Wireless World

RADIO, TELEVISION AND ELECTRONICS

42nd YEAR OF PUBLICATION

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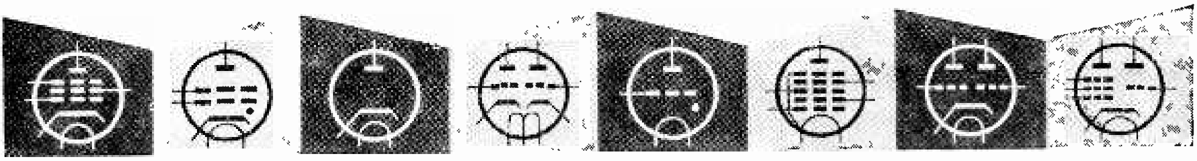
FEBRUARY 1953

In This Issue

PUBLISHED MONTHLY (last Tuesday of preceding month) by ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1. *Telephone:* Waterloo 3333 (60 lines). *Telegrams:* "Ethaworld, Sedist, London." *Annual Subscription:* Home and Overseas, £1 7s. 0d. U.S.A. $4.50. Canada $4.00. BRANCH OFFICES: *Birmingham:* King Edward House, New Street, 2. *Coventry:* 8-10, Corporation Street. *Glasgow:* 26B, Renfield Street, C.2. *Manchester:* 260, Deansgate, 3.



VALVES, TUBES & CIRCUITS

2. A PUSH-PULL AUDIO OUTPUT STAGE EMPLOYING TWO ECL80 TRIODE-PENTODES.

The Mullard ECL80 is a combined triode and output pentode having a single cathode which is common to both sections. Among its numerous applications is the use of the pentode section as an audio power amplifier preceded by the triode section as a voltage amplifier. With an h.t. line voltage of 200V, a simple single-valve amplifier having no feedback arrangements can deliver 1.4W power output at a total harmonic distortion of 10%.

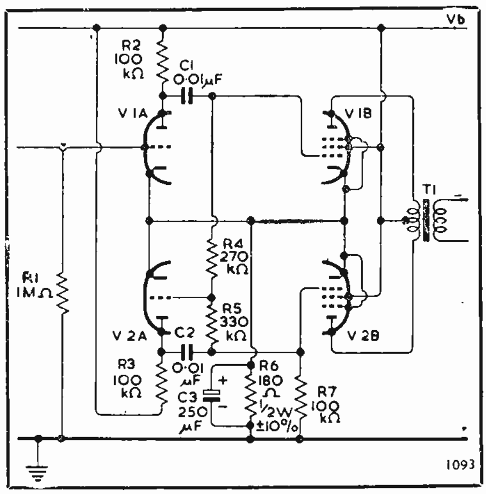


Fig. 1 Circuit diagram of amplifier.

This output may not be sufficient for domestic requirements, particularly if feedback is introduced to reduce the distortion. In particular, it may be desired to take advantage of the better quality sound transmitted in the television service. This can be accomplished by using a push-pull output stage. A simple, economical circuit in which the output stage is combined with a suitable voltage amplifier and phase inverter can be constructed with two ECL80's.

A circuit diagram for the amplifier is given in Fig. 1. With an h.t. (Vb) of 200V, a power output of 3W may be obtained with a total distortion of approximately 3% from an input of 0.6V r.m.s. to the amplifier. This input voltage is small enough to be supplied direct from the demodulator of a receiver even when negative feedback is incorporated in the amplifier in order to reduce the distortion. The circuit is stable and free from self-oscillation at all frequencies. In addition it has been designed so that the total current consumption changes as little as possible from no-signal to full output conditions. This ensures good output and low distortion if the circuit is operated from a power supply having poor regulation. It also reduces the effect of the amplifier upon other circuits working from the same power supply.

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Wireless World

FEBRUARY 1953 VOL. LIX No. 2

Alternative Television Service

WHEN the Government's proposals for an alternative television system, independent of the B.B.C., were announced last summer, *Wireless World* ventured to criticize them as unrealistic—as something for the dim and distant future. We may have been wrong in that opinion, but some seven months have now elapsed, and the project is certainly at least one stage further from fruition than when it was launched. At that time the Government announced that the start of independent television would be contingent, among several other things, on completion of the B.B.C.'s system for nation-wide coverage. A month or so ago, it was announced that authority to erect the five B.B.C. low-power stations that are part of the scheme must be postponed indefinitely. And the starting of competitive television is contingent on many other things.

Not only must the B.B.C. television system be completed according to plan, but a B.B.C. sound broadcasting service on v.h.f. must be at least initiated. And before this v.h.f. service can start, the Postmaster-General must be advised by the Television Advisory Committee, which is also charged with the task of advising him on the conditions for competitive television. *Wireless World* has already criticized the composition of the T.A.C., and we shall be indeed surprised if it produces an immediate solution of the delicate problems with which it is confronted. When these preliminaries are disposed of, the licensing of competitive stations must be debated in Parliament, presumably with all the party-political acerbity that accompanied the proceedings on the renewal of the B.B.C. Charter. Until all these things are done, it would surely be unwise to start the manufacture of a single piece of transmitting apparatus.

If to-day we lack the national resources to complete the B.B.C. chain, is it reasonable to expect an overnight change enabling us to afford a complete independent system? *Wireless World* suggests a less grandiose experimental start of competitive television —the leasing of time on the B.B.C. network to commercial organizations. Need the B.B.C. stations be sacrosanct? In all probability the Corporation would in fact, welcome the substantial increase in its income that could be earned in this way. This is not a new idea; it was brought forward by Sir Ian Fraser during the B.B.C. Charter debate, and, according to newspaper stories, has recently been revived. We can get no confirmation of the report that there is influential Government support for this scheme, but it would at least allow an early trial without heavy capital commitments.

Non-broadcast Television

ACCORDING to a report from New York last month, a performance from the Metropolitan Opera House there was relayed by television to nearly 30 American cities, and shown to paying audiences on full-sized screens in cinemas. An American correspondent who amplified the report for us says distribution was through the radio relay systems and r.f. cables normally used for linking television broadcast stations. The projection apparatus for the cinemas was produced by R.C.A. and the normal 525-line American standards were used. The show was not broadcast.

What interests us about this story is not so much the technical achievement as the comparison with conditions obtaining in this country. Here, although big-screen television attained a high state of technical development several years ago, it has never been shown to a paying audience, at any rate on a commercial scale. The Post Office has consistently refused to license radio distribution of television to cinemas, apparently on the grounds that it necessarily conflicts with broadcast television. In America, on the other hand, there were no "political" obstacles to what appears to have been a highly successful trial of a new technique. As "public carriers," the owners of the radio relay networks and r.f. cables handled the television signals like any other kind of traffic. The experiment will at least show our Post Office that television in the cinema has not of necessity any connection with broadcast television. It seems a pity that we have to learn this lesson from abroad.

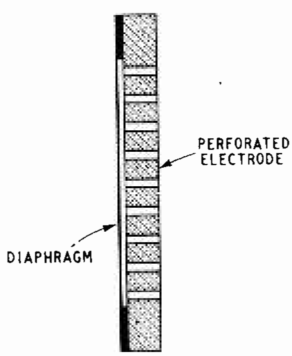
New High-Grade Condenser Microphones

1—Considerations Leading to the Design of Recent Neumann Types

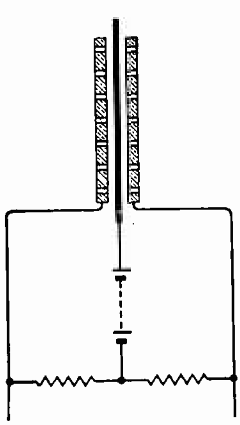
By F. W. O. BAUCH

AN essential part of all conventional microphones is the diaphragm, which responds by vibration to periodical forces in the surrounding field of sound. The transformation of the diaphragm movements into electrical energy can be achieved by various principles, the most important, as far as modern broadcasting and recording studio technique are concerned, being the electro-magnetic and the capacitive. Moving-coil and ribbon microphones represent the first, condenser microphones the second.

The moving-coil microphone, mainly used for speech or outside broadcasts, is always made as a pure sound pressure receiver, i.e., it responds to periodical variations of air pressure under the influence of a field of sound. Sound pressure is of scalar magnitude, therefore pressure microphones have an omni-directional sensitivity, actually a spherical characteristic with equal e.m.f. output, which can conveniently be expressed as a sectional plan in the form of a circle with the diaphragm vertically in its centre. Ribbon and condenser microphones can be made to follow the same polar diagram pattern, but more often they are built to act as receivers with decidedly directional characteristics, either in the form of a figure of "8" or of a cardioid (heart-shaped) polar response. Ribbon microphones incorporating such characteristics are widely used in this country, and it can be assumed that the principles of their response to sound pressure and/or sound pressure-gradient (also referred to as "pressure difference" and "velocity") are well known. But it may not be so widely known how cardioid characteristics were achieved with condenser microphones.



Right: Fig. 1. Condenser microphone with perforated fixed electrode.



Left: Fig. 2. Symmetrical push-pull action is obtained with two perforated fixed electrodes.

In principle, a condenser microphone consists of a more or less tightly stretched metal foil (diaphragm) in front of and electrically insulated from a fixed flat metal electrode, thus forming a condenser. A polarizing voltage connected via a high-value resistor completes the system. The change of capacitance consequent upon movement of the diaphragm produces an alternating voltage across the load resistor.

As early as 1935, v. Braunmühl and Weber[1] described methods designed to modify the hitherto purely pressure-type condenser microphone into a pressure-gradient type with directional characteristics of the figure-of-eight and the cardioid.

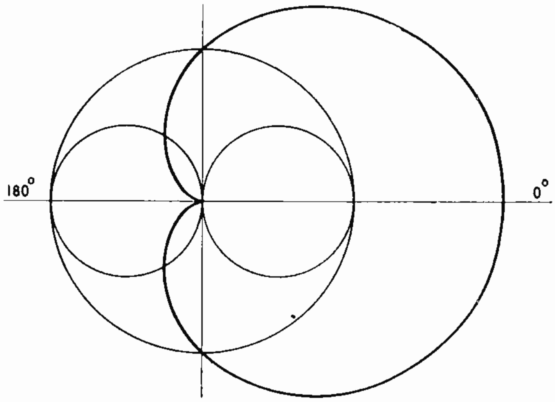
Braunmühl and Weber Principle.—The normally solidly built fixed electrode which prevented the excitation of the diaphragm by sound waves from its back is replaced by a similar electrode with a number of perforations in the form of small round holes (Fig. 1). Both sides of the diaphragm are now exposed to the field of sound, the driving force is now changed from one-sided sound pressure to the sound pressure-difference between front and back of the diaphragm. Accordingly, the maximum sensitivity will be perpendicular to both surfaces of the diaphragm, decreasing towards side-excitation with the cosine of the angle of incidence. The relationship is expressed: $e=\sqrt{e_0^2\cos^2\alpha}$, where e_0 is the sensitivity at maximum excitation and α is the angle incidence.

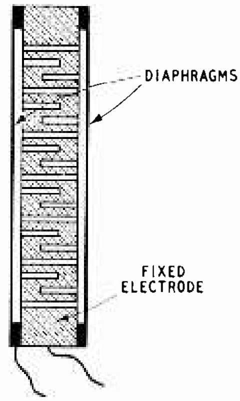
The magnitude of the effective pressure gradient depends on the wavelength of the sound and on the physical size of the microphone, actually on the distance from the middle of the diaphragm in front to the middle of the back, via the edge of the microphone capsule.

There is also the possibility of producing a completely symmetrical microphone by adding another similarly shaped perforated electrode on the so far unoccupied side of the diaphragm. There need not be any electrical connection to this second electrode, but if used it should be connected in push-pull, as shown in Fig. 2, in order to relieve the diaphragm of electrostatic attraction and to take advantage of the increased sensitivity, which is doubled.

Cardioid Characteristic.—It was known at the time how to combine two microphones with omni-direc-

[1] v. Braunmühl and Weber, *Hochfrequenztechnik u. Elektroakustik* Vol. 46 (1935) pp. 187-192.





Left: Fig. 3. Construction of a cardioid by the addition of circular and figure-of-eight characteristics. Right: Fig. 4. Diametral section of cardioid-type condenser microphone.

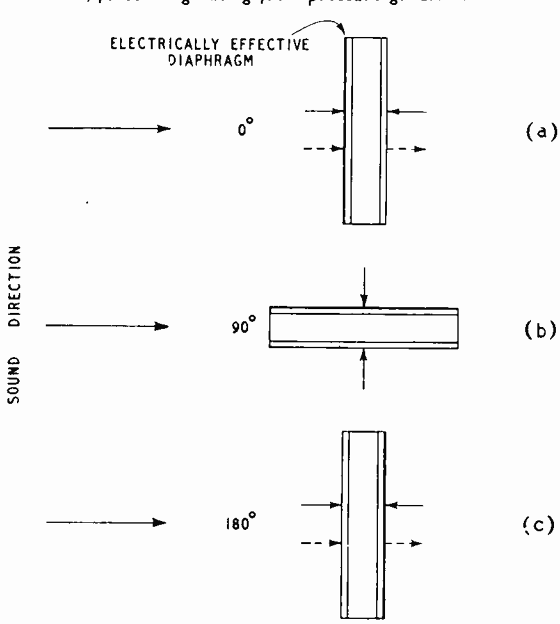
tional and figure-of-eight characteristics into a single sound receiver with a polar diagram of cardioid shape.[2] Such combinations are used in modern ribbon-type microphones, where one-half of the ribbon acts as a pressure-gradient receiver, while the other half, backed by a specially designed sound chamber, works as a pressure receiver. Fig. 3 shows the construction of a cardioid by combining circular and figure-of-eight polar diagrams. It is essential, however, that the sensitivity of both halves of the ribbon should be equal for their respective characteristics, i.e., the circle must exactly enclose the figure-of-eight. Simple addition and subtraction of all vectors, taking into account their respective directions, shows the ideal cardioid, with its mathematical expression: $e = e_0\ (1 + \cos\alpha)$. The cardioid characteristic can be provided by the condenser microphone principle by fixing two equal diaphragms to both sides of a perforated fixed middle electrode which, moreover, is also supplied with a number of cavities on both sides (Fig. 4). The flexibility of both diaphragms is such that their initial stiffness need not be taken into consideration when compared with other existing resistances, and the great stiffness of the air inside the perforations can be regarded as a very tight coupling between the two diaphragms of which one is electrically ineffective.

The mechanical operation under the influence of sound can be explained in the following way. The sound pressure is a force which tends to move the two diaphragms towards each other against the compression of the enclosed air pocket. At the same time, the pressure gradient tries to move the enclosed air pocket to and fro by exciting the two diaphragms in co-phase movements and to force the enclosed stiff air through the holes from one side to the other. The resulting movement can be seen in the much-simplified drawing of Fig. 5 (a), in which the approach of the sound comes from the left. The two forces add on the left and on the electrically effective diaphragm (thick line) and cancel each other on the right-hand side of the capsule with the electrically ineffective second diaphragm (thin line). Fig. 5 (b) shows the sound approach from the side, with the pressure component alone having an effect. Fig. 5 (c) has the sound approach from the back, i.e., unto the electrically inactive diaphragm, and shows the two forces on the right-hand diaphragm opposed to each other. It must be emphasized that this explanation is much simplified for the sake of showing the principle in great clearness. Fig. 6 shows a more modern version of the "Braunmühl-Weber" cardioid capsule.

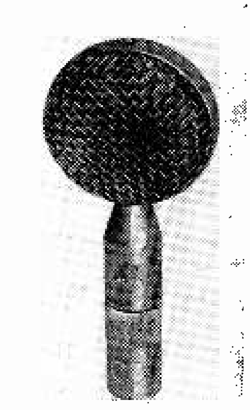
Recent Developments.—Microphones are the first link in the chain of apparatus necessary for the distribution of sound impressions. Any deficiency here cannot easily be improved in later links. The sound engineer must therefore have microphones at his disposal which are able to convey a favourable sound picture, and which can cope with the various difficulties in complicated musical assemblies. Modern microphones, furthermore, must answer to very high demands in frequency response, linearity, and freedom from noise—and the number of types should be limited to very few.

Twenty years of continuous experience with con-

Fig. 5. Equivalent forces acting on the cardioid microphone for various directions of the source of sound. Full arrows, forces originating from sound pressure; broken arrows, forces originating from pressure gradient.



Below: Fig. 6. Neumann cardioid condenser microphone capsule, Type M7.



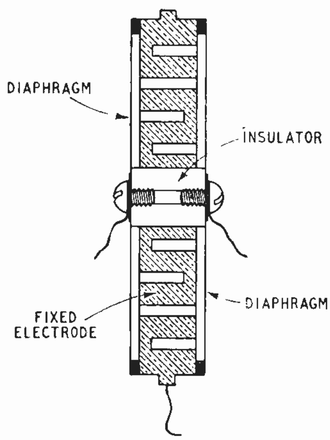
[2] Weinberger, Olson and Massa; *J. Acous. Soc. Amer.*, Vol. 5, p. 139.

denser microphones in German broadcasting, and the application of modern ideas in the technique led to the development of two new microphone types with a number of very interesting properties.[3]

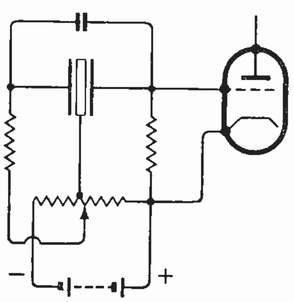
The demand for a choice of directional microphones could be fulfilled with the creation of one single novel pressure - gradient type microphone with adjustable characteristics. This microphone (Neumann Type M49) provides the possibility of changing its directional sensitivity at will and continuously by remote control, and it possesses an extremely flat frequency response which is widely maintained over its three main characteristics. Any section of a concerted musical performance can be picked out with objective truthfulness, and the result is also satisfactory where the direct sound outweighs the indirect, i.e., when receiving from a relatively short distance, where a flat response becomes of particular importance.

[3] H. Grosskopf, *FTZ* (Sept., 1951); p. 398; *Techn. Hausmitt. des NWDR*, Vol. 3 (1951), p. 172.

Left: Fig. 7. Neumann Type M49 condenser microphone with continuously adjustable directional characteristics.



Below left: Fig. 8. Simplified section of Neumann Type M49 microphone capsule.



Below: Fig. 9. Electrical connections of M49 microphone.

Large philharmonic orchestras, and other widely spread sources of sound, force the receiving single microphone to a much greater distance from the source of sound, into the practically diffused field of sound. At this great distance, pressure-gradient microphones do not produce a really satisfactory quality, and the reproduction is of an exaggerated hollowness.

Good results, on the other hand, were always achieved with omni-directional microphones which become directional with increasing frequency. This progressive change from an omni-directional to a directional characteristic goes automatically hand in hand with a rising sensitivity to frontal sound waves. But the directional effect must also not be too pronounced in order to give a good reception of large sound sources, and must be equally good for all frequencies.

These reflections led to the development of a pressure-type microphone (Neumann Type M50) with gradually rising frequency response (+5db at 15 kc/s), going directional at the same time with a still very wide characteristic at the highest frequencies.

These microphones M49 and M50, developed in collaboration with the Acoustics Laboratory of the Nordwestdeutsche Rundfunk, seem to satisfy all demands in sound broadcasting, and the range of necessary microphones for any purpose could be limited to two types only.

Adjustable Directional Characteristics.—The principle of the Neumann Type M49 microphone (Fig. 7) is a combination of two equal cardioid condenser systems with their maximum sensitivity in opposite directions. Fig. 8 gives a simplified version of the construction. Both systems work into a common single-stage amplifier, the front one being energized by a constant voltage, while the other receives its voltage via a potentiometer, the setting of which

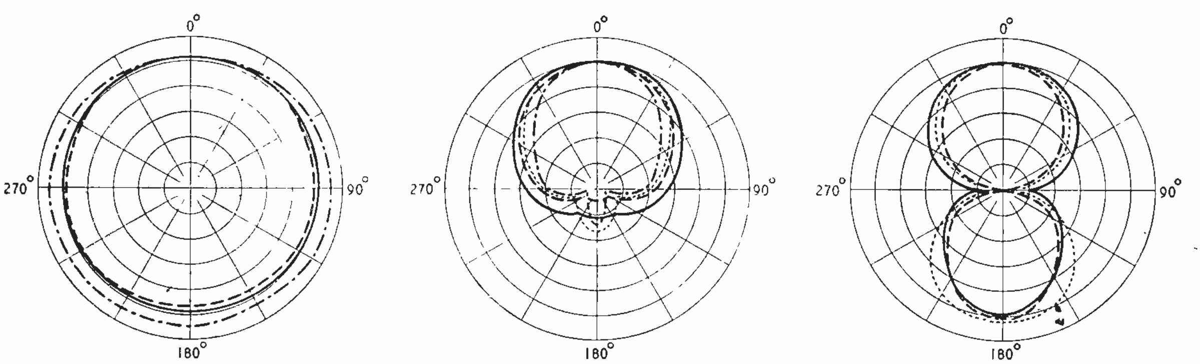


Fig. 10. Principal polar characteristics of Neumann Type M49 microphone.

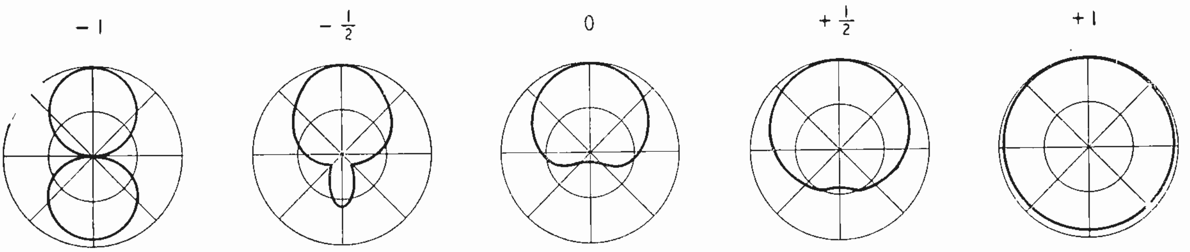


Fig. 11. Polar diagrams of the M49 microphone for intermediate settings of the potentiometer (frequency 1,000 c/s).

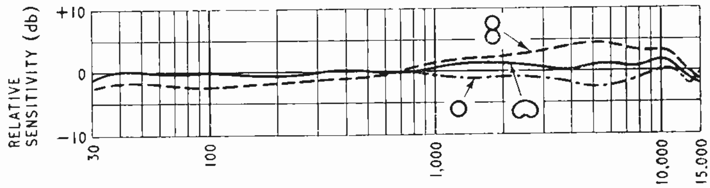


Fig. 12. Frequency response curves of M49 microphone with the control set for each of the principal polar characteristics.

determines the directional characteristic of the combination. Fig. 9 shows the connections, with the slider in the middle, giving a cardioid characteristic. As the slider is moved to the right the cardioid changes gradually to the omni-directional characteristic, with the same voltage applied to both systems; as it is moved to the left the diagram changes into a figure-of-eight, with reversed voltage. Normally, the potentiometer is housed in the mains unit, which will be described later.

