Wireless World

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Amenities and Necessities

RADIO communication has now reached a stage where the "amenity" use for non-vital purposes tends almost to overshadow its original functions. First accepted as an indispensable aid to the safety of life at sea, and then as an adjunct to existing methods of marine navigation, it soon became of equal—perhaps even greater—importance to aviation. Wireless in the service of many other human activities is now making a niche for itself.

In the past the Post Office has been accused of over-cautiousness in failing to encourage secondary uses of radio for purposes where its advantages are evident, but where some other form of communication would, at a pinch be made to serve the purpose, even if less effectively. Such accusations against the monopolitic power that rules our destinies are not entirely without foundation, but a good case can be made out for our national policy of making haste slowly in this matter. It is only quite recently that transmitting and receiving apparatus operating in the e.h.f. bands has reached a state of development where it could be entrusted to untrained policemen, taxi drivers, firemen and all the others who are today using it successfully. Reliable and easily operated gear is now made by a number of firms. Many technical obstacles to the growth of "amenity" radio have been overcome, and others are being tackled energetically. Organizational obstacles are similarly being overcome, and *Wireless World* is satisfied that the Post Office no longer refuses a sympathetic hearing to applicants for licences who can make out a good case for using radio communication for any new purpose.

Typical of the newer applications is the Thames Radio Service, described elsewhere in this issue, which provides for linking vessels in the Thames estuary with the inland telephone service. This radio link is primarily intended for small craft, and so has a limited traffic-handling capacity. Somewhat similar services for large passenger ships inside the harbour limits of several of our seaports would certainly provide a much-appreciated radio amenity but, as the traffic handled would be compressed into a very short space of time, the organizational problem would probably be greater than the technical.

Studying Television

DURING the recent visit of the C.C.I.R. Study Group the delegates have been given a good picture of the technical progress of television in this country. No effort has been spared to show them everything that will help in their task of advising on transmission standards for Europe.

No secret has been made of the wish generally entertained here that the delegates' choice will fall on the British 405-line system, and so allow us to participate in international exchanges of programmes. It is unnecessary to repeat here the many arguments adduced as to the extreme practicability of our system. Demonstrations to the delegates have suggested that the 625-line system, towards which European opinion has tended to incline, is hardly worth the virtually doubled bandwidth which it requires. It has also been demonstrated to them that such transmissions, confined to a sub-optimum bandwidth, are clearly inferior to the 405-line standard.

We have gained the impression that some of the delegates fear the adoption by their countries of so low a definition as 405 lines would incur the risk of early obsolescence. That is natural enough, but the doubters may perhaps be reassured by knowing that more than one British television engineer has said that, if we were today starting the service *ab initio* in this country, we would be well advised to choose the present standard. With that opinion *Wireless World* agrees.

Narrow-Band Pulse Communication

New Method of Reducing Inter-channel Interference in Time Division Multiplex

By THOMAS RODDAM

THIS is not the first article on pulse modulation that has appeared in *Wireless World*. Judging by the amount of work which is being done on pulse systems it will not be the last. The chief interest of the pulse system to be discussed in this article is that it is the first narrow-band pulse system which has been described. All earlier systems have used bandwidths which were monstrously extravagant in terms of the actual information transmitted: ten channels of 4 kc/s would occupy 2 Mc/s video bandwidth, a ratio of 50:1. The return for this squandering of bandwidth is, of course, an improvement in signal-to-noise ratio, and in systems like pulse code modulation the theoretical improvement is almost achieved.

When engineers started to build pulse multiplex systems they made a most important discovery. It is very much cheaper to divide up one millisecond into ten equal time intervals than it is to divide up 40 kc/s into ten equal frequency intervals. Gating circuits for producing time allocation multiplex cost much less than crystal filters for producing frequency allocation multiplex. The full significance of this was not appreciated at first, but as the idea went home the telephone administrations and the firms which supply them realized that long-distance telephone circuits, especially those using coaxial cables, involved a huge amount of capital expenditure at the terminal stations, and that the filters for the frequency allocation multiplex systems represented an important part of this cost. If a pulse system can be appreciably cheaper, the first firm to get on the market will scoop in quite a lot or orders.

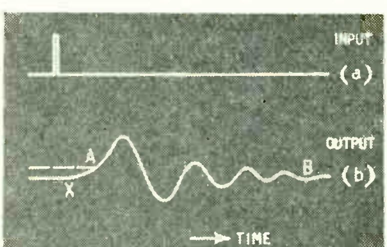
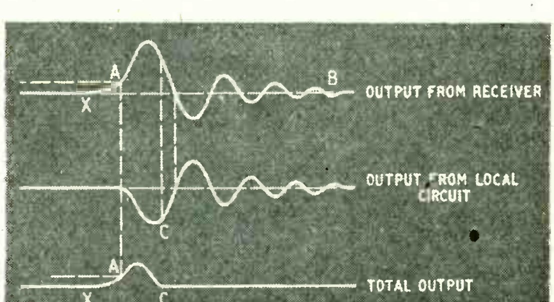


Fig. 1. (a) Short pulse and (b) after passing through filter to limit bandwidth.

Fig. 2. Cancellation of oscillatory distortion of pulse.



The problem with which the engineer is confronted is that of applying a pulse system to a cable, the bandwidth of which is limited, in such a way that a maximum number of channels can be used. The microwave honeymoon is over, and indeed even the microwave people are beginning to watch the bandwidth price pretty closely. The aim has been to get the bandwidth down to 4,000 c/s for each speech channel, which means an efficiency of about 80 per cent (useful bandwidth/bandwidth occupied).

The solution which has been receiving the most attention, unless someone is hiding a surprise, was hinted in an article on Communication Theory*. In that article I showed how a local circuit at the receiver could compensate for distortion caused by a restricted bandwidth. In Fig. 1(a) we see the very short pulse which we intend to modulate, and in Fig. 1(b) we see the train of oscillations produced by passing this pulse through a filter to limit the bandwidth. As soon as the pulse has risen to A, however, the local circuit generates a compensating wave. The result is shown in Fig. 2, and it will be seen that after the point C the output is cleared and ready to accept a new pulse. I have skimmed through this quickly because the article quoted does make it all quite clear.

Gaussian Pulses

In this discussion I assumed, for simplicity, that the compensating circuit was required to clear the base-line completely once the pulse had been established. Life becomes a great deal easier, however, if we use pulse amplitude modulation, because we need only clear the base-line for very short intervals corresponding to the middle of each pulse. Inside the receiver we can use as much bandwidth as we like, so that we could, if we knew how, arrange a new pulse centre to occur at each of the crossing points of the first diagram in Fig. 2. What has actually been done is formally equivalent to this, but differs in rather important practical details.

First of all, the short square pulses and the oscillating trains produced by ordinary filters are very inconvenient to work with. The short square pulse is not too bad, but as quickly as possible we convert it into what is called a Gaussian pulse. This is a very important type of pulse, and I cannot remember anyone explaining it, so we will digress for a moment. The Gaussian pulse has the equation $\epsilon^{-k^2t^2}$, and is, to use rather outmoded slang, a smooth job. It just gets bigger and bigger, and then gets smaller and smaller, as shown in Fig. 3(a). The frequency spectrum is shown in Fig. 3(b): the dotted part is what

* *Wireless World*, May, 1949.

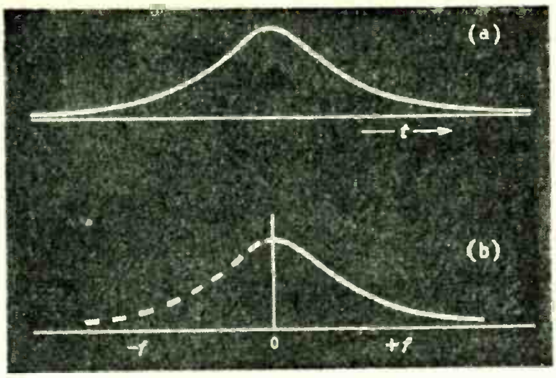


Fig. 3. Gaussian pulse and the corresponding frequency spectrum.

the mathematics says happens for negative frequencies. As you see, the time response and the frequency spectrum are the same shape. The simplicity does not end here. Suppose that a pulse like this is passed through a filter which cuts off quite smoothly and gently, and has a response which is also Gaussian, the output pulse is, as the enthusiasm

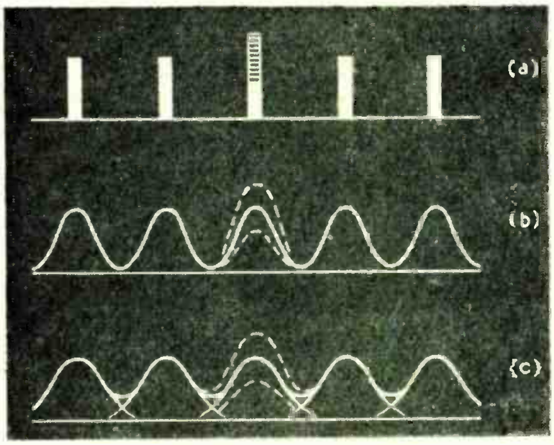
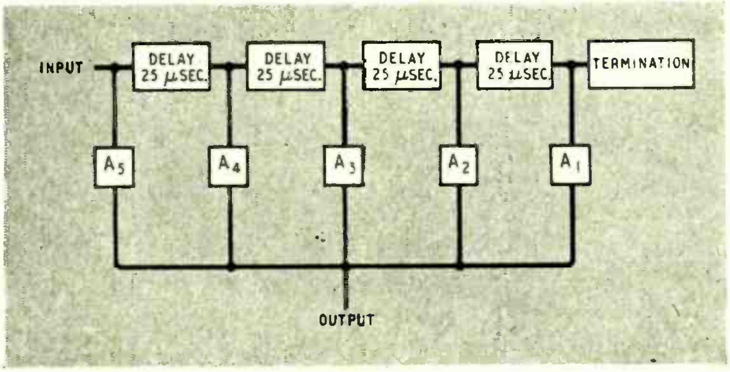


Fig. 4. Short pulses (a) are lengthened by passing through a wide Gaussian filter (b), and may overlap if the filter is made narrower (c).

Fig. 5. Corrector circuit for balancing cross-talk due to pulse overlap.



for this shape must have made you expect, a Gaussian pulse, longer than the original, but still that simple bell-like shape.

The reader may have noticed one awkwardness: the Gaussian pulse started at $t = -\infty$, and lasts, theoretically, for ever. There is another difficulty: the Gaussian filter, which must have a linear phase shift, cannot be obtained by means of a finite number of components. We seem to be staring into infinity on all sides. A good approximation to the right pulse shape can be obtained, however, either by using the curvature of a valve characteristic, which I mention only because that is the first method proposed, or by putting a short pulse through an amplifier with a lot of simple RC couplings. The third and most efficient way is to use an amplifier with several "maximal flatness"* stages and one plain RC stage. Once we have our Gaussian pulse we can arrange that all the amplifiers which we shall need along the length of the cable, and which we must call repeaters when we talk to the telephone men, are of this Gaussian kind. Then our pulses will be lengthened but will not be changed from their essential Gaussian shape.

Elimination of Cross-talk

Let us now take a look at Fig. 4. In row (a) we have a set of nice short pulses, which we shall assume belong to different speech channels. Only channel 3 is modulated, and the shading shows that the amplitude lies somewhere within the limits indicated. An n-channel system will have n pulses in about 1/8,000th second (125μ sec) and will then start a new train, because we need about 8,000 pulses per second for each speech channel. If we have 5 channels, as I have shown, the spacing between the *circuit* pulses is 25μ sec.

After these pulses have been passed through the Gaussian amplifier at the transmitter they will have the appearance shown in Fig. 4(b), and after travelling along the cable with its Gaussian amplifiers we shall have the shape shown in Fig. 4(c). It will be seen that the signal at the receiver is made up of pulses which are overlapping, so that the modulation on pulse 3 will have some effect on the amplitudes of the neighbouring pulses, 2 and 4. When we cram the pulses together by reducing the bandwidth still more, even pulses 1 and 5 are affected by the modulation on pulse 3.

At the receiver we want to eliminate the effect of the modulation on pulse 3 from channel 4. We therefore "gate" pulse 4 at its centre, and subtract a voltage obtained by delaying pulse 3 for 25μ sec and attenuating it suitably. The amount of attenuation is determined by balancing out the modulation produced in channel 4 from channel 3. We do not need to know the exact shape of the pulse, provided it remains constant. Obviously we can also get rid of the cross-talk from channel 3 into channel 5 by using a 50μ sec delay network..

The smooth shape of the pulses implies that channel 3 will produce cross-talk in channel 2. All we need is a network which produces a nega-

* V. D. Landon, *R.C.A. Review*, Jan., 1941, p. 354.

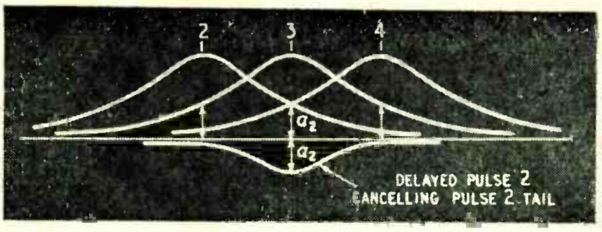


Fig. 6. Detail of Fig. 4 (c) to explain the cancellation process.

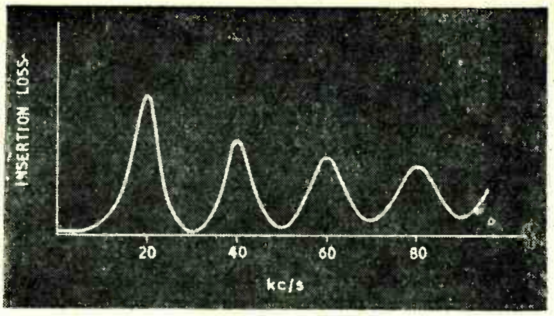
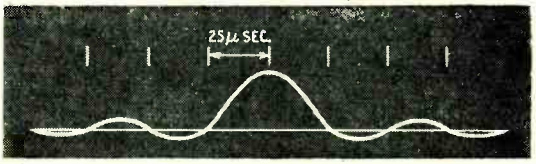


Fig. 8. Response of corrector regarded as a filter

Fig. 9. Pulse after pa sing through corrector.



tive time delay of 25μ sec. The trick which is used is to tap off a little of pulse 2 and feed it in, with reversed sign, to a delayed pulse 3. The total circuit of the compensation system is shown in Fig. 5, with the values appropriate to the example we have chosen. The units marked A are attenuators, and may include reversing circuits. At the instant when the centre of pulse 3 is available at the output of A_3, the centres of pulses 1, 2, 4 and 5 are also available at the outputs of A_1, A_2, A_4 and A_5, and a suitable portion of each of these pulses is used to balance out the corresponding tail which is passing through A_3. The shape of the pulses is shown more accurately in Fig. 6. The amplitude of the tail of pulse 2 which occurs at the epoch of the centre of pulse 3 is a_2, and this is cancelled by the small delayed pulse obtained at the output of A_2 in Fig. 5. The other pulse tails are balanced out in the same way by the outputs of the other A's.

The reports so far available suggest that in experimental systems the balancing of the cross-talk can be made to be sufficiently good for commercial use, even when the pulses are so elongated that the bandwidth is only 4 kc/s per channel. It seems likely that successful operation is obtained because the balancing operation is fairly simple: not quite so simple as this account suggests, because there is interaction between the settings of the various attenuators. The main problem is to make sure that the pulse shapes, which are not in themselves critical, do not alter as the equipment is running. I do not propose to discuss this problem because it is purely one of engineering refinement: can we make a system using a coaxial cable have exactly constant response? Can we make a perfectly constant f.m. system? The real problem is one of cost.

Fig. 7. Transmitting terminal equipment.

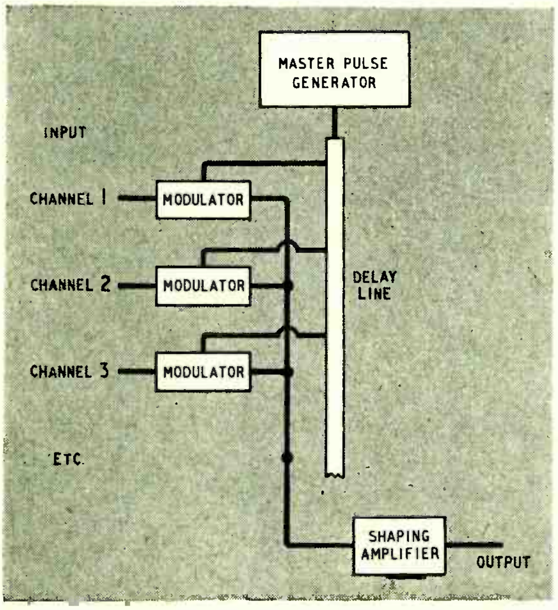


Fig. 7 shows the general arrangement of the terminal equipment at the sending end. The modulators are actually gating circuits, which are opened in turn by pulses produced in the master pulse generator, the order being maintained by tapping off the gate pulse along a delay line so that the pulse spacing is absolutely independent of valve characteristics. The receiving end is very much the same. Additional circuits are used to provide synchronization between the two ends, but these are not parts of the basic system. It will be seen that the complex filters of the frequency allocation multiplex systems have been replaced by the single delay line in this pulse system. Unless there are some exceptional difficulties, the pulse equipment should be very much cheaper.

Future Developments

The details cannot be discussed any further, because nothing has yet been published about systems of this type which will satisfy the standards needed for European telephone circuits. Lengthy field tests of a number of different arrangements will be needed before we can see just what performance can be achieved in practice, both on lines and using frequency-modulation links. It is even possible that in the final form the compensating device will be used in conjunction with pulse code modulation, because it must be noted that by using the arrangement described we do not gain anything in signal-to-noise ratio.

One very interesting point is probably mainly of theoretical interest. If we have a connection between the output of the transmitting terminal and the input of the receiving corrector circuit which is absolutely linear, the corrector can be transferred to the transmitting end. We may then regard the corrector as a rather queer sort of filter which some readers may recognize as a sort of big brother to the re-entrant line filters used occasionally in feeders. The sort of response which this filter will have is shown in Fig. 8, and it is obviously what is sometimes called a "comb filter." When a pulse input is applied to such a filter the output takes the form shown in Fig. 9, and the amplitude is seen to be zero at all multiples of 25 μsec before and after the pulse peak. Thus the use of the corrector at the transmitter amounts simply to the use of a special filter circuit which produces a pulse having zero amplitude where it can interfere with the other pulses. The reason why this arrangement, or rather this way of thinking, is not so useful in practice is that the operation of balancing cross-talk is very much easier to carry out than the operation of adjusting the filter to the exact characteristic needed. This is an example of how it is sometimes better to think in terms of physical behaviour than in terms of standardized concepts like frequency response or transient response.

When I wrote, 12 months ago, that "the thoughts of a few philosophers will set in motion many men who have no understanding of their philosophy," I did not expect that we should be so soon within sight of a new system with such enormous application. I do not know how many frequency allocation multiplex systems are operating in Europe, but I would guess that there must be of the order of one hundred thousand channels altogether. Each new coaxial cable carries nearly one thousand channels. The system described here may make all the terminal equipment obsolete. It looks as though we should all be pretty busy.

SHORT-WAVE CONDITIONS

April in Retrospect : Forecast for June

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

DURING April the average maximum usable frequency for these latitudes decreased considerably during the day and increased somewhat during the night, these being the normal seasonal variations. Both by day and night they were considerably lower than during April of last year, due, no doubt, to the effect of the "decreasing" phase of the sunspot cycle.

Day-time working frequencies decreased appreciably, though, on the whole, they were higher than had been expected. U.S.A. stations on frequencies above 28 Mc/s were seldom heard during the month, and U.S.A. 28-Mc/s amateurs, though they were more or less regularly received during the first part of the month, were rarely heard towards the end. South and Central Americans on this frequency were, however, coming through well till the end of the month. Frequencies as high as 15 Mc/s were often usable till after midnight.

Sunspot activity was, on the average, somewhat lower than during the previous month.

April was a very disturbed month, and frequent periods of poor conditions occurred. The most disturbed periods were 1st, 6th, 13th, 20th, 24th and 30th.

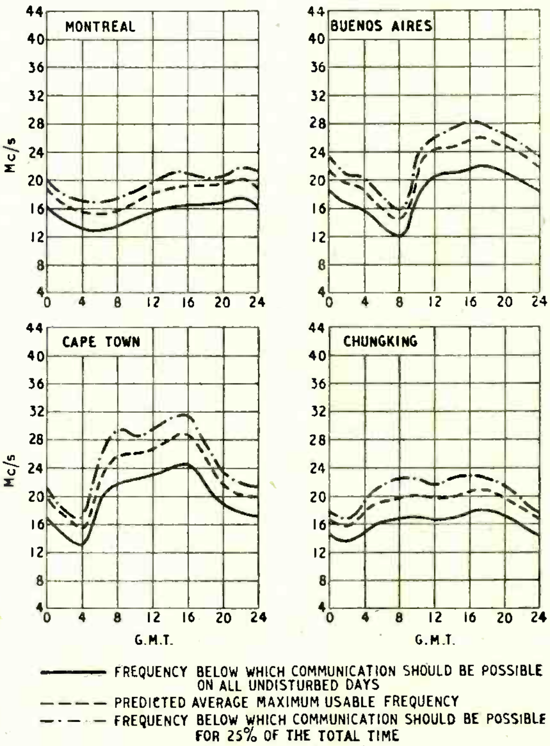
No less than fourteen Dellinger fadeouts were reported during the month, the two most severe of these occurring on 14th; at 1242 and 1335 G.M.T.

Forecast.—During June, day-time m.u.fs in these latitudes should continue to decrease towards their lowest seasonal value, which should be reached towards the end of the month. Night-time m.u.fs should reach their highest seasonal values at about the same time.

Working frequencies for long-distance transmission should therefore be generally lower by day, and higher by night, than during May. Over east-west circuits it is unlikely that frequencies higher than about 22 Mc/s will ever be usable, while even over north-south circuits 28 Mc/s is likely to be above the m.u.f. most of the time. 15 Mc/s should remain usable till well after midnight over many circuits, and the lowest night-time frequency for regular communication should be of the order of 12 Mc/s.

For medium distance transmission—up to about 1,900 miles— the E or F_1 layers will control transmission for long periods during the day, and in these cases, day-time, as well as night-time, working frequencies should be higher than during May. Transmission by way of Sporadic E over medium distances is likely to be a frequent occurrence, and may often take place on exceptionally high frequencies. Trouble from ionospheric storms is not usually very bad during June.

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



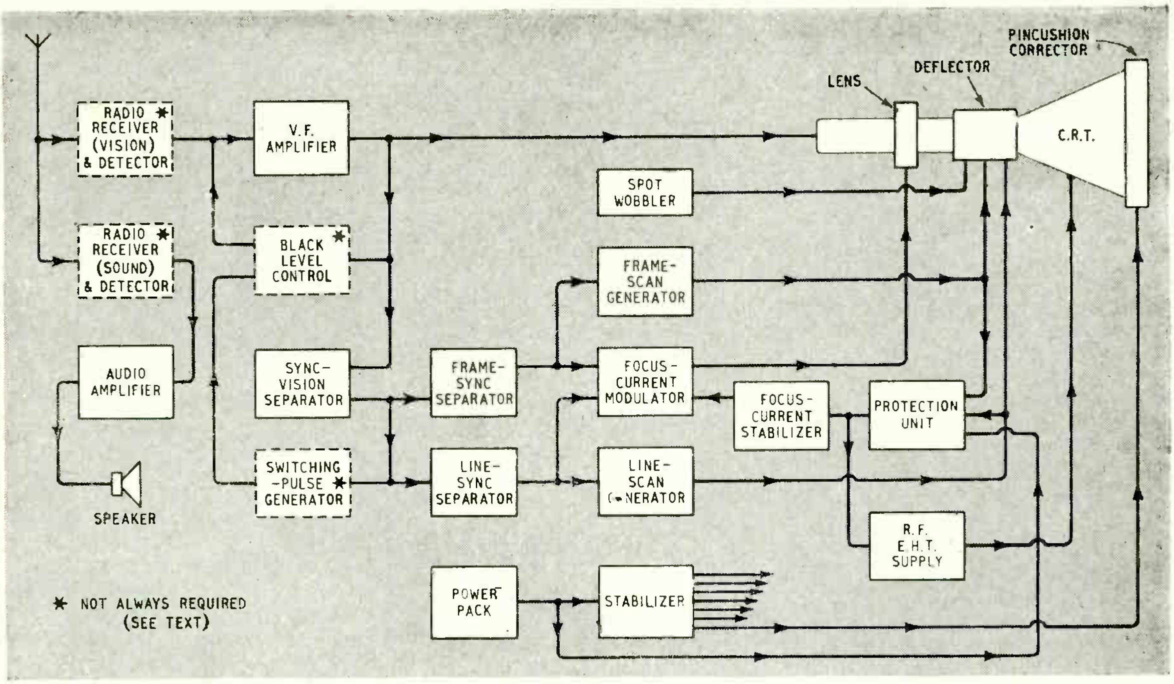


Fig. 1. Block schematic diagram of complete sound and vision monitor, including ancillary receiving equipment.

Television Monitors

Performance Requirements

By J. E. B. JACOB, B.Sc.Eng., A.M.I.E.E. (Cinema-Television, Ltd.)

IT has long been the practice in sound broadcasting to provide high quality reproducing equipment specifically designed for monitoring the transmitted signal. Little or nothing has so far been published about similar equipment for television, although there is evidence in the current literature[1] of the need for vision monitors specially designed for the purpose.

The station vision-monitoring equipment should be designed to furnish the quality-checking engineer with the best picture obtainable within the prescribed bandwidth of the particular television system in use. The equipment should, therefore, be of considerably higher quality than any likely to be in the possession of home viewers. The ideal to be aimed at is that the observing engineer should be able to detect and rectify any small loss of picture quality long before the ordinary viewer becomes aware of it at all.

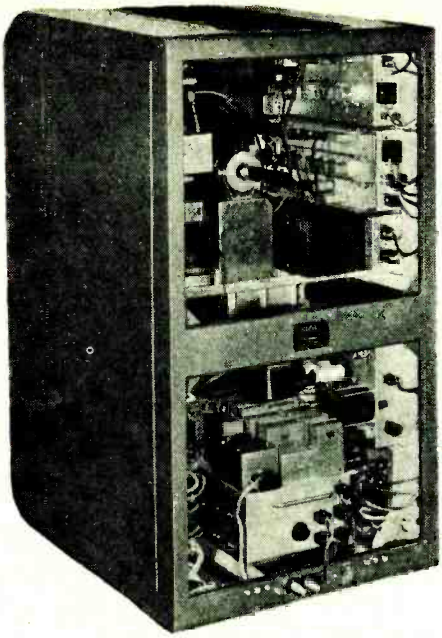
The monitor should preferably receive the radio-frequency output of the transmitter in the normal way so as to check the overall performance of the station, but if this is not convenient it should be connected to a point in the transmitting chain as near to the aerial as possible.

Recently two line-operated vision monitors, fitted with 20-in diameter direct-viewing cathode-ray tubes and capable of very good performance, have been supplied to the British Broadcasting Corporation. It is proposed to indicate in this article some of the measures required, as compared with an ordinary television receiver, to provide the improved performance.

