W. Amos (February, 1950). 6d (7½d).

A Modern Crystal Set. Pre-selection three-station germanium crystal receiver. By B. R. Bettridge (September, 1951). 6d (7½d).

Ex-Government Valves and C.R. Tubes. Valve-type designations and their equivalents (August, 1945) and characteristics of ex-Service c.r. tubes (December, 1947). 6d (7½d).

B.S.R.A. ANNUAL CONVENTION

ONCE again the Exhibition and Convention organized by the British Sound Recording Association at the Waldorf Hotel, London, W.C.2, on May 16, 17 and 18 proved a focal point of the year's activities in the technical aspects of recording. It was well attended by enthusiasts from all parts of the country and representatives from abroad.

Although the space available for commercial exhibitors limited the number of firms showing to about 25, they represented a fair cross-section of the industry, and the demonstrations of sound reproduction given throughout the Saturday and Sunday were well attended on both days. A selection of the more recent products shown at the Exhibition are described on another page.

The Friday evening meeting, with which the proceedings opened, took the form of a "Musicians v. Technicians" debate under the able chairmanship of Sir Steuart Wilson. The musicians were represented by Julian Herbage and Anna Instone, of the B.B.C., and the technicians by D. Thomson (Decca) and P. J. Walker (Acoustical Mfg.). Each "side" played records which they regarded as of outstanding merit, and criticisms were offered by their opponents and by members of the audience. It soon became apparent that the musicians were prepared, if necessary, to ignore small distortions provided that the general atmosphere of the recording was in keeping with the composer's intentions. They liked, metaphorically, to stand back and see the whole, whereas the technician climbed the rostrum and moved about the orchestra, listening to individual instruments. Fidelity to the original sound satisfied recording engineers, but musicians asked more—fidelity to the creative thoughts of the composer. In summing up, the Chairman said that the problem was primarily one of communication between musicians and technicians, who apparently talked different languages. Technicians had been accused of having no hearts and musicians no heads. There were not only problems to be solved, but many yet to be stated, more particularly in the formulation of criteria which could be measured.

A very high standard was again reached by the exhibits entered by B.S.R.A. members for the amateur competition. The President's Trophy was won by C. L. Appleby with a portable clockwork-motor-driven tape recorder with an ingenious single mechanical control, and facilities for playback. The Committee Prize went to C. G. H. Chalker for a disc recording machine, notable for its high standard of workmanship and finish, and the *Wireless World* Prize which the Association decided should go to the competitor exhibiting the highest originality or ingenuity in design was won by P. J. Baxandall for a single-valve negative feedback tone control giving, without the use of switching, continuously variable bass and treble "cut" or "lift" with a maximum range of the order of ± 20 db.

NEW "SOUND" PUBLICATIONS

ANOTHER volume of the B.B.C. Engineering Training Manuals, published by arrangement from the *Wireless World* office, has just appeared. This is "Sound Recording and Reproduction" written by J. W. Godfrey and S. W. Amos, with the collaboration of M. J. L. Pulling, K. R. Sturley and P. J. Guy. Being primarily an instructional manual for the Corporation's technical staff, the emphasis throughout is on B.B.C. equipment, but the book is of interest to a much wider circle of readers concerned with high-quality recording. It is claimed to be the most comprehensive textbook on this subject yet.

The principles of electrical recording and reproduction are first set out clearly and at length. Disc recording is then discussed, with a detailed description of the B.B.C. Type D recorder and other equipment now in use in British broadcasting services, followed by chapters on processing of discs. The principles of magnetic recording are next explained, with descriptions of the Marconi-Stille, Magnetophon and E.M.I. magnetic systems which have been used at different times by the B.B.C. The book then deals with recording on film. A number of appendixes contain reference information not readily available elsewhere. There are 272 pages and 186 illustrations, and the book, issued by our Publishers, costs 30s (postage 8d).