Fig. 10 shows polar diagrams of the three principal directional characteristics at selected frequencies. Fig. 11 shows what happens to the characteristic at intermediate settings of the potentiometer. The frequency response curves for each of the three characteristics is shown in Fig. 12. Other relevant electrical characteristics are as follows: *Frequency response,* 40-15,000 c/s; *output impedance,* 200 ohms; *sensitivity,* approx. 0.7mV/microbar (dyne/cm^2); *overall noise,* $<2\mu$V ($<$22 phon).

As will be seen in Fig. 13, the microphone capsule is flexibly mounted on the top of a Perspex cover, which houses all essential parts of the single-stage amplifier. Cover, amplifier and base-plate can be easily detached for servicing.

The relatively small capacitance (75-80pF) makes it essential to build microphone and amplifier close together. The amplifier has an extremely high input resistance (150 MΩ)—necessary for feeding the condenser a.c. voltage independently of frequency to the grid of the amplifier valve, and also in the interest of low equivalent noise level which becomes less with higher input resistance.

The grid circuit and valve noise, which determines the lowest useful signal level, must not exceed 1 to 1.5 μV. To this end a special valve, Type MSC2, was developed. This has a directly heated oxide-coated cathode and is soldered directly into the circuit wiring.

Fig. 14 shows two of the component parts of the Type M49 microphone capsule. On the left can be seen one of the polyvinyl chloride diaphragms with a thickness of only 8 μ (μ=1/1,000 millimetre), and coated on one side by a sputtering process with pure gold having a thickness of 0.3 μ. On the right is the partly perforated middle electrode. When mounted on either side of the fixed electrode the effective diameter of the diaphragm becomes 28mm. The diaphragm vibrates in the form of a ring and contact

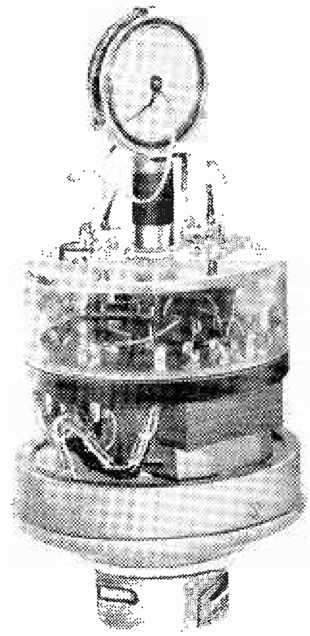


Fig. 13. Neumann Type M49 microphone with cover removed.

Fig. 14. (Right) Fixed central electrode, and (left) one of the gold-sputtered p.v.c. diaphragms before mounting.

is made to the centre by a screw fitting into an insulating bush in the fixed electrode.

The distance between diaphragm and fixed electrode is 40μ. The tension of the diaphragm is just such that it does not fall against the fixed electrode under the influence of the maximum polarizing voltage. The stiffness of the diaphragm is 60 times less than the stiffness of the air behind it, and its resonance is low —between 600 and 800 c/s.

The change of capacitance caused by the application of the maximum polarizing voltage (60V) amounts to 3 to 4pF. This is an important factor having a bearing on the response at lower frequencies. The e.m.f. of one condenser side is approximately 1.4mV/μb.

Of the highest importance is the employment of insulating materials of the best possible grade for all critical parts in the microphone and amplifier. This again calls for extremely clean production methods involving the use of special cleaning materials.

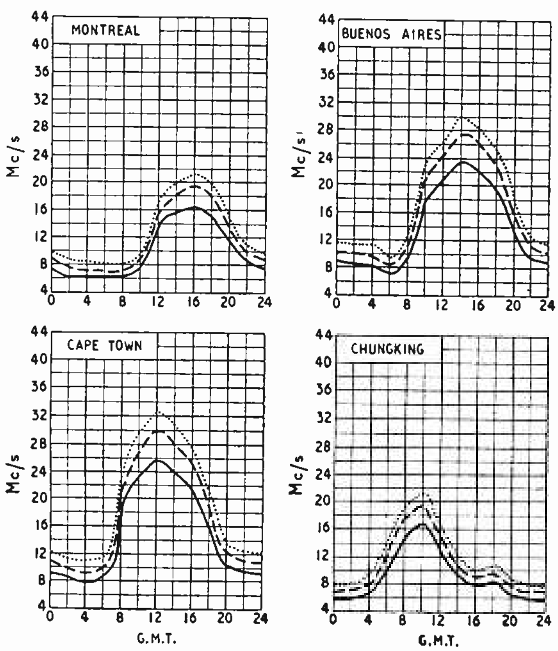
(To be concluded. Part 2 will contain a description of the Neumann Type M50 pressure-type microphone and some auxiliary apparatus.)

Short-wave Conditions

Predictions for February

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

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



——— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

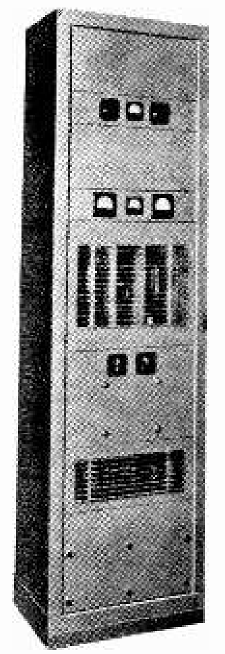
– – – – PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

.... FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

HIGH-POWER AMPLIFIERS

OUTPUT powers of the order of a kilowatt are not uncommon in audio amplifiers designed for broadcast relay systems, and the Savage Mark II kilowatt amplifier, which has been used not only for speech and music amplification but as a driving source for vibration research and measurement, has a frequency range within 2 db of 40 to 14,000 c/s with distortion less than 1 per cent between 65 and 4,000 c/s.

More recently the Savage V.L.F. amplifier has been produced to meet the demand for comparable outputs at very low frequencies (10 c/s-1,000 c/s). It is of similar rack-mounted design to the standard kilowatt amplifier, but the output transformer, which is of necessity a very heavy component, is mounted on wheels as a separate unit. Distortion is claimed to be less than 5 per cent, which is exceptionally good having regard to the low frequencies involved. Series-parallel secondary windings give ratios to match load impedances of 2.5, 10 or 40 ohms.



The inherent frequency response at low output levels is within 5 db between 2 c/s and 4,000 c/s but at maximum output there is some falling off below 10 c/s and above 1,000 c/s.

To some extent the available power is controlled by the nature of the load and is limited to 350 watts into a purely reactive load. However, the full output of 1 kW can be obtained if inductance or capacitance is added to the load to bring the power factor to unity (resonance).

The manufacturers are W. Bryan Savage, Ltd., Westmoreland Road, London, N.W.9.

Ignition Interference

IT is estimated that, of the 4½ million motor vehicles that regularly use the roads and likely to cause interference to television viewers, only half a million are fitted with suppressors. It has been proved beyond all doubt that a suppressor does no harm to the engine and has negligible effect on the performance.

The Radio Industry Council has said that, for a start, a single suppressor in the distributor to coil lead will give adequate suppression in some 60 per cent of the offending motor vehicles, while of the remainder half will be suppressed to a just acceptable amount.

Aircraft piston engines always have resistors in their plugs to reduce plug erosion or burning; in fact, they dare not fly without them. Many experts agree that resistors in the plug lead assist cold starting of car engines, but it appears that the benefit is really only apparent at very low temperatures.

For the suppression of interference with v.h.f. radio and television any value over 5,000 ohms will suffice, and 10,000 ohms is a good compromise value. With one resistor in each plug and distributor lead a total of 20,000 ohms only is in circuit, and it has been proved that it needs from a half to one megohm to produce any noticeable effect on engine performance.

As for reliability, investigation has shown that over the past 25 years there have been only a dozen or so known failures to engine suppressors.

The above are a few of a host of interesting facts on suppression of interference contained in a paper "Current Radio Interference Problems" read to the British Institution of Radio Engineers by E. M. Lee, B.Sc., and published in the Institution's journal for November, 1952.

Television Sync Separator

With Positive-going Output Pulses

By D. CLEMENTS

THIS is a two-valve sync separator which accepts the composite video signal and effects the separation of line and frame sync pulses in such a way that these pulses are both produced with positive-going polarity. Many separating circuits suffer from the disadvantage that the separated pulses, for synchronizing either one or both of the time bases, are produced with negative-going polarity which prevents their direct application to certain types of sawtooth generators (e.g., those employing thyratrons).

The separated pulses for both line and frame time bases have vertical leading edges. In the frame circuit the edge coincides with the trailing edge of the first frame pulse. The amplitude of the separated pulses is large and independent of signal input voltage.

Since the circuit accepts video signals of negative polarity (as would be present at the anode of a video output stage which modulates the cathode of a c.r. tube) the circuit can be used to replace an ordinary type of separator.

The principle of the circuit is orthodox as far as the separation of the line sync pulses is concerned. Separation is achieved in the first valve V_1, Fig. 1, which is a pentode. This operates in the usual way as a limiter, the video signal being applied to its control grid. The output is taken from the screen and the phase of the negative pulses is changed in a second valve V_2. The separated frame pulses are derived from the anode of the first valve which is normally cut off by a bias voltage applied to the suppressor grid. The positive pulses, from the second valve, are used to unblock this anode during the first frame pulse by applying them to the suppressor via an integrating circuit. At the end of the first frame pulse the anode is cut off sharply by the control grid and a steep-fronted positive-going pulse ensues.

Fig. 1 shows the basic circuit of the separator. The video signal, of negative polarity (i.e., positive-going sync pulses), is fed to the control grid of V_1, which is driven into grid current by the tips of the sync pulses and thereby effects d.c. restoration. The anode of this valve is cut off by the suppressor which is returned to a negative bias. Due to the low h.t. the grid base of this valve is short and the picture signal is driven beyond the cut-off of the control grid, with the result that separated negative-going sync pulses appear at the screen. These pulses are fed to the control grid of V_2 and the resulting positive-going pulses at the anode are used to synchronize the line time base.

The output from the anode of V_2, besides synchronizing the line time base, is used to gate the anode of V_1 during the first frame pulse by means of the suppressor. This is done by coupling the suppressor to the anode of V_2 by an integrating circuit CR, of

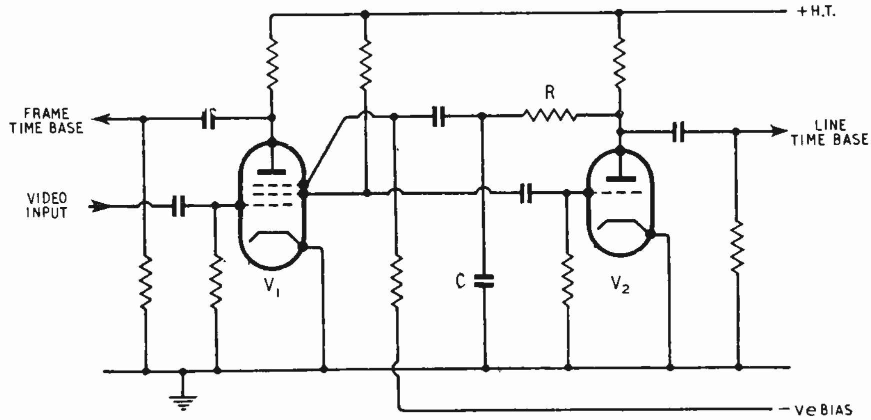
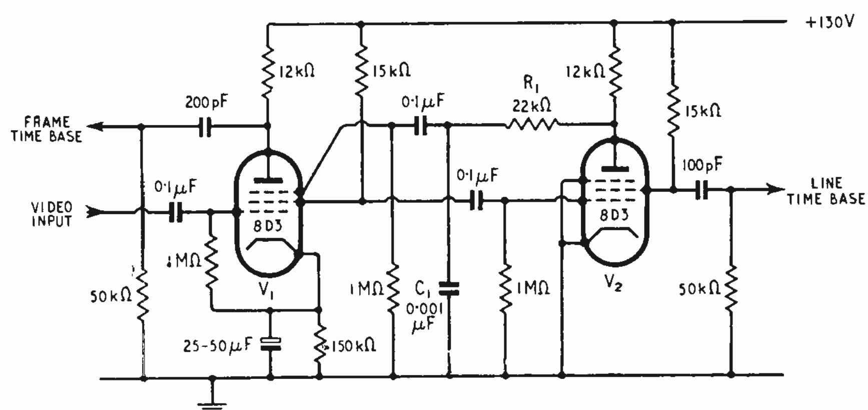


Fig. 1 (above), shows the Basic circuit, and Fig. 2 (below), the Prac ical circuit.



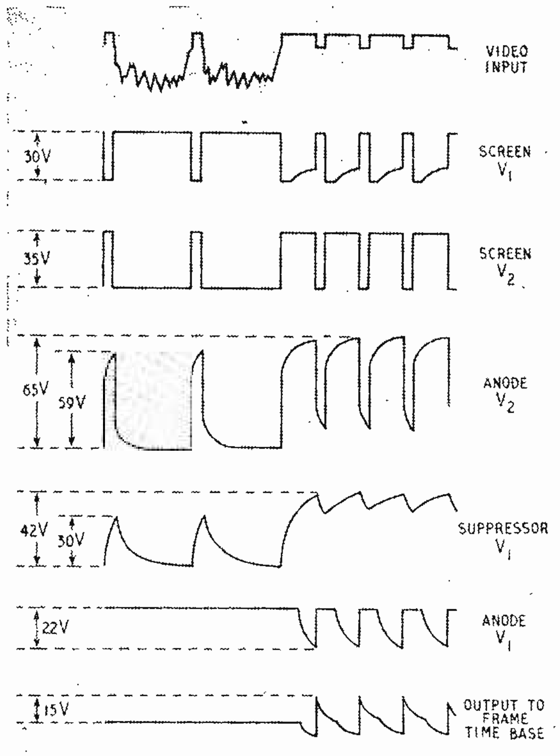


Fig. 3. Voltages and waveforms in the circuit shown in Fig. 2.

critical time constant, such that during a line pulse the positive voltage built up on the suppressor is insufficient to open the anode circuit; but during the longer frame pulse the suppressor is driven sufficiently positive for the anode to conduct and the anode potential falls. This fall in anode potential is comparatively slow, as the integrated pulse on the suppressor has a sloping leading edge, but at the end of the frame pulse the control grid of V_1 is driven very sharply negative, cutting off the anode current and thereby causing the anode potential to rise very steeply. If the waveform at the anode is differentiated this sudden rise in anode potential produces a steep-fronted positive-going pulse coinciding with the trailing edge of the frame pulse.

A practical circuit is shown in Fig. 2 using two valves of the high-slope pentode type. The bias on the suppressor of V_1 is derived from a bypassed cathode resistor, the control grid being returned to the cathode. Since the second valve is also a pentode, the screen is a convenient place from which to obtain the line sync pulses. The integrating circuit R_1C_1 has a time constant of 22 μsec which gives the largest difference in amplitude resulting from the application of either line or frame pulses. A line pulse of 10 μsec reaches approximately 0.5 of its amplitude across C_1 and a frame pulse of 40 μsec approximately 0.85 of its amplitude.

If it is desired to use this circuit with other types of valve (e.g., EF50, EF54, etc.) the only change required is in the value of the cathode resistor of V_1 to allow for any difference in suppressor-grid characteristics. The correct value for this resistor may quite easily be found by temporarily substituting a variable resistor in the cathode of V_1 and adjusting for the largest value of resistance that gives a reliable frame hold and finally replacing it with a fixed resistor of suitable value. Care must be taken that sufficient time elapses between different settings of the resistor for V_1 to reach a steady working condition, for the time constant in its cathode is fairly high.

Fig. 3 indicates the various voltages and waveforms that can be expected at different parts of the circuit. The average cathode currents of V_1 and V_2 are approximately 0.3 mA and 8.0 mA respectively.

SOCIETIES AND CLUBS

Additions and Amendments to our Directory†

BIRMINGHAM.—Birmingham and District Short Wave Society.—A. O. Frearson, 66, Wheelwright Road, Erdington, Birmingham, 24.

CHESTER.—Chester and District Amateur Radio Society.—New Sec.: N. Richardson, 1, Victory Villa, Newton Lane, Upton, Chester.

HASTINGS.—Hastings and District Amateur Radio Club.—W. E. Thompson, 8, Coventry Road, St. Leonards-on-Sea, Sussex.

LONDON AREA.—British Two-Call Club.—G. V. Haylock, 63, Lewisham Hill, London, S.E.13.
Ravensbourne Amateur Radio Club (G3HEV).—W. H. J. Wilshaw, 4, Station Road, Bromley, Kent.
Sanderstead and Purley Amateur Radio Society, now Purley and District Radio Club.

MANCHESTER.—Manchester and District Radio Society.—K. Brockbank, 17, Burleigh Road, Stretford, Lancs.

PETERBOROUGH.—Peterborough Radio and Scientific Society (G3DQW).—S. Woodward, 72, Priory Road, Peterborough, Northants.

SOUTHEND.—Southend and District Radio Society* (G5OK).—New Sec.: G. Chapman, Bell Hotel, 20, Leigh Hill, Leigh-on-Sea, Essex.

STOCKPORT.—Stockport Radio Society.—G. R. Phillips, 7, Germans Buildings, Buxton Road, Stockport, Cheshire.

SUNDERLAND.—Sunderland Radio and Television Society.—C. A. Chester, 38, Westfield Grove, High Barnes, Sunderland, Co. Durham.

WELLINGTON.—Wrekin Amateur Radio Society.*—New Sec.: G. N. Myatt, 12, Swan Street, Broseley, Salop.

WIRRAL.—Wirral Amateur Radio Society.*—New Sec.: L. Roberts, 18, Croxteth Avenue, Wallasey, Cheshire.

† *Wireless World,* November, 1952.
* Clubs affiliated to the R.S.G.B.

Amateur Valve Guide

IN order to help home constructors (excepting amateur transmitters) to choose the right kind of valves for a particular set or amplifier and to operate them to the best advantage, Mullard has issued a 48-page booklet "The Amateur's Guide to Valve Selection."

Abridged technical data, operating conditions and base connections of some 35 different types of Mullard valves and c.r. tubes are given. It is explained that almost all amateur requirements can be satisfied with this number. There is a useful applications section in which circuits and complete design data are given for three receivers and five amplifiers.

The valve guide is obtainable from radio and television retailers at 1s 6d.

Radio Road Patrols

Some Problems Encountered when Equipping Motor Cycle Combinations with Radio Telephones

THE first stage of a national scheme designed ultimately to provide two-way radio communication between road patrols and area headquarters was recently inaugurated by the Automobile Association.

Initially the new service will operate over an area covered by a 20-mile radius from Fanum House, the Association's London headquarters, and is a logical extension of the A.A. radio-controlled night breakdown services which have been in operation in London and the provinces for some time past. With the equipping of the daytime motor cycle patrols this area now has a 24-hour radio-controlled patrol and breakdown service in operation.

The idea of equipping A.A. patrols with radio was actually attempted before the recent war, but technical developments had not gone far enough then to make the idea practicable. Now with so much more known about mobile v.h.f. communications the scheme is capable of being brought to fruition.

Transmitter Site

Two radio frequencies in the v.h.f. band have been allotted to this service: 85.525 Mc/s for all fixed transmitters and 72.025 Mc/s for all mobiles throughout the country. The equipment is mainly Pye, although a few Marconi sets are also in use. At the London headquarters' station a Pye Type PTC703 does duty. This is located on high ground at Hampstead and is remotely controlled. It gives a power output of 15 watts and is amplitude modulated. There is a stand-by transmitter at the London headquarters for use in the event of equipment failure at Hampstead, or trouble with the land lines.

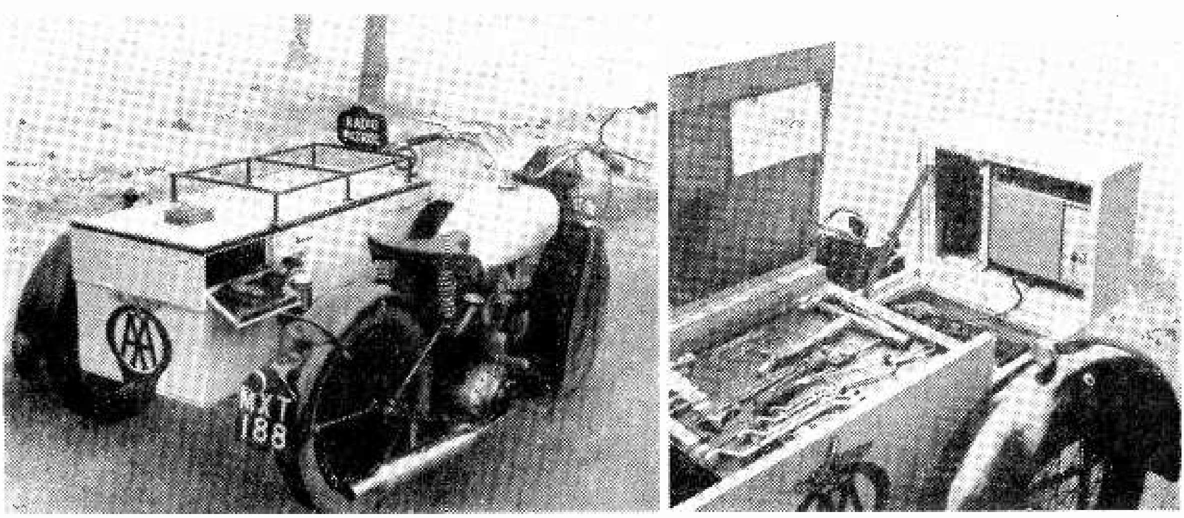
The mobile sets are Pye "Reporter" Type PTC116 giving about 2.5 watts output. The equipment is housed in a separate rear extension of the motor cycle sidecar. This has a deep lid containing the transmitter and receiver and a compartment below for the battery. There is also a drop-down flap, convenient to the rider's left hand, which carries a combined telephone-microphone hand set. A loudspeaker is used to warn the patrol when he is being called.

A number of technical problems were encountered when fitting the motor cycle combinations with radio. The customary quarter-wave vertical aerial proved somewhat inefficient owing to its low height and lack of an adequate earth plane, such as the metal roof when a closed vehicle is used. Recourse was made, therefore, to a half-wave vertical aerial with special coupling arrangements at the base as this is a high-impedance point.

Power to operate the mobile equipment also proved a little troublesome. The usual method of fitting a larger accumulator to the existing electrical system and either increasing the dynamo output or fitting a larger dynamo was not applicable in the present case, as during the busy motoring months the road patrols might spend so much time giving road-side assistance to stranded motorists that insufficient running would be done to keep the battery charged.

This problem has been solved by operating the

Left: Radio-equipped A.A. road patrol; note the convenient placing of the hand telephone set. Right: The radio transmitter and receiver are housed in a deep lid on the rear extension of the box sidecar, with the battery in the space below.



radio from a separate battery supply and allotting two large 12-volt batteries (in 6-volt units for ease of handling) to each vehicle and trickle charging the spare battery at night. The normal battery consumption of this receiver is 3 A only.

So far only a limited number of motor cycle patrols have two-way radio telephones and the present scheme is to allot one to each of six zones around London. These are in addition to main-road and special-duty patrols and they have roving commissions within their particular zone, but can be directed to any zone by headquarters should the necessity arise.