Fig. 1 shows a detailed block schematic diagram of such a monitor. In general, of course, it embodies the same equipment as is required in any television receiver, but each part is designed from the performance point of view, cost being a relatively secondary consideration.

The degree of complexity of the monitor depends partly on the performance required and partly on the quality of the input signal. The signal may be subject in varying degrees to different types of interference and the various units comprising the monitor must be designed to minimize unwanted disturbances of the picture.

[1] D. G. Fink: "Avenues of Improvement in Present-day Television." *Proc. Inst. Radio Engrs,* July 1948, Vol. 36, pp. 896-905.



Interior view of a monitor made by Cinema-Television.

The cathode-ray tube used in a high-performance monitor is perhaps the most important single component. The ability of the monitor as a whole to reproduce the required quality picture depends finally on the tube, however good the performance of the circuits may be. The magnetically-focused and deflected tube, when so designed, is eminently suitable for this particular purpose.

The dimensions of the monitor picture should be such that it can be examined in sufficient detail at a reasonable viewing distance and experience has shown that for a 405-line system a 12-in (30 cm) diameter tube is just adequate though a 15-in (38 cm) tube is to be preferred. The screen should be of the largest possible radius of curvature consistent with the necessary mechanical strength.

The tube should be capable of a picture highlight brightness of at least 25 foot-lamberts with a contrast range of 100 : 1 or better. An aluminized screen operated at 12-15 kV, and 200-300 μA in the highlights is quite satisfactory for our purpose and has the additional advantage of preventing negative-ion burn.

The electron gun must be so designed that (1) it can provide the necessary beam power, with a reasonable expectation of life, for exciting the fluorescent screen to the required brightness and at the same time the size of the focused spot must be such that, in relation to the picture size, the full definition of the picture can be reproduced, and (2) the gamma of the tube, which may be defined as the slope of the curve connecting the logarithm of the brightness with the logarithm of the driving voltage from the beam-current cut-off point, should be of the same order as that of the average picture tube in a typical home receiver.

This latter factor is of considerable importance, for if the monitor tube has a gamma markedly different from the average, the picture-quality checking engineer at the transmitting station will gain a false impression of the tone quality of the picture as it appears in the average home.

The majority of current tubes designed for use in the home have a gamma which lies between 2 and 3 and a good average value is 2.5.

The 20-in diameter cathode-ray tube which has been used in high performance monitors is fully capable of meeting these requirements.

The Magnetic Lens

The magnetic lens must be designed to focus the relatively large diameter beam without introducing appreciable spherical aberration. One of the necessary conditions to achieve this object is that the beam should pass centrally through the lens and, subsequently, the deflector. In case the gun is misaligned in the tube, means must be provided, therefore, to deflect the beam before it is focused or deflected so that it passes along the common axis of the lens and deflector.

An additional desirable feature in the design of the lens is that it shall be so constructed as to enable its power to be varied in a suitable manner in synchronism with the line- and frame-scanning waveforms.

Distortion of the picture can arise from two main sources. In the first place the television picture would ideally be presented on a flat surface as we have all, in the course of our lives, developed the ability to appreciate perspective in a flat representation of a three-dimensional scene. Unfortunately, due to other considerations, the screen of the cathode-ray tube is usually a spherical surface and some distortion is bound to occur when an ideal flat picture is reproduced on it. The distortion can be made to occur in a form which is, for our particular purpose, the least objectionable by the use of a suitable geometrical projection to relate the flat picture to the spherical one.

If the spherical and flat surfaces are imagined to be in contact at the centre of the picture and corresponding points in the two pictures are joined by projection lines, a stereographic projection will be obtained when the projection lines pass through the opposite pole of the sphere. The recommendation for this type of projection is the accuracy with which shapes are reproduced all over the picture. An object moving outwards from the centre of the picture will become slightly smaller in size, but its shape will be accurately maintained. The corner angles and indeed all angles all over the picture are correctly reproduced.

A second form of distortion arises because in modern cathode-ray tubes, using wide-angle deflection, the centre of curvature of the screen is not coincident with the centre of deflection and consequently the distance moved by the spot from the centre of the screen is not proportional to the angle through which the beam is turned. This results in pin-cushion distortion which can be corrected by means of a suitably positioned static 8-pole magnetic field. As applied to a cathode-ray tube, the field is arranged to pull out the edges of the picture in the horizontal and vertical directions and to compress the picture in the intermediate 45° directions. The pin-cushion corrector is only part of the complete solution. It reduces the distortion in the 45° directions, but increases it in the horizontal and vertical directions.

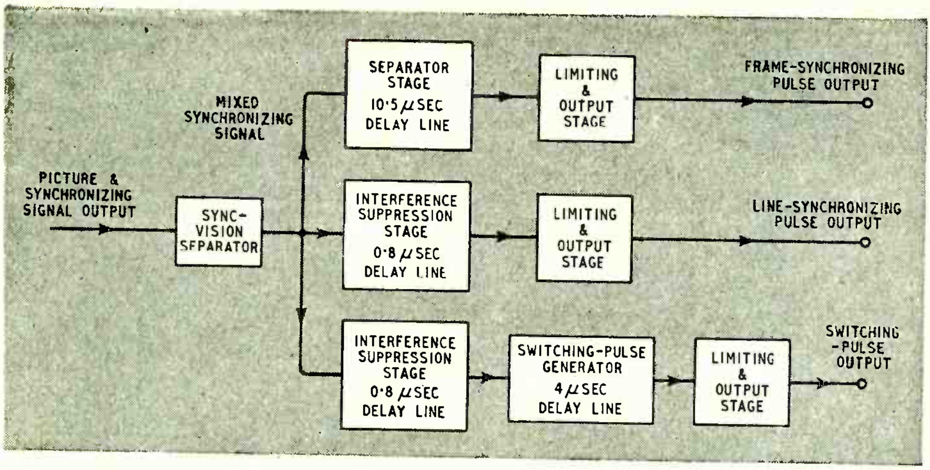


Fig. 2. Block diagram of synchronizing-signal separator giving protection against interference

Its usefulness arises from the fact that this redistribution converts all the distortion into a form which can be corrected by simple changes in the linearity of the scan generators. Without this facility it would be necessary either to intermodulate the two scanning waveforms[2] or to modify the scanning yoke in an empirical manner to provide a correction. Neither of these methods is to be recommended since intermodulation of the scanning waveform is impracticable for most purposes and modification of the scanning yoke necessarily implies non-uniformity of the deflection fields, which is certain to introduce more deflection astigmatism than can be tolerated in this case.

It follows that the scan generators must be designed to produce scanning currents of the correct waveform, in order that, when used with a deflection yoke designed to produce uniform deflecting fields (which introduce a minimum of astigmatism) and in conjunction with a pin-cushion corrector, the picture shall be a stereographic projection of the ideal flat picture. The waveforms should be correct to within ±2% since a 10% error is objectionable and 5% is still noticeable. In addition, the frame-scan generator must be designed to interlace accurately under all normal conditions of service.

Focus Modulation

The use of wide-angle deflection causes the picture to be defocused in the corners due to the depth of focus of the magnetic lens being inadequate to handle the variations of throw distance between the centre of deflection and the screen as the spot scans the picture area. The power of the lens can be varied in a suitable manner to correct this defect by adding two small alternating-current components of parabolic waveform, repeating at the line and frame frequencies respectively, to the main direct-current component required by the focus coil.

A cathode-ray tube which is designed, focused and scanned in accordance with the principles outlined above will require a "spot wobbler," but since this has been described in some detail elsewhere in this journal (May 1950, p. 189) it will not be dealt with here.

Picture monitors fall into two general types, those which receive a radio-frequency signal and those which are fed by means of a transmission line at video frequency.

The first type will contain a radio receiver which must be designed to exploit to the full the quality of the transmission. It will need only a fairly simple video amplifier to raise the level of the signal from the detector to that required to modulate the cathode-ray tube. Normally the d.c. component present in the transmission will be preserved since its constancy or otherwise will be of interest to the observer.

The overall frequency response, including the aerial, should be level from zero to a frequency just above the maximum useful value radiated by the transmitter followed by a rapid cut-off.[3] No useful purpose is served by extending the bandwidth beyond this value, as the home viewer cannot receive it and the monitor picture may have an undesirably high noise level in consequence.

The sharp cut-off will result in appreciable phase distortion which can, and should be, corrected.[4] This will result in ripples being observable on close examination of the picture both before and after narrow vertical bars and sharp edges, but they are of small amplitude and do not detract from its quality at the normal viewing distance. In fact there is a net gain in picture quality since the maximum use is made of the prescribed bandwidth of the transmission.

The signal will probably be subject to some degree of impulse interference and some form of signal limiter should be fitted to the amplifier.

The design and complexity of the video amplifier required for the line-fed monitor will depend to a large extent on the quality and level of the signal presented to it. If the input signal is of the order of 1 volt overall, picture and sync, as seems likely as this is now an international standard, it is not practicable to use a directly-coupled amplifier even though the d.c. component may be present. The gain of the amplifier will necessarily be of such a value that drift of the d.c. level is likely to be troublesome. Moreover, if the transmission line is of considerable length it may happen that a 50-c/s sine-wave signal of considerable amplitude, as well as other forms of interference, become added to the signal.

[2] M. Bowman-Manifold. British Patent No. 417,103.

[3] H. A. Wheeler. "Wide Band Amplifiers for Television." *Proc. Inst. Radio Engrs,* July 1939, Vol. 27, pp. 429-438.

[4] T. C. Nuttall. "Some Aspects of Television Circuit Technique." *J. Television Soc.*, March 1949, Vol. 5, pp. 257-265.

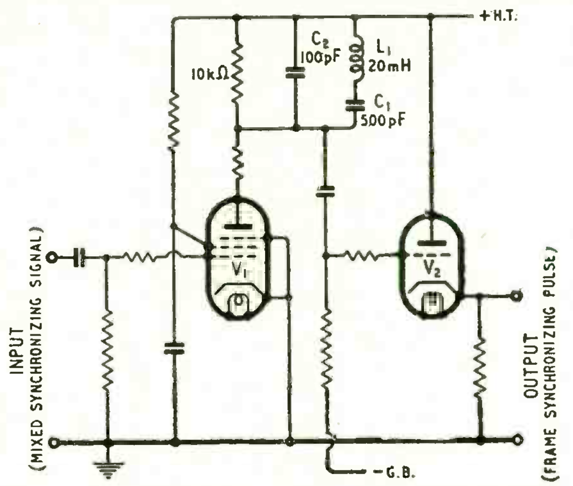


Fig. 3. Circuit of frame synchronizing-signal separator.

Thus it is necessary to use a.c. coupling at the input and to include some precise form of d.c. insertion which maintains the signal level constant during the "back porch"; i.e., the picture-suppression interval after the synchronizing signal.

The amplifier must be fitted with a gain control which should be so arranged that neither the black level of the signal nor the amplitude of the synchronizing signals change as the gain is varied.

The amplitude distortion introduced by the radio- and video-frequency amplifiers should be kept to a minimum in order to avoid modifying the gamma of the picture to any appreciable extent.

One method, due to Nuttall,[5] of controlling the black level in the picture is to feed the output vision signal from the video amplifier into a circuit which compares its voltage level during the back porch with a reference voltage. The signal arising from the difference, if any, between the black level and the reference is fed back to the input stage of the main video amplifier with the required polarity to correct the error at that point.

By this means the black level in the picture can be maintained constant to a high degree of accuracy despite sudden changes in the picture content or the addition of a relatively large amplitude of low-frequency sine wave to the signal. Since this is a feedback circuit, with appreciable loop gain, any drifting of the black level due to the d.c. coupling in the amplifier is automatically reduced to negligible proportions.

The feedback circuit is only complete during the specified period and is brought into operation by a switching pulse derived from the synchronizing signal.

Synchronizing Signal Separation

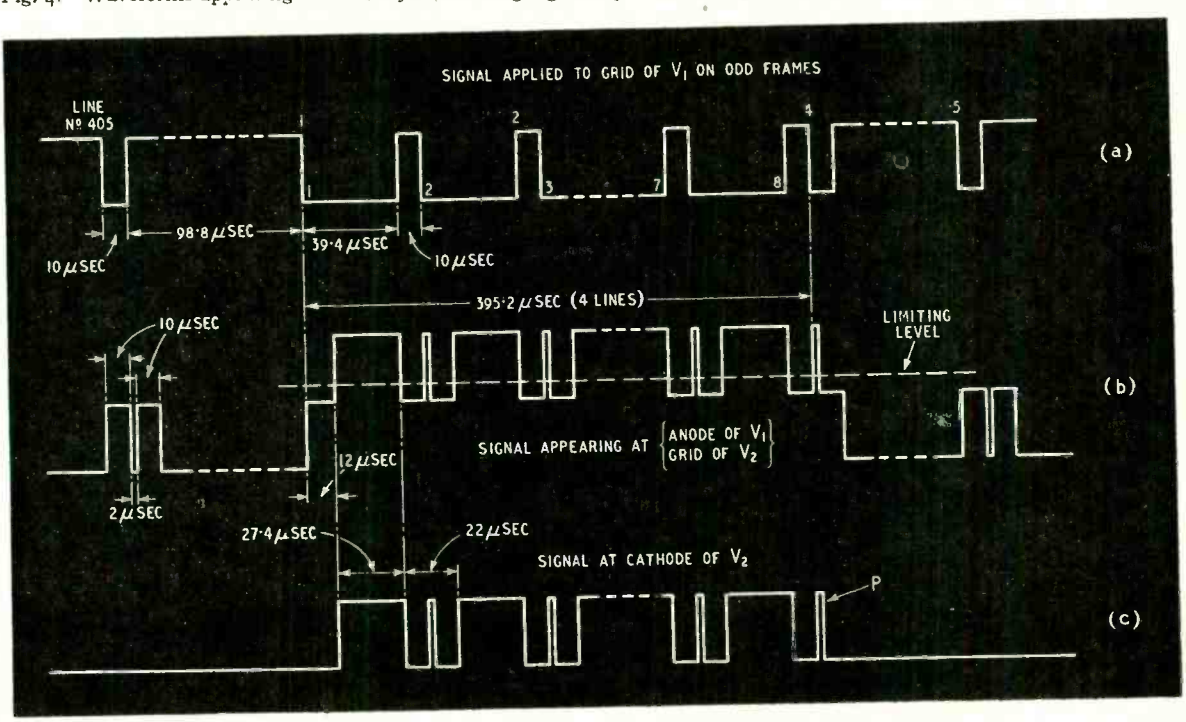
The synchronizing-signal separator must be designed with an eye to the conditions in which the monitor is required to operate. If the signal is free from interference of all kinds, the separator can be of conventional design with the proviso that the frame-synchronizing signal is of such a form that the frame-scan generator will interlace properly.

If, however, the monitor has to operate in conditions in which various forms of interference may be superimposed on the signal, the separator must be designed to ignore as far as possible such unwanted signals.

The separator described is one type which is suitable for a monitor and affords good protection against impulse interference.

[5] T. C. Nuttall. British Patent No. 514,271.

Fig. 4. Waveforms appearing in frame synchronizing-signal separator, (a) grid of V_1, (b) grid of V_2, (c) cathode of V_2.



The separation of the synchronizing signals is carried out in two stages. The first stage serves to separate the synchronizing signals from the vision signals and can be quite conventional. The second stage operates on the mixed synchronizing signals and provides the following outputs.

(1) Frame-frequency synchronizing pulses.

(2) Line-frequency synchronizing pulses.

(3) A 4-μsec switching pulse for the Black Level control unit (not necessarily required in the radio-frequency monitor).

A block diagram of the complete separator is shown in Fig. 2 and the basic circuit of the frame-frequency separator in Fig. 3. The mixed synchronizing signal, Fig. 4(a), is fed to the grid of V_1 which has in its anode circuit an artificial delay line, comprising L_1, C_1 and C_2, open-circuited at the end remote from the valve. The total time taken for a signal to travel to the end of the line, suffer a reflection and return to the sending end, is adjusted to be slightly longer than the duration of the line-synchronizing pulses, a suitable delay time is 12 μsec. The effect of this arrangement is that, as the reflected signal is the same polarity as the original, the line-synchronizing pulses appear side by side with their reflections. In the case of the frame pulses, however, which are of longer duration than the "echo" time of the line, the reflected signal adds on to the original and produces a total voltage excursion at the anode of twice the original signal as shown in Fig. 4(b).

The modified signal is then fed to a limiter stage, V_2, adjusted to pass only signals in excess of the amplitude of the original pulses applied to the delay line, with the result that only those parts of the waveform in which the pulse duration is longer than the echo time of the line appear at the output, Fig. 4(c).

The advantages of this type of frame-synchronizing signal separator are:—

(1) Although the leading edge of the pulse is delayed by several microseconds, the delay is caused by a passive network and the timing of successive pulses is as accurate as in the original waveform.

(2) Equalizing pulses are not required to obtain accurate interlacing as the leading edge is identical on odd and even frames. The only difference between the frames is that the pulse, P, Fig. 4(c), occurs only in the odd frames but does not affect the synchronizing.

(3) A large proportion of the impulse interference which may be mixed with the original signal will be suppressed since the great majority of such pulses will be very short (approximately 0.33 μsec if the overall bandwidth is 3 Mc/s) compared with the echo time of the line and they will only appear in the output if they occur during a frame-synchronizing pulse or if a second interference pulse occurs at the instant the echo of a preceeding pulse returns to the anode of the valve.

The line-scan generator is synchronized from the mixed synchronizing-signal waveform and is designed to ignore the alternate double line-frequency pulses which occur during the frame-synchronizing interval.

The waveform is subjected to exactly the same process as that used for the frame pulses, in order to suppress impulse interference, except that the echo time of the delay line is reduced to 0.8 μsec.

The use of the interference-suppression circuit results in the line pulses being delayed with respect to the picture signal by 0.8 μsec and, although part of this delay is cancelled out by the time taken for the picture signal to pass through the video amplifier, allowance must be made for it in the design of the line-scan generator.

Black Level Control Switching Pulse

The switching pulse is derived from the mixed synchronizing signal. The signal is first "cleaned" and is then fed to a valve having a short-circuited artificial delay line in its anode circuit. The echo time of the line is designed to be 4 μsec and the signal polarity is arranged so that the pulse derived from the trailing edge of the line-synchronizing pulses (i.e., it occurs during the back porch) is passed to the output.

The artificial delay lines used in a synchronizing-signal separator of this type can be two-terminal networks designed in accordance with Foster's reactance theorem[6] with the advantage that they are more easily made and adjusted than the corresponding four-terminal networks.

The remainder of the equipment in the monitor is in no way unusual and will only be mentioned briefly.

The performance of the sound channel, if required, should be in keeping with the quality of the vision equipment and requires no comment here.

The power supplies of the monitor can be of conventional design. All the d.c. supplies, including the e.h.t. supply, should be stabilized against mains input voltage and load-current fluctuations. The transformers and smoothing chokes should be orientated so that there is negligible stray magnetic field from them in the space occupied by the cathode-ray tube. The monitor must be capable of being operated when the frame frequency is not locked to the mains without brightness or focus modulation being visible in the picture and with deflection effects in any direction reduced to the absolute minimum.

A device for protecting the cathode-ray tube screen from damage in the event of failure of either or both scan generators should be incorporated.

So far, vision monitors have been built which incorporate all the feaures outlined above with the exception of a pin-cushion corrector and focus-current modulation, though these have been used in other equipment.

The quality of picture obtainable on the 405-line standard when full use is made of the 2.7-Mc/s transmitted bandwidth is considerably better than many people imagine. On seeing a first-class picture, received by radio in the ordinary way, reproduced on a high-performance monitor, it is clear that the decision to continue with the 405-line standard was the right one and that there is plenty of room for improvement in both transmitting and receiving equipment in the years to come before it can be said that the system is being exploited as fully as possible.

This article is based on a paper read by the author before the British Institution of Radio Engineers on March 23rd, 1950. The author's thanks are due to his colleagues for help and advice and in particular to Mr. T. C. Nuttall, who is responsible for many of the circuit techniques used and for the work on the reduction of scanning distortions.

[6] R. M. Foster. "A Reactance Theorem." *Bell Syst. Tech. J.*, April 1924, Vol. 3, p. 259.

Screening

Back to First Principles When "Rules of Thumb" Fail

By "CATHODE RAY"

CERTAIN people pride themselves on being "practical," and can scarcely hide their contempt for "theorists." They joyfully quote the story of the Professor of Mathematics who came off worst in an argument with the bus conductor about the correctness of his change.

It is true that the learned are often found to be strangely out of touch with practical affairs, even in their own field of study; but that is no reason why knowing as much as possible about the theoretical basis of a job should not make the practical man better at it. I can think of nothing that illustrates this better than screening. It is a thoroughly practical subject, but its rules of thumb are complicated and liable to let one down when tackling anything a bit out of the usual. Lots of questions arise, and we cannot be sure that the answers for one application will fit another even when it seems similar.

There is a surprising vagueness about the subject in most of the books, and (it is to be feared) in many of the minds. This, I am sure, is due to vagueness about the underlying principles. It may possibly comfort a beginner to picture the screen-grid in a valve as a kind of sieve that lets the tiny electrons through and holds back the electric fields, or to suppose that a can round a coil protects it from stray fields much as a roof over one's head keeps out the rain. But when he comes to devising his own apparatus, that sort of idea isn't good enough. What he really needs is a clear picture of the theory of fields. Given that, he knows all (or nearly all) the answers.

This is hardly the place for a complete exposition of fields from the beginning. What I am about to do is to emphasize a few facts about them in relation to screening.

The first, which hardly needs emphasis, is that (so far as *Wireless World* is concerned) there are two kinds of field—electric and magnetic. The only point in mentioning it is in case someone says: what about an electromagnetic wave; is that a third kind? It is true that an electromagnetic wave has certain peculiarities not possessed by electric or magnetic fields considered separately; such as the ability to go on after whatever caused it has been switched off. But that is merely a matter of organization; the magnetic and electric fields of which electromagnetic waves consist are exactly the same in themselves as the fields around the loudspeaker magnet and the h.t. terminal in the power pack. It happens, however, that a moving magnetic field generates an electric field, and a moving electric field generates a magnetic field; this mutual back-scratching pact makes it possible for electric and magnetic fields to keep one another going without any visible (or invisible) means of support, once they have been started.

The starting process necessitates field movement or variation, so no electromagnetic radiation results from a constant fixed field of either kind. Theoretically, there is radiation wherever there is a.c. (though it is negligible at low frequencies such as 50 c/s). And since electromagnetic radiation consists of electric and magnetic fields in equal proportions, one can theoretically only have one kind without any trace of the other when it is quite steady, such as that produced by an electrostatic charge or a permanent magnet. But at low frequencies the radiation is generally so small that it is possible for one kind of field to predominate, even though it is alternating. The field close to a low-voltage coil carrying a heavy 50 c/s current is almost entirely magnetic, and the field close to high-voltage open-circuited terminals is almost entirely electric. But at radio frequencies the tendency is for the production of a strong magnetic field to necessitate a high voltage across the coil (and hence an electric field); similarly, a high voltage can hardly exist without producing at least a capacitive current (and hence a magnetic field).

This matter of frequency keeps coming into the question of screening.

Now for methods of screening. There are two basic types of weapon in our armoury: diverting the

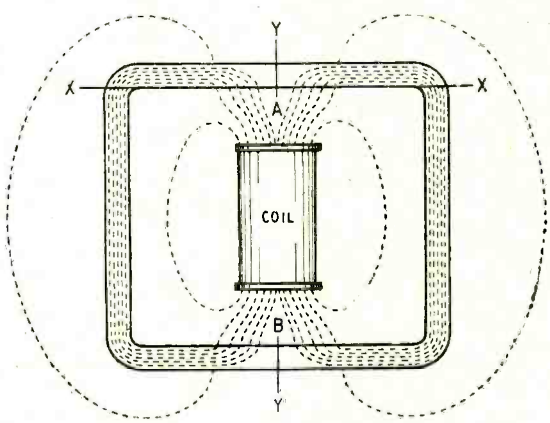


Fig. 1. For the lowest frequencies, the best protection against magnetic fields is a substantial cover made of special low-permeability metal, with no joints or gaps such as XX in the way of the flux.

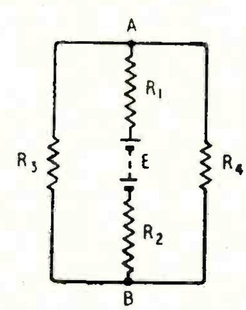


Fig. 2. Electrical analogy of Fig. 1.

course of the field; and cancelling it out with an opposing field.

Fig. 1 shows an example of the first method applied to the magnetic field from a coil. It consists in shutting it up in a box of high-permeability material, which provides such an easy path for the magnetic flux that very little spreads out into places where it would be unwelcome.

Magnetic Screening

Anybody who is not used to magnetic circuits may perhaps grasp the principle more clearly by studying the electrical analogy, Fig. 2. Here the electromotive force of the battery, E, corresponds to the magnetomotive force of the current-carrying coil in Fig. 1, and R_1 R_2 are high resistances corresponding to the large magnetic reluctances of the air spaces at the ends of the coil. Before the low resistances R_3 R_4 are connected, the full voltage E appears between the points AB; but with R_3 R_4 in place this voltage is more or less short-circuited. Similarly, the low reluctance of the screen reduces to a very small amount the magnetomotive force available for driving flux through the surrounding space. The single pair of dotted lines representing such flux in Fig. 1 does not mean, of course, that the flux consists of lines; it is spread throughout the space, but (if the screen is a good one) very thinly.

Just as any breaks in R_3 and R_4 would nullify their action, so one has to take care that the arrangements for opening the box do not introduce even the smallest gap in the flux path as seen from the outside—across XX, for example. It is all right to have a crack *along* the flux lines such as YY.

If the box is to be reasonably thin and light, it must have a very high permeability indeed to offer a far easier path for the flux than the much thicker chunk of space outside. Ordinary iron or steel is not really good enough; that is why a special high-μ alloy much as Mumetal is recommended.

Note that this kind of screen tends to increase the

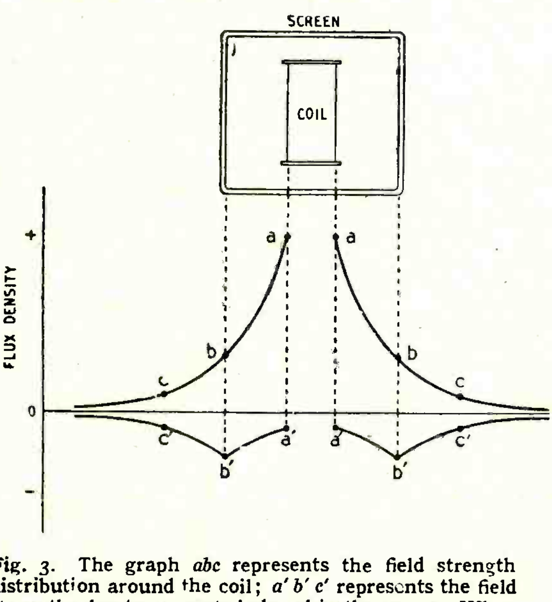


Fig. 3. The graph *abc* represents the field strength distribution around the coil; *a' b' c'* represents the field strengths due to currents induced in the screen. When the two are added, the result is nearly zero outside the screen.

inductance of the coil by increasing the flux produced by a given current.

