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Radiolympia 1949

THE 16th National Radio Exhibition ("Radiolympia") organised by the Radio Industry Council, is to be held at Olympia, London, from September 28 to October 8 this year, and will be opened by Mr. Herbert Morrison, M.P., Lord President of the Council, on the afternoon of Wednesday, September 28.

Thereafter, the Exhibition will remain open from 11 a.m. to 10 p.m.

The Royal Navy, the Army and the Royal Air Force are to exhibit their radio and radar equipment for the first time since the war. The Department of Scientific and Industrial Research, for which Mr. Morrison is the responsible Minister; the various research establishments of the Ministry of Supply, the G.P.O. and the Ministry of Civil Aviation are all to give demonstrations of their exhibits, while the Board of Trade are having offices for the reception of overseas visitors.

In this issue of ELECTRONIC ENGINEERING is included an eight page review of electronic equipment exhibited mainly in the National Hall (Electronics Section)—a feature which we are sure will be of interest.

Readers of ELECTRONIC ENGINEERING will be very welcome at our Stand No. 155 in the National Hall where the full range of our monographs and booklets will be available.

Our own exhibits will comprise the Home Built Televisor working with a 12 in. cathode ray tube and a new De Luxe Televisor designed by W. I. Flack, and incorporating a high quality amplifier, a three waveband tuning unit and a gramophone turntable unit.

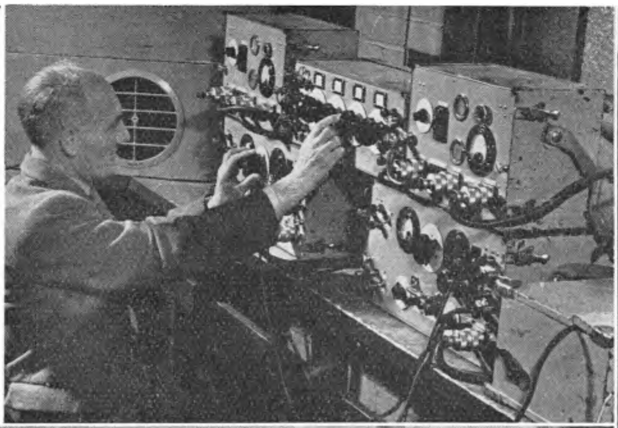
The Sutton Coldfield version of the Home Built Televisor, also designed by W. I. Flack, will be on view, and preliminary tests made for us by an independent authority indicate that it is working most satisfactorily at a range of 25 miles from the pilot transmitter, comparing very favourably with the performance of commercial receivers.

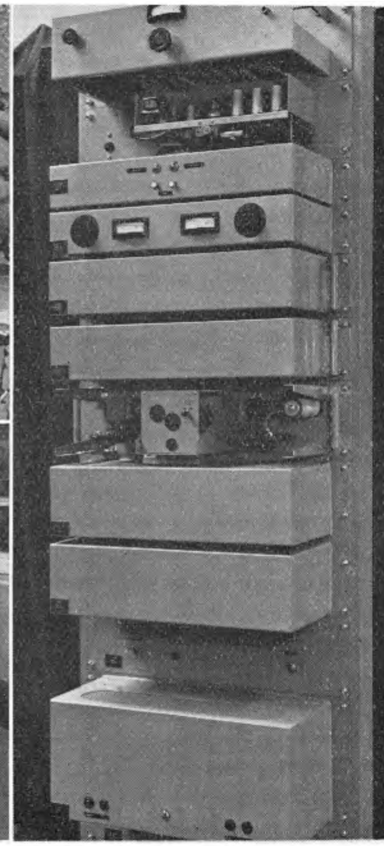
Taking into consideration the fact that the Sutton Coldfield Transmitter will have a power of 35 KW, we feel confident that the Midlands Home Built Televisor will have ample sensitivity in the fringe areas.

Another version of the original Televisor will be that designed by N. H. Bentley. This has an entirely new mechanical construction with a single chassis, mounting both cathode ray tube and loudspeaker. The electrical circuits are basically unchanged, but the power supply for the tube is provided by an R.F. E.H.T. unit while the normal power supplies are obtained direct from the mains by a voltage doubling circuit.

The Frequency Modulated Receiver designed by Dr. K. R. Sturley will also be exhibited, but we regret that owing to delays in printing, the booklet dealing with its construction will not be available in time.

THE B.B.C. AT RADIOLYMPIA, 1949





Apart from the Television Theatre, from which sound and television programmes will be broadcast each day, the B.B.C. will again have a stand in the National Hall at Olympia. The stand will be surmounted by a large mural depicting the world-wide services of the B.B.C., and visitors will be able to listen to any of the programmes actually being broadcast at that instant by operating a dial telephone.

Recording equipment will be represented by permanent and transportable apparatus. The type-D Recorder (shown in centre photo) is being exhibited as an example of the latest practice in disk recording equipment. It is capable of making recordings of the highest quality and is extremely robust and reliable in operation. Alternative turntable speeds of 78 r.p.m. and 33⅓ r.p.m. are available, and particular care has been taken in the design to ensure that the turntable rotates at constant speed without any vibration. In the mobile recording exhibit, one of the Humber 'Pullman' cars complete with type-C recording gear will be on view (bottom left). The equipment consists of the recording machine and amplifier, microphones and fader unit, with accumulators for supplying the power, and it can be removed for operation away from the car if desired. The accumulators are charged from an additional dynamo driven off the car engine, thus making the unit practically independent of external battery charging. An interesting feature of this equipment is the stroboscope consisting of 100-c/s oscillator and tube for getting the turntable speed correct.

Would-be commentators will be able to put their abilities to the test at the outside-broadcasting exhibit. There will be a commentator's box equipped with a lip microphone, a control point, and a loudpseaker over which visitors will be able to hear whatever is said into the microphone.

Among the working exhibits is the automatic monitor, which has been designed to replace human monitors at certain points in the broadcasting chain, thus saving man-power, and making for more consistent results. The principle is to compare the programme signals from two points in the chain and to indicate by means of an alarm signal any predetermined differences between them as regards volume, frequency spectrum, or noise level. Visitors will be able to demonstrate for themselves the operation of the automatic monitor on show by deliberately altering the characteristics of the programme signal at one point in the chain.

Another working exhibit is an automatic carrier-wave frequency corrector (top right) designed by the B.B.C. for maintaining the carrier-wave frequency of one group of synchronized transmitters exactly the same as that of the Master Transmitter of the group. The exhibit will consist of a corrector, and two r.f. oscillators, one of which simulates the Master Station, and the other the Slave Station. The oscillator outputs will be connected to a cathode-ray oscilloscope to give a Lissajou figure on the screen. Visitors will be able to alter the frequency of one of the oscillators by about 1 part in a million, and then see on the oscilloscope how the corrector automatically brings it back to the correct value.

The photo at the top of the page illustrates B.B.C. mobile equipment set up for an outside broadcast.

The Design and Limitations of D.C. Amplifiers—

PART II.

By E. J. HARRIS, Ph.D., D.I.C.* and P. O. BISHOP, M.B., B.S. (Sydney)†

Resistors

In addition to the specific effect of cathode temperature, the temperature coefficients of the various components making up the apparatus are of importance. The only active components of the amplifier are valves and resistors. As a matter of principle the current carrying resistors should be wire wound, and of large physical dimensions, so as to assist equilibration with their surroundings. The latter provision is made not only because the temperature coefficient of metallic resistors is less than that of the semi-conductor type, but also because the semi-conductive resistors give rise to current noise, which, like flicker noise, is most serious at low frequencies.[12] In order to keep the load resistors of the two sides of a stage balanced it is desirable to mount them close together, if not actually in a single container, and they should not be close to any component which heats up in operation.

Electromotor Input

The chief advantage of a valve amplifier is the high input impedance over a wide range of frequencies which it presents to the source. Thus, it is possible to achieve a power sensitivity over a frequency range which is impossible by any other means. A direct coupled amplifier which is designed for general use should, therefore, combine a high input resistance with a low input capacitance. The most important factor determining the input resistance of a valve is the value of the grid current. Several authors,[16,17,18] have described the use of common valve types under reduced operating potentials so as to result in grid current of 10^{-15}A or less. The allowable value of the resistance in the grid circuit can be considerably increased by operating the valve as a cathode follower.[13,19] Although this enables the resistance in the grid circuit to be increased without causing instability, the value of the grid current remains unchanged.

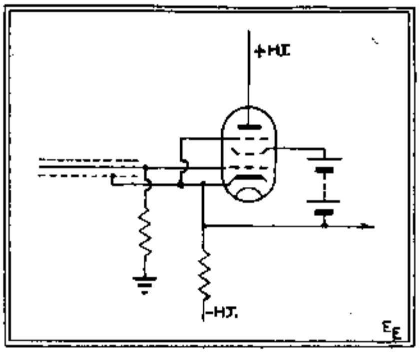


Fig. 2. Arrangement of cathode follower to achieve low input capacitance

The input capacitance can be reduced to a minimum by the use of a pentode under the conditions referred to above and by connecting the screening on the grid lead to the cathode and supplying the screen grid potential from a small floating battery (Fig. 2).

The application of these principles to the acorn types R.C.A. 954 and 955 is described in more detail elsewhere.[20] By these means it is posible to achieve an input resistance of 10^{17} ohms and an input capacitance less than 1 $\mu\mu$F.

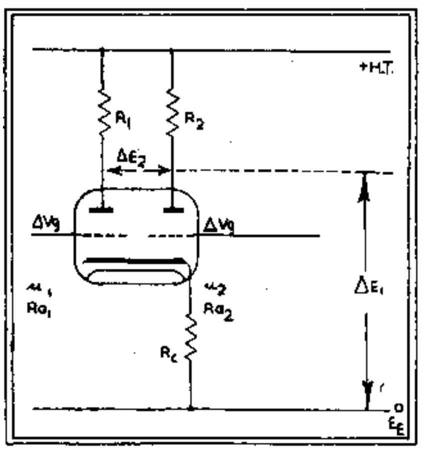


Fig. 3. Balanced stage to illustrate definitions of gain and input ratios

The First Amplifying Stage

In a recent paper Artzt[21] has given a comprehensive review of the principle circuit arrangements which have been devised to minimise the effect of disturbances due to changes in the external parameters. As pointed out above, it is proposed to limit the discussion here to the design of multi-stage amplifiers of the balanced type. The central problem in the design of such an amplifier is concerned with preserving the compensating features of the single stage amplifier without making the circuit too complex. The properties of the balanced circuit have been described by Parnum[22]; only a brief discussion is needed here.

Consider the circuit in Fig. 3. The equal signal voltages V_g may be applied to the grids either in-phase or out-of-phase. Considering the properties of this circuit two definitions are useful.

1. The in-phase/out-of-phase gain ratio, which may be called the gain ratio (r), i.e.,

$$r = \frac{E_1 \text{ when } \triangle V_g\text{'s are in-phase}}{E_1 \text{ when } \triangle V_g\text{'s are out-of-phase}}$$

2. The in-phase/out-of-phase output ratio, which may be called the output ratio (r'), i.e.,

$$r' = \frac{E_2 \text{ when } \triangle V_g\text{'s are in-phase}}{E_2 \text{ when } \triangle V_g\text{'s are out-of-phase}}$$

If an in-phase signal is applied to the grids of an amplifier, the halves of which are exactly matched, there will be no unbalance at the output (i.e., $r' = 0$) whatever the value of r until the signal level is high enough to swing the valve characteristic outside the linear range. By increasing R_c the gain ratio (r) can be made very small so that large in-phase signal can be handled without causing non-linearity. The output ratio (r') becomes equal to zero when $\triangle V_g$ applied between the two grids causes an equal change in the anode potential of both sides. Making R_c large also greatly reduces the output

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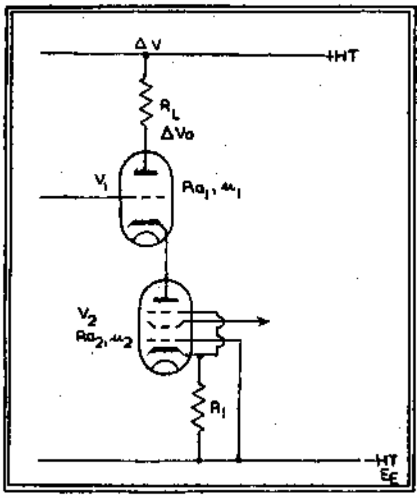


Fig. 4. Use of pentode as cathode load

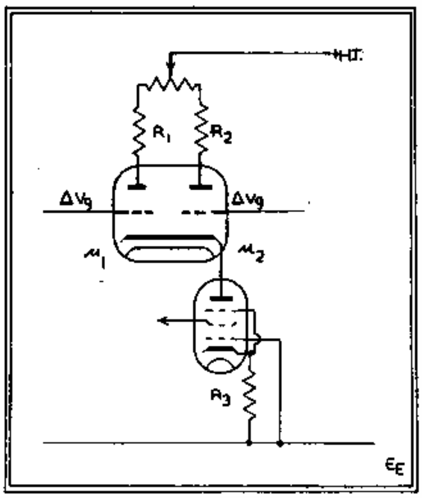


Fig. 5. Use of pentode as cathode load for balanced stage

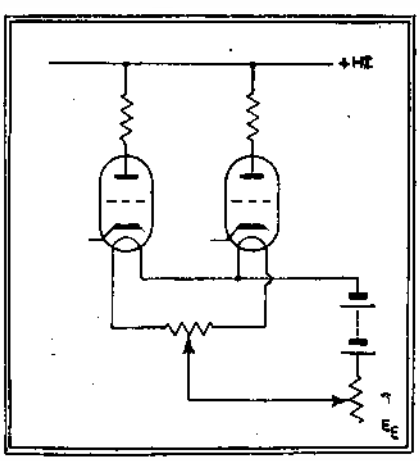


Fig. 6. Circuit employed to obtain equal $(\delta Ia/\delta If)$ from two valves by choice of operating currents

ratio. The value of the common cathode load for a given negative H.T. supply can be considerably increased by using the anode impedance of a pentode. The gain ratio can be made even smaller by the use of mean D.C. level feedback which will be discussed later.

In seeking to eliminate the residual instability due to variations in external parameters a balanced system will only be effective if the disturbances are equally applied to the two sides. Once an unbalance is produced at any stage in the amplifier it cannot be corrected in subsequent stages. This limits the degree to which the amplifier will reject pick-up from electrostatic and electromagnetic fields. Assuming an output ratio of 10^{-5} a signal of 10 μV could be measured in the presence of interference of about 100 mV. However it is most unlikely that the interference inputs of 100 mV will be balanced to within 1 μV. It is obviously important to arrange the circuit so that the electrostatic and electromagnetic pick-up is as small and as nearly equal in the two halves as possible.

The position is much more favourable with respect to changes in the H.T. supplies. Consider the circuit shown in Fig. (4) where V_2 is a pentode used as a cathode load. The change in anode voltage, ΔV_a, for a given change in H.T. voltage, ΔV, is given by the expression

$$\Delta V_a = \Delta V \times \left\{ \frac{R_{a1} + (\mu_1+1)[(\mu_2+1)R_1 + R_{a2}]}{R_L + R_{a1} + (\mu_1+1)[(\mu_2+1)R_1 + R_{a2}]} \right\}$$

where μ_2 = effective μ of valve V_2 taking into account feedback on the screen grid.

As the valve V_2 is a pentode the expression $(\mu_1+1)[(\mu_2+1)R_1 + R_{a2}]$ will be of the order of 100 MΩ and, taking R_{a1} = 30K and R_L = 100K, ΔV_a will be very nearly equal to ΔV. Consider now the balanced stage shown in Fig. (5).

The anode load resistors R_1 and R_2 and the anode impedances of the valves are now in parallel and so ΔV_a will even more closely approximate to ΔV. Thus changes in H.T. will cause equal changes in the anode voltages of a stage and these will be applied as equal in-phase signals ΔV_g to the next stage. Consider now Fig. (5) as being this next stage.

The rigorous analysis of a balanced stage is complicated by the fact that the two sides are mutually dependent. However, the unbalance at the anodes produced by an in-phase signal, ΔV_g, applied to the two grids may be very roughly determined in the following way. When a pentode is used as the cathode load, R_c is considerably greater than R_a and R_L (where R_L is the anode load resistor) and the gain for in-phase signals is $R_L/2R_c$ each side. Any inequality between the two sides will generate an unbalance at the anodes. Assuming the two halves are matched to within 20 per cent, the unbalance will be approximately $[\Delta V_g.R_L/2R_c] \times 0.2$ which in a practical case may be 1/200 of ΔV_g. This allows an estimate to be made of the signal which will appear when an in-phase potential is applied if the separate characteristics of the two sides are known. The signal equivalent at the input of the two stages to a 1 volt change in the anode supply to the first stage may now be calculated for the above example. When triodes are used in the two stages with an out-of-phase stage gain of 20, the signal equivalent is $1/200 \times 1/400\text{V} \approx 13\mu\text{V}$.

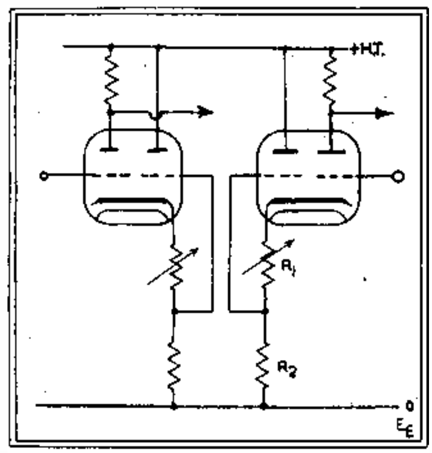


Fig. 7. Miller's circuit for compensating for variations in heater current

It is generally convenient to use a potentiometer in the anode circuits of the balanced stage as shown in Fig. (5). This enables the anode voltages to be balanced so that the grids of the next stage are at approximately equal potential. The operation of this potentiometer has very little effect on the output ratio of the stage when a pentode is used as a common cathode load.

The unbalance due to changes in

heater voltage is perhaps the most critical feature in the design of direct coupled amplifiers. This is because it is difficult to arrange that the signals equivalent to a change in heater voltage shall be equal in the two sides of the amplifier. If they can be made equal they will obviously suffer the same attenuation as has been shown to occur for changes in H.T. supply. The use of 6J6 double triode in this connexion has been discussed above.

Wynn-Williams[22] has discussed the conditions necessary for the ratio of anode currents to remain constant despite changes in heater voltage. The type of circuit used is shown in Fig. (6); it requires the use of separate valves.

Another possible method is that

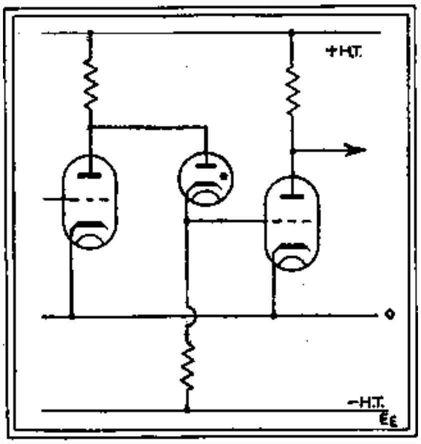


Fig. 8. Use of gas discharge tube to couple stages without loss of gain.

described by Miller.[13] The application of this method of cathode compensation to a balanced stage is shown in Fig. (7). For one side of the balanced stage the anode current in R_3 is unaffected by changes in heater voltage when $R_2 = \frac{1}{g_m}$ where g_m = the mutual conductance of the non-amplifying valve. A 50/1 improvement is claimed for a balanced circuit with, as opposed to without, cathode compensation. This would mean that it would probably only be necessary to ensure that the L.T. supply was stable to about 10 mV if the residual instability resulting from changes in heater voltage are not to exceed about 20 μV.

Interstage Coupling

The problem of interstage coupling has been treated at considerable length in recent years and it is proposed to do no more than list the principal methods that have been suggested, giving references to the original papers. An attempt will be made to arrive at some estimate of their worth in designing a high gain amplifier. Most of the methods have a very limited application.

1. Direct anode to grid coupling.
2. Potential divider coupling.
3. Potential divider coupling with negative bias.
4. Backing off battery.
5. Gas discharge valve[13] (see Fig. 8)
6. Cathode of one stage coupled to the anode load of the previous stage[13] (see Fig. 9).

The voltage drop in the anode load provides the grid bias for the second stage.

7. Direct anode to screen coupling[24] (see Fig. 10).

Tetrodes are used, the screen acting as the control grid. This does not require any increase in voltage over stages, but the gain per stage is low.

8. The use of the anode impedance of a pentode in the potential divider network[25] (see Fig. 11).

$$\frac{\Delta V_2}{\Delta V_a} = \frac{(\mu + 1)R_2 + R_a}{(\mu + 1)R_2 + R_a + R_1}$$

where μ = effective amplification factor taking into account feedback on the screen grid.

9. The use of a triode in interstage coupling.[26]

(a) In a single sided amplifier (see Fig. 12).

There is no attenuation of the signal (i.e., $\Delta V_a = \Delta V_g$) when $R_4 = R_3/\mu$, where μ = amplification factor of the coupling triode.

(b) In a balanced amplifier (see Fig. 13).

In this application the grids of the coupling valve V_2 may be joined to a point on the common cathode load of the succeeding stage. This leads to considerable attenuation of in-phase signals appearing at the anodes of V_1, but out-of-phase signals are applied to the grids of V_3 without attenuation if the relationship $R_4 = R_3/\mu$ still holds.

The use of voltage dropping arrangements, whether by potential divider or otherwise, is to be avoided in the early stages of amplification even if the overall gain is required to be relatively small. This particularly applies to the use of valves and glow discharge tubes, because of the noise arising in them. Valves are, however, much better than neons in

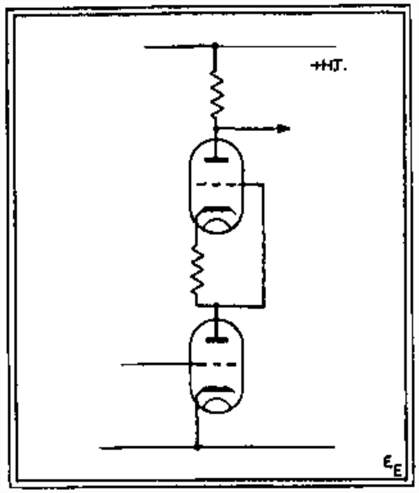


Fig. 9. Amplifier in which the cathode of one stage is coupled to the anode of the preceding stage

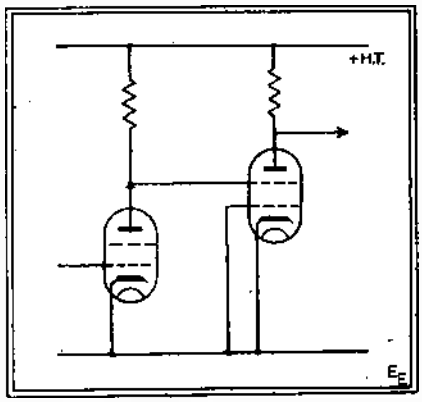


Fig. 10. Amplifier with anode coupled to screen of next stage

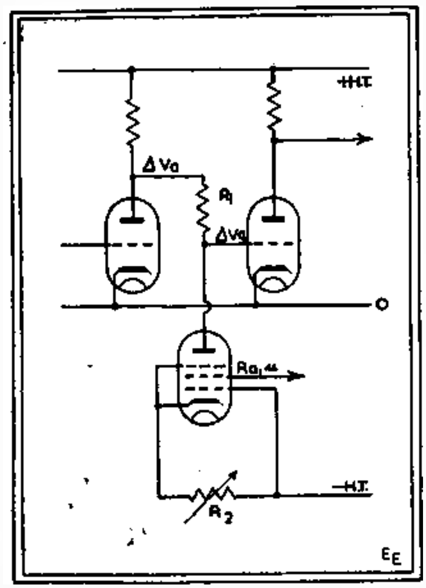
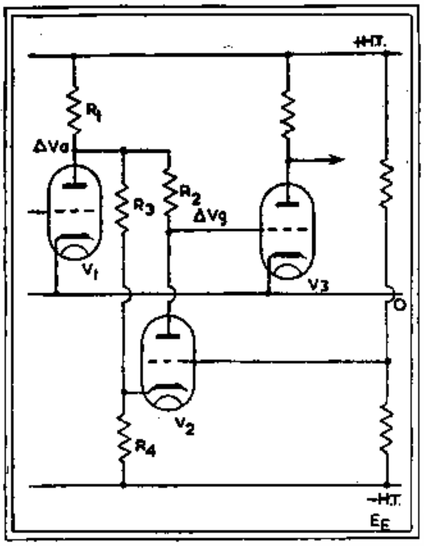
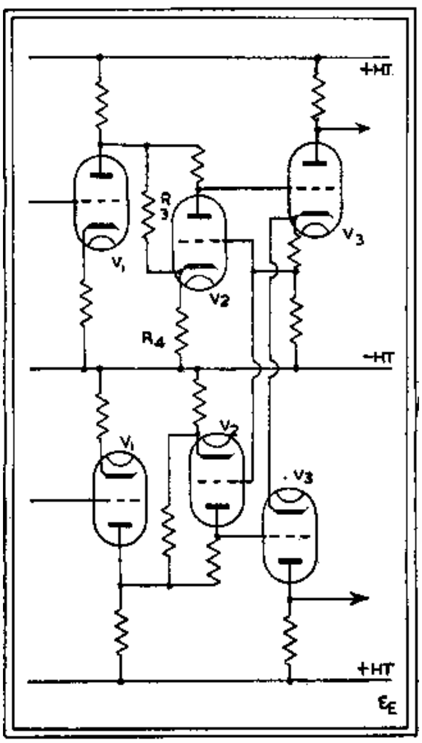


Fig. 11. Use of pentode to provide high impedance for coupling network





this respect. In relatively low gain amplifiers (up to 10,000 times) direct anode to grid coupling can be used throughout without excessive anode voltages on the last stages, if triodes are used at least in the early stages. The voltage gain for a triode such as the 6J6 (ECC91) or 6SC7 does not vary very much with anode potential provided the other factors are kept at an optimum. The use of the

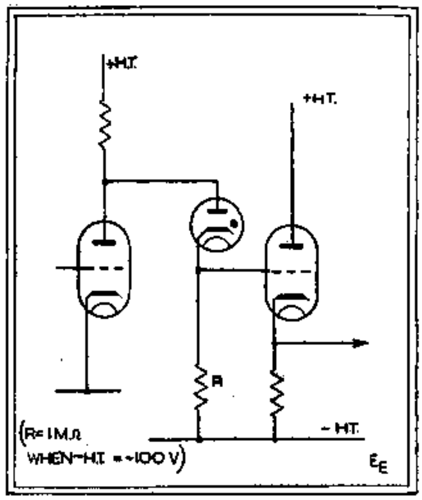


Fig. 14 (*above*). **Use of gas discharge tube to provide low impedance output at earth potential**

Fig. 12. (*above, left*). **Use of feed-back triode to provide high impedance for coupling network**

Fig. 13 (*left*). **Application of previous circuit to balanced stage**

double triode type is desirable for reasons referred to above. Furthermore, the signal amplitude in the early stages is so small that they will not be required to handle large voltage swings. Thus, 6J6's can be used in the first two stages with only 30 V and 40 V respectively across the valve. The voltages across the valves of successive stages should increase in step with the increased signal amplitude to be handled. An amplifier with a gain of 80 db. need not have a final anode potential of more than 250 V using direct anode to grid coupling throughout.

Thus, the problem of avoiding high anode potentials only becomes of importance in the final stages of a high gain amplifier. The use of glow discharge valves is perhaps the simplest method of avoiding signal attenuation. This system is, however, the least stable of the methods described above, and should be reserved for the final inter-stage coupling. Gas discharge tubes are also very valuable as a means of coupling the final anode to the grid of an output cathode follower in order to provide a low impedance output at earth potential (Fig. 14). Used in this position the authors have found the VR105 and VR150 sufficiently stable although passing only 100 μA.

If it is found necessary to use some voltage dropping arrangement in an earlier stage, it is probably preferable to use a simple potential divider rather than the more elaborate valve circuits Nos. 8 and 9, for the valve used to avoid signal attenuation in the inter-stage coupling would be better employed in an additional stage of amplification. Valve coupling has the further disadvantage that the anode current of the coupling valve must flow through the anode load of the previous stage, which reduces the value the anode load can have for a given high tension supply. This type of coupling is only satisfactory in the final stages where large anode currents and low anode loads are used. However, as pointed out above, glow discharge tubes are quite satsfactory for this purpose and need much less current for their operation.

In any high gain direct coupled amplifier that has been designed for general use the question of proviing alternative capacitor coupling should be considered. The performance of direct coupled amplifiers is so much inferior to capacitor coupled amplifiers that their usefulness would be considerably restricted if this additional method of coupling is not available. A method for doing this is discussed elsewhere.[21] It is only necessary to provide resistance-capacitance coupling at one point in the amplifier.

Stabilisation by Negative Feedback

The advantages of negative feedback in general are so well known that they need not be elaborated here. To obtain the maximum stabilising effect it is desirable to take the feedback from the output and apply it at the input in the correct phase for degeneration. The degree to which feedback may be applied depends upon the phase shift brought about at the higher frequencies by the stray capacitances. High frequency oscillation will occur when the feedback factor is large, unless some means other than stray capacitances are taken to limit the upper frequency response of the amplifier.

Feedback in D.C. amplifiers should be degenerative for mean D.C. level changes as well as the differential voltage changes. While it is possible to degenerate the differential components over any number of stages, odd or even, by crossing the feedback from one side of the balanced circuit to the other, changes in the mean D.C. level of a balanced stage can only be degenerated over an odd number of stages if grid injection is used. If separate cathodes are used in the first stage, cathode injection may be used and negative feedback may then be applied over an even number of stages. Mean D.C. level feedback may be applied separately from differential (signal) feedback. This is desirable because the required level of signal amplification limits differential feedback. By applying mean level feedback separately 100 per cent degeneration can be achieved. Buchthal and Nielsen[28] appear to be the first to have considered this problem. They used the circuit shown in Fig. 15.

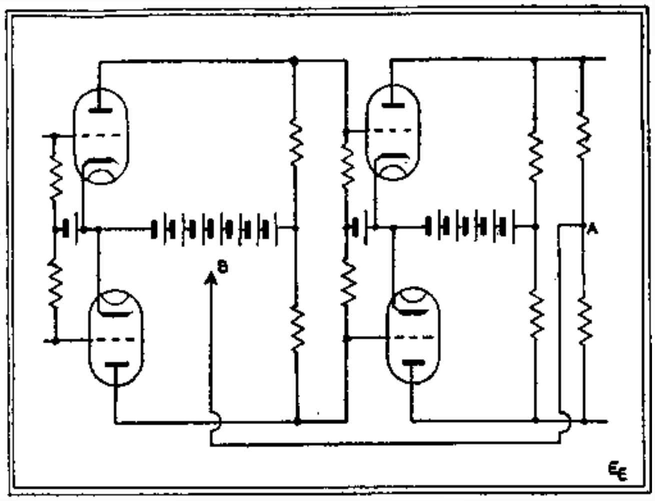


Fig. 15. Feed-back of mean D.C. level when using batteries

In-phase fluctuations of potential are fed back from A to B. Johnston[29] has described a similar arrangement (Fig. 16).

By a simple modification of Johnston's circuit the authors[30] have been able to achieve 100 per cent mean level feedback without introducing a high resistance in the anode circuit of the earlier stage. The circuit is shown in Fig. 17.