The "Williamson" amplifier shows no sign of waning in popularity; indeed, it seems now to have been accepted as a standard of design and performance wherever sound reproduction is discussed. There are few countries in which descriptions of "local" versions have not been published, but many users prefer to adhere exactly to the designer's specification, with the original valve types. All the information published in *Wireless World* on the amplifier, including the latest data on adaptation to high-impedance pickups and correction for $33\frac{1}{3}$ r.p.m. records is to be found in a new (second) edition of "The Williamson Amplifier" booklet, just issued by our Publishers at 3s 6d (postage 3d).

Simple Square-Wave Generator

An Economical Design Covering 15c/s to 160kc/s

By L. F. SINFIELD

THE testing of audio and video amplifiers with a square-wave input has become increasingly popular. Two main methods of waveform generation are usual: (a) by clipping and amplifying a sine wave; (b) generation by relaxation oscillators such as the transitron or multivibrator. For maximum versatility a waveform with 50/50 "mark-space" ratio is probably best, as this can be used to provide beam switching for oscilloscope amplifiers and other applications. Also the balanced spacing gives more accurate indication of "ringing" at frequencies near that of the square-wave input.

Method (a) can provide an approximately 50/50 waveform, but the whole set-up becomes unnecessarily complicated. Method (b) is simpler, but usually requires two sets of time constants in the oscillator, to be matched and switched on each range. Another point is that the multivibrator has normally two forms of distortion which are undesirable, and subsequent clipper stages are needed to overcome them. The first is the slow rise of anode voltage due to the fact that the other valve is driven into grid current by the coupling condenser, and the coupling condenser has to charge during the rise. The rise is therefore equal to the time constant of the anode load and the coupling condenser. At low frequencies, with fairly large capacitance, this time is unduly long. The second form of distortion of anode waveform is a negative pip when the valve's own grid takes grid current.

After experimenting with several generator circuits, one was adopted which is simplicity itself and overcomes all these troubles, for the following reasons: (a) one CR circuit determines both negative and positive half-cycles; (b) the waveform is virtually self-balancing to a 50/50 condition; (c) no grid current flows at any time, so that anode rise time is limited only by stray capacitances; (d) the fall time also has only this limit, so that rise and fall wave-shape are similar; (e) no negative pip is present, again due to absence of grid current.

Examination of the waveform generated has shown it to be of good shape with only some attenuation of high-frequency components, and no "overshoot" or "undershoot."

Basically the circuit of the square-wave generator (Fig. 1) is a cathode-coupled multivibrator.[1,2] By suitable choice of component values the anode waveform has limited amplitude and the input valve is arranged to follow this amplitude without grid current. The valve is a double triode, so that each section has a matched grid cut-off point. Static grid bias conditions are equal and also the static anode voltages are approximately equal (R_3 being of low value).

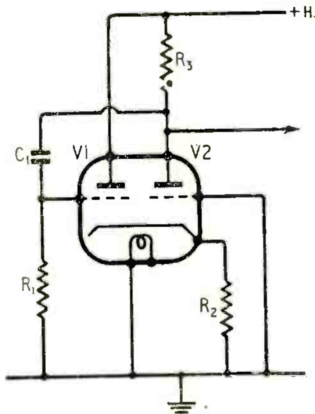


Fig. 1. Basic oscillator circuit.

A square wave at the anode of V2 is fed back by C_1 R_1 and at the grid of V1 gives a differentiated waveform, balanced about earth potential. On the negative half-cycle V1 is cut off, so that the bias on V2 falls and V2 takes more current and V2 anode voltage falls. On the positive half-cycle V1 acts as a cathode follower so that cathode voltage rises. This cuts off V2 so that V2 anode voltage rises. Provided that the waveform at V1 grid is not distorted by grid current it will be

1. "The Cathode-Coupled Amplifier" by K. A. Pullen, *Proc. I.R.E.* Vol. 34, p.402, June, 1946.
2. Cathode-Coupled Multivibrator (Electronic Circuitry, by J. McG. Sowerby), *Wireless World*, July, 1948, p.249.