This method is at its best with zero- or low-frequency current in the coil. As the frequency is raised the μ drops, and at radio frequencies it is too little to be much help. That is where we bring out our other weapon. Suppose the box to be made of copper. As the μ of copper is practically the same as of air it is completely useless as a flux diverter. But what it does do is to act as a short-circuited secondary winding to the coil, and the current induced in it sets up a field that very nearly cancels out the field of the coil.

If the copper were to be wrapped closely around the coil winding, so as to be close coupled to it, as in a tranformer, the inductance of the coil would be reduced nearly to zero, so that it would cease to be worth screening. To avoid this, the screen should be as large as space and cost will allow.

In Fig. 3, the lines *abc* are graphs showing how the flux density falls off rapidly the farther one gets away from the coil. Just outside the coil itself it is very intense, as indicated by the height of *a*. At the screen it is much less (*b*); and *c* denotes the density at some point outside the screen, where it is less still, but presumably more than is wanted. Since the flux is supposed to be alternating, and the copper screen forms a closed circuit around the coil, it generates currents in the screen which set up their own flux. And if the resistance of the screen is very low, a very much smaller flux than *b* is sufficient to generate enough e.m.f. to drive enough current through the screen to produce a reverse flux equal to *b*. (If you don't follow that at the second attempt, try reading on before going back to it!) What happens is that the reverse flux, b′ grows until it *nearly* neutralizes *b*, the small difference between them being what is needed to generate b′. The screen can never neutralize the coil's field completely. because if it did there would be nothing to generate the neutralizing field. But it can be made to do so very nearly by making the resistance of the screen very low in the direction of the current. The direction of the current is quite different from the direction of the flux in Fig. 1; it is in a continuous ring parallel to the turns in the coil. So a gap at XX in Fig. 1 would be allowable, but one along YY (supposed to be continued right down the screen) would interrupt the screen currents and make it useless.

The Fig. 1 screen would not in any case work well as a neutralizing screen, because high-μ materials have a far higher resistance than copper.

The field strength and flux density due to the screen also fall off on each side, and Fig. 3 shows that outside the screen this is just what is wanted; for example, *c′* practically cancels *c*. But inside the screen the cancellation becomes less and less as one gets near the coil; which again is just what is wanted. If the screen is spaced well away from the coil, *a′* does little to cancel *a*, and the inductance of the coil is only slightly reduced. But if you draw a diagram like Fig. 3, for a screen fitting tightly round the coil, you will see how nearly it would neutralize the coil as well.

Obviously this type of screen is no good at all against a d.c. field, because d.c. can induce no screen currents. And it is not very good at low frequencies, because such a lot of screen current is needed to generate the neutralizing field, and the difference between *b* and *b′* is comparatively large. So the two

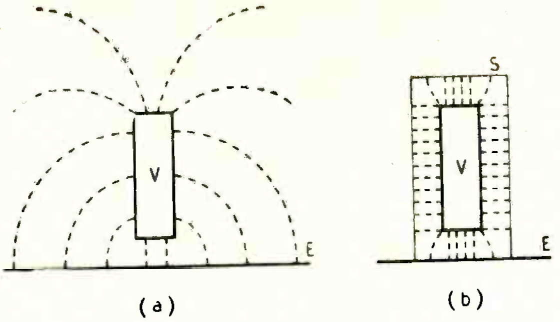


Fig. 4. (a) Unscreened object V at high potential relative to E. (b) Same object with screen, S. The electric flux is denser, but confined inside the screen.

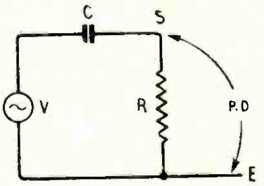


Fig. 5 (above). Equivalent circuit of Fig. 4(b) when the screen has appreciable resistance to earth.

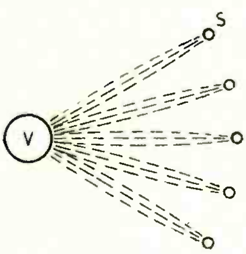


Fig. 6 (right). Showing how an earthed grid or cage is nearly as effective as continuous metal.

methods are complementary: Mumetal for a.f. and lower frequencies; copper for r.f. But remember to have the lids in the right places relative to the coil!

So far we have considered the problem to lie in shutting up a source of objectionable magnetic field, but, of course, the same methods work in reverse, if the interfering field is outside and the screen is for protecting the coil inside.

Electric Screening

You will have noticed that nothing has been said about earth, because earthing has nothing to do with magnetic screening. But it has everything to do with electric screening. The method corresponding most closely to Fig. 1, which would consist in enclosing the source of electric field in a high-permittivity box, is (so far as I know) never used, because even the latest titanium ceramics do not offer a κ anything like so high as the available μ; and such materials are not very handy for screen-making anyway. If you regard metals as materials having practically infinite permittivity, that is different. But it is more usual to regard metallic screens as working by virtue of their conductivity. However they are regarded, the fact is that they do work, and very well too, especially at low and zero frequency. All one has to do is to shut up the offending (or offended-against) article in an earthed conductor.

In Fig. 4, V represents some component, such as a rectifier, having a high voltage to earth or other zero-potential structure such as the chassis, represented by E. The electric field, when there is no screen, is suggested by the dotted lines in diagram (a), which mean that every point in the space around is at some potential between those of V and E, and therefore not zero. In (b), the offender is shown shut up in a metal box S, connected to E. All points on S are thus brought to the same potential as E, so there can be no electric field between S and E.

This is strictly true for unvarying fields, even if the resistance of S is not negligible; because any charge that the first switching-on may have set up on parts of S leaks off more or less rapidly to E, and there is nothing to renew it. But if the potential of V is varying at high frequency there will be capacitive currents induced in S, and unless S has a low resistance, these currents will cause a voltage drop in it. This situation could be represented as in Fig. 5, where C is the capacitance between any selected part of the screen and V.

Unless C is rather large and the frequency and voltage of V is very high, the current is not likely to be enough to set up an appreciable p.d. across the extremely low resistance of even a thin metal screen. But if these conditions exist, one does have to think of using thickish copper sheet. Or, better still, two screens, one inside the other. For most purposes, however, the thinnest tinfoil is good enough. It is not even essential to have continuous metal, so long as it makes a good contact to earth. A sort of parrot cage is quite effective. Suppose Fig. 6 represents V and a few wires of such a screen, looking down on it from above. If one maps out the field by the methods described in the books one finds very little of it exists much beyond the boundary of the screen, even when the gaps are fatter than the wires. But a vertical spiral or coil of wire would be bad, because it would place a comparatively large resistance—and inductance—between the upper part of itself and E.

For the same reason it is not a good idea to screen a wire by winding a spiral of wire around it, earthed at only one or two places.

In general, the need to avoid contact resistance is not so acute in an electric screen as in a magnetic, because it is usually a high-voltage low-current system, whereas a magnetic screen is exactly the opposite. So, although a push fit between a can S and its base E puts a contact resistance in the direct line of current, it is usually good enough.

As in Fig. 3, the farther the screen is away from the screened, the better. A close-fitting screen increases the capacitance to earth of its contents, which is often a bad thing in itself, and in so doing it also increases the screen currents and so reduces the effectiveness of the screening.

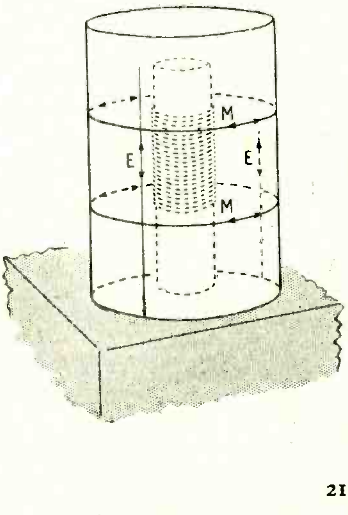


Fig. 7. An earthed metal can is effective against both fields, provided that the resistance is low throughout the paths of magnetically - induced currents (such as M) and electrically - induced currents (such as E). If there has to be a joint or seam, it is better for it to affect E than M.

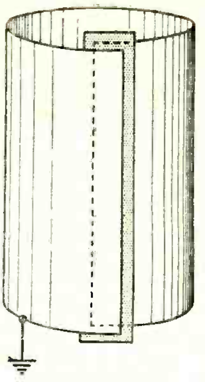
One advantage of knowing the underlying principles of screening, and thereby the directions in which screen currents or flux take, is that it enables one to contrive a screen so that it deals with either electric or magnetic field alone, or with both.

When the object to be screened is such a thing as a tuning coil, one usually wants to screen both fields, and an earthed copper can does both jobs very effectively, provided, of course, that there is nothing (such as a doubtful seam) to obstruct the currents induced in the screen. The circles marked M and the straight lines marked E in Fig. 7 are typical current paths necessary for screening alternating magnetic and electric fields respectively.

But sometimes one wants to stop electric (capacitive) coupling without interfering with magnetic coupling—between the windings of a transformer, for example. If the primary were completely enclosed in a copper cylinder before the secondary was wound on, it wouldn't be a very good transformer! All one has to do to remove the magnetic screening while retaining effective electric screening is to stop all the magnetically induced currents by slipping a strip of insulation between the overlapping edges of an earthed non-magnetic metal sheet (Fig. 8).

The reverse process—magnetic screening without electric—is not normally a requirement, but if it were it could be accomplished with a set of insulated rings, like hoops round a barrel, parallel to the wire in the coil.

Fig. 8. By breaking the M paths by a strip of insulating material, magnetic screening can be avoided while obtaining electric screening by earthing.



The only thing that need be said about screening against electromagnetic waves is that it must be of the combined type (Fig. 7) in order to deal with both electric and magnetic components, and the slightest hole or crack lets out enough leakage to be detected by a sensitive receiver.

Summing-up:

Magnetic Screening. *Method* 1 (for zero and low frequencies): High permeability metal, giving continuous low-reluctance path for magnetic flux (Fig. 1). *Method* 2 (for high frequencies): High-conductivity metal, giving continuous low-resistance path for induced currents (at right-angles to flux paths).

Electric Screening. Low-impedance conducting paths to earth. Easy to fulfil except at highest frequencies.

Electromagnetic Screening. A combination of both.

But it is better to remember the principles, which enable one to devise suitable screening for any situation—not just the simple examples shown here.

C.C.I.R. VISIT

Studying British Television Progress

SOME fifteen countries were represented in the delegation of the International Radio Consultative Committee which has been here to study television. They have also visited America, France and Holland.

During a visit to the E.M.I. works delegates saw the manufacture of Emitron camera tubes and had 405- and 625-line television demonstrated on a closed circuit. A direct comparison between the two was possible. A 3-Mc/s bandwidth was used for 405 lines and a 5.5-Mc/s for 625 lines. The difference of picture quality obtained was remarkably small. The sensitivity of the cameras was demonstrated by pictures of a scene illuminated by 1 ft candle.

The new vision transmitter for Holme Moss was shown by the Marconi Company at Chelmsford and an evening television party was given at Great Baddow. In addition to 405-line closed circuit demonstrations, which included good pictures at dusk, a series of demonstrations of television effects was staged. Among these was an experiment showing that a 50-c/s frame frequency is no bar to the attainment of a flicker-free picture which is bright enough for viewing under conditions of high ambient illumination.

In their visit to the B.B.C. research station the delegates were shown 405- and 625-line pictures transmitted through a carefully equalized 3-Mc/s channel. Known amounts of delay and echo distortion could be introduced and their effect on the picture observed. It was clearly demonstrated that while a delay distortion of only 0.02 μsec, which it is difficult to avoid in cable links, caused only moderate distortion of the 405-line picture it intolerably degraded the 625-line one. Cinema-Television, Ltd., demonstrated large-screen television, as reported on page 220.

Club News

Birmingham.—A talk on the radio control of models will be given to members of the Slade Radio Society on June 9th by Dr A. C. Dawes. The second discussion in the series on television fundamentals will be opened by W. E. Merrill on June 23rd. Meetings are held on alternate Fridays at 7.45 in the Parochial Hall, Broomfield Road, Erdington. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Bradford.—The Bradford Amateur Radio Society meets on alternate Tuesdays at 7.30 at Cambridge House, 66 Little Horton Lane, Bradford. Sec.: V. W. Sowen, "Rushwood," Grange Park Drive, Cottingley, Bingley, Yorks.

Brighton.—Membership of the Brighton and District Radio Club (G3EVE) is now nearly 100. Meetings are held on Tuesdays at 7.30 at the Eagle Arms, Gloucester Road, Brighton. A series of lectures on the history of radio is being given by the secretary, L. F. Hobden, whose address is 17 Hartington Road, Brighton, Sussex.

Edinburgh.—Weekly meetings of the Edinburgh Amateur Radio Club are held on Wednesdays at 7.30 at Unity House, 4 Hillside Crescent. A visit to the local R.N.V.(W)R. headquarters is being arranged. Sec.: D. A. E. Samson (GM3EQY), 56 Elm Row, Edinburgh, 7.

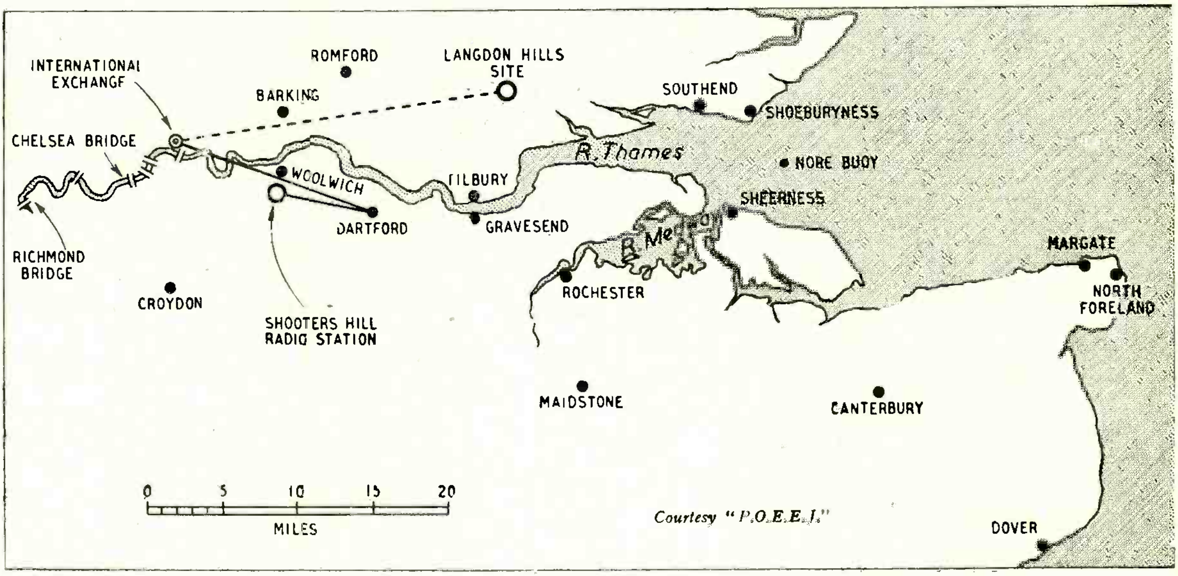
Middlesbrough.—A new club room and workshop has been secured for members of the Tees-side Amateur Radio Society in All Saints' Hall, Grange Road, Middlesbrough. To encourage junior members they are now admitted free of charge up to the age of 15. Sec.: J. H. Davies, 85 Cobden Street, Thornaby-on-Tees, Yorks.

Sweden DX Fan Club, which has its headquarters at 5 Aldred Street, Worksop, is being re-organized. Details of this international club are obtainable from Eric Good at the above address.

Walworth.—Meetings of the Walworth (Men's Institute) Radio Club are held on Wednesdays and Fridays at 7.0 in the L.C.C. Evening Institute, John Ruskin Street, London, S.E.5. The club's new technical instructor is H. Lambert. Sec.: B. E. Symons, 100 East Dulwich Grove, London, S.E.22.

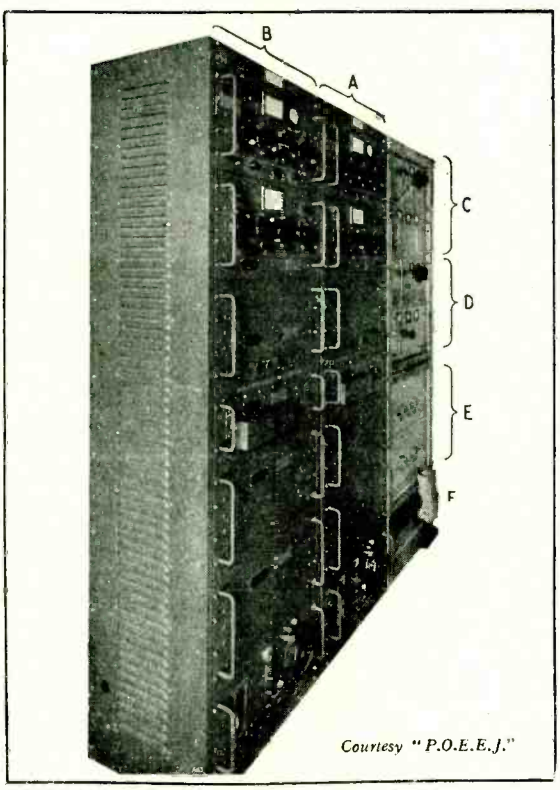
Thames Radio Service

Introduction of 160-Mc/s Service Linking Public with River Craft



Courtesy "P.O.E.E.J."

Location of the fixed station at Shooters Hill and the site of the proposed second station north of the Thames are shown on this map. The route of the cable link between the existing station and the exchange in central London is also shown. Equipment at the Shooters Hill station is shown below. A & B, main 50-watt transmitter and standby; C, main receiver and analyser; D, spare receiver and analyser; E, control unit; F, power equipment.

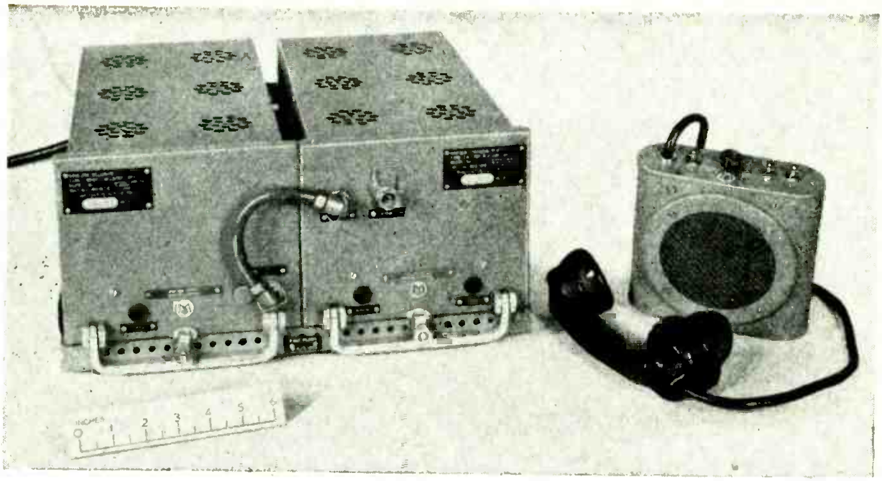


Courtesy "P.O.E.E.J."

THE navigable stretch of the River Thames—a distance of some 50 miles—comes under the control of the Port of London Authority and it was as a result of their request for radio-telephone facilities to their patrol launches which led to the introduction by the Post Office of the service now linking small craft plying on the Thames with the public telephone service. An article giving a survey of the problems involved and a description of the equipment used for this service was given in the January issue of the *Post Office Electrical Engineers' Journal.*

Two-frequency working is provided, with transmission in each direction on frequencies separated by several megacycles; this allows full duplex operation as on the ordinary telephone. Six channels are planned with 100-kc/s spacings and a frequency separation between incoming and outgoing carriers of 4.5 Mc/s. The carriers of the first and second channels of the Thames Radio Service—as it is called—are 157 and 157.1 Mc/s (mobile to fixed) and 161.5 and 161.6 Mc/s (fixed to mobile). Amplitude modulation is being used in conformity with the recent decision to standardize a.m. for marine services in the U.K.

The lower reaches of the Thames flow through rather flat country and the number of sites on which it is possible to obtain the necessary height for the aerials of the fixed stations is very limited. After tests it was decided to utilize two water towers—one north of the river and the other south. Since the introduction of the service it has been found that the southern station at Shooters Hill (see map) gives adequate coverage and the second site—at Langdon Hills—is not being used, unless it is subsequently



Courtesy "P.O.E.E.J."
Marconi equipment as installed on river craft for the initials tests for the Thames Radio Service.

decided to extend the scope of the service. Simple centre-fed vertical dipoles for both the transmitter and receiver are mounted on the top of the 530-ft water tower. The receiving dipoles are connected to a pre-amplifier installed at the top of the tower and filters are inserted in the feeders to prevent high voltages from the transmitting aerials—which are within a few feet—being applied to the receivers. The pre-amplifier consists of an earthed-grid triode with a broadly tuned anode circuit. Power for the amplifier is superimposed on the co-axial cable connecting the amplifier to the receivers which are at ground level.

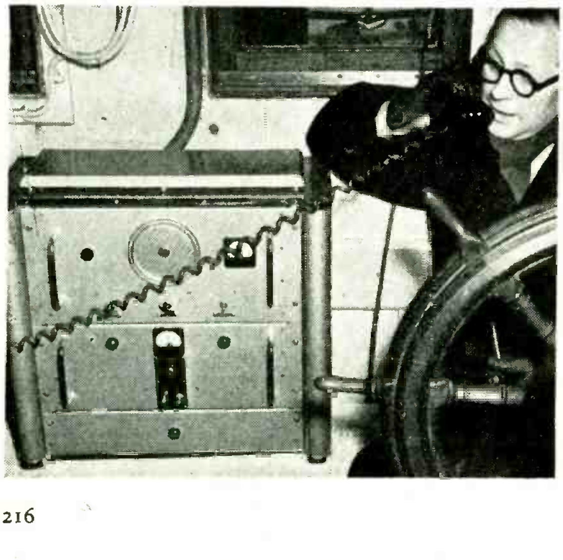
The radiated power from the fixed station can usefully be greater than that of the mobile transmitters, but this increase can only be effective in improving range, or quality of service, if the receivers at the fixed station are correspondingly more sensitive than the sets afloat. The fixed receivers at present in use have a noise factor of approx. 5db and, with the simple aerials installed, their sensitivity is such that an average signal/noise ratio of 15db is obtained on transmissions from 5-watt mobile equipment operated at distances up to 40 miles away. A signal analyser is incorporated in the receiving equipment, one function of which is to examine the quality of an incoming signal and to pass it on to the operators' switchboard only if it has a signal/noise ratio of 15db or more.

The radio station at Shooters Hill is connected by line to the switching centre for the Thames Radio Service at the International Telephone Exchange in central London—a distance of 7 miles. The proposed site of the second station is, however, some 23 miles from central London. As a precaution therefore against difficulties which might have been encountered due to the difference in transmit time should two stations be used, the line from Shooters Hill is routed circuitously so that it is approximately equal to that from the second station.

Whilst the service is provided by the Post Office it is the responsibility of the owners of boats to equip and maintain the gear on board, which, however, has to conform to a P.O. specification. Two manufacturers are now producing the equipment and typical sets are illustrated. The sets are similar to those used for land mobile services—such as in police cars. The use of frequencies around 160 Mc/s is, however, comparatively new and the Thames Radio Service is the first mobile service in the U.K. to use full duplex working with a common T/R aerial.

The operating procedure for the service, which is available throughout the 24 hours, is as follows in the case of calls from river craft. On lifting the telephone handpiece from its hook the monitoring loudspeaker, which is used for calling the craft for incoming calls, is disconnected and the transmitter is brought into operation. The automatic signal radiated from the transmitter operates the calling lamp at the International telephone exchange and the operator on being asked for the required number completes the circuit. In the opposite direction—land to water—telephone subscribers served by any exchange in the U.K. may make a call to a boat. At the moment the operator broadcasts a call for the boat required and when a reply is received the correspondents are linked. A refinement—a selective calling system—is, however, being introduced.

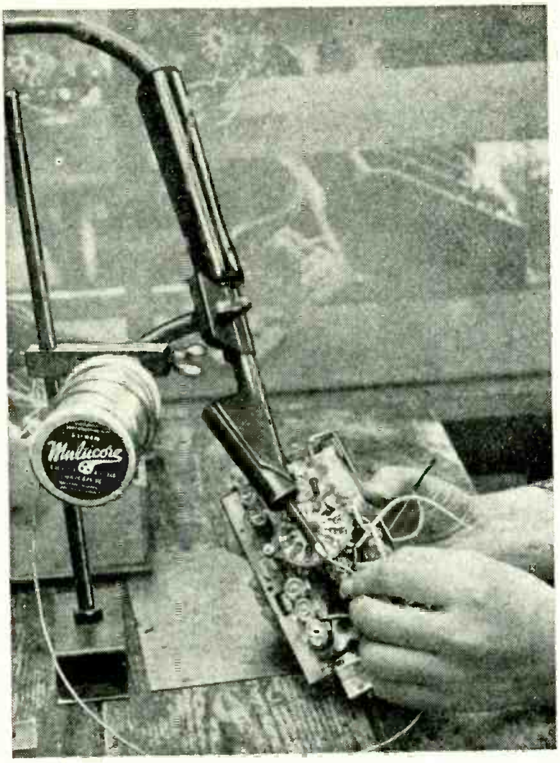
This Pye equipment was used to demonstrate how sea-going vessels may benefit from the Thames service when their deep-sea radio is closed down.



EQUIPMENT AFLOAT

The mobile equipment supplied by Marconi's for the Thames Radio Service is the standard Type H16 adapted for use in the 156- to 184-Mc/s band. The receiver (shown on the left of the above illustration) and transmitter are separate units which, mounted together on a rack, measure 16 inches square by 8 inches high.

The Pye equipment used is shown in the photograph on the left. It is the high-band version (100-185 Mc/s) of the Type 703, slightly modified for the Thames Radio Service. R.F. output of the transmitter is up to 12 W.



A switch unit for a Pye receiver has 75 soldered joints made entirely with a bench fixed iron. This unusual method of soldering enables a very fine bit to be employed and reduces fatigue on the part of the worker.

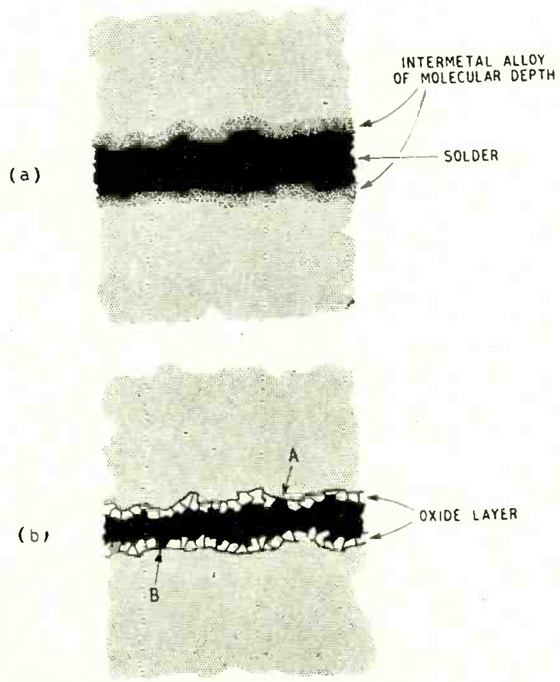


Fig. 1. (a) Magnified section of a well-soldered joint. (b) Magnified section of a high-resistance dry joint.