Use is made of a cathode follower V_2 to provide the high tension supply to valves V_1, the grid of V_2 being controlled by the mean potential of the anodes of the second stage. This method of applying mean level feedback has the advantage that the gain of the first stage can be increased by reason of the higher H.T. supply available compared with the case if direct coupling is used. It is also easier to set up. In practice where the third stage is cathode coupled, the grid of the cathode follower V_2 may be connected to this common cathode. If the common cathode load is large there is very little attenuation of the mean level fluctuation of potential applied to the grid of V_2 and the resistors R_1 and R_2 are eliminated. If the amplifier is perfectly balanced and provided the in-phase changes are not sufficiently large to swing the valve characteristic outside the linear range, these changes will not produce any differential unbalance and mean level feedback would be unnecessary. In practice, however, any shift of the working voltages over a stage will cause some unbalance, and this form of feedback will tend to minimise the effect.

When the feedback factor is large, precautions have to be taken to avoid disturbing the D.C. working voltages of the stage into which the feedback is introduced; this occurs if the feedback is taken from a stage whose operating potential is considerably higher than that of the earlier stage. As the input grids are generally at about earth potential, the feedback may be very conveniently taken from the earthy end of the cathode load resistor if a cathode follower output stage is used.

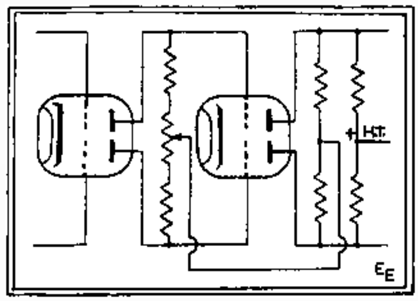
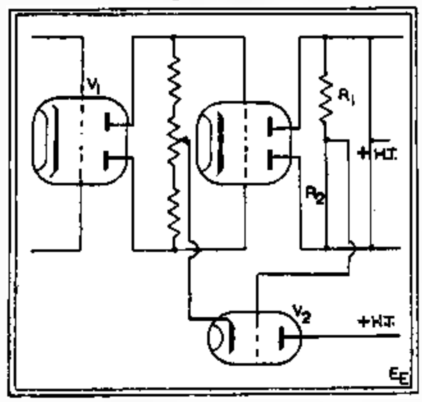


Fig. 16 *(above)*. **Feed-back of mean D.C. level through resistance**

Fig. 17 *(below)*. **Feed-back of mean D.C. level through cathode follower**



Conclusions

Some general conclusions may now be stated. It is probable that the design of direct coupled amplifiers is approximating to the condition in which the residual instability occasioned by disturbances in the external parameters is of smaller consequence than that due to random fluctuations. The most critical external parameter is the heater current supplied to the first valves. The probable order of magnitude of these random fluctuations has been discussed for two cases of valve application. The best performance as regards residual instability that can be expected from a direct coupled amplifier with the input grid shorted to earth and the frequency response flat from 0 to 5 Kc/s. is 50 – 100 μV peak to peak over a period of 30 minutes. Increasing the resistance in the grid circuit does not impair this performance very much until the grid leak becomes very large. It is quite practicable to obtain the necessary power supplies from the A.C. mains.

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A Time-Sharing System of Multiplex

By H. D. B. KIRBY, M.A.*

MANY years ago it was realised that multiplex radio links could be inserted in communication systems in many cases where it was impracticable to lay cables or build overhead wire routes, and much development work during the last twenty years has been directed toward the practical realisation of an efficient and reliable system. Since only one or two radio frequencies are normally available for such a service some system has to be devised by which all the telephone or similar channels may be transmitted on the same carrier frequency. Two general methods have been used.

In the first the channels each modulate a different sub-carrier frequency, the whole group of frequencies which results being then used to modulate the R.F. carrier. This is the arrangement which was used in the Belfast-Stranraer Radio Telephone Link[1] inaugurated in 1937, the first application of the system in which as many as nine telephone channels were passed simultaneously over a single radio link.

The second general method is the time-sharing method in which, as in the original Baudot telegraph system, the channels are transmitted in rotation. Although the idea of applying this system of telephony dates back to the beginning of the century, it was only during the late war that a practical application was evolved—as exemplified by the Army No. 10 set. This application is based on the fact that a speech or other voice-frequency waveform can be transmitted by sending samples of the instantaneous amplitude at comparatively infrequent successive instants. A sine wave, for instance, can be adequately represented by three or four samples per cycle. Fig. 1 shows a section of a speech wave (with D.C. polarisation), which could be represented by transmitting the amplitudes of the ordinates indicated and joining up these points by suitable means at the receiver. Thus, since short discrete signals can be used to indicate these amplitudes, it is possible to interleave a number of different channels by transmitting samples from each one in rotation.

Since it is necessary in a telephone system to transmit frequencies up to about 4,000 cycles per second the number of samples which must be be sent is at least 10,000 per second. Thus in a twenty-four-channel system 250,000 samples would have to be sent (including those required for synchronising the receiving equipment to the transmitter). Thus some form of high-speed switch is needed to connect each channel to the transmitting equipment at the right moment and this can only be provided by electronic means. Two forms of switch can be used, the first being a rotary type and the second consisting of a number of simple on-off switches, only one of which is closed at any time. The rotary type consists of a cathode-ray beam arranged to scan targets disposed round the periphery of a screen[2]. The second type comprises a number of electronic "on-off" switches and is used in the system to be described.

The obvious method of applying the necessary information to a radio frequency carrier is to transmit pulses of R.F. energy whose amplitude is representative of the sample. This method, however, is not the only possible one. For various reasons a constant amplitude method of modulation is more satisfactory. One such method is pulse-width modulation as used, for instance, in the Army No. 10 set[3]. In this system the leading edge of each pulse occurs with uniform spacing in time, while the position in time of the trailing edge is indicative of the signal amplitude.

* Standard Telephones and Cables, Ltd., London.

Fig. 2. (right) Block Schematic of System

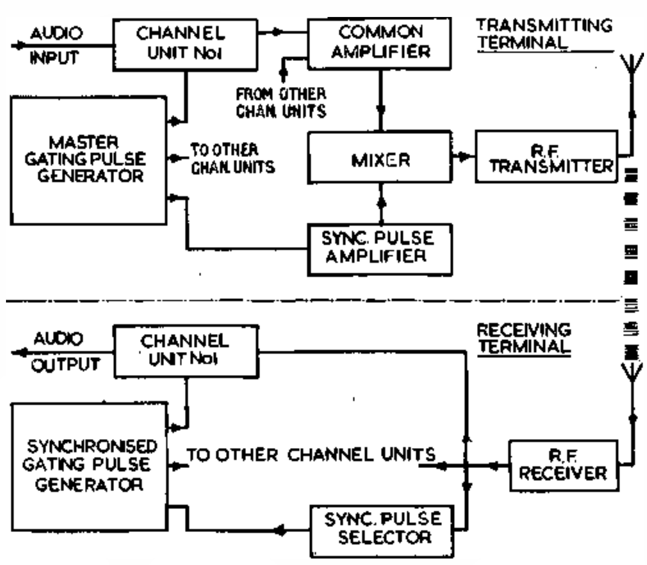
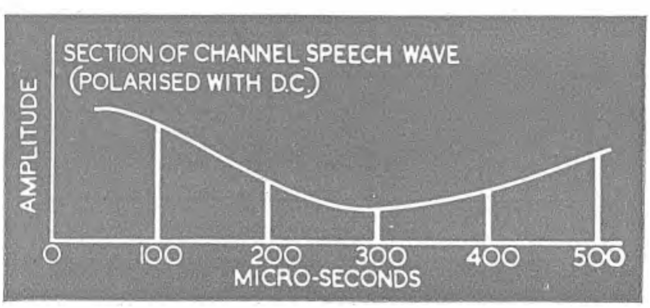


Fig. 1. (left) Polarised speech wave with ordinates set at 100 microsecond intervals



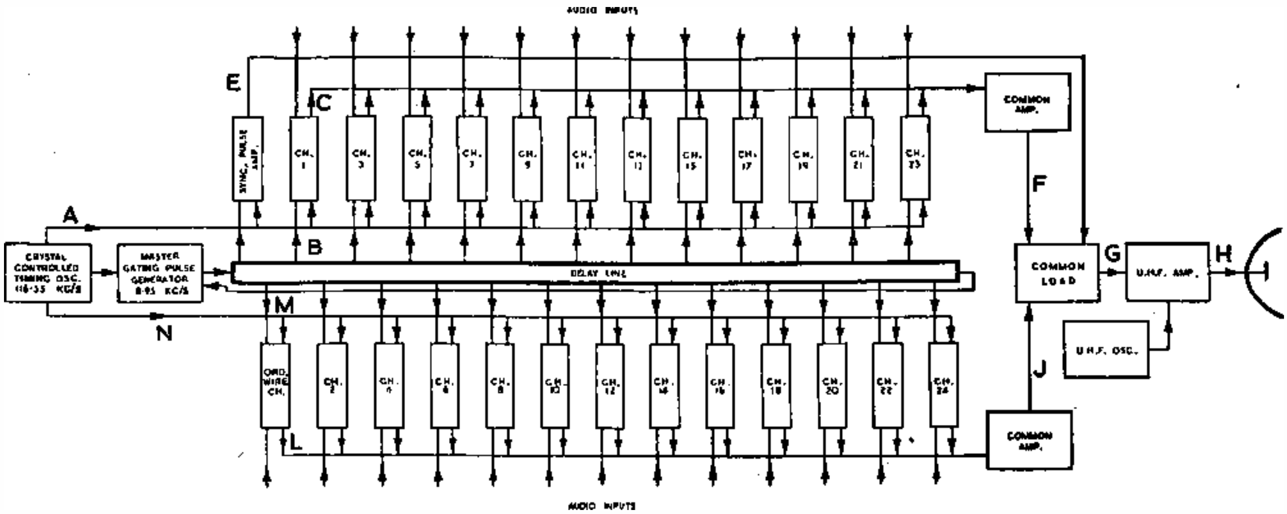


Fig. 3. Block Schematic of Transmitter

An extension of this idea is to use one synchronising pulse as a datum for all channels and to make the position in time of each signal pulse with reference to this synchronising pulse the indication of signal amplitude. In this way pulses of constant amplitude and constant width can be used which are advanced and retarded in time about their unmodulated positions by the positive and negative swings of the signal waveform.

A nine-channel system using this method of modulation was developed by Standard Telephones and Cables, Limited, for the Netherlands P.T.T. and has now been in service for two years. Similar 24-channel systems have recently been installed and are now in operation in Czechoslovakia and South Africa.

Principle of Operation

The general scheme of these systems is shown in Fig. 2 in which, for clarity, the elements for only one channel are shown. At the transmitter the master gating pulse generator delivers a continuous train of constant amplitude D.C. pulses from each of its output terminals in succession. There is one train for each signal channel and one for synchronisation. The synchronising pulses are widened to distinguish them from the signal pulses and are then passed through the synchronising pulse amplifier and the mixer to modulate the R.F. transmitter. The signal pulses are passed to the various channel units where they are modulated in time by the audio inputs. They are then taken through the common amplifier and the mixer to the transmitter. At the receiving terminal the R.F. pulse trains are amplified and demodulated in a super-hetrodyne receiver and delivered as trains of D.C. time-modulated pulses to the synchronising pulse selector and the various channel units. The synchronising pulses are selected by virtue of their greater width and used to drive the synchronised gating pulse generator which delivers a number of trains of switching pulses to the channel units. These units separate out the incoming channel trains, since they only pass those signal pulses which arrive in synchronism with the pulses from the synchronised gating pulse generator. The time modulated D.C. pulse trains are then converted to width-modulated pulses which are demodulated in passive filters and thus reproduce the original modulating waveform.

Since the pulses must, in addition to being sent at about 250,000 per second, also be of short duration and steep-sided, a bandwidth of about 6 Mc/s. is required for their transmission. The minimum carrier frequency is therefore about 300 Mc/s and the working range is limited practically to line of sight distances. This range can, however, be considerably extended by the the use of repeaters, especially with pulse-time modulation since there are, with this system, no rigid requirements to be met in regard to the accurate maintenance of amplitude levels to avoid channel intermodulation, and the insertion of repeaters causes only a very slight deterioration of signal to noise ratio.

The 24-Channel System

The system which has been installed in Czechoslovakia and South Africa is of the general form shown in Fig. 2. It is equipped for 25 speech channels, each of which is designed to pass any form of signal in the voice-frequency range 300 to 3,400 c/s. in addition to D.C. currents for signalling. Separate frequencies in the band 400 to 500 Mc/s. are used for transmission in each direction. Fig. 10 shows the general layout of the equipment, the transmitter being on the right and the receiver on the left of the photograph.

The Transmitter

A group consisting of a synchronising pulse followed by 25 channel pulses is transmitted every 112 microseconds. Thus the period available for transmitting the information about the instantaneous amplitude of each channel signal is 4.3 microseconds and 8,950 groups are sent per second. The duration of the channel pulses is approximately half a microsecond and of the synchronising pulse 2 microseconds.

Fig. 3 shows a block schematic of the transmitter and Fig. 4 some typical waveforms, those for the odd channels being shown from the top and those for the even channels from the bottoms of the diagram.

Referring to Fig. 3 the 116.35 Kc/s. Crystal-controlled Timing Oscillator shown on the left delivers a two-phase square wave output as

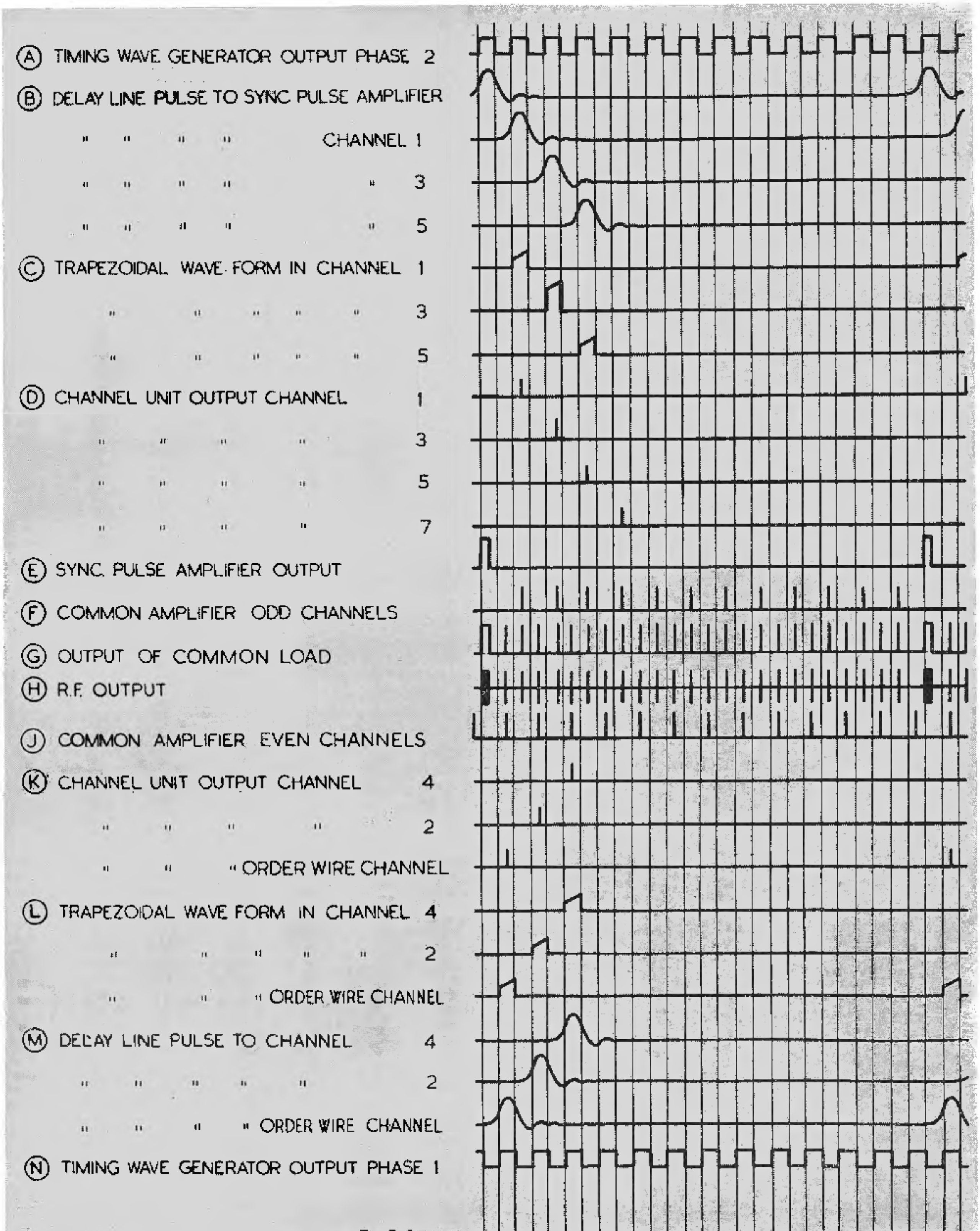


Fig. 4. Waveforms in Transmitter

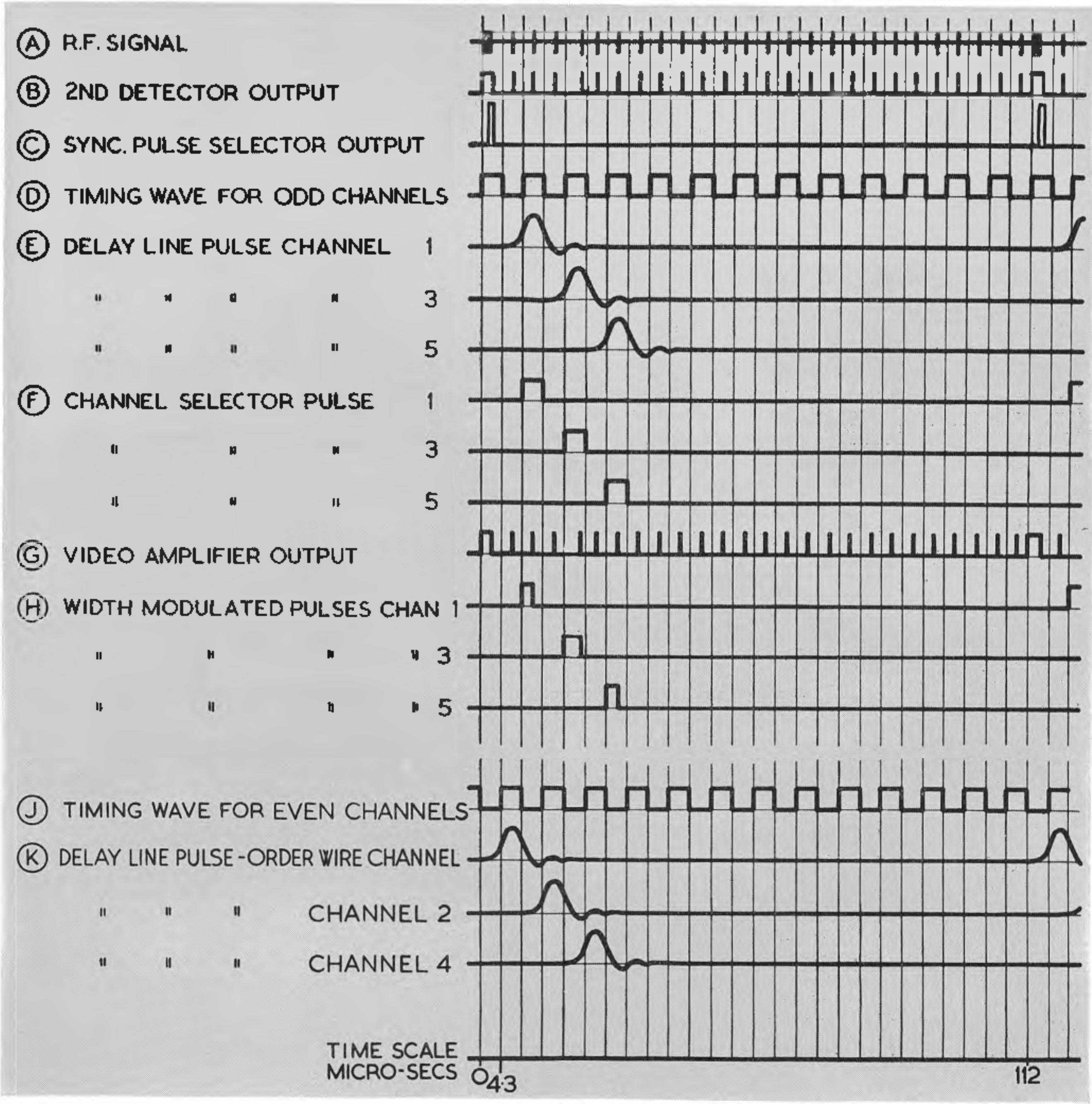
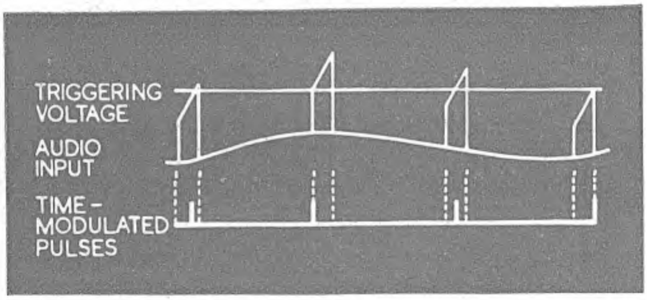


Fig. 7. Waveforms in Receiver

illustrated at (A) and (N) in Fig. 4. The master gating pulse generator comprises essentially a multivibrator, the frequency of operation of which is determined by the delay line. The multivibrator is synchronised by the timing oscillator and outputs as shown at (B) and (M) are tapped off along the delay line. The output from the beginning of the delay line is taken to the Synchronising pulse amplifier together with one phase of the timing oscillator and is there converted to a square pulse (E) of 2 microseconds duration. In each channel unit a gating valve is arranged so that it only passes those pulses from the timing oscillator which coincide with the output from the delay line connected to that channel. Those pulses which are passed through are then converted to trapezoidal form (C) and (L) and added to the audio inputs, so that the height of the trapezoidal pulse is indicative of the amplitude of the signal. The trapezoidal pulses are then used to trigger another pulse generator so that the time at which the resulting pulses occur is dependent on the height of the trapezoidal pulses and thus on the amplitude of the audio input. This process is shown in



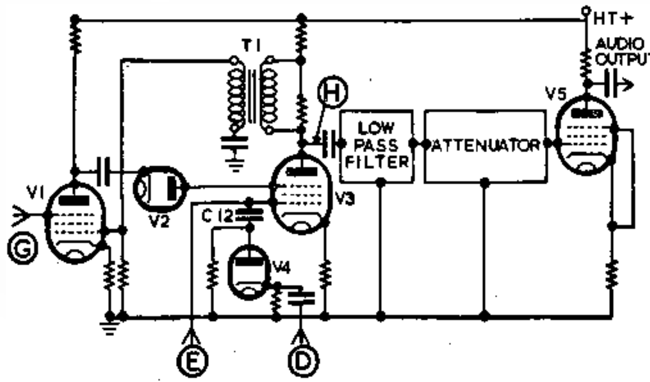


Fig. 5. (above) Formation of time-modulated pulses

Fig. 8. (right) Receiver channel unit (Simplified Schematic)

Fig. 3 and it can be seen that as the amplitude increases, the triggering time is advanced and as it is decreased the triggering time is retarded.

The time-modulated pulse outputs from the channel units are amplified by two amplifiers, one common to all the odd channels and one to the even channels. The outputs from these common amplifiers and from the synchronising pulse amplifier are combined in the common load into an interlaced group of pulses (G).

The continuously running U.H.F. oscillator drives an output amplifier which is normally biased to cut-off. This bias is removed by the D.C. pulses (G) so that pulses of R.F. energy (H) are delivered to the antenna.

The Receiver

Fig. 6 shows a block schematic of the receiver and Fig. 7 shows some typical waveforms, channel 8 being modulated.

The R.F. signal (A) after amplification and demodulation is passed on as D.C. pulses (B) from the second detector to the video-frequency amplifier. The Synchronising pulse selector passes the synchronising pulses and rejects the channel pulses by virtue of the greater width of the former in the following manner. The output from the video-frequency amplifier is applied to a short delay line via a cathode follower, and from two tappings, separated by a time delay greater than the width of a channel pulse but less than the width of a synchronising pulse, two series of positive pulses are obtained, one of which is applied to the control grid and one to the suppressor grid of a pulse amplifier. Since this valve is biased so that it will only pass current when the pulses applied to the control and suppressor grids overlap, the output will consist of negative pulses at the group repetition frequency (8.95 Kc/s.). These pulses are converted to positive pulses by means of a pulse transformer and passed to a cathode follower.

The output (C) from the cathode follower is used to drive the synchronised gating pulse generator which supplies a train of square pulses to the delay line. Outputs as shown at (E) and (K) are tapped off along the delay line and applied to the channel units. The positive pulses (C) from the cathode follower are also applied to the timing wave selector and amplifier, which selects the thirteenth harmonic by means of tuned circuits and is arranged to give two out-of-phase square outputs (D) and (J) at 116.35 Kc/s.

The operation of the receiver channel units can be seen from the simplified schematic Fig. 8. The gating pulses (E) from the delay line are applied to the control grid of *V3* and one of the 116.35 Kc/s. outputs (D) from the timing wave selector and amplifier is applied to the cathode of *V4*. The positive pulses of the timing wave cause *V4* to cut-off and therefore effectively remove the capacitor *C12* from the grid circuit of *V3*. This does not normally affect the operating condition of *V3*, but when a pulse from the delay line arrives it causes the valve to conduct at the instant when *C12* is removed by the timing wave. The resulting negative pulse at *V3* anode is applied to the control grid of *V1* after phase-reversal in the transformer *T1*. The whole group of synchronising and channel pulses (G) is applied to the suppressor grid of the same valve which is normally biased beyond cut-off. Anode current commences to flow, however, as soon as the positive pulses on the

Fig. 6. Block Schematic of Receiver

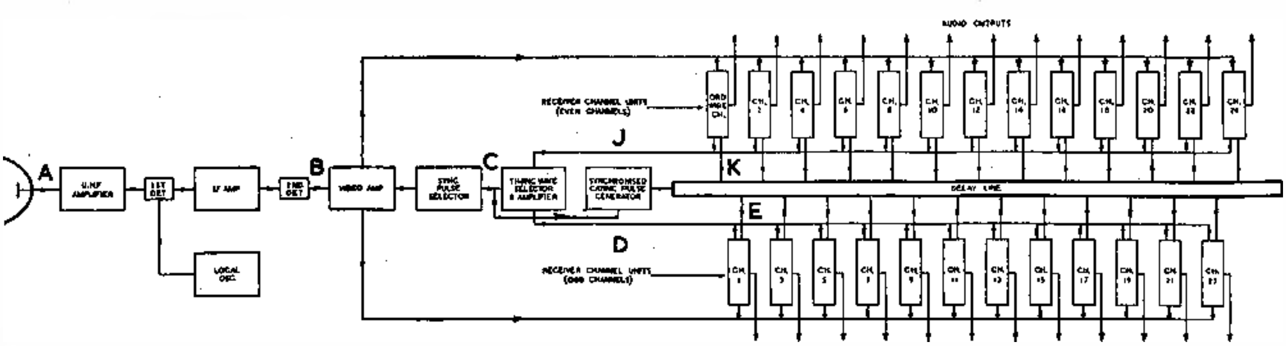


Fig. 9. One of the aerials at Flushing

suppressor and control grids coincide. The resulting negative pulse at the anode of $V1$ is applied via the diode $V2$ to the suppressor grid of $V3$ which immediately ceases to conduct. Thus a square pulse (II) is produced at the anode of $V3$, commencing with the arrival of the timing wave positive pulse in the presence of the pulse from the appropriate part of the delay line and ending with the arrival of the channel pulse. Since the channel pulses are time-modulated the pulses at the anode of $V3$ will be correspondingly width-modulated. They are then converted to the form of the original A.F. input to the transmitter by means of a low-pass filter. After amplification in $V5$ this signal is passed out to line.

Performance

The 9-channel link has now been in use in the public telephone service of the Netherlands P.T.T. for two years between Vlissingen (Flushing) and Oostburg across the River Scheldt. Fig. 9 shows one of the dipole aerials with its corner reflector at Flushing during installation. The link carries practically the whole of the external telephone traffic from West Zeenwsch Vlaanderen. Measurements made daily during the first five weeks of operation show the following results:

(1) The average signal-noise ratio with reference to 100 per cent modulation was 52.4 db. at Oostburg and 52.0 db. at Vlissingen.

(2) The average value of inter-channel cross-talk was less than 60 db. Although at one time this rose to 53 db. between two channels at the Oostburg receiver, there was no audible interference between these channels under normal service operation.

One of the 24-channel systems is in operation between Poprad and Strbske Pleso in Czechoslovakia. The latter is a health resort situated 1,350 metres above sea-level in the High Tatra mountains, where weather conditions can be most severe. However no trouble has so far been experienced from ice on the aerials or similar causes.

Preliminary tests gave satisfactory values of signal-noise ratio and inter-channel cross-talk, and the link was put into service on April 6, 1948. Maintenance of the equipment was carried out for a week by British engineers and was then handed over to Czechoslovak engineers, who had been specially trained for the purpose during the initial tests.

A similar system was installed in South Africa between Port Elizabeth and Uitenhage and was handed over to the South African Post Office in November, 1948. Measurements taken during the installation period and the first 12 weeks of commercial operation gave an average signal-to-noise ratio of 63 db. and a cross-talk value also of 63 db.

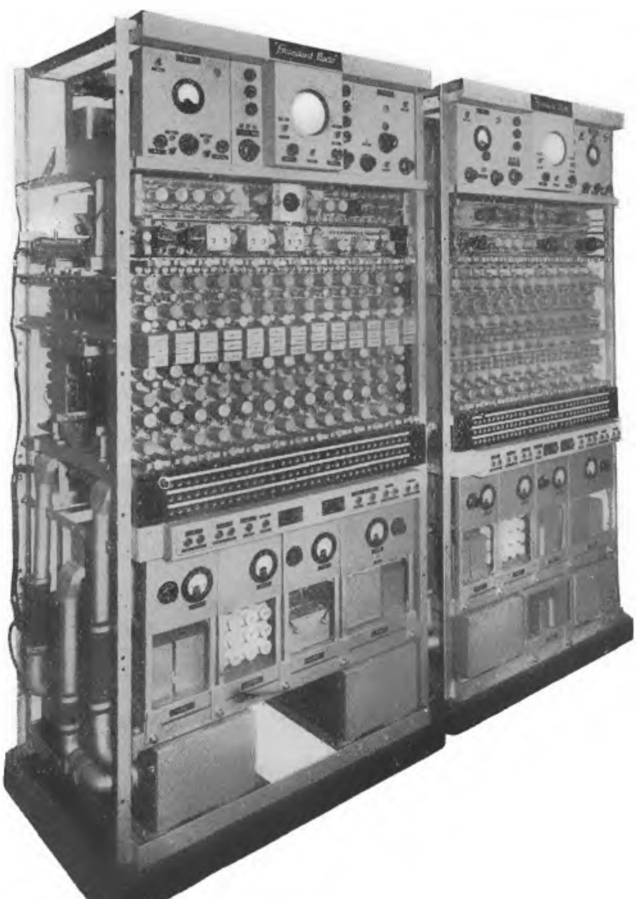


Fig. 10. 24-Channel Equipment, with covers removed

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1 The Belfast-Stranraer 9-Circuit Ultra-Short Wave Radio Telephone System, D. B. Mirk. *P.O.E.E. Journal*, April 1938.
2 Pulse-Time Modulated Multiplex Radio Relay System Terminal Equipment, D. D. Greig and A. M. Levine, *Electrical Communication*, June 1946.
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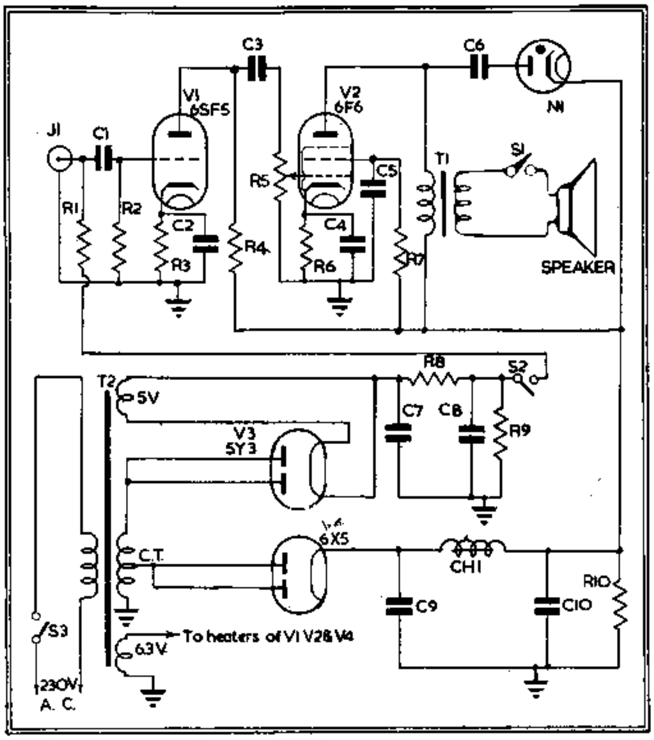
September Meeting

Television Society— Constructors Group
Date: September 29. Time: 7 p.m.
Held at: C.E.A., 164 Shaftesbury Avenue, W.C.2.
Lecture: "Notes on the Reception of B.B.C. Television signals in Guernsey."
By: F. T. Bennett.