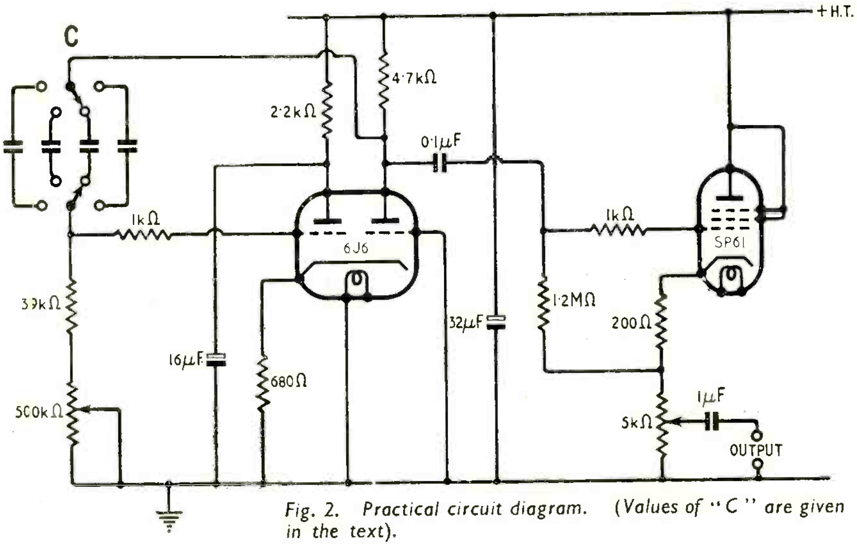


Fig. 2. Practical circuit diagram. (Values of "C" are given in the text).

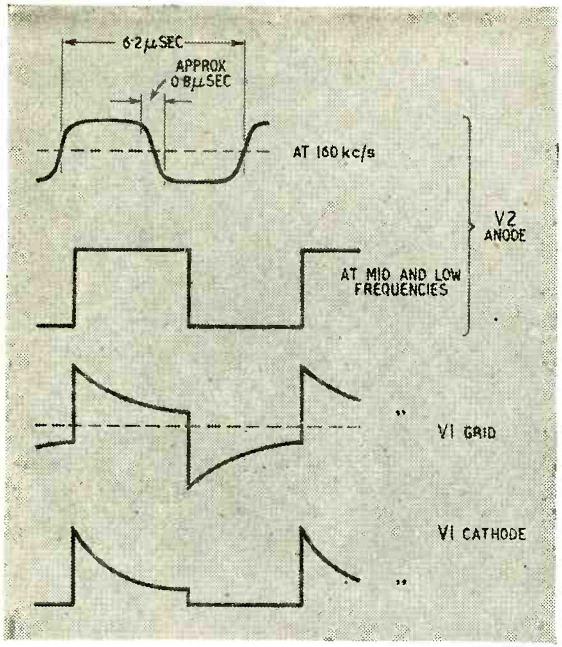


Fig. 3. Voltage waveforms at different points in the circuit.

virtually self-balancing to a 50/50 waveform. (This is not strictly true due to loss in cathode follower action of V1, but by making R_2 larger than would normally be expected this can be minimized, and it also helps in countering grid current, as V1 does not have to draw such heavy current in following the positive half-cycle). The resistor R_1 is not critical, but must always be of considerably higher value than R_3.

A practical circuit is shown in Fig. 2, with the oscillator followed by a cathode follower to reduce the effect of stray capacitances on R_3 and to give a low output impedance. It will be noticed that a two-pole, four-way switch is indicated, also in order to reduce stray capacitance.

Measurements taken on the test unit with an h.t. supply of 200V are as below:—

Range	*"C" (µF)*	*Frequencies*
1	0.05	15-200c/s
2	0.005	150-2,000c/s
3	0.0005	1.5-20kc/s
4	0.00005	15-160kc/s

Amplitude: 13V peak-to-peak with amplitude variation of less than 1db throughout all ranges.

Rise (or fall) time: Less than 1 microsecond.