Modern Soft-Soldering Technique

Present-day Methods for Obtaining Speed and Reliability

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

SOLDERING is amongst the most ancient branches of the metal worker's art, for soldered joints are found in the gold chains and in a considerable variety of the other jewels taken from the oldest Egyptian tombs, and from those belonging to other early cultures. Until comparatively recently, all of the three methods of soldering—brazing, silver-soldering and soft-soldering—remained parts of the "art and mystery" of skilled metal-working crafts. To a great extent this is still true of the first two; but the same cannot be said of soft-soldering, which is now regularly done, mechanically or by semi-skilled labour, in factories; and in an unknown number of workshops (and on a still less ascertainable number of kitchen tables!) by amateur craftsmen the world over.

Soft-soldering was mainly the speciality of the tinsmith until the advent of electrical power and lighting. Almost every kind of electrical apparatus must contain many soldered connections in its make-up. Means had to be found, and were duly found, of so simplifying the technique that it ceased to be the prerogative of expert craftsmen. With the coming first of radio and later of television, further simplification was needed, for the average broadcast receiver contains some 500 soldered joints and there may be from 1,500 to 2,000 or more in a combination televisor-radiogram.

At this point we had better, perhaps, settle just what we mean by soldering (hard, silver or soft) and by the term "dry joint."

Soldering of any kind may be defined as the process of uniting two pieces of metal by means of a thin layer of another metal of lower melting point than either; this last metal is the solder. The correct procedure is to apply the solder to the joint, then heat the latter until the solder becomes liquid. A sound joint can be made only if the solder "wets" the surfaces of both the metals to be joined. By "wetting" is meant that the solder penetrates each surface to molecular depth and forms a thin layer of "intermetal," which is virtually an alloy. This condition is illustrated diagrammatically in Fig. 1 (a).

Fig. 1 (b) shows what happens in the case of a dry joint. As the term suggests, a dry joint occurs when the solder fails to wet one or both of the surfaces to be joined. The solder adheres to some extent to the surface irregularities, and may penetrate between the particles of oxide to make contact with the metal at one or two places (A and B for instance), but there is no genuine union. Owing to the very small contact areas at such points as A and B, the joint would have a high resistance which would vary considerably with vibration or mechanical strain.

Another particularly deceptive dry joint sometimes occurs when a wire is being soldered on to a tag, using resin flux, and the tag has not been properly tinned. As can be seen from Fig 2, a layer of solidified flux collects on the tag and sticks the wire in position, whilst the solder simply forms a blob on top, giving every appearance of a well-soldered joint. Then again, even if the solder does wet the tag, it often happens that the wire is not properly wetted but is merely clamped mechanically by the solder solidifying around it.

Feeling that readers, both professional and amateur, would like to know something of the latest developments in the soft-soldering used in radio and television construction, I consulted Richard Arbib of Multicore Solders, Ltd., as an admitted authority on the subject, and from him I obtained a mass of interesting information.

The making of a successful joint of the kind used in electrical apparatus depends upon the use of:—

(*a*) The proper quantity of the right kind of flux.
(*b*) A solder which is a suitable alloy of tin and lead.

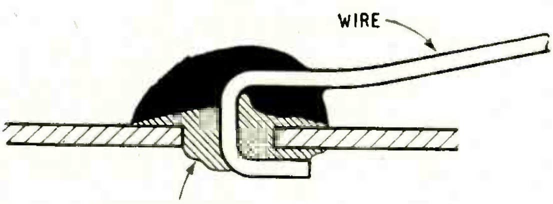


Fig. 2. Joint which has every appearance of being soldered but is actually held together by solidified flux.

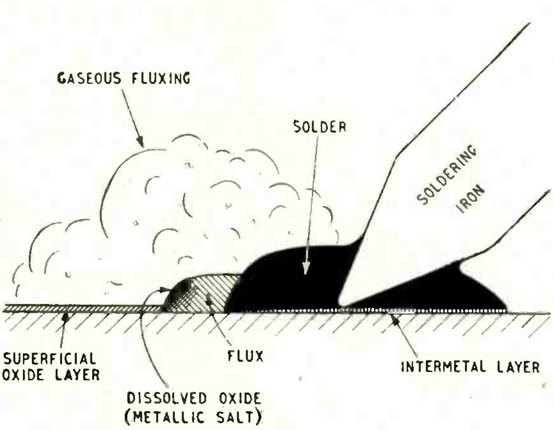


Fig. 3. Illustrating the process of fluxing and tinning.

(*c*) A temperature, applied by iron, blowpipe, or other means sufficient to ensure "wetting."

The main purposes of the flux are as follows. First, it removes any oxide coating from the surfaces of the metal to be joined. The oxide is dissolved by the advancing edge of the flux and forms a metallic salt in solution, as shown in Fig. 3. As a result, the advancing edge of flux often becomes highly viscous and stops flowing—which may explain the failure of some materials that are *theoretically* good fluxes. Sometimes a phenomenon known as "gaseous fluxing" takes place as well. When the flux material is heated, certain substances in it are volatilized into gas, which attacks the oxide before the ordinary liquid flux can get to it. The effect can be seen by a bright corona of cleaned metal surrounding the advancing edge of the flux.

Secondly, a flux serves to lower the surface tension of the molten solder, enabling it to flow readily. In fact, some fluxes, which are not chemically strong enough to dissolve the oxide, act by virtue of this alone, always provided that the oxide coating is not thick enough to prevent the solder from wetting the metal. Thirdly, it goes without saying that the molten flux acts as a very effective seal against the atmosphere, and so prevents the formation of any more oxide whilst the soldering-iron is heating up the metal.

Resin-cored Solder

Metals such as copper and tin are known as "easy" from the soldering point of view, since there is comparatively little difficulty in wetting them with solder. But there are "difficult" metals, of which aluminium is the outstanding example. The trouble with aluminium is that oxidation occurs almost instantly after the surface has been cleaned and that ordinary fluxes cannot keep pace with it. The Mullard supersonic soldering tool, designed particularly for dealing with aluminium, tackles this special problem in an entirely new way; the vibrations set up literally shake off the oxide film as it forms.

In radio work we are concerned mainly with "easy" metals and the problems are to some extent simplified. There is, however, only one generally available basic flux which satisfies all electrical requirements. This is resin. The main constituents of resin are abietic or pimaric acids which, in the molten state, do the work of dissolving the oxide, but have the great virtue of being non-corrosive when the resin has set once more into the solid and the soldered joint is made. In the early days of radio, many of us tried our hands at soldering, using powdered resin as a flux—and didn't we make some nasty looking messes! Powdered resin is definitely not an easy flux to use, at any rate for fine work. Later, fortunately, somebody conceived the idea of dissolving the powder in industrial spirit, which made it very much more convenient to use

The advent of resin-cored solder brought about something like a revolution in electrical soldering methods. With a well-designed resin-cored solder, reasonably clean surfaces and an iron at the right temperature, it is next to impossible to fail to make good joints with "easy" metals.

One essential of a cored solder is that the resin should be chemically "activated" in order to ensure speedy action, since resin by itself is a slow-acting flux—at any rate, far too slow for modern radio production. Moreover, there are one or two difficult surfaces, such as on nickel- and cadmium-plated components, for which activated resin is the only answer, since plain resin will not remove the oxides. It is important, however, that the activating substance, whilst being strong enough in the molten state to dissolve the oxide, should leave a non-corrosive residue. Furthermore, the residue should have good insulating properties and be non-hygroscopic, for otherwise it would absorb water under humid conditions and so cause electrolytic leakage. Another point is that the residue should be hard and non-sticky to prevent the collection of dust and moulds, which again would lead to leakage. The activators used are various, but in general are the hydrochlorides of certain organic substances, for instance, amine hydrochlorides.

Cored solders are made with single and triple cores. Two arguments are put forward for triple-core solder: one is that there is less likelihood of a discontinuity occurring in the supply of flux, and consequently less likelihood of dry joints and wastage of solder, if there is more than one core in the solder wire. The other claim is that the triple-core principle of construction provides thinner walls of solder and thus allows more rapid melting.

Now a word about the composition of solder. In radio and electrical work the solders used most extensively are alloys of tin and lead. But there is more to it than this. The actual proportion of tin to lead is of great significance, for it makes all the difference to the way in which the solder is used, and most of all it affects the melting point. Alloys with different percentages of tin and lead have different melting points, as can be seen from the curve ACB in Fig. 4. At point A we see that a predominantly lead alloy (30 per cent tin, 70 per cent lead) has a melting point of about 255°C, whilst at point B a predominantly tin alloy (80 per cent tin, 20 per cent lead) has a melting point of about 210°C. The lowest possible melting point, 183°C at point C, is that of an alloy consisting of 63 per cent tin and 37 per cent lead. To give it the correct name, "eutectic" solder.

Now eutectic solder is a thing apart. It is the only tin/lead alloy which has no plastic or "pasty" range. It solidifies and liquefies at 183°C. All the other alloys *solidify* at 183°C, but become entirely liquid at different temperatures, depending on their composition. It might be thought, then, that the eutectic alloy would be the best for high-speed work, since its transition from the solid to the liquid state is the most rapid of all the alloys. Practical experience has shown, however, that for most work for which cored solder is used in the radio industry, there is an advantage in having a plastic range. Consequently 60/40 alloy is widely employed, as it obviates fractures which may occur owing to slight vibration whilst the solder is setting solid. The 6°C difference in melting point from that of the pure eutectic is so small that it is of little importance.

From the curve it will be seen that as far as obtaining a low melting point is concerned, there is no advantage in using a greater tin content than in 63/37 alloy, as the alloys with greater tin contents actually have higher melting points.

It may not be out of place to give one or two tips about the correct use of solder in various jobs. The wrong method is to take up a "blob" from the cored wire on the bit, for the flux is then "fried" where it has no chance of doing its proper work, and a dry

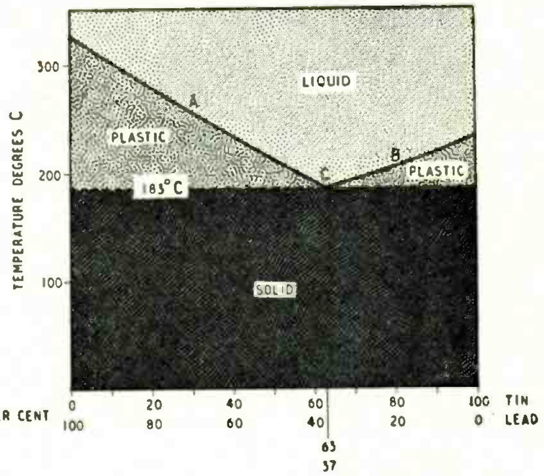


Fig. 4. Curve (ACB) showing the melting point in degrees centigrade for various alloys having different tin/lead percentages. The alloy with the lowest melting point (183°C) is shown at point C, and consists of 63 per cent tin and 37 per cent lead, i.e. eutectic solder.

joint is almost a certainty. Lay the end of the cored solder wire on the work and apply the point of the bit to it.

Next, it is of the greatest importance to use an iron that is sufficiently hot. Untold numbers of resistors, capacitors and other such components are damaged or even ruined by the use of insufficiently hot irons. If the bit is not hot enough, it has to be applied to the work for some little time before the solder runs, and during this time the body of a component may be heated up to an undesirable temperature. On the other hand, when the bit is hot enough (and the flux sufficiently active) the solder flows almost instantly. There is not time for the body of the component to be brought to an over-high temperature.

The quicker your work, the less the risk you run of injuring delicate components. The speed at which soldered joints can be made depends (given a quick-acting flux) upon the temperature of the iron and the melting point of the solder. My own practice for 60/40 solder is to let the iron warm up until the application of the bit to a piece of newspaper produces singeing in no more than five seconds.

Sweating is one of the most useful branches of soldering. It enables two metal surfaces which may be quite large to be firmly joined together. The principle is that each surface is tinned by the application of a thin and even layer of solder. The tinned surfaces are then brought together, heat is applied, the solder runs, and a firm union is made.

For making joints in this way we can use either a separate solder and flux or cored solder, or, alternatively, one of the brands of solder paste which consist of finely divided solder in a flux medium. However, perhaps the quickest method is to clamp the surfaces together, heat them, and apply cored solder to the junction; the flux and solder will then flow in between the surfaces by capillary attraction. Recently, Multicore Solders, Ltd., have introduced a cored solder using "Arax" flux, which enables these kind of jobs to be done very quickly on "difficult" metals. It is already being used by manufacturers and amateur constructors for assembling chassis and other metal parts of radio equipment.

WORLD OF WIRELESS

Exhibition Plans ✦ Cinema Television ✦ Atomic Research ✦ German Broadcasting

Birmingham Exhibition

TELEVISION demonstrations are not to be confined to the normal transmission hours of Sutton Coldfield during the National Radio Exhibition at Birmingham (September 6-16). The organizers are installing a studio in the exhibition and with this and a film scanner a continuous programme will be provided. B.B.C. transmissions will, of course, also be used at suitable times.

The studio will be open to inspection by the public. There will be a central demonstration room where the products of exhibitors will be seen in operation side-by-side; and receivers will be demonstrated on individual stands.

To this end, the r.f. sound and vision signals will be conveyed to each stand by cable and will be at a level of 1 mV at 70Ω. Great care is being taken to avoid interference; suitable suppressors are being fitted to the electrical equipment of the building and the use of certain types of apparatus on the stand is prohibited.

The vision and sound signals provided are to be at 45 Mc/s and 41.5 Mc/s—the London frequencies. As a result, all the receivers demonstrated will be London models. This is necessary because Sutton Coldfield programmes are not to be used all the time. Intolerable interference would result if the distribution were at Sutton Coldfield frequencies and this station started operation when the exhibition studios were in use.

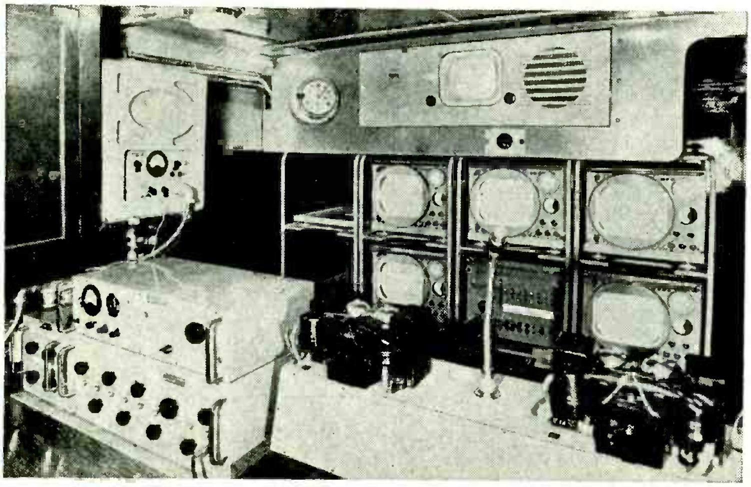
It is necessary that the distribution take place on different frequencies from those of the local transmitter and it is expected that at the next London radio show Birmingham model will be used.

Large-Screen Television

A DEMONSTRATION of large-screen television was given by Cinema-Television, Ltd., at the Odeon Theatre, Penge, on 29th April, to a private audience.

The B.B.C. transmission of the Cup Final at Wembley was shown on a screen 20ft by 15ft, being projected by a Schmidt optical system from a c.r. tube operating at 50 kV. The average beam current of the tube is 1-2 mA with a peak current of 15 mA. In order to maintain good focus with such a large current, the focus current is modulated by the line- and frame-scanning circuits (see "Television Monitors" on p. 206). The tube face is cooled by an air blast. The projection mirror is of 27-in diameter with an 18-in plastic correcting plate; a metallized-fabric directional-viewing screen is used, and a high-light brightness of 7ft-lamberts is obtained.

The picture obtained during the demonstration was extremely good. The detail and tone gradation were excellent and the brightness quite adequate. Judging by the reactions of the audience to events in the game, the viewers quite lost consciousness of the medium by which they saw it. Indeed, one viewer, who repeatedly exhorted Liverpool to "come on," was obviously at Wembley in the spirit.



Interior of the television mobile central control room supplied to the B.B.C. by Emitron Television Ltd. It provides for the control of up to four O.B. units each of which uses three cameras. The picture selected for transmission to the station, either by radio or line, is displayed on the centre c.r.t.

Harwell Linear Accelerator

THE Ministry of Supply announce that a linear accelerator of the travelling-wave type, similar to that developed by the Atomic Energy Research Establishment at Malvern, has been installed at Harwell and is being used for the production, indirectly, of neutrons for research into the behaviour of materials in nuclear reactors.

A 10-cm pulse generator is used as the source of energy in the wave guide, and successive short bursts of electrons are produced with energies of 3.5 Mev and speeds approaching the velocity of light. These impinge on a metal target to produce gamma rays, which are absorbed in heavy water and release neutrons from the hydrogen nuclear at the rate of 10^9 per sec.

Development and construction was undertaken by Mullard Electronic Research Laboratories, to the basic design of a group at Harwell.

E.H.F. Broadcasting

A NETWORK of extra-short-wave broadcasting stations was introduced on the 30th April by the broadcasting organization in the British Zone of Germany—the Nordwestdeutscher Rundfunk.

Four stations will at first form the chain but will be increased later this year to six. The first stations are at Hamburg and Langenburg (88.9 Mc/s, 10 kW), Cologne (89.7 Mc/s, 1 kW), and Hanover (89.3 Mc/s, 0.5 kW—later to be increased to 10 kW). The additional transmitters will be at Etzhorn, near Oldenburg, (88.5 Mc/s, 10 kW) and Teutoburger Wald (89.7 Mc/s).

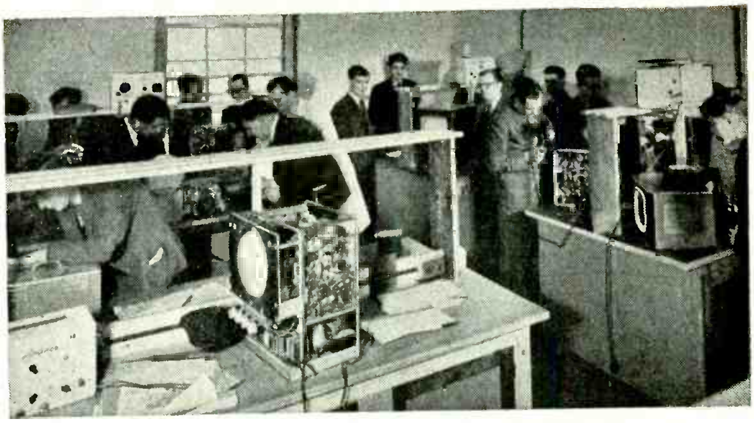
Danish Television

WITH the resumption of tests in April the schedule of transmissions from Denmark's experimental television station has been revised and extended. Test patterns are now transmitted as follows: Monday, 1100-1600; Wednesday and Friday, 1100-1600 and 2000 to 2100; Saturday, 1100-1200 B.S.T.

According to our Danish contemporary, *Radio Ekko*, the frequencies used are 62.5Mc/s vision, and 67.75 Mc/s sound, with powers of 100 watts and 50 watts respectively. Scanning rate is 625 lines with 25 pictures per second. Double side-band transmission is employed with positive picture modulation on Wednesdays and Saturdays and negative modulation on Mondays and Fridays. Sound is frequency-modulated with a maximum frequency deviation of ±75kc/s.

Colour Television

DEMONSTRATIONS of colour television were given by Pye, Ltd., in Hilversum, during the recent Utrecht Fair, and at the Milan Fair. The system, which was demonstrated at Radiolympia last year, and more recently at the Dental School of Guy's Hospital, London, is being developed mainly for use on a closed circuit. The scanning rate is 405 lines with 150 frames. Colour presentation is by sequential additive colour scanning using three-colour rotating discs on both the camera and the receiver. The bandwidth required is 9 Mc/s. Delegates of the C.C.I.R. Television Study Group also saw demonstrations during their recent visit to this country.



Students in the laboratory at the new college of E.M.I. Institutes at 10 Pembridge Square, London, W.2., where full-time courses are provided.

PERSONALITIES

Lord Reith, who was the first Director-General of the B.B.C., gave oral evidence before the Broadcasting Committee at the invitation of Lord Beveridge, the Chairman. Lord Reith is now Chairman of the Commonwealth Communications Council.

I. J. St. A. Crawshaw, B.Sc.(Eng.), M.I.E.E., informs us that he has resigned from the board of Airmec Laboratories, Ltd., of High Wycombe, one of the companies in the Radio and Television Trust group. He joined the company in 1944, shortly after its formation, as Patents Manager for the group and later was appointed Sales Manager and Director of the Laboratories.

John Dyer, who was with the Philco organization as Sales Promotion Manager prior to joining Philips in 1937, has now been appointed general sales manager of Philco (Overseas), Ltd., the British subsidiary of the Philco Corp., of Philadelphia, U.S.A. The company is responsible for the design and production of British-made Philco sets.

J. B. Kaye, M.A., A.M.I.E.E., has relinquished the post of head of Philips' Technical Commercial Department (Radio and Television) in order to join Painton & Co., of Northampton, as chief engineer. Prior to joining Philips Electrical in 1937, he was for fourteen years in the London office of the International Standard Electric Corporation.

J. S. Smith, N.W. Area manager of the Marconi International Marine Communication Co., has retired after 40 years' service with the company. After serving for some years as a radio officer he was placed in charge of the Marconi Marine Depot in New York and then appointed Liverpool Depot manager. He has been manager of the N.W. Area since 1947. **H. C. Maguire** is taking over all contracts work in the Merseyside area upon Mr. Smith's retirement.

IN BRIEF

Television Licences in the United Kingdom increased by over 105,000 during the first quarter of this year, bringing the total at the end of March to 345,100. The total number of licences—both sound and vision—in force at that date was 12,243,500.

Wired Television.—In reply to a question in the House, the P.M.G., Mr. Ness Edwards, stated that he was prepared to issue licences to television rediffusion companies on terms corresponding to those applicable to sound broadcast relay services. He added that detailed arrangements were not yet complete and that the industry is to be consulted on technical matters.

Consol.—The Bushmills, Northern Ireland, Consol station has changed its frequency to 266 kc/s as its old frequency of 263 kc/s was allocated to Moscow under the Copenhagen Plan. A revised edition of the Ministry of Civil Aviation publication "Consol—An Aid to Navigation," which will give the revised Counts/Bearing Tables for Bushmills, is in course of preparation.

T.I.D.U.—The Technical Information Documents Unit of the Board of Trade, which disseminates reports on German wartime industrial developments and research reports made available by the U.S. Government and also acts as the national centre for the Documents' Exchange Scheme of O.E.E.C., has moved to Lacon House, Theobalds Road, London, W.C.1 (Tel.: Chancery 4411).

"Navigator," the Decca Company's motor yacht, left her Thames berth near Blackfriars Bridge at the end of April for a 5,000-mile tour of Scandinavian and Northern European ports. Demonstrations of Decca radar equipment and the Decca Navigator System will be given to marine interests in some twenty centres. Equipment for both these navigational aids has recently been installed under operational conditions on Scantlin Pier, Blackfriars, to provide facilities for training Merchant Navy officers and for demonstration purposes.

Radio Facilities.—A revised series of charts showing the radio navigational facilities operating at aerodromes throughout the U.K. has been issued by the Ministry of Civil Aviation. Each of the eight charts in the series (GSGS4694) measures 8½in × 10½in, costs 3d, and is printed in two colours.

Ship-Shore Service.—The Post Office coast stations communicated with 367,000 ships during last year. The fourteen stations round the coasts of the British Isles also handled 790,700 radio-telegrams and 16,400 radio-telephone calls, received 598 messages from aircraft, 302 distress calls and gave advice to 241 ships through the service known as Medical Advice to Ships at Sea.

Radio Industries Club.—At the nineteenth annual general meeting of the Radio Industries Club is was announced by the retiring chairman, W. E. Miller (Editor, *Wireless and Electrical Trader*), that the fourth Radio Industries Club Ball will be held on September 29th. Membership of the club is now 684. Norman Collins, B.B.C. Controller of Television, was elected president, Guy R. Fountain (Tannoy) chairman, and J. G. G. Noble (Regentone) vice-chairman, at the first meeting of the new committee.

Radio Mechanics, especially those experienced in the assembly or repair of instruments, are required for the Cumberland establishment of the Ministry of Supply's Atomic Energy Production Division. Applicants should have a sound theoretical knowledge of radio and be educated to School Certificate standard. Enquiries should be sent to the Superintendent, Windscale Works, Sellafield, Cumberland.

"Safety at Sea" was the title adopted for two recent functions—an exhibition in the booking hall of Charing Cross L.T. station and a gathering of international marine officials. During the latter twenty officials from five European countries took part in a series of meetings arranged by the British Council which included lectures on and demonstrations of radio aids to marine navigation. The exhibition, which closed on May 20th, was held as part of the Marconi Marine Co.'s jubilee.

"Temgas" is the name given by the North Thames Gas Board, which serves an area of 600 square miles, to the recently inaugurated radio-communication system linking its service vans with headquarters. Initially five vans, operating in two of the Board's six areas, are equipped. The main 50-watt transmitter is at Hampstead with its aerial 500 feet above sea level. It is remotely controlled by line from the central control office in Westminster. Frequency modulation is employed and the frequencies used are 71.775 Mc/s, mobile and 85.275 Mc/s, fixed. All the equipment was supplied by G.E.C.

Mechanical Handling.—The second Mechanical Handling Exhibition, which is being organized by our associate journal *Mechanical Handling*, opens at Olympia, London, on the 6th June. Some 160 exhibitors will be taking space and among them are a few—

including B.T.H. and Metrovick—who will be demonstrating electronic control gear. During the exhibition a convention will be held at which a number of papers dealing with various aspects of mechanical handling will be read. Tickets for both the exhibition and the convention are obtainable from *Mechanical Handling*, Dorset House, Stamford Street, London, S.E.1.

Jamaican Police Force is to be equipped with Marconi v.h.f. radio-telephony gear. The installation includes seven 10-watt transmitter-receivers, five of which will be in cars and two in launches. The main 50-watt transmitter will be erected on a hill providing complete coverage of the island and will be linked by radio with the police headquarters.

Commonwealth Communications.—In conformity with the provisions of the Commonwealth Telegraphs Agreement, signed by representatives of the Commonwealth governments in May, 1948, Canada has formed the Canadian Overseas Telecommunication Corporation to acquire the external telecommunication assets operating in the Dominion. This new Crown-owned company will take over some of the equipment and services at present operated by the Canadian Marconi Co. and Cable & Wireless, Ltd.

Canada's Television stations in Montreal and Toronto, the first of which will not be in operation until the autumn of 1951, have already been allocated frequency channels. Because it is anticipated that eventually the Canadian Broadcasting Corporation will operate two stations in Montreal—one English- and one French-speaking—two channels have been allocated to the city: 54 to 60 and 76 to 82 Mc/s. Toronto has been assigned 186 to 192 Mc/s. Although the stations will be operating on American standards, the equipment for the two studios in each city, the control rooms and film-projector rooms has been ordered from Marconi's and includes ten image-orthicon cameras.