BUILD YOUR OWN GEIGER COUNTER

From an article by Walter B. Ford in *Radio and Television News*, July, 1949



Schematic of the Geiger-Muller tube amplifier and counter. Radio-activity pulses are indicated by flashes on a neon light and loud clicks in the speaker

R1	= 10 megohm, ½ w.	C2	= 0.05 μFd., 400v.	Ch1	= 30 Hy. @ 50mA filter choke.
R2	= 20 megohm, ½ w.	C3	= 0.01 μFd. mica.	S1, S2	= S.p.s.t. toggle sw.
R3	= 2000 ohm, 1 w.	C4	= 0.5 μFd., 400 v.	S3	= S.p.s.t. sw. on R5.
R4	= 100,000 ohm, 1 w.	C5	= 0.01 μFd., 400v.	N1	= Neon lamp (NE-51).
R5	= 250,000 ohm, pot. with sw. S3.	C6	= 0.5 μFd., 400v.	Spkr.	= 5" p.m. speaker.
R6	= 500 ohm, 2 w.	C7, C8	= 0.25 μFd., 1500v.	J1	= Single contact chassis jack for lead to tube.
R7	= 1000 ohm, 1 w.	C9, C10	= 16 μFd., 450v. elec.	V1	= 6SF5.
R8	= 50,000 ohm, 1 w.	T1	= Output trans., match to 7000 ohms.	V2	= 6F6.
R9	= 1 to 5 megohm. (See text)	T2	= Power trans. 350-0-350v, 70mA.; 5v. 2 amp.; 6.3v. 2 amp.	V3	= 5Y3.
R10	= 18,000 ohm wirewound 20 w.			V4	= 6X5.
C1	= 500 pF, 1500v. mica				

THE amplifier, the schematic of which is shown here, consists of a two-stage unit in which the pulses are indicated by flashes on a neon light accompanied by loud clicks in the loudspeaker, or by the neon light alone. This last feature is particularly desirable where the loudspeaker noises might become annoying to the operator over long periods of time.

The circuit diagram follows the conventional audio frequency amplifier, with the exception of the input circuit and the neon light indicator. Owing to the high value of the grid resistor of the 6SF5 input valve, hum is apt to be pronounced unless the builder makes the input leads as short as possible. A further aid to keeping hum to a negligible amount is to shield both the grid resistor and the 500 pF coupling capacitor. Since we are not concerned with any particular frequency response, the capacitors C2 and C4 are much lower in value than would normally be required.

The power supply is unique in that it provides high voltage for the counter tube from a conventional low-power transformer, and is similar to some television power supply circuits. The plate voltage for the amplifier valves is obtained through a 6X5 valve from the centre tap of the transformer and an outside lead, which is grounded. The other lead from the transformer is connected through a 5Y3 valve, acting as a half-wave rectifier similarly to the 6X5, then to the filter circuit and the Geiger tube resistor. Since the current drawn by the counter tube is a negligible two or three microamperes, the voltage available from the 5Y3 valve will approach the peak value and will be approximately 1000 volts, and because the current drain of the Geiger tube can be ignored, the builder has within his means almost perfect regulation of the high-voltage circuit. The voltage available will be determined by the current drawn from the power supply and may be regulated to fine degree by varying the value of bleeder resistor R9. A simple way to check the voltage in to insert a low reading milliammeter in series with R9 and calculate the voltage from Ohm's law. A switch, S2, is provided in the high-voltage lead to protect the counter tube from surges when the power is first turned on and to provide a standby switch to keep the amplifier active, yet conserve the Geiger tube when it is not in use. The capacitors used in the high-voltage filter circuit, C7 and C8, were obtained from war surplus and consist of two 0.5 μfd, 1000 volt capacitors connected in series for each unit.

The Geiger tube should operate at 1000 volts and should be of the self-quenching type. While it would be possible for the counter builder to make his own probe for holding the Geiger tube, it is strongly recommended that both the tube and probe be bought as one unit. An unmounted Geiger tube is generally a rather fragile affair and is easily damaged by one not familiar with handling them.

Normally, a tube operating in the gamma region will meet the needs of prospectors and experimenters, but Geiger tubes for both gamma and beta rays may be obtained if desired. The tube used in these counters was a type TA-B3-AP with a P4 probe and cord.

The background count of a Geiger tube, that is, those counts due to cosmic radiations, is apt to vary widely with the manufacture of the tube. In any event, the useful counts given off by any specimen will be those per minute over and above the background count. The generally accepted count of worthwhile uranium ores is anything above 40 counts per minute.

ELECTRONIC EQUIPMENT AT RADIOLYMPIA, 1949

On this and the following pages is given a review of electronic equipment, including measuring apparatus for industrial and electro-medical applications, radar, television and communication equipment, compiled from information supplied by the exhibitors. Much of the equipment will consist of working demonstrations and The Service organisations or manufacturers concerned will be pleased to supply fuller technical information on request.

The Automatic Coil Winder & Electrical Equipment Co. Ltd., Winder House, Douglas Street, S.W.1 (Stand 85)

Electronic Test Unit (illustrated below)

This versatile unit, when used in conjunction with an oscillator or signal generator, such as the "AVO" signal generator, and a valve voltmeter such as the Electronic Testmeter, virtually converts the combination into a Q meter and enables the inductance, self capacitance and magnification of coils to be determined between the ranges of 0.5μH-50 mH, and the measurement of R.F. capacitors from 1 pF-1000 pF.

When used in conjunction with a valve voltmeter (electronic testmeter) alone, it is a wide range amplifier with a magnification of 40, from 30 c/s.-20 Mc/s. in five ranges. The first range extends from 30 c/s.-2 Mc/s. and is aperiodic, four further ranges including the range to 20 Mc/s. being flatly tuned and compensated to give virtually constant amplification.

The basic range of the electronic testmeter is thus extended to 25 mV full-scale deflexion up to 20 Mc/s., with indication at 2.5 mV, while, with reduced sensitivity, the combination can be used to give high frequency voltage indications at an extremely low input capacitance.

Westinghouse Brake & Signal Co., Ltd., King's Cross, London, N.1 (Stand 177)

A complete range of metal rectifiers for broadcast and television receivers, and for electronic and associated apparatus used in production and testing, will be shown.

Four models of the "Westeht" are now available. This unit provides E.H.T. from the 350—0—350 volts winding of the standard mains transformer and takes up less space than the E.H.T. rectifier valve and transformer it replaces. Positive outputs of 5, 3 and 1.7 KV are provided, the 3 KV also being available as a negative potential.

A Westeht will be demonstrated electrically and will be supplemented by a mechanical model showing working of the balanced multiplier circuit. 36 E.H.T. rectifiers will be demonstrated by a pulse circuit.

"Photector" photo-electric generators will be demonstrated. These photo-electric cells are of the barrier layer or rectifier type and are most suitable where the required electrical output is at low impedance, such as an indicating instrument or relay, which may be operated directly from the cell.

A demonstration of the "Stabilistor" shows the high degree of stabilisation and good output waveform attained with this A.C. voltage stabiliser under conditions of varying load and mains.

An automatic train announcer will be demonstrated. This has sixteen messages pre-recorded on magnetic tape, and automatically announces to passengers the destinations and intermediate stops of trains. It is connected to the existing visual train describer and track circuits, so that the approach of the train itself initiates the appropriate announcement.

E.M.I. Sales & Service Ltd., Hayes, Middlesex (Stand 67)

E.M.I. Oscilloscope

This versatile oscilloscope contains many refinements, enabling a wide range of circuit investigations outside the range of normal service gear to be carried out. A special feature is the voltage measurement system which, with the aid of the built-in voltmeter, enables D.C. or A.C. peak-to-peak voltages to be rapidly and accurately ascertained.

E.M.I. Automatic Monitor

An ingenious instrument which will automatically indicate, by buzzer or signal lamp, the occurrence or re-occurrence of an intermittent fault in any radio receiver to which it may be connected. Once set, the monitor requires no attention whatsoever until the fault is indicated.

E.M.I. Component Bridge

Measurements of inductance, capacitance and resistance over extensive ranges can be made with this advanced bridge.

E.M.I. Output Meter

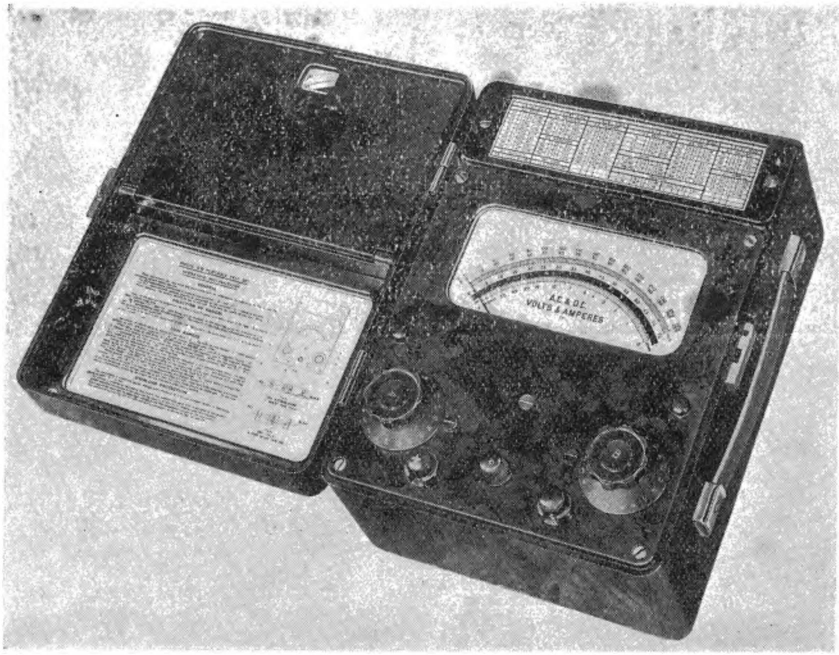
The E.M.I. output meter is a high-grade instrument measuring output both in decibels and watts. Accurate receiver alignment is greatly facilitated by the use of such an instrument and there are also a great many other uses to which this output meter may be put.

Taylor Electrical Instruments, Ltd., Slough, Bucks. (Stand 14)

The complete range of Windsor and Taylor radio test equipment will be exhibited, together with a suitable selection of panel instruments, marketed under the "Taylor" trade mark and a wide range of components.

The items of major interest are:—

1. Model 170A electronic testmeter (*illustrated below*).
2. Model 240A, a pattern generator for television servicing. This is probably the first instrument of its type available at a competitive price.
3. Model 190A, a new and improved version of the Taylor audio oscillator.
4. Series 46A valve testers.
5. A new VU meter, particulars of which will be released at the Exhibition.



Standard Telephones and Cables Ltd. Connaught House, Aldwych, London, W.C.2 (Stand 173)

The exhibits are representative of the Company's activity in the fields of radio and television engineering, and comprise:—

Vestigial Sideband Transmission Equipment for Television

One sideband is transmitted completely, and the other up to 500 Kc/s. only. This means that the overall bandwidth required to be sent between transmitters is lessened, without undue distortion.

Thus with the equipment demonstrated, smaller cables can be efficiently used and the original B.B.C. signal before and after transmission through the system can be compared.

Microwave Radio Link

Recent developments have enabled radio links to supplement still more the wire telecommunication networks, and under suitable conditions they can be used in main line circuits. Transmission is limited to "line of sight"—roughly 30 miles—but repeater stations can increase this range. A radio link employing straightforward modulation processes would carry a proportion of the total circuits possible in a cable (perhaps as many as three supergroups, i.e., 180 channels). Range can thus be extended without introducing undue cross-talk or two cable terminals can be linked.

The model displayed illustrates, on a reduced scale, a typical repeater station with tower 200 feet high operating automatically, with surveillance over a service channel and monthly visits by maintenance personnel.

Time-Sharing Multiplex Radio Link

The U.H.F. radio link equipment, type D.P.1, is for use where a wire system between points is impracticable or uneconomical to install. Simultaneous duplex working is provided on up to 24 channels, each passing voice frequency between 300 and 3,400 c/s., and having a D.C. signalling circuit. Alternatively channels may be used for telegraph or teleprinter working.

The equipment operates within the band 400 to 500 Mc/s. over "line of sight" distance, extensible by use of repeaters and terminating in two-wire or four-wire circuits, as required. Remote control and alarm systems are included along with built-in test and monitoring facilities. Each channel unit is replaceable without interruption of other channel services.

Point-to-Point Transmitter

The D.S.10, a 3·5 KW. short-wave transmitter, operating on C.W., M.C.W., and telephony, is the type used in H.M.S. *Vanguard* during the Royal Tour to South Africa. With a frequency range of 2.5 to 22 Mc/s., it provides high quality telephone transmission and electronic keying up to 600 words per minute, and is suitable for airport control, ship to shore, and point-to-point communication.

Sangamo-Weston Ltd., Enfield, Middlesex (Stand 219)

Sangamo Weston will be showing the following ranges of meters: electrical measuring instruments, ammeters, voltmeters, wattmeters, in panel, switchboard and portable types. Frequency meters, decibel meters and relays, the latter including both miniature and G.P.O. types. A new portable test set model S.75 (*illustrated left*), which has 53 ranges, controlled by rotary switches, will also be on show. Of interest to manufacturers, laboratory standard and sub-standard instruments in various forms will be shown, as well as the insulation tester and the high voltage voltmeter which reads up to 6 KV.

Birmingham Sound Reproducers Ltd., Old Hill, Staffs. (Stand 81)

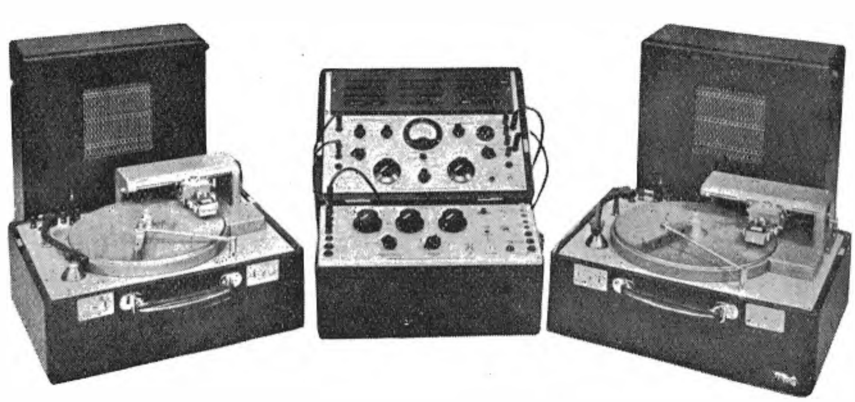
Disk Recording Equipment

Here a completely equipped disk recording and control bay is in operation and not only displays the new DR.66M transportable disk recording equipment (*illustrated below*), but also includes a new studio, electronic mixing and control console which is a versatile new conception primarily intended for large professional studios engaged on serious recording work.

New recording room equipment, for use in professional studios, is also shown and consists of console-mounted recording machines with the recording room main amplifiers and control equipment all rack mounted. A new microphone "boom," for studio or location work, with the usual range of mixing units, microphone, disks, stylii, etc., are also exhibited.

Laboratory Equipment

A full range of acoustic laboratory equipment includes the LO.50 and LO.800 audio frequency oscillators, vibration meter, audio transformers and chokes, together with one of the latest developments from the B.S.R. Research Laboratory, which is a new wave analyser and is especially suitable for noise analysis. This analyser, which is rack mounted, has a variable speed motor drive for frequency sweeping over the range 30 c/s to 30 Kc/s. Various degrees of selectivity are obtainable and provision for operating a pen recorder is also made.



Advance Components Limited, Back Road, Shernhall Street, Walthamstow, E.17. (Stand 209)

On this stand will be exhibited a range of signal generators, audio generators and constant voltage transformers. The signal generator exhibits will include the two wide-range models which have met such a big demand for the installation and servicing of television in both the London and Midland areas.

The Type B.4 is a substandard instrument made in two models. "A" covering 100 Kc/s. to 70 Mc/s. and "B" from 30 Kc/s. to 30 Mc/s.

The Advance Signal Generator, Type E.2, covering 100 Kc/s. to 100 Mc/s. on fundamentals, has already established its reputation as the ideal instrument for the T.V. service engineer. It is finished in cream and black and has a reliable attenuator system.

The Advance Type H.1 Audio Generator is an entirely new wide-range R-C oscillator covering from 15 c/s. to 50 Kc/s. It has provision for both sine wave and square wave output with reliable attenuation, allowing a variation from 200μV. to 20V. on sine wave and 400μV. to 40V. on square wave. It has the same cream and black finish as the Type "E" Signal Generator.

The Advance range of *Constant Voltage Transformers* reduce all voltage variations of ±15 per cent to within ±1 per cent and are available in all ratings from 4 watts to 6 kilowatts.

The General Electric Co. Ltd., Kingsway, London, W.C.2. (Stand 175)

On this stand will be displayed communication equipment, including some of the V.H.F. transmitters and receivers developed for commercial and industrial use and incorporating frequency or amplitude modulation. Airborne equipment will be shown, also the Radio Compass developed by the G.E.C. in conjunction with the Royal Aircraft Establishment.

Point-to-point radio transmitters will be on view and equipments designed for special purposes such as use on railway locomotives or for pack transport in remote overseas areas.

Other exhibits on this stand will include a representative selection of Osram products, including cathode-ray and Geiger-Muller tubes, photocells and valves. The last group will embrace valves in the broadcast range (transmitting and receiving), co-planar valves and magnetrons.

There will be a selection from the very wide range of G.E.C. sound equipment, covering loudspeakers, amplifiers, microphones, rack equipments and the new G.E.C. Tape Recorder.

A small section of this stand will be devoted to demonstrations of Geiger-Muller tubes, photocells, Watch Rate Recorder and Tape Recorder. A small selection from the Company's extensive range of testing and measuring equipment will be on show.

The British Thomson-Houston Co. Ltd., Rugby (Stand 178)

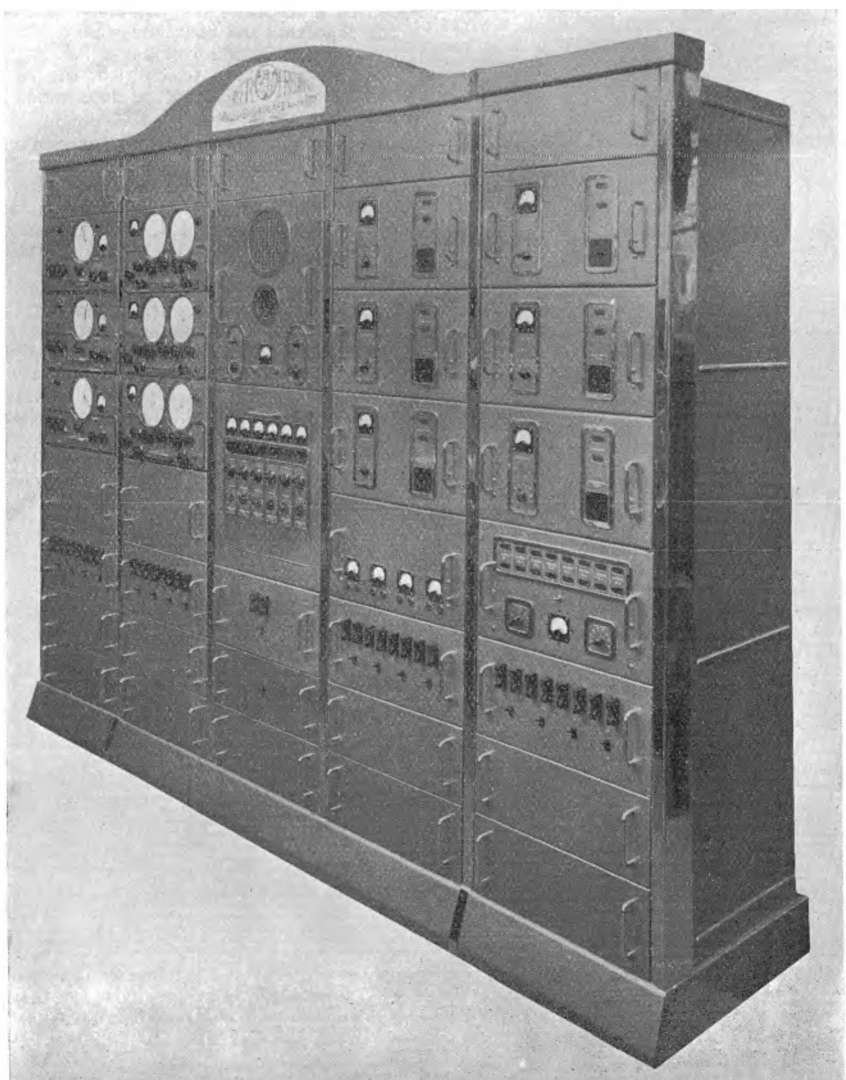
The B.T.H. is exhibiting marine radar and a representative selection of industrial electronic equipment, including "Emotrol" (electronic motor control); photo-electric relays; electronic timers for industrial processes; H.F. heaters of the dielectric and induction types; ignitrons (some in section), thyratrons, and hot-cathode rectifiers; a complete range of ignitron contactors and synchronously fired spot and seam ignitron panels, as used with resistance spot, seam, projection, flash and flash-butt welders; six-channel multi-broadcast relay equipment; 35 mm. SUPA and 16 mm. Type 301 sound-film projectors; crystal rectifiers; graded copper/glass seals; glass/metal seals, etc.

The B.T.H. marine radar is a 3 cm. equipment. It is supplied in completely prefabricated form in two units: (*a*) the radar cabin which houses the radar and control units, scanner and alternator equipment—normally fitted on the monkey island; and (*b*) the display unit, which is situated in the wheelhouse or chartroom. A monitoring system enables every valve in the complete set to be metered, individually, under load.

The multi-broadcast equipment (*illustrated below*) is a complete main-station equipment for providing six programmes, all of which are transmitted at carrier frequencies over a single pair of wires.

When compared with any audio-frequency relay system requiring multicore cables of large diameter or a multiplicity of smaller diameter overhead wires at the rate of two per programme, carrier frequency has the advantage of great simplicity, and a performance unaffected by the number of subscribers or length of line between transmitter and subscriber.

This equipment is manufactured for use in this country by B.T.H. for Multi-Broadcast (Engineering) Ltd., Rugby, and is available for export.



The Royal Air Force.

Among the most interesting of the R.A.F. exhibits will be a model of a typical permanent R.A.F. Station, constructed to scale by R.A.F. experts.

It will show the siting on the station of various types of radio installations for providing radio flying aids for navigation, approach, and landing, and radio communications. Also shown will be the hangars, workshops, administration buildings, living quarters, and sports grounds and other recreational amenities of the station.

The item is of particular interest, because it is so constructed as to give a complete bird's-eye view of an Air Force Station. Owing to the size of many stations to-day, their complete layout is often impossible to appreciate when visiting them.

The model represents the beginning of the general theme of the R.A.F. Radiolympia stand, which offers a representative collection of radio and radar equipment used by the Royal Air Force. The equipment being shown is indicative of the extent to which the Royal Air Force relies upon the radio industry to produce dependable radio equipment, able to withstand Service conditions, at great altitudes, and at very low temperatures and pressure.

Berlin Air Lift

The intricate flying control organisation of the Berlin Air Lift will be illustrated by a large diagrammatic wall map, showing the air corridors used to and from Berlin. It will show how the close control of many aircraft was absolutely dependent upon very close radio control, pin-point accuracy in flying, and compliance with instructions and regulations, so that the aircraft could land and take off, as they did, at an average rate of one aircraft every two and a half minutes.

Radio-Telephony Transmitter/Receiver

This is a 4-channel radio-telephony installation, for use in all R.A.F aircraft. It is an improved and lightweight type of transmitter/receiver, crystal-controlled on four pre-set radio channels.

Aircraft Radio Compass

This piece of equipment enables an aircraft to obtain a bearing on any radio station, within the frequency range of the specially designed radio receiver. It is particularly useful on overseas routes, and in areas where the development of radio aids for navigation is not up to usual standards.

Aircraft Radar Scanner

This type of Scanner is usually installed inside a perspex dome in the nose of the aircraft, for the purpose of scanning a large volume of space with a radar beam, to search for other aircraft. This type of equipment is invaluable for carrying out night interceptions.

Radio Altimeter

This instrument enables a pilot to determine instantaneously, by radar impulses and their reflexions from the ground, the exact height of the aircraft above the earth's surface at any moment.

Navigational Aid " Gee."

This radio navigational aid enables a pilot to fix his position quickly and accurately, by obtaining, simultaneously, two hyperbolic position lines transmitted from fixed ground stations. The position lines are determined from cathode-ray tube readings transcribed on to plotting charts.

Radio Navigation Aid " Rebecca "

" Rebecca " is an airborne, short-distance aid to navigation, operated in conjunction with omni-directional, pulse-repeating ground beacons known as " Eureka," which measures accurately the distance from the beacon, and gives a rough estimate of its bearing relative to the aircraft's course. " Rebecca " is also used as a beacon approach aid when used with a ground beacon known as B.A.B.S. (Beam Approach Beacon System), situated at the end of a runway. The exhibit shows the latest version of " Rebecca," and is an interesting example of modern miniaturised and pressurised equipment suitable for use in the latest types of jet aircraft.

Other Radar Equipment

This embraces radar equipment used in the reporting and control system operated by the R.A.F., and includes a P.P.I. (Plan Position Indicator), which gives the range and bearing of an aircraft as determined by radar.

Also on view, in the Olympia annexe near the R.A.F. stand, will be a mobile radio vehicle in which can be seen the methods used for plotting radar information, and carrying out controlled interceptions of aircraft.

Tele-Communications Apparatus

This apparatus illustrates how R.A.F. signals offices send messages between Air Force units, at home and abroad, by the radio-teleprinter system. The public will be permitted to send their own messages across the R.A.F. stand, and thus see exactly how R.A.F. signals are transmitted and received. Copies of the messages sent will be handed over and may be taken away as mementoes of the occasion.

Note.—Most of the R.A.F. exhibits will be arranged to show their operating conditions.

The General Post Office, London, E.C.2. (Stand 301)

On the G.P.O. stand will be exhibits as follows:—

(1) *London-Birmingham Television Cable.* The B.B.C. television transmitters at London and Birmingham will be linked by two coaxial tubes to provide for the interchange of programme material. The television tubes are 1 in. in diameter and form part of a composite cable with smaller tubes for multi-channel telephony. The cable also includes a number of balanced pairs which can be utilised for sound programmes and for control purposes. Samples of the complete cable are exhibited. Transmission over the special television tubes will occupy a frequency range of 3 to 7 Mc/s.; video frequencies up to 3 Mc/s. being transmitted on an asymmetric sideband system using a 6.12 Mc/s. carrier wave. The signals are amplified at intervals of approximately 12 miles along the length of the cable. The exhibit includes working examples of the equipment to be used for amplification and for modulation and demodulation at the terminal stations.

(2) *Interference Suppression.* To illustrate the importance of a good aerial the Post Office exhibit a model house equipped with examples of good, average, and poor aerials. Visitors can observe that the degree of interference is reduced as the height of the aerial and its spacing from the house electrical wiring are increased. Another exhibit demonstrates the suppression of interference from small electric motors such as desk fans, etc. There is also a demonstration of interference with television reception by motor-car ignition systems. It is shown how, by the use of simple and inexpensive suppressors, this type of interference can be minimised. Advice on how to obtain good reception and what to do if interference is experienced can be obtained from the Information Bureau on the Post Office stand. Equipment used by the Post Office for measuring, testing and suppressing interference is on display, whilst owners of electrical plant and manufacturers can also obtain advice.

(3) *Radio Links with Isolated Communities.* A low power V.H.F. radio-telephone system has been developed to provide normal telephone service to remote communities, e.g., the smaller islands of the Scottish coast. The equipment is operated from primary batteries and has been designed to work for long periods without skilled maintenance. To economise in energy consumption the transmitters and receivers are continuously energised only when a call is in progress. At other times the receiver operates intermittently, testing for a calling radio signal every half-minute. The transmitted power is between 20 mW. and 50 mW., and the frequency range is in the order of 75 Mc/s. to 90m Mc/s. Signalling facilities are provided so that the equipment will interwork with the normal telephone system. The exhibit shows prototype equipment operating as a radio connected subscriber on an automatic exchange.

(4) *3 Centimetre Radio Link.* Centimetric wave radio links may be used extensively in the future for relaying television signals and for multi-channel telephony. The demonstration shows the principles of operation of typical equipment. The transmitter consists of a 10,000 Mc/s. (3 centimetre) low-power reflex klystron oscillator which is frequency modulated by the television signal. The output of the transmitter is fed through a waveguide to a lens-horn aerial which produces a narrow beam of radio waves thereby concentrating most of the radiated power towards the distant receiver. Similar aerials are used on the receiver, the narrow beam width in this case serving to exclude unwanted signals and noise. The receiver is of the superheterodyne type with a reflex klystron local oscillator and a crystal mixer. The mixer is followed by a 60 Mc/s. I.F. amplifier, a limiter and a discriminator, the output from which is a replica of the television signal applied to the transmitter.

Marconi's Wireless Telegraph Co., Ltd., Chelmsford, Essex (Stand 174)

On the Marconi stand will be shown some of the latest developments in radio, radar and television, which fall into five main categories : Television; V.H.F. equipment; communications; aircraft radio and navigational aids.

The display will include live demonstrations of television and V.H.F. equipment–the latter showing how Marconi V.H.F. apparatus can be applied to daily newspaper reporting for the sending of news reports and photographs from the scene of a story to the newspaper's head office, whence it can be distributed simultaneously to all offices in a chain of newspapers.

Television Equipment

The portable light-weight television equipment in use on the Marconi stand will comprise two Image Orthicon cameras and associated control equipment, a picture control unit, and a picture monitor. Scenes inside the exhibition will be televised by the cameras and shown on the screen of a monitor receiver installed in a special viewing tunnel.