Fugitive from Pandemonium

American Television Technician's Reactions to an Abrupt Change

By JOHN D. BURKE

LET me introduce myself. I am an American, whose only knowledge of your country was gained during a few months' service in England with the U.S. Army Signal Corps *en route* to France. Less than a month ago I closed my TV and radio repair shop in New York; now I am working at the same job in London. What are my reactions to that abrupt change?

In all honesty, I can say my first reaction to British TV was to miss about 100 lines of picture. As technicians, we must, of necessity, be highly critical of definition. Does this mean that American 525-line TV is better? No! For the viewer is just as satisfied with 405. Your system has other advantages.

Then I was surprised to see that auto interference causes white flecks, whereas U.S. sets get black interference. Also, I missed the black-faced tubes which are widely used in the U.S. But it was pleasant to find less hum on 50-c/s sets than on 60 c/s. I sought the reason and learned that you use more smoothing.

Where was the band-switch? Then I learned about your five frequencies, and understand how they are being used. My reaction: what a pleasure to be free of noisy band-switches, defective tuner units, irate customers who expect perfect reception on seven channels! And what a relief it is not to have to deal with u.h.f., for which band tuners are first sold to the public and then later perfected.

Your TRF television sets were quite a surprise, as was the absence of the inter-carrier method of sound reception. This method, originally introduced for economy of manufacture, is now generally used in the U.S., even in high-priced sets, because it permits considerable oscillator drift without loss of sound. This problem becomes acute now with the necessity to design all v.h.f. receivers so as to work with u.h.f. converters, which drift badly. At the same time, I am glad to get rid of the problem of intercarrier buzz—a frequent result of overmodulation on TV commercials.

Having heard so much of the economic difficulties of life in post-war Britain, I was surprised that you do not use rebuilt picture tubes. However, with your tax problems it may be there is little justification for rebuilding tubes if they must sell almost at new tube prices.

I miss—and am glad to miss—some of the factors in the American TV scene which are driving radio people in the U.S. quite mad. I have in mind such things as price cutting on TV sets; advertised dirt-cheap service calls; "Fix-it" books which assure the public that repairs are very easy—all repairmen are thieves.

Vertical, instead of horizontal, antennas still look strange to me. It is, of course, an advantage that directional aerials are not needed in strong signal areas, and I shall get used to coaxial cable instead of 300-ohm line.

While you do have many makes and models to service, I have come from a country where over 80 manufacturers have produced over 5,000 models already. Enough said! But I have a feeling that your manufacturers are more responsible in trying to assure that their sets continue to give service. As a repairman, this is a relief to me, for the public tend to blame us for manufacturers' irresponsibility.

Your manufacturers may be right in restricting the distribution of technical and service data on their sets; I simply record my surprise. Perhaps it is because there are so few independent service businesses, as compared with U.S.A.

I am almost overwhelmed by the hundreds of European and British valves I must now learn, besides their bases and sockets. I am in process of learning, too, a different technical language and must master different styles of circuit diagrams.

I cannot end without touching on the programmes—even when writing for a technical journal. I personally am "fed-up" with commercial TV. My countrymen are going mad with as many as seven stations simultaneously transmitting completely different TV programmes. Some of these operate from 7 a.m. continuously till midnight and sometimes till 2 a.m. People sit endlessly before their sets, select what pleases them and do practically nothing else.

As for the B.B.C.'s programmes, from what I have seen I should say that what you are getting is quite similar to what a discriminating viewer would seek, and sometimes find, by switching from channel to channel in the U.S.

In one respect you excel—the production of plays without advertising interruptions and in their entirety. However, I did find "Down You Go!" lacking some of the wit and spontaneity of its American counterpart.

British viewers influence the B.B.C., whereas the sponsors determine what appears on American TV screens. Well-liked programmes simply disappear without a trace due to "sponsor trouble."

Ionosphere Review: 1952

Continuing Decrease in Sunspot Activity and Maximum Usable Frequencies

By T. W. BENNINGTON*

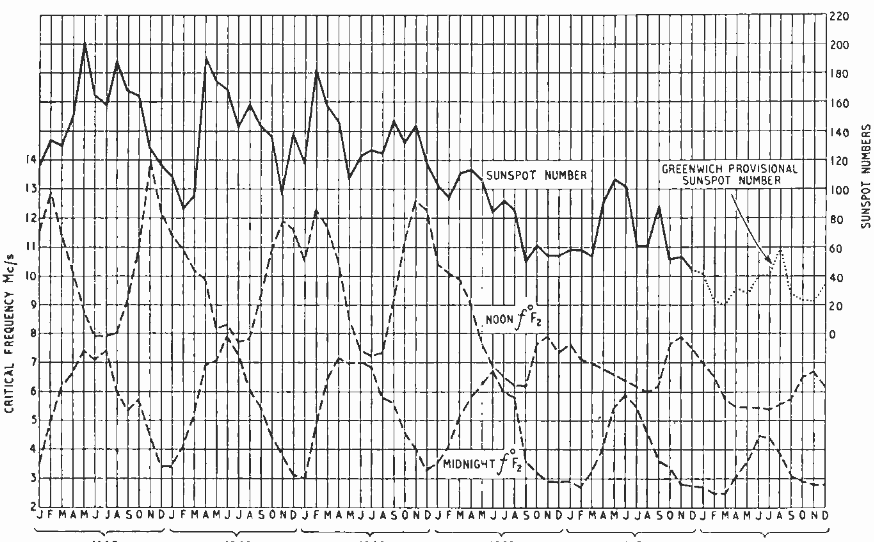
AT the end of 1951 the average sunspot activity was only slightly lower than at the end of the previous year: there had been, during 1951, an arrestment in the previous sharply decreasing tendency. The average critical frequencies of the ionospheric layers, and the maximum usable frequencies for long-distance short-wave propagation had, similarly, undergone but a small decrease throughout the year. During the early part of 1952 the sunspot activity reached generally lower values than it had during the previous year, and the average sunspot activity showed a further considerable decrease during the year. The average critical frequencies and m.u.fs also decreased. In short, the sunspot cycle continued its course towards the minimum, and, at the end of 1952, low values of sunspot number, critical frequency and m.u.f. had been reached.

Fig. 1 shows (a) the monthly mean value of the sunspot relative number for each month since the last sunspot maximum, (b) the monthly mean of the noon F_2 layer critical frequency, and (c) the monthly mean of the midnight F_2 layer critical frequency, the last two curves being from the measurements made at the Slough station of the D.S.I.R.

The sunspot number, which fluctuates greatly from month to month, has now, it is seen, an average value which is very low compared with those which prevailed around the maximum in 1947. The fluctuations in the other two curves are those due to the seasonal effects; there being every year a pronounced minimum in the day-time critical frequency around midsummer, and in the night-time critical frequency around midwinter. However, the long-period decrease due to the decreasing solar activity is also apparent in both the curves, and it is seen that during 1952 the critical frequencies, both for noon and midnight, have been considerably lower on the whole than during 1951. They are now, in fact, at what might be called "quasi-minimum" values. This means, of course, that the m.u.fs for long-distance short-wave communication—which are directly related to the critical frequencies—are also very low at the present time.

Fig. 2 gives the 12-month running means of the sunspot numbers and Slough critical frequencies for the same period as in Fig. 1 By taking 12-month running averages the fluctuations in the curves of Fig. 1 are smoothed out, and it is possible to see the long-period tendencies more clearly. Up to the epoch June/July 1952 (for which the 12-month running mean is the mean for the months January to December 1952 inclusive) the sunspot number had fallen from the values of the order of 150 which prevailed at the solar maximum to a value of about 30. During the same period the mean noon critical frequency had fallen from about 10 Mc/s to about 6 Mc/s, and that for midnight from about 5.7 Mc/s to about 3.2 Mc/s. This implies that the mean noon m.u.f. for transmission over the longest possible one-hop trajectory, with the ionosphere over Slough as its apex, had decreased since sunspot maximum by about 12 Mc/s, and that for midnight by about 7 Mc/s. This gives us some idea of the large variation in m.u.fs which occur over a sunspot cycle, and it must be remembered that the variation in some parts of the world may have been even greater than that for Slough. It will be noticed, however, that the largest decreases in sunspot number and in critical frequency occurred during 1949 and 1950, and that since then there has been a

Fig. 1. Monthly mean sunspot numbers and noon and midnight F_2 critical frequencies since the last sunspot maximum.



* Engineering Division, B.B.C.

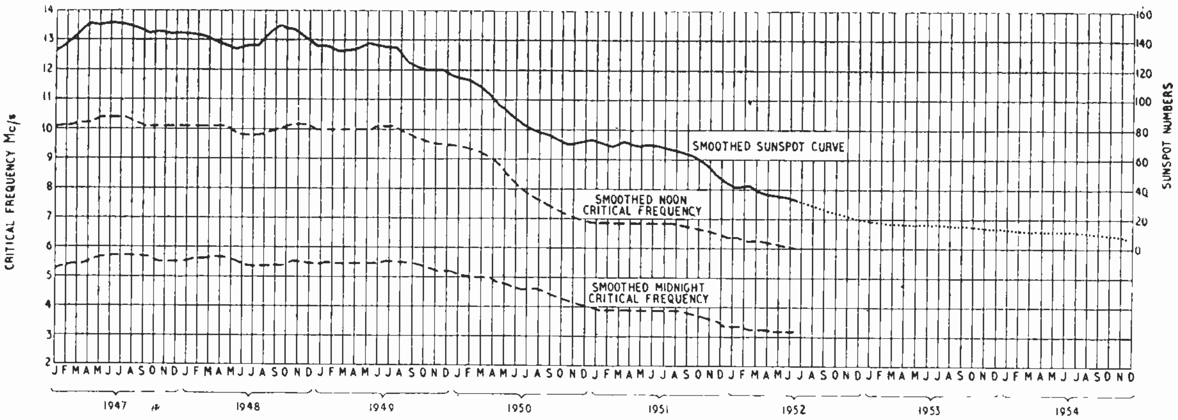


Fig. 2. Twelve-month running averages of sunspot numbers and noon and midnight F_2 critical frequencies since the last sunspot maximum, with possible future values of sunspot number.

distinct tendency for the curves to flatten out. This, indeed, is a usual feature during the years preceding the sunspot minimum, and is likely to be even more pronounced in the immediate future. This brings us naturally to a rather important question. What further decreases in the sunspot number are there likely to be, and when will the epoch of minimum activity be reached?

This, however, is a question which it is impossible to answer with any degree of certainty, for the law which governs the variation in sunspot activity, if law there be, is as yet unknown. The sunspot cycles vary very considerably, both in their amplitude and in their duration, and one cannot be very certain of anything about them. However, a close study of the past cycles back to 1750 (for which period relatively continuous records are available) enables certain features to be observed about the cycles, permitting them to be classified into types and classes. According to such a classification (one made by the present writer) the present cycle belongs to the type with high maximum and medium-long duration. By matching it to a "representative" cycle of this type—which is the mean of all the previous cycles of that type—one might hope to obtain some information relevant to the question which we have just asked. The dotted-line end of the curve in Fig. 2 gives the answer as obtained in this way, indicating the possible future values of the 12-month running average sunspot number and the epoch of minimum sunspot activity as being that of November/December 1954. Of course, such an empirical method can give results which are no more than a rough guide (though theoretical methods give results which are no better), and so it should be remembered that the dotted-line curve in Fig. 2 is given as having a "probability" value only. Because insufficient data regarding past cycles is available it is not possible to give a more authentic prediction.

What, then, are the variations of critical frequency and m.u.f. likely to be during the present year? It would seem from Fig. 2 that they will continue to decrease but that this further decrease from present values will be a very small one: in fact, the mean noon critical frequency is likely to decrease by only about 1 Mc/s between now and sunspot minimum. So far as m.u.fs for short-wave communication are concerned they are not likely to vary greatly from present values, albeit tending to decrease. The higher day-time broadcasting frequencies at present in use—21 Mc/s and 17 Mc/s—may become of somewhat decreased utility, and those for the summer night may become somewhat lower—9 Mc/s replacing 11 Mc/s in some cases. As to the winter night, already only the lowest broadcasting frequencies—7 Mc/s and 6 Mc/s—are generally of use at that time, and it is already apparent that a lower frequency than any now available for transatlantic broadcasting would greatly assist in maintaining winter night service.

Some further indications as to the time of occurrence of the sunspot minimum are likely to be provided by the sun itself before that event actually takes place. For there are certain observable features about the sunspots—such as a change in the solar latitudes in which they occur and a reversal in their magnetic polarity—which take place as the minimum approaches and usually about a year before it happens. None of these phenomena has so far been reported by the astronomers as having been observed in association with the presently approaching minimum.

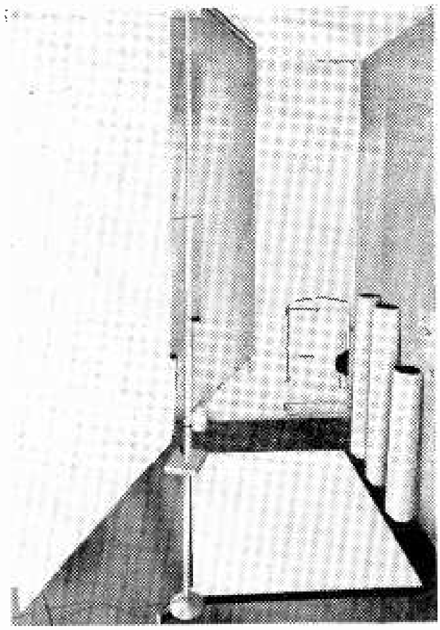
BOOKS RECEIVED

Data and Circuits of Modern Receiving and Amplifying Valves. Book IIIA, Supplement 2, by N. S. Markus and J. Otte. Description and design data relating to Philips receiver, amplifier and rectifier valves introduced during the years 1945-1950. Includes Rimlock, Miniwatt and some Noval types, and also a description of Philips test and measuring equipment. Pp. 487+xi; Figs. 505. Philips Technical Library. Distributed in U.K. by Cleaver-Hume Press, Ltd., 42a, South Audley Street, London, W.1. Price 40s.

Storage Tubes, by M. Knoll and B. Kazan. A survey of principles and a description of types of charge—controlled storage tubes for television and computing devices, with an extensive bibliography Pp. 143+xiii; Figs. 34. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 24s.

Radio and TV Hints. Edited by Martin Clifford. Test and workshop wrinkles for servicemen and amateurs. Pp. 112; Figs. 125. Gernsback Publications, 25, West Broadway, New York 7, N.Y., U.S.A. Price $1.

High Fidelity Simplified by H. D. Weiler. Review of current "hi-fi" equipment and ideas in America. Pp. 208; Figs. 104. John F. Rider, Publisher, 480, Canal Street, New York 13, N.Y. Price $2.50.



Reverberation chamber at Riverbank Acoustic Laboratories, showing rotating vanes and dispersing pillars.

Loudspeaker Efficiency

Technique of Measurement Using a Reverberation Chamber

MOST figures for loudspeaker efficiency are derived by calculation from free-field measurements of the sound pressure at selected points, on and off the axis. It is customary to undertake this work only where the radiation from the loudspeaker and its enclosure has an axis of symmetry, and even with this simplification, at least 18 measurements are usual for each chosen frequency. When the output is asymmetrical the integration becomes prohibitively laborious. There are also difficulties in making accurate measurements at the low levels off the axis which are experienced when the microphone is at a sufficient distance from the source to ensure that normal spherical propogation is established.

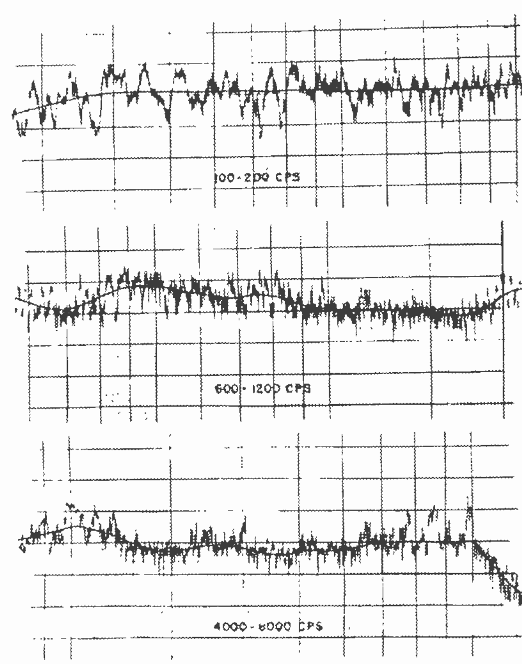
Echo-free rooms of sufficient size to satisfy this condition would be very expensive as the method of sound absorption must be thorough if it is to give satisfactory results at very low frequencies.

Given ideal conditions of measurement there still remains the problem of how to integrate the results. Most of the power output it radiated not along the axis but at angles of 40 to 60 degrees from it at low frequencies, and at smaller angles at high frequencies. At the angle of maximum radiation, diffraction effects may be marked and they result in a jagged response curve which considerably enhances the difficulties of carrying out an effective integration.

A reverberation method which not only simplifies procedure, but is more closely related to conditions of use is described in a recent issue of the Transactions of the I.R.E. Professional Group on Audio.[1] The sound energy in a room builds up until the power supplied by the loudspeaker is in equilibrium with the absorption losses consequent on reflection from the walls and furnishings at low and medium frequencies and on molecular absorption by the air itself at high frequencies, and in a small room the reverberant sound may exceed the direct sound from the loudspeaker at a distance of 5ft. In an ordinary room, due to eigentone resonances and other causes, the sound distribution is not uniform, and a single measurement of sound pressure would not necessarily indicate the average. Random distribution can, however, be induced by the use of a "warble" tone source, in which the frequency is varied by a few cycles per second about the mean, by cylindrical dispersing surfaces and by rotating vanes which continuously break up standing vibration modes. Such devices are normally employed in reverberation rooms designed for the measurement of absorption in building materials, and the accompany-

[1] "Direct Measurement of the Efficiency of Loudspeakers by Use of a Reverberation Room" by H. C. Hardy, H. H. Hall and L. G. Ramer *Trans. I.R.E., P.G.A.*, Nov-Dec. 1952.

Fig. 1. Sections of typical record taken in the reverberation chamber, with average curve superimposed.



ing photograph shows the reverberation room at the Riverbank Acoustical Laboratories of the Armour Research Foundation.

Corrections are necessary for the total absorption characteristics of the room at different frequencies, and Table 1 gives the figures for the Riverbank room. Conditions below 1,000 c/s are stable, but at high frequencies the absorption may vary with humidity. The microphone must also be calibrated or corrected for random sound pick-up.

When using a microphone with a small active surface, the random calibration usually follows the 90-degree incidence calibration up to 3,000 c/s and is only 1 db higher at 5,000 c/s and 2 db at 10,000 c/s. The microphone used in the Riverbank tests was a 640AA condenser type.

In terms of the reverberant sound pressure p_{rev} the power output P of a sound source in a room is given by the expression:

$$P = \frac{p^2_{rev}\, a}{4\rho c \times 10^7} \text{ watts}$$

where a is the absorption in c.g.s. units, ρ is the density of the air and c the velocity of sound.

In decibels above 1mW the power level becomes

$$L_{rev} + 10 \log a - 106.5$$

where L_{rev} is the pressure level in db referred to 0.0002 dyne/cm² and a is the absorption in sabins.

Loudspeaker and microphone are spaced widely apart—usually in different corners of the room—and the loudspeaker is energized under "constant available power" conditions from a "warble" tone generator which sweeps the frequency range of 20 to 10,000 c/s in 40 minutes. During this time the vanes make 40 half-revolutions. The output from the microphone is applied to a graphic level recorder, and typical sections of the record are shown in Fig. 1. Minor fluctuations, of the order of 5db at low frequencies and 2db at high, are averaged and the final curve can be relied upon to 1db.

Corrections are applied for the microphone characteristic and the room absorption, and the final result is of the form of the lower curves of Figs. 2 and 3, the upper curves being the free field response of the same loudspeakers taken on the axis at a distance of 10ft.

From the power output curves and the known input to the loudspeaker the electro-acoustic efficiency can be calculated and the results are given in Table 2. That the figures are lower than those often quoted is attributed by the authors of the original paper to the fact that the axial response usually forms the basis of calculation and that this ignores the directivity factor which is of the order of 6db. Power outputs computed from free-field response measurements at a number of positions round the loudspeaker are shown by circular points.

Not everyone has access to a properly designed reverberation chamber, but it is pointed out by the authors that if a loudspeaker calibrated under ideal conditions is available, useful results can be obtained, using this as a sub-standard, in any large empty room with an ordinary noise level meter and a "warble" tone generator.

TABLE 1.

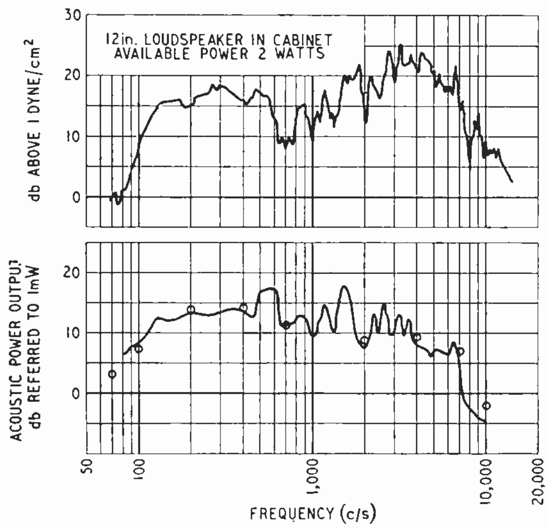
Frequency (c/s)	125	250	500	1,000	2,000	4,000	8,000
Absorption (sabins)	97	96	99	101	116	160	250

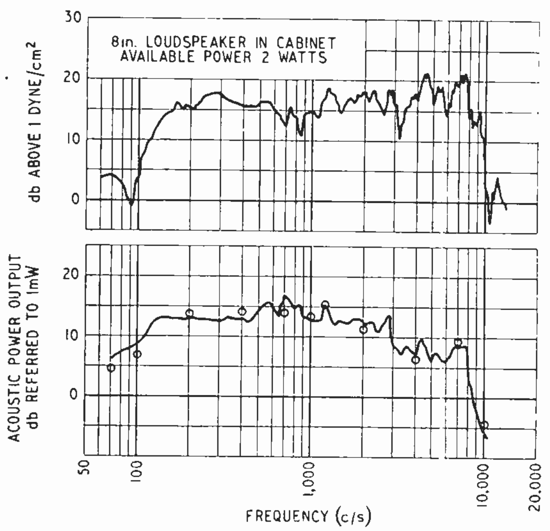
TABLE 2.

Frequency (c/s)	EFFICIENCY (Per cent) 12-in Speaker	8-in Speaker
70	0.1	0.1
100	0.4	0.5
200	1.1	1.1
400	1.1	1.1
700	0.7	2.2*
1,000	0.5	1.0
2,000	0.3	0.6
4,000	0.3	0.3
7,000	0.1	0.4
10,000	0.02	0.01

* Resonant peak.