Mexican Television stations will operate on American standards—525 lines, 60 frames, horizontal polarization —in thirteen channels each 6Mc/s wide between 44 and 216 Mc/s. The vision carrier will be amplitude modulated and f.m. will be employed for the sound signal. The picture modulation will be negative.

Canadian Enquiry.—The United Kingdom Trade Commissioner at Montreal states that information regarding radar and microwave electronic components made by British manufacturers is required by Harry H. Schwartz, of Electrodesign, 445, Saint Peter Street, Montreal.

Directories of North American a.m. and f.m. stations and U.S. television stations are included in the 1950 issue of the "Broadcasting Year Book." This 544-page directory of broadcasting information is issued to subscribers to *Broadcasting*, our Washington contemporary.

Brazil's largest broadcasting network, Emissoras Associadas, is equipping Sao Paulo's first television station with an R.C.A. transmitter; it will operate on American standards in the 60-66 Mc/s band. The three-tier cruciform aerial will be installed on the State Bank Building 520 feet above the ground.

BUSINESS NOTES

Alloys made by the Telegraph Construction and Maintenance Co., and now available in Canada, are being exhibited by the company at the Canadian International Trade Fair which is being held in Toronto during May and June. They will be exhibiting magnetic alloys—such as H.C.R., a high-permeability alloy with rectangular hysteresis loop, and Hysat, a cobalt-iron alloy—and a range of Telcoseal glass sealing alloys.

Licensing Arrangements for the manufacture of metallized paper capacitors in the U.S.A. and Canada under Hunt's patents have been investigated by Sydney H. Brewell, M.B.E., chairman and managing director of A. H. Hunt, Ltd., during his visit to North America.

RCA Photophone, Ltd., notifies us that, whilst technical advice on RCA cathode-ray tubes is obtainable from the London office, 36, Woodstock Grove, London, W.12, sales are restricted because the tubes are of American manufacture. Where, however, there is no British-made equivalent, arrangements can be made to import tubes under licence if they are for development or research work or for incorporation in equipment for export. A 16-page booklet giving operating data and physical features of RCA tubes is obtainable, price 1s 6d, from the above address.

"Autoselector" automatic tuning and selecting mechanism is to be manufactured and sold in this country by Mullard Electronic Products under an arrangement made with Philips Telecommunications Industries. The accuracy claimed for these units, which have industrial as well as radio applications, is ±0.050 deg from the predetermined setting. Two types are available, the smaller type, SZT101, is suitable for aircraft radio gear and has provision for twelve pre-set positions.

Resistors.—The largest single export order despatched in one consignment by Morganite Resistors, Ltd., was recently shipped to Brazil. It comprised 52,000 potentiometers which were produced in the firm's new factory at Jarrow, Co. Durham.

Conversion Kits are to be produced by Belling & Lee to make "Sutton Coldfield" aerials erected in the Holme Moss service area usable for the latter's transmissions when radiated.

Ekco radio and gramophone equipment is being installed in a further nineteen schools in the County Borough of West Ham.

Schools' Radio Equipment is being developed by the Aerotron Radio Co., of Peel Street, Chadderton, Lancs, in collaboration with the local education authority.

Mullard Overseas Ltd., has been formed to co-ordinate the export activities of the Mullard company.

Thermionic Products, Ltd., manufacturers of the Soundmirror magnetic-tape recorder, announce that G. Trevor-Johnstone has resigned from the position of divisional sales manager and that E. M. Gamble has been appointed sales superintendent.

Appointment of E. P. Harris, G3GFN, as technical manager is announced by Mail Order Supply Company.

International Aeradio, Ltd., which is now handling marine radar in addition to its normal aeronautical radio and radar activities, has opened an office at 65, Chulia Street, Singapore.

"Baird Journal" is the title adopted by Scophony-Baird, Ltd., for the new house journal of the Baird Television Division of the company.

NEW ADDRESSES

Radio Heaters, Ltd., manufacturers of Radyne radio-frequency heaters, have moved to Eastheath Avenue, Wokingham, Berks. (Tel.: Wokingham 1030/1.)

Acoustic Products, Ltd., manufacturers of Lectrona speakers, have moved from North London to Stonefield Way, Victoria Road, South Ruislip, Middlesex. The sale of the equipment is handled by Edstone, Ltd., who are now at 15, Buckingham Place Gardens, S.W.1 (Tel.: Sloane 0621-3).

MEETINGS

Television Society

"Modern Developments in Phosphors for Television," by Leonard Levy, M.A., D.Sc., at 7.0 on 26th May at the Cinema Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

Institution of Electronics

North-West Branch. — "Television Pick-Up Tubes," by a member of the staff of E.M.I. at 6.30 on 9th June in the Reynolds Hall, College of Technology, Manchester.

MANUFACTURERS' LITERATURE

DESCRIPTIVE leaflet dealing with the new range of neon indicator lamps, from the Acru Electric Tool Manufacturing Co., 123, Hyde Road, Ardwick, Manchester, 12.

Leaflet describing amplifiers and sound equipment, from Aerotron Radio, Peel Street, Chadderton, Lancs.

"Choosing the Right Loudspeaker" —guide to Ardente Units for outdoor, indoor and diffusion applications, from Ardente Acoustic Laboratories, Guildford, Surrey.

"A Comprehensive Guide to 'Avo' Electrical Instruments," from The Automatic Coil Winder and Electrical Equipment Co., Douglas Street, London, S.W.1.

Catalogues, "Radio Materials" and "Radio-frequency Cables"; and leaflets, "Television Downlead Cables" and "Cables for Public Address Systems," from B.I. Callender's Cables, Norfolk House, Norfolk Street, London, W.C.2.

Illustrated leaflet giving details of the latest "CDP" disc recorder, from Bourne Instruments, Bourne, Lincs.

Details of Ekco car-radio aerials, from E. K. Cole, Southend-on-Sea.

Current catalogues and stock lists of radio components, from Coulphone Radio, 53, Burscough Street, Ormskirk, Lancs.

ELECTRONIC CIRCUITRY

SELECTIONS FROM A DESIGNER'S NOTEBOOK

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

Selective RC Circuits at Low Frequencies

FOR some purposes selective amplifiers are very useful at low frequencies, and they are used in bridge measurements, distortion measuring gear, servo-mechanisms and so on.

At frequencies of 10 kc/s upwards selective circuits are usually resonant combinations of inductance and capacitance. It is usually assumed that all the losses in the circuit—which are detrimental to selectivity—lie in the resistance of the coil, and this is nearly true at low frequencies. The selectivity of a tuned circuit is determined, at low frequencies, by the Q factor of the coil which is

$$Q = \frac{2\pi f L}{r} \quad \ldots \quad (1)$$

where

f = frequency
L = inductance
C = capacitance
r = resistance

or the ratio of reactance to resistance in the coil. From (1) it is seen that for a given coil of known inductance and resistance the Q factor becomes smaller as the frequency is reduced, so that if a coil has a Q of 20 at 1 kc/s it will have a Q of only one at 50 c/s. In order to obtain a reasonably high Q of 10 or more at 50 c/s the inductance has to be increased for the same resistance, or the resistance has to be reduced for the same inductance. Either way this leads to a larger coil of thicker wire, and at frequencies of 0.1 to 1 c/s the design of a suitable coil becomes quite out of the question and other methods have to be adopted.

Effort has therefore been devoted at various times to the design of selective circuits (in particular, selective amplifiers) using only resistive and capacitive components. Such circuits are not only useful at very low frequencies outside the range of inductances, but also at audio frequencies up to 5 or 10 kc/s because of the weight and space saved by their use. Such selective amplifiers fall into two main classes, one of which uses a bridge network—or a network derived from a bridge—and it is this class of circuit the derivation of which will be considered in some detail here.

All these RC bridge selective amplifiers depend on the use of a frequency-sensitive bridge in the feedback network of a negative feedback amplifier. The overall amplification, A, of a negative feedback amplifier, in terms of the amplification, A_0, without feedback, is given by

$$A = \frac{A_0}{1 - \beta A_0}$$

or, if there is a phase reversal in the amplifier we may write this

$$A = \frac{A_0}{1 + \beta A_0} \quad \ldots \quad (2)$$

If we can find an RC network to determine the feedback factor β, such that $\beta = 0$ at one frequency only, there will be no feedback at that frequency and so the full amplification will be obtained. If at all frequencies, other than this one, there is some feedback the amplification will be reduced, so that a form of resonance will be obtained in the amplifier. It turns out that—as has already been suggested—the required RC feedback network can take the form of a bridge, so that perhaps a short digression on bridges will not be out of place.

Fig. 1 represents a perfectly general bridge network composed of four impedances Z_1, Z_2, Z_3, and Z_4. A supply voltage V_0 is applied, and when the bridge is balanced the p.d., V_D, across the detector terminals is zero. The condition for balance can be found by considering the bridge to be made up of two potential dividers across V_0, each composed of two impedances. By this means the potential across Z_2 is found to be $V_2 = V_0Z_2/(Z_1 + Z_2) = V_0/(1 + Z_1/Z_2)$, and similarly that across Z_4 is $V_4 = V_0/(1 + Z_3/Z_4)$. Now at balance $V_2 = V_4$, so that

$$V_0/(1 + Z_1/Z_2) = V_0/(1 + Z_3/Z_4) \text{ or}$$

$$\frac{Z_1}{Z_2} = \frac{Z_3}{Z_4} \quad \ldots \quad (3)$$

If each impedance consists of a resistor the network becomes the well-known Wheatstone bridge. In an a.c. bridge at least *two* of the impedances must contain reactive components otherwise a balance cannot be obtained. These reactances may be capacitive or inductive, but here we are concerned only with the former. The capacitances are sometimes arranged in the bridge so that the balance is independent of frequency, but such arrangements will not serve the present purpose.

It has been found that the Wien[1] bridge of Fig. 2 is quite suitable for the purpose, because a balance can only be obtained at one frequency. This is the case because capacitance enters two arms (Z_3 and Z_4) in different ways, being of a series combination in Z_3, and a parallel combination in Z_4. The frequency of balance is that at which the phase shift in Z_3 is

[1] Hague, B. "A.C. Bridge Methods." Pitman. 5th Edn., pp. 336, 344.

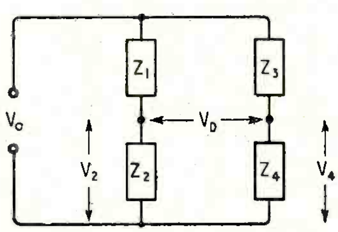


Fig. 1. General bridge network.

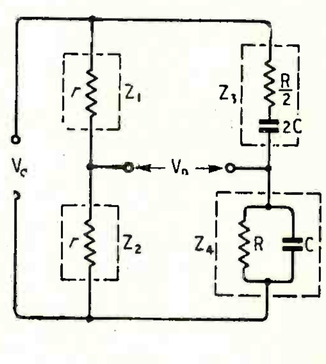


Fig. 2. (Right) Wien bridge.

equal and opposite to that in Z_4, so that at the balance frequency Z_3 and Z_4 behave as a resistive potential divider. This balance frequency is given by

$$f_b = \frac{1}{2\pi RC} \quad .. \quad .. \quad .. \quad .. \quad (4)$$

when

$V_D = 0$,

provided the circuit proportions of Fig. 2 are maintained.

Now consider the combination of amplifier and bridge to form a selective amplifier[2] as shown in Fig. 3. The output voltage, V_0, of the amplifier is here applied to the Wien bridge and the p.d. obtained across the bridge detector terminals is fed back to the input of the amplifier. The general operation can be seen in a qualitative way by considering what happens at a very low frequency, and a very high frequency compared with that at balance.

[2] Valley, Wallman. "Vacuum Tube Amplifiers." McGraw-Hill. 1st Edn., p. 384.

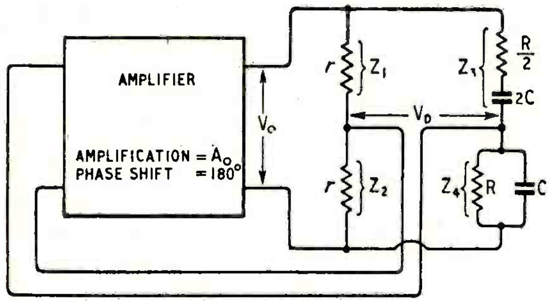


Fig. 3. Amplifier with feedback via Wien bridge.

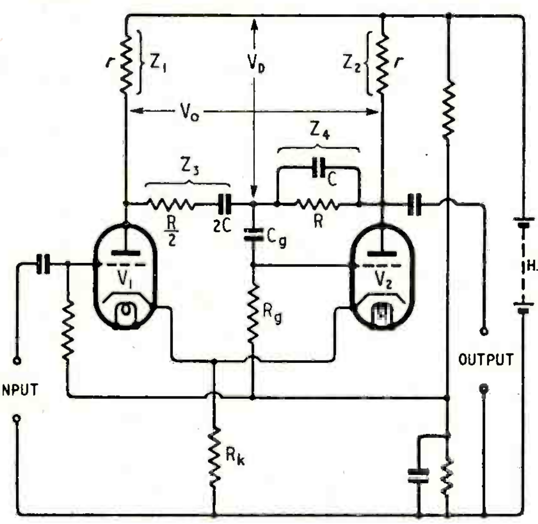


Fig. 4. Selective amplifier using a Wien bridge.

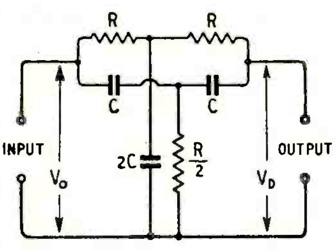


Fig. 5. (Left) The parallel-T circuit.

At the balance frequency there is no feedback and the full amplification, A_0, is obtained. At some very low frequency the bridge reactances become very large and approximate to an open circuit. Under these conditions Z_3 is effectively an open circuit, so that no potential appears across Z_4. It follows that V_D—the fed-back signal—must be half the output voltage, V_0, as it is divided in this ratio by the resistive Z_1, Z_2 arms. Under these conditions, if A_0 is very large the overall net amplification will approximate to 2. At some very *high* frequency the capacitive reactances, will become very small, and approximate to a short-circuit, so that again there will be no potential across Z_4, and the fed-back signal will again be $V_0/2$, leading to a net amplification of 2 if A_0 is large. If, in fact, $A_0 = 50$ (a reasonable value) than at resonance $A = 50$. Very far from resonance the amplification (by (2)) will be $50/(1 + 25) = 1.92$. Therefore the discrimination between wanted and unwanted frequencies can never be better than 26 : 1 or 28.3 db. If we had started with $A_0 = 100$ we should have obtained a maximum discrimination of 51 : 1 or 35.2 db, and so on.

Effectively we have now deduced the amplification at three points on the resonance curve. To find further points it is necessary to calculate the ratio $V_D/V_0(= \beta)$ for all frequencies and, taking account of the phase shifts introduced at different frequencies, calculate the net amplification obtained. A different curve will be obtained for each new value of initial amplification A_0, and curves for various values of A_0 have been computed and are shown in Fig. 7. It will be seen that these curves bear a strong resemblance to the resonance curve of a tuned LC circuit. It is possible, by analogy, to find an expression which gives—roughly—the equivalent Q of an amplifier with Wien bridge feedback, and this is useful in doubtful cases as it gives a quick means of comparison with coils that may be available for the same resonant frequency. It turns out that the equivalent Q of a Wien bridge feedback amplifier is

$$Q_W = \frac{\frac{A_0}{2} + 1}{4} \quad .. \quad .. \quad .. \quad .. \quad (5)$$

with an error not exceeding 1 per cent, provided A_0 is 25 or more.

Before the Wien bridge can be used as the feedback path in a practical amplifier, one difficulty—perhaps not very obvious—has yet to be overcome. All amplifiers have at least two input and two output terminals, but usually one in each pair is common, so that there are effectively only three terminals—one of which is usually "earthy." As the bridge has four terminals, such amplifiers will not be of any use. The difficulty could be avoided by coupling the bridge to the amplifier with a transformer, but apart from the phase shift troubles this is likely to introduce, a coupling transformer to work (say) at 1 c/s is just as difficult to make as the original coil we abandoned in favour of the RC circuit.

There is, however, a class of amplifier which can be pressed into service here, of which the cathode-coupled phase-splitter is an example. In such amplifiers a push-pull output is obtained when an input is applied to either of two pairs of input terminals. As the resistive arms of the bridge are equal, they may be used as the anode loads of the phase-splitter, and the detector terminals of the bridge may be connected to one pair of input terminals as shown in Fig. 4.

The circuit of Fig. 4 is fundamentally a cathode-coupled phase-splitter with equal anode loads. An accurate push-pull output for an input to one grid is obtained only when R_k is very large, and consequently the grids are returned to a positive source of supply as shown, so that R_k can be made large. In further discussion of this circuit it will be assumed that the anode signal voltages are equal and opposite in phase, as this simplifying assumption leads to theoretical results only slightly at variance with practice. The time constant $C_g R_g$ is long enough to ensure that even at 1/10th of the resonant frequency there is negligible loss in this coupling; R_g must be large compared with R so that the grid circuit of V_2 imposes negligible loading on the reactive arms of the bridge.

At the balance frequency V_D is zero, so that the input to V_2 is zero and the circuit behaves as a cathode-coupled splitter as if the bridge were not present. At frequencies very low or very high compared with the balance frequency, voltage negative feedback is applied from anode to grid of V_2 in the manner already described, and at extreme frequencies all the anode signal of V_2 is fed back directly to its grid provided the reactance of C_g is very low, and that R_g is very large compared with R. At high frequencies the resistance (R/2) in Z_3 is effectively connected between the two anodes (the capacitors being a virtual short-circuit) so that r should be small compared with R/4 to preserve the amplification at high frequencies. The input is applied to the grid of V_1 and the output taken from the anode of V_2, as shown.

The amplification at resonance is approximately,

$$A_0 = \frac{\mu r}{2(r_a + r)}$$

where μ = amplification factor of V_1 or V_2
r_a = anode resistance of V_1 or V_2

from input to output, but for calculating the equivalent Q of the circuit, an amplification of twice this value must be taken. This is because the signal input, V_0 to the bridge is twice the amplitude of the signal at either anode, owing to the push-pull output obtained from the two valves.

The circuit of Fig. 4 behaves well in practice, but it suffers from one snag. If, due to variations in the bridge network components, the conditions for balance call for a larger output from V_2 than from V_1, then instability can take place in extreme cases. Nevertheless, experience indicates that if the bridge components are built to a tolerance of 1 per cent, or, better, adjusted on test, no trouble need be expected with any of the double-triodes currently available. This difficulty can be overcome in another way, however, by the use of another RC circuit which also has other advantages. This is called the parallel-T circuit[3, 4] and is now in widespread use.

The parallel-T circuit is shown in Fig. 5 and is particularly advantageous because it is essentially a three-terminal network, one input and one output terminal being common. It is derived from the Wien bridge and the equations describing its behaviour are identical in form to those for a Wien bridge, with one merely numerical difference. It will be remembered that in considering the output at the detector terminals of the Wien bridge at high and low fre-

[3] Scott, H. H. *Proc. I.R.E.* Vol. 26, p. 226, 1938.
[4] Tuttle, W. N. *Proc. I.R.E.* Vol. 28, p. 23, 1940.

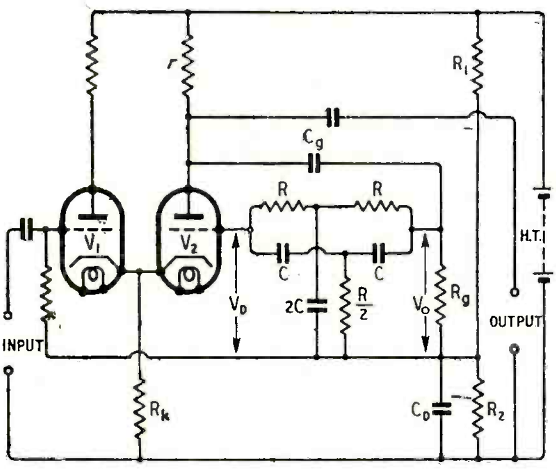


Fig. 6. Selective amplifier using a parallel-T. Typical values (f_b = 50c/s): V_1, V_2 = ECC33; r = 47kΩ; R_k = 12kΩ; R_1 = 330kΩ; R_2 = 68kΩ. C_g = 0.25μF; R_g = 1MΩ; C_d = 2μF; R = 1MΩ; C = 3180pF; H.T. = 300 V. For selectivity see curve in Fig. 7 labelled A_o = 10.

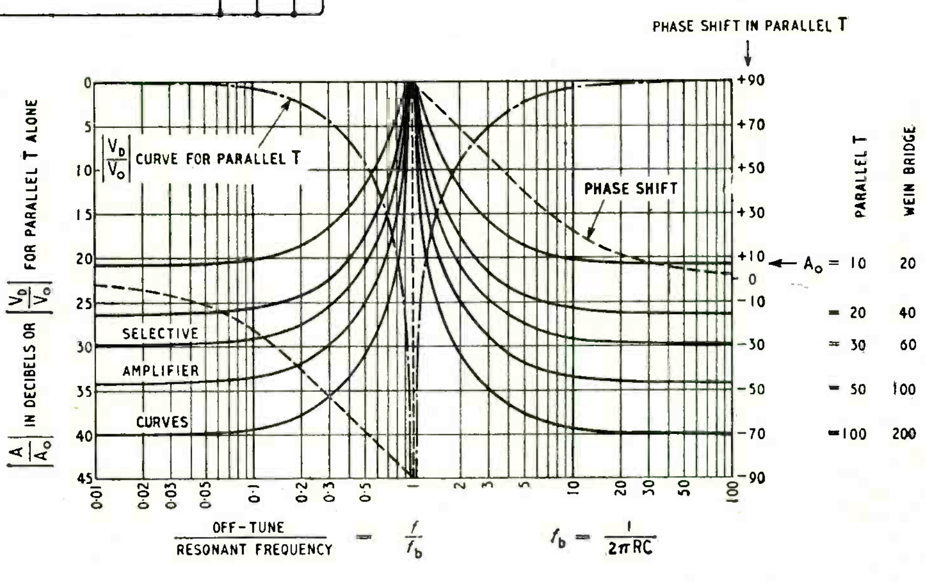


Fig. 7. Selectivity and phase shift curves for amplifiers with parallel-T feedback circuit. Equivalent Wien bridge amplifier values included for reference.

quencies it was found that V_D could never exceed $V_0/2$. In the parallel-T this is not so, and a little consideration will lead to the conclusion that at frequencies very remote from the balance frequency V_D approaches V_0. The balance frequency for the parallel-T is, as for the Wien bridge

$$f_b = \frac{1}{2\pi RC}$$

and the network may be used in the feedback path of a cathode-coupled phase splitter as shown in Fig. 6.

The performance of the amplifier of Fig. 6 is the same as that of Fig. 4; this can be seen by the following chain of reasoning. In the case of Fig. 6 V_D is equal to V_0 at frequencies remote from the balance frequency, so that the feedback factor here is twice that in Fig. 4. On the other hand the overall amplification to the Wien bridge of Fig. 4 is twice that to the parallel-T in Fig. 6. These effects conveniently cancel so that the same result is obtained in each case. The possible instability in Fig. 4 is avoided in Fig. 6, however, so this must be regarded as the preferable circuit. The permissible tolerances on the components of the parallel-T are, as might have been expected, no wider than on the Wien bridge.

The selectivity obtained from the amplifier of Fig. 6 depends, like the previous circuit, on the initial amplification obtainable. It can be shown that the equivalent Q of an amplifier with a parallel-T is given by:

$$Q_T = \frac{A_0 + 1}{4} \text{ approximately}$$

Selectivity curves for amplifiers with amplifications between 10 and 100 are shown in Fig. 7 from which results to be expected may be estimated. The transmission and phase shift curves of the parallel-T alone are also shown, from which it can be seen that the network may be used as a coupling between amplifier stages to suppress a given frequency.

In these rather brief notes it has only been possible to describe the general operation of RC selective amplifiers and numerous detailed circuits have been described at various times. One of the most interesting[2] makes use of the 'cascode' circuit and is especially convenient when it is desired to cascade several selective amplifiers to obtain greater selectivity (as in r.f. practice), or to arrange a number of stagger-tuned amplifiers to yield a bandpass characteristic.

Tuned amplifiers along the foregoing lines have been used for many purposes, some of which have been mentioned. Probably readers new to these circuits will see further applications of their use. Networks other than the Wien bridge and parallel-T have been described,[5] and some of these may be especially useful when it is required that the resonant frequency of the amplifier be variable.

[5] Harris, G. R. *Proc. I.R.E.* Vol. 37, p. 882, 1949.

Appendix

The parallel-T of Fig. 5 may be analysed by considering each of the T's separately, and deriving for each the equivalent π network. If these derived networks are then placed in parallel a composite parallel-π network is obtained. The first shunt arm of this composite π may be ignored since it merely shunts the input which is assumed to be supplied from a source whose internal impedance is small compared with the network. The remaining two arms of the composite π then form a potential divider. This method of analysis leads to the expression for the transmission :—

$$\frac{V_D}{V_0} = \frac{1}{1 + \frac{4ja}{1 - a^2}} = \beta \quad \ldots \quad (A1)$$

where $a = \omega T = \omega RC$ and $\omega = 2\pi f$.

Using this value for β in (2), and finding the absolute value, or modulus, of the ratio of amplifications with and without feedback :

$$\left|\frac{A}{A_0}\right| = \sqrt{\frac{1 + \left(\frac{4a}{1 - a^2}\right)^2}{(A_0 + 1)^2 + \left(\frac{4a}{1 - a^2}\right)^2}} \quad \ldots \quad (A2)$$

From which the curves of Fig. 7 are plotted.

When $a = 1 = \omega RC$ then $\beta = 0$ in (A1). Hence the balance frequency is

$$f_b = \frac{1}{2\pi RC} \quad \ldots \quad (A3)$$

The transmission and phase shift of the parallel-T alone are found from (A1).

$$\text{Transmission} = \left|\frac{V_D}{V_0}\right| = \frac{1}{\sqrt{1 + \left(\frac{4a}{1 - a^2}\right)^2}} \quad \ldots \quad (A4)$$

and

$$\text{Phase shift} = \phi = \tan^{-1} \frac{4a}{a^2 - 1} \quad \ldots \quad (A5)$$

The curves corresponding to (A4) and (A5) are also plotted in Fig. 7. The equation for the Wien bridge of Fig. 2 is the same as (A1) except that the numerator is ½ instead of 1. In (A2) this leads to a change in the term containing A_0 which becomes $\left(\frac{A_0}{2} + 1\right)$.

The equivalent Q factor of an RC selective amplifier may be based on the bandwidth obtained about off-tune frequencies where $\left|\frac{A}{A_0}\right| = \frac{1}{\sqrt{2}}$, by analogy with an LCR tuned circuit. This leads (for the parallel-T) to

$$Q_T = \frac{\sqrt{(A_0 + 1)^2 - 2}}{4} \simeq \frac{A_0 + 1}{4} \quad \ldots \quad (A6)$$

and, for the Wien bridge,

$$Q_W = \frac{\sqrt{\left(\frac{A_0}{2} + 1\right)^2 - 2}}{4} \simeq \frac{\frac{A_0}{2} + 1}{4} \quad \ldots \quad (A7)$$

HIGH-POWER TRANSMITTING VALVE

WHAT is believed to be the world's most powerful transmitting valve, a "super-power beam triode" capable of 500 kilowatts continuous output, has been announced by R.C.A. This is the type 5831, a compact valve for its high power, standing 38¾in high and weighing 135 pounds. It is intended primarily for use as a class C r.f. power amplifier, but is also useful as a class B a.f. power amplifier and modulator. For unmodulated class C working, it has a maximum anode voltage of 16 kV, a maximum anode consumption of 650 kW and a maximum anode dissipation of 150 kW. Because of electron-optical principles embodied in the design, it draws low grid current and only requires about 900 watts drive to produce an output of 500 kW on class C working.