V.H.F. Radio

The complete range of Marconi V.H.F. equipment comprises a walkie-talkie, 2-watt transportable radio telephone; 10-watt transmitter/receiver; and 50-watt headquarters installation. The Marconi walkie-talkie (Type H.19) works within specified frequency bands between 36 and 132 Mc/s., and is a completely self-contained V.H.F. transmitter/receiver weighing only 12 lb. It can be supplied for either amplitude or frequency modulation. Type H.18 is a 2-watt V.H.F. transmitter/receiver and weighs 15 lb. As with the walkie-talkie, the H.18 can be supplied with either amplitude or frequency modulation. The transmitter and receiver can be set independently to operate on any of five crystal-controlled spot frequencies, in selected bands between 36 and 132 Mc/s.

The same frequency ranges are available in the Type TGV.401 10-watt V.H.F. transmitters/receivers. These, also, are optional A.M. or F.M. and both the transmitter and receiver weigh 15½ lb. In addition to its versatile mobile uses this 10-watt V.H.F. equipment forms a reliable stand-by for the 50-watt headquarters equipment.

The 50-watt Type TGV.472 is a fixed station installation which can be remotely controlled over ordinary telephone lines up to three miles distance.

Communications

The display of Marconi communication equipment will include a short-wave transmitter for telegraphy or radio-telephone; a communication receiver; and triple-diversity receiving equipment. The triple-diversity equipment is supplied either for single-sideband reception of two or three simultaneous telephone channels or for high-speed telegraphy, for frequency shift or on-off signalling.

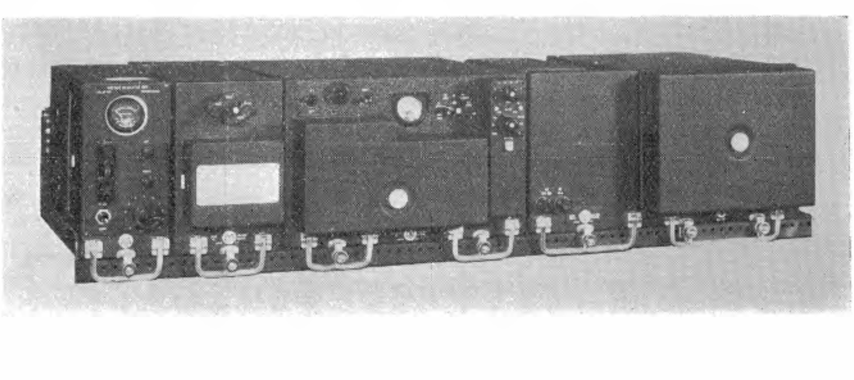
Aircraft Radio

Post-war demands for reduction in size and weight, and increased range and efficiency—brought about by the enormous strides made by the aircraft industry during recent years—have been met by the new Marconi range of light-weight aircraft radio equipment, which has been chosen for installation in the latest types of British air-liners. The high-power aircraft transmitter Type AD.107 (HF edition) is illustraed below.

On the stand will be seen a typical installation comprising H.F. and M.F. high and low power transmitters; aircraft receivers; beam approach receiver; and an automatic direction-finder.

Radar Equipment

A working model of the Marconi Company's "Radiolocator" land-based radar equipment is to be shown. Visitors to the stand may see how the "Radiolocator" traces a picture of an area up to 30 miles in radius about the observing station under all conditions of visibility. The exact location of objects appearing on the screen can then be accurately determined in relation to the observer's position, a factor which also makes the "Radiolocator" eminently suitable for use on board ship.



The Electrical and Radiological Instrument Co. Ltd., Church Road, Acton (Stand 181)

Among the instruments displayed will be a high impedance electronic voltmeter and an electronic timing device.

The latter is suitably housed in a metal case, together with a printing frame. The ranges provided for the time of operation vary from one second to 30 seconds and another scale which multiplies this scale by 20 times. The setting is by means of a calibrated pointer and is practically instantaneous. At the end of the time for which the apparatus is set, it is automatically switched off. Duplicating and printing of photographs can therefore be undertaken by entirely non-skilled personnel.

Department of Scientific and Industrial Research, 4-12 Regent Street, London, S.W.1 (Stand 53)

Of main interest to scientifically minded visitors to Radiolympia will be storm location equipment and automatic Ionospheric Recorder, and brief descriptions of both equipments are as follows:—

Storm Location Equipment

Every day observers in the British Isles "see" thunderstorms a thousand miles or more away. Storms which may be out in the Atlantic or over the Dalmatians are located by direction-finders at four stations in the United Kingdom. The information they collect is used mainly in compiling weather forecasts, and planning routes for aircraft.

Visitors will be able to watch a demonstration of location while seeing for themselves what is happening on the screens of supplementary cathode-ray tubes placed at intervals round the stand. These tubes will reproduce the images of the master tube in the apparatus.

At the end of the demonstration the equipment will be switched into an actual location period, so that the public will be able to see storms happening at that moment, perhaps over Benghazi or Spitzbergen, and watch them being "fixed".

Automatic Ionospheric Recorder

At Slough, the Radio Research Station has been carrying out experiments for the past twenty-five years to discover as much as possible about the behaviour of the ionosphere. An important piece of apparatus used for this purpose is the Automatic Ionospheric Recorder. This apparatus consists of a transmitter and a receiver, constantly in tune with each other. Radio waves sent out by the transmitter, sweeping through a frequency band of 0.55 Mc/s. to 25 Mc/s. (corresponding to wavelengths of 12 to 550 metres) in a few minutes, are echoed back by the ionosphere. The echoes are displayed by the receiver on a cathode-ray tube, and photographed. From the photograph the heights of the layers and their density can be determined. These photographs are obtained every hour at Slough, the other D.S.I.R. stations in Scotland, the Falkland Islands and Singapore, and about fifty other stations all over the world. The results of such measurements are exchanged.

From all these observations it is possible to forecast the behaviour of the ionosphere for some time ahead. Predictions of the best frequencies or wavelengths to use for communication and broadcasting are compiled six months in advance and issued to the Post Office, Cable and Wireless, the B.B.C., and many other authorities in this country and overseas.

The B.B.C., for example, uses these forecasts to decide when the frequency of an overseas transmission should be changed to get the best reception in the country aimed at, and ships and aircraft know in advance what frequency band to use for the best communication.

Airmec Laboratories Limited, High Wycombe, Bucks (Stand 156)

Airmec Laboratories are featuring a frequency sub-standard of wide application; a D.C. oscilloscope with a time-base down to one microsecond; a motor-driven oscilloscope camera and a non-destructive insulation tester which provides an indication of ionisation voltage.

Other instruments displayed include signal generators from 30 c/s. to 30 Mc/s.; electronic counters; direct reading frequency meter; time interval meter; valve voltmeter; power output meter; H.F. millivoltmeter; bridge amplifier and detector; heterodyne bridge detector; process timer; photo-electric cell equipment; magnetic amplifier and a radiation monitor for detection and measurement of alpha, beta and gamma rays.

Radiation Monitor, Type No. 1021 (illustrated below)

The Airmec radiation monitor has been designed for detecting and measuring the presence and amount of radio-active emanations and is suitable for indicating radio-active contamination of benches, floors, walls, chemical glassware and other places. It is also suitable for tracing radio-active materials in chemical analysis and for measuring contamination of effluent resulting from such processes.

The design of the unit is such that it may be used for accurate measurement of beta particles and gamma rays.

The instrument is mains operated and entirely self-contained. Controls and indicators are incorporated in the main part of the instrument.

The radiation sensitivity device is housed in a probe unit, two of which are available, one suitable for detecting beta gamma radiation and the other suitable for detecting alpha particles.

Indication of radio-activity is given by means of a miniature loudspeaker situated on the front panel and by a meter which reads in counts per second. The instrument has four ranges covering from 2 counts per second to 2,000 counts per second.

Valve Voltmeter, Type No. 712 (above)

This valve voltmeter is designed as a general-purpose instrument, possessing a high degree of accuracy and covering a wide frequency range. In addition to the normal A.C. voltage ranges, the instrument also measures balanced or differential A.C. voltages.

E. K. Cole Ltd., Southend-on-Sea, Essex (Stand 153)

On this stand Ekco display a representative range of their more advanced products in the V.H.F. and Nucleonic fields—developed and manufactured in the Development and Engineering Division at Southend, and in the Electronics Division, Malmesbury Wilts. A greatly extended range of Ekco aircraft communications equipment (both ground and airborne) will be shown, including the highly successful Ekco twin and 4-channel installations for light aircraft with complete D.F. facilities; a new multi-channel installation suitable for a wider field of regular civil aviation requirements and a compact test equipment for V.H.F. Mobile V.H.F. transmitter/receivers for other than air use (services such as Police, Fire, Ambulance, Taxis, etc.) will be on display. Ekco cloud and collision warning radar apparatus demonstrates the Company's valuable contribution to navigation and examples of Ekco advance production in nucleonic and atomic progress include scalers, monitors and amplifiers developed in conjunction with the Government Establishment at Harwell. A small but interesting item is the Ekco solder pencil, developed for miniature electronic work and now generally available.

Pye Telecommunications Ltd., Ditton Works, Cambridge. (Stand 180)

Messrs. Pye Telecommunications Ltd. are exhibiting a range of mobile telecommunication equipment designed primarily for use in V.H.F. Radio Telephony.

Exhibited will be:—

(a) A 3-watt mobile set (Series PTC. 108).
(b) A 5-watt mobile set (Series PTC. 113).
(c) A "Dolphin" marine set (Series PTC. 110).
(d) A 15-watt mobile set (Series PTC. 114 and 115).
(e) A 15-watt fixed station (Series PTC. 703 and 704).
(f) A Voltage Regulator.

This new Pye equipment has been designed to provide, as far as possible, a standard high performance mobile radio-telephone for use on any frequency from 30 Mc/s. to 184 Mc/s.

Universal 3-watt Mobile Equipment A.M.

The Pye Universal 3-watt Radio-Telephone (*illustrated below*), has been designed to meet the need for a compact, single-unit equipment of high performance.

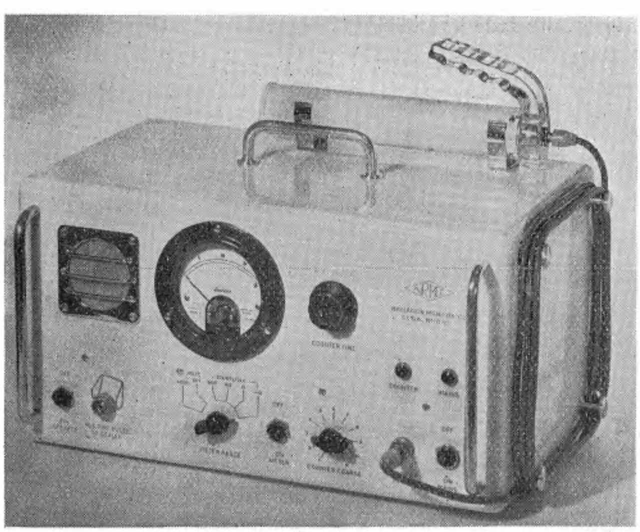
The small size, light weight and low battery consumption of this transmitter-receiver make it ideal for many uses where installation of high-powered equipment is impracticable.

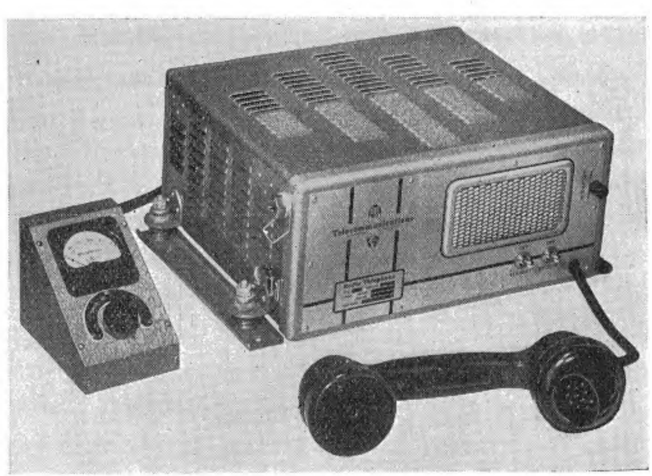
Technical Specification

Receiver: This incorporates 11 valves, comprising R.F. amplifier, mixer, crystal oscillator multiplier, 2nd multiplier, three I.F. amplifier stages, double-diode signal and A.G.C. detector, double-diode noise limiter, A.F. amplifier, pentode output.

Transmitter: This incorporates five valves, comprising crystal oscillator multiplier, 2nd multiplier, power amplifier, push-pull modulator.

Microphone: Double button carbon.
R.F. Output: 3-4 watts.
Modulator Response: 6 dbs. down at 200 and 3,000 c.p.s.





Murphy Radio Ltd., Welwyn Garden City, Herts. (Stand 160)

On this stand will be exhibited products of the Electronics Division of Murphy Radio Ltd.

Selected exhibits, with brief descriptions of each, are:—

(1) *Radar Navigational Beacon*, 5KW.

(2) *V.H.F. and H.F. Transmitters.* 50 watt.

(3) *H.F. Communication Receiver.* Crystal controlled. For aircraft and general communication.

(4) *Voltage Regulator.*

(5) *Public Address Amplifier.*

(6) *Multi-Channel V.H.F. Transmitter/Receiver for Aircraft.* Five channels immediately available; additional channels by changing crystals.

(7) *Single-Channel V.H.F. Transmitter/Receiver for Light Aircraft.*

(8) *MF/DF Radio Equipment for Light and Medium Aircraft.* Receives Airmet, Radio Ranges, Consol, etc., and gives bearings on MF/DF beacons.

(9) *Business Radio.* Transmitter/Receiver.

(10) *Naval B40/B41 Receivers.* High performance communications receivers.

(11) *Marine Receivers.* Approved general-purpose communications receivers.

(12) *Dielectric Welding Machine.* For jig-welding of plastic materials.

Of particular interest are the equipments employed in interference tracing and measuring.

They are:—

(*a*) *The Interference Measuring Set*, which is primarily a V.H.F. receiver for field strength and terminal voltage measurements to approved standards; and

(*b*) *The Interference Tracing Set* (*illustrated*) which is a lightweight portable interference locating receiver, covering the frequency range 30-100 Mc/s. and particularly suitable for tracing interference with Television, Business Radio and Police services.

This receiver is a sensitive superheterodyne covering the frequency range in three bands with ganged tuning of aerial and oscillator circuits, supplemented by an aerial trimmer control. A plug-in attenuator of approximately 30 db. provides additional attenuation at the signal frequency for use in areas of exceptionally high noise field intensity.

Special attention has been paid to the frequency changer stage in order to avoid spurious signals and the fundamental frequency of the local oscillator is used on all bands with the same object. The I.F. frequency is 3Mc/s., providing high gain in four stages. The 1st, 3rd and 4th I.F. stages are gain-controlled by adjustment of screen voltage with a total range of approximately 30 db. and the potentiometer provides an approximately logarithmic scale. The 2nd I.F. stage is arranged to modulate an incoming CW signal at an audio frequency. 1.4 volt low consumption battery valves are used throughout operating from dry batteries.

Two separate detectors are a feature of the instrument, one having time constants suitable for impulsive noise indication and the other for audio frequency detection. One valve acts as a combined D.C. amplifier feeding an indicating meter and the other provides the output stage for listening.

Both rod and loop type aerials are provided, the latter being a semi-stiff screened loop which gives useful indication of the direction of an interference source. The rod aerial is in demountable sections, giving an additional means of reducing pick-up from strong signals.

Hazelhurst Designs Limited, 186 Brompton Road, London, S.W.3. (Stand 205)

On the Hazelhurst Stand can be seen the new C4/6 R.F., E.H.T. unit (*illustrated*) with an output voltage of 6 to 8 KV. This has been designed for television and other applications and is a considerable improvement on the earlier types, having a far greater stability of output over wide temperature changes, greater efficiency and better regulation.

The C4/2 is a new 33 KV. coil unit which will supply up to 1mA. and has been designed for breakdown testing equipment.

A new 15 to 25 KV. variable, stabilised unit will also be shown. This unit has a current range up to 500 microamps with less than 1 per cent change of output voltage.

Other exhibits include:—

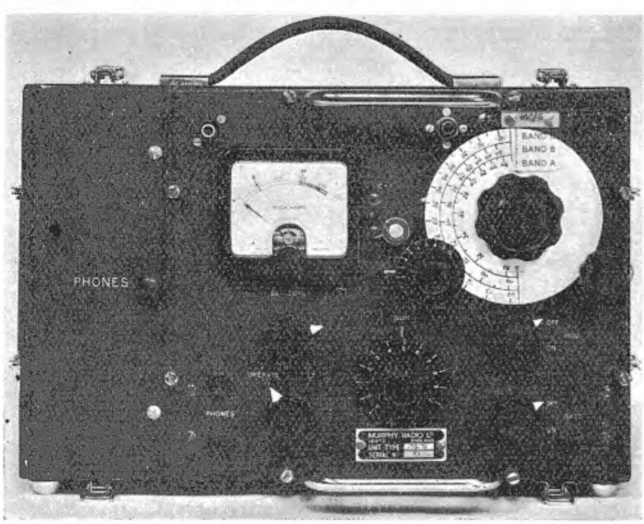
(*a*) Cheap 25 KV. unit for projection television.

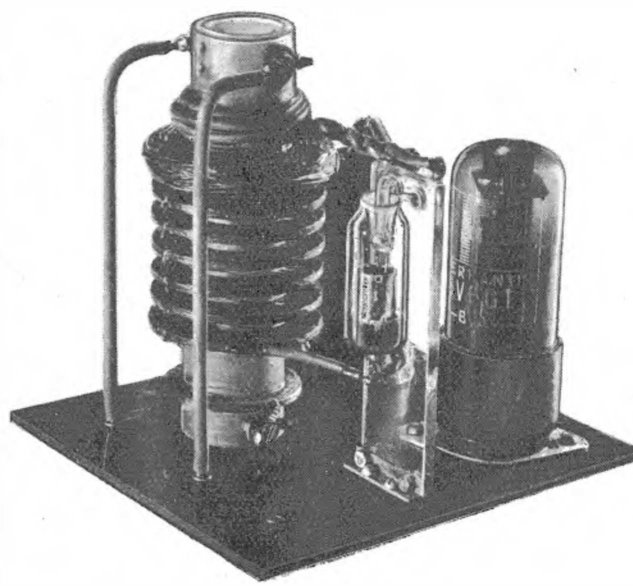
(*b*) High voltage insulation filament transformers (R.F.) up to 25 KV. A.C. or D.C. insulation. These are incidentally used in the Hazelhurst variable units.

(*c*) 10 to 12.5 MKV. unit.

(*d*) 2-5.5 KV. unit. This is the model which has been so successful this year.

(*e*) A full range of coils from 2 to 33 KV.





Metropolitan-Vickers Electrical Co. Ltd., Mosley Road Works, Trafford Park, Manchester, 17. (Stand 179)

Particulars of M-V exhibits are given below, and items demonstrated to visitors are marked with an asterisk (*).

*1. *Seascan Console and Associated Equipment (including Auxiliary Display Unit in Navigator's Cabin).*

Auxiliary Display Unit. By incorporating this equipment, the display can be reproduced in any other part of the ship, e.g., the chart-room, or lounge, for the interest of passengers.

*2. *Miniature Oscilloscope, Type* 244 (*illustrated*). This is a miniature instrument with a front panel little larger than a post-card. All the essential features of a large cathode-ray oscilloscope are retained, and the time-base is a push-pull saw-tooth oscillator with a frequency range from 10 c/s. to 50 Kc/s. A Y amplifier is incorporated which may be switched to select a gain of either 35 db. flat ± 1 db. from 50 c/s. to 150 Kc/s., or 20 db. ± 2 db. from 50 c/s. to 3.5 Mc/s.

*3. *Universal Meter, Type* 214. This will perform all the usual current, resistance and low frequency voltage measurements encountered in electrical, electronic and radio engineering.

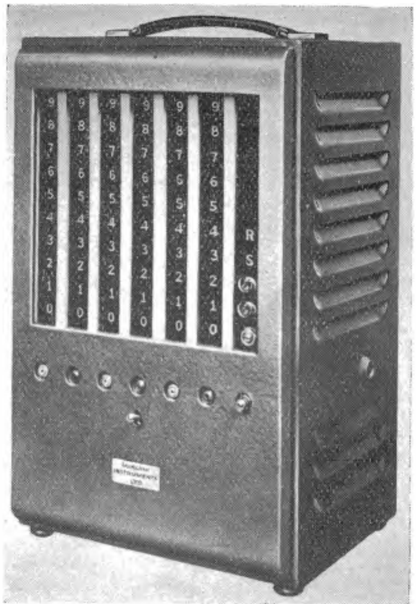
4. *Stabilised Power Unit, Type* 222. This is a unit designed primarily for providing a steady D.C. supply to meter and instrument test benches. It has an output of 660 to 680 volts D.C. (fixed) at up to 250 mA, the maximum drift over 10 min. being 4 parts in 100,000, and over one hour, 1.5 parts in 10,000.

5. *Audio Amplifier, Type* 243. This is a self-contained portable unit suitable for public address and educational work.

6. *Radio Frequency Heaters, Types 311D and 311E.* Type 311D is a dielectric heater and Type 311E an induction heater.

7. *Industrial High Frequency Generator, Type* 330E. This induction heater has a maximum continuous output of 5KW.

*8. *Metrosil.* A television set will be in operation in order to demonstrate the use of Metrosil in its construction. Samples of Metrosil will also be displayed.



Marconi Instruments Ltd., St. Albans, Herts. (Stand 154)

A wide range of test equipment will be displayed, together with a representative selection of industrial measuring instruments and electro-medical apparatus will be on view. The exhibits include:—

Communications

50 c/s. *Visual Detector, TF.*536B, employed as a null indicator in bridge balance determinations at the supply frequency.

*Signal Generator TF.*801A, for use in the range 10-300 Mc/s.

*Electrostatic Viewing Unit, TF.*816A is primarily intended for the investigation of the performance of pulsed V.F. or R.F. equipment.

*Standard Signal Generator, TF.*867. Frequency coverage is from 16 Kc/s. to 30 Mc/s.

*Universal Bridge, TF.*868, for the direct measurement of inductance, capacitance and resistance by means of a single dial.

*Video Oscillator, TF.*885, is a heterodyne oscillator for laboratory use, covering the range 20 c/s. to 5 Mc/s. in two bands and having a maximum direct output of 1 watt into 1,000 ohms (31.6V).

*Circuit Magnification Meter, TF.*886, a direct-reading Q meter, for use in R.F. testing over the frequency range 15-170 Mc/s.

*F.M. Receiver Tester, TF.*913, a crystal standardised C.W., F.M. and A.M. signal generator with an audio frequency power meter in a single assembly of notably small size and weight.

*Mobile X-Ray Unit, TF.*1511, a 30 mA· 85 KV equipment for mains operation.

Six Channel Electro-Encephalograph, OA.180A.

*Portable Direct-reading pH Meter, TF.*889.

*Electronic Counter, TF.*922 (*illustrated*) which will count at ultra-high speeds objects coming from a machine or production line: it can also be used for accurate timing.

A. C. Cossor Ltd., Highbury Grove, London, N.5 (Stand 15)

On this stand are shown the latest lock-in valves, together with cathode-ray tubes for television and industrial uses. These latter include the unique double beam tubes in the Cossor oscillographs, model 1035 and 1049, which are also displayed in company with the new Cossor direct-recording electro-cardiograph, model 1314 (*illustrated below.*)

Double beam oscillograph, model 1035, is a general-purpose instrument with C.R. tube operating at 2 KV., a time-base, Y deflexion amplifiers and internal power supplies. The two simultaneous traces are presented over the full area of a 90 mm. dia. flat screen. It is designed for quantitative measurements and waveform analyses over the widest field of research and industrial testing. Generally similar in presentation is the oscillograph, model 1049, for the measurement of very low frequency phenomena and the photographic recording of transients. Two independent direct-coupled D.C. amplifiers for Y deflexion are provided, as are stabilised power supplies giving alternative tube operating voltages of 2 KV. and 4 KV. Provision is made for the measurement of input voltages and time on calibrated dials, and the specification also includes facilities for time marking.

Developed for use with both the foregoing oscillographs, the camera model 1428 provides a simple means of recording stationary or non-recurrent waveforms and slow transients on standard 35 mm. moving film or paper. Provision is made for power drive by means of a three-speed motor attachment model 1429.

SOME AIDS IN SKETCHING FIELD STRENGTH DIAGRAMS

By F. DUERDEN

THE simplest form of polar diagram to deal with is that produced by two radiating elements carrying equal currents in phase with each other. The field at P in Fig. 1 will then be the vector sum of the fields F_A from A and F_B from B. Although starting out in phase, the fields will not be in phase on arrival at P, because F_B has travelled a distance greater by BX. Since the vector representing a travelling field turns through 360° or 2π radians for each wavelength (λ) travelled, the vector F_B will lag on F_A by $BX.2\pi/\lambda$ radians.

Finding the length BX becomes simple, if the point P is at a distance large compared to AB (greater than ten times say), when AP and BP become approximately parallel and AXB becomes a right-angled triangle. The vector diagram is further simplified if distances and phases are reckoned relative to the centre point C of the array (Fig. 2), the advantage being that F_A will now lead by an angle ϕ equal to that by which F_B lags, and the sum of the vectors will lie in the fixed direction Oc (Fig. 3).

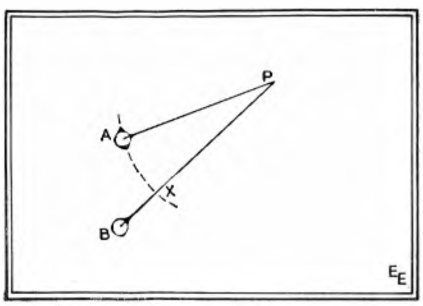


Fig. 1. Paths from two radiators to the point P

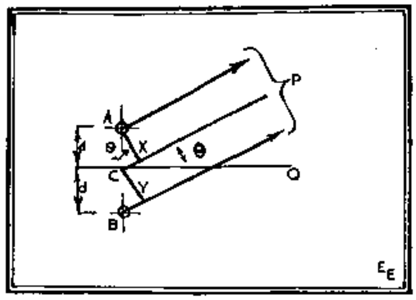


Fig. 2. Paths from two radiators to P at infinity, centre of array as reference point

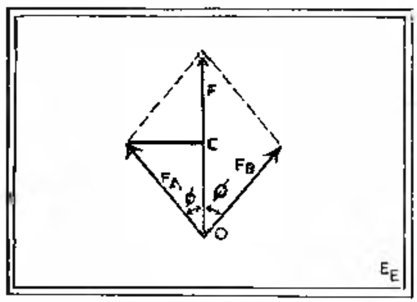


Fig. 3. Vector diagram corresponding to Fig. 2

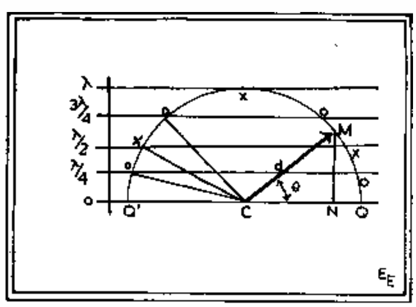


Fig. 4. Geometrical construction giving the salient features of the Field Strength diagram

It is now easily seen that the resultant field $F=2.Oc=2F_A \cos\phi$ (Fig. 3), where $\phi = CX.2\pi/\lambda$ ($=BY.2\pi/\lambda$) (Fig. 2). Also, $CX = AC \sin\theta$ (Fig. 2) so that:

$$F=2F_A \cos\frac{2\pi d}{\lambda}\sin\theta \qquad \text{(1)}$$

where $d = AC = CB$.

A Useful Construction

Examination of Fig. 3 shows that F will have a maximum value, equal to $2F_A$, when $\phi = 0$, 180°, 360°, etc., and that F will be equal to zero when $\phi = 90°$, 270°, 450°, etc., *i.e.*, from Equation (1) maxima occur in the polar diagram when $2\pi d/\lambda \,.\, \sin\theta = 0, \pi, 2\pi$, etc. (radians)

$d \sin\theta=0, \lambda/2, \lambda, 3\lambda/2$, etc. ... (2a)

is the condition for a maximum therefore. Similarly zeros occur whenever

$d \sin\theta=\lambda/4, 3\lambda/4, 5\lambda/4$, etc. ... (2b)

This leads to a very simple geometrical construction, which deserves to be more widely known, since it gives the salient features of a polar diagram so readily. A circle of radius d is drawn to cut a number of parallel lines spaced $\lambda/4$ apart on the same scale as that taken for d (Fig. 4). The centre of the circle lies on the zero line. Fig. 4 is drawn for the case $d = \lambda$, *i.e.*, for two radiating elements $AB = 2\lambda$ apart. Then $MN = d \sin\theta$ and, whenever M lies on one of the parallel lines,

$d \sin\theta=MN=0, \lambda/4, \lambda/2, 3\lambda/4$, etc.

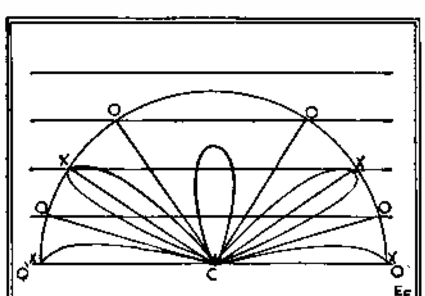


Fig. 5. Polar diagram for two radiators 1½ wavelengths apart

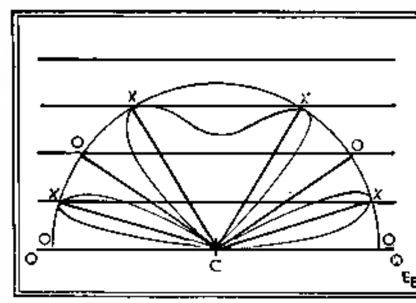


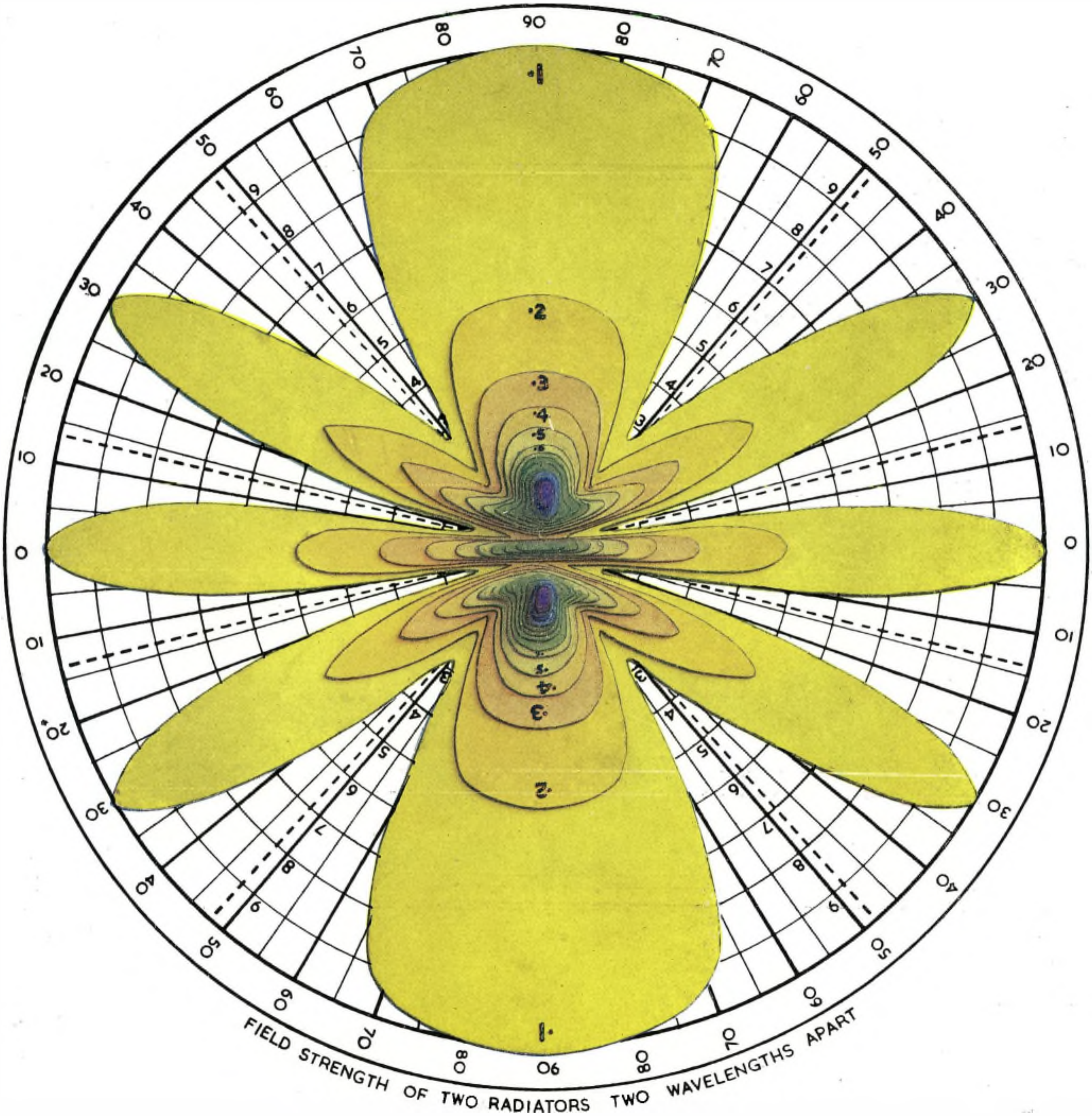
Fig. 6. Polar diagram for two radiators 1¾ wavelengths apart

The conditions of Equation (2) for the maxima and zeros of the polar diagram are therefore satisfied, and the complete construction lies in joining the centre of the circle to the intersections of the parallel lines and circle. The direction CQ will give a maximum for the case considered, where the currents in the radiators A and B are in phase, and the remaining intersections will be alternately zeros and maxima (marked 0 and X). CQ' will give a maximum also, since (Fig. 2) F_A and F_B have travelled equal distances to any point along CQ or CQ'.