Left: Fig. 2 (a) Free-field pressure response on axis at 10ft of 12-in speaker in closed cabinet 32in x 32in x 16in deep. (b) Acoustic power output measured by reverberation room method. Right: Fig. 3 Curves of 8in speaker taken under the same conditions as those of Fig. 2.-





LETTERS TO THE EDITOR

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

Television Modulation

YOUR article on low-level modulation (December issue) brings out many, but naturally by no means all, of those factors which must be taken into account in deciding the design of a television transmitter. It is not possible in a letter to touch on all the more important points, but I think that one or two of the points made in the article could perhaps be misinterpreted, and it is on these that I would like to comment.

While in sound broadcasting there are many fundamentally different systems of modulation, in television all transmitters so far constructed have used the same system of modulation, namely, grid modulation, and the difference between various designs resides in the level at which the modulating voltage is applied. It would be technically possible to add amplifier stages at the output of any transmitter so far constructed.

It is true that the transmitter unit itself is bigger in the high-power than in the low-power modulated case. But the difference is only some 100 square feet, and this is small in comparison with the overall size of a transmitter building. If, however, the size of the transmitter is appropriately reflected in its initial cost, then this can be a most important factor.

The power consumption of the transmitter is undoubtedly of the greatest interest, but only in the condition under which the station is normally operated. Full carrier condition on peak white does not represent such a condition, and the power consumption of a television transmitter should be related to the average light intensity of the picture, which is very considerably less than peak white. It is in this condition that the power consumption is of importance.

The difference in power consumption between two typical transmitters operating with a peak-white power of 50 kW, under Test Card C conditions, is relatively small. The advantage, of course, is with the low-power modulation system, but this in itself is not sufficient to be decisive, and it was not in fact the main reason why low-level modulation was adopted for the last two transmitters ordered.

On overall circuit complexity there is not much to choose between the two types of transmitter; the simplicity of the low-power modulator being offset by the complexity in the broad-band r.f. amplifier circuits and by the additional precautions to be taken in the clamping circuits. The design of television transmitters is still fluid, and it is to be expected that many of the developments that have occurred in sound transmitter design will also occur in television equipments. These may be in the direction of parallel operation in order to obtain greater reliability or possibly unattended operation, and higher output powers than have yet been used. The choice of the modulating level, and indeed of the modulating system, has to be considered with all these factors in mind, and it is, I think, too early to draw any firm conclusions as to the relative merits of high- and low-level modulating systems.

London, W.1. F. C McLEAN,
Deputy Chief Engineer, B.B.C.

YOUR article on low-level modulation in the December issue of *Wireless World* contains certain statements which seem to be based on inaccurate information.

Taking first the question of the relative floor space occupied by high-level and low-level modulation transmitters, if one compares the transmitter at Holme Moss with those at Wenvoe and Kirk o' Shotts, one should take into consideration that 40 per cent of the floor area of Holme Moss is occupied by low-tension switchgear.

While you are correct in stating that the modulator of a high-power modulation transmitter is larger than that used on the low-power system, nevertheless I feel that you have based your statement on an out-of-date design. The modulator of the Holme Moss transmitter is a small unit and occupies a very small area. I think it is safe to claim that from the practical engineering point of view there is no difference in the space occupied by transmitters of either type.

With regard to power consumption I note that in your remarks you have coupled the Sutton Coldfield and Holme Moss transmitters. I have no information as to the power consumption of the former, but with regard to Holme Moss, since the design of the power amplifying stages are similar to those of the later low-power modulated transmitters at Kirk o' Shotts and Wenvoe, in the absence of specific figures it is reasonable to assume that the only difference in power consumption is due to the additional power taken by the high-power modulator. In the case of Holme Moss this is only 30 kW, and this figure is difficult to reconcile with your statement.

The comparison of the power consumption of these two types of transmitter at peak-white level is misleading because transmitters are never operated in this condition for any length of time except for test purposes. In any case, I would suggest that power consumption is not the most important criterion; the desirable characteristics of a television transmitter can be written in this order:

1. Adequate performance consistent with the highest reliability.
2. Ease and constancy of adjustment.
3. Power conversion efficiency.

In conclusion, I should like to point out that the cost of the additional 30 kW of power consumed by the Holme Moss transmitter amounts to one or two shillings per hour and is infinitesimal compared with the cost of running the television service as a whole.

Writtle, Essex. E. GREEN.

Editorial footnote.—Statements in the article referred to on the relative sizes and efficiencies of the low-level and high-level modulation transmitters were based partly on information from an I.E.E. Paper "Television Broadcasting Stations" by P. A. T. Bevan, of the B.B.C. In a list of advantages of the low-level system the author put first the smaller size and lower intial cost and second the greater efficiency and reduction in running costs.

We agree that the peak-white criterion, mentioned by both our correspondents, is somewhat unreal, but, nevertheless, it is widely used as a measure of efficiency by transmitter engineers.

Directional Reception

I WAS interested in G. Bramslev's article in the November issue of the *Wireless World*, which described a small tuned loop for long-wave broadcast reception. I have found that a loop aerial can effectively reduce interference due to harmonics from the time-base circuits of television receivers, as well as electrical interference from motors, switches etc. As this action does not involve the directional properties of the loop, the orientation may, in suitable cases, be adjusted to reduce interference from a continental station as well.

A simple arrangement which I have found to work quite well on both medium and long waves consists of a single loop of plain wire round one wall of a living room. By using fine wire (e.g., 36 s.w.g.) and running it along suitable woodwork such as picture rails, skirting boards, door frames, etc., it is possible to make it practically invisible, particularly if painted over at a later date. The advantage of a large loop is that enough signal may generally be obtained without individual tuning for each station. Being unbalanced and unscreened, it will not be a perfect loop, but a rough calculation shows that the fraction of the output voltage arising from "vertical" pick-up is only about 1/25th at 200 kc/s and 1/5th at 1 Mc/s, if the dimensions of the loop are about 7ft by 10ft.

The ends of the loop are arranged at a convenient point round the wall, and a short length of twin flex is run from there to the receiver. Direct connection to the "aerial" and "earth" terminals gives quite good results if a suitable fixed condenser (usually about 1,000 pF) is placed in parallel with the loop. If whistles due to poor second-channel rejection are encountered other methods of coupling may be tried in order to reduce loading or "pulling" of the input circuit of the receiver.

The plane of the loop is chosen if possible so that any principal station to be received lies in a direction less than 45 degrees from the plane of the loop. A loop may perhaps be bent round the corner of a room so that its vertical sides lie in a plane at right angles to the direction of an interfering station. The usual connection of the earth terminal of the set to earth may be left; the presence or absence of an earth connection appears to have little effect on the loop performance.

An aerial along these lines may appeal to some readers as a basis for experiment if they are troubled by interference either from some local source or from the continent. It should be mentioned that, on stations subject to slight fading, an improved signal-to-noise ratio may also be obtained at the expense of more severe fading. A good outdoor aerial and a good earth form the soundest proposition in such cases. A switch can always be used to select the type of aerial which gives the best results on any particular station.

London, S.W.16. G. J. PHILLIPS.

I HAVE recently used loop aerials to reduce fading and distortion caused by synchronized transmissions; the Ayrshire coast is recognized as a "mush area." Encouraging results have been obtained on 647 kc/s. (Third Programme) where it is required to accept the ground-wave from the low-powered transmitter at Glasgow while rejecting a sky-wave of about the same strength from Daventry. Rejection of the sky-wave is improved by inclining the plane of the loop at about 30 deg to the vertical. Reception of the Home Service (809 kc/s.), which is often spoiled by whistles and by fading, has also been improved.

The loops are auto-transformer coupled to lengths of lighting flex which serve as feeders, the connection to the receiver being made through a small transformer. A loop about four feet square has about the same sensitivity as a short indoor aerial of the conventional sort.

The improvement to be obtained, of course, depends upon the disposition of the transmitters; nevertheless these results show that it is worth while considering the directional properties of loops as well as the noise-rejecting properties stressed by Mr. Bramslev as aids in overcoming present reception difficulties.

West Kilbridge, Ayrshire. R. A. W. HILL.

Drying-out Transformers

J. MACINTOSH'S article (December issue) has prompted me to make some observations on the subject, based on experiences whilst serving in the R.A.F. in Bombay during the war.

The main power transformers of certain radar equipment were found to break down soon after the equipment was put on test after receipt from U.K. Failure was generally found to be due to insulation breakdown between windings, rather than from primary to core; and this was certainly the case with those transformers which had the filament winding of a 4-kV e.h.t. rectifier wound adjoining l.t. windings. This failure-liability was removed by disconnecting the rectifier from this winding and connecting it to a new winding which was added on the outside of the e.h.t. bobbin ("window space" permitted this).

All the main transformers of this equipment were removed on receipt and subjected to a "drying-out." For this they were placed on top of two 1,250-watt flat heaters, which were connected in series so that each received only a quarter of its nominal power. No cover was used, so that moisture could be carried away by the warm air. This was followed by soaking in a beeswax/resin mixture, and, when cool, by "flash-dipping" in a compound of asphalt and other substances.

While some aspects of the this treatment may be criticized by transformer designers, records showed that the reliability of transformers so treated was increased very considerably, even when some time elapsed before they were put into regular service.

Other factors found liable to lead to the breakdown of tropically operated transformers were:

(a) Winding layers filling the space between, and therefore touching, the "cheeks" of a bobbin. Condensation on the "cheeks" encourages shorts between layers. Cheeks are undesirable.

(b) Use of certain types of impregnated cloth for inter-winding insulation. Such "tapes" appear to react with the enamel on the wire; probably the effect is akin to the acidity of bitumen compounds.

Stroud, Glos. T. H. HILL.

V.H.F. as an "Extra"

THE letter published in your issue of December, 1952, is based on what I believe to be a common misunderstanding about v.h.f. broadcasting. The principal reason for introducing v.h.f. in Europe is simply that the medium broadcast band is inadequate to meet the demands now required of it; sooner or later new channels will have to be found. To justify the expenditure involved, the service must eventually be capable of an appeal far wider than that envisaged by your correspondent; to establish it merely as an "extra" would be indefensible for the reasons given in his letter.

The Germans have been obliged to base their broadcasting on v.h.f. as described in your April, 1952, issue. A further study of the German service would be a far more useful guide to the value of v.h.f. broadcasting than reports from America which, however excellent in themselves, often have no relevance to broadcasting conditions in Europe.

Newbury, Berks. D. R. A. MELLIS.

Future of Broadcasting

YOUR correspondent, L. Streatfield (January issue) says, "Interference from other transmitters is a question of set design." How I wish he lived in East Anglia and had struggled for two years to receive the B.B.C. on medium waves with reasonable entertainment value. Perhaps he could then tell me how to eliminate a 1-kc/s heterodyne from an adjacent carrier without seriously impairing quality. An AR88 communications receiver will not give interference- and fading-free reproduction of any B.B.C. regional programme here (during the hours of darkness). Neither is an audio filter with a 1-kc/s cut off conducive to good quality.

Others must feel, as I do (paying the licence fee and living outside the television service area), that a little of the B.B.C.'s attention might be diverted from television to giving a country-wide sound service.

Apathy in places outside the real service areas probably arises from ignorance. The inhabitants may imagine that Londoners, etc., sit huddled around their receivers trying to catch a word here and there, while, throughout, their eardrums are assailed by a deafening whistle.

I, for one, would welcome a local v.h.f. transmitter.

Ipswich. H. S. KING (G3ASE).

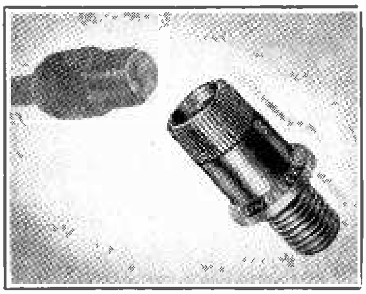
THE "BELLING-LEE" PAGE

Providing technical information, service and advice in relation to our products and the suppression of electrical interference

Meet the "Sparkmaster"

As nobody seems to want his car "suppressed," we are going to sell our distributor suppressor and sparking plug suppressor under the names "Sparkmaster" and "Sparkmaster de luxe" respectively. There is no doubt that the desirability of suppressing ignition interference in motor cars has stimulated research into what happens when so doing, and that the industry has learnt that there are several benefits, and so far nothing detrimental in fitting resistors in the ignition circuit.

For example, the resulting spark is less violent but its useful period is prolonged. There would appear to be smoother combustion, with a tendency to reduce plug erosion. Then there is the fairly well known United States army report on the greater ease of cold starting. We do know that one of our biggest motor manufacturer customers interested in expensive high performance cars, fits resistors as part of the electrical design, and not as suppressors. It is all very interesting, but still the public is doubtful.

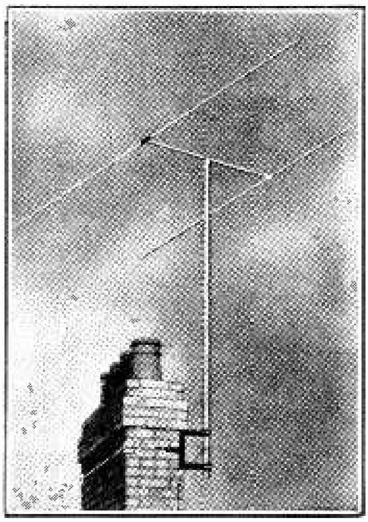


"Belling-Lee" "Sparkmaster".

If the public won't fit resistors, perhaps they can be coaxed into so doing with advantage to themselves and viewers. The writer drives a "Velox" with a "Sparkmaster de luxe" at each plug and a "Sparkmaster" at the distributor, and believes the car goes better that way. Certainly nothing detrimental has been noticed while driving a ¼ million miles.

An Interesting Thought

Will there be horizontal aerials in Wigtownshire? It is the shortest crossing from Britain to Ireland—36 miles. From Belfast to Stranraer is just about 45 miles, practically all across sea. Kirk o' Shotts to Stranraer is about 80 miles all across land. Other towns that might be affected are Wigtown, Kirkcudbright, Newton Stewart, Glenluce. Our guess is that there is every possibility that reception of television from Belfast may be better than from the Scottish Station, particularly when Belfast goes to 5 K.w.



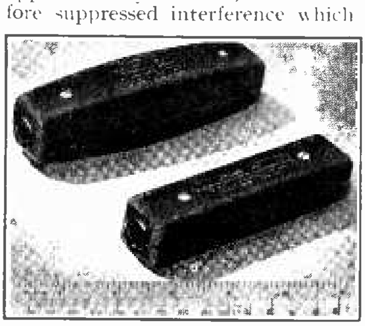
A "Belling-Lee" horizontally polarised television aerial.

Can you beat it?

Some months ago a customer purchased one of our flex lead suppressors, the L.301, to suppress a hair dryer which caused interference with a neighbour's television receiver. In spite of the fact that each L.301 suppressor is supplied in a carton bearing the warning "ineffective at television frequencies," the suppressor was fitted, and the interference disappeared completely.

All went well until recently, when the receiver was changed for one of a different manufacture; at this juncture the interference returned and could not be overcome by any amount of experiment with the suppressor—quite a problem but not without a simple explanation.

The L.301 is effective up to approximately 20 Mc/s, and therefore suppressed interference which was being picked up by the 10 Mc/s I.F. stages of the original receiver, and not, most fortunately, by the aerial or first stages of amplification at the frequency of the television transmission. The second receiver, which was tunable, possessed tunable I.F. stages of approximately 30 Mc/s, and interference radiated by the hair dryer made itself only too evident.



Flex lead suppressors, top L.301, lower L.1174.

For the suppression of interference at television frequencies, some form of filter network must be fitted within the case frame of the offending appliance, and since space and airflow within such appliances as hair dryers involves mechanical rather than electrical consideration, suppression in many cases may not be practicable.

At normal broadcast frequencies, interference may be suppressed satisfactorily by our L.301, but at television frequencies the majority of interference is radiated directly from the offending appliance.

The Coronation

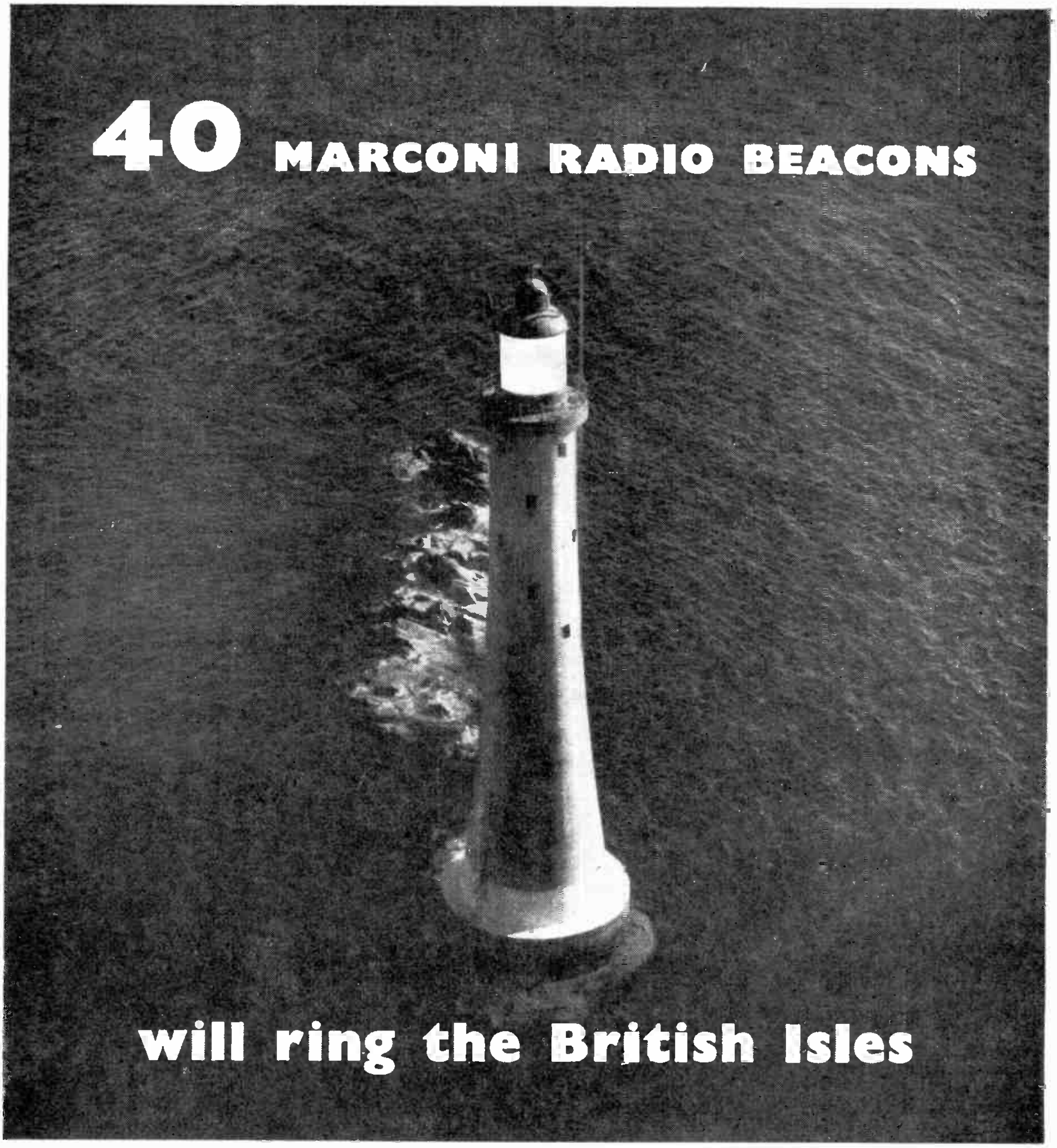
There is no doubt that the Coronation will be a terrific boost to television. Many hundreds—nay, thousands of people—will decide that they must have a receiver in time.

We have said it before, and will probably say it many times again, a pantechnicon full of television receivers may pull into a town, and they may all be delivered that day, but it would take some days, depending upon the weather and the time of the year, to erect all the aerials. Every firm doing aerial installations is going to be up to its eyes in work until the Coronation is over. The better qualified and better known they are, the busier they will be.

We know, as sure as we are writing this page, that friends will ring us up "in plenty of time"—a month or so to go—to ask us to do "that special job" that we would dearly like to do. For example to install a television system for a visiting dignitary, or to equip a hall with a number of receivers to show the Coronation to the very old and the very young. Such a lot of that kind of work will come along, and we do like the unusual and the difficult. Please help us to help you, and please do not expect the impossible.

Written 30th December, 1952

BELLING & LEE LTD
CAMBRIDGE ARTERIAL RD., ENFIELD, MIDDX., ENGLAND



From the Channel Islands to the Shetlands, from the Thames to the West Coast of Ireland . . . 40 lighthouses and lightships around the coasts of Great Britain and Ireland are to be equipped with Marconi Marine Beacons by the Lighthouse Authorities. These M.F. Beacons will be fully duplicated with changeover switching, indicating and alarm facilities; in addition specially selected stations in the vicinity of the main ports will provide 'request' transmissions.

MARCONI marine beacons

MARCONI'S WIRELESS TELEGRAPH COMPANY LTD · CHELMSFORD · ESSEX

WORLD OF WIRELESS

Fringe-area Television Repeater ◆ Components and Instruments Shows ◆ Extending Home Service Coverage ◆ Captain Round Honoured

Television Booster

ALTHOUGH, as reported last month, the Asst. P.M.G. had stated that the Government could not, for the time being, sanction any further television stations, the B.B.C., acting upon an earlier Ministerial statement that the Corporation hoped to be able to improve reception in the Brighton area, is planning to install a booster station in the locality in time for the Coronation. A low-power repeater station, made by Ekco and installed experimentally in Essex, was described in our December issue.

The transmitter for Brighton, if sanctioned by the P.M.G., will operate in Channel 3 (used by Kirk o'Shotts). It has been stated in some published reports that the transmissions will be horizontally polarized, as will those from the temporary stations in Belfast and Newcastle. It is learned, however, from the B.B.C. that as the Stockholm Plan provides for the proposed Isle of Wight station to use vertical polarization, the booster will, if sanctioned, do the same to save viewers from making a change when ultimately the permanent station comes into service.

At the time of going to press, tests are being conducted on Truleigh Hill, north of Shoreham.

Servicemen's Wages

OUR report on page 24 of the last issue on the award of an increase of 15s per week in the minimum rates of pay to servicemen was apparently open to misinterpretation. There should have been no implication that the dispute was taken to arbitration jointly by the Radio and Television Retailers' Association and the Guild of Radio Service Engineers. It was, in fact, G.R.S.E. which reported the dispute to the Minister of Labour and National Service who referred the case to the Industrial Disputes Tribunal.

Two April Shows

AS has happened during the last two or three years, the dates of the Physical Society's exhibition of scientific instruments and apparatus overlap those of the Components Exhibition organized by the Radio and Electronic Component Manufacturers' Federation. The Physical Society show is planned for April 13th-17th and the R.E.C.M.F. show for April 14th-16th.

The Physical Society's thirty-seventh annual exhibition will be held in the Royal College of Science, Imperial Institute Road, South Kensington, and the component show at Grosvenor House, Park Lane, London, W.1.