The principle of construction has been to divide the valve into 48 independent electron systems, arranged cylindrically so that, in effect, there are 48 parallel triodes concentrated within a small space. Each electron system consists of a thoriated tungsten filament in a slot in the common beam-forming cylinder, tungsten grid rods, and the common anode. Even though the grid may be positive, few electrons reach it because of the focusing effect of the beam-forming cylinder. An internal water-cooling system is provided for the beam-forming cylinder and the anode.

Amplifiers for Cardiography

Simplified Input Circuit for Balancing Out Interference

By

B. J. SHELLEY

AS pointed out by Dr. Parnum in his review of biological amplifiers (*Wireless World*, Nov. 1945), the input circuit is perhaps the most important feature of such amplifiers, and the two chief difficulties concern the elimination of interference pick-up and the elimination of interaction between amplifiers connected to the same patient.

The solution of these difficulties has resulted in the development of special balanced amplifiers which effectively discriminate against interference, and admit of connection to more than two electrodes on the same subject.

In the present article a balanced input circuit is described which is particularly suitable for cardiography and has the merits of single-ended simplicity. The operation of the circuit will be better appreciated after a brief consideration of the electrical conditions involved in the patient circuit.

An electrocardiogram is obtained by attaching leads to certain agreed parts of the body and recording the potential changes between these leads as a result of the activity of the heart. A typical connection, for example, is to right arm and left leg. The potentials developed are of the order of 2 mV and take the form of triangular pulses repeated at the same rate as the heartbeat, together with certain smaller waves. The spectral composition is from about 0.1 c/s to 100 c/s, the intensity diminishing rapidly with frequency. A resistance of about 2,000 Ω is measurable between the electrodes and this constitutes the internal resistance of the equivalent generator circuit, as far as cardiac potentials are concerned.

Patients are usually placed in a lying position upon a couch and may be regarded as earth-free. The disturbing effects of mains wiring and apparatus are almost wholly attributable to the action of electrostatic induction upon the subject, the interference potential assumed by a patient corresponding to his position in the disturbing field.

The intensity and configuration of such disturbing fields will vary widely according to the nature and

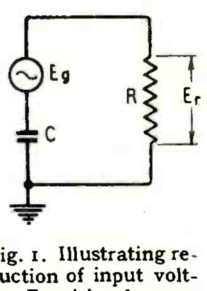


Fig. 1. Illustrating reduction of input voltage E_r arising from an unwanted e.m.f. Eg.

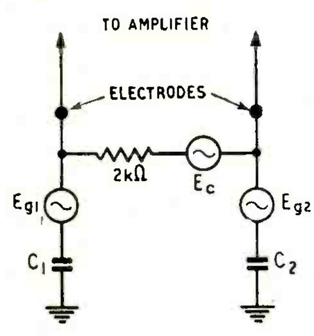


Fig. 2. (Right) Equivalent circuit of cardiac generator with interference sources.

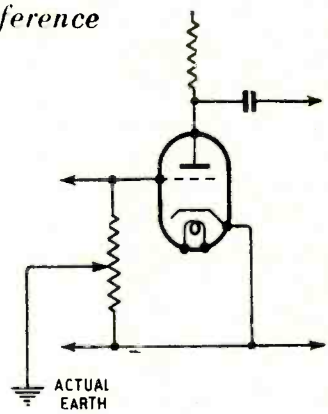


Fig. 3. Practical input circuit.

distribution of wiring and apparatus. Measurements of the open circuit voltage induced in a subject within a laboratory, having plenty of the usual equipment operating (cathode-ray tube, generators, soldering-irons, fluorescent lighting, etc.) have shown values of about 500 mV. Fortunately, however, the equivalent generator impedance of the body—as far as interference is concerned—is that of a capacitor of about 500 pF to earth, so that the actual voltage appearing across a resistance load may be very much smaller. Thus, for example, in Fig. 1 the voltage which appears across the resistor R is $E_r = E_g \, . \, R/\sqrt{(R^2 + X_c^2)} \doteqdot E_g \, . \, R/X_c$ when $R \ll X_c$. Taking $C = 500$ pF, $X_c = 1/2\pi f C = 6.3\,M\Omega$ at 50 c/s, if $E_g = 0.5$ V and $R = 12k\Omega$, then $E_r = 0.001$ V, a reduction of 500 times as compared with the induced voltage pickup, and thus, of the same order as the cardiac potentials.

Equivalent Circuit

The simple equivalent circuit of the cardiac generator must now be modified to include the effects of the interference, and the situation may be represented as in Fig. 2. E_c is the cardiac potential it is desired to record, E_{g1} and E_{g2} are the open-circuit voltages due to interference pick-up, and C_1 and C_2 are the capacities to earth from the two electrodes on the body.

In general, E_{g1} and E_{g2} are closely equal and in phase, and likewise C_1 and C_2 are also equal, although under some conditions these equalities may not hold, particularly where the subject is very close to an interfering source. The phase equality, however, appears to be quite constant under all conditions, which is to be expected.

Now consider the patient circuit connected to the amplifier input circuit of Fig. 3. A potentiometer of 10kΩ is connected between grid and cathode, and the slider is taken to earth (i.e. actual earth). It will be evident that by moving the slider a position will be found where the interference voltages across the two portions of the potentiometer can be made exactly equal. Also, since $R \ll X_c$ the phases will be practically equal and the two voltages will balance, so that only the cardiac voltage appears across the potentiometer. For example, in the diagram of Fig. 4 the phase angles of the voltages E_{r1} and E_{r2} are given by

$$\beta_1 = 90 - \tan^{-1}R_1/X_c$$

and

$$\beta_2 = 90 - \tan^{-1}R_2/X_c.$$

Suppose that for voltage equality the values of R_1 and R_2 are 6kΩ and 4kΩ respectively, and that $C_1 = C_2 = 250$ pF, then at 50 c/s $X_c = 12.7$ MΩ and the phase angles become $\beta_1 = 89.97°$ and $\beta_2 = 89.96°$. The difference is therefore quite negligible. This result is due, of course, to the fact that $R \ll X_c$, so that the phase angles of the voltage across the resistors is always very close to 90° and any difference between the two will be the difference between two angles $(90 - a)$ and $(90 - b)$ where a and b are both extremely small. Hence quite considerable variations in the values for E_{g1}, E_{g2}, C_1, and C_2 will produce no important difference between the phases of the two voltages. This holds good even for the harmonics of the 50 c/s mains.

By using a potentiometer of 10 kΩ the actual interference voltages developed across each section are quite small, while a load of 10 kΩ is presented to the cardiac generator, permitting 5/6 of the cardiac signal to appear at the amplifier input. This is quite a favourable condition (the Eindhoven galvanometer string presents some 3 or 4 kΩ only) and any polarizing effects due to the load current are quite small.

In practice the whole of the amplifier may be built on an insulated sub-chassis which constitutes the h.t. negative line, and this is enclosed in a metal case directly earthed, with the slider of the input potentiometer connected to this outer case. The output must not be directly earthed in order to prevent the flow of feedback currents through the lower portion of the potentiometer. A mirror galvanometer forms a most suitable indicating device, balance for d.c. being provided in any conventional manner. An interference balance indicator is a most useful adjunct and permits fine adjustment of the input circuit. This may be very simply a leaky-grid detector with anode current meter, coupled to one of the later stages, where any interference unbalance would be amplified.

Fig. 5 shows the situation which arises when several amplifiers using this input circuit are connected to the same subject. Three electrodes are shown, providing three simultaneous records. Obviously the three inputs cannot be separately balanced since the movement of any one slider will upset the inputs of the other two amplifiers. This, however, is easily remedied by the insertion of swamping resistors of about 100 kΩ in each of the three separate earth leads, so that the movement of any one slider produces a quite negligible change in the condition of the other two input circuits, and all three may now be independently balanced. The insertion of the swamping resistor produces no change in the absolute values of the interference voltages in the potentiometers, since the resistor is still very small compared with X_c, and is in the neutral lead.

The writer has not used the circuit described in a mains-operated amplifier, but there seems to be no serious reason why it should not be applicable, provided that certain precautions are taken; for example, the mains transformer should be fitted with an electrostatic screen to eliminate unwanted capacity coupling from mains to power supply.

As stated above, the circuit is particularly useful for cardiographic work, and it is possible that workers in the field of encephalography may find that it has possibilities of development to suit the special requirements of their own field, too.

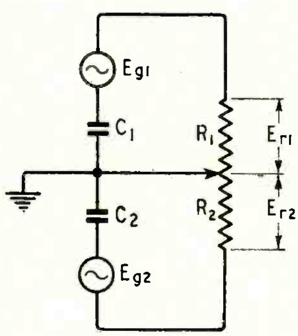


Fig. 4. The phase angles of E_{r1} and E_{r2} are not seriously disturbed in practice by alteration of the ratio R_1/R_2.

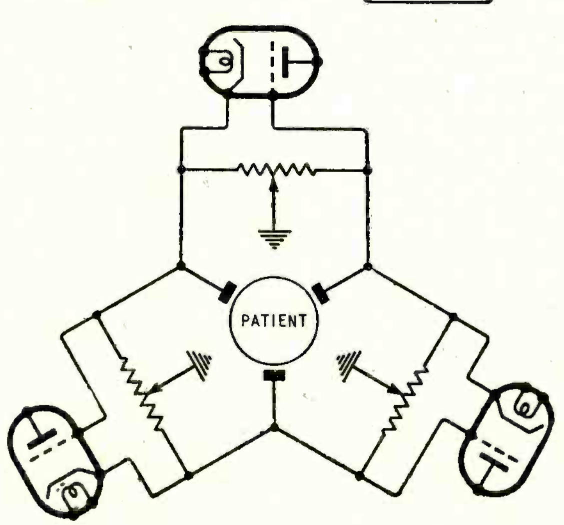


Fig. 5. (Below) Connections for more than one circuit. Swamping resistors are in practice connected between each slider and earth to preserve independence of adjustment.

Published Report

Measuring Radio-frequency Voltages

AN up-to-date presentation of fundamental principles and techniques used in radio-frequency voltage measurement is given in a booklet recently published by the U.S. National Bureau of Standards.

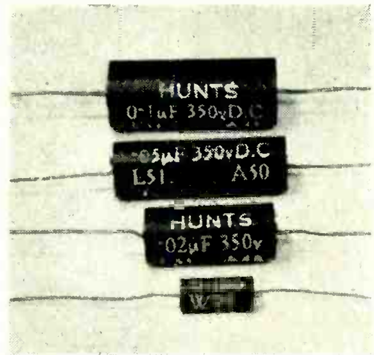
The subject matter has been selected to give professional workers and students a more comprehensive picture of these measurement methods than is generally available in current text-books. It is, however, limited to techniques that have proved successful in practice, with emphasis on those developed for standardization work at the National Bureau of Standards. High-precision methods based on d.c. measurements are dealt with first, then moderate-precision methods involving thermionic and other rectifiers, and finally pulse-peak voltage measurements and miscellaneous methods. The frequencies concerned range from the l.f. band to part of the e.h.f. band.

"High-frequency Voltage Measurement" is available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., price 20 cents, plus 7 cents postage. Remittances must be in U.S. currency.

Trends in Components

Review of the R.E.C.M.F. Exhibition

The annual private exhibition of components and accessories, organized by the Radio and Electronic Component Manufacturers' Federation was held in London from 17th—19th April. Our survey of exhibits in each category is followed by a list of makers. A general list of exhibitors, with addresses, is given at the end of this review.



Group of Hunt's latest moulded cased tubular capacitors. They are suitable for use under tropical conditions.

CAPACITORS

Variables.—In order to meet the extended medium-wave coverage now needed under the Copenhagen Plan for broadcasting either a larger tuning capacitor must be used or the stray capacitance in circut must be reduced. Catering for the first alternative, Plessey have increased the capacitance swing in some of their gang condenser assemblies to 580 pF; this has been achieved with practically no change in minimum capacitance or increase in overall dimensions. The extra capacitance is obtained by employing slightly thicker vanes for the rotor sections. Actual vane spacing, centre-to-centre, is unchanged, but the dielectric spacing is reduced and the rigidity is improved so that no more risk of microphony is entailed.

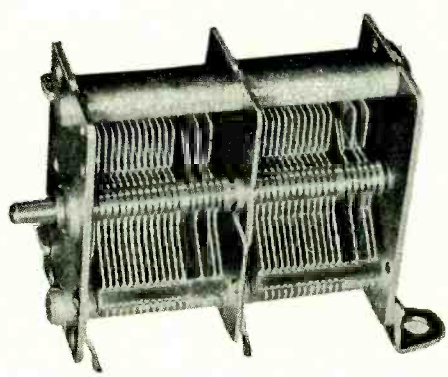
Concurrent with this change, Plessey have bonded the tips of the rotor vanes in the short-wave sections of the bandspread models to the main rotor vanes as a means of combating microphony on short waves.

Elsewhere, few changes were seen in the design of variable capacitors; Cyldon still cater for the instrument designer with a comprehensive range of high-precision variables, while Polar had, among other models, a wide selection of v.h.f. tuning and miniature air trimming capacitors. One minor change introduced by this firm is the inclusion of a locking device on one of their miniature models. This effectively locks the capacitor without the slightest change in its adjustment. The model, which measures just over $\frac{7}{8}$ in × $\frac{5}{8}$ in over the ceramic base, is available in sizes of 2-20 pF and 3-30 pF.

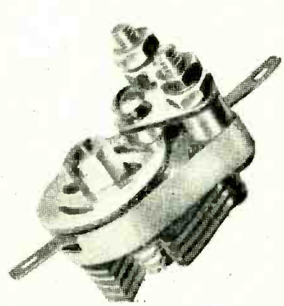
Fixed.—In addition to minor improvements, T.C.C. have introduced three new types of ceramic capacitor, two being fully insulated and the third a metal-cased miniature. For one type the insulating coating is applied by dipping in a special hard-drying compound, while in the other the capacitor is enclosed in a glass tube with Neoprene end-seals. Since the outer case is glass, the use of synthetic rubber end-seals does not degrade the power factor of the ceramic element. A silver-plated copper sheath is used for the screened variety, and one end is swaged over and soldered to the lead-out wire connected to the outer silvering on the ceramic body. At the opposite end the "live" connection passes through a PTFE seal. This super-tropical model is an improved version of the existing "Metalicon."

Hunt has now largely eliminated cardboard tubes for paper capacitors and the latest models of this type are encased in a hard wax moulding which will also pass tropical tests. Most of the standard sizes are now available in this form, which is known as "Moldseal." Overall size is practically unchanged; indeed, in some cases the capacitor is smaller than hitherto. For example, a 0.1-µF, 350-V working tubular measures $\frac{5}{8}$ in dia × $1\frac{1}{8}$ in long, while an 0.01-µF size in the W99 range, also 350-V working, is $\frac{1}{4}$ in dia and $\frac{9}{16}$ in long. The new models are also non-inductive.

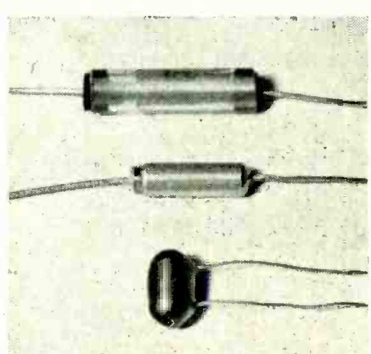
Silvered-mica capacitors in un-



Left: Plessey two-gang bandspread variable capacitor with 580pF coverage in the main sections.



Below left: Midget air trimmer with locking device which does not cause any change in capacitance. It is a Polar product.



Below: Group of new T.C.C. ceramic capacitors, showing glass-insulated, all-metal cased and insulation-dipped varieties.

usually high values were shown by L.E.M. Using plates of 1,000 pF each, capacitances up to 0.5 μF have been produced but as the reliability of the component will be governed by the weakest plate in the stack, the larger capacitors in the series are rated at 200 V instead of 350 V working.

Many varieties of tropical capacitors were seen at the exhibition, but particular interest centres round a new range shown by S.T.C. Designed especially for very high working temperatures—100°C is the figure given—they are assembled in drawn metal containers having a single seam only. The case is in two halves fitting snugly together and the edge of the outer is swaged over before soldering. The swage takes all stresses caused by expansion and contraction, and so the soldered joint is subjected to practically no strain. Oil-impregnated paper foil capacitors are employed and normal values range from 0.5 μF to 8 μF and for working voltages up to 5 kV.

Some additions have been made to the varieties of electrolytic capacitors available, but few new developments could be traced. B.E.C. had some large dual-capacitance models in various combination; one, for example, being 100 + 200 μF. These will handle quite large ripple currents, and values up to 0.5 A are permissible in some cases. Hunt showed also a range of large capacitance dual models, this style being intended for use in the transformerless type of television receivers using half-wave mains rectification, but they have other applications as well.

Makers*: B.E.C. (E); B. I. Callenders (E. M, P); Bulgin (T); Cyldon (T. V); Daly (E); Dubilier (C. E. M. P. T); Erie (C, T); Ferranti (E, P); Hunt (C. E, M. P); J.B. (T, V); L.E.M. (C, M); Mullard (T); N.S.F. (P); Polar (T, V); Plessey (T. V); S.R.C. (M); S.T.C. (P); Static Condenser (P); T.C.C. (C, E, M, P, T); T.M.C. (M, P); Walter Instruments (T); Wego (C. M. P); Welwyn (T).

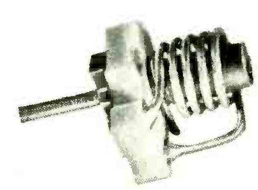
**Abbreviations:* C, ceramic; E, electrolytic; M, mica; P, paper; T, trimmers and pre-set; V, air dielectric variables.

COILS and TRANSFORMERS

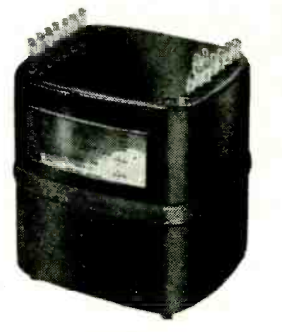
Radio Frequency.—Examples of both air-core and dust-iron core r.f. tuning coils and i.f. transformers were exhibited by Advance, while Plessey showed a wide range fitted with Caslite cores. These included television types, the i.f. transformers of which are designed for operation at 13.5 Mc/s and are screened. They are intended for use in sets designed either for London or Birmingham. The oscillator coil is self-supporting and wound with silver-plated wire; by changing the dust-iron core for one of different characteristics, the coil can be used for London or Birmingham frequencies.

Highly stable inductors for v.h.f. were exhibited by Steatite; they comprise a "coil" made by a silver deposition in a groove in a steatite former.

Makers: Advance, Avo, Igranic, Plessey, Steatite, Varley.



Plessey dust-core oscillator coil for television and (right) Parmeko "Neptune" sealed transformer.



Mains and A.F.—Transformer design has not changed much in recent years, so far as the ordinary types are concerned, but for special purposes great improvements have been made. The Ministry of Supply showed models designed for operation at a temperature of 150°C which are about 66 per cent lighter than equivalent normal types. The core is of Hypersil Cut-C, and glass and silicore insulation is used.

Parmeko showed a range of hermetically sealed transformers and chokes the Neptune series also using a C-core wound from a continuous strip of grain-oriented high-permeability steel. A reduction by 50 per cent of the external field is claimed. Ratings of 5 VA to 2 kVA are made.

Partridge exhibited push-pull audio transformers as well as mains types. There are three PPO types rated for 12 W at 0.5 per cent distortion at 50 c/s, and there are the WWFB models intended particularly for the Williamson amplifier.

Potted mains transformers and smoothing chokes, including swinging chokes, were shown by Woden; and Ferranti exhibited a range of miniature hermetically-sealed types.

Makers: Advance, A.E.E., Avo, Bulgin, Berco, Elac, Electronic Components, Ferranti, Goodmans, Igranic, Lectrona, Mullard, Parmeko, Partridge, Plessey, R. & A., Rola, Taylor Electrical, Truvox, Varley, Vitavox, Woden.

RESISTORS

Variable:—The greater variety of pre-set variable resistors attracted attention this year and most of them have been designed for use in television sets. They generally take the form of a strip-wound element with a simple sliding contact. This style of construction enables several units to be accommodated side-by-side in a small space and they form convenient banks of pre-set controls.

Some examples of the sliding contact wire-wound variety were shown by Colvern, while Egen favours a sliding contact actuated by a rotary control at one end. The control knob is knurled and slotted for either finger or screw-driver adjustment. These components take up very little panel space and the normal values extend from 1 kΩ to 40 kΩ.

Pre-set resistors with sliding contacts and fitted with carbon elements were seen among the Welwyn exhibits. In this form much higher values are possible; the normal types range from 25 kΩ to 1 MΩ. They are made in single and multiple assemblies.

Of interest to designers of precision apparatus were the newest types of cam-corrected wire-wound potentiometers made by Colvern. Much smaller models are now available, but the high accuracy and number of correcting points of the larger sizes are retained by fitting smaller correcting screws (8BA in place of 6BA). One of the new type measures 2½ in in diameter and and 1 in deep. The moving contact has continuous rotation although the resistance element occupies 300° only. It can be centre-tapped if needed and values up to 100 kΩ are available. A linear accuracy of better than ±0.1 per cent is attainable.

Another Colvern development is a wire-wound potentiometer fitted with a helical resistance element. Its external diameter is 1¾ in and its depth 2⅜ in. The helix has 10 turns and the moving contact makes 10 revolutions, giving an effective travel of 3,600°. Resistance values extend to 100 kΩ and the linear accuracy is of the order of ±0.1 per cent.

Another unusual potentiometer was a midget carbon-track type, designed for hearing-aids and small personal portables, shown by Morganite. Known as type DA, it can be had with or without a switch (10 V at 0.25 A) and is available in values up to 3 MΩ (0.1 W dissipation). The overall size is 29/32 in diameter and 9/32 in deep, the projecting contacts adding another ¼ in. Knobs of the full diameter, or larger, can be fitted and various colours are available.

A number of new miniature potentiometers of orthodox design were seen on Morganite's stand and elsewhere; for example, N.S.F. had one of only 15/16 in dia. The Plessey pattern is 1⅛ in, fitted with a moulded track of high stability and durability. Dubilier showed a range of small hermetically-sealed tropical volume controls known as type "Q," rated at 0.5 W, Berco a wire-wound 5-W sealed type and Erie a tropical carbon-track model rated at 0.5 W and made in values up to 3 MΩ.

Sealing of the case of these miniatures is relatively simple, but various ingenious devices are employed to obtain a perfect seal in the spindle housing. In most cases annular grooves cut in the spindle are fitted with Neoprene washers, which, being under compression, effectively bar ingress of moisture. Berco use two such seals in cascade, with an oil ring between, while Erie have three Neoprene seals in tandem.

Fixed.—Vitreous enamelling of wire-wound resistors continues to find further adherents. A new range was shown by Painton, including types of 4-W and 5-W rating which were actually smaller in size than an average ½-W carbon type. Another new entrant in this field was Electronic Components whose range of "Elcohm" miniature vitreous resistors exhibit a number of interesting features, such as secure junction of lead-out and resistance wires and satisfactory operation up to 300°C.

Hitherto specialists in wire-wound resistors of all kinds, Painton this year have turned their attention to the production of high-stability resistors using the cracked carbon technique and a ceramic base. They are fully insulated and range in size from ⅛ W to 2 W and from 10 Ω to 18 MΩ, but the highest values are limited to the higher ratings. They can be supplied with tolerances of from 1 to 5 per cent. Protection is given by a multiple coating of a hard-drying heat-resisting varnish.

The Welwyn range of high-stability resistors has been extended to include a variant of the more orthodox design with wire ends. Their special e.h.t. types are retained for use as attenuators in waveguides. The new types are made in ¼-, ½- and 1-W sizes and with resistance ranging from 10 Ω to 2.5 Ω.

Makers*: Advance (A); Belling & Lee (S); Berco (P, V, W); Bulgin (P. W.); Colvern (P, W); Dubilier (C. HS, SP. S, V, W); Egen (P, W); Electronic Components (A, V, W); Erie (C, P, S, W); Igranic (W); Morganite (C, P, S); Mullard (HS, NC); N.S.F. (P); Painton (A, HS, P, W, V); Plessey (P); S.T.C. (A. NC); Taylor Electrical (W, P); Varley (W); Welwyn (HS, V, W).

**Abbreviations:* A, attentuators; C, composition; HS, high stability; NC, negative coefficient; P, potentiometers; S, supressor; V vitreous; W, wire-wound fixed and pre-set.

VALVES

THE trend towards miniaturization continues, with emphasis on B7G and B9A bases. Mullard showed a number of 1.4-V battery miniatures on B7G bases and had two valves of particular interest in their B9A range, a high-slope r.f. pentode EF80 and a triode-pentode ECL80. Also on view were two flat subminiatures for use in lightweight hearing-aids, an amplifier pentode DF66 and an output pentode DL66. G.E.C. had complete ranges of B7G Osram valves for 1.4-V battery operation, a.c. operation and d.c./a.c. operation; whilst their range of miniatures for television included a new line-scan pentode KT36 and an e.h.t. rectifier U37. Another firm concerned with television valves was Ediswan, who showed a twin-triode time-base valve 20L1 with series-run heaters (6L1 being the version with a 6.3-V heater), a rectifier U25 suitable for e.h.t., and a time-base amplifier 20P2.

Cathode-ray tubes were exhibited by the above firms and by Ferranti and Brimar. The last-mentioned, as well as producing a 15-in aluminized tube, has entered a new field with a 2½-in projection tube for use with the Schmidt optical system; it requires an anode voltage of 20 kV and has a beam current of 1 mA. Mullard also showed their 2½-in projection tube MW6-2.

Miniaturization was the rule in quartz crystals of the plug-in type shown by S.T.C. and Salford. One of the latest S.T.C. types measures ¾in × 51/64in × 11/32in and can be supplied for a range of frequencies between 2 and 20 Mc/s fundamental or 20 and 60 Mc/s on overtones. A new miniature crystal shown by Salford can be supplied for 6, 8, 10 and 14 Mc/s and has an accuracy of 0.01 per cent. The latter firm also demonstrated an interesting 100-c/s crystal, which was built up with a two-valve battery oscillator into a portable unit to act as a replacement for a tuning-fork. The crystal itself was constructed of overlapping plates of quartz in three sections, and had an accuracy of about 20 parts in a million.

Makers: Brimar, Ediswan, Ferranti, G.E.C., Mullard Electronic Products, Salford Electrical Instruments.