The h.t. supply voltage is not critical, but calibration will depend to some extent on voltage to be used. The amplitude will also be dependent on supply voltage. A regulated h.t. supply is ideal in order to maintain squareness at the very low frequencies, although a conventional supply is satisfactory if extra large smoothing condensers are used. The mean current drawn by the unit (about 20mA) is constant throughout the range, so that regulation should present no difficulty.

The frequency stability is, in general, better than the usual type of multivibrator, and as the number of components is less and the output balanced, the circuit is ideal for general replacement of multivibrators in circuits such as dividers, etc., where a large output is not necessary. Synchronizing may be applied at almost any point in the circuit, but the grid of V2 is probably best as it gives maximum isolation and prevents feedback troubles, but static bias conditions on V2 must not be changed.

Fig. 3 shows the waveforms at different points in the circuit. The variation in rise or fall times is only that due to variation of stray capacitance on each range, and not to the size of coupling capacitance, so that this time is virtually constant, whether at 15c/s or 160kc/s. Examination of the oscilloscope pattern at 160kc/s shows, however, that the total time of rise (or fall) is less than 1 microsecond and that 80 per cent of the change occupies only about 0.5 microsecond.

With regard to actual construction and layout, the main point is that all the time-constant capacitances should be mounted directly on the range switch. The 0.1µF coupling condenser to the SP61 should be away from the chassis. If metal-cased condensers are used the case should be insulated to prevent bonding to earth. The object of these precautions is to reduce stray capacitance to earth.

The 1µF d.c. blocking condenser in the output lead is suitable for most high-impedance input circuits, but may be increased if desired. Although in practice the capacitance to earth of this condenser has been reduced by using a miniature type in the wiring, the effect of stray capacitance at this point is naturally much less.

A 6SN7 may be used in place of the 6J6 but the rise or fall time is longer. The common cathode resistor should be 2.2kΩ for this valve.

ROYAL SOCIETY CONVERSAZIONE

AMONG the exhibits arranged for the entertainment of Fellows and their friends at the recent Conversazione of the Royal Society were several of radio interest.

Prof. H. M. Barlow and Dr. A. L. Cullen of University College demonstrated the transmission of non-radiating surface waves along a wire on the principle foreseen by A. Sommerfeld in 1899 and realized by G. Goubau (*Journal of Applied Physics*, Vol. 21 (1950) No. 11, p. 1119). The wave is launched and received by concentric conical horns and its propagation along the wire is dependent upon the surface reactance of the conductor, which can be increased by roughening or by coating with a dielectric. The ability of the wave, which has a field distribution equivalent to the E_{01} mode in a coaxial line, to negotiate bends when so treated was demonstrated by comparison with a bare polished wire which radiated freely from sections showing any marked change of direction.

The mechanical forces, akin to radiation pressure, which are exerted on a metal rod suspended in a high-Q cavity resonator were demonstrated by R. A. Bailey and C. M. Burrell of the Radar Research and Development Establishment. The torque obtained from comparatively small input powers is considerable, since the Q value (of the order of 50,000) obtainable with a cavity resonator builds up high values for the electric field. The effect is being investigated as a possible absolute method of measuring powers of the order of a fraction of a watt at centimetre wavelengths.

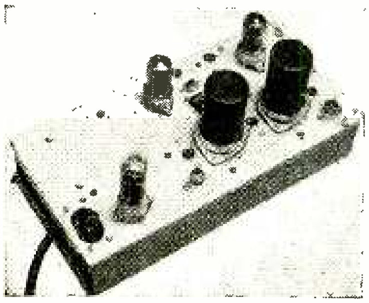
A miniature radio link using only transistors in both transmitter and receiver was shown working by Standard Tele-communication Laboratories. The power available in the transmitter was 10mW at 10.5 Mc/s.

Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

Television Converter

A NUMBER of improvements have been made to the AC/4 television frequency converter which Spencer-West, of Quay Works, Great Yarmouth, originally brought out in 1950. As a result the converter can now be used with superhet receivers and with receivers whose alignment did not allow for the increasing number of transmitters and the use of the vestigial-sideband system. The new version still permits individual adjustment of the sound and vision channels.