Tickets for the scientific instruments show, which is open daily from 10 a.m. to 8 p.m. (with the exception of the last day when it closes at 5 p.m.), are available from exhibitors or the Physical Society, 1, Lowther Gardens, Prince Consort Road, London, S.W.7. Early application should be made for tickets which, as in previous years, are valid for specified days or sessions (mornings 10 a.m. to 1 p.m., evenings 5.30 p.m. to 8 p.m.).

It should be noted that the exhibition is this year confined to the Royal College of Science.

The components show, which will also include test gear, valves and accessories, will be open daily from 10 a.m. until 6 p.m., except on the last day when it will close at 5 p.m. Admission to the show is by invitation ticket, obtainable from the organizers (R.E.C.M.F., 22, Surrey Street, London, W.C.2) and exhibitors, but these are only available to those having a professional, industrial or trade interest in the equipment exhibited.

Armstrong Medallist

CAPTAIN H. J. ROUND, who will be remembered by our older readers as the originator of the Round "soft vacuum" valve and the regenerative self-heterodyne circuit (1913) and for his development of d.f. equipment during the first World War, has been awarded the Armstrong Medal by the Radio Club of America. The award has been made "in recognition of his contributions during half a century to the radio art, and especially of his revolutionary developments during World War I in the fields of direction and position finding and the high amplification of short-wave signals."

CAPT. H. J. ROUND (right) receiving the Armstrong Medal from the president of the Radio Club of America.

Home Service Transmitters

THE temporary caravan transmitter at Fremington, between Barnstaple and Bideford, which has been in service since last March has now been replaced by a permanent station on the same site. It is completely automatic and the two 660-W Marconi transmitters work in parallel. A third unit will be added later to bring the power up to 2 kW. The station operates on 1,052 kc/s.

Caravan transmitters have been brought into service at Towyn, Cardiganshire, on 881 kc/s, and at Mousewald, near Dumfries, on 809 kc/s, where permanent stations are eventually to be built to improve reception of the Home Service. It has also been announced by the B.B.C. that a Home Service transmitter is to be installed at Redruth, Cornwall, where there are already two transmitters radiating the Light and Home Programmes. The 2-kW transmitter will radiate on 1,457 kc/s.

Italian Television

PLANS have been completed by the Italian broadcasting service—Radio Audizione Italiana—for a network of 14 television stations with studios in Rome, Milan and Turin. The first phase in the implementation of the plan is to erect nine transmitters in Northern Italy.

British equipment is being employed for some of the stations which will operate in the 174- to 216-Mc/s band on 625 lines. A £300,000 order has been placed with Marconi's for four cameras and associated studio equipment at both Rome and Milan (which will, incidentally, be linked by radio), two O.B. vehicles and $7\frac{1}{2}$-kW vision and $2\frac{1}{2}$-kW sound transmitters for Rome and Monte Serra.

In addition to the experimental television stations operating in Turin and Milan and those already mentioned, there will be transmitters at Monte Venda, Monte Penice, Portofino, Florence and Monte Peglia.

PERSONALITIES

Dr. E. F. W. Alexanderson, originator of the r.f. alternator (1909) has, at the age of 74, joined the Radio Corporation of America as a consultant. He joined the General Electric Co. of America in 1902 and, except for a brief period in the early 'twenties, was with that company until his retirement a year ago.

Capt. R. T. Paul, C.B.E., A.M.I.E.E., R.N.(Retd.), has joined Mullard's Equipment Division as commercial manager, co-ordinating the activities of the groups producing radio, telephone and electronic equipment. As Chief Signal and Radio Officer to the Allied Naval C.-in-C., Expeditionary Force, he was responsible for the naval signal, radio and radar organization for the Normandy invasion and was the first chairman of the Western Union Communications Committee (Naval).

Leslie Cooper, the new president of the Radio Society of Great Britain, has been a member of the Society for 23 years and has operated his own station (G5LC) for 22 years. He is also in radio and telecommunications professionally as a production engineer. He was for 15 years with E.M.I. and during the war was in charge of ground radar production. Mr. Cooper, who was honorary secretary of the R.S.G.B. in 1951, is also president of the Thames Valley Amateur Radio Transmitters' Society, and is holder of a number of amateur operating certificates.

LESLIE COOPER

Major Rowland Shears has been elected the first honorary member of the German Amateur Radio Society in recognition of his services on behalf of amateur transmitters when he was secretary of the Radio Committee of the British Signal Communications Board in Germany. It was largely due to his efforts that German amateurs were granted licences in 1949. Major Shears, who is now a senior development engineer at the Electronics Laboratory, Burndept, Ltd., Erith, operates his own transmitter (G8KW) and whilst in Germany used the call DL4KW.

R. P. Browne, secretary of the Radio Industry Council and its predecessors N.A.R.M.A.T. and R.M.A., has been given leave of absence to enter the London Hospital for an orthopædic operation. During his absence, which we regret to learn is expected to be for some months, **G. B. Campbell,** the deputy secretary, who is normally engaged on the work of the technical committees of the Council, will be acting as secretary.

R. P. BROWNE, O.B.E., B.Sc.

D. C. Brice has joined the staff of the R.I. Council as temporary assistant to Mr. Campbell, mainly for the technical side of the Council's work. Mr. Brice served in Royal Signals during the war and in 1942-43 was at the G.H.Q. Wireless Station, New Delhi. He was a member of Lord Mountbatten's staff, both during the war and later at Viceregal headquarters.

Edward Cattanes, M.Brit.I.R.E., Assoc.I.E.E., has resigned his position as manager of the Industrial Electronics Department of the English Electric Co., Stafford, which he had held since 1949. He was previously manager of the Electronics Products Division of the Radiotel Corporation (Philco) and of the engineering sales of its subsidiary Airmec Laboratories. From its inception in 1936 to 1947 he was manager of Cossor's Electronic Instruments Division and was responsible for introducing the well-known double-beam oscilloscope. He is a member of the Technical Committee of the Brit.I.R.E. and, until recently, was chairman of the Industrial Electronics Section of the R.C.E.E.A.

N. D. Bryce, sales development manager, **E. A. Taylor,** commercial sales manager, and **A. Cook,** M.B.E., secretary, who have all been with Belling and Lee for over twenty years have been appointed executive directors of the Company.

Alan P. Ross, has joined Thorn Electrical Industries, Ltd., and will be mainly concerned with the sale of special products and components. He was previously with Belling & Lee.

A. G. Coates, M.I.E.E., was recently appointed superintendent of communications, Iraq Petroleum Co., Ltd., which he joined in 1948. He had previously held the positions of deputy engineer-in-chief, Palestine Posts & Telegraphs, and chief engineer, Iraq Posts & Telegraphs.

L. C. Bingham, general sales manager of Venner, Ltd., and Venner Accumulators, Ltd., is on a two-month tour of India and Pakistan.

NEW YEAR HONOURS

B. E. Nicolls, C.V.O., C.B.E., who was, until recently, Director of Home Broadcasting (B.B.C.) and during the interregnum was acting Director-General, is created a knight bachelor.

J. A. Smale, B.Sc., M.I.E.E., engineer-in-chief, Cable and Wireless since 1948, is appointed C.B.E. He joined C. & W. in 1932 and, in addition to development work on long-distance s.w. relay stations for overcoming unfavourable propagation conditions, has been concerned with the development of frequency-shift keying. He is a vice-chairman of the I.E.E. Radio Section.

H. T. Bennett, managing director of the Marconi Telegraph Co. of Egypt, also becomes a C.B.E.

A. A. Dyson, managing director of Eric Resistor, Ltd., is appointed an O.B.E.

R. H. A. Carter, senior experimental officer at T.R.E., Malvern, who was awarded £750 by the Royal Commission on Awards to Inventors for his work on I.F.F., becomes an M.B.E.

G. B. CAMPBELL
(See centre column)

A. H. Farman, chief radio officer of the *Queen Elizabeth*, is also appointed an M.B.E. He has been a sea-going radio officer since 1913 and has served with the International Marine Radio Co. for 21 years. He joined the *Q.E.* as chief radio officer for her secret maiden voyage in 1940.

S. Wort, station officer at the War Office Wireless Station, is also among the new M.B.E.s.

OUR AUTHORS

F. W. O. Bauch, who contributes the article on p. 50, studied physics at Berlin Technical University. In 1930 he became a member of the Heinrich Hertz Institute, where he did research work on supersonics. Then followed a short spell at the G.E.C. Research Laboratories, Wembley, prior to joining the Dutch Philips Co. in Berlin, where he remained for eight years. The latter years of the war were occupied with research on high-frequency pulse technique. After the war, he was appointed chief engineer of the Berlin broadcasting station "RIAS." Returning to this country in 1947, he first worked at the Electrical Research Association but is now scientific and technical representative of various German research organizations and manufacturers.

F. W. O. BAUCH.

J. F. Hartwright, contributor of the article on television O.B. units, served as a sea-going radio officer before joining the B.B.C. staff at Daventry as a maintenance engineer in 1935. He was transferred to the London television station in 1938 and after the closing of the television service in 1939 stayed at Alexandra Palace working on radio counter-measures. He became senior engineer-in-charge of a television O.B. mobile control room in 1948.

D. F. W. Champion, co-author of the article "Magnetic Powder Cores" in this issue, graduated from London University in electrical engineering in 1948. He joined the Research Laboratories of the General Electric Co. in 1942, where he has worked on the applications of magnetic materials and the development of special test equipment.

E. G. Wilkins, who, with D. F. W. Champion, contributes the article on p. 83, joined the G.E.C. Research Laboratories in 1941. After service in the R.A.F. from 1943-46 he studied at Durham University and graduated B.Sc. in 1948. In the same year he rejoined the G.E.C. and has been working on problems associated with the preparation of magnetic materials.

L. S. Allard, who contributes the article in this issue on a storage tube for digital computing machines (p. 95), graduated from London University (Chelsea Polytechnic) with a B.Sc. degree. He joined the G.E.C. Research Laboratories in 1941 and has worked on cathode-ray tubes, specializing in the design of electron guns and cathode-ray beam devices.

OBITUARY

It is with regret that we announce the death, on December 27th at the age of 53, of **William Thomas Gibson,** O.B.E., M.A., B.Sc., M.I.E.E., chief valve engineer of Standard Telephones and Cables, Ltd., and manager of their Ilminster laboratories and factory. He joined the staff of the Western Electric Co. (later S.T.C.) in 1922 to initiate the manufacture of radio valves. He also set up the valve laboratory of Le Matériel Téléphonique in Paris in 1928, and the Newark, New Jersey, valve laboratory of Federal Telephone Laboratories in 1932.

IN BRIEF

Receiving Licences. — A further 81,000 television receiving licences were issued in November, bringing the total at the end of the month to 1,813,790. There were also 10,860,521 licences current for sound receivers and 170,429 for car radios, making a total of 12,844,740.

Radio Astronomy Research.—One of the two Mackinnon Research Studentships of the Royal Society has been awarded to R. C. Jennison, of Manchester University, to work on radio astronomy at the Jodrell Bank station.

E.P.T.A.—Non-members are welcome at the all-day meeting of the Electro - Physiological Technologists' Association which begins at 10.30 a.m. on February 7th at the Institute of Psychiatry, Maudsley Hospital, Denmark Hill, London, S.E.5, when papers and demonstrations will be given. Application should be made to the honorary secretary, G. Johnson, Hurstwood Park Hospital, Haywards Heath, Sussex, before February 1st.

Surveying and Charting the Norfolk Broads after an interval of 18 years has recently been undertaken with the aid of a Marconi "Seagraph" recording echometer modified for shallow sounding work. The permanent contour graph of the bed indicates not only the depths—even where there is less than 2ft of water—but also whether the bottom is hard sand, gravel or soft mud.

Patents Exhibition.—Of the 100 "important patent specifications granted during the century in the major industries" which were displayed at the recent Patent Office Centenary Exhibition, a dozen or more related to radio, including Armstrong's super-regenerative circuit (1923), Baird's original television patent (1924) and Watson-Watt's first radar specification (1936).

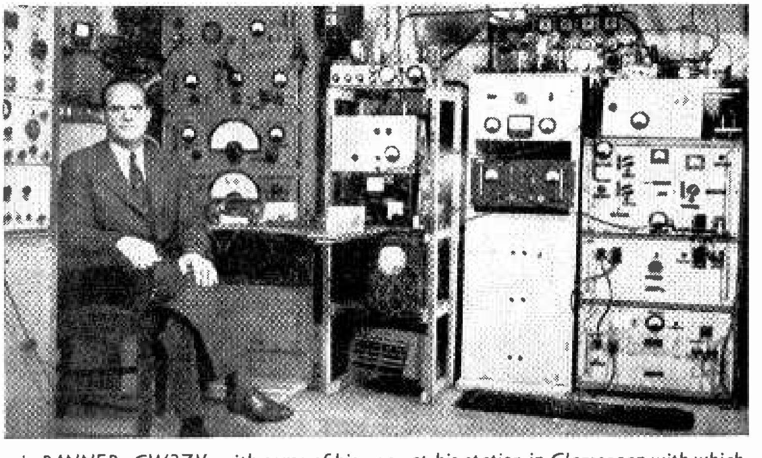
Insulating Materials.—A symposium of papers dealing with the selection and use of dielectrics in electrical engineering has been arranged by the Measurements Section of the I.E.E. and will be held at Savoy Place, London, W.C.2, from March 16th to 18th.

R.S.G.B. Officers.—At the annual general meeting of the Radio Society of Great Britain on December 19th, Leslie Cooper (G5LC) was elected president. The new vice-president is A. O. Milne (G2MI), who is the Society's QSL manager. D. A. Finlay (G3BZG) is honorary treasurer, C. H. L. Edwards, A.M.I.E.E., (G8TL), is honorary secretary and John Hum (G5UM) continues as the honorary editor of the Society's *Bulletin*. The following were elected members of the committee: I. D. Auchterlonie (G6OM); P. W. Winsford (G4DC); R. H. Hammans (G2IG); H. A. Bartlett (G5QA); L. E. Newnham (G6NZ); F. Hicks-Arnold (G6MB); H. McConnell (GM2ACQ).

Higher Technology Courses.—Among the courses listed in the latest Bulletin issued by the Regional Advisory Council for Higher Technological Education are a number covering radio and allied subjects beginning in the next month or two. The courses, listed both alphabetically under colleges at which they are held and by subject, are mostly part-time or short full-time. The Bulletin, which covers some 80 courses in higher technology in colleges in London and the Home Counties, is available (price 1s 6d) from the Secretary, the Regional Advisory Council, Tavistock House South, Tavistock Square, London, W.C.1.

Plastics Exhibition.—The second British Plastics Exhibition, originally arranged by the organizers, *British Plastics*, for the period June 3rd to 13th (before the date of the Coronation was known), has been postponed until June 8th to 18th. The Convention, running concurrently with the Exhibition, and also at Olympia, will cover the most recent developments in plastics technology and applications.

Glass Exhibition.—Although glassware is one of the many "raw materials" used in radio it is certainly at the heart of affairs in a television set. We, therefore, think it worth while drawing readers' attention to the first National Glass Industries Exhibition which will be held in the New Horticultural Hall, Westminster, S.W.1, from May 11th to 16th.



J. BANNER, GW3ZV, with some of his gear at his station in Glamorgan with which he scored the highest European marks in the A.R.R.L. contest, and for the third successive year made the highest score in the British Isles. He uses separate transmitters for each of the six bands from 1.7 to 28 Mc/s and employs a triple-diversity 84-valve receiver.

Projection Television Receivers are to be installed in the Lambeth Town Hall on Coronation Day to enable 2,000 elderly and disabled citizens of the Borough to see the B.B.C. transmission of the procession and ceremony. The forward-projection receivers, providing a 4ft × 3ft picture, are being lent by Decca Radio and Television, whose head office is in the Borough of Lambeth.

F.M. in France.—The experimental 200-watt f.m. transmitter at Paris-Grenelle is to be replaced by a 15-kW transmitter. The station radiates on 99 Mc/s.

PUBLICATIONS

"Radio Designer's Handbook," edited by F. Langford-Smith, which has been out of print for a long time, has now been rewritten and greatly enlarged (1474 pp.). The fourth edition (price 42s) is expected to be available by the end of May. Originating in Australia, it is again being issued in this country by our Publishers, who ask us to advise readers to place their orders early with their booksellers.

Purifying Germanium.—As is known, germanium for use in rectifiers must have a high degree of purity. In order to follow the elimination of arsenic—the most important impurity—the Inorganic Group of the D.S.I.R. Chemical Research Laboratory has developed a radio-active tracer method. An account of this investigation is given in "Chemistry Research, 1951" published by H.M.S.O., price 4s 6d ($1.15 U.S.A.).

Research in Universities.—What is hoped will be an annual publication has recently been issued under the ægis of D.S.I.R.—the title is "Scientific Research in British Universities 1951-2." Details of the research being undertaken in universities and colleges throughout the U.K. include the names of the staff working on the problem and a brief description showing the scope of the research. It is available from H.M.S.O., price 8s ($1.80 U.S.A.).

"ZL" Calls.—The annual call-book number (January, 1953) of *Break-In*, the official organ of the New Zealand Association of Radio Transmitters, gives the addresses of all amateurs in the North and South Islands.

Italian Call Book.—A special number of our Italian contemporary *Radio e Televisione*, published in August, contains a complete list of "I" amateur calls.

BUSINESS NOTES

Marconi Valves.—We are asked to point out that whilst the Marconiphone Valve Department, as announced last month, is now at 3, Stanhope Street, London, N.W.1, Marconi valves or Emiscope c.r.ts returned with claims for replacement should be sent as previously to the Valve Test Division, E.M.I. Sales & Service, Wadsworth Road, Greenford, Middx.

Sobell Industries advise us that their five-valve three-waveband a.c. table receivers, 512W and 553, have been approved by the School Broadcasting Council for use in schools.

International Aeradio has installed synthetic air-traffic control training equipment at the French Civil Aviation School at Orly Airport, Paris.

An English Subsidiary of Phillips Control Corporation, of Joliet, Illinois, to be known as Phillips Control (G.B.), Ltd., is being set up to manufacture solenoid actuators in this country. The company will operate in association with Harvey Electronics, Ltd., of 273, Farnborough Road, Farnborough, Hants, where it is planned to produce initially two types of solenoid—Type 41 with a maximum stroke of ⅜in and Type 42 with a maximum stroke of ⅝in. Both will be available for voltages from 6 to 400 (a.c. or d.c.).

Airmec has dropped the word Laboratories from the name of the company as it is felt that it is misleading and bears no relation to the manufacturing capabilities of the company. The registered name and address is now Airmec, Ltd., High Wycombe, Bucks.

Kits of Parts, including the necessary assembly tools, for the construction of prototype "H" switches are now available from A.B. Metal Products.

Vidor's Bristol distribution depot is now in Cumberland Street, Day's Road, and the company's television service depot is in Day's Road, St. Phillips, Bristol (Tel.: Bristol 58481, Ext. 5). J. Boorman Leonard is the service technician in charge.

Exide and Drydex Depot in Bristol was recently moved from Broadmead to Whitehouse Street on the city's Bedminster industrial estate.

Telecraft, Ltd., manufacturers of aerials and accessories, advise us of changes of address of two of their depots. The Birmingham depot is now at 75, Holyhead Road, Handsworth (Tel.: North 6301, Ext. 2) and the Cardiff depot at 1 & 2, Stuart Street (Tel.: Cardiff 25955).

MEETINGS

Institution of Electrical Engineers

Radio Section.—"A Method of Designing Transistor Trigger Circuits" by Prof. F. C. Williams, O.B.E., D.Sc., D.Phil., F.R.S., and G. B. B. Chaplin, M.Sc., on February 11th.

"Radio Aids for Airport Control" by G. W. Stallibrass, O.B.E., on February 23rd.

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

"Ignition Interference with Television Reception" by A. H. Ball and W. Nethercot at 5.30 on February 10th. Joint meeting with the Institution of Mechanical Engineers at Storey's Gate, London, S.W.1.

Cambridge Radio Group.—"Electronic Aids for Film-Making" by T. C. MacNamara at 6.0 on February 17th at the Cambridgeshire Technical College.

North-western Radio Group.—"Television Receiver Design" by A. J. Biggs, Ph.D., B.Sc., at 6.30 on February 18th at the Engineers' Club, Albert Square, Manchester.

North Scotland Sub-Centre.—"Topics on the Design and Testing of High-power Valves" by A. M. Hardie, M.A., B.Sc., at 7.30 on February 11th at the Caledonian Hotel, Aberdeen, and at 7.0 on February 12th at the Royal Hotel, Dundee.

South Midland Centre.—Discussion on "The Co-ordination of Technical and Practical Training" at 6.30 on February 20th at the College of Technology, 53, Broad Street, Birmingham. (Joint meeting with the Students' Section.)

Southern Centre.—"Principles of Colour Television" by J. H. Mole, Ph.D., and J. W. R. Griffiths, B.Sc., at 6.30 on February 4th at the Municipal College Extension, Portsmouth. (Joint meeting with the Students' Section.)

"The Technique of Manufacture of Reliable Valves" by E. A. Roberts, Ph.D., M.Sc., at 6.30 on February 25th at the South Dorset Technical College, Weymouth.

Oxford District.—"Colour Television" by G. G. Gouriet at 7.0 on February 11th at the Southern Electricity Board, 37, George Street, Oxford.

Reading District.—"Colour Television" by G. G. Gouriet at 7.0 on February 2nd at the Electricity Demonstration Room, Market Place, Reading.

London Students' Section.—Visits to the G.E.C. Research Laboratories, North Wembley, at 2.15 on February 4th and the E.M.I. Factory, Hayes, at 2.0 on February 18th.

British Institution of Radio Engineers

London Section.—"Modern Trends in Communications Materials" by L. A. Thomas, B.Sc., F.Inst.P., at 6.30 on February 11th at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

Scottish Section.—"The Principle of Electronic Computing Machines" by B. V. Bowden, Ph.D. (Ferranti) at 7.0 on February 5th at the Department of Natural Philosophy, The University, Edinburgh.

Merseyside Section.—"A Port Radio-Telephone System" by D. G. Holloway at 7.0 on February 5th at the Electricity Service Centre, Whitechapel, Liverpool.

North Eastern Section.—"Design Considerations of a Commercial F.M. Receiver" by F. H. Beaumont, A.M.Brit.I.R.E., at 6.0 on February 11th at the Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle-on-Tyne.

West Midlands Section.—"The Development of the Radio and Electronics Industry in India" by G. D. Clifford, M.Brit.I.R.E., at 7.15 on February 24th at the Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.

British Sound Recording Association

London.—"The Human Ear and Audiometry" by T. S. Littler, M.Sc., Ph.D., at 7.0 on February 20th at the Royal Society of Arts, John Adam Street, London, W.C.2.

Manchester Centre.—"Loudspeakers" by H. Collings-Wells (Goodmans) at 7.30 on February 23rd at the Engineers' Club, Albert Square, Manchester.

Portsmouth Centre.—"Reproduction in the Home" by P. J. Walker at 7.15 on February 12th at the Central Library, Guildhall, Portsmouth.

Television Society

London.—"The Importance of the D.C. Component" by D. C. Birkinshaw, M.B.E. (B.B.C. Television), at 7.0 on February 12th.

"The Scanning Electron Microscope" by D. McMullan, M.A. (Cambridge University), at 7.0 on February 27th.