If the currents in A and B had been 180° out of phase, CQ and CQ' would be zero directions, the others being maxima and zeros in turn. This is because the 180° phase angle can be regarded as made up of a

DUERDEN ..... Fig. 12

Field Strength diagram for two radiators 2 wavelengths apart calculated by hyperbolic method



lead of 90° given to F_A and a lag of 90° to F_B in Fig. 3, so that zeros now occur when $\phi = 0, \pi\ 2\pi$, etc., and maxima when $\phi = \pi/2, 3\pi/2$, etc., thus reversing the conditions of Equations (2a) and (2b).

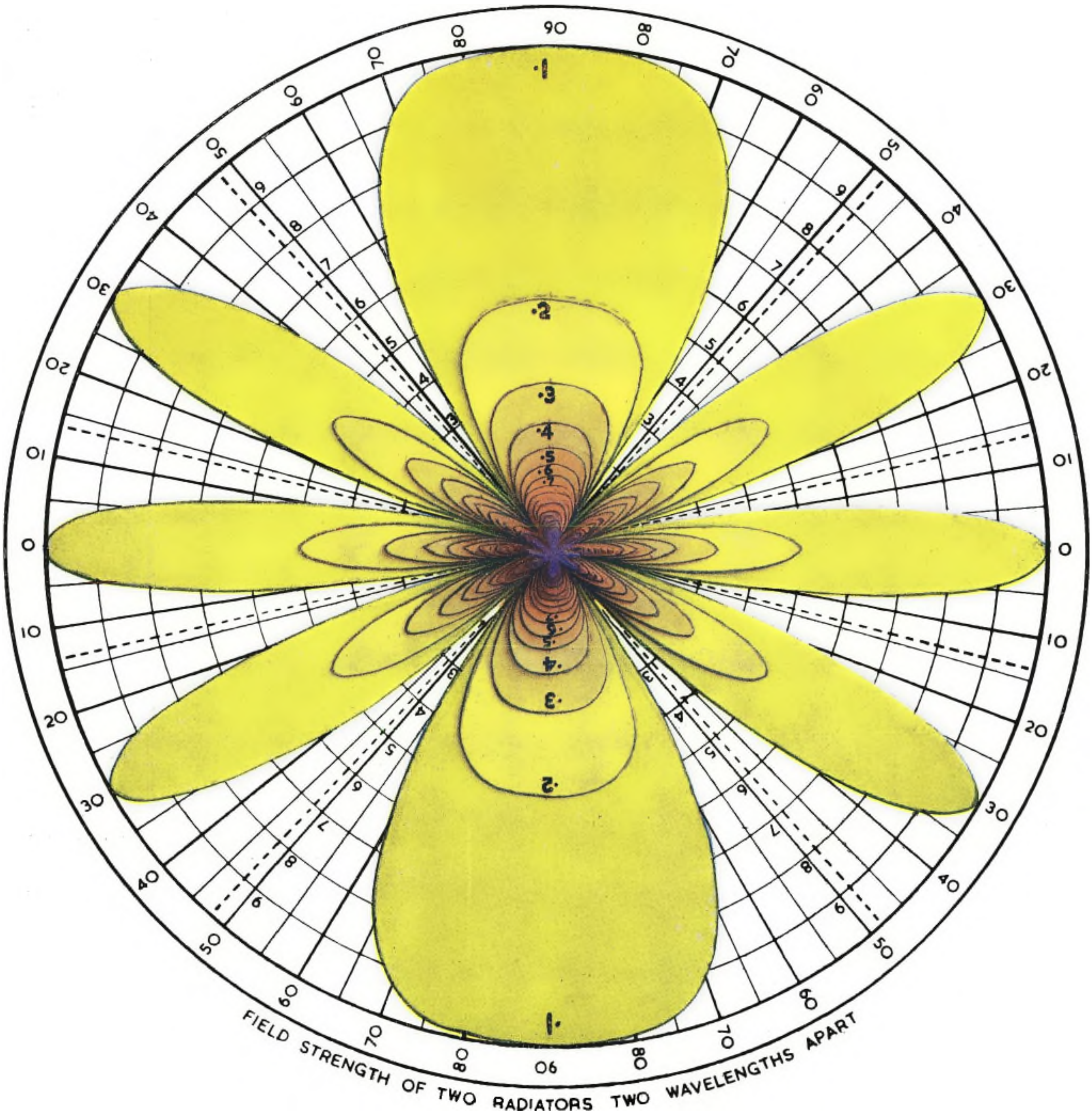
Figs. 5 and 6 show the construction with polar diagram sketched in for the case $d = \frac{7}{8}\lambda$. When two neighbouring zeros occur as in Fig. 5, a minor lobe exists between the two; when there are two neighbouring maxima the effect is as in Fig. 6. Only half the diagram, which is symmetrical, has been drawn in each figure. The reader will be able to decide which figure represents the in phase and which the 180° relative phase between the currents in A and B.

Effect of Current Phase Angle

If the phase angle between the currents in A and B is 2α, A lead-

DUERDEN ..... Fig. 13

Field Strength diagram for two radiators 2 wavelengths apart by usual approximations



ing and B lagging by α, the vector diagram of Fig. 3 becomes that of Fig. 7, and the condition for a zero in the polar diagram becomes

$$\phi + \alpha = \pi/2,\ 3\pi/2, \text{ etc.}$$

i.e., $(2\pi d/\lambda . \sin \Theta) + \alpha = \pi/2$, $3\pi/2$, etc.

so that Equation (2b) becomes

$$d \sin \Theta = \lambda(\tfrac{1}{4} - \alpha/2\pi),$$
$$\lambda(\tfrac{3}{4} - \alpha/2\pi), \text{ etc. } \ldots\ldots\ldots \quad (3a)$$

Similarly Equation (2a) becomes

$$d \sin \Theta = \lambda(-\alpha/2\pi),$$
$$\lambda(\tfrac{1}{2} - \alpha/2\pi), \text{ etc. } \ldots\ldots\ldots \quad (3b)$$

This can be taken into account, in the construction, by offsetting the centre of the circle a distance $\lambda.\alpha/2\pi$ from the zero line. *E.g.*, if the phase angle 2α, between the currents in A and B, is 90°, $\alpha/2\pi = 45/360 = 1/8$, and the circle centre is offset by $\lambda/8$, as shown in Fig. 8.

$d \sin \Theta$ $(=MN)$ is now equal to $(3\lambda/4 - \lambda.\alpha/2\pi)$ in the position shown in the figure, or $(-\lambda.\alpha/2\pi)$,

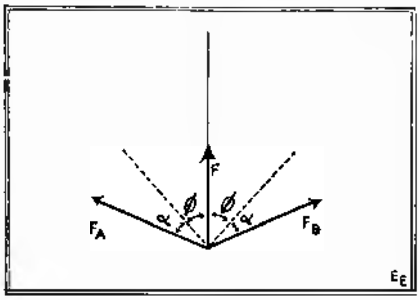
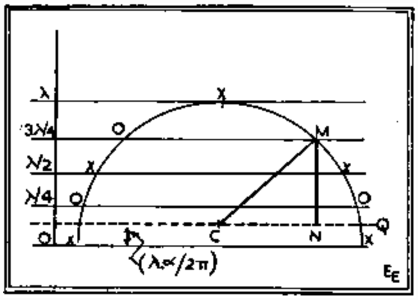


Fig. 7. (*above*) **Vector diagram for two radiators with phase angle 2α between the currents in the radiators**

Fig. 8. (*below*) **Construction of polar diagram for two radiators $1\frac{1}{2}$ wavelengths apart with phase angle 2α between the currents in the radiators**

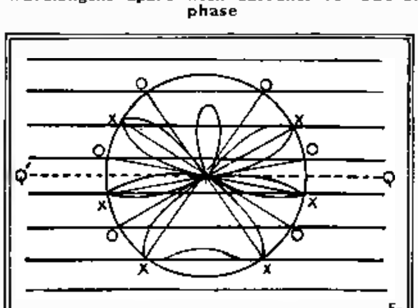


$(\lambda/4-\lambda.\alpha/2\pi)$, $(\lambda/2-\ .\alpha/2\pi)$, etc., as M lies on the intersection with each successive parallel line. The conditions of Equations (3a) and (3b) are satisfied therefore. Fig. 9 shows a sketch of the polar diagram for $d = 3\lambda/4$ and $\alpha = 45°$, *i.e.*, the polar diagram for two radiators spaced $1\frac{1}{2}\lambda$ apart with the current in the upper radiator leading that in the lower by 90°.

Field at Short Range

The previous work was simplified considerably by the assumption that the point P in Fig. 1 was sufficiently far away for AP and BP to be approximately parallel. It has also been tacitly assumed throughout that the vectors F_A and F_B are equal in length, which is true so long as AP and BP are approximately equal in length, since F_A is proportional to $1/AP$ and F_B to $1/BP$. The condition is that BX is small compared to BP, which is satisfied by the same assumption that P is remote from the array.

Fig. 9. Polar diagram for two radiators $1\frac{1}{2}$ wavelengths apart with currents 90° out of phase



When P is not sufficiently remote to justify these approximations, the work can still be simplified a good deal if calculation is carried out, not in polar co-ordinates, but along a series of hyperbolae. Along the hyperbola QQ' (actually a straight line) in Fig. 10, the distances $d1$, $d2$ from the elements A, B are equal. The fields are therefore equal (with amplitude proportional to $1/d$) and also in phase, so that the resultant field at any point is found by arithmetic addition. Along the hyperbola SS', the distance $d2'-d1'$ $=\lambda/2$ everywhere. The fields (amplitudes proportional to $1/d1'$ and $1/d2'$ respectively) are 180° out of phase, and the resultant field at any point is found by subtraction. Thus relative field strengths may easily be calculated along the hyperbolae for which $(d_2-d_1) = 0$, $\lambda/2$, λ, $3\lambda/2$, etc., by simple addition or subtraction of two quantities F_A and F_B proportional to $1/d_1$ and $1/d_2$ respectively.

If further values of field strength are required, hyperbolae may be used for which $(d_2-d_1) = \lambda/4$, $3\lambda/4$, etc., and the two component fields are then 90° out of phase. In this case the resultant field is found from the hypoteneuse of a right-angled triangle having its other two sides proportional to $1/d_1$ and $1/d_2$.

For example, consider the case of two radiating elements, carrying equal in phase currents, spaced one wavelength apart. In Fig. 11 a set of circles having radii $\lambda/4$, $\lambda/2$, $3\lambda/4$, etc., centred on A, and a similar set centred on B, have been drawn. At point C, the distances from A and B are each $\lambda/2$, and the fields are therefore in phase and each proportional to 2, giving a resultant field strength of 4 (arbitrary units). At the four points marked D, in each case the distance from one radiator is $\lambda/2$ and from the other λ, giving fields 180° out of phase and of amplitudes proportion to 2 and 1. Hence the resultant field strength at D is 1. Points E are $3\lambda/4$ from each radiator, and the fields are therefore in phase and of amplitudes 4/3, the resultant field strength being $8/3=2.67$. The $\lambda/4$, $3\lambda/4$ points F give a resultant field $(4-4/3)=2.67$. The $\lambda/2$, $3\lambda/4$ points G give a phase difference of 90° and amplitudes 2, 4/3; so that the resultant field is $\sqrt{2^2+(4/3)^2}=$ 2.4.

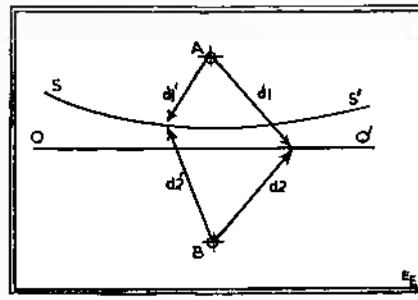
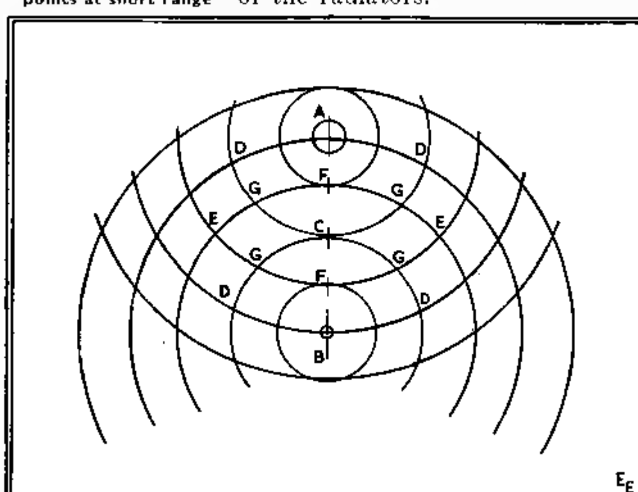


Fig. 10 Hyperbolae for use in calculating fields at short range

This simple though tedious process may be continued for the various intersections, and finally contour lines of constant field strength may be drawn. Figs. 12 and 13 (in colour) are photographs of the field strength diagrams for radiators 2λ apart, constructed as solid models. Fig. 12 has been calculated by the above process, and Fig. 13 using the approximations of Fig. 2. It will be noticed that the greatest errors occur around the zeros closest to the AB direction, and also in the immediate vicinity of the radiators.

Fig. 11. Calculation of fields at various points at short range



The Analysis and Synthesis of Musical Sounds

By A. W. LADNER

A MUSICAL sound is defined as one to which a pitch can be assigned, and the definition thus covers a very wide field of both simple and complex sounds which, in general, are sustained in character although not necessarily at constant amplitude. In musical composition we have, of course, not only musical sounds but non-musical as well, that is, sounds which in themselves have no pitch, such as are produced by instruments of the purely percussion type or transients inherent in the build-up or stopping of a musical sound, but except as they modify it we are not concerned with their composition. Non-musical sounds, nevertheless, are very important, for as will be seen later the recognition of any isolated sound is often dependent not only upon the sustained musical portion but also upon its build-up and decay times. A good example is that of speech articulation. Here the vowel is the musical element and gives us vowel recognition and pitch, but the consonants at beginning and end give us recognition of the articulatory sound as a whole.

The subject of sound analysis has interested scientists and musicians from very early times; as has its counterpart synthesis, but to a much less extent. In the 17th century Wilkins attempted to explain the formation of vowels and even made up acoustical models to produce synthetic vowels. Many others made small contributions from time to time, but is was not until the middle of the 19th century that any serious advances were made and published by a number of people, chief of whom was Helmholtz. The great researches Helmholtz conducted and published in his work "The Sensations of Tone" gave results on which he postulated his theories of complex musical sounds and musical harmony.

In the last few years, due to the importance of developing media for the transmission of musical sounds, and to the introduction of so-called electronic musical instruments, much of the work done by Victorian scientists has been carefully revised, much additional detail has been collected and many measurements made which were impossible in those days. But the general premises made by Helmholtz are still recognised as the basis of the theory of harmony and the composition of complex musical sounds.

Harmonic Theory of Complex Musical Sounds

This theory briefly is that any sustained sound may be regarded in terms of a fundamental and harmonics. This being so it is clear that we should be able to express any complex musical sound in terms of a Fourier series; and furthermore we should be able to rebuild any given sound exactly by synthesis of these same components.

The usual method of analysis is to inject the sound into a suitably corrected microphone, followed by a linear amplifier, inspection of the individual component frequencies of the output being made by any type of harmonic analyser. Where short duration sounds are being investigated, such as vowels, etc., it is desirable first to impress them on a recording device such as a film or tape so that an endless band can be made to give a continuous record, as considerable time is required to make accurate measurements of numbers of harmonics. Several analyses of musical sounds have been made and waveforms recorded both of speech vowels and sounds from many musical instruments. For demonstration purposes in connexion with instruction work at the Marconi School of Wireless Communication, the author has recorded many such and analysed them. And further, synthesised these same sounds by means of a sound harmonic synthesiser employing electrostatic generators, the apparatus being described in the Appendix.

Disagreement between Analysis and Synthesis

It is of interest to observe that while finding the synthesised sound in agreement with that analysed for sounds produced from harmonic generators energised by a single impulse, such for instance as struck or plucked strings, *as judged by ear*, it has been very evident that where the sound is continuously produced, as with blown pipes and bowed strings, there was apparently much less agreement, even with comparatively simple sounds; and these differences could not be accounted for by errors of measurement and are sufficiently great it is thought to call into question the validity of the premises on which the harmonic analysis of sustained sounds is based.

Objective and Subjective Qualities

It will be observed that we are questioning the validity of an objective analytical study by an aural test. Now the scientist is very loth to admit any but strictly objective evidence. However, in all aural communication systems it is, after all, the ear which is the final judge of any sound heard. And although it is well known that the ear is quite incapable of making any quantitative measurement but only a comparison, where analysed and synthesised sounds are being judged it is comparison of the two that is in question. Hence if the ear senses a disagreement between two sounds deemed to be the same we cannot dismiss such subjective evidence as of no account simply because it is subjective without being quite sure that our objective method of measurement is above suspicion. The fact that the ear has rectifying properties and therefore introduces frequencies which were not present in the original sound is of no importance since the two sounds being compared are supposed to be the same and therefore the same subjective frequencies should be involved in both cases.

Accepting for the time the harmonic theory of complex sounds, any such sound has three qualities which are defined objectively and subjectively as follows:—

	Objective	Unit	Subjective	Unit
1.	Intensity	db or millibars	Loudness	Phon
2	Frequency	c/s	Pitch	Octave
3.	Harmonic Composition	Fourier series	Timbre	Compared with pure tone

We are not much concerned with the first two in the present paper except inasmuch as they may qualify the third, and to remark that whereas the ear has only a poor discrimination of amplitude difference it has acute tonal sense. Thus nearly a 30 per cent change of intensity is necessary before the ear can detect any change of loudness for tones offered one after the other; whereas less than ½ per cent change of frequency is easily detected by the average individual, for frequencies within the octave. It is not uncommon for judgment to be an octave wrong even when comparing pure tones and it is a well known fact that people who have the gift of knowing absolute pitch can be an octave wrong in their estimation. The first two qualities may modify the third. Thus increase of the intensity from most musical instruments increases the number of harmonic frequencies produced and changes their relative values; and an increase of loudness of any given sound to the ear increases the number of subjective tones heard. Thus a change of volume has a two-fold effect in the quality of sound heard by the ear and it is for this reason that when judging two similar sounds they should be produced and received at the same level.

We are chiefly concerned with the third quality of sound, frequency composition objectively and timbre, or tone-colour, as it is sometimes called subjectively. From the premises that complex sounds are composed of a harmonic series, we can analyse any such complex sound objectively by the use of a harmonic analyser, and this will give a harmonic frequency/amplitude series. Phase relationship between the various components can be measured as well, but since it is found the ear is quite incapable of assessing phase, such a refinement of measurement is usually dispensed with.

The recognition by ear of the timbre of any given sound is dependent upon a number of factors which can be classified in many different ways, but for our purposes we can reduce these factors to a few simple ones. Since all sounds are of finite duration, we associate any musical sound as having a sustained middle portion, although not necessarily of constant amplitude, from which we judge the pitch of the sound, at a begininng and end, called "attack" and "decay" periods, these having in some cases a marked effect on the general character. Where the sound gradually dies away we cannot dissociate the middle and the decay parts. Our first rough mental classification will assess the relative duration of the attack and decay times to the central sustained part. For instance, most organ sounds have attack and decay times negligible with the constant amplitude middle, and recognition is from the character of this middle sound. Whereas with sounds produced from bells, tuning forks, and undamped struck or plucked strings there is no constant amplitude middle, but a short attack time and a long-drawn decay time, and recognition is determined by these characteristics, the latter determining pitch and harmonic complexity. We may for convenience call the sounds in the latter class "musical transients" to distinguish them from the sustained class.

We also classify sounds as either consonant or dissonant, i.e., whether the components blend together agreeably to form a consonant whole, or if harshness is present making the sound dissonant. Thus most piano sounds are consonant, unless the hammers are hard or worn, as are sounds from most flue organ pipes, but speech sounds are usually dissonant as are nearly all the reed-type instruments.

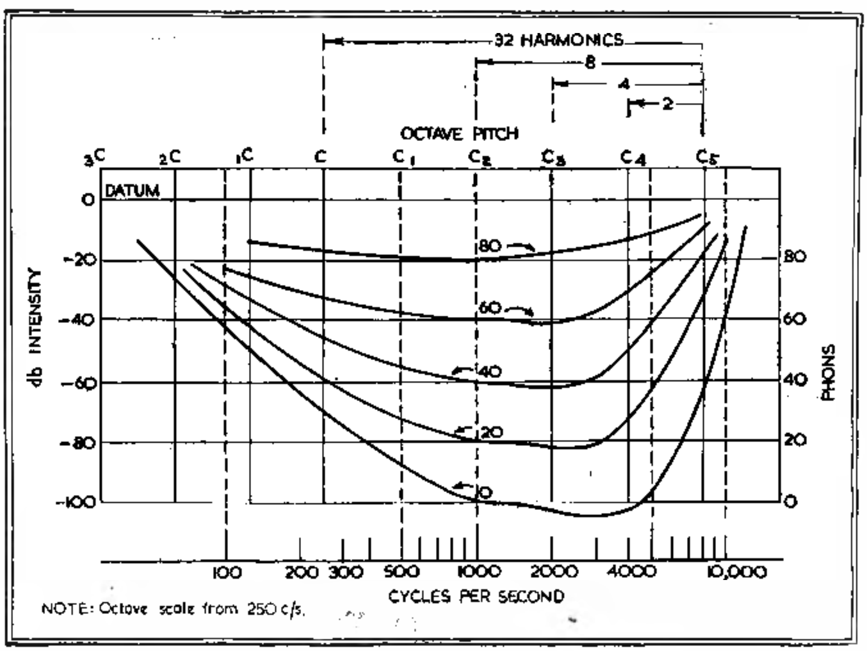
Characteristics of Ear

Before considering these various factors it is desirable to mention a few relevant characteristics of the human ear and to set out the harmonic relationship of tones in terms of the musical scale since sound recognition is largely a matter of musical appreciation.

Although 10 octaves, i.e., 16 c/s. to 16 Kc/s., is given as the hearing range of the human ear with an optimum hearing efficiency at between 2 and 4 Kc/s., this range is only possible at very high intensity levels and with young people. At lower and more usual intensities the range is much restricted, the lower the level the smaller the range and the sharper the falling off of the ear's efficiency above and below the optimum. These facts are seen from the equal loudness curves given in Fig. 1, plotted with a log frequency scale below in c/s., and the corresponding linear octave pitch scale above. A significant point to observe is that for a medium sound level for tones having a low frequency fundamental each harmonic up to those in the region of 3 Kc/s. will be exaggerated in value by the ear, whereas with a high-pitch fundamental near 3 Kc/s., the harmonics will be diminished relatively.

Knowing the fundamental of any complex wave it is easy to determine the number and importance of

Fig. 1. Aural characteriscics



the harmonic series by reference to Fig. 2, which also sets out the possible harmonic series from different unity pitch values for an average level of sound which would embrace frequencies up to 8 Kc/s. Thus with a fundamental at middle C, we could sense up to 32 harmonics, those up to 2C would be important, but beyond this they become of negligible interest. Whereas if the fundamental was 1,000 c/s., however many harmonics are being produced, we could only sense up to 8, and of these only the first four will have any effect, but the 3rd and 4th, if produced at all strongly, will be very intense indeed. In making any analysis of a musical sound it is therefore very desirable to keep these facts in view as by doing so we can give proper attention to the measurements being made over different parts of the scale.

Consonance and Dissonance, and the Harmonic Series

It was Helmholtz who postulated the theory that consonance or dissonance was determined by the musical interval between the constituent frequencies, and that when this interval diminished to such a point that fast beats were heard dissonance was the result. He considered the general case of dissonance between any two pure tones, i.e., not having any harmonic relationship, and showed that within any octave the points of worst dissonance occurred nearest the points of greatest consonance; that is each side of the octave and then each side of a musical fifth, and then a musical fourth, etc. We are concerned with harmonic tones of a complex sound and Fig. 2 shows the relationship between a justly intoned musical scale and the harmonic series from a datum tone of C. From this it is observed that harmonics up to the 6th are consonant since they coincide with the musical octave, musical 5th, i.e., G, and musical 3rd, E, but after that many even and all the odd harmonics become dissonant. Thus the 7th, B♭, is very dissonant, and to a less extent the 9th, D, the 11th, nearly F♯, and so on. The 7th and 9th, since they are near the octave, are the most dissonant, as again are the 14th, 15th, 17th and 18th nearest the next octave. It will be observed that many of the higher harmonics do not coincide with any note on the musical scale.

Synthesised Sounds

As mentioned previously the author has analysed and synthesised many complex sounds, and in the synthesis has observed a number of interesting features which it is proposed to discuss. Although a description of the apparatus used is given in the Appendix, it is desirable here to mention briefly its scope and general performance. The synthesiser is capable of adding up to 20 sinusoidal components whose individual amplitudes can be separately adjusted. Phase relationships of a few selected components can also be varied by external control during operation. Each component is controlled by a separate key, but a master key is provided which enables any pre-set arrangement to be sounded as a whole, and two further keys enable either the pre-set odd or even series, apart from the fundamental, to be switched in or out at will. Attack and decay circuits are also incorporated and the pitch tone is such that harmonics beyond the 20th are negligible.

Before dealing with individual examples it will simplify the discussion if we mention factors that are common to many. Thus if we set up the amplitudes of a group of individual harmonic frequencies to any arbitary values, say in a gradually descending ratio we can by combining certain groups observe the various musical effects produced. Thus it is simple to demonstrate the fact that the first six harmonics give a consonant sound; that 2 and 4, and following octaves add brilliance and a possible raising of pitch whereas 3 and 5, and 6, add considerable character. Beyond the 6th the dissonance introduced by the odd and many even harmonics can be easily demonstrated. It can be observed that the introduction of the 7th and to a less extent the 9th added a distinctive type of dissonance reinforced by the 14th, 15th, 17th and 18th. And that the dissonance produced by the whole series of higher harmonics up to the 20th is again of a different type, being more a jangling than a clear-cut roughness. It can also be demonstrated that any alterations of attack and decay times have very marked effect.

Masking

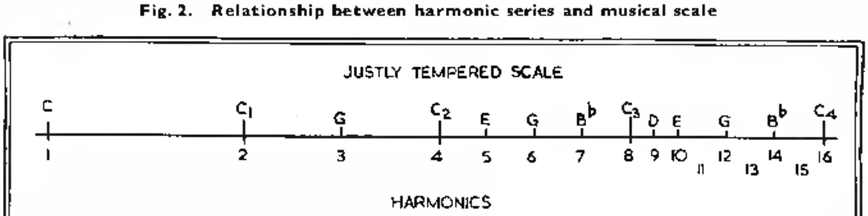
In synthesising any complex sound it was found necessary to control the series with a master key and only by this means were the various components completely masked so as to form a complex whole. If each individual component of such a series was added one by one the ear was quite incapable of assimilating the various components as a whole but retained each separate tone for an appreciable lapse of time. This means that there was negligible masking for this period, even though the sounds heard are all in harmonic relationship and some at a relatively low level. In fact when listening to any complex sound at quite a high level, if we introduce a new component even just above threshold this new sound is momentarily heard and then becomes masked. When all the components are given as a whole the ear accepts the sound as a complex whole and only very considerable mental effort could determine some of the constituent high amplitude frequencies.

The absence of masking mentioned appears to be somewhat important. Thus if in a series the amplitude of any given component is not constant in amplitude but is varying, its presence will be more noticeable than if we had an equivalent steady component of the same average value.