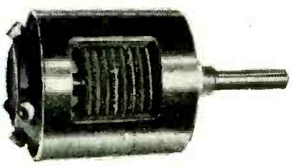
METAL RECTIFIERS

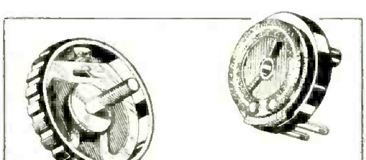
THE copper-oxide type of metal rectifier now finds its main application as an instrument rectifier and the selenium pattern is more common in power applications. The trend towards a.c./d.c. operation in television sets, in particular, has caused a demand for a heavy-duty rectifier capable of withstanding very large peak currents. Standard Telephones showed types capable of an output of 290 V at 250 mA for an input of 250 V, 625 mA, with a 60-μF reservoir capacitor. The peak current is unlimited and operation can be at an air temperature of 40°C.

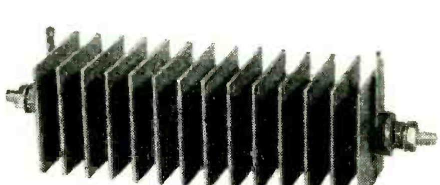
Similar types are also made by Westinghouse who, in addition to the well-known 36 series of e.h.t. rectifiers, now have a range designed for operation as "damping diodes" in economy line-scanning circuits. This is the 14D series and includes units of up to 4.47 kV peak-inverse rating with mean-current ratings of 50-100 mA; higher curent patterns can be supplied, but as cooling fins are needed they become physically larger.

This firm also features the use of metal rectifiers for spark suppression in switch contacts, and claims that they enable this to be done while retaining fast operation.

Makers: Salford, S.T.C., Westinghouse.







Colvern helical wire-wound potentiometer giving a scale equal to 3,600° rotation of the spindle; (top right) miniature carbon-track volume control made by Morganite for hearing aids and personal portables and (right) RM4 contact rectifier by S.T.C.

TELEVISION COMPONENTS

EXCEPT for a yoke-type frame coil for a self-oscillating current generator which was shown by Plessey, the deflector coils on view were of the bent-up-end type. The Plessey models have an external mu-metal ring, but Igranic use a stack of laminations. There is a tendency, however, to adopt special materials, and a one-piece slotted-ring made of Ferroxcube was shown by Mullard and is of particular interest for the production of coils combining high efficiency and high Q.

The same material was also shown in shapes suited to line-scan coupling transformers. The Plessey transformers embody "Caslam" cores. This material not only gives a high Q but is claimed to give a great reduction of acoustic noise. Salford showed dust-iron, three-piece cores for transformers. The advantage of these special materials lies mainly in improved circuit efficiency when using the so-called economy circuits—in particular, the ones providing h.t. boost.

Focus coils of conventional pattern appeared on the Igranic and Plessey stands, but development in focusing methods lies chiefly in permanent-magnet types. The Plessey unit has a front plate which can be tilted by three screws for picture centring, the unit as a whole sliding along the tube neck for focusing. The Elac model is similarly arranged as far as centring is concerned, but the focus is adjustable by varying the air gaps by the same three screws. Elac also showed an exceedingly compact focus unit for projection tubes, and centring magnets for use with c.r. tubes having ion traps.

Rubber masks for tubes were exhibited by Long and Hambly and thermoplastic types by Thermo-Plastics. These have a transparent front which replaces the usual safety glass.

Makers: Elac, Igranic, Long and Hambly, Mullard, Plessey, Salford, Thermo-Plastics.

SWITCHES AND RELAYS

NO startling changes were to be seen in the design of switches this year. Bulgin showed a new micro-switch capable of breaking 10 A peak, and A.B. Metal Products had what is claimed to be the smallest rotary switch in the world, but manufacturers, on the whole, kept to their standard types. There were, however, two switch-driving mechanisms of considerable interest. One of them, shown by N.S.F. and described as a rotary relay, works on the screw principle reversed, in that a lateral movement produced by an electromagnet is converted into a powerful rotary movement suitable for driving a bank of rotary switches. The other mechanism, by Salford, was a fully sealed stepping motor arranged to drive, in steps of 30 deg, a bank of six ceramic wafer switches. It requires an average input power of 16 watts and weighs 10 oz, whilst the rate of stepping is 10 ± 4 impulses per second.

Several types of Carpenter polarized relay were shown by T.M.C., and one of the latest, for use in proximity to a radio receiver, incorporates an anti-interference filter. The frequencies suppressed are in the range 5-150 Mc/s, and the filter is physically small enough to fit inside the standard cover of any of the existing Type 3 relays.

Makers: A.B. Metal Products, Berco, Bulgin, Clix, Electronic Components, Electrothermal Engineering, Erie Resistor, N.S.F., Painton, Plessey, Salford Electrical Instruments, Sangamo Weston, S.T.C., Taylor, T.M.C., Varley, Walter Instruments.

CHASSIS FITTINGS

MOST of the new valveholders this year were for B7G and B9A valves, as might be expected. Of particular interest was a non-microphonic B7G valveholder effective up to 800 c/s, shown by McMurdo. The valveholder proper is held in a flexible PVC moulding, which is fitted with metal eyelets to take the fixing bolts so that the PVC cannot be squashed when the assembly is bolted to a chassis. Another feature is that the spacing of the fixing holes has been made the same as for B8A and B9A valveholders, thereby simplifying chassis drilling and interchanging of valves. The valveholder can be supplied with or without screening. A B9A valveholder shown by Cinch has a new type of contact giving improved grip on the valve pins.

Possibly with an eye to the high voltages used in television, two anti-corona devices have made their appearance; an anti-corona tag by Clix and an anti-corona clip by Cinch, the object in both cases being to make a connection with no sharp edges. Amongst various fittings shown by Belling & Lee was a polythene-bushed terminal with the extremely high leakage resistance of 20 million megohms. New items on the Bulgin stand included a bayonet neon holder, a signal flasher and a fuseholder that unscrews like a fountain-pen and can be conveniently inserted in a conductor without being chassis mounted. A multi-way socket for connection to printed circuits on glass plates was shown by Painton, together with an unbreakable two-pin plug and socket and a high-voltage six-point plug and socket suitable for anything up to 10 kV.

Considerable interest was aroused by two new techniques in the housing of radio and electronic apparatus, demonstrated by Widney. One of them was the use of telescopic mountings to enable chassis to be slid out of their cabinets in the same way as drawers are slid out of a filing-cabinet, a smooth action being ensured by the use of steel ball-bearings throughout. The other technique was that of the prefabricated cabinet. A variety of formed sections, corner diecastings and connecting brackets are available, rather on the "Meccano" principle, so that engineers and home constructors can, with the minimum of tools, assemble their own cabinets in whatever shape or form they please.

Makers: Antiference, Associated Electronic Engineers, Belling & Lee, Bulgin, Cinch, Clix, Colvern, Electronic Components, Electrothermal Engineering, Igranic, Imhof, J.B., Long & Hambly, McMurdo Instruments, Painton, Plessey, Polar, Reslosound, Ripaults, S.T.C., Telcon, Thermo-Plastics, T.M.C., Tucker Eyelet, Walter, Widney.

AERIALS

TWO outstanding features of the television aerials on view this year were greater mechanical strength and improved directivity for fringe-area reception. Most of the aerials on view were designed to stand up to 80-100 m.p.h. gales, and had alternative methods of fixing, usually either wall-brackets or chimney lashings.

An unusual aerial configuration in the shape of a cross was exhibited by Antiference, two of the elements acting as a director and the other two as a dipole. Compared with an ordinary "H"-type dipole and reflector, this "X" arrangement possesses greater mechanical strength and gives an increase in forward gain of 2 db. It has an input impedance of 70-80 Ω, forward gain of 5 db, front-to-back ratio of 22 db, and weighs, without its mounting, 1½ lb. An advantage in construction is that the four aluminium-alloy rods can be screwed into the central bakelite insulator after the aerial has been assembled and wired. By connecting the director to the lower element of the dipole, a depression is made in the base of the vertical polar diagram, thereby decreasing the amount of interference received from immediately below.

Another aerial for fringe areas was the "Multirod" by Belling & Lee. This has four elements in all—two directors, a dipole and a reflector—giving a forward gain of 8 db on a simple dipole and a front-to-back ratio of 24 db. A demonstration television aerial was also shown, in which a bracket supporting the pole could be clamped to an upstairs window whilst the bottom of the pole rested on the ground. A.B. Metal Products exhibited, amongst other television aerials, a fringe-area array consisting of a folded dipole and three reflector elements arranged to give parabolic focusing.

Makers: A.B. Metal Products, Antiference, Belling & Lee.

VIBRATORS

IT was noticeable this year that the makers of vibrators were aiming at higher power ratings than have been achieved in the past. One outstanding example was the heavy-duty model shown by Wimbledon. This was a non-synchronous type, intended to operate from 220-V d.c. mains and having a power rating of 440 W. It has a double-pole double-throw action and heavy tungsten contacts. To prevent frequency drift as a result of heat, the vibrating parts are arranged to have compensating expansions and contractions, and the frequency stability claimed is 50 ± 1 c/s. Plessey showed another heavy-duty non-synchronous vibrator which can be supplied for 6-V, 12-V and 24-V working and power ratings up to 60 W; with an output power of 45 W, its life would be in excess of 1,000 hours. A model shown by the Ministry of Supply was capable of handling approximately 100 watts at voltages up to 24 V.

Two miniature vibrator power packs, working at 400 c/s and 250 c/s, were also on view at the Ministry of Supply stand, whilst Wimbledon displayed their standard range of vibrators and power packs for input voltages of 2-24 V.

Makers: Plessey, Wimbledon.

SOUND REPRODUCTION

THE general impression remaining after a tour of the principal loudspeaker manufacturers was of a marked extension in the range and variety of types now available to the set maker. This is due not only to the home demand for new designs for small portables and television receivers, but also to a willingness to supply special types with frequency characteristics modified to meet the preferences of the overseas markets. Elliptical loudspeakers for use in car radio receivers were much in evidence.

A versatile new pickup, for standard or long-playing records has been introduced by Goldring. The cartridge (Type 150), which is available separately to manufacturers, is of the needle-armature magnetic type and has an output of 150 mV (at 3.16 cm/sec r.m.s. lateral groove velocity). Interchangeable sapphire-tipped styli are colour-coded and are provided with a neat housing moulded in conjunction with the tone-arm rest. Tip radii of 0.001, 0.0025, 0.003 and 0.0035 inch are available. The stylus pressure is variable by means of an adjustable counterbalance in the tone arm, from 7 gm for long-playing records to 14 gm for standard 78-r.p.m. records. A coupling unit giving a 1:2 step up of output voltage and providing equalization for the alternative systems of recording is available as an accessory, and provides enough output for the gramophone side of the average table-model radio receiver.

Piezo-electric devices shown by Acos included a new lapel microphone (Mic28), a vibration pickup for industrial applications, (VP3), and an inertia-type pickup cartridge (VP1) designed for attachment to musical instruments. The VP1 is protected by a moulded rubbed case and has an output of the order of 0.1 V with a range of frequency

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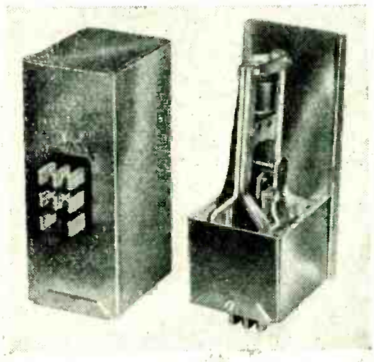

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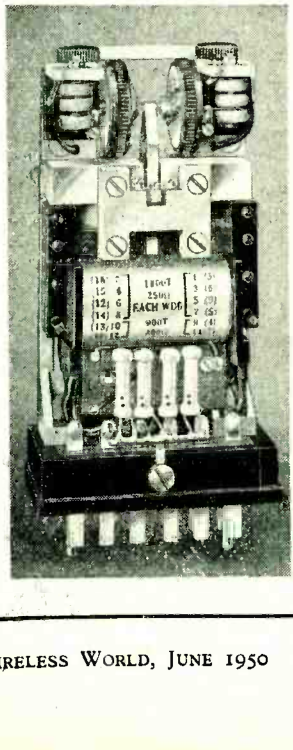

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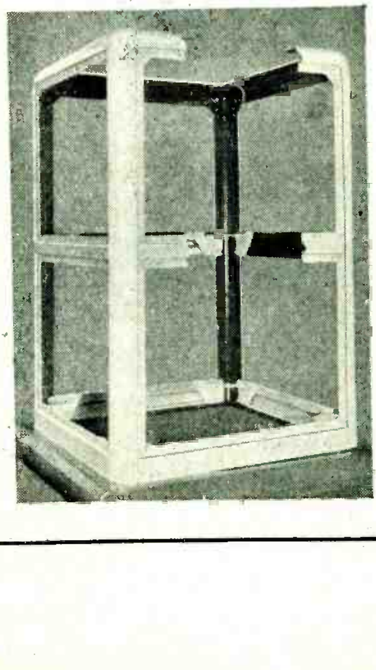

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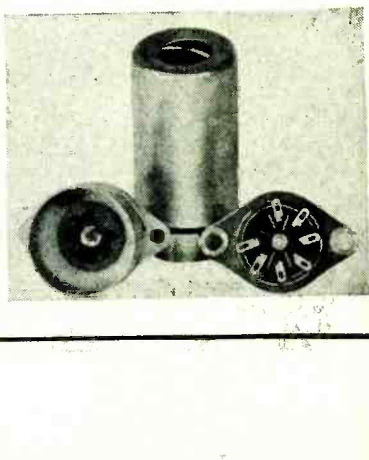


1. Mullard Ferroxcube "iron-circuit" for deflector coils.

2. Wimbledon heavy-duty vibrator with (right) casing cut away, (left) model for horizontal mounting.

3. Carpenter relay type 3S showing coils and resistors comprising the anti-interference filter.

4. Demonstration Widney-Dorlec pre-fabricated cabinet.

5. Non-microphonic valveholders by McMurdo, shielded on the left and unshielded on the right.

response from 30 to 6,000 c/s.

An ingenious adaptation of a standard dialling telephone instrument to the control of tape recording machines in a multi-channel message recorder known as the "Teletape," was demonstrated by Astronic. The system is suitable for the dictation of letters, and the user, by dialling an appropriate number, can erase mistakes without calling on the services of the operator. Channels in use are safeguarded by an "engaged" signal and the system is provided with numerous other devices for foolproof operation. The same firm also demonstrated a self-contained laboratory instrument (Type A1216) with variable a.f. oscillator, metering and calibrated equalizer circuits for investigating the properties of wire recording media.

Makers*: Acos (M. PU); Astronic (MR); Celestion (LS); Ediswan (LS. PU); Elac (LS); Garrard (DR, GM, GU, PU, RC); Goldring (PU); Goodmans (LS); Lectrona (LS); Plessey (LS, GM, GU, RC, PU); R. & A. (LS); Reslosound (LS, M); Rola (LS); Truvox (LS); Vitavox (LS, M).

**Abbreviations*:* DR, disc recorders; GM, gramophone motors; GU, gramophone turntable units; RC, record changers; M, microphones; MR, magnetic recorders; PU, pickups.

MATERIALS

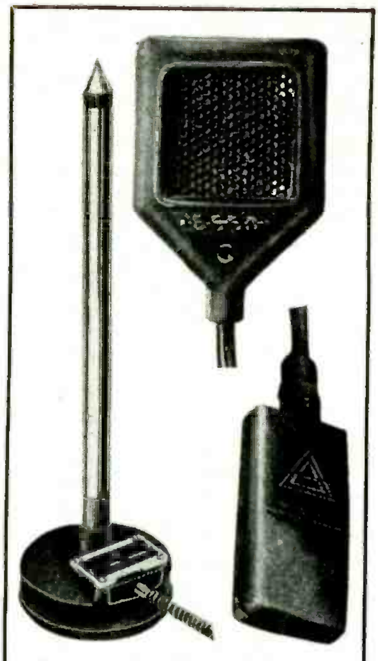
AMONG insulating materials the products of firms specializing in small and intricate ceramic mouldings continue to earn general admiration. Bray have added to their already extensive range some microscopic bushes for electrode assemblies in miniature valves and Steatite and Porcelain were showing new multi-point hermetic seals. The latter firm also exhibited examples of precision grinding in ceramic materials.

The wide range of transformer bobbins and other built-up parts in impregnated laminated paper and other insulating materials made a noteworthy exhibit on the stand of H. Clarke & Co. (Atlas).

Ferromagnetic powder materials for use in dust cores now include Mumetal, which was shown by Telcon in 150- and 300-mesh grades. This firm is now producing laminations in HCR alloy for magnetic amplifiers and was also showing "Hysat," an alloy, which, as the name implies, has a very high saturation value and is suitable for polepieces.

A new brazing technique has been developed for the manufacture of composite permanent magnets of soft and active materials, and examples, including magnet assemblies for ribbon microphones, were shown by the Permanent Magnet Association. The method facilitates accurate machining and considerably reduces the cost of production.

Cables can be regarded as one of the basic materials of the radio engineer, and there is no doubt that the industry is well served in this category. Telcon were showing some fine examples of coaxial aerial feeders for high-power transmitters, including a polystyrene disc insulated type in a seamless aluminium outer conductor, and a helical-membrane cable, employing polythene insulation, which is not subject to the frequency limitations inherent in disc-spaced designs.



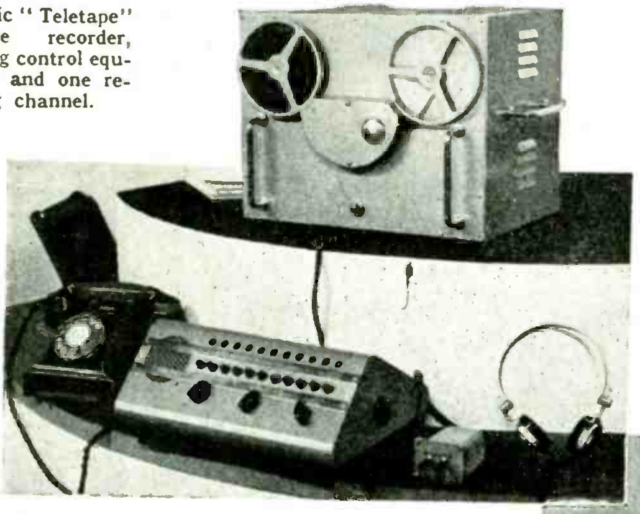
Lapel microphone (MIC28), musical instrument (VP1) and industrial vibration (VP3) pick-ups by Acos.

The range of television downleads made by B.I. Callender's Cables, which includes low-attenuation types for fringe areas, has been extended and includes a coaxial semi-airspaced type.

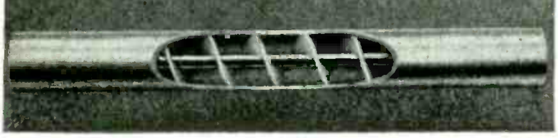
An interesting multi-strand cable with internal water-cooling pipes for coupling r.f. heaters to the work circuit was shown by Reliance.

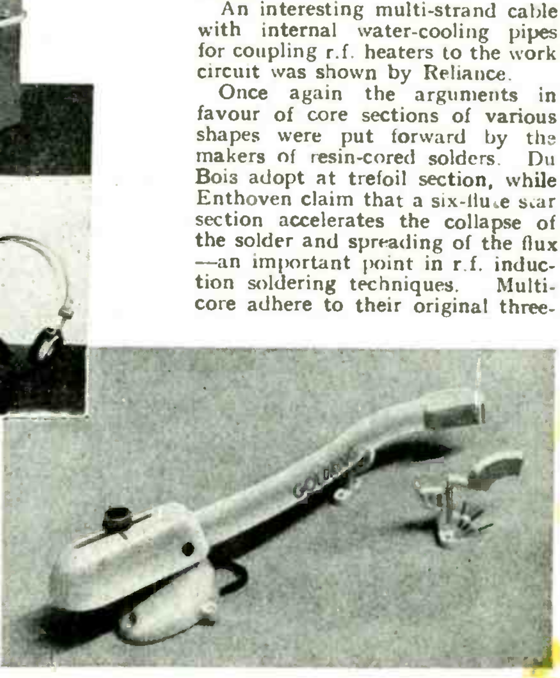
Once again the arguments in favour of core sections of various shapes were put forward by the makers of resin-cored solders. Du Bois adopt at trefoil section, while Enthoven claim that a six-flute star section accelerates the collapse of the solder and spreading of the flux—an important point in r.f. induction soldering techniques. Multicore adhere to their original three-

Astronic "Teletape" message recorder, showing control equipment and one recording channel.



Right: Goldring "Three-Way" pickup. Interchangeable styli are housed in the tone-arm rest. Below: Telcon helical-membrane cable.





cored method in which it is claimed that the independent channels greatly reduce the possibility of flux discontinuity at any given point. The new N-type Ersin activated flux has enabled an appreciable reduction to be made in the percentage of flux required, and most Multicore Ersin solders now contain only 2.2 per cent flux. For use in the assembly of sub-miniature components in electronic equipment gauges down to 22 s.w.g.—still with three cores—are available.

Magnetic recording tape is now being manufactured in quantity by the G.E.C. Two grades are available: Type A with the latest high-coercivity mix giving "radio quality" at 7½ in/sec, and Type B for use on Continental equipments based on German designs giving radio quality (6 kc/s) at 15 in/sec and "studio quality" (12 kc/s) at 30 in/sec. The tapes are not interchangeable and must be used with equipment having the required characteristics for each type of coating. Standard reels, with or without aluminium spools, are available in 1,250-ft (7 in dia.) and 1,000-metre (11 in dia.) sizes.

Makers*: Astronic (CF), Associated Technical Manufacturers (C, CO, IS, PVC, W); Atlas (CF, IM, IS); Bray (CE); B.I. Callender's (C, IS, W); Bullers (CE); De La Rue (IM, IS, W); Du Bois (S); Duratube and Wire (C, IS, PVC, W); Ediswan (C); Electrothermal Engineering (CO); Enthoven (S); G.E.C. (MT); Hellermann (IS); Lewcos (IS, W); Long and Hambly (RP); Magnetic and Electrical Alloys (M, L); McMurdo (CF); Mullard (M, DC); Multicore (S); Murex (M); Mycalex (IM); Permanent Magnet Association (M); Plessey (DC); Reliance (B, C, CO, IS, PVC, RP, W); Ripaults (B, C, CO, IS); Salford Electrical Instruments (DC); Scott (L); Steatite and Porcelain (CE); Suflex (B, CO, IS, PVC, W); Symons (IM, V); T.M.C. (DC); Telcon (C, CO, IM, M, W); United Insulator (CE).

**Abbreviations:* B, braiding; C, cables; CE, ceramics; CF, coil formers, bobbins; CO, cords; DC, dust cores; IM, insulating materials; IS, insulating sleeving; L, laminations; M, magnets and magnetic alloys; MT, magnetic recording tape; PVC, polyvinyl chloride tapes, wires, etc.; RP, rubber products; S, solder; V, varnished materials; W, covered wires.

LIST OF EXHIBITORS

A.B. Metal Products, Ltd., 107, Fleet Street, London, E.C.4.
AVO (Automatic Coil Winder & Electrical Equipment Co., Ltd.), Winder House, Douglas Street, London, S.W.1.
Acos (Cosmocord, Ltd.), 700, Great Cambridge Road, Enfield, Middx.
Advance Components, Ltd., Back Road, Shernhall Street, London, E.17.
Antiference, Ltd., 67, Bryanston Street, London, W.1.
Associated Technical Manufacturers, Ltd., Vincent Works, New Islington, Manchester, 4, Lancs.
Astronic (Associated Electronic Engineers, Ltd.), Dalston Gardens, Stanmore, Middx.
Atlas (H. Clarke & Co., Ltd.), Atlas Works, Patricroft, Manchester, Lancs.

B.E.C. (British Electrolytic Condenser Co., Ltd.), 52, Vicarage Lane, Ilford, Essex.
Belling & Lee, Ltd., Cambridge Arterial Road, Enfield, Middx.
Bray, Geo., & Co., Ltd., Leicester Place, Blackman Lane, Leeds, 2, Yorks.
Berco (British Electric Resistance Co., Ltd.), Queensway, Ponders End, Middx.
B.I. Callender's Cables, Ltd., Surrey House, Embankment, London, W.C.2.
Brimar (Standard Telephones & Cables, Ltd.), Connaught House, Aldwych, London, W.C.2.
British Moulded Plastics, Ltd., Avenue Works, Walthamstow Avenue, London, E.4.
Bulgin, A. F., & Co., Ltd., Bye-Pass Road, Barking, Essex.
Bullers, Ltd., 6, Laurence Pountney Hill, Cannon Street, London, E.C.4.

Celestion, Ltd., Ferry Works, Summer Road, Thames Ditton, Surrey.
Cinch (Carr Fastener Co., Ltd.), Brantwood Works, Tariff Road, London, N.17.
Clix (British Mechanical Productions, Ltd.), 21, Bruton Street, London, W.1.
Colvern, Ltd., Mawneys Road, Romford, Essex.
Cyldon (Sydney S. Bird & Sons, Ltd.), Cambridge Arterial Road, Enfield, Middx.

Daly (Condensers), Ltd., West Lodge Works, The Green, Ealing, London, W.5.
Dawe Instruments, Ltd., 130, Uxbridge Road, Hanwell, London, W.7.
De La Rue, Thomas, & Co., Ltd., Imperial House, 84/86, Regent Street, London, W.1.
Dubilier Condenser Co. (1925), Ltd., Ducon Works, Victoria Road, North Acton, London, W.3.
Du Bois Co., Ltd., 15, Britannia Street, King's Cross, London, W.C.1.
Duratube and Wire, Ltd., Faggs Road, Feltham, Middx.

Ediswan (Edison Swan Electric Co., Ltd.), 155, Charing Cross Road, London, W.C.2.
Egen Electric, Ltd., Craven Avenue, Canvey Island, Essex.
Elac (Electro Acoustic Industries, Ltd.), Stamford Works, Broad Lane, Tottenham, London, N.15.
Electronic Components, Weedon Road, Industrial Estate, Northampton.
Electrothermal Engineering, Ltd., 270, Neville Road, London, E.7.
Enthoven, H. J., & Sons, Ltd., Enthoven House, 89, Upper Thames Street, London, E.C.4.
Erie Resistor, Ltd., Carlisle Road, The Hyde, Hendon, London, N.W.9.

Ferranti, Ltd., Hollinwood, Lancs.

G.E.C. (General Electric Co., Ltd.), Magnet House, Kingsway, London, W.C.2.
Garrard Engineering and Manufacturing Co., Ltd., Newcastle Street, Swindon, Wilts.
Goldring (Erwin Scharf), 49/51, De Beauvoir Road, London, N.1.
Goodmans Industries, Ltd., Lancelot Road, Wembley, Middx.
Guest, Keen & Nettlefold, Ltd., Box No. 24, Heath Street, Birmingham, 18, Warwicks.

Hellermann Electric, Ltd., Tinsley Lane, Crawley, Sussex.
Hunt, A. H., Ltd., Bendon Valley, Garratt Lane, London, S.W.18.

Igranic Electric Co., Ltd., Elstow Road, Bedford.
Imhof, Alfred, Ltd., 112/6, New Oxford Street, London, W.C.1.

J.B. (Jackson Brothers, Ltd.), Kingsway, Waddon, Surrey.

L.E.M. (London Electrical Manufacturing Co., Ltd.), 459, Fulham Road, London, S.W.6.
Lectrona (Acoustic Products, Ltd.), Stonefield Way, Victoria Road, South Ruislip, Middx.
Lewcos (London Electric Wire Co. & Smiths, Ltd.), 24, Queen Anne's Gate, London, S.W.1.
Long & Hambly, Ltd., Empire Works, Slater Street, High Wycombe, Bucks.