Spencer-West television converter

No alterations to the television receiver are necessary, as the converter has its own power supply and only has to be inserted in the aerial feeder of the set. Models are available for conversion between any receiver and any transmission.

Signal Generator

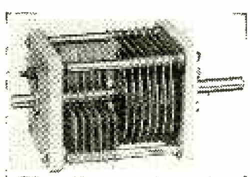
THE model 66A signal generator produced by Taylor Electrical Instruments, Ltd., provides frequencies from 100 kc/s to 80 Mc/s in six ranges, with a frequency-calibration accuracy of within ± 1 per cent. An additional range of 60-160 Mc/s is available from the second harmonic of the highest range. The output can be varied in amplitude over a total range of 100 db up to a maximum of 100 milliwatts, and can be obtained modulated or unmodulated. The modulation (depth approximately 30 per cent) is provided by a 400-c/s internal oscillator, which also acts as an independent tone source giving an output of 1 volt.

Designed to work from a.c. mains supplies of 105-125 V and 200-250 V, the instrument is housed in a metal case with crackle finish and enamelled panel, and weighs 14lb. The address of the makers is Montrose Avenue, Slough, Bucks.

Variable Capacitors

TWO new variable capacitors recently put on the market by Jackson Brothers, Ltd., of Kingsway, Waddon, Surrey, are notable for the features of low loss and high stability combined with small size. They have robust ceramic end-plates which are silicone-treated to give protection against moisture, and all the metal parts are silver plated. The size of the end plates is $2\frac{1}{8}$in × $2\frac{1}{8}$in while the distance between them varies from about $1\frac{1}{2}$in to $2\frac{3}{4}$in according to the capacitance.

Type C9 with an air gap of 0.048in between the plates is available in capacitances up to 150 pF, or, with an air gap of 0.024in, up to 500 pF. A split-stator version is also available and with this the capacitance figures are halved. The C10 is a differential capacitor, otherwise it is similar to the C9 and is available with the same range of capacitances and air gaps. Both types have a straight-line-capacitance law. If desired, larger capacitances or wider air gaps can be provided to special order.



Jackson Brothers low-loss variable capacitor with ceramic end-plates.

Left: Taylor Electrical Instruments signal generator model 66A has a frequency range of 100 kc/s to 80 Mc/s.

RANDOM RADIATIONS

By "DIALLIST"

Long-lived Valves

A WEEK OR TWO before writing this I was telling an American friend something of the work now being done at the G.P.O. research station at Dollis Hill on the development of pentodes which have lives of 40,000 hours or so of continuous running before any marked falling off in their performance sets in. (Useful tip for quick calculations: 1,000 hours = 6 weeks; to be exact, 6 weeks = 42 days = 1,008 hours.) "Why," said my friend, "there's surely nothing very new in that: long-lived 'toobs' with lives of that order have been available in the States for years. Not generally available: they are not used in radio sets; but they are used for many industrial purposes and for telecommunications." For the moment I was taken aback. But when I came to investigate the matter I found that he was right—up to a point. It is quite true that long-lived valves have been produced in America (and in this country, for that matter) for years; but these have been valves with slopes of the order of 1 mA/V. The thing that really matters in a pentode is the slope, for the stage gain is as near as makes no matter $g_m \times r_a$. Long life is readily obtainable, if you are prepared to sacrifice the slope. The task which Dr. Metson and his colleagues at Dollis Hill set themselves was to produce something very much more worth while: the 40,000-hour (or more) pentode with a high slope. Their work is not yet finished; but their present long-lived 6-mA/V pentodes go far beyond anything achieved by others.