Pitch

We have mentioned previously the difficulty the ear has in determining octave pitch. This is easily confirmed experimentally and it is found the greater the complexity of the tone the greater the difficulty

Fig. 2. Relationship between harmonic series and musical scale



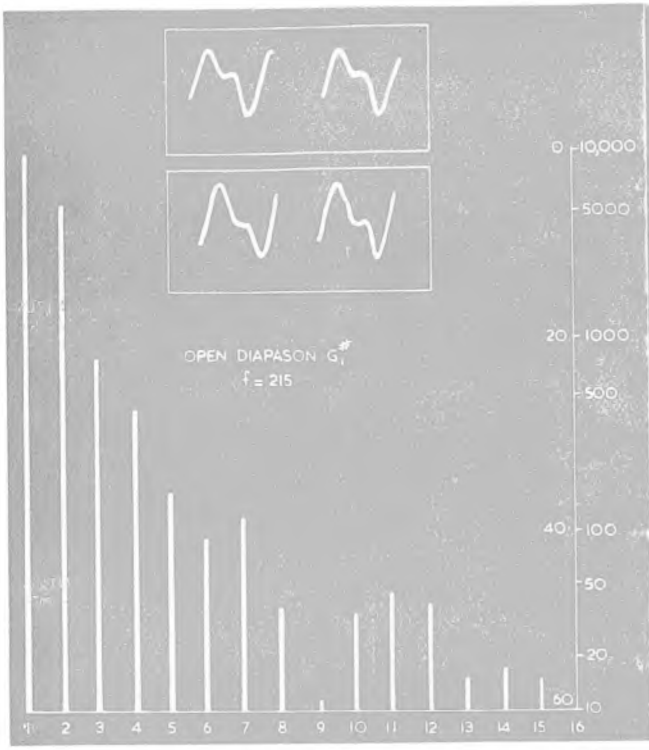


Fig. 3. Synthesis (*lower inset*) and analysis (*upper inset*) of organ sound, Springfield Church Grand

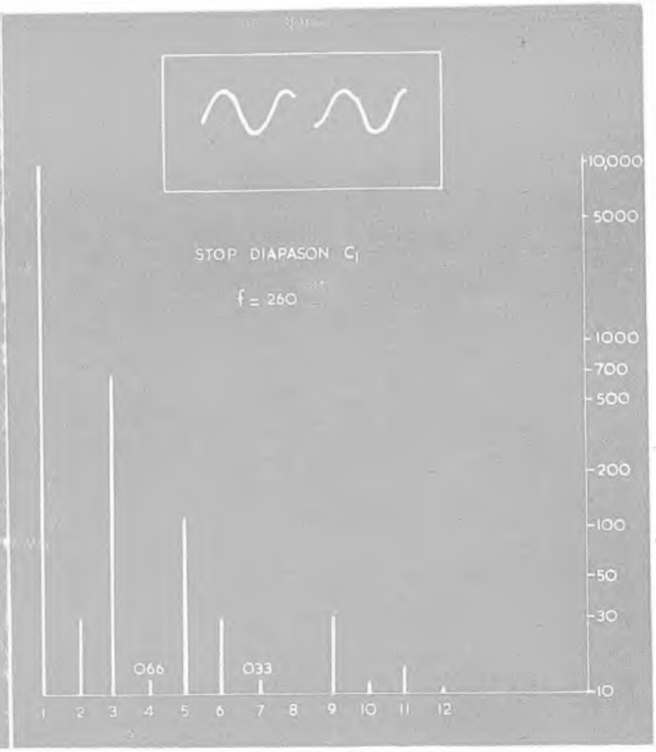


Fig. 4. Analysis of organ sound, Springfield Church Swell

in determining octave pitch. For instance, if a pure tone be offered as reference, and then in turn two complex tones in unison but an octave apart, such, for instance, as two sung vowels, a group of listeners will have great difficulty in determining the correct comparative pitch.

It has been stated that pitch recognition is a function of difference frequencies and not fundamental, and experiments have been made by removing the fundamental and first few harmonics of a musical sound without listeners observing noticeable pitch change. Further, it is well known that good quality speech is often transmitted through a system having a cut-off below 500 c/s. even though the average speech fundamental frequency is nearer 150 c/s. without any noticeable loss of either character or apparent pitch change. The author's experience is, however, that it is not a question of difference frequences but more a psychological one. For instance, given a synthesised sound rich in harmonics, whose fundamental is equal to the difference frequencies, then removal of the fundamental, even when at low level, and the lower harmonics in succession, is immediately noticed by every observer both in terms of a rise of pitch and a change of character, if the sounds are offered one after the other. It is agreed that if each individual sound was offered in comparison with a pure tone without the association of its previous state, then the ear would have some difficulty in judging pitch, as stated above. What result is obtained depends upon how the experiments are carried out. The ear appears to be so uncritical of octave pitch difference that it will not notice the particular pitch in question provided the important intervals within the octave are maintained. Thus with speech, the articulatory sounds are all provided by a group of frequencies above 500 c/s. and as long as these are not affected the ear will tolerate an alteration of pitch unless its attention is called to it.

We now propose to consider a few examples of synthesised sounds, all of which have first been analysed.

Constant Amplitude Sounds

Open and Stopped Diapason Pipes

Fig. 3 and Fig. 4 show the waveform and spectra of open and stopped metal diapasons taken from a wind organ, Fig. 3 also showing the synthesised wave with different phases. Both sounds are typical of this class of pipe and both would be considered as consonant sounds. The components were set up on the synthesiser in turn and it was observed that as far as could be judged the synthesised sound was in fair agreement with that analysed. With the open pipe, both even and odd harmonics are present, but only strongly produced up to the 6th and it was easily demonstrated that the brilliance of this pipe is due to the strong 2nd and 4th, as reduction of either, or removal dulled the sound appreciably. Regarding the stopped pipe this acts like a quarter-wave aerial, namely, its fundamental is four times its length and not twice as the open pipe, and only odd harmonic modes are possible. Thus the stopped pipe has none of the brilliance of the open, and its character can be shown to be due to the strong 3rd and 5th harmonics present.

Clarabella

This pipe is an open wooden pipe of the flue type and as can be seen

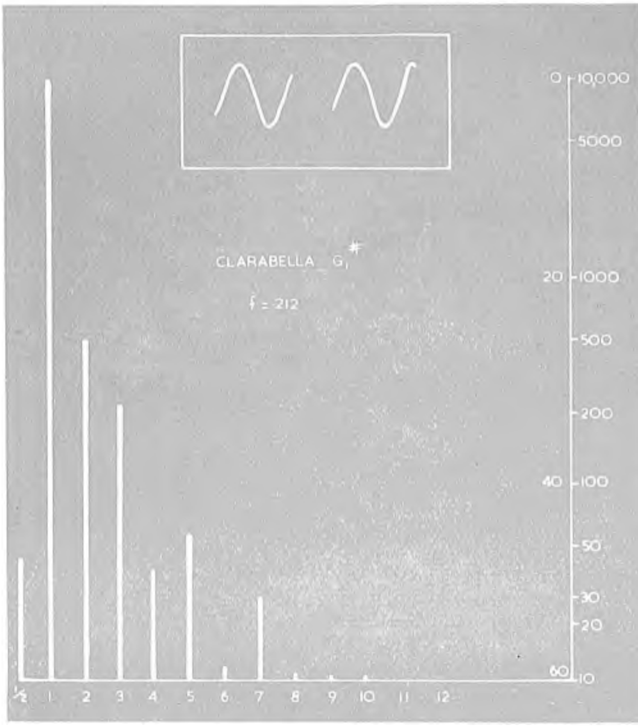


Fig. 5. Analysis of organ sound, Springfield Church Grand

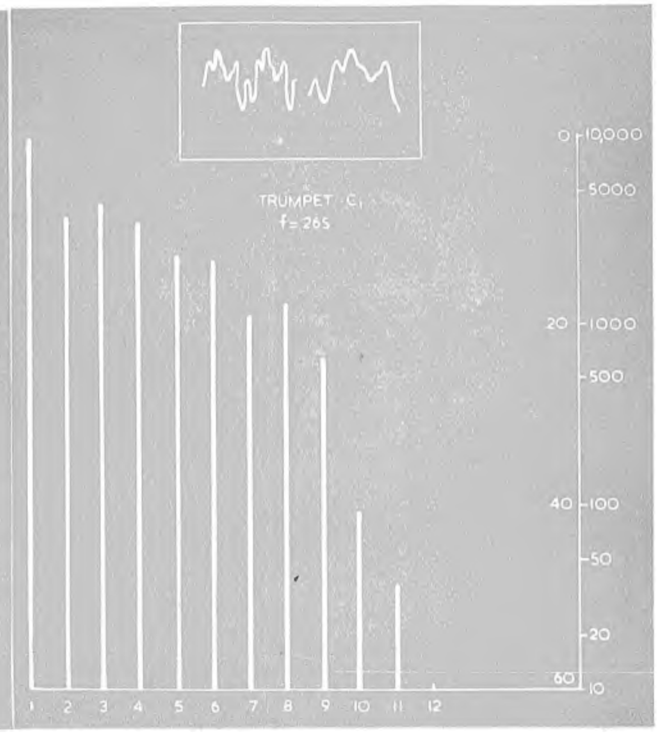


Fig. 6. Analysis of organ sound, Springfield Church Grand

from Fig. 5 has a comparatively simple frequency/amplitude spectrum. Like all wood pipes it has that peculiar hollow sound we associate with the wooden instrument. The general theory of the action of wood pipes is that due to the greater damping effect of the wood the successive harmonics are reduced in amplitude over those for a corresponding metal pipe because each harmonic air motion gets more and more out of tune and there is greater difficulty making them each "speak." Theoretically, therefore, on this basis the difference is merely one of relative harmonic amplitudes. But when such a sound was synthesised it was observed that the result was not like the original, and neither alteration of the amplitudes nor change in the number of harmonics used helped to get any better simulation.

Reed Pipes

Fig. 6 shows the waveform and analysis of a typical wind organ trumpet, rather a good one incidentally of its kind, and this shows a very strong harmonic content up to the 10th. In carrying out a synthesis of this sound it became very evident that the reedy effect was due principally to the presence of the strong 7th and to a less extent the 9th. In fact, without these it was not possible to simulate the particular form of strident dissonance so characteristic of reed pipes in general, and the trumpet in particular. The author does not agree, as has been stated, that the reed effect is due to the presence of strong 3rd and 5th harmonics. Although the amplitudes as set up gave a fair reproduction of the trumpet pipe, a better simulation appeared possible when the higher harmonics were increased relatively, and it suggests that some of these may in the original wind instrument not be steady in amplitude, but varying Any such variations would be ignored by an analyser since it would merely record the average value, and we have noted previously that a variable tone is more noticeable than one of constant amplitude.

Vowels

The Bell Telephone Laboratories have given very complete analyses of vowel sounds, in harmonic form. Examples of these have been set up on the synthesiser and although some of them are recognisable as such, they are not very realistic, even allowing for the fact that vowel recognition is always a difficult matter if given without accompanying consonants. But from the experimental work carried out it was quite clear that no amount of "juggling" with either the number or amplitude of the harmonic series would give correct vowel sounds. This difficulty has been appreciated by the Bell Telephone Laboratories, who more recently produced synthetic speech by the introduction of an inharmonic background to a harmonic series.

Résumé of Constant Amplitude Sounds

By the variation of the number and amplitude of even a comparatively few harmonics an infinite variation of timbre can be produced, but it is significant that some apparently simple wind instrument sounds cannot be so produced, nor the vowel sounds of the human voice and it is clear from experiments and confirmed by work done elsewhere that such sounds have in addition an inharmonic content which is not revealed by the present method of analysis. In the case of all the sounds under review it will be noticed that their method of production is much the same. Thus we have an acoustical resonating system energised from a D.C. or modulated D.C. source which is in the nature of a pulse generator, such as edge-tone wind pulses directly, or modified by a vibrating system. It is significant that the synthesised sounds most easy to simulate are those having metallic resonators and those most difficult having resonators of softer material. This is to be expected, as, with the former, the more accurate will be the harmonic modes and the more nearly will the resultant energy spectrum be confined to discrete frequencies.

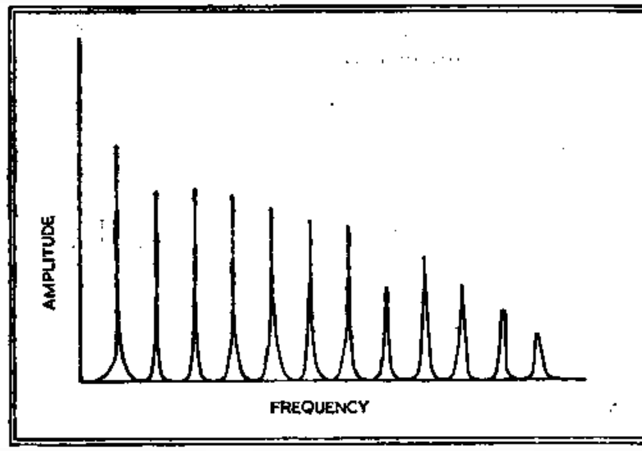


Fig. 7. Suggested spectrum of musical sound

Musical Transients

The principal class of instruments for producing musical transients are bells and plucked or struck strings all these being energised by a single blow or movement. The various modes of vibrating strings have been extensively analysed and it can be shown that the harmonic series produced is dependent upon the position along the string where it is energised, whether it is struck or plucked, and how it is struck or plucked. In general the number of harmonics produced with struck strings is greater than with those similarly plucked, and when struck with a hard hammer near one end, the series can be very great indeed. In the case of a piano, a soft felted hammer is used and the string struck about an eighth from the end. In this way although the consonant 8th is entirely eliminated, because of the broad and soft hammer face, the 7th and 9th harmonics are reduced to very negligible values. By such a design the piano produces a consonant series up to the 6th, unless the keys are struck very hard, or the felting wears when further groups appear between the 8th and 16th and perhaps even beyond the 16th.

If we set up a series in accordance with that analysed but reproduce them as a constant tone, there is no recognition whatever by ear, but if the correct attack and decay times are added, particularly the latter, the sound heard is immediately accepted as a perfect reproduction. The series produced by a metallic hammer is very much larger, so many high harmonics being produced that the sound heard has the familiar jangling, and here again when the correct decay and attack times are added, a faithful reproduction is immediately obtained. Plucked strings and bells are also quite simple to simulate. In the latter case, the component frequencies of which incidentally are not in harmonic relationship, it is necessary to introduce separate decay times for each component frequency as they differ so widely.

General Résumé of Results

A general review of the results obtained from the synthesis of complex sustained tones and musical transients makes it clear that the former, contrary to expectation are in general much more difficult to reproduce from a harmonic series than are the latter, although the reverse should be the case. As has been remarked, the former are produced from resonating systems energised by a broken up D.C. source, and the latter by a single impulse. With the latter exact similitude can be made by the employment of the analysed harmonic series, provided the correct attack and decay times are introduced. This means, of course, that we are amplitude modulating the harmonic series in the same way as that in the original sound and by so doing are introducing the correct inharmonic components which were present in the original wave.

Regarding the constant amplitude waves we must inquire in what way the synthesis fails and why the analysis is incorrect. Dealing with the first, it has more or less been established, anyway in the case of vowels, that some inharmonic content is necessary, but what form this should take is a matter of empirical rule or conjecture. From our experiments it is certain that increase of inharmonic frequencies of high frequency value relative to the fundamental will not help, as at these frequencies the interval is diminishing so much that there is but little difference beween harmonic and inharmonic sounds. It would appear probable therefore that low inharmonic frequency energy is what is wanted and it is suggested this might be provided by the addition of subharmonic tones rich in harmonics, with a suitable filter to cut off the unwanted higher components, since the harmonics of a sub-frequency will be inharmonic to the main series. As regards the present method of analysis, when a continuous sound is made, the ear records this as would a gramophone, recording tape or film, namely as a series in time. But when analysing such a wave by the present method, we are taking the average of a large group of waves as if each wave of the series is an exact replica of each other. In other words, by adopting such an analytical method we are prejudging the issue and making an unjustifiable assumption that we are dealing with a repeating series. Since the waves are not all exactly the same as can be seen from inspection of recorded waveforms such an analysis will give only an approximate answer, sufficient no doubt for ordinary purposes where first order effects are needed, but not sufficiently accurate to determine second-order effects which become necessary if exact simulation of a complex sound is desired. But since the waves reveal amplitude and frequency differences, the energy therefore will not be concentrated at discrete frequency points, but like any modulated wave there will be a frequency spread, it is suggested, as indicated in Fig. 7, which is not revealed by the present method of analysis. Hence it is thought that in addition to analysis by the present type of analyser, the sound should also be examined for frequency changes by frequency discriminating circuits.

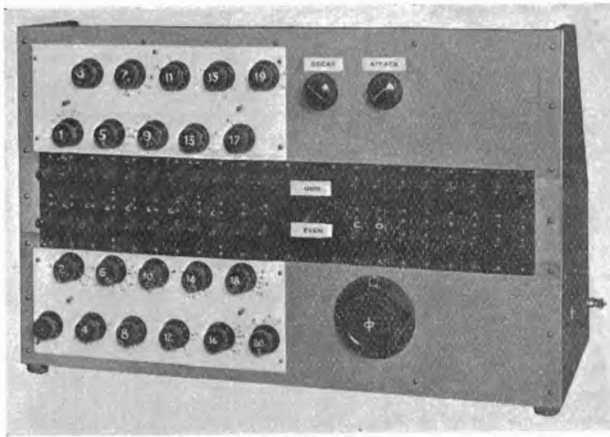


Fig. 8. Front view of the acoustical harmonic synthesiser

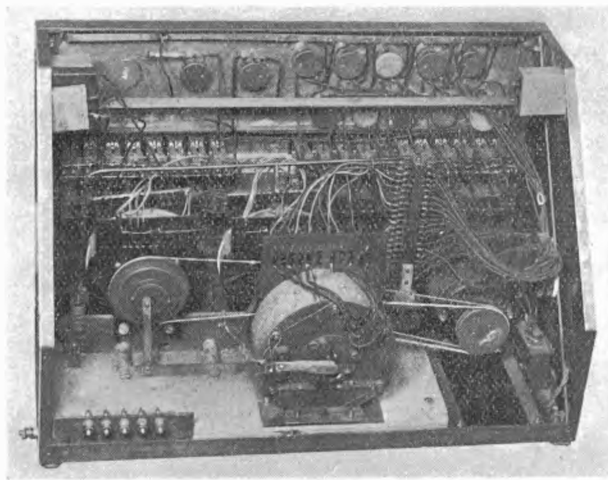


Fig. 9. Rear view of the synthesiser. The electrostatic tone wheel generators are mounted two in the centre and one to the left

Appendix

Acoustical Harmonic Synthesiser

Fig. 8 shows a general view of the front, and Fig. 9 one of the back of the synthesiser, which is capable of combining up to the 20th harmonic of a given fundamental, this normally being fixed at about 230 c/s., so that harmonics beyond the 20th are from the aural point of view, of no account.

In the back view, Fig. 9, can be seen the three tone wheel generators used to provide the various component sounds, all of which are approximately sinusoidal in waveform. The generators used are of the electro-static type, two being Compton organ units, kindly provided by the Compton Organ Company, and the third, which covers the harmonic series from 10 to 20, was built at the Marconi School of Wireless Communication by the author in collaboration with Mr. L. E. Q. Walker, who carried out all the photographic and processing work, and acknowledgment is made to Marconi's Wireless Telegraph Co. for photographs Figs. 8, 9 and 10. The principle on which electrostatic sound producers operate is well known and they have been fully described elsewhere.[1] We may mention here that there are two types in general use, one in which the sinusoidal variations of capacitance are obtained by the relative movement of the electrodes themselves, usually a sine stator and rotating scanner, and the other in which both electrodes are stationary and a variable dielectric scanner is employed. In the present machine the first type is used. The tone wheels made by the Compton Organ Company are built with solid cast scan wheels as the rotating element, the stator electrodes being made by separated sine groups cut by an engraving machine from a tin surface sputtered on to an insulating plate. The scanning rotor is insulated from earth and the common output is made by leading out an insulated connexion from the wheel through its tubular shaft to a rubbing contact at one end.

The generator made at the Marconi School is similar in principle except that the scanning elements are made static and the sine waves rotate, this making a simpler mechanical job, but the method of construction is quite different. First a single wave envelope of sinusoidal form was carefully drawn on a large scale. Batches of correctly reduced scale photographic prints were then made of this and these prints were pasted up in circles of appropriate diameters. A similar procedure was adopted in the case of the scanning blanks, though in this case the small prints were of nearly rectangular shapes. To maintain extreme accuracy large diameter circles were used, and after a complete series was so set up, the whole was photographically reduced to the final dimensions required. A photographic negative was then made which was printed down on to the surface of a sensitised copper sheet The usual half-tone process technique was followed wherein the surface was sensitised with a bichromated fish glue. Under the action of light this surface becomes insoluble in water and thus after exposure under the negative, by the washing of the plate in water the parts not affected by light are removed, leaving a layer of fish glue corresponding to the transparent portions of the negative. This layer was then "burned in" and the plate was etched in an electrolytic etching bath. Since a deep etch is necessary, it was essential to protect the sides of the waveforms

(*Concluded from p. 385*)

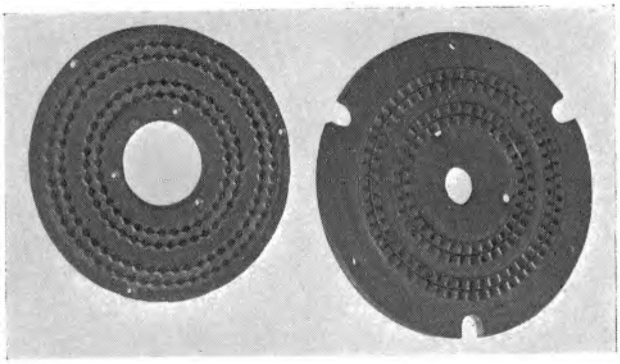


Fig. 10. Sine-wave tone wheel for the third tone generator

during etching to prevent undercutting and this was accomplished by the frequent removal of the plate from the bath and protecting the etched edges by brushing up with "dragons blood," which is then fixed by heat. By such a process it was found possible to get an etch as deep as 3/32 in., and first model wheels are shown in Fig. 10. In this design the sine waves form the rotor and are common, the wheel being insulated and a lead taken out through the shaft as with the Compton wheel. The scan rings were etched on a solid plate, which was then pinned in appropriate places to an insulating back, the rings then being separated one from the other by means of a fine parting tool.

Any resultant output from the three wheels is taken to a pre-amplifier whose first valve is of the top-grid low-noise level type, this pre-amplifier being followed by a main amplifier capable of giving 10 watts undistorted output into a loud speaker. In conjunction with the equipment a cathode-ray oscilloscope with a 9 in. diameter screen is used so that not only could any synthesised sound be viewed, but the effect of phase changes observed, and such an addition makes the setting up and checking a very simple matter. Fig. 8 shows the general layout of the keyboard and controls. The top row of keys, left centre, include a master key shown at the extreme left for controlling any pre-set arrangement of tones, and keys for the fundamental and the odd harmonic series, whose individual amplitudes are determined by the control knobs set above each key. A similar set of keys and controls, shown below, determine the even series in operation, the key shown at the extreme bottom left being used to enable a sub-harmonic to be introduced, usually a half or third. The keys labelled O and E, top centre, are arranged to switch in or out either the odd or the even series previously set up, and these keys operate independently of the fundamental. With such an arrangement of keys and controls, having set up previously any given complex combination, this can be given as a whole, or we can give fundamental only, fundamental plus even series, fundamental plus odd series, or both, quickly one after the other, and, of course, any given frequency can be switched in or out at will.

The group of switches shown on the lower right-hand side control elements in the attack and decay circuits, fine tuning of these being carried out with variable resistor elements whose controls are shown above, and the top right-hand row of keys is arranged to give a justly intoned diatonic scale. The control marked "ϕ" controls the phase relationship between a few selected harmonics and is provided more to demonstrate the absence of phase effect on the ear rather than to be able to modify any resultant waveform being produced.

Reference

[1] Winch and Midgley, "Electronic Musical Instruments and the Development of the Pipeless Organ," *J.I.E.E.*, June, 1940.

A Record Changer and Record of Complementary Design

(Condensed from the R.C.A. Review, June, 1949)

WHEN the phonograph and record industries had their commercial beginnings almost a half century ago in the Camden (U.S.A.) machine shop of Eldridge Johnson, the size of the records and the rotational speed of the turntable were established on a basis which was largely a matter of experimental compromise based on the state of the art at that time. The standards which finally evolved (10 and 12 in. for diameter, and 78.26 revolutions per minute for speed) have remained unaltered for many years. While there have been some noteworthy refinements of record making and playing techniques, these were accomplished within the pre-established limitations of record size, groove dimensions and turntable speed. Record-changing mechanisms, in particular, have been handicapped by the requirement that they accommodate both 10-in. and 12-in. records. Further, records have been costly, fragile, subject to wear, of limited quality and inconvenient to handle and to store. The result of this situation has been that a truly satisfactory performance seemed to be unattainable within the limitations of the system as established. It therefore became evident that an entirely new approach was indicated, namely, one specifically designed to eliminate these problems and limitations.

About 17 years ago there began a programme aimed at a fundamental improvement in the reproduction of recorded music, unhampered by any previous restrictions. Some nine years of research and experimentation culminated in a new record playing means to be discussed in this paper.

After study of the problem, it was concluded that a simple record changer design could be accomplished if the following conditions were satisfied:

1. A large centre spindle housing the separating means. It was found

that a $1\frac{1}{2}$-in. diameter spindle would house an economical selecting mechanism, provide adequate record stability on the spindle without external support, and make for easy loading of records on the spindle.

2. Provision of a depressed area around the centre hole in the record so that the selector blades would not touch the records during the separating operation.

3. A single diameter record having fixed dimensions for starting, and tripping grooves so as to reduce record changer complexity.

4. A small diameter record, rotatat a low speed. The small diameter results in a reduction in size of the record changer and also permits a decrease in length of the tone arm. By choice of a low rotational speed, it is possible to accomplish the complete change cycle in one revolution of the turntable.

Figs. 1 and 2 show the principle of operation of the record selector mechanism. Two oppositely positioned and inwardly retractable shelves (*a* in the figures) are located in the spindle. In direct association are two outwardly rotatable blades (*b* in the figures) spaced at a definite distance above the shelves. The design is such that in the playing position the shelves extend beyond the periphery of the spindle supporting the record stack, and the blades are housed within the spindle. The cycling operation causes the blades to rotate out beyond the outside diameter of the spindle just before the shelves are retracted. To complete the cycle, the shelves move back to their normal extended position just before the blades are rotated back to their normal retracted position.

As may be seen from Fig. 1 the centre area of the record about the centre hole is depressed on either side of the record, so that when the two records are stacked together, an air space is provided between them. This design offers a distinct advantage in that the records are not knived or otherwise separated, or even touched by the blade during the selecting operation.

The tripping mechanism is of particular interest. It is designed so that the work to trip the mechanism into cycle does not require any appreciable force between the reproducing stylus and the record groove. A small lever having very low friction, is moved by the inward motion of the tone arm, to a specific position where a lug on the turntable picks up the lever and causes it to cam the mechanism into cycle. The work of putting the mechanism into cycle is thus supplied by the moving turntable rather than by the pick-up stylus and record groove.

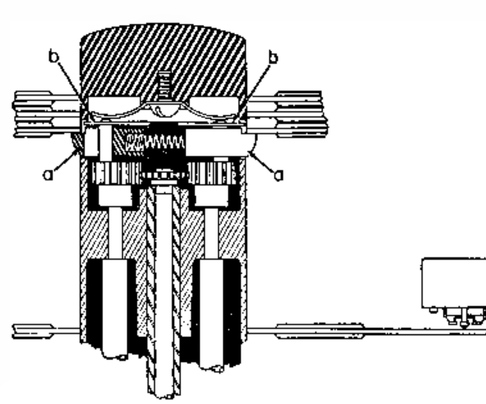


Fig. 1. Cross-sectional diagram of the R.C.A. record changing mechanism in the playing position

Factors Influencing Record Design

Record breakage has been a problem to manufacturer, dealer and consumer ever since the present design of 78 revolutions-per-minute records was adopted. The advent of synthetic thermoplastic resins made it possible to produce unbreakable records,[1] although such resins were not economically practical to use for commercial records.

For reproduction with increased frequency ranges, the surface noise of the average commercial record composition is higher than desirable. The noise reduction that can be obtained by using the finest available fillers does not approach that obtained with unfilled resins, and toughness, which results in greatly increased record life, is a characteristic of many of the synthetic thermoplastic resins that makes their use desirable in phonograph records.

It is obvious that for an economic solution of these problems, the amount of material in the record should be reduced, and that is compatible with the requirements of improved record changer design and reduced storage space. A drastic reduction in record size was therefore indicated as a major design requirement.

For a given distortion a reduction of reproducer stylus radius allows a reduction in linear speed of the record and therefore a smaller record. Experience dictated the choice of a 1-mil. radius as the minimum for the reproducer stylus and a 90-degree, 0.25-mil. bottom

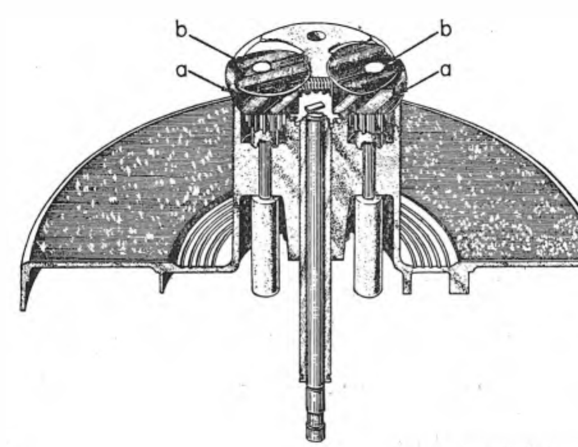


Fig. 2. This explanatory diagram of the record changer shows the mechanism out of cycle

radius groove. Since stylus and record wear are dependent on pressure, it was considered desirable to reduce the vertical stylus force. A saphire was chosen for the stylus in order to achieve long life.

Tests have proved that with a vertical force of five grammes, stylus life is equal to or better than that obtained in the present-day home phonograph. Unfilled vinyl records reproduced under these conditions show life far in excess of commercial filled compositions played on present-day phonographs.

The remaining parameters to be determined in order to design the record are peak recording level; maximum permissible grooves per inch and playing time.

With the improved processing methods available and the use of unfilled vinyl compositions, highly satisfactory signal-to-noise ratios can be obtained with a peak recording level of 14 centimetres per second (about 4 decibels below standard 78 revolution-per-minute records). Any further reduction in recording level (and therefore signal-to-noise ratio) was considered inconsistent with the objectives of high quality reproduction. This recording level permitted the selection of 275 grooves per inch as a maximum.

To determine optimum playing time an analysis was made of selected typical music in the Victor Catalogue. The playing time of each musical unit was determined and cumulative distribution curves prepared. It is rather surprising to note that 70 per cent of the musical units in the "classical" portion of this catalogue are less than five minutes long. It would appear from this that undue weight may, at times, have been given to the importance of long playing time. It was decided as a result of this analysis, that a playing time of a little more than five minutes, or the same as the 12-inch 78-revolution-per-minute record, would represent the best compromise.

The parameters necessary to design the record have therefore been chosen as follows:—

1. Playing time—$5\frac{1}{3}$ minutes.

2. Terminal linear velocity—$11\frac{1}{2}$ inches per second.

3. Maximum grooves per inch—275.

The criteria involved in the selection of record diameter and rotational speed are:—

1. The record should contain a minimum volume of material (this, as will be shown later, is not necessarily consistent with the minimum diameter constant thickness record).

2. The rotational speed should be selected considering optimum mechanical performance of the record changer.

3. An adequate label area (to provide identification of the music) should be included.

It is necessary that the radial length of the label area be large enough to provide adequate driving force and preclude the possibility of slipping.

A study was then made of the volume of material in the record and the radial length of the label area for different rotational speeds. Considerable study of the changer and of record manufacturing operations resulted in the following decisions:

1. A radial distance of 3/16 inch is desirable between the last music groove and the concentric finishing groove to provide reasonable tolerance for the trip mechanism and allow a very slight interval between the last note and actual tripping.

2. A radial length of 3/16-inch is desirable between the concentric groove and the outside diameter of the thicker centre section.

3. The depressed centre area of the records which forms the air space in which the selector blades operate should have a radial length of approximately $\frac{1}{8}$ inch.

Careful testing of large numbers of records played with a pickup of 5 grammes stylus force under different conditions of stylus and record wear, showed that the minimum label diameter to provide adequate traction was $3\frac{1}{2}$ inches. This required that the minimum diameters of the concentric finishing groove and the last music groove be $3\frac{7}{8}$ inches and $4\frac{1}{4}$ inches respectively. This diameter provides a radial length of about $\frac{7}{8}$ inch, which is sufficient for printing requirements.

The advantages and disadvantages of the three speeds in record designs that satisfy the previously established parameters ($5\frac{1}{3}$ minutes playing time, 275 groove per inch, $11\frac{1}{2}$ inches per second terminal velocity) may be listed as follows:—

78.26 *revolutions per minute.*

1. A speed reducing mechanism must be incorporated in the record changer increasing its complexity and cost.

2. The minimum volume depressed music area design is impractical.

3. The label area in the constant thickness minimum volume design is entirely inadequate.

4. The diameter of a $3\frac{1}{2}$-inch label depressed music area record would be $\frac{5}{8}$ inch greater than at 45 revolutions per minute and require 17 per cent more material.