Magnetic & Electrical Alloys, Ltd., 101/103, Baker Street, London, W.1.
Mazda (Edison Swan Electric Co., Ltd.), 155, Charing Cross Road, London, W.C.2.
McMurdo Instrument Co., Ltd., Ashtead, Surrey.
Morganite Resistors, Ltd., Bede Trading Estate, Jarrow, Co. Durham.
Mullard Electronic Products, Ltd., Century House, Shaftesbury Avenue, London, W.C.2.
Multicore Solders, Ltd., Mellier House, Albemarle Street, London, W.1.
Murex, Ltd., Rainham, Essex.
Mycalex Co., Ltd., Ashcroft Road, Cirencester, Glos.

N.S.F. (British N.S.F. Co., Ltd.), Ingrow Bridge Works, Keighley, Yorks.
Painton & Co., Ltd., Kingsthorpe, Northampton.
Parmeko, Ltd., Percy Road, Aylestone Park, Leicester.
Partridge Transformers, Ltd., Roebuck Road, Tolworth, Surbiton, Surrey.
Permanent Magnet Association, 301, Glossop Road, Sheffield, 10.
Plessey Co., Ltd., Vicarage Lane, Ilford, Essex.
Plessey International, Ltd., Vicarage Lane, Ilford, Essex.
Polar (Wingrove & Rogers, Ltd.), Polar Works, Old Swan, Liverpool, Lancs.
Pullin (Measuring Instruments, Ltd.), Electrin Works, Winchester Street, London, W.3.

R. & A. (Reproducers and Amplifiers, Ltd.), Frederick Street, Wolverhampton, Staffs.
Reliance Electrical Wire Co., Ltd., Staffa Road, Leyton, London, E.10.
Reslosound, Ltd., 359, City Road, London, E.C.1.
Ripaults, Ltd., Southbury Road, Enfield, Middx.
Rola (British Rola, Ltd.), Ferry Works, Summer Road, Thames Ditton, Surrey.

S.R.C. (Stability Radio Components, Ltd.), 14, Norman's Buildings, Central Street, London, E.C.1.
S.T.C. (Standard Telephones & Cables, Ltd.), Connaught House, Aldwych, London, W.C.2.
Salford Electrical Instruments, Ltd., Peel Works, Silk Street, Salford, Lancs.
Scott, Geo. L., & Co., Ltd., Cromwell Road, Ellesmere Port, Cheshire.
Static Condenser Co., Ltd., Toutley Works, Wokingham, Berks.
Steatite & Porcelain Products, Ltd., Stourport-on-Severn, Worcs.
Suflex, Ltd., 35, Baker Street, London, W.1.
Symons, H. D., & Co., Ltd., Park Works, Kingston Hill, Surrey.

T.C.C. (Telegraph Condenser Co., Ltd.), Wales Farm Road, North Acton, London, W.3.
T.M.C. (Telephone Manufacturing Co., Ltd.), Hollingsworth Works, Martell Road, West Dulwich, London, S.E.21.
Taylor Electrical Instruments, Ltd., 419/424, Montrose Avenue, Slough, Bucks.
Taylor, Tunnicliff (Refractories), Ltd., Albion Works, Longton, Stoke-on-Trent, Staffs.
Telcon (Telegraph Construction and Maintenance Co., Ltd.), 22, Old Broad Street, London, E.C.2.
Thermo-Plastics, Ltd., Luton Road Works, Dunstable, Beds.
Truvox Engineering Co., Ltd., Truvox House, Exhibition Grounds, Wembley, Middx.
Tucker, Geo., Eyelet Co., Ltd., Walsall Road, Birmingham, 22, Warwicks.

U.I.C. (United Insulator Co., Ltd.), Oakcroft Road, Tolworth, Surbiton, Surrey.

Varley (Oliver Pell Control, Ltd.), Cambridge Row, Woolwich, London, S.E.18.
Vitavox, Ltd., Westmoreland Road, London, N.W.9.

Walter Instruments, Ltd., Garth Road, Lower Morden, Surrey.
Walter, J. & H., Ltd., Farm Lane, Fulham, London, S.W.6.
Wego Condenser Co., Ltd., Bideford Avenue, Perivale, Greenford, Middx.
Welwyn Electrical Laboratories, Ltd., Bedlington Station, Northumberland.
Westinghouse Brake & Signal Co., Ltd., 82, York Way, King's Cross, London, N.1.
Weston (Sangamo Weston, Ltd.), Enfield, Middx.
Widney (Hallam, Sleigh & Cheston, Ltd.) Widney Works, Bagot Street, Birmingham, 4, Warwicks.
Wimbledon Engineering Co., Ltd., Garth Road, Lower Morden, Surrey.
Woden Transformer Co., Ltd., Moxley Road, Bilston, Staffs.

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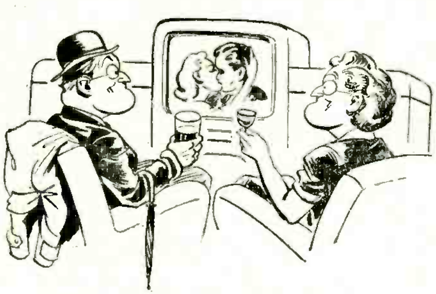
Telearchic Tuners

RADIO manufacturers expend a lot of time, energy and money in producing new types of receiver intended to incite us to break open the children's money boxes in order to possess them. Some makers tempt us with high sensitivity and the ability to pick up strange sounds from Samarkand. Others pander to our possessive instinct by giving us expensive and expansive cabinets containing not only a combined radioteleceiver (copyright reserved) but also cocktail shakers and other



" The necessary mellow mood "

adjuncts to the Waters of Lethe with which we can impart to our friends and ourselves the necessary mellow mood to appreciate some of the B.B.C.'s uplift programmes.

No manufacturer, however, really gives us the set which, if it were marketed, would sweep the board. I refer, of course, to a set having associated with it a small radio control unit for the adjustment of tuning and volume from our fireside chair. Please note that I said *radio* control unit. We don't want any more of those units which are linked to the set by an old-world multi-wired cable over which, sooner or later, somebody trips and breaks his neck. The fact that such radio units would be popular is shown by the tremendous number of mains-powered portables that are now marketed for placing beside one's armchair.

These portables naturally fall short of the large set in the matter of quality of reproduction, partly because of the necessarily small and boxed-in loudspeaker and partly because the sound from them is at foot level. Also they possess a mains lead with its neck-breaking potentialities, whereas a radio control unit could be operated by batteries since its use would only be intermittent. The P.M.G. couldn't quarrel with it any more than he did with the r.f.-generating gramophone unit which was once produced for shooting ether-borne recordings across the room to the wireless set. Any objections, please?

Ex-Cathedra

MR. H. BISHOP, the Chief Engineer of the B.B.C., is a person of no mean achievements in the realm of radio engineering and his views on any matter in this particular branch of applied science are worthy of attention and respect by all. Like many another great man, however, he fails to remember the proverb about the shoemaker and his last; he sets forth on uncharted seas without even a second mate's certificate when he tries to interpret for us the views of the listening public on stereophonic broadcasting in his recent letter to the Editor (April).

With truly episcopal authoritarianism well befitting his name, he tells us that this system of broadcasting would interest only a relatively small number of listeners.

This is to my mind only another way of saying that few people are interested in getting as near to the goal of perfect reproduction as is scientifically possible. How does he know this so definitely? Has he been conducting a private Gallup poll of his own or has he been infringing the law by using one of his crystals for occult divination instead of for its more legitimate purpose of de-wobbling wavelengths.

Mr. Bishop's technical and financial arguments, as well as his people-don't-want-it attitude, remind me strongly of those used in the very early 'twenties by people who were opposed to the introduction of broadcasting. The firm stand which he makes is strangely reminiscent of the stubborn attitude of the Inland Revenue officials in 1752. They joined the ignorant masses with their parrot cry of "Give us back our eleven days," and refused to adopt the New Style Calendar, which, of course, accounts for the tax year still being calculated from Lady Day O.S. or, in other words, April 6th N.S.

Maggie and All That

I WAS very interested in the exhibition held by the Marconi Marine Co. to mark its jubilee. It consisted of a series of ships' wireless cabins, one for each decade since the beginning of the century. Quite frankly, I feel all at sea where the modern ship's wireless rooms are concerned. I was, however, singularly fortunate in bumping into an ex-wireless operator—they call them radio officers nowadays—who explained these modern maritime mysteries to me.

His chief comment on the whole show was its lack of realism. The exhibition, he complained, just didn't smell like a ship, and—still more unlike reality—one could sit in comfort in any of the operator's chairs without the cabin lurching about all over the place. To my astonishment, he declared this was sometimes the case even in port when coming aboard in a place like B.A.: wherever that may be. Also, so he explained, ship's wireless cabins weren't always so clean and comfortable as those on show, especially after bunkering, when I gathered there was apt to be a layer of coal dust over everything, despite tightly closed ports.

His complaints made little impression on the exhibition officials, however, until in the cabin representing the early 'twenties he suddenly pounced with a whoop of triumph on the aerial tuning inductance of the receiver—a slider instrument looking like a giant reel of cotton standing on end—which,

" To my astonishment "

he explained, had not the necessary hole bored in the top as required by H.M. Customs. The officials hastily summoned a charm-exuding individual obviously learned in the law and steeped in the lore of tactfully wriggling out of awkward situations. I removed my hat in silent tribute to his genius and departed while the going was still good.

RANDOM RADIATIONS

By "DIALLIST"

Television and Co-ax

INFORMATION REACHES ME from one who knows what he is talking about, that, instead of their present 2.4—2.8-Mc/s coverage, the coaxial cables of the future will be able to handle 4.2 Mc/s. The reason is that a cable of this kind can comfortably deal with a 405-line television transmission with one sideband partly suppressed in the most modern way. The G.P.O., though, would not have gone in for wider-band coaxial cables purely for the purpose of improving television. It was found that the bandwidth increase to 4.2 Mc/s has enormous advantages for multi-channel telephony working. As you may know, in multi-channel telephony individual speech channels, each 4 kc/s wide, are combined at the sending end into groups by the first stage of modulation. Subsequent modulation stages twine groups into super-groups and super-groups into a "system." At the receiving end the system is disentangled into super-groups, the super-groups into groups and the groups into individual channels. Present cables can handle 600 speech channels apiece; with 4.2-Mc/s cables the number is increased to over 900.

One to Fetch and One to Carry

What a remarkable thing a coaxial cable is! Those used by the G.P.O. are under one inch in overall diameter. Inside the outer casing are two "tubes",* each consisting of an outer cylindrical conductor which encloses an inner conductor, maintained in an exactly central position by low-loss insulators. One tube (or pair of tubes in a large cable) carries the outward system; the other the inward—the arrangement brings to mind the White King's two messengers in "Through the Looking Glass": one to fetch and one to carry! Each cable contains also two ordinary pairs used for control purposes. Did you know that the 50-c/s a.c. for the repeater power packs was also carried by the cable, without any additional wires? A kind of push-pull arrangement is used, with the inner conductors of tubes acting as phase leads and the outers as neutrals.

* Large cables have four tubes.

Good Show

THIS YEAR'S R.E.C.M.F. exhibition was even more interesting than the last—and that is saying a lot. The exhibits included not only the components of which radio sets and other electronic appliances are made up, but also the things of which the components are made — wires, solders, insulators, magnetic materials, and so on. It's a pity in some ways that it has to be a private exhibition, with admission by invitation only, but business is business.

Radio Slimming

As an old hand, what interested me most was to observe the quite amazing reduction that time has brought in the sizes of radio components of every kind. Memory went back to my first three-valve receiver, built somewhere about thirty years ago. In this the grid of the r.f. valve received its input from the aerial by means of a device known as the loose-coupler. This consisted of an outer solenoid about five inches in diameter and twelve inches long with an inner coil, some four inches by six, which could be moved inwards or outwards along quarter-inch round brass guide-rods. The two 0.0005 μF tuning capacitors (not ganged) were each about as large as small saucepans. The three "R" valves had much the same dimensions as the 25-watt glow lamp of to-day. The a.f. transformer weighed something like three pounds. With its batteries the set (hailed in its day as the acme of compactness) was fitted on the two tiers of a dumb-waiter, which made the receiver transportable. To-day tuning coils, capacitors and transformers have become small, light things. The miniature glass-based valve is rapidly ousting the larger types, and a very efficient little valve it is. A battery set, for instance, containing four miniatures (including a power valve) requires a total of only 250 mA at 1.4 V from the l.t. source.

Soldering Economy

As an enthusiastic solderer one of the first stands I visit at the R.E.C.M.F. show and Radiolympia is that of the Multicore people. This time they'd no novelty so spectacular as the Arax core-flux of last year; but they were showing over 300 types of cored solder wire, each designed with some particular job in view. For example, it wouldn't perhaps strike everyone that the increasing use of miniature components means that smaller "blobs" of solder are needed to make the required joints. It struck the Multicore people, who were quick to realize that in the circumstances sound joints could be made with solder wire of considerably smaller gauge.

A Conductivity Problem

IT IS RELATED, this time on completely unreliable authority, that there was in America a hot-tempered bus conductor who became so annoyed with one of his passengers that he pushed him off the rear platform of the bus onto the road. The unfortunate passenger was killed and the conductor was convicted of murder and sentenced to the electric chair. As he took his seat he was asked whether he had any last request to make. "Why yes," he said, "I'd like a banana." This having been provided and consumed, the final adjustments were made and then the switch was closed. At the end of a full two minutes he was completely unaffected. All efforts to carry out the sentence having proved vain, he was informed that he was a free man. He soon obtained a job with another bus company; but the ejection of a passenger whilst the bus was travelling at speed resulted in a broken neck for his victim and a second murder charge against himself. Again he was brought to the chair. Again he asked for a banana. Again the closing of the switch was ineffective. Again he was set free. "It seems," they said to him, "that those bananas somehow render you immune. Our research department is baffled; would you tell us the secret?" "See here," said he, "I've a kind of passion for bananas; but they don't signify. Surely you've read about a bad conductor? Well, that's *me*! Yes, *Sir*."

LETTERS TO THE EDITOR

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

British and American Television

IN your issue of April, 1950, it is stated in the column "Random Radiations" that ". . . the B.B.C.'s technique is *immeasurably* superior to that behind the *bulk* of U.S.A. television transmissions" (my italics). Such a sweeping statement would appear to require some qualification, if your contributor is not to lay himself open to criticism of the same kind as that which he makes elsewhere.

Perhaps "Diallist" would tell us in what particular respects the techniques of transmission used in the U.S.A. are so immeasurably inferior to those used in Great Britain? The quality of the received picture in this country has nearly always compared favourably with that to be seen in Britain as I remember it, and I have no reason to believe that my perceptive qualities are inferior to those of the "average viewer" in either country. Neither do I recall any occasion on which the non-linearity has been sufficiently bad to send me running to the telephone. In fact, the quality of picture from a good studio transmission looks slightly superior to the British equivalent. The American system appears to have a slight but definite advantage in immunity from impulsive interference.

There is obvious justification for past complaints that American authors have failed to acknowledge British work, although this has been attributed in some cases to the difference in speeds with which the two countries released information for publication after the war. But during an extended stay in the U.S.A. I have met many, both inside and outside the engineering profession, who have shown interest in and awareness of work done outside this country, and I do not believe that the attitude of which "Diallist" complains is typical.

D. R. A. MELLIS.

Passaic, New Jersey.
U.S.A.

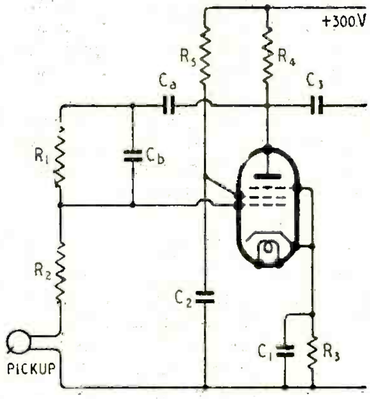
Pre-amplifier Circuit

AFTER reading the article by D. T. N. Williamson on the design of a pre-amplifier in your November issue, I should like to make the following comments:—

Many pickups in use to-day are designed for direct connection to grid and earth without a coupling transformer, and I suggest the following circuit as an alternative since it permits one side of the pickup to be earthed.

It is not new, but has not been given the attention it deserves.

If the circuit constants are chosen to give a middle frequency gain of about three, and no capacity is placed in series with the lower arm of the "see-saw," then a nice "very-low-frequency" roll-off is



Pre-amplifier circuit for high-impedance pickups. Suitable values, using an EF37 valve are: $R_1 = 1\ M\Omega$, $R_2 = 0.33\ M\Omega$, $R_3 = 3.3\ k\Omega$, $R_4 = 0.22\ M\Omega$, $R_5 = 0.39\ M\Omega$, $C_1 = 25\ \mu F$ electrolytic, $C_2 = 0.25\ \mu F$, $C_3 = 0.1\ \mu F$, C_a & C_b, see text. The pickup must provide a path to complete the grid circuit.

achieved, which is adequate for normal requirements.

Bass correction is controlled by C_a and "top cut" by C_b; these approximately are 600 pF and 25 pF respectively, but I advise the use of "trimmer" capacitors and these adjusted to give correct response when playing a frequency record. Worthy of mention is the importance of correct record speed; I have seen frequency runs taken without even a glance at a stroboscope.

Any further gain can be obtained from another anode-follower after this stage, adjusted to give the required level.

H. G. WARREN.

Luton, Beds.

Pickup Design

IN your report in the April issue on H. J. Leak's lecture-demonstration before the B.S.R.A., I see it stated that Mr. Leak expressed his preference for a multi-turn moving-coil pickup rather than a single-turn ribbon, on the grounds that the latter was, he thought, liable to hum pick-up. I contend that hum pick-up is not influenced by number of turns on the coil.

If we take, for example, a single turn of coil having an impedance of 1 ohm and cut it spirally to produce 10 turns, we find that both the "signal" voltage output and induced hum voltage increase ×10 across an impedance of 10^2 ohms, and therefore for a given output load the output voltage and signal/hum ratio are unaltered. If, on the other hand, we add nine more turns equal in size to the original, we shall get ×10 the output voltage into ×10 the impedance or $\times\sqrt{10}$ the voltage into a given output load, whereas the voltage due to stray magnetic fields will have increased by only a small amount depending on the coil dimensions.

All other things being equal, the signal/hum ratio varies in the proportion of rather less than √change in coil mass. Furthermore, since for a given coil and magnet system the signal output varies in direct proportion to coil velocity, the signal/hum ratio varies directly with coil velocity.

Since both coil mass and coil velocity are reflected as point impedance, we see, first, that the signal/hum ratio can be improved solely at the expense of increased point impedance, and, secondly, that if we are considering only this aspect of design, there is an optimum proportion for the location of the moving conductor and the point, relative to their common fulcrum.

I would point out—in case it is not immediately self-evident—that since the signal/hum ratio is to some degree proportional to point impedance for a given set of external circumstances, then the ribbon design, utilizing the principle that the moving conductor is either self-supporting or substantially so, will obviously have, for a given performance, a better signal/hum ratio than a moving coil, since the "waste" mass of the supporting coil former can be transferred to the effective working mass of the moving conductor.

J. H. BRIERLEY.

Liverpool.

IN his lecture-demonstration before the British Sound Recording Association on February 24th (reported in your April issue), H. J. Leak, in discussing gramophone pickups, commented that "tungsten carbide styli were also open to the objection that the surface often showed pitting as a result of imperfections in the sintering process by which they were formed."

As manufacturers of cemented tungsten carbide, we feel that Mr. Leak must have been unfortunate in his choice of carbide needles for test. We should, of course, be the first to agree that it does at times happen that imperfections in the sintering process, or for that matter other processes appertaining to powder metal production, may cause a slight porosity. We maintain, however, that such surface porosity can be detected when the needle is being polished, and faulty material can be rejected at this stage. We would also point out that incorrect polishing technique can be the cause of an uneven and pitted surface even when the hard metal as such is perfect.

We have recently studied the methods of grinding and polishing these needles, in the light of our experience in the finishing of carbide dies, and have established a small production unit for this purpose in our carbide die shop. Needles made under these conditions have given very favourable results on performance tests.

For Murex, Limited.
B. E. BERRY.
Rainham, Essex.

Physical Society Electronics

TO the conscientious technician in search of knowledge, a visit to the Physical Society's Exhibition represents a day of exhaustion, both mental and physical. Not only does he have to expend a large part of his energies in tramping the labyrinthine corridors and stairs of the Imperial College to find what he wants, but he is then faced with the task that somebody should have done for him, of sorting the wheat from the chaff.

The blame rests partly with the organizers and partly with the exhibitors. One condition applied to the exhibitors, I believe, is that they shall have something new to show, but this does not prevent them from bringing along a mass of their standard products which are already well known. The result is congestion, and many of the new and interesting items are crowded into dark corners and corridors where they are least likely to be seen. If the exhibitors showed more restraint and the organizers more discrimination in selecting the exhibits, this would not happen. Why, for instance, cannot components and test gear be left to the R.E.C.M.F. exhibition?

Electronics being largely "a lot of uninteresting tin boxes with knobs on," as one visitor put it this year, I feel that exhibitors should be at more pains to show the insides of their "tin boxes" (dare they?) and arrange more practical demonstrations for the benefit of the non-specialist in their particular art. I am aware that the exhibition is not intended to be a fun-fair, but visible, tangible and moving things are as readily appreciated by the super-intelligent as by the infantile. Science is not degraded by being made more attractive.

"RADIOPHARE."

Manufacturers' Products

New Equipment and Accessories for Radio and Electronics

Television Accessories

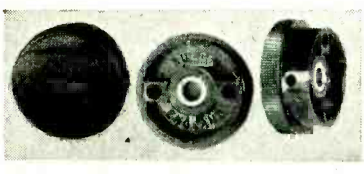
TO combat the sporadic impulse type of interference on their television receivers, G.E.C., of Magnet House, Kingsway, W.C.2, have introduced two picture interference inverters, BT 150 and BT 151. These reverse the phase of the incoming impulses, so that black spots appear on the screen instead of the usual white ones and the beam does not suffer defocusing. The units, which derive their power supplies from the receiver and are designed to mount on the existing chassis, cost £2 5s each.

For use in areas of low signal strength, G.E.C. have also produced a television pre-amplifier. Model BT 161/L for London transmissions has a gain of five over a bandwidth of 6 Mc/s, whilst model BT 161/M has a gain of twelve over a bandwidth of 4 Mc/s; both obtain their power supplies from the main receiver and are priced at £2 5s. Where fading is prevalent, a remote armchair gain control can be added for an extra £1 10s.

In addition, the firm has an H-type dipole aerial and reflector with provision for altering the polar diagram, at £3 10s; a demonstration aerial for dealers at the trade price of £15 12s; 10-ft and 6-ft aerial masts in light alloy, a chimney mounting, and a wall mounting.

Television Knobs

A RANGE of moulded knobs with special television engravings has been introduced by A. F. Bulgin and Co., Bye Pass Road, Barking, Essex. They are 1½in in diameter, have flat faces, straight sides and knurled edges to ensure a firm grip for precise adjustments. They fit ¼-in spindles and have 4BA steel grub screws threaded into brass insets with the heads of the screws sunk deep into the body of the knob for protection against high voltages.



Specimens of the new Bulgin knobs with television engravings.

Five engravings have been selected; they are: brightness, contrast, focus, switch and volume, the lettering being carried out in gold on a brown background. Black knobs are also available. The price is 1s 6d each for either colour.

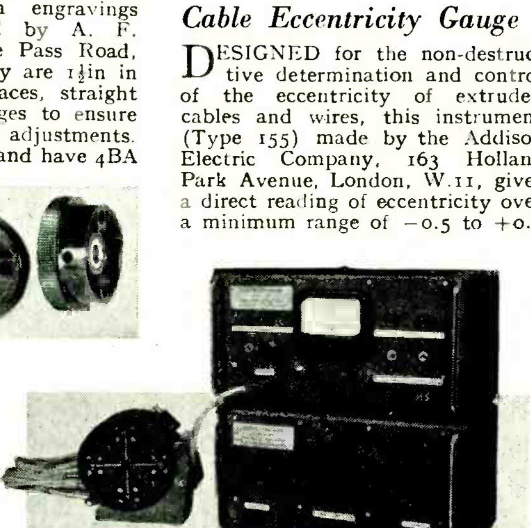
Television Converters

NON-TECHNICAL viewers who wish to adapt their London television receivers for reception of Sutton Coldfield with the least possible trouble will be interested in two new converters now on the market. These are both self-contained units for insertion between the aerial and the aerial socket of the receiver, and have their own power supplies.

Model AC/4, by Spencer-West, of Quay Works, Great Yarmouth, has five valves, enables either of the two stations to be selected, and costs £15 15s. Model S.C. "88," by Sphere Radio, of Heath Lane, West Bromwich, has one 6A8GT valve and costs £6 6s. Both are fitted with coaxial input and output connections.

Cable Eccentricity Gauge

DESIGNED for the non-destructive determination and control of the eccentricity of extruded cables and wires, this instrument (Type 155) made by the Addison Electric Company, 163 Holland Park Avenue, London, W.11, gives a direct reading of eccentricity over a minimum range of −0.5 to +0.5 mm. An internal polarized relay can be set to operate an indicator alarm, or automatic die re-setting mechanism, when the eccentricity exceeds ±0.1 mm.

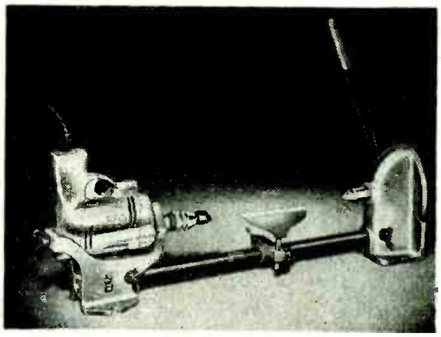


Type 155 cable eccentricity gauge, made by the Addison Electric Co., showing gauge head, control and oscillator units.

The principle of operation is the exploration of the field produced by current in the central conductor, supplied from a local oscillator. Pairs of coils arranged on X and Y axes at right angles are selected alternately by a switch and their voltages are applied to a differential amplifier and calibrated output meter.

Multi-Purpose Electric Tool

MAINLY for the benefit of amateurs, Wolf Electric Tools, Ltd., have produced an inexpensive and versatile tool which can be adapted for drilling, turning, sawing, grinding and polishing. The basic unit is a "Wolf Cub" electric drill, costing £4 19s 6d, which can be incorporated as the driving unit in a number of different kits. For instance, one kit will convert the hand drill into a bench drill, and this, when laid flat on the bench, becomes the lathe illustrated, for an additional sum of 13s 6d. The electric drill can be seen clamped upside down, whilst the long handle used for raising the drilling platform here becomes a means of moving the back centre of the lathe. Alternatively, the bench drill can be converted into a circular-saw kit for an extra £2 8s 6d.



Amateur's lathe assembled from a "Wolf Cub" kit.

There are, in fact, many ways in which the amateur can ring the changes on these kits, and he is not obliged to buy them in any particular order. If all the available items are purchased, the total cost is in the region of £11. The firm is at Pioneer Works, Hanger Lane, London, W.5.