Both meetings will be held at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

Radio Society of Great Britain

"Oscilloscopes" by Frank Hicks-Arnold (G6MB) at 6.30 on February 27th at the I.E.E., Savoy Place, W.C.2.

Simul…neous Translation … T.O.

a … Westinghouse R.F.

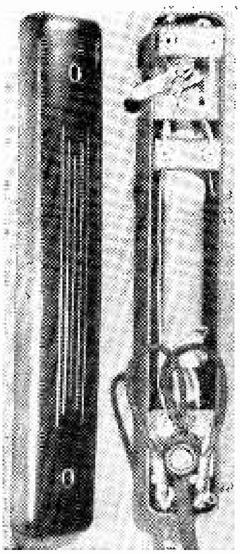
By E. AISBERG*

…s, where language diffi- …se impede the smooth …t is customary to employ a … translation. Trained linguists … speech on headphones and give …islation into a microphone, the output …nplified and relayed to headphones con- …r each delegate's seat.

…system has proved effective, but has this dis- …ntage that the delegate is virtually tied to his seat.

The receiver is hung from the pocket, and volume can be varied by inclining it from the vertical.

Recently, portable wireless receivers have been tried, with switched choice of wavelengths carrying translations in different languages, but in spite of recent advances in miniaturization these sets remain relatively cumbersome and heavy because of their battery power supplies. They are also liable to go out of service at inconvenient times.



A Ferroxcube core is used in the inductance, and a simple switch at the top of the unit selects alternative frequencies.

At the last conference of the North Atlantic Treaty Organization at the Palais de Chaillot in Paris a new system was tried which successfully overcomes the drawbacks of its predecessors. This system, which has been developed by F. C. G. van Baerle, of the Compagnie des Freins et Signaux Westinghouse, depends on the establishment of a radio-frequency magnetic field of uniform intensity by means of loops encircling the building. This energy is picked up by a simple form of crystal receiver which requires no batteries and can be carried without inconvenience.

There are two loops fixed at heights of 2 and 4 metres, energized by 4- to 5-watt modulated oscillators, one for French with a carrier of 300 kc/s and the other for English at 400 kc/s. Although a uniformly strong signal is obtained within the building, the field strength falls off rapidly outside, and at a distance of 3 metres from the building is inaudible in the receiver.

As will be seen from the accompanying photographs, the plastic receiver housing is little larger than a toothbrush case, and it is provided with a clip for attachment to the breast pocket. The tuned circuit inductance is a long single-layer winding over a Ferroxcube core. Fixed capacitors are switched across the coil to tune it to 300 or 400 kc/s. The rectifier is a Westinghouse germanium crystal, Type G54, tapped down the coil and working into headphones with a nominal resistance of 100 Ω.

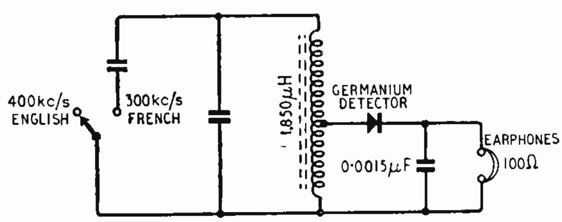
Volume control is effected simply by inclining the receiver unit from the vertical and so reducing the coupling with the r.f. field.

All journalists attending the conference were provided with earphone-receiver units and were thus able to move freely. Excellent reception, free from interference from the many electrical installations of the Palais de Chaillot, was reported in all parts of the hall.

The system is one which has many possible applications—for example, in co-ordinating activities in television and film studios or in providing alternative language dialogue for cinema patrons.

In conclusion, and as a tribute to the essential simplicity of the scheme, it is worth recording that the entire installation at N.A.T.O., including the provision of 200 receivers, was carried out in a fortnight.

Circuit diagram of the crystal receiver.



* Editor, *Toute la Radio*, Paris.

TRANSISTORS

1—Introductory Survey of Recent Developme

By THOMAS RODDAM

RATHER more than four years ago a new device, the transistor, was announced. Many of us, I suspect, looked rather sceptically down our noses: after all, *Wireless World* was describing semi-conductor oscillators in 1924, and even the valves with secondary emitters built in, which give wonderful mutual conductances, still seem to be things we read about, not things we use. It was not very long, however, before it became apparent that the transistor was something in quite a different class. The problem became one of actually acquiring a transistor. Now, if you are privileged, you can get hold of a handful, and the production plans suggest that there will soon be some suppliers who are not completely overloaded by the orders from military sources and commercial associates. Most important is the fact that if you get a batch of transistors of a given type, they do not vary from sample to sample any more than valves do. The circuit problems are thus becoming reasonably straightforward ones, instead of the bespoke tailoring of the early transistors.

In this and succeeding articles I shall be drawing heavily on Bell Telephone Laboratories material.* The transistor was invented there, and the major theoretical and experimental studies have come from Bell, though some transistors have been made, and some papers published, in England, France, Germany and Russia.

In this first article, I do not propose to try to explain how the transistor works; but it is, perhaps, desirable to explain what it is. A transistor is a multi-electrode semiconducting amplifier device. That is as formal as I can make it at the moment, and it can be simplified by saying that almost all current transistors are made up of a small piece of germanium crystal having three electrodes arranged in such a way that the unit acts as an amplifier. In its standard mounting it is a small metal tube, half an inch long and less than a quarter of an inch in diameter. A unit of this kind will give perhaps 20db gain, and a pair in push-pull will give some hundreds of milliwatts of power. There is no heater: the estimated life is over 70,000 hours.

I have been rushing things rather in that last paragraph, and we must take a rather closer look at the nature of the transistor before we can consider any of the problems of circuit design. The commonly available type of transistor is the point type. This consists of a small slice of germanium, cut from a single crystal and mounted on a base through a non-rectifying contact. Two very closely spaced cats-whisker points are applied to the face of the crystal. Each of these, of course, will act as an ordinary diode rectifier, though for various reasons it need not be a rectifier of the highest class. If, however, you apply a negative supply through a resistance to one pc an important effect can be obtaine through the collector will be small, flowing in the high-resistance direc rectifying point. Now apply a small po to the other point contact, the *emitter*. '. taken as at earth potential. Current flows the emitter, and an applied voltage of ab will produce something of the order of 5mA. as the emitter is made to pass current, an adc current will flow in the collector circuit, and typical point transistor we shall get an extra 2 m. the collector circuit for each 1 mA in the em circuit. Futher, since the collector impedan is normally high, we can put a high resistance in serie with the collector to act as a load, although we only need to force the emitter current in through a low impedance. Typical values are: $R_{in} = 300$ ohms,

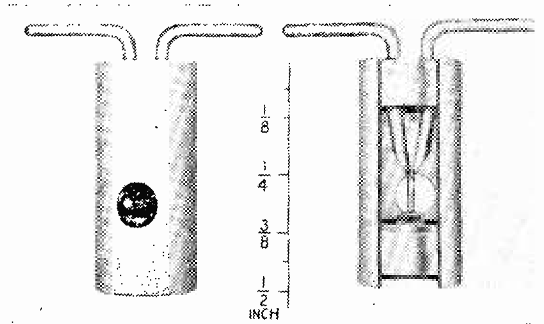


Fig. 1. Original form of the point transistor.

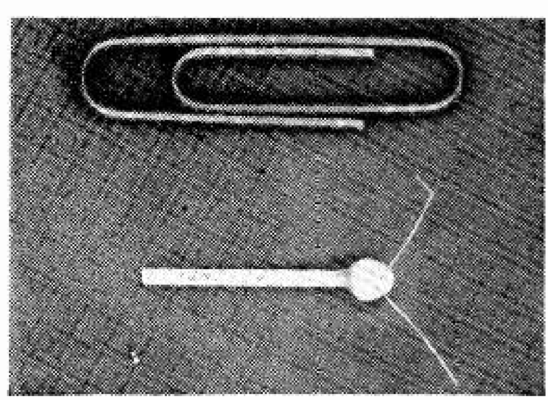


Fig. 2. Point transistor in "bead" form.

* Figs. 1, 2, 7 and 8 are reproduced from or based on an article by J. A. Moreton, *Bell System Technical Journal*, May, 1952.

$R_{out}=6000$ ohms, current gain=2 so that power gain$=2^2 . 6000/300=80$ times, or 19db.

It is possible to proceed discreetly through a long trail of network theory, analogue derivation and all sorts of blinding science to establish the principles of transistor circuit design. My guess is that I have read close on half a million words on transistors to date, and I want to get somewhere before the end of this few thousand. The simplest approach to transistor circuit design, therefore, seems to be to relate it to valve circuit design. We must keep one eye on the physics, so let us try a simple experiment.

We will take a transistor, Type A1698, and connect a −200 volt supply through 100kΩ to the collector, with the base earthed and the emitter open-circuited. We shall find that the collector current is about 1.6 mA and the collector voltage about −40V. Now we take the emitter back through 100kΩ to a potentiometer across a 2-volt battery, with earthed centre point. We adjust the potentiometer to cause a current of 0.5 mA to flow into the emitter. The collector current cannot change very much, because of the 100kΩ resistance, but the collector voltage drops to about −18V. This experiment is the equivalent of applying a voltage to the grid of a triode valve and measuring the change of anode current: just as we find a mutual conductance of, say, 4 mA/V, so in this transistor we have a mutual resistance of 44 V/mA.

Now we can carry out a second experiment. Let us fix the emitter current at 2mA, and vary the resistance in series with the collector battery so that we have first 5 mA and then 6 mA in the collector circuit. We find that a change of 1 mA in collector current produces 20 volts change, from −40 to −20 volts, at the collector. Just as a valve may have an anode impedance of 10,000 ohms (volts/mA), so the transistor has a collector admittance of 1/20,000 mhos.

This discussion has been directed towards the current control aspect of the transistor, because this is the vital thing to be borne in mind by the circuit designer; nothing but trouble greets the man who starts worrying about applying volts to the emitter. It is only in more advanced designs that you need to proceed beyond this simple view. Think always of the transistor as a valve dual, replacing current by voltage, and voltage by current, and you can go quite a long way.

Obviously, with this point of view, we can draw a set of transistor collector characteristics rather like a set of valve anode characteristics, except that now we measure collector voltages as a function of collector current using emitter current as a parameter. With a valve we use constant voltage supplies for testing: here we use "constant current" supplies, for example, a high voltage source with a high resistance in series, or even a pentode if we want to be pedantic. The curves shown in Fig. 4 are typical and on them I have also shown the 120-mW maximum dissipation hyperbola. If you turn the page upside down, you will see that this set of curves looks very much like a set of triode curves in shape, and I have added a loadline for a 10,000-ohm load passing through the rather arbitrary working point −20 V, −4 mA, corresponding to about 1.5 mA emitter bias. As you can see, the curves are fairly uniformly spaced, so we might put in 1.5 mA peak on the emitter, and get out nearly 20 V peak at the collector. There is some limiting near the collector *voltage* cut-off, just as a triode cirrent cuts off in the full drive condition, but we have

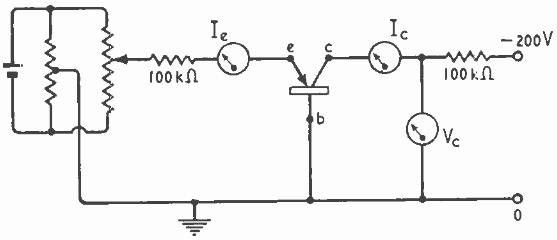


Fig. 3. Circuit for studying earth-base characteristics of point transistor.

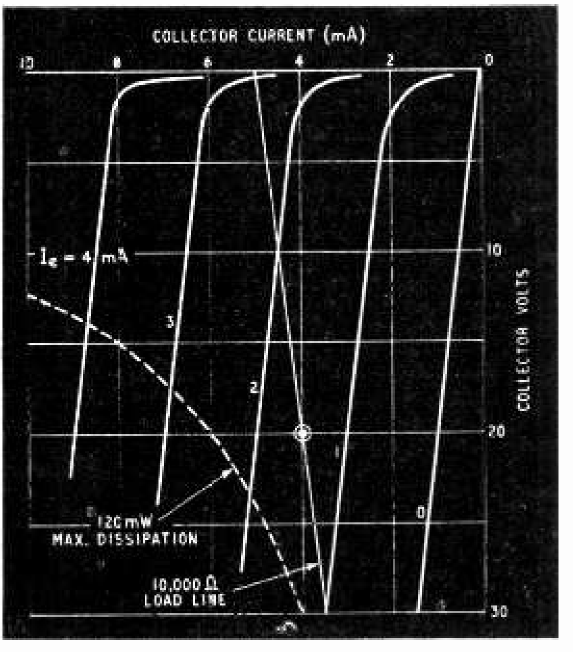


Fig. 4. Family of collector characteristics for a point transistor.

some 20 mW of output. Notice, by the way, that if we are using an output transformer, as we usually will be, we need only a 20 volt battery and 80 mW of power from it.

The input impedance of this type of transistor is of the order of 500 ohms. I shall come back to this input impedance question later, because it raises a lot of interesting problems. For the moment, however, it is enough to notice that we were applying 1.5 mA peak at the emitter, so that the input power is 0.56 mW and the gain, at this low level, is about 36 times in power, or 15.5 db. Let us be satisfied with this for the moment.

We do not want to use a separate bias source for the emitter if we can help it. Is there any way in which we can apply self bias to the emitter? We know that the emitter must be slightly positive with respect to the base, and that since the current from collector to base is −4 mA and from emitter to base is 1.5 mA, there must be 2.5 mA flowing into the base. If we put 100 ohms in the base lead, this will give us 0.25 volts negative at the base, or will make the emitter +0.25 volts with respect to base if the emitter is returned to earth. This is about the right sort of value, and with our present information we can build up the circuit of Fig. 5, and vary the base resistance to get the best working conditions. Here, then, is our first amplifier circuit, with an input transformer designed to match the source to 500 ohms and a 10,000-ohm load output transformer.

Here, too, is our first headache. As we vary the base resistor, the amplifier bursts into vigorous oscillation. Let us see why. Forget for the moment the d.c. bias conditions and assume we have 250 ohms in the base. Let the collector current increase by 1 mA, thus producing an extra 0.25 volts drop in the base resistance. This will raise the emitter-base voltage 0.25 volts and thus cause the emitter current to rise by about 0.5 mA. But 0.5 mA emitter current rise will make the collector current rise about 1 mA more, and so it goes on until the transistor reaches collector voltage cut-off. The base resistor is a positive feedback element and if it is too large the circuit becomes unstable. Furthermore, since at very low frequencies there is no impedance in series with the collector, except the resistance of the transformer winding, it is possible for the collector current to run right up to perhaps hundreds of milliamps: you will not know exactly where, because if you are lucky the meter will burn out; if you are unlucky the transistor will burn out. For tests of the simple transistor circuit always make sure that you have a few thousand ohms in series with the collector and a few hundred ohms in series with the emitter.

Experimental Oscillator

This instability suggests that we should start off by using it in a controlled way. Instead of trying to make an amplifier, let us get our hands in on an oscillator circuit. We can make some extremely simple transistor oscillators and keep things under control at the same time. Then we can go back to the various amplifier possibilities.

First of all, notice that if we make the emitter go positive, we increase the emitter current, increase the collector current and thus make the collector more positive (or less negative, if you like it that way). Feedback from collector to emitter will thus be positive feedback: we can, therefore, provide positive feedback at one frequency by putting a series tuned circuit between collector and emitter. The circuit, using good protective resistance bias circuits, can be that shown in Fig. 6. This will oscillate if R is of about the same size as R_l, for reasons which we shall discuss later, and the amplitude of oscillation can be controlled by adjusting R. For experimental work, take a variable resistance of a few thousand ohms, start at maximum resistance and turn down until the circuit just oscillates. You can get an idea of the size of inductance by noticing that the reactance of L must be much more than R for good frequency control. Thus if we are working at 1,000 c/s we should use several henries, since we expect R to be several thousand ohms.

Frequency Stability

This oscillator circuit is not particularly stable in frequency. In fact the point transistor will not give enough gain to produce a really first-class oscillator—or a really first-class amplifier, either. Reasonable supply variations may produce changes in frequency of a few cycles per thousand, which is on the limit for even the simplest of broadcast receiver frequency-changer oscillators. There are some rather better circuits, which we shall consider later: the advantage of this circuit is that it is simple and all the variables are independent.

As you can see, this circuit lends itself to quartz crystal control: a crystal connected between oscillator and emitter should oscillate if it has not too high a resonant impedance. When I use this circuit with crystal control, I shall put a parallel-tuned circuit across either the emitter resistance or the collector resistance to make sure that the crystal is driven on its fundamental frequency, and not at one of the spurious frequencies which oscillator crystals provide for the unwary.

This article, which is trying to serve as an introduction and yet remain self-contained, would not be complete without a short discussion of the other main type of transistor, the junction type. To understand the operation of this it is first necessary to know that although pure germanium can be an intrinsic semiconductor, the actual material used for transistors is not quite pure, but may contain a few parts in 100 million of impurity. Certain impurities will fit into the regular crystal pattern, except that they may have one electron too many, or one too few. If there is one electron too many, it will float off homeless through the crystal lattice, and can act as a current carrier: the germanium is then said to be of *n*-type. If there is one electron too few in the cuckoo atom there will be a "hole" into which an electron could fit. An electron from a neighbouring atom can move into this hole, leaving its own place vacant, so that the hole appears to move. The hole behaves, indeed, rather as a sort of positive electron (it is *not* a positron), and can act as a current carrier. Germanium with an excess of holes is said to be of *p*-type. As you might expect, a point contact applied to a piece of *n*-type germanium does not allow electrons to flow into the germanium easily: the germanium is already overcrowded. Electrons will flow out easily, so that the low resistance condition is given for a positive voltage on the point.

Not surprisingly, a piece of *p*-germanium in contact with a piece of *n*-germanium is a rectifier, and since the contact area can be large, it is a rectifier with a much lower forward resistance than a point contact type.

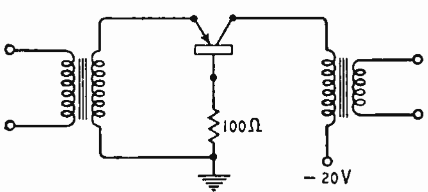


Fig. 5. Simple Class A amplifier using a point transistor.

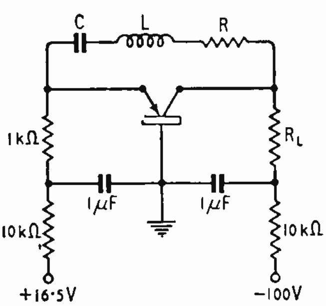


Fig. 6. Simple point transistor oscillator circuit.

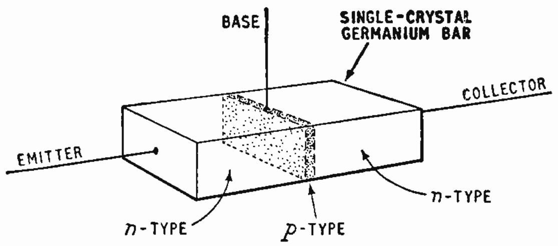


Fig. 7. Essential elements of the n-p-n junction transistor.

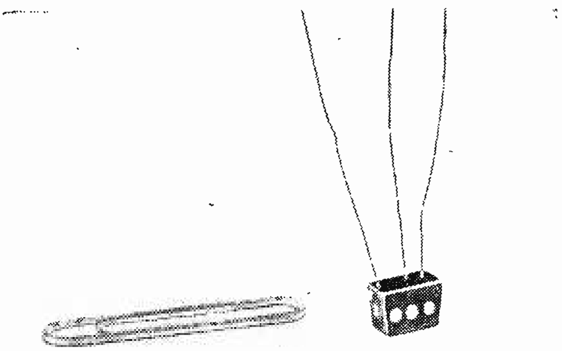


Fig. 8. Type M1752 junction transistor.

Once it was known how to make *n-p* junctions, and the technique is not easy, it was a short step to making *n-p-n* systems. A typical *n-p-n* transistor consists of a bar of germanium like that shown in Fig. 7, in which the area of the junction is about 0.01 sq cm and the base (of *p*-germanium) is about 1.5×10^{-3} cm thick. Wires are fastened to this unit, it is moulded in plastic and is then of the form shown in Fig. 8.

The *n-p-n* transistor is a much more attractive device than the point transistor. A gain of 50 db at audio frequencies is not difficult to obtain, Class A efficiencies of about 48 per cent are practicable, the noise is only 10-20 db above Johnson noise at 1,000 c/s, and lower at higher frequencies, and there seems to be no reason why it should not last for ever. The characteristics are rather pentode-like, compared with the triode-like characteristics of the point type transistor. Finally, and perhaps most important of all, it is so well understood that it can be designed to have predicted characteristics.

What is the future of the transistor? At the moment, if you can buy one, it will cost you nearly ten times as much as a valve. It will be much smaller, of course, and since you can work it down to very low levels, most of the components can be very small. Hearing aids and portable receivers can be reduced still further in size, and the batteries will be very much smaller, and last longer. For hearing aids, which are used for long periods, the reduction in running costs will certainly justify the high initial cost, and this may fall as production processes improve. Line communications will profit enormously, because the problem of heat dissipation is becoming serious in telephone carrier equipment, and all that heat is, of course, paid for in electricity supply. Long life means less maintenance, too. I need hardly point out the advantages of smallness, lightness and mechanical toughness in military applications. In general we may expect transistors to do all the jobs of small valves below about 10 Mc/s, with the possible exception of low-noise audio amplification. I propose, therefore, to cover the general problems of circuit design in future articles, interrupting the flow to discuss the physical side in more detail.

DO WE PLAN ENOUGH?

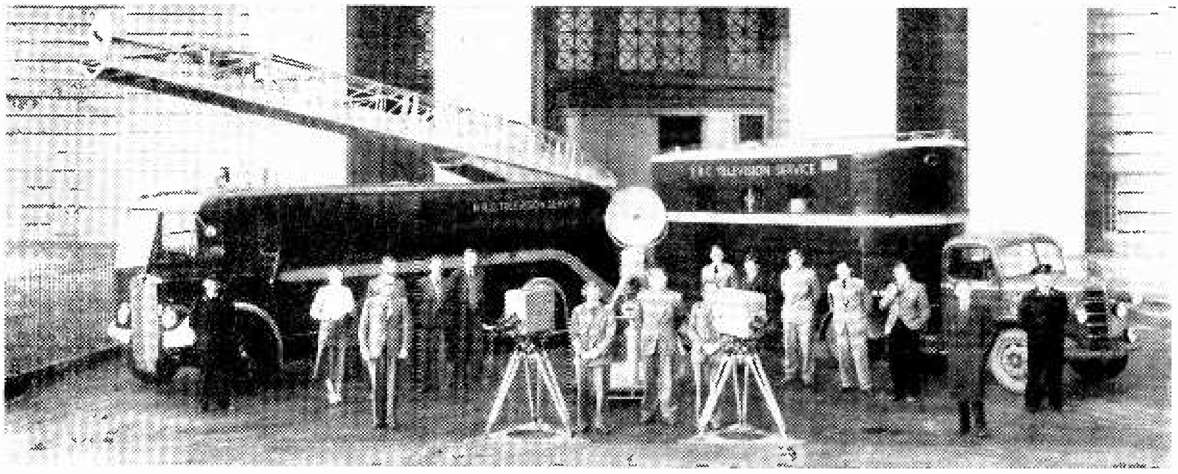
TOO many radio technical people fail to see the wood for the trees. They concentrate too much on the details of equipment design and not enough on the overall planning of radio systems. As a result of this lack of planning a great deal of effort is often wasted on the design of unsuitable equipment.