Billions and Trillions

THE LETTER FROM E. J. F. Thierens in the May issue of *W.W.* was a surprise to me, for I thought that, unlike ourselves, the inhabitants of all Western European countries and of the United States called 10^9 a billion, 10^{12} a trillion and so on. One gathers from Mr. Thierens' letter that the Dutch use the same logical nomenclature as we do. And it definitely is logical and simple. An American or a Frenchman who is not used to working in such numbers must have to do a bit of thinking before he can write down in figures the equivalents of his trillion (10^{12}) or sextillion (10^{21}). His billion is 1,000 million, his trillion 1,000 times that, and so on. In other words, the prefixes bi-, tri-, quadri- . . . give no straightforward clue to the tale of noughts in the written figure. With our more logical system the billion is $10^6 \times 10^6$ or $10^{(2\times6)}$ and the number of noughts is 2×6. Even if you were challenged to write down in figures a duodecillion, you wouldn't be stumped . . . provided you knew that duodecim is Latin for twelve: you would have no hesitation in writing: $10^{(12\times6)} = 10^{72}$. Try working it out for the American or French duodecillion! The simplest formula I can think of here is $N = 10^{3+3n}$, where N is the number and n the numerical significance of the prefix. I *think* the answer is 10^{39}, but I would not like to bet on it!

Sponsored Television

MYSELF, I'M ALL AGAINST the Government's present proposal that in the future a place should be found for sponsored television transmissions; or, in other words, for advertising by means of television. I can't claim to base this attitude on personal experience of sponsored visual programmes, for I have not been in the United States (the only country which has so far given them a trial) since television grew up there. But I do know that the comments of American friends, visiting this country, on our television service can be summed up in this way: Your British television programmes don't yet cover a very large part of the twenty-four hours, and you've no alternatives. With us there's a choice of programmes at any reasonable hour; but few of them are watt-worthy and almost all are marred by crude publicity. Some have been so vulgar as to give widespread offence. Never stop thanking your stars that your British television programmes are free from sponsoring.

Hear for Yourself

If I haven't seen the sponsored television programmes, I've made quite a study of its "sound" counterpart. Over the years, I've listened on the medium and the short waves to countless American transmissions. Here and there they were grand; but one's impressions, on the whole, of the sponsored variety are scrappiness (the prevalent 15-minute item, often called the So-and-So *Hour*), cheapness (not in the financial sense—they probably cost the earth in dollars) and childishness (in the crude plugging of the product of the sponsors). Many readers of *W.W.* must have heard such transatlantic programmes and most of those who haven't can easily do so. There's no need, either, to span the Atlantic in order to sample the sponsored programme. In the columns of some newspapers correspondents have maintained that sponsored broadcasting in Britain would always remain on a high level because of the value attached by well-known firms to their reputation for etc., etc., etc. Well, tune in some of the broadcasts from the Continent and see what you think about the high level! Don't get me wrong: I'm no highbrow.

The Light that Didn't Fail

A STORY TOO GOOD to miss appeared in a recent issue of the *Wireless Trader* and, with due acknowledgment, I pass it on. A service man had spent the evening in driving a score of miles to his sister's home, putting her receiver to rights and driving back again. Tired, he went to bed early; but he hadn't been there long before he was forced by the insistent ringing of the telephone to drag himself from between the sheets. It was the sister calling: "I don't know what's happened," she said, "but the set's behaving so queerly that I am afraid to leave it and go to bed." The trouble, he learned, was that when she switched off, the set duly became silent; BUT the light inside it wouldn't go out and the tuning dial remained brightly illuminated. Hastily turning over in his mind certain highly undesirable possible causes, he decided that the only thing to do was to make the journey once more. We will draw a kindly veil over what he said and what he thought as he struggled into his clothes and then drove at top speed through the night. A veil still more impenetrable must be drawn over his mental and verbal reactions when, having worried off the back of the receiver, he found that he had left his inspection torch alight inside it! He might have tumbled to what had happened had he been sufficiently awake to tell his sister over the 'phone to remove the mains plug.

Daylight Fading in Devon

LAST MONTH I QUOTED an account from a reader who lives near Okehampton of the daylight fading that has been in evidence since the temporary low-powered transmitter at Barnstaple got to work. I sent my correspondent's letter to the B.B.C.; the case was investigated and here is the gist of the report. At the place in question the field-strength ratio of the Start Point and Barnstaple transmissions is about 2 : 1; some daylight fading is therefore to be expected. Normal B.B.C. practice, when operating synchronized medium-wave transmissions, is to keep the beats down to about one in 10 seconds. More rapid beats may occur in daylight owing to random phase changes.