$33\frac{1}{3}$ *revolutions per minute.*

1. The record diameter must be increased by $1\frac{1}{4}$ inches and the volume of material by 33 per cent over than required at 45 revolutions per minute. The limiting groove velocity of 11.5 inches per second is reached at a diameter of 6.6 inches. This diameter is greater than the diameter of the first music groove of the 45 revolution-per-minute record.

45 *revolutions per minute.*

1. The volume of material in the record is less than that required at either $33\frac{1}{3}$ or 78.26 revolutions per minute.

2. With the depressed music area design, which reduces record scuffing, the diameter is $6\frac{7}{8}$ inches compared to $8\frac{1}{2}$ inches at $33\frac{1}{3}$ or $7\frac{1}{2}$ inches at 78.26 revolutions per minute.

3. The record changer design provides reliable performance.

4. A playing time of $7\frac{1}{4}$ minutes may be obtained at a reduced terminal quality (though superior to 78 revolutions per minute records).

Based on the above considerations, the speed of 45 is obviously superior to either 78.26 or $33\frac{1}{3}$ revolutions per minute, and was therefore chosen for this system.

It is believed that the system described represents a basic advance in disk record reproduction. The desired improvements in quality, both noise and distortion, size reduction, long life, simplified and rapid record changer operation and elimination of record breakage have been achieved, and this record meets the requirements for high fidelity reproduction.

Reference

[1]F. C. Barton, *Jour. Soc. Mot. Pic. Eng.* 18 452, 1932.

"ARALDITE" A New Plastic Material With Excellent Electrical and Mechanical Properties

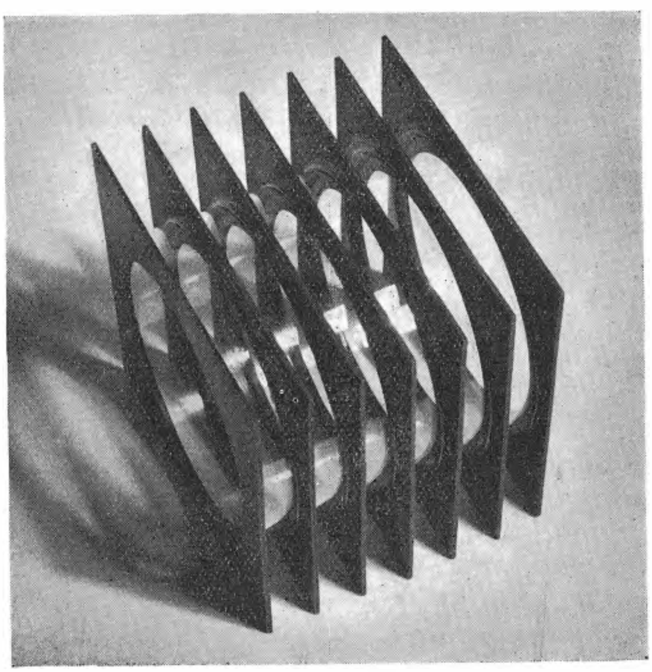
By C. J. MOSS, B.Sc.

MANUFACTURERS of radio and similar equipment have for some time been faced with serious difficulties in meeting the specification laid down for Service equipment. The components must be sealed so as to withstand a combination of high humidities and a range of temperatures from −40 to +100° C. for long periods of time. They must also be robust enough to stand up to the rough handling occurring in their use, e.g., the vibration from aircraft. Any sealing medium used must insulate the connecting leads one from another and also from the case of the component when this is made of metal.

Many efforts have been made to meet these conditions but hitherto none of them has proved wholly satisfactory. Clearly good sealing depends on adhesion, without which there will always be capillaries through which moisture may enter the component. There are few materials which possess good adhesion to the wide variety of materials used in the radio industry: metals, porcelain, mica, etc. In addition to good insulation properties the sealing medium may sometimes be required to have a good resistance to "tracking" and perhaps also a low power factor. Finally it must be possible to apply the sealing in some practical manner.

Experiments have already shown that "Araldite"* offers a good promise of fulfilling all these conditions. It is an entirely new synthetic resin of a rather complex composition which, when fully cured, combines good mechanical and electrical properties. Unlike many other resins it does not give off water or volatile products when it sets, and thus is not liable to cause corrosion of metal parts with which it may be in contact. Another result is that it does not shrink very much when it hardens, and is therefore not very liable to form cracks when it cools from the curing temperature. "Araldite" also has remarkable adhesion to metals, mica, quartz, porcelain, glass and to many other materials. Indeed it was as an adhesive ("Araldite" Type I) that it was first introduced into this country although it is now also available in the form of a casting resin, and as a wire coating resin. All three forms are hot setting, adhere well to metals, and are free from any corrosive influences. They are each described in some detail below.

* Registered Trade Mark.



An example of steel sheet bonded to glass for a piece of specialised research equipment

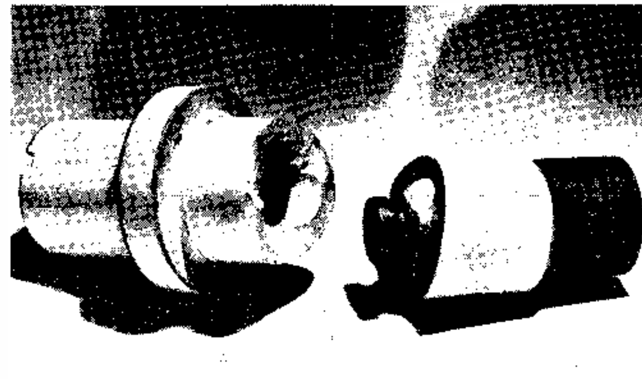
I. "Araldite" Casting Resin

The "Araldite" casting resin is available in the form of small yellow lumps while the hardener 901 is a fine white powder. When making castings the resin is first melted in any convenient vessel and then 25-35 per cent by weight of hardener added and well stirred into the resin. Since the hardener will combine chemically with the resin it is important that the two should be intimately mixed together. This can be carried out most conveniently at a temperature of about 125-130° C., when it will be found that the "Araldite" is quite mobile, and becomes even less viscous after adding the hardener. As soon as the hardener and resin come into contact chemical reaction begins to take place. The effect of this is that the viscosity of the mixture gradually increases, and if a long enough time elapses, it will become too thick to flow freely into moulds. At 120° C. the usable life of the mixed resin and hardener is about 1½ hours, but at higher temperatures it is rather less. After mixing the "Araldite" and the hardener 901, they may be cooled to room temperature when they will have a storage life of many months but at any time the mixture may be remelted and used for castings.

Addition of Dyes and Fillers

Castings made from "Araldite" are normally a brownish colour, but if it is desired powdered dyes may be added to the molten resin before making castings.

Various fillers may also be added to the molten resin, and they will, of course, increase its viscosity. Up to 25 per cent by weight of slate or up to 300 per cent of porcelain or silica sand or mica dust may be added to the molten resin in the form of thoroughly dried fine powders. By adding such large percentages of inert fillers to the resin not only can castings be made much more cheaply than with the pure resin, but they also have the effect of considerably reducing the coefficient of thermal expansion of the castings.



Porcelain to Brass joint. When tested to destruction failure occurred in the porcelain and not in the "Araldite" joint
(Courtesy—B.T.H., Willesden)

Temperature of Casting and Preparation of Moulds

In general any temperature above 120° C. may be used for pouring the "Araldite" resin, but when making large castings there is a decided advantage in using a temperature in the region of 160° C. provided that the curing of the castings is to be carried out at once. The reason for this is that the mass of the resin is already at a suitable stoving temperature and there is no time lag while heat gradually penetrates through it. It must be remembered, however, that at 160° C. the life of the mixed resin and hardener, before it thickens sufficiently to make pouring difficult, is not many minutes.

A wide variety of materials may be used for making moulds, but there is nothing better than metal if large quantities of castings are required. On the other hand materials such as plaster of paris or P.V.C. (containing not more than 160-170 parts by weight of dibutyl phthalate plasticiser to 100 parts of P.V.C.) may be used for small numbers of castings. Occasionally moulds may be made from thin sheet aluminium. In order to facilitate the removal of the castings from the moulds it is desirable that they should be rubbed with a silicone wax such as the Mould Release DC.7 supplied by Messrs. Albright & Wilson Ltd. Alternatively a 2 per cent solution in carbon tetrachloride of Mould Release Fluid (supplied by the same firm) may be brushed or sprayed on to the moulds. Large moulds must always be preheated to 130° C. before pouring the castings, but small ones may often be used at room temperature.

Curing of Castings

The table below gives a range of times and temperatures which are suitable for stoving castings. Large ones must be cooled comparatively slowly from the stoving temperature if internal stresses are to be reduced to a minimum.

TABLE I

Temperature		Curing time in hours
°F.	°C	
392	200	1—2
356	180	2—3
320	160	5—7
284	140	7—10
248	120	10—14
212	100	14—20

It is not advisable to stove large castings at temperatures above 160° C., and those containing metal inserts should never be cured at temperatures above about 130° C., but small castings may be treated at temperatures up to 200° C.

One firm using this resin has found it an advantage to cure the resin by stoving it overnight at about 100-120° C. Another method which has been adopted so as to secure an economical use of expensive moulds depends upon the fact that fairly early in the stoving period the resin thickens and then solidifies. Soon after this occurs the castings are removed from the moulds and the stoving completed without them. The moulds are then available for use for making a further batch of castings. Such a method is suitable when dimensional accuracy of the finished castings is of little importance.

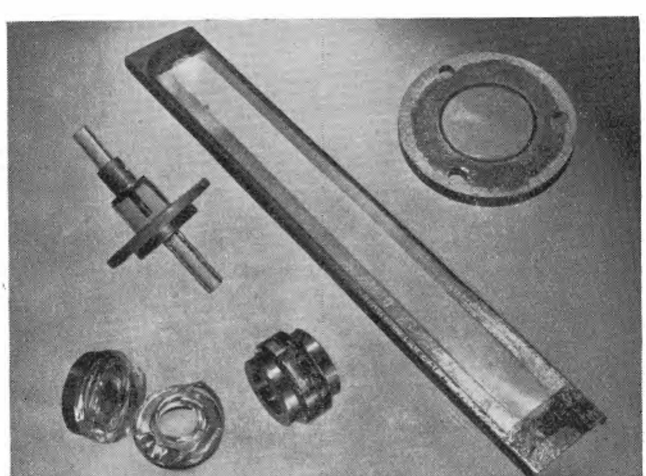
The Shrinkage of Castings

It has already been stated that, when the "Araldite" resin combines with the hardener during the curing treatment, no water or volatile materials are evolved. As a result there is only a very small contraction of the resin when it sets. Thus "Araldite" has a great advantage over many other synthetic resins. In addition to this small shrinkage due to chemical factors there is also a contraction in volume when the casting is cooled from the temperature of stoving to that of the workshop. Therefore, if shrinkage is to be kept to a minimum, castings should be stoved at as low a temperature as possible. This point is illustrated by the following figures:—

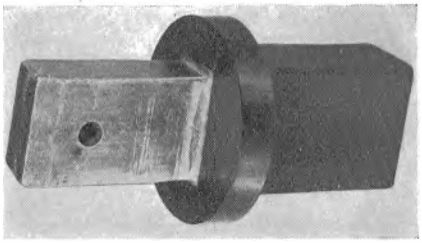
Total volume contraction of castings cured at 200° C., 2.3 per cent.

Total volume contraction of castings cured at 100° C., .5 per cent.

There is another aspect of this matter. Since the outside of a hot casting cools more rapidly than the inside there are always some in-



A selection of "Araldite" bonded components made for a Research Laboratory. The joints shown are mica to "Nicosil" alloy, mica to brass, quartz to steel, and quartz to "Invar." The specimen in the bottom left-hand corner shows that when tested to destruction the glass failed while the "Araldite" remained intact



" Araldite " is suitable not only for bonding metals but also thermosetting plastics. This photograph illustrates steel glued into an insulating plastic holder

ternal stresses set up on cooling. These are smaller if castings are cooled slowly. Clearly this is far more important with large masses than with smaller ones.

Electrical Properties of Castings

(a) Breakdown strength under steady voltage:—
30 kV for 1 m.m. thickness
5 kV for 0.1 m.m. thickness
(b) Dielectric constant:— approximately $3\frac{1}{2}$ throughout a frequency range of 1 to 100 megacycles per second.
(c) Power factor:— Approximately 3 per cent throughout a frequency range of 1 to 100 megacycles per second.

Mechanical Properties of Castings

Specific gravity, 1.22-1.23.
Tensile strength, 7,800-9,400 p.s.i.
Young's modulus of elasticity, 0.42-0.48 p.s.i.
Heat resistance (Marten's test) 110-120° C.
Percentage water absorption after:—

7 days at 20° C.	0.12-0.14
30 days at 20° C.	0.3
90 days at 20° C.	0.55

Coefficient of thermal expansion 60×10^{-6} per ° C.

Effect of Fillers on Properties

As must be expected there is some loss in mechanical and electrical properties when inert fillers are added to " Araldite " but they are not thought to be serious. To offset this there is a definite gain since the rather high coefficient of thermal expansion is reduced to a figure much nearer to that of the metals commonly used in electrical equipment.

It is not unreasonable to expect that when a material with a high coefficient of thermal expansion is cast round metals or other materials having lower coefficients of expansion that failures by cracking of the " Araldite " would occur on cooling from the stoving temperature. Such difficulties are largely overcome by using temperatures in the lower part of the range given in Table I, or by adding fillers to the resin. That satisfactory results may be achieved is shown by the examples of the uses of " Araldite " photographed.

Uses of " Araldite " Casting Resin

One of the problems facing the electrical industry is the protection of many kinds of equipment against tropical conditions. It is almost impossible to meet the requirements laid down for military equipment by conventional methods, but the introduction of " Araldite " has completely altered the situation. It is now possible to seal capacitors so effectively that they will withstand prolonged immersion in boiling water. One Swiss firm has been producing transformers completely encased in " Araldite," while another has already produced large numbers of capacitors of different kinds, some completely encased in resin and some in aluminium containers with the tops sealed by " Araldite." There seems to be no reason for doubting the efficiency of such equipment or its ability to pass exacting Government specifications. It will be appreciated that one of the reasons why this new plastic gives such a good seal is because it adheres so strongly to the material from which the equipment is made. Without this adhesion there would always be moisture penetration between the resin and the component itself.

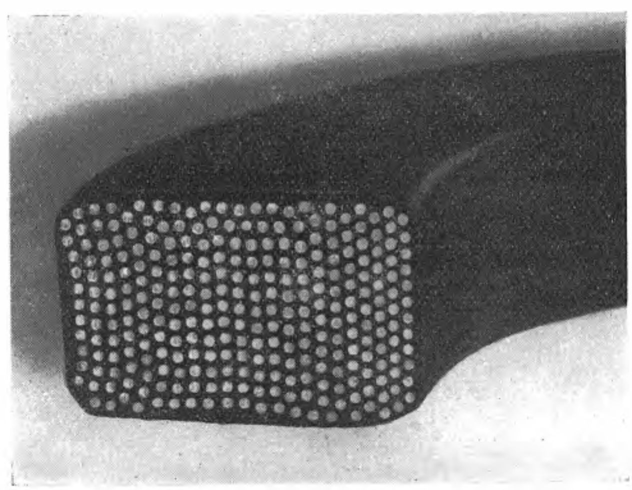
II. " Araldite " Wire Coating Resin 970

The " Araldite " Wire Coating resin has excellent resistance to abrasion and to solvents, oils and moisture. That it is very flexible, and adheres well to copper may be demonstrated in a simple manner by flexing a piece of coated copper wire to and fro until it breaks; even then the coating will not come away from the wire. Another of its outstanding properties is its resistance to high temperatures. This is important because the operating temperatures of many kinds of electrical equipment is limited to what the insulation on the wire will stand. In the past this has seldom been more than 100° C. for prolonged use, but Swiss experience has shown that " Araldite " wire coatings are practically unchanged after 100 hours at 150° C. It appears, therefore, that the introduction of this wire coating resin may make possible an increase in the temperatures at which electric motors, transformers, etc., can operate.

Method of use

The resin is supplied as a practically neutral solution containing about 45 per cent of solids but before application it is usually diluted to a solids content of between 20 and 25 per cent. For this purpose a mixture of solvents is always used and never a single solvent. Such mixtures may contain ketones, esters, alcohols, aromatic hydrocarbons and chlorinated hydrocarbons, but not aliphatic hydrocarbons. Naturally, the choice of solvents and the precise degree of dilution will depend upon the wire coating machines used, the speed of coating, and the temperature of curing. However the resin has been used successfully on both horizontal and vertical wire coating machines with curing temperatures in the region of 400° C. It

" Araldite " has been used in Switzerland for encasing cables (*Courtesy — Moser-Glaser, Basle, Switzerland*)



is common practice to apply between 5 and 7 coats of resin to the wire, but in this matter (as, in fact, in all matters connected with the technique of wire coating) practice tends to vary somewhat from factory to factory. However, on a 24 s.w.g. wire it would not be unusual to finish with a coating almost .001 in. thick.

It will be appreciated that it would be difficult to lay down precise instructions on the method of using the "Araldite" wire coating resin when there are different types of plant used and when the general conditions of coating vary so widely. The resin is, however, now widely used on the Continent and its excellent properties merit very serious consideration in this country as well.

III. "Araldite" Adhesives

Mention has already been made of the adhesive properties of this material. As it has already been described at length in articles in technical journals it will perhaps be sufficient if only a brief mention of the adhesive is made here. "Araldite" Type I is available in the form of rods, or as a powder, and both are applied to surfaces preheated to about 120° C. The parts to be joined are then clamped together and stoved according to the table below.

TABLE IV

Temperature		Minimum
°F.	°C.	Curing time
464	240	10 mins.
428	220	20 mins.
392	200	40 mins.
374	190	1 hour
356	180	2 hours
320	160	5 hours
284	140	15 hours

The above curing times may be exceeded by considerable amounts without the joint suffering any loss in properties. In fact, one of the advantages of the adhesive is that its stoving time is not critical. On the other hand a prolonged overheating will ultimately cause deterioration of the glue. For example, at 180° C. there will be only a very slight fall in joint strength after 24 hours' stoving, but if it is continued still longer then the strength will gradually fall off until the resin has finally decomposed.

Joints may be made with "Araldite" between metals, glass, porcelain, mica quartz and a wide variety of other materials. They are resistant to boiling water and solvents and to the attack of mould growths.

Sometimes it is impossible to preheat surfaces before applying the resin, and to overcome this difficulty the resin may be applied as a thin solution in acetone, i.e., as "Araldite" Type XI. If this modification is used it is necessary to allow about 1 hour at room temperature or a few minutes at 80° C., after brushing or spraying the resin solution, for the solvent to evaporate. The procedure is then exactly as for "Araldite" Type I, i.e., the joints are closed and the resin stoved as specified in Table IV. Joints made in this way are not usually quite as strong as those made with "Araldite" Type I, but nonetheless it is often much more convenient to use the "Araldite" in the form of a solution than as a rod or powder.

Another method is now available since it has been found possible to spray "Araldite" powder by means of the "Schori" gun. As with Type XI, when the "Schori" gun is used there is the advantage that preheating the metal surfaces is unnecessary. There is also the interesting possibility of preparing insulating layers of spraying the "Araldite" in this manner and subsequently stoving them. It appears that this technique would offer a simple solution to the problem of insulating metal surfaces since the insulating medium actually adheres by itself to the metal without any separate attachments being necessary.

Conclusion

There are some plastics with better electrical properties than "Araldite," but there is probably no other material which combines such good electrical and mechanical properties with such outstanding adhesion to the materials used in electrical equipment. It is this unique combination of properties which make "Araldite" of such value to the electrical engineer. In Switzerland it is already widely used, but in this country it is only just becoming generally known.

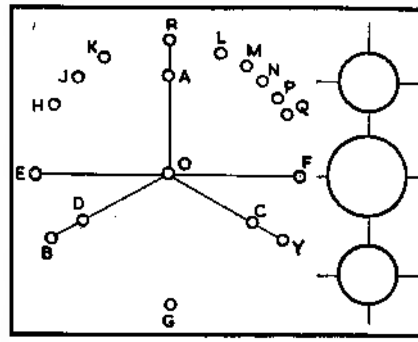
"Araldite" was developed by Messrs. Ciba Limited, Basle, Switzerland, and is marketed in this country by Messrs. Aero Research Limited, Duxford, Cambridge.

Bibliography

[1] Technical Notes Nos. 66, 70 and 77.
[2] "Araldite," British Plastics, Nov 1948, pp. 521-7.

TEMPLATE FOR VECTOR DIAGRAMS

Increased speed and accuracy can be attained with the help of this simply made vector drawing instrument



The template illustrated is made from clear plastic sheet about 1/16" thick. Points H, J and K give angles of 15°, 30°, 45°, and 60°. Points L, M, N, P and Q give angles whose cosines are 0.9, 0.8, 0.7, 0.6 and 0.5. B, R and Y fix the vectors of a three-phase system.

It is often found that a roughly-drawn vector diagram is very misleading. The template described below can be used to overcome the difficulties experienced with free hand drawing, since sketches of reasonable accuracy may be made quickly.

The template, which is made of celluloid or Perspex, is shown in the sketch, the actual size being about 4 in. by 2½ in. Each of the lettered points is actually a hole 1/16 in. diameter, the distances OR, OY and OB, each 1 in. long, representing the vectors of a three-phase system, and OA, OC and OD the same vectors to a different scale. Points E and F in line with O enable a horizontal datum to be drawn, and point G in line with O, R and A fixes a vertical axis.

The angle HOE is 30°: the angle JOE 45° and KOE is 60°. It follows that angles JOH and KOJ are each 15° and KOR is 30°. The several angles ROL to ROQ are angles whose cosines are 0.9, 0.8, 0.7, 0.6 and 0.5 respectively. As a refinement, the angles in degrees could be indicated against the points E to K, and similarly the cosine values could be marked against the points L to Q.

The three circular holes at the right of the template are ¾ in., ⅝ in. and ½ in. in diameter. They are very convenient for drawing instruments or relays in a wiring diagram.

The required angles are marked on a diagram by means of a pencil point inserted in the appropriate holes, and instruments by running a pencil round the larger holes.

—*Contributed by F. C. Gill, to "Distribution of Electricity," Sept. 1949.*

Decoupling in Video Amplifiers

In a form of video amplifier the load impedance of a stage consists fundamentally of a resistance with the addition of a tuned circuit for providing a more level response. The elements of such a stage are shown in Fig. 1. As it is usual, however, to decouple the anode circuit of the stage the actual circuit arrangement tends to correspond to that of Fig. 2. In this Fig. R1 is the commonly inserted decoupling resistance and C2 the capacitance of the co-operating decoupling capacitor. At high frequencies this capacitor behaves as if it possessed appreciable inductive reactance connected in series with its capacitance and accordingly the inductance L_2 is shown inserted in the diagram. Furthermore, the lead to the capacitor exhibits its own inherent self-inductance so that the extra inductance L3 is shown in serieswith L2. These elements additional to the fundamental circuit are objectionable, since they may cause spurious resonances and are liable to introduce instability at frequencies beyond the normal pass-band.

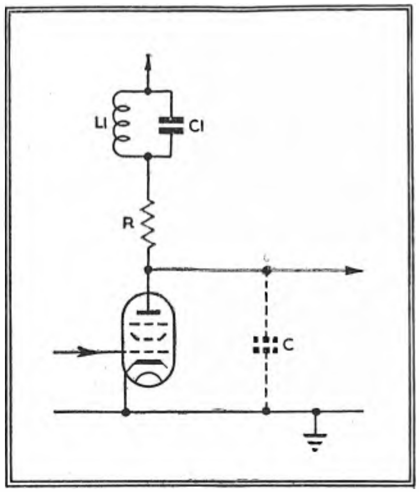
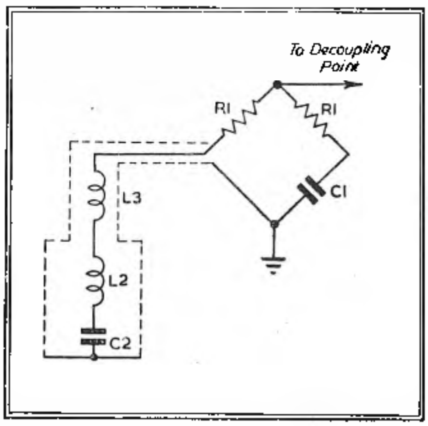


Fig. 1 (above). Essentials of a video amplifier stage



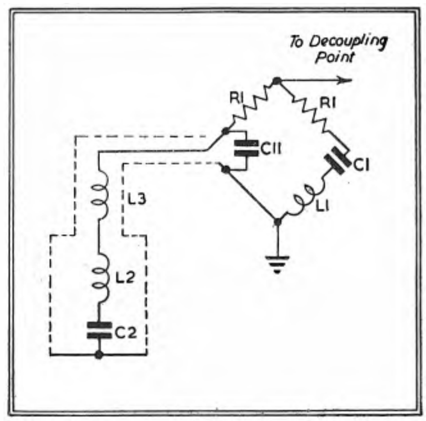
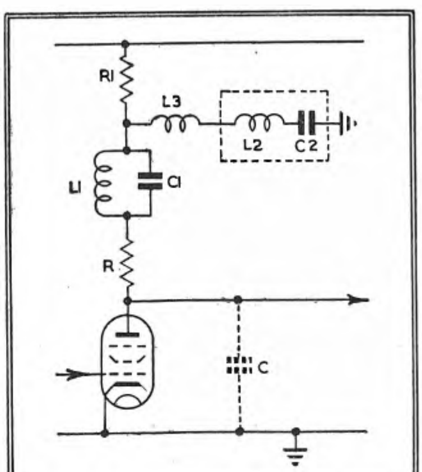


Fig. 2 (below). The same circuit, showing the unwanted factors introduced by decoupling

Fig. 3 (left). Decoupled circuit avoiding the undesirable effects of Fig. 2

Fig. 4 (right). Showing capacitor (C11) added to offset fall in network impedance which occurred with rise in frequency



The circuit of Fig. 3 indicates a method of decoupling by which such difficulties are not encountered. In this circuit the decoupling capacitor forms part of a low-resistance constant impedance network connected to the decoupling point, so that the elements L3, L2, C2 of Fig. 2 are replaced by a circuit of impedance that is small and resistive for all frequencies concerned.

The circuit consists of the parallel connexion of a branch formed of resistance in series with capacitance. These are shown as the branches R1, L3, L2 and R1, C2 in Fig. 3. The impedance presented by the circuit has the constant resistive value R1 if

$$\frac{L2 + L3}{C2} = R1^2$$

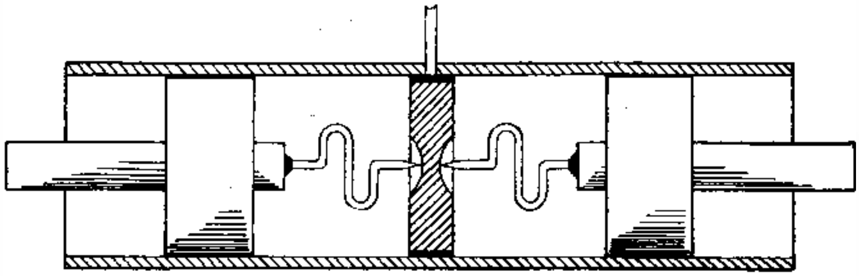
Suitable values are R1 = 10Ω, C1 = 1,500 *pF*. Following common practice the decoupling capacitor may be remotely located. In this event it is connected in the circuit via a screened cable, as indicated in Fig. 3, and instead of grounding the decoupling capacitor directly it is grounded by connecting it to the shielding of the cable, the other end of which is earthed.

With the typical values given it is found that at frequencies above 6 Mc/s. the network impedance falls, until at 20 Mc/s. it is reduced from 10.6Ω to 9.1Ω, due to the residual series inductance of the capacitor C1. This effect may be balanced out by adding a small capacitor across the end of the shielded cable remote from the decoupling capacitor. Fig. 4 illustrates the addition of the capacitor, C11, and the presence of the residual inductance, L1. The modified criterion for constant impedance is

$$R1^2 = \frac{L2+L3}{C1} = \frac{L1}{C11}$$

With this form of the circuit the error at 20 Mc/s. is no more than 0.2Ω.

—*Communication from E.M.I., Ltd.*



The Coaxial Transistor

SHORTLY after the discovery of the Transistor, J. N. Shive, of Bell Telephone Laboratories, observed that amplification could be obtained with a germanium wedge when the emitter and collector points were placed on opposite sides of the wedge.[1] In this construction, the germanium wedge is narrowed down to a sharp edge and the point contacts are placed on opposite sides at a point where the wedge is only a few thousandths of an inch thick.

Investigation of the wedge device seemed to indicate that the current passing between emitter and collector was actually passing through the semi-conductor and not around the wedge surface. Thus the effect was apparently not a surface phenomenon but rather a current amplification process occuring within the semi-conductor itself. If this were true, transistor action should also be possible by reproducing the wedge geometry in circularly symmetrical form, thereby providing complete shielding between emitter and collector points.

1. "The Double Surface Transistor" J. N. Shive, *Physical Review*, p 689, Feb. 15, 1949.

A disk of germanium $\frac{1}{8}$ in. in diameter and 20 mils. thick was cut from a thin slab of germanium by means of a hole saw. Two dish-shaped depressions were ground and lapped into the faces of the disk by means of a spherical tool. This wafer was placed in a mount and held by spring pressure.

The germanium disk, normally grounded electrically, is seen to provide an electrostatic shield between the emitter and collector points, and all three parts—emitter point, collector point and germanium disk—are coaxial.

With the highly polished surfaces desirable for operation at higher current, it had been found with the Type A Transistor that points which were not perpendicular to the surface often had a sufficient tangential component of force to cause them to slip as they were pressed against the surface. In the coaxial construction, the two contact points are on opposite sides and thus can be exactly perpendicular to their contacting surfaces.

Characteristics are comparable with those of the Type A Transistor, which has both points on the same side of the disk.

Advantages which might be attributed to the coaxial construction are: improved stability of the points, especially on highly polished surfaces; electrostatic shielding between input and output circuits; and the avoidance of construction problems involving the placing of two spring contacts within a few thousandths of an inch of one another. Close tolerances are not completely avoided by this design, however, since the two points should be accurately in line on opposite sides of the germanium for most satisfactory operation.

—*Bell Lab. Record.* April, 1949.

ELECTRONICS SYMPOSIUM—*Examination Hall, Queen Square, London, W.C.1.* November 2–4, 1949

IN organising the 1949 Electronics Symposium and Exhibition, the Scientific Instrument Manufacturers' Association endeavours to call the attention of as many industries as possible to the increased uses of electronic techniques in fully instrumenting their methods.

A wide range of communication test gear, manufactured by members of the Association, will be of interest to those connected with this industry. In addition to health-metering equipment for radiation laboratories, those interested in medical applications will be able to see electronic cardiographs and encephalographs. Workers in the chemical industry will be interested in many of the special instruments developed on electronic principles on process control. These will include special D.C. amplifiers, recording pH meters and temperature equipment: in the research field, special spectrophotometers and infra-red spectrometers will be of great interest to the research chemist.

It is not possible in this short note completely to mention the fields to be covered, but a final list of the instruments to be shown will be published in a leaflet, summarising the Symposium and Exhibition, which will be available in October on application to the Secretary at 17 Prince's Gate, Kensington, S.W.7 (KEN 0061).