These views were implicit, if not stated in so many words, in a recent I.E.E. discussion on the subject of "How to Plan a Radio Project." The opener, J. Thomson, said that a failure in our technical teaching to-day is a lack of proper attention to radio system analysis. Radio textbooks tend to be design handbooks: the examination of what equipment is designed to do is discussed too casually. The same is true of radio courses in universities and technical colleges.

For a plan to be successful, said Mr. Thomson, it is necessary first to make a rigorous analysis of all the physical factors governing the operation of the project. "System analysis," as it is called, can save much waste and frustration. Equipment design must always await the outcome of this examination of the physical parameters.

Outlining the general procedure of planning, the speaker suggested that first the sphere of interest should be decided, for example, the frequencies and methods of modulation that might be used. Technical limitations, such as the outputs of the valves available and the degree of frequency stability, should then be assessed. Next, analysis of the proposed system would disclose the probable losses, noise factors, aerial requirements and also any unwanted effects such as cross-modulation. Only after these steps have been taken, and retraced if necessary, should the design of equipment commence.

In summing up, Mr. Thomson observed that the possibility of accurate prediction of performance is now well established, particularly in v.h.f. work, and that radio engineering is no longer an empirical art.



Operating Television O.B. Units

Problems of Planning and Producing Outside Broadcasts

By J. F. HARTWRIGHT *

THE five television outside broadcast units used by the B.B.C., although provided by different manufacturers, are essentially the same, each having three camera channels and sound equipment capable of handling up to eight microphones. It is not, however, the technical details of the equipment with which we are concerned in this article, but the operation of these O.B. units.

Owing to limitations of space in the vehicle every effort is made to keep the apparatus as small as possible and to employ a minimum of operational staff. Even so the technical team, including cameramen, vision control engineers, sound mixing and maintenance staff, normally numbers nine.

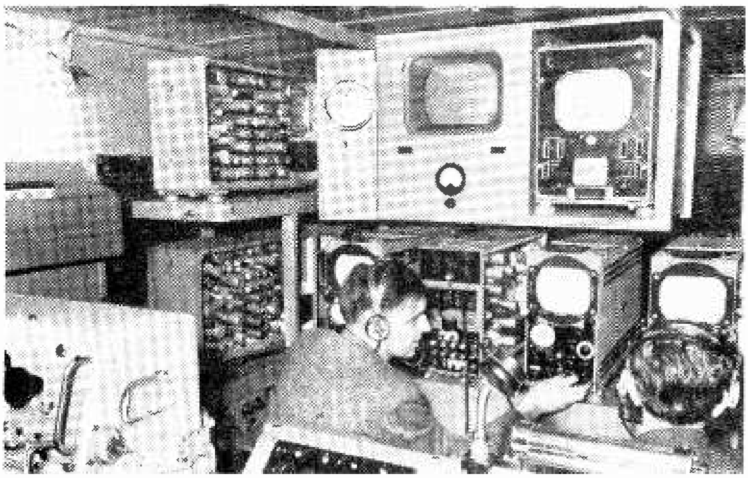
At those sites where a G.P.O. vision cable is not available a mobile radio transmitter is used to send the picture signal to the nearest available point for reception and injection into the Post Office television distribution network. This necessitates the inclusion of a further two engineers to man the transmitter. Thus, with the producer and his team, the total staff at an outside broadcast site may be as many as twenty. For distances up to about 20 miles a transmitter unit consisting of a 90ft extensible ladder carrying the aerial, a 185-Mc/s transmitter and motor generator (all carried in one vehicle) is used. For greater distances a series of e.h.f. relay links are employed.

The vision control engineers are responsible for the setting up and control of the cameras and associated equipment and on these adjustments depend the quality of the pictures as far as the output to G.P.O. cable or mobile radio transmitter. Beyond that point definition can, of course, be lost and great care must be taken when lining up prior to programmes to see that picture quality is maintained throughout the system. A test card is used in front of a camera if there is any sign of loss of definition and this picture is then examined at various points along the chain.

Considerable experience is required by the vision control engineers on outside broadcasts where very often there is little or no control over the lighting, costumes and scenery and little choice at times of even the camera positions. In these circumstances the cameras may be pointing from a dark to a light subject in a matter of a few seconds or sometimes even looking at a light source. Experience in the quick and accurate operation of the camera control unit is, therefore, very necessary. In addition to a picture monitor, the vision engineer also has before him an oscilloscope showing the electrical waveform of the picture. The control equipment enables accurate adjustments to be made to modulation, correct " sit " of the waveform above black level, to the shading of the picture, and to remote control of the camera iris. Pictures may easily be spoilt by a slight maladjustment of electrical focus, target voltage and camera tube beam-current controls or selection of the incorrect lens stop for the scene to be televised. The use of a lens stop that is too wide will cause, among other faults, a narrower tonal range because of the black compression if the camera tube is operated too far over the knee of the output curve.

All the outside broadcast cameras are now fitted with the image orthicon low-velocity pick-up tubes which are capable of working over a larger light range than any others yet available. The colour response is high in blue and green, good in yellow and red but

* British Broadcasting Corporation.

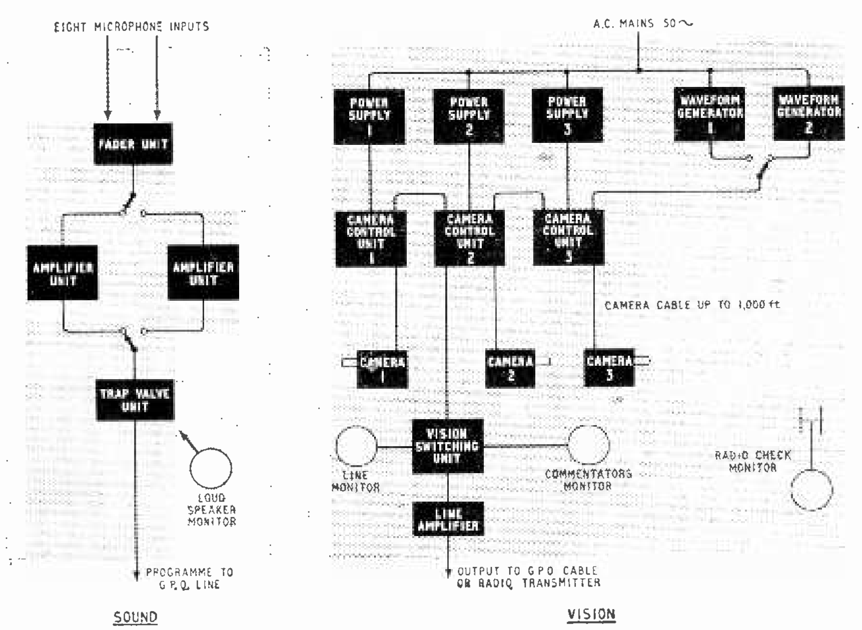


Interior of the Marconi mobile control room shown with the transmitter van on the opposite page. The vision engineers are adjusting the camera monitors, above which are monitors for the outgoing and radiated pictures

very low in infra red and, so far as the eye is concerned, renders colours in nearly their true tone gradation. A filter could be used to further improve the spectral response but would, of course, result in loss of sensitivity. The camera response to the various colours is: violet appears black, blue—dark grey, green—light grey, yellow—white, orange—light grey, and red—light grey.

The cameras are normally fitted with a four-position lens turret which is operated from the rear of the camera by the cameraman on instructions from the producer, the cameraman's other duties being optical control of focus and picture composition. A recent and most successful addition to the camera facilities is the Watson Zoom lens which enables a distant shot to be brought into "close-up" in a few seconds. With this lens the actual angle of view can be extended from roughly 4 degrees to 15 degrees or a focal range of 4 inches to 20 inches, thus a picture viewed at, say, 100 yards can be zoomed up to appear only 20 yards away. The action of zooming is very smooth and is controlled by a servo motor operated by the cameraman. The exact framing of a scene can be carried out without any delay due to changing lenses, the picture is uninterrupted and remains in focus throughout the operation. The aperture throughout the range given is f/6.3 and this remains constant when zooming. It is interesting to note that using a very fine pinhole in copper foil as a lens a recognizable picture can be obtained on a bright day, the focus control then operates as a zoom control. All the cameras are now fitted with electronic viewfinders. The loss of light in an optical viewfinder was such that in low light, though quite fair pictures were being obtained by the camera tube, the cameraman could not see the picture sufficiently well to maintain focus.

Owing to the specialized problems involved, the lighting for broadcasts from halls, theatres, etc., is carried out under the supervision of an engineer whose duties are mostly confined to this type of work. The method adopted is to raise the overall level of illumination so that satisfactory pictures can be obtained by the cameras using a lens stop of such a value as to give a reasonable depth of focus. This is the "foundation" lighting which should cover the whole of the programme area and be well diffused. Either incandescent or white fluorescent lamps can be used for this purpose, the advantage of the latter being good diffusion, but a faulty tube can cause a bad flicker. Incandescent lamps have the disadvantage that the efficiency falls off rapidly with mains variation—a 10 per cent decrease in mains voltage will drop the illumination by roughly 30 per cent. The effects lighting consisting of "key" and "modelling" light is next added by means of spot lights which are adjustable for coverage and intensity. "Key light" is arranged to give the effect of a single light source and to have a brightness of roughly the same as that of the foundation lighting when measured by an exposure meter looking towards the light source. "Modelling light" is used to accentuate any required feature, texture, shadow or background and to give effects such as lighted windows. Top lighting by means of spot lamps is undesirable with cameras fitted with image



Block schematic of the general arrangement of the equipment in a television O.B. van.

orthicon tubes owing to the dark halo it produces over light-coloured hair or any shiny surface such as a piano or bald head.

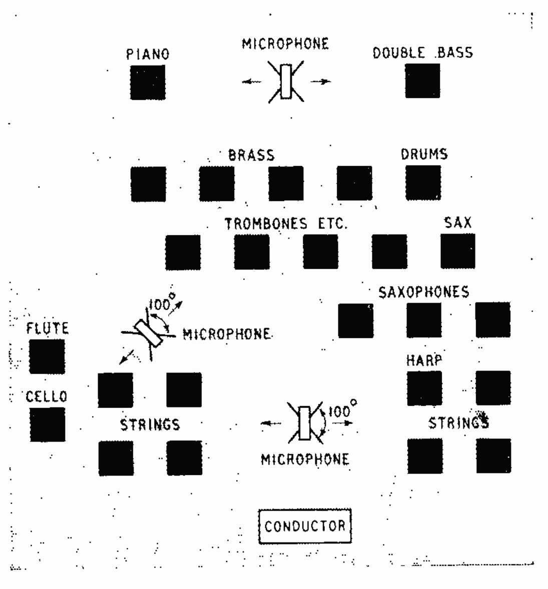
Where the special effect of dimming lights is required the picture quality will, of course, suffer, becoming blotchy and mottled as the dimming proceeds. This can be avoided if the effect is obtained electrically, by lowering the picture to black level on the camera control unit, but where a local audience is involved the dimming of lights may have to be carried out. Sometimes it is possible to televise a theatre show without any additional lighting being installed, but this also depends a great deal on the type of backcloth and costumes.

Owing to the high sensitivity of the image orthicon cameras, the amount of light required for satisfactory operation is considerably less than that necessary for the ordinary motion picture camera. With a black to white contrast of 2 to 1 or less, however, the cameras are not capable of producing a good picture. Because of this, good picture quality cannot be obtained from some outdoor scenes in winter. On the other hand, a lighting contrast ratio in excess of 20 to 1 is not desirable.

These are only the general principles of lighting for television. Many problems arise which prevent them being carried out in practice and many are the compromises and improvizations which have to be adopted.

Inter-dependence of Sound and Vision

The sound engineer is responsible for positioning and installing all the necessary microphones and for their balance and control during the programme. It is of course desirable that the microphones should be concealed from the view of the cameras when possible and that a minimum number be used to avoid unnecessary rigging. A proper balance has to be obtained between background effects and essential programme material and care has to be exercised in routing the



Disposition of three microphones, having a figure of eight polar diagram, to give a reasonable balance where the seating arrangements of an orchestra cannot be altered.

microphone cables to avoid hum induction from power supply circuits.

The effect of the picture is in many ways dependent on sound balance. For example, it would be wrong if the cameras were using a wide-angle lens on a military band some distance away and the sound appeared to be loud and near as perspective would be lost. It would also be wrong, when televising a symphony concert, if the sound intensity were to vary every time a wide-angle picture was shown or for the orchestral balance to be upset by raising the volume of the strings when showing that section of the orchestra in close up.

The problem of separating the orchestra from the stage microphones is usually overcome by the use of microphones having a unidirectional cardioid characteristic near the footlights and a further microphone slung over the stage sufficiently high to avoid coming into camera shot. Microphone booms, as used in studios, can rarely be employed in outside broadcasts as there is seldom enough space available for manœuvring. When it is desired to pick up sound from some distance away, such as at the centre of a football field or cricket pitch, the parabola microphone is used. This arrangement consists of a moving-coil microphone fixed in the centre of a 4-foot diameter aluminium parabolic reflector, focus being adjusted by sliding the microphone along the axis of the reflector. The frequency response of this arrangement is not quite good enough for music but is adequate for speech or effects noises. It is usual to have the parabola placed in high position as it tends to pick up intervening noises in its path which might easily be louder than that from the required source.

In tidal waters, such as the Thames, it does not pay to leave an unattended microphone slung over the river side to pick up "lapping water effects." Either the tide recedes from it giving no effects, or it fills with water giving the wrong sort—a melancholy gurgle.

The miniature crystal microphone which is attached to the coat lapel of an interviewer has the advantage of being inconspicuous yet effective. The microphone preamplifier is carried in the pocket of the wearer and is supplied by a small dry battery. The battery has a life of a few hours only which is long enough for normal purposes. When using this type of microphone it has to be borne in mind that boiled shirts or medals can cause some trouble. The creaks from the former are magnified beyond belief and the clang of medals near this microphone sounds like a busy shipyard.

Walkie-talkie radio equipment has been used successfully where trailing microphone leads are impracticable but so far the quality has not been of a sufficiently high standard and the signal is subject to fading and interference.

The technical planning of an outside broadcast is usually commenced three or four weeks before the date of the programme. A planning sheet showing all the arrangements is then issued for information of the unit crew. Temporary cables are rigged on site a day before the arrival of the mobile control room. These cables are required for cameras, microphones, monitors, cue lights, telephones, power supplies and lighting. The cameras may be as far as 1,000 feet from the control vehicle.

On the production side, apart from all the usual problems of putting over entertainment for a large audience a wide knowledge of the possibilities and limitations of the medium is very necessary.

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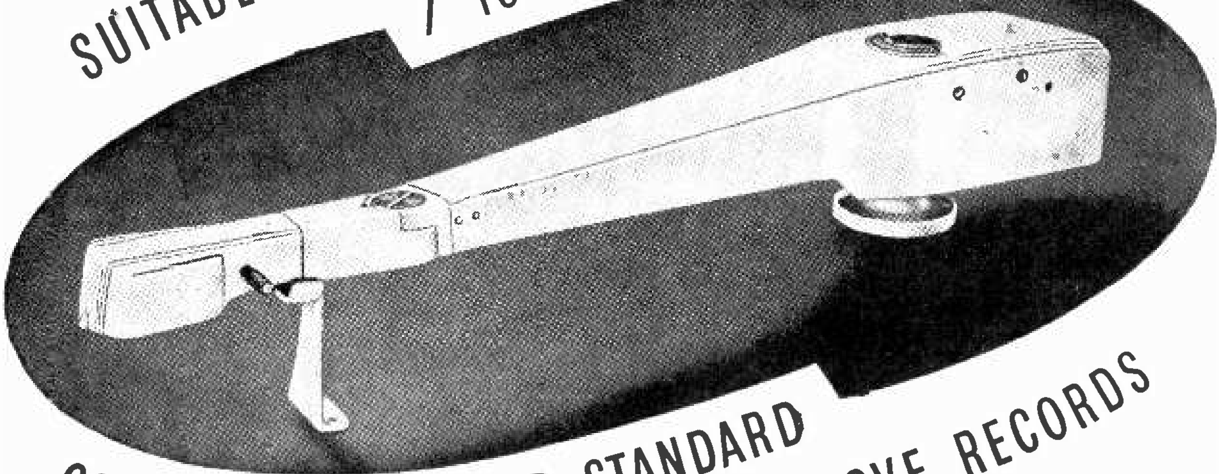

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A simple adjustment is provided in the pick-up arm to enable the head to be set to give the optimum tracking angle for all sizes of records up to 17″ diameter.

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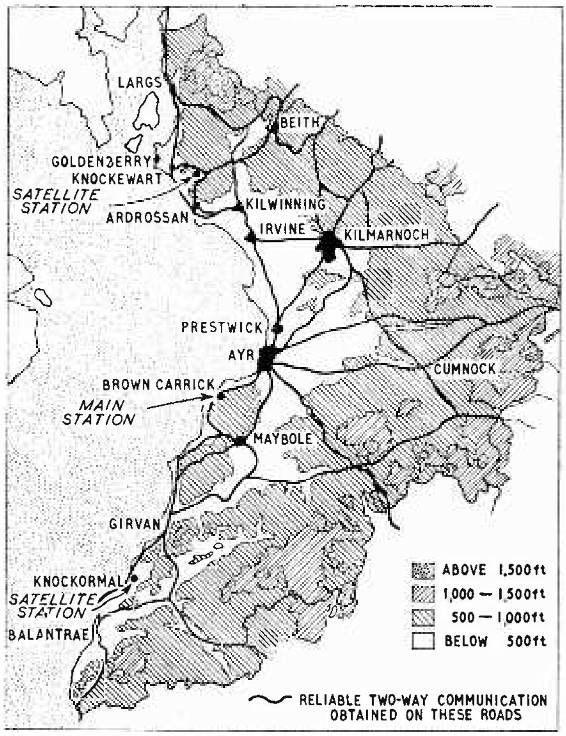
Synchronous F.M. System

Multiple-Station Installation for Ayrshire Police



Sketch map of the county of Ayr showing the terrain and the main roads over which the police cars normally operate.

THE complete v.h.f. coverage of a hilly, and in places mountainous, area, such as Ayrshire, was virtually impossible with one station, so multiple-station working was accepted as inevitable for the County Police radio system. Since a mobile station may travel from one end of the county to the other, synchronous carrier-frequency working was another requirement. But could synchronous f.m. be achieved? The G.E.C. has shown that it can by providing the Ayrshire Police Authorities with the only multiple-station synchronized f.m. installation of its type in the U.K.

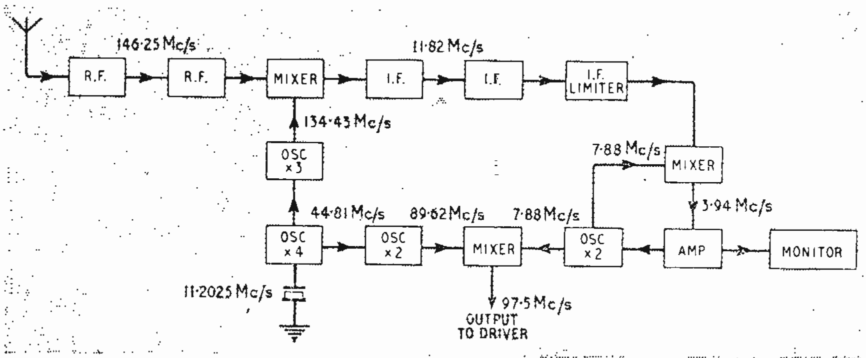
It was decided that the most satisfactory arrangement would be to use a master station near Ayr controlling two satellites, one to the north at Knockewart and the other to the south at Knockormal. The carrier frequency of the link transmitter is controlled by that of the master station, being derived from the same crystal, and this in turn, by means of suitable multiplying and dividing circuits, controls the frequency of the satellite transmitters. Thus it is possible to ensure complete synchronization of frequency of all three stations. Time delay circuits ensure that speech radiation is simultaneous from both the satellites and the master.

In the overlap areas the signals arriving at a mobile station will not necessarily be in phase. In practice, of course, this is not important because the overlap areas are not large and with a car moving at a normal speed the effect is unnoticeable.

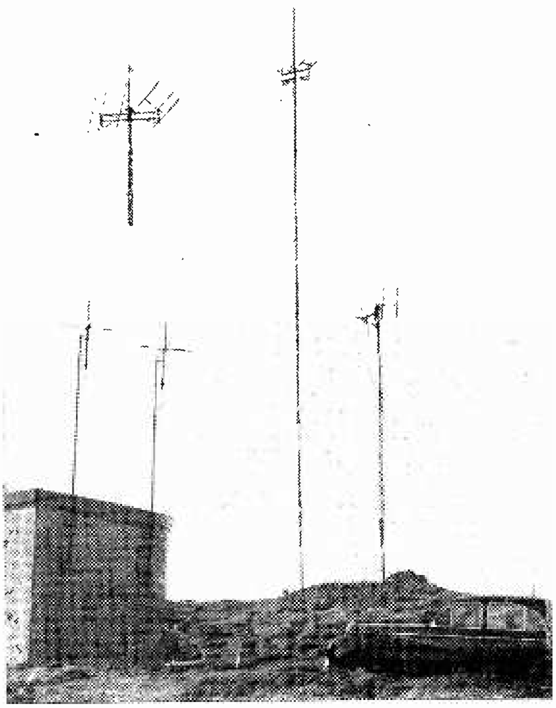
The main transmitter operates on a carrier frequency of 97.5 Mc/s and the link transmitters feeding the satellites operate on 146.25 Mc/s. Both the broadcast carrier and the link frequency are controlled by a master crystal working on 1.35416 Mc/s.

So far the problem is a simple one. At the satellite stations, however, not only has the intelligence, provided by the control station, to be conveyed from the link to the satellite (a simple enough matter) but also the carrier frequency of the link must be suitably divided and multiplied to produce the 97.5 Mc/s carrier for the satellite broadcast transmitter.

Two stages of r.f. amplification are interposed between the aerial and the mixer which is fed with a mixing signal at 134.43 Mc/s, derived from a twelve-



Block schematic of a satellite station showing the general arrangement of frequency division and multiplication to provide the transmitter's 97.5 Mc/s carrier from the link carrier (146.25 Mc/s).



On the main mast (see inset) are the broadcast aerial and horizontally polarized arrays for the transmitter linking the master station with the satellites. The link receiving aerials are on the smaller mast and the folded-unipole ground-plane aerials on the building are for the radio-control link to the H.Q. at Ayr.

times multiplied signal generated by a local crystal oscillator at 11.2025 Mc/s.

Thus an intermediate frequency of 11.82 Mc/s is produced and this signal is fed through two stages of i.f. amplification and an i.f. limiter to a second mixer, which is part of a three-valve regenerative divider. The "local oscillator" input to this mixer is at an intermediate frequency of 7.88 Mc/s, producing a beat frequency of 3.94 Mc/s (i.e., $\frac{1}{3}$ of the first i.f.), which is then doubled to provide the 7.88 Mc/s for the "local oscillator." This divider operates on any input signal whose frequency is near 11.82 Mc/s so that the f.m. appears on the 3.94 Mc/s and 7.88 Mc/s outputs.

The modulated signal at 3.94 Mc/s is also fed to a monitor for test purposes at the satellite.

Returning to the local oscillator, which provides the basic signal for mixing with the incoming r.f., another output, multiplied eight times, is fed to a mixer circuit at 89.62 Mc/s. Fed to the same circuit is a signal tapped off from the circuit, described previously, at 7.88 Mc/s. The sum of these frequencies, at 97.5 Mc/s, is then fed to the driver stage of the satellite broadcast transmitter. Since the 7.88 Mc/s signal is already modulated at the correct percentage no modulated problems arise in this transmitter.

It will probably be asked what happens to the frequency synchronization between master and satellite if the crystal (11.2025 Mc/s) in the link receiver drifts. In practice this does not matter, as the following example shows. Suppose that the frequency of oscillation of this crystal moves up 100 cycles. The multiplied signal fed to the first mixer will rise by 1,200 c/s and the resultant i.f. will fall by the same amount. Thus at the point from which the 7.88 Mc/s signal is derived there will be a drop in frequency of 800 c/s, and therefore a drop of the same amount at the mixer feeding the driver of the broadcast transmitter.

But this mixer is also fed from a frequency multiplier deriving its basic signal from the 11.2025 Mc/s crystal, so, instead of receiving a signal at 89.62 Mc/s, it will receive one 800 c/s higher. The frequency drop of 800 c/s on the other side of the circuit is thereby balanced and the mixer still provides a drive at 97.5 Mc/s. Thus full synchronism is maintained at all times.

In the reception arrangements for signals from the mobile stations, each fixed station receives the signals and feeds them to an audio mixer at the master station. The links in this direction operate at 154.3 Mc/s and 155.3 Mc/s. At the master station a delay network is again introduced so that received signals are synchronous. The signals are mixed in inverse proportion to the amount of noise present in each, thus avoiding degradation of a good signal by a bad one.

Simplex working is used between fixed and mobile stations but in the case of the link between the control station at the County Police H.Q. at Ayr and the master station at Brown Carrick duplex working is used. This enables the control station operator to over-ride an incoming signal. The control links operate at 146.8 and 154.8 Mc/s.

CLUB NEWS

Brighton.—The meeting of the Brighton and District Radio Club on February 3rd will be devoted to a discussion on the R.S.G.B. National Field Day. On February 17th, G. Austin will speak on "Tape and Disc Recording." Meetings are held at 7.30 at the Eagle Inn, Gloucester Road, Brighton, 1. Sec.: R. T. Parsons, 14, Carlyle Avenue, Brighton.

Manchester.—Meetings of the Manchester and District Radio Society are held on the first Monday of each month at 7.30 at the Brunswick Hotel, Piccadilly, Manchester. Sec.: K. Brockbank, 17, Burleigh Road, Stretford, Lancs.

Peterborough.—The arrangements for the February meetings of the Peterborough Radio and Scientific Society include talks on automatic gain control in television receivers by C. J. Guscott (19th) and quality amplifiers by S. Woodward (26th). Meetings are held each Thursday at 7.30 at the society's headquarters in St. Paul's Road. Sec.: S. Woodward, 72, Priory Road, Peterborough.

Redhill.—The headquarters of the East Surrey Radio Club (G3ISR), is now the Ex-Service Men's Club, British Legion H.Q., High Street, Redhill, where meetings are held every 4th Thursday at 8.0. Sec.: L. Knight, Radiohme, 6, Madeira Walk, Reigate, Surrey.

Southend.—Arrangements have now been made for the meetings of the Southend & District Radio Society (G5QK) to be held in one of the electrical laboratories of the Municipal College. Meetings will be held on alternate Fridays; the first February meeting being on the 6th. Sec.: G. Chapman, Bell Hotel, 20, Leigh Hill, Leigh-on-Sea, Essex.

Stoke-on-Trent.—Meetings of the Stoke-on-Trent Amateur Radio Society (G3GBU) are held every Thursday at 7.30 at 2, Racecourse Road, Oakhill, Stoke-on-Trent. Sec.: J. R. Brindley, 45, Rosendale Avenue, Chesterton, Newcastle, Staffs.

Ravensbourne Amateur Radio Club, which is associated with the Downham Men's Evening Institute, Durham Hill School, Downham, Kent, meets every Wednesday from 8.0 to 10.0. A basic radio and television course is being conducted together with morse instruction classes. Sec.: W. H. J. Wilshaw, 4, Station Road, Bromley, Kent.

The Complex Number

Is It Really So Complex ?

By "CATHODE RAY"

I SOMETIMES wonder what the reaction of the uninitiated is when in technical literature they come across the word "complex." It is unlikely that anyone would guess what it means without being told, and I imagine that with only the non-technical meaning of the word to go on they get the impression that this is something very complicated and difficult to understand and had better be skipped. Certainly a dictionary does not shed much light on references to "the complex impedance of the circuit" or "the complex gain of the amplifier." One might guess that it meant that the circuit in question was a complicated one, made up of a lot of components (and one would be quite wrong !); as for "complex gain," one wouldn't have a clue.

It is true that complexity in this special sense is often bound up with advanced mathematics, but that is nothing to go by; so are + and − signs. The general idea (notwithstanding that the dictionary says "complex" means "not simple") is quite easy to grasp. It is the same idea as plotting a point on graph paper, given two numbers; or specifying a position on a map by grid references or by latitude and longitude. In the sense that having to cope with two numbers at a time is not so simple as just one, then I suppose the description "complex" may be justified. But it seems rather an exaggeration. One does not need a brilliant intellect to grasp the principle that if one is reckoning the quantities of two different kinds of things one has to keep a separate account of each and therefore always has two numbers. A position cannot be located by knowing it is 10 miles away; there have to be at least two numbers, say 6, 8, meaning that it is 6 miles East and 8 miles North, as in Fig. 1. This is the *rectangular* or squared-paper system. Alternatively they could be 10, 53°, meaning 10 miles away in the direction 53° anti-clockwise from due East, as also in Fig. 1. This is the *polar* or angular system. Obviously it is necessary to know how the numbers are reckoned—whether East is positive or negative, and whether angles are measured clockwise or anticlock, and from which direction. These are the "conventions" that have to be agreed on beforehand, and if somebody didn't hear what was agreed it is too bad, because the numbers won't make much sense to him. But when he is in the know it is quite plain.

If the place P were known to be a station on a single railway line without junctions, then one number would be enough to fix its position relative to any starting point—for a line has only one dimension. It could be agreed to make positive numbers mean distance up the line and negative numbers distance down. But in Fig. 1 there are two dimensions; hence the need for two numbers. If we want to make an impression of great learning we can call such a two-part number a complex number. Then to people who know only the ordinary meaning of complex it will appear that we have mastered something very difficult, though in fact it is just as easy as before. If this manœuvre goes down well we can try developing people's respect for our brain-power into something like awe by deciding to describe distances measured eastwards as "real" and distances northwards as "imaginary," and distinguishing the latter from the former by attaching to them the mystic symbol "*j*," which, we shall take care to whisper (with the lights turned low and the gramophone playing "The Sorcerer's Apprentice"), stands for something beyond human ken—*the square root of minus one !* The finishing touch is to reveal that we not only comprehend this black art but actually practise it.

In this secret code, the complex number that would signify the journey from O to P in Fig. 1 is "$6+j8$." Writing it "$6+8j$" or "$j8+6$" makes no difference. Three miles East and five miles South would be given as "$3-j5$." It's as easy as that !

Specifying Impedance

Having made this bold step forward, to find that the apparently impregnable fortifications are a vanishing mirage, you can follow up the advantage in any good textbook. That was really all I set out to do—to encourage any who have hitherto been deterred by the awesome word "complex." But while we are at it perhaps I might go on to show some of the ways in which complex numbers are used in connection with circuits, and how they tie up with other ideas on the subject.

Impedance is one of the things that need two numbers—or a "complex number"—to specify

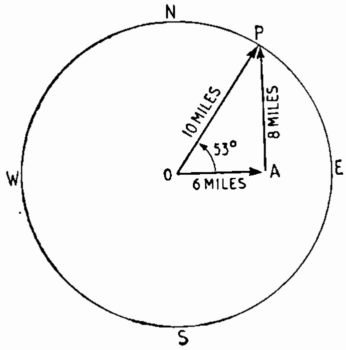


Fig. 1. Two methods of indicating the position of a point P in relation to O; each calls for two related numbers: the distances in two directions at right angles, or alternatively the direct distance and the angle measured from a reference direction. It is the same with impedance and other things.

properly, because although it is all reckoned in ohms it is made up of two parts that must not be confused by adding them together. Resistance is one part, and the other—reactance—can conveniently be kept separate by marking it "j." Although there are two kinds of reactance, these need not be kept in separate accounts, because the inductive kind is reckoned as positive and the capacitive kind negative, and I hardly need explain how to deal with them. With impedance, resistance, and reactance represented by the usual symbols, the complex-number specification of impedance in terms of its series values of resistance and reactance is

$$\mathbf{Z} = R + jX\,^{*}$$

For example, the impedance of 20 Ω resistance in series with 50 Ω inductive reactance is $20 + j50$ ohms. If the reactance had been capacitive it would have been $20 - j50$. When there are a lot of resistances and reactances in series the resistances can all be added together in one lot, and so can the reactances in another lot (paying due attention to + and − signs), and the two lots written as one complex number. The mathematically minded people like to describe this as separately equating the real and imaginary parts, but I hope nobody will get the idea from this that reactance is any less real than resistance. Misguided though the mathematicians may seem, there is a grain of method in their madness. What they have in mind is that j (and anything that appears to be multiplied by it) is not a real number, because there is no number which when squared is negative. But that need not worry us, so long as the method works. The important thing to remember is to keep all the j-marked numbers separate from the others. Thus, if the resistances of two impedances in series are 150 Ω and 400 Ω, the resistance of the whole must be 550 Ω no matter what the reactances may be.

This would be very nice if everything were always in series, but what about items in parallel? Well, all the procedure for calculating simple d.c. circuits, with resistances only, holds good for a.c. circuits, complex numbers taking the place of simple numbers. Of course the same *apartheid* law for complex numbers has to be strictly observed. Calculating these more complicated circuits often involves multiplying one complex number by another. Take Fig. 2 for example; what is the impedance of the whole thing, expressed as one complex number? If there had been resistances only, we would have said

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

which can be manipulated into

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

The same thing applies to complex impedances:

$$\mathbf{Z} = \frac{\mathbf{Z}_1 \mathbf{Z}_2}{\mathbf{Z}_1 + \mathbf{Z}_2}$$

With the details filled in from Fig. 2, this becomes

$$\mathbf{Z} = \frac{(R_1 + jX_1)(R_2 + jX_2)}{R_1 + jX_1 + R_2 + jX_2}$$

The denominator—the part below the line—is, metaphorically, a piece of cake; there need be no hesitation in "equating the real and imaginary parts":

$$(R_1 + R_2) + j(X_1 + X_2)$$

The multiplication in the numerator—the part above the line—is done according to the ordinary rules of algebra, thus:

$$R_1 R_2 + jR_1 X_2 + jR_2 X_1 + j^2 X_1 X_2$$

and if we remember that $j = \sqrt{-1}$ we see that the $X_1 X_2$ is transferred to the ranks of the "real," for $j^2 = -1$. So the numerator can be written as

$$(R_1 R_2 - X_1 X_2) + j(R_1 X_2 + R_2 X_1)$$

We now have Z as one complex number divided by another. Can this be reduced to a single complex number without going beyond the same rules of manipulation? It can, but a little dodge is needed to get over the immediate difficulty. It exploits the fact that when $(a + b)$ is multiplied by $(a - b)$ the answer is $a^2 - b^2$; non-squared terms go out. If we do this with the complex denominator, j goes out and we are left with a simple number. The factor to multiply by in this case is $(R_1 + R_2) - j(X_1 + X_2)$; and, of course, to keep the whole thing right it is necessary to multiply the numerator by the same amount. You will soon find that this "reducing" begins to cover the paper with vast numbers of symbols! But since it involves no new principle I won't waste *Wireless World* paper in the effort, but just report the end result of my private calculation, hoping it is the same as yours:

$$\mathbf{Z} = \frac{R_1 R_2 (R_1 + R_2) + R_1 X_2^2 + R_2 X_1^2}{(R_1 + R_2)^2 + (X_1 + X_2)^2} + j\,\frac{X_1 X_2 (X_1 + X_2) + R_1^2 X_2 + R_2^2 X_1}{(R_1 + R_2)^2 + (X_1 + X_2)^2}$$

This almost begins to justify the description "complex"! But when one fills in the values of R_1, etc., each of these two formidable expressions melts down into a single number of ohms, the first being R and the second X, so it is just a particular case of the basic $\mathbf{Z} = R + jX$. And Fig. 2 covers a very large variety of circuits, for R_1, X_1, etc., can each be the total of several items in series. In fact, with obvious extensions of the same methods it covers most of the circuits one is likely to need to calculate. Incidentally, don't you admire the beautiful symmetry of this equation? Note, too, that every separate term in it is ohms-cubed divided by ohms-squared, so is in ohms, as it ought to be; if this were not so it would be the sign of a slip somewhere, as I ex-

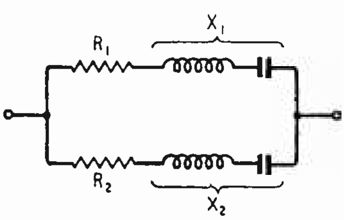


Fig. 2. *A very important type of circuit, taken as an example of complex-number calculation.*

*Heavy type is the standard device for distinguishing quantities that need complex or two-part numbers to convey the full information from mere magnitudes. An alternative is to distinguish magnitudes by putting them in straight waistcoats, thus: | Z |. But often one does not bother to distinguish either, unless there might be some doubt as to which was meant, or some other reason exists for emphasizing the distinction.

plained in "Dimensions" (November, 1951) with reference to this very same equation.

If you prefer to express the impedance as a resistance and a reactance in parallel, you can change over from the series values by means of the formulæ I quoted last month (but I don't advise you to try it with the particular specimen above !).

Going back to Fig. 1, you will remember that the complex number was not the only way of locating the point P. To say that it was $(6 + j8)$ miles from O would not be the most helpful form of the information to anyone who wanted to know how far it was away and/or in what direction, even if he knew the complex-number code. He would, however, knowing that the angle PAO is a right-angle, and having learnt at school the celebrated Theorem of Pythagoras, realize that $OP^2 = OA^2 + AP^2$, so OP would be $\sqrt{OA^2 + AP^2}$. Or if he were a little more sophisticated he would see that $\frac{AP}{OP} = \sin A\hat{O}P$, and hence $OP = AP/\sin A\hat{O}P$, which if he had a table of sines would be a little easier to work out. Alternatively $OP = OA/\cos A\hat{O}P$. But forget about this for a few minutes and dwell on the fact that $P\hat{A}O$ is a right-angle. In the complex number, 8 is added to 6 on condition that it is set off in the direction at right angles to the 6. Only in this way do they add up to 10. So one can look on the prefix "j" as the command "Left turn !" If we were to stick a j on the front of something that already had one—say jx—the result would be jjx, which if treated according to the rules of algebra would be $j^2 x$, which is equal to $-x$. This fits in beautifully with the turning idea, because the effect of two left turns is to reverse the direction, which is the meaning given to a minus sign. It continues to fit in however many times the process is repeated ; for instance, $j^4 = (-1)^2 = 1$, which is "as you were"—the same as four successive left turns.

The beauty of this simple code, whereby ordinary numbers represent easterly distances (or resistances) and j numbers represent northerly distances (or reactances), is that using only ideas that are obvious from Fig. 1 we can specify *any* direction—not just the four main points of the compass—or *any* impedance.

If one does not feel happy with trigonometry or even Pythagoras, then at least one can solve such problems by drawing a diagram to scale. Given the information "$6 + j8$ miles" it is a very simple matter (knowing this code as we now do) to draw the lines OA and AP to the scale of say 1 inch to the mile and find by actual measurement that OP is 10 miles in the direction 53° N. of E. Exactly the same method can be used for finding an impedance, given the resistance and reactance.

"Direction" of the Impedance

That is, so far as the actual amount or magnitude of impedance is concerned. What the "direction" of the impedance signifies may not be so obvious. Perhaps the best approach is to consider the voltages across R and X and both together when a current is passed through them, because this starts from the best-known electrical idea—Ohm's law. In one of its forms it says that the voltage across a resistance is proportional to the resistance and to the current through it ($V = IR$). If there are two resistances in series, R_1 and R_2, the same current passes through

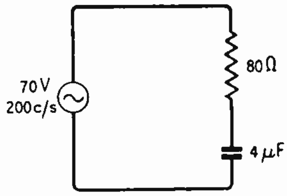


Fig. 3. *A numerical example to demonstrate complex numbers.*

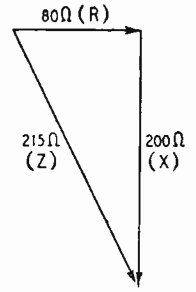


Fig. 4. *Impedance triangle for Fig. 3.*

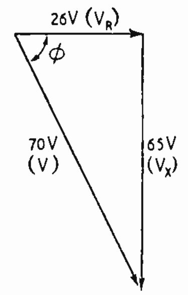


Fig. 5. *Voltage triangle for Fig. 3.*

both, so $V = V_{R1} + V_{R2} = IR_1 + IR_2 = I(R_1 + R_2)$. The same principle holds for a.c. and impedance, provided that the complex-number rules are followed. So we have $V = IZ = I(R + jX) = IR + j\,IX = V_R + jV_X$. This shows how to calculate the voltages across a resistance and a reactance in series, given the current ; and how to calculate the current, given the voltage across the whole impedance. (Strictly speaking V and I are complex or vectorial quantities, but there is no necessity to emphasize that here.) Just in case this is not all very old familiar stuff, we'll take an actual example presently ; but without stopping for that just now let us go on to take note of the fact that in this relationship—which obviously can be shown as a diagram of the Fig. 1 type—*direction* represents *phase*. Thus if "volts" were substituted for "miles" in Fig. 1, OA would represent the voltage across the resistance (V_R), AP the voltage across the reactance (V_X), and OP the voltage across the whole impedance (V) ; and the fact that OP is 53° relative to OA would signify that V was 53° ahead of V_R in phase. AP is 90° (or quarter of a revolution) more anti-clockwise than OA, and this agrees with the fact that V_X is always 90° (or quarter of a cycle) ahead of V_R, which is in phase with the current. So everything hangs together beautifully—the diagram, the algebra, and the measurable electrical conditions.

Now, for the sake of anyone who is still learning, here is the example—Fig. 3. The first thing is to find the reactance. Using the *Wireless World* Radio Data Charts (5th edition) No. 22, or the formula $X_C = 1/2\pi fC$, we find that X = nearly 200Ω. So the complex number for the whole impedance in ohms is $Z = 80 - j200$. What this amounts to can be found by drawing a scale diagram (Fig. 4) or working it out from $Z = \sqrt{(R^2 + X^2)}$. Either way the answer is just over 215. Knowing the e.m.f. and the total impedance, we can now calculate the current $I = 70/215 = 0.325$A. This passes through both R and X, so the voltages across them can be found, either by the Ohm's law calculation $V_R = IR = 0.325 \times 80 = 26$ and $V_X = IX = 0.325 \times 200 = 65$, or by the Fig. 4 triangle again, using the length of the longest side to represent the whole 70V, whereupon the lengths of the other sides represent to the same scale the voltages across the corresponding components (Fig. 5). Finally, the phase relationships of the various voltages. The voltage across positive reactance is always 90° ahead of the voltage across resistance in series with the reactance; in this case the reactance is negative, so V_X is 90° *behind* V_R. That would be so in any case, regardless of the values of X and R. What has to be found is the phase angle between the applied voltage V and any of the others. Fig. 5 shows that the voltage V_R across the resistance leads the whole applied voltage V by the angle marked ϕ, which a protractor measurement shows to be just over 68°. To make the total angle between V_R and V_X equal to 90°, as it must be, V_X must *lag* V by the angle needed to bring 68° up to 90°, namely 22°. And if we remember that the current is in phase with the resistance voltage V_R, we see that it is 68° ahead of the whole applied voltage V. So now the whole situation is completely known.

This example ought to confirm how the complex number idea fits into the other ideas about a.c. circuits. To say that the impedance is 215 Ω isn't the whole of the story, any more than saying P in Fig. 1 is 10 miles from O is enough to fix the position of P: 215 Ω and 10 miles are merely the *magnitudes*. Relative position in two-dimensional space, and a.c. impedance, among a number of other things, need two data to specify them. In the Fig. 3 example we can either say that the impedance is 215 Ω $\angle -68°$, meaning that its phase angle is 68° behind the resistance (which is the same as saying the voltage across the impedance is 68° behind the current), or specify the impedance as a complex number, in this case $80 - j\,200$ ohms. Sometimes one way is more convenient and sometimes the other. Given either, the other can be found, as I have just explained.

Calculating the Angle

One thing is missing, however. Whereas we worked out the magnitude Z in two alternative ways—by scale diagram and by calculation—we used only the diagram method for finding the phase angle ϕ. The diagram method is quite simple, but one may not always have a protractor handy, and even if one has the answer is not likely to be very precise unless unusual care is taken over the drawing. Actually I did mention a second calculation method for finding Z from R and X (or vice versa) which gave a clue to calculating the angle, but told you to forget it for a while so as to keep to one thing at a time. Now we can go back to the sophisticated method of calculation. It involves trigonometry, but only as far as Lesson One. With reference to Fig. 1, I mentioned that AP/OP = sin $A\dot{O}P$. In that case, AP = 8 and OP = 10, so sin $A\dot{O}P$ = 0.8, and if you look up a table of sines you will see that the angle whose sine is 0.8 is (to the nearest degree) 53°. So that is one alternative to drawing the diagram. The other alternative I mentioned, cos $A\dot{O}P$ = OA/OP, gives the same answer from a table of cosines. The scheme works with the electrical example; in Fig. 5, $\sin\phi = -65/70$ (or, from Fig. 4, $-200/215$), and the table shows ϕ to be a little over $-68°$ (which, to be quite honest, was how I arrived at it in the first place! But with renewed honesty I confess I don't actually bother with + and − signs to find whether ϕ is leading or lagging—the tables don't help one in this, anyway. If in any doubt I make a rough diagram). Either sin or cos will do, but it is convenient to have still another way, which enables one to get ϕ straight from R and X (or V_R and V_X), without necessarily having to find Z first. The relationship is $\tan\phi = X/R$, or $\phi = \tan^{-1} X/R$ (read as "the angle whose tangent is X/R").

Summing up, then, an impedance consisting of R and X in series can be expressed either as a complex number, in terms of its components, thus,

$$\mathbf{Z} = R + jX,$$

or by its magnitude and phase angle, thus,