UNBIASED

By FREE GRID

The No-Radio Doctor

SINCE the day I read a report in this journal of a lecture on radio-therapy by a doctor specializing in this subject (*Wireless World*, October, 1940) I have been intensely interested in the medical uses of wireless waves. When, therefore, I saw on the railway bookstall the other day a new book entitled "The Radio Doctor's Dictionary of Health," I promptly bought it. Hurrying to my train, I hastily scanned its pages to learn the latest news of radio-therapy, for who, I thought, would be likely to tell me more about the healing powers of radio than the radio doctor, that learned member of the medical profession whose soothing and reassuring voice we used to know so well?

A small lightning conductor

Feverishly I turned to the letter "R" in the index to seek the magic word "radio" but was disappointed to find nothing between "rabies" and "radium." Puzzled and baffled, I sat awhile in thought until it suddenly dawned on me that so erudite a man would certainly be a reader of *Wireless World* and would, therefore, almost subconsciously use the word "wireless" instead of "radio." Eagerly, therefore, I turned to the letter "W," only to be disappointed once again, for among the many things sandwiched between "warts" and "worms" which form the alpha and omega of this section of the book, I looked in vain for anything about wireless. I was equally unsuccessful when I searched for physiotherapy, s.w. therapy and all the other synonyms and pseudonyms I could think of.

A search for diagnostic and remedial measures of an electronic nature other than radio also proved abortive, as I found X-rays only were dealt with. I was similarly unable to slake my thirst for knowledge about electro-encephalography. I did, however, find important information about electric shock, and, as a result of Dr. Hill's stern warning about the danger of carrying an umbrella in a thunderstorm, I have taken the precaution of putting a small lightning conductor on the ferrule of mine and attaching it, and the umbrella ribs, by means of a stout cable to a small anchor which I can drop in an emergency.

My family motto being *Dum Spiro Spero*, I have placed an order for the second edition of the book when it appears, as I feel sure that this omission of radio-therapy will have been repaired and the learned doctor will warm the cockles of my heart by telling me the correct wavelength to employ for that purpose.

Television Derby Jubilee

AS I sit in shivering shirtlessness writing these words after the annual bookies' benefit race at Epsom, it seems difficult to realize that a quarter of a century has passed since the Derby was first televised. Those of us who witnessed this historic television transmission in 1927 did not complain of the low definition and general poorness of the crude picture which we saw through the queer little "window" but marvelled that we could see anything at all.

It was, of course, Baird and not the B.B.C. which made this wonder possible 25 years ago. But, although our television screens of to-day are as much in advance of the "window" of 1927 as a rifle is of a blunderbuss, there is room for a great deal of improvement in our existing domestic viewing arrangements.

One of the improvements which could be made forthwith would be the provision of what I will call three-screen television for the greater comfort of large families who to-day sit bunched together, klystron fashion, in front of the conventional type of set. If they sit in a semi-circle, those at each end get an oblique and unsatisfactory view of the picture. By using three screens, arranged so that they are at an angle of thirty degrees to each other—or in other words by designing the set so that the cabinet is like half a hexagon in plan—conditions would be ideal for a family semi-circle.

If the projection system were used we should avoid the tails of the cathode-ray tubes fouling each other and also the great expense of full-sized tubes Projection c.r. tubes are cheap enough, but we must not overlook the expense of their associated optical systems. These are, however, permanent and don't wear out. At any rate, I have just completed the construction of a set of this type and it has proved a great success and, of course, a great deal cheaper than three separate sets.

I am constructing another in readiness for the Coronation when I expect to be entertaining a large party. This set will be like a miniature Big Ben standing in the middle of the room and we shall all sit round it in a circle. It will, however, not have four faces like the famous clock tower but eight. The miniature c.r. tubes will project vertically up the "clock tower," the optical arrangement being like the old Victorian seaside *camera obscura* in reverse.

A family semi-circle