Papers to be Read

Wednesday, November 2, at 2.45 p.m. "*Electronic Instrumentation in Atomic Research.*" Denis Taylor, M.Sc., Ph.D., M.I.E.E., F.Inst.P. (A.E.R.E., Harwell).

Thursday, November 3, at 10 a.m. "*Electronic Amplifiers.*" D. L. Banks (Furzehill Laboratories Ltd.).

Thursday, November 3, at 11.15 a.m. "*Magnetic Amplifiers.*" A. V. Hemingway, B.Sc.(Eng.), A.M.I.E.E. (Elliott Brothers (London), Ltd.).

Thursday, November 3, at 2.30 p.m. "*Some Recent Improvements in Electronic Measuring Techniques.*" C. H. W. Brookes-Smith and J. A. Colls, B.Sc., A.R.C.S. (Southern Instruments, Ltd.).

Thursday, November 3, at 3.45 p.m. "*The Measurement of Some Transient Phenomena.*" H. A. Dell, Ph.D. (Mullard, Ltd.).

Friday, November 4, at 10 a.m. "*An Industrial Servo Mechanism.*" P. H. Briggs, B.Sc.(Tech.) (Ferranti, Ltd.).

Friday, November 4, at 11.15 a.m. "*Co-operative Research at B.S.I.R.A.*" A. J. Maddock, D.Sc., F.Inst.P., M.I.E.E. (B.S.I.R.A.).

NOTES FROM THE INDUSTRY

Third Amateur Radio Exhibition

The Third Annual Amateur Radio Exhibition organised by the Radio Society of Great Britain, will be opened at 2.30 p.m. on Wednesday, November 23, 1949, by Baron Sandhurst, O.B.E. The Exhibition will remain open until November 26 (hours 11 a.m. to 9 p.m.), at the Royal Hotel, Woburn Place, London, W.C.1 (nearest Underground station, Russell Square. Bus routes 68 and 77 pass the door).

Twenty-five concerns have reserved space, including the G.P.O., who are to stage a special exhibit.

Admission will be by catalogue, either purchased at the door, or 1s. 3d. on application to the Society (New Ruskin House), Little Russell Street, London, W.C.1.

Enquiry for Domestic Appliances

The Board of Trade Exports Department has been advised by the British Consulate General at Detroit that Messrs. Buhl Sons Company, one of the principal distributors in the U.S.A. of hardware and allied lines, has agreed to consider offers from United Kingdom manufacturers who are in a position to quote firm c.i.f. Detroit prices.

Among the items in which the American company have expressed interest are the following classes of goods which are handled by their Major Appliance Department: clothes dryers (electrical and gas), electric ironers, electric ranges, electric refrigerators, fans and electric washing machines.

The Acoustics of Concert Halls

The problems in acoustical design set by the new London County Council South Bank Concert Hall and by the rebuilding programme for other halls have led to an increased interest in recent attempts to replace the present statistical and geometrical theories of room acoustics by wave theories. (Cf. Morse & Bolt: Sound Waves in Rooms. *Reviews of Modern Physics*, *16*, 2, 1944). Arrangements have been made for Professor R. H. Bolt, Director of the Acoustics Laboratory, Massachusetts Institute of Technology, to deliver a course of six lectures on this topic under the auspices of the Acoustics Group of the Physical Society, with the general title "Modern Principles of Room Acoustics." The course of lectures will outline the present position reached in the development of new ideas, and will cover the following ground. Classical practice—Physical and psycho-acoustic foundations—Standing waves—Wave statistics and transition regions—Free waves and pulse statistics—Indications for future practice. The lectures will be given in the Lecture Theatre of the Royal Institution, Albemarle Street, W.1, at 5 p.m. on September 29 and 30, and on October 3, 4, 5 and 7. A registration fee of 10s. 6d. (which may be waived in the case of students) will be charged for the course. Further particulars may be obtained from the Joint Honorary Secretaries, the Acoustic Group of the Physical Society, 1 Lowther Gardens, London, S.W.7.

Multicore Record Export Sales

Statistics prepared by the Export Department of Multicore Solders, Limited, show that during the second quarter of 1949, record sales of Multicore Solder were made in export markets. Over 1,900 miles of Ersin Multicore Solder made at the Multi-Core factories at Slough, Bucks, were shipped to the U.S.A. alone. This earned 72,000 dollars for Britain.

British made Ersin Multicore Solder containing three cores of Ersin flux is now being used by more than 30 U.S.A. television transmitter and receiver manufacturers, and is now regularly exported to over 40 countries. Technical literature in Arabic is now available, in addition to that in nine other languages.

British Television in U.S. Markets

For the first time a British television manufacturer is to challenge American makers on their own ground. The Canadian National Exhibition opening at Toronto on August 26 will see the very first demonstration of British television receivers working on American transmissions. Pye (Canada), Ltd., subsidiary of the well-known Cambridge radio and television firm, have opened a factory at Ajax, Ontario, to make sets operating on 525-line definition, with frequency-modulated sound and negative (black instead of white) interference. The six pioneer sets to be shown at Toronto will receive transmissions from both the U.S. station at Buffalo and from a Pye Monoscope ("still") projector working in a different hall of the exhibition.

Murphy Radio Company Expands

Murphy Radio, Ltd., announce an increase in its capital for the acquisition of two powerful interests in the electro-medical field; General Radiological, Limited, and Solus-Schall, Limited. Murphy also has a joint interest with Pye, Limited, in Link Sound and Vision Services, Limited, a company occupied in the dissemination of television and radio by means of wires and cables.

General Radiological and Solus-Schall will continue to operate as before, each specialising in production of their own particular equipments.

Royal Statistical Society

Industrial Applications Section

A provisional group of this Section has been successfully operating in South Wales, and meetings have been held in Crumlin, Cardiff and Swansea during the last year. A formal group to be called the South Wales Group has now been inaugurated under the chairmanship of Dr. T. Starkey of the Technical College of Monmouthshire.

The Section is concerned with the application of statistical techniques to all aspects of the industry, including industrial research, development and manufacture, and inspection, and is playing its part in satisfying the current need for higher and more efficient production.

Visitors are cordially invited to attend its meetings, and further information and forms of application for membership can be obtained from Mr. E. Lloyd, at the Technical College of Monmouthshire, Crumlin. Information concerning groups already existing in Birmingham, London, Newcastle, Sheffield and Tees-side can be obtained from the Secretary of the Section, Miss J. Keen, G.E.C. Research Laboratories, Wembley, Middlesex.

Distinction for Moisture Meter

At the 1949 Royal Show the Marconi Moisture Meter type TF 993 was awarded the Royal Agricultural Society's New Implement Silver Medal and no doubt as a direct result more orders were taken for the instrument than at any previous agricultural show.

Apart from cereals and cereal products, the Moisture Meter has proved extremely effective in measuring the moisture in tobacco and already it has been adopted by several of the large cigarette manufacturers.

Photocell Control for Pylon Lights

The 272 ft. high pylons which carry the 132 KV power lines across the river Orwell at Ipswich have recently been fitted with aircraft warning lights which are switched on and off by G.E.C. photocell equipment actuated by the prevailing light conditions. The equipment was installed to the requirements of the consultants (Messrs. Merz and McClellan) for the British Electricity Authority.

Each pylon has a set of lights at the top and two other sets 150 ft. from the ground. It is interesting to note that owing to the great height of the towers and their lattice-work construction, it was necessary to mount the photocell unit on a 25 ft. pole so that shadows would never fall across the cell and cause premature operation.

BOOK

Electronics and their Application in Industry and Research

Edited by B. Lovell. 660 pp. 404 figs. Pilot Press 1947 (now issued by Chapman & Hall). Price 42s.

THE title is unfortunately both misleading and ungrammatical (does one refer to Mathematics, Physics or any other one science in the plural?) since we have here, not yet another amateurish rehash of elementary electronics, but a long, soundly written, roundly edited account of *recent developments*, written by leading specialists. Much of it appears for the first time in book form, including many useful practical data.

The editor, a physicist at Manchester University, contributes an introductory chapter on the development of electronics, with particular and perhaps excessive emphasis on its growth during World War II, considering the solid industrial groundwork laid pre-war. Everyone will agree, however, that in the future " there are few scientific investigations which will not benefit from the application of electronic techniques." One important omission from a useful bibliography of basic books is Gulliksen and Vedder: *Industrial Electronics* (John Wiley, 1935).

Dr. Vick, also of Manchester University, gives a concise theoretical review of modern Electron Physics, including electrons in metals, emission, contact potentials, insulators and semi-conductors, luminescence and photo-conductivity, and metallic/nonmetallic contacts.

Photocells for the Visible and Ultra-Violet are described by Dr. Lubszynski of EMI Research Labs. He valuably summarises theory and practice on the three main types—emissive, conductive and voltaic, with much data, particularly on the first, and a brief general survey of applications.

Dr. Elliott of the Admiralty Research Laboratory deals with Recent Advances in Photocells for the Infra-Red, an important field in which wartime communications accelerated novel developments. Photoelectric devices respond more rapidly than the classic thermal (black-body) absorbers, and among the new sensitive infra-red cells, the lead sulphide photoconductive cell appears the most interesting industrially, responding optically up to 3.5 microns and in speed up to about 10 Kc/s. One possible novel application is in high-speed radiation pyrometry for surface temperatures as low as 100° C.

Electronic Generation of Television Signals, by Dr. McGee of EMI Research Labs., is an admirable review of past and present methods and tubes. All the important current tubes (except the recent CPS Emitron') are discussed, and a most useful table critically grades eight members of the Emitron and Orthicon families in respect of ten important features. This is probably the best general account yet published.

Dr. Thompson of Marconi Valve Labs. follows on Thermionic Valves for Very High Frequencies, i.e., for wavelengths of 10 cm. and less. The frequency limitations of normal valves were first reduced by " acorn," " door-knob" and eventually "lighthouse" constructions, working up to 1,000 Mc/s. The two radically new types are the klystron, best for C.W. working, and the multi-segment magnetron, ideal for high-power pulse conditions. Both depend on cavity resonators for delivering power at up to 10,000 Mc/s., and theory and practice are given in detail.

Radar follows logically, and is lengthily reviewed by Dr. Smith of T.R.E. A short historical review is succeeded by fundamental considerations. The F.M. system is best for observing one object, but the pulse system is advantageous for time-delay displays of several objects. Examples of range calculation follow, with notes on anomalous propagation and radar responders (re-radiating relays on friendly aircraft, etc., for enhancing an artificially-produced echo). Features of radar aerials, transmitters, receivers and displays fill 24 pages, with another 32 pages on measuring, bearing, elevation and range. In considering the effect of radar on the advance of science the author mentions meteorology (cloud structures and weather forecasting, the ionosphere), astronomy (distance to the moon), radio propagation (sunspot and galaxy noise measurement), pulsed ultrasonics and light, peacetime transport, television, industrial control circuits and nuclear physics (particle acceleration). One should also remember the wartime aggregation of specialists from many fields who have now returned to them, enriched by their experience in electronic techniques.

Cold-cathode valves have an exceedingly long intermittent life as compared with thermionic types, a very valuable industrial feature. Mr. Atkinson, of Ferranti, describes the characteristics and control applications of the cold-cathode triode, ignitron, servotron, stroboscopic lamps and pulse trigger valve in counting and control, magnetising, half-cycle welding, stroboscopy, depth sounding and high-speed flash-photography.

Mr. Wood, of Ferranti, next describes High Frequency Heating, introduced as making use of induction and dielectric

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"losses." Spark and thermionic-valve generators are briefly compared. I.H. applications include valve heating, hardening and tempering of ferrous metals, melting of various metals, brazing and soldering. C.H. applications cover moulding of plastics, laminated timber, welding of plastics and diathermy. The mathematical theories are considered, followed by detailed circuits and operation of H.F. thermionic-valve generators, illustrated by typical equipments made by the author's company.

The same author also describes briefly a Moisture Content Control Equipment, seemingly incongruous with the rest of the book, but said to be included as "an example of an electronic apparatus which facilitates, and renders more accurate and inexpensive, an existing control function." The machine controls the moisture content of cloth from a dryer by means of the effective Q of a capacitor formed between two parallel plates on either side of the cloth. The detecting circuit, including a swept-frequency oscillator, is interesting, but it is most unfortunate that the article is illustrated by pictures of an obvious development model. It certainly reveals no new constructional technique and is bad for British engineering prestige both at home and abroad.

Electronics Applied to Servomechanisms is discussed by Mr. Belsey of Metropolitan-Vickers. He establishes the need for difference-signal actuation in automatic position or speed control and for electrical error detection in stabilising against hunting; the advantages of thermionic servo-amplifiers; the essential parts and classification of servo-mechanisms. Error-measuring systems include potentiometric, electromagnetic and photoelectric devices. General types of A.C. and D.C. servomotor systems are described and compared, followed by a section on electronic servo-amplifiers, particularly those of the D.C. push-pull type. Incidentally, good electronic engineers will be horrified to observe the use of potential dividers for interstage D.C. couplings, considering that much more efficient methods have been developed. Phase-discriminating and thyratron A.C. amplifiers are also included. Speed/torque characteristics of various D.C. servo-motors (split-field, Ward-Leonard, Metadyne) are assessed. Applications briefly reviewed include calculating machines, auto-pilots, remote control of gun-mountings, auto-controlled machine tools, variable-gear-ratios for large machine tools (e.g. boring mills).

Dr. Grimmett, formerly of the Radiotherapeutic Unit of the Medical Research Council, excellently reviews Electronics in Medicine, proving his contention that medicine is always quick to profit by new developments in Physics. High energy radiations, used for treatment (radiotherapy) and for examination (radiology), depend on the acceleration of charged particles by devices ranging from X-ray tubes to the cyclotron and betatron and their derivatives. Other related topics include the action of radiotherapy, electronic (counter) dosemeters, applications of tracers (path indicators) and therapy, and Geiger-Muller counters. H.F. oscillations are used in deep tissue heating (diathermy), electrosurgery (blood stimulation, drying and burning or "cutting" of tissue) and location of foreign metallic bodies. Advances in wartime cm. wave generation due to the klystron are of interest to medicine also. The theory, application and biological action of H.F. heating is discussed. The electron microscope is of tremendous significance in studying microscopic organisms. The author makes a plea for a direct-viewing X-ray "screen amplifier," based on television pickup tubes, and it is interesting to note that this has subsequently been done.[2] The minute bioelectric potentials developed by active nerves and muscles are important in physiology, particular electronic measuring instruments being the electrocardiograph and phono-electrocardioscope, and the electroencephalograph, for heart and brain respectively. Electronic acoustics in medicine includes hearing aids based on assessment of deafness (audiometry) and the biological effects of ultrasonic vibrations. Photoelectric devices are used in analytical tools (colorimeter, etc.) and in sensory aids for the blind.

Dr. Pumphrey, of Cambridge University, expands part of the previous chapter under Electronics in Physiology, a typical field where the sensitivity of the thermionic valve opened up entirely new ground, especially in obtaining faithful transient records. A moving account of early experimental difficulties is followed by an interesting discussion of nervous electrical activity. Finally the author directly challenges electronic engineers to produce a really high-gain low-noise very-low-frequency amplifier, and bemoans the lack of ultrasonic generating and recording equipment for experimental work on animal hearing.

Dr. Craggs of Metropolitan-Vickers enlarges another earlier topic, the Betatron, which provides the most economical method of accelerating electrons to high velocities. He describes the early experiments, Kerst's work and theory, and constructions ranging from Steenbeck's and Kerst's

BOOK REVIEWS *(continued)*

models to the M-V 20 MeV and G-E 100 MeV versions. Various curves illustrate applications to deep therapy, nuclear physics and radiography.

The final chapter of over 100 pages is mainly devoted to the most exciting, revolutionary research tool of the century—the Electron Microscope. Dr. Cosslett, of the Cavendish Laboratory, Cambridge, points to its relatively recent origin in 1931 and rapid development to an indispensable tool in all research concerning the fine structure of matter, both organic and inorganic. Principles are explained by comparison with optical microscopes, and electron lens theory is treated in detail, with a long section on actual magnetic electron microscopes, including the M-V and RCA desk types. Some other special types, including Hillier's "Microanalyser." are mentioned later. Applications are classified according to preparation technique (finely divided particles, sectioned specimens and surface replicas), and illustrated by many fine photographs. Finally the theory and practice of Electron Diffraction, important in studies of material structure, is briefly considered. Diffraction adapters may often be fitted to electron microscopes and the author considers that this will encourage use of the same basic instrument for future investigations.

Two useful appendices contain abbreviations for scientific journals and a list of physical constants and units. Detailed subject and author indices follow.

This book can be strongly commended to all electronic engineers and to others who would gain a wider view of the possibilities of electronics, as it combines to an uncommonly high degree the virtues of scientific authority and compact, interesting presentation. The copious illustrations include many half-tones, and the refrences in each self-contained chapter are generally good, complete and to recent dates, and of truly international outlook. The printing is clear, on high-quality paper, but it is to be hoped that further impressions will be finished in a stronger binding and more glamorous title blocking. Although the price is high, as is all too common nowadays, it is better justified here, in the opinion of this reviewer, than in any other British post-war text in the field.

J. C. Finlay

References

[1] The New Television Camera. *Electronic Engineering*. 20, 59, 1948.
[2] (Westinghouse X-Ray Division) : New X-Ray tube magnifies 500 times—*Electronic Ind. and Electronic Instrumentation.* 2, 11, 1948.

"Vacuum Tube Amplifiers"

By Valley and Wallman, McGraw-Hill Publishing Co., Ltd. 743 pages. Price 60s.

THE preface of this book gives an admirable review of its contents but it is important to remember that it is one of a specialist series, or even more precisely, one of a group within a series, and that it was never intended to be a text book. It is, in fact, exactly what it claims to be—"the collective result of work done in many laboratories" during the war; in consequence the explanations and mathematical treatments throughout assume a considerable knowledge of the various subjects discussed. The book is an invaluable work of reference but it is perhaps limited by the too rapid manner in which some of the explanations are developed and the somewhat dogmatic statements of some results.

It is unfortunate that the contributors found it necessary to introduce the word "elastance" for capacitance in Chapter 1 on "Linear-circuit Analysis"; however, use of this word is restricted to this chapter. In Chapter 2 on "High-fidelity Pulse Amplifiers," distributed amplifiers are dismissed in half a page with no reference to the results published in *Proc. I.R.E.*; this is unfortunate, as there can be little doubt that this type of amplifier will find ever increasing applications in the future.

Use of the term "phase inverter" for paraphase amplifier is to be deprecated and it is surprising that mention is not made of the "see-saw" paraphase and cathode-coupled amplifiers. It is also surprising to observe that resistance loads are recommended for "phase splitters" operating at 10 Mc/s. and higher frequencies; one would have thought that tuned transformers were essential for accuracy.

Treatment of the overshoot problem in Chapter 3 on "Pulse Amplifiers of Large Dynamic Range" is particularly good, except that on p. 129 there is a mix-up between the charging and discharging of capacitor C_s. Chapters 4, 5, 6, and 7 on single and double-tuned bandpass amplifiers, high frequency feedback amplifiers, and pulse response in bandpass amplifiers respectively are excellent, but assume fairly comprehensive grounding in the subject.

Chapter 8 discusses measurements and testing but is not as useful as one would expect because many of the statements contained therein will confuse the uninitiated and are quite unhelpful to the more experienced. Both Chapters 9 and 10 on "Low-frequency Amplifiers with Stabilised Gain" and "Low-frequency Feedback Amplifiers" respectively are very clear and concise statements on their respective subjects although something has gone astray in Fig. 10/16.

Chapter 11 is an excellent discussion on direct coupled amplifiers and their peculiarities; it is surprising, however, that mention is not made earlier than Fig. 11/64 to the use of pentodes as constant current devices, as for example, in Fig. 11/26. It is also surprising to see "cancellation" spelt with two "l's" followed by "canceled" spelt with one "l" on p.459. In Fig. 11/42 a diode is shown; this valve carries the Service number for a diode. No reference is made to the work of S. E. Miller on compensating for the effects of variations in equivalent grid potential due to heater temperature variations, to the use of neon discharge tubes as blocking devices in D.C. amplifiers, or to pentodes as equivalents for large grid leaks combined with high bias voltages.

The discussion on "Noise" in Chapter 12 is very thorough and is intended for those who have to inquire deeply into the subject to achieve optimum results from very low-level amplifiers. The remaining Chapters 13 and 14 on minimising and measuring "noise" call for little comment.

The book is comparatively free from typographical errors the illustrations are excellent throughout, and, in general, it can be most thoroughly recommended to the professional engineer.

H. A. Thomas

CORRESPONDENCE

Variable Frequency R.C. Oscillators

DEAR SIR,—We have studied with interest Mr. Parton's table of coefficients for R-C and C-R ladder networks. An addition to his list of differing formulæ is that of $f = \dfrac{1}{19.9CR}$ given by Amos and Kellaway[1] for a 3-stage CR oscillator.

It should be pointed out, however, that the formulæ quoted (with the exception of (1)), neglect any phase change in the valve itself and its anode load. As in many cases this is not justified, practical results may diverge considerably from theoretical values.

Our own method of obtaining an approximate formula applicable to any number of sections may be of interest. For an R-C ladder network of n sections having its first resistance equal to $R/2$ instead of R, the formula $f = (\tan \pi/n \ \sin \pi/n)\ CR$ or $\beta = (\tan \pi/n \ \sin \pi/n)$ can be shown to hold for 180° phase shift. For large values of n the second of these formulæ becomes $\beta = \pi/n^2$ approximately. Although this is strictly true only for large values of n and for a first resistance of $R/2$, it will be found under the usual working conditions to give a good approximation for all values of n above 3 and with all resistances equal to R.

No. of Steps n	After Parton	Approximate formula	Experimental Value
3	.390	0.349	0.407
4	0.1905	0.196	0.207
5	0.1178	0.125	0.136
6	0.0812	0.0872	0.098
7	0.0593	0.065	0.075
8	0.0457	0.049	0.057
9	0.0363	0.0388	0.045
10	0 0296	0.0314	0.037
α	0	0	—

The table shows the value of β as worked out by the approximate formula, from Mr. Parton's table, and as determined experimentally. The agreement can be seen. For the C-R network similar analysis yields the formula $\beta = n_2/4\pi^2$. This gives results in approximate agreement with Mr. Parton's values, but differs from results obtained experimentally.

One other point may be mentioned. Some doubt is expressed by Mr. Butler as to the performance of phase shift oscillators at very low frequencies. We have, however, constructed an oscillator of this type which gives reasonably sinusoidal oscillation once in ten minutes.

Yours, faithfully,

W. BACON, F. W. CLARK.

Department of Electrical Engineering,
Municipal College,
Portsmouth.

[1] "*Radio Transmitters and Receivers*"—Amos and Kelloway.

Programme Level

DEAR SIR, —I cannot disagree more with your comments in the July issue on the relative loudness of broadcast speech and music.

You refer to the "Listener Answers Back" series, but surely few people took these seriously, and I am sure the B.B.C. would be very misguided if they did so. You do not mention that in the official reply to the relevant question was also the counter complaint that millions of people listen to sets giving terrible reproduction, this giving indirectly the correct answer.

The trouble is that the majority listen to speech at a level much too loud, consequently music must also be too loud. The reason for this is that the distortion in the reproduction makes it necessary for intelligibility. So it would be strange indeed if when the output changes to music the result is not uncomfortable, to say the least.

A great number of high-fidelity fans make the opposite complaint that when the output changes from music to speech the noise "booms out." I think these are mostly victims of the fallacy of correction for so-called scale distortion (see *Wireless World,* January, 1942), when the fault really lies in their own equipment, generally the loudspeaker and/or its mounting. As a general rule they have boosted the bass, and sometimes the top, to give what is really an unnatural result. Then how can they possibly expect speech to sound otherwise than boomy or throaty? These listeners, too, usually listen at too high a level of loudness for their listening conditions. This "boom and jingles" effect is very impressive, but not true reproduction.

My experience is that with good equipment it is possible to listen to broadcast speech at a natural conversational level, just as if the announcer is actually in the room, with perfect intelligibility. With this condition satisfied it will generally be found that when the change to music takes place the reproduction is both realistic and comfortable as regards loudness.

Sometimes it will be found that the announcer of a musical programme has to be heard above a noisy background, but the control engineers quickly bring the speech down to a natural level as soon as practicable. A good example of this was during the Prom. broadcast on Saturday, July 30.

The announcer usually speaks into the microphone at a conversational level, and this is how he should be heard, not booming out into the wide open spaces.

I think that on the whole the B.B.C. are to be congratulated on the way they overcome their difficulties to give us such a good and consistent balance.

I know that you will agree that one can listen to the output from really distortionless equipment at a realistic level without causing annoyance to others, but at anywhere near the same output nearly all commercial sets are nothing less than a confounded nuisance.

A. S. EVANS.

New Malden, Surrey.

Television Weather Forecasts

DEAR SIR,—In the August issue of Electronic Engineering you state, in reference to the televised weather forecasts and charts, that "they will be prepared by the B.B.C. in collaboration with the Meteorological Office."

Both the forecasts and charts are prepared solely by the Meteorological Office. I should be obliged if you would publish this correction so as to remove any misapprehension on the matter which may have been created in the minds of your readers.

Yours faithfully,

E. G. BILHAM.

Meteorological Office,
Air Ministry,
Dunstable,
Bedfordshire.

OCTOBER MEETINGS

The Institution of Electrical Engineers

All meetings, unless otherwise specified, are held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2.

Date: October 6. Time: 5.30 p.m.
President's Inaugural Address.
Professor E. B. Moullin, M.A., Sc.D.

Date: October 11. Time: 5.30 p.m.
Inaugural Address as Chairman of the Measurements Section.
By: Professor J. Greig, M.Sc., Ph.D.

Date: October 13. Time: 5.30 p.m.
Inaugural Address as Chairman of the Utilisation Section.
By: C. T. Melling, M.Sc. Tech.

Date: October 14. Time: 6 p.m.
Discussion on: "Application of Psychological and Other Tests to the Selection of Students for Courses and to Vocational Guidance."
Opened by: D. Smith, B.Sc.(Eng.)

Date: October 19. Time: 5.30 p.m.
Inaugural Address as Chairman of the Radio Section.
By: R. T. B. Wynn, C.B.E., M.A.,

Date: October 24. Time: 5.30 p.m.
Discussion on: "Should Research in Electrical Engineering be pursued mainly in Research Departments in Industry or should it be transferred to Special Establishments."
Opened by: The President.

Date: October 26. Time: 5.30 p.m.
Inaugural Address as Chairman of the Supply Section.
By: J. W. Leach.

Date: October 31. Time: 5.30 p.m.
Lecture: "The C.B.S. Colour Television System in the U.S.A."
By: P. C. Goldmark, B.S., Ph.D.

The Secretary: Institution of Electrical Engineers, Savoy Place, W.C.2.

The Institution of Post Office Engineers

Date: October 10. Time: 5 p.m.
Held at: The Institution of Electrical Engineers, Savoy Place, W.C.2.
Lecture: "The Provision of Cable Circuits for Television Outside Broadcasts."
By: T. Kilvington, B.Sc., A.M.I.E.E., and K. P. Wellman, A.E.Brit.I.R.E., Assoc. I.E.E.

Date: October 26. Time: 5 p.m.
Held at: Conference Room, 4th Floor, Waterloo Bridge House, S.E.1.
Lecture: "Planning of C. J. Cables."
By: A. C. Holmes, A.M.I.E.E.

Local Secretary: W. H. Fox, Engineer-in-Chief's Office (T.P. Branch), Alder House, E.C.1.

Secretaries of Societies are invited to submit details of their winter programme to the Editorial Department of this journal for publication.

The Television Society

Midlands Centre

Date: October 3. Time: 7 p.m.
Held at: The Lecture Hall (1st floor) The Crown Restaurant, Corporation Street, Birmingham.
Open meeting.
Hon. Lecture Secretary: W. Summer, 31 Beech Road, Bourneville, Birmingham, 30.

Constructors Group

Date: October 13. Time: 7 p.m.
Held at: Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, W.C.2.
Lecture: "Technical Features of the Denco Television Kit Set."
By: Technical Staff of Denco.

Main Group

Date: October 21. Time: 7 p.m.
Held at: The Royal Institution, Albemarle Street, W.1.
Lecture: Fleming Memorial.
By: J. T. Mould, K.C.
Lecture Secretary: T. M. C. Lance, 35 Albemarle Road, Beckenham, Kent.

Brit. I.R.E.

London Section

Date: October 13. Time: 6.30 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Gower Street, W.C.1.
Lecture: "An Experimental Study of the Magnetic Amplifier."
By: E. H. Frost-Smith, B.A.

Merseyside Section

Date: October 5. Time: 7 p.m.
Held at: Accountants' Hall, Derby Square, Liverpool.
Lecture: "The Sensitivity and other Properties of Television Camera Tubes."
By: L. H. Bedford, E.B.E., M.A., B.Sc.

Scottish Section

Date: October 5. Time: 6.30 p.m.
Held at: Electrical Dept., University, Glasgow.
Lecture: "Electronics in Aircraft Design."
By: A. L. Whitwell (Graduate).

West Midlands Section

Date: October 26. Time: 7 p.m.
Held at: The Technical College, Wulfruna Street, Wolverhampton.
Lecture: "Television Receiver Design."
By: W. Jones.

South Midlands Section

Date: October 27. Time: 7 p.m.
Held at: The Technical College, The Butts, Coventry.
Lecture: "The Performance and Stability of Permanent Magnets."
By: A. J. Tyrell (Member).
General Secretary: G. D. Clifford, 9 Bedford Square, London, W.C.1.

The Institute of Physics

All meetings, unless otherwise specified are held at the Institute of Physics, 47 Belgrave Square, S.W.1.

Electronics Group

Date: October 18. Time: 5.30 p.m.
Lecture: "Some Recent Developments in Mercury Vapour Lamps and their Associated Equipment."
By: A. H. Willoughby.

Education Group

Date: October 5. Time: 3 p.m.
Held at: The Institution of Electrical Engineers, Savoy Place, W.C.1.
Lecture: "A Scientific Education."
By: Sir Philip Morris, C.B.E.

London and Home Counties Branch

Date: October 12. Time: 5 p.m.
Held at: Physiology Theatre, University College, Gower Street, W.C.1.
"Demonstrations of Equipment and Techniques used by the Biophysics Research Unit."
By: Professor A. V. Hill, F.R.S., and his colleagues.
Admission by ticket only.

Midland Branch

Date: October 15. Time: 10 a.m.
Held at: University of Birmingham.
Lecture: "The Experimental Approach to the Thermodynamics of Alloys."
By: Dr. G. V. Raynor.

Manchester and District Branch

Date: October 21. Time: 4.30 p.m.
Held at: The University of Manchester.
Lectures: "Some Factors Influencing the Formation of Azeotropes." "The Development of a Low Temperature Air Expansion Turbine."
By: E. Crewdson and P. E. F. Crewdson.

Date: October 21. Time: 7 p.m.
Held at: The University of Manchester.
Reports by British physicists on the "Conference on Very Low Temperatures" held at the Massachusetts Institute of Technology under the auspices of the *Union de Physik.*

Industrial Spectroscopy Group

Date: October 21. Time: 4 p.m.
Lecture: "Physical Methods in the Forensic Laboratory."
By: Dr. F. G. Tryhorn.
Assistant Secretary: 47 Belgrave Square, London, S.W.1.

The Radio Society of Great Britain

Date: October 28. Time: 6.30 p.m.
Held at: The Institution of Electrical Engineers, Savoy Place, W.C.2.
Lecture: "Design and Application of the Cathode Ray Oscillograph."
By: O. H. Davie (A. C. Cossor, Ltd.)
Secretary: New Ruskin House, Little Russell Street, W.C.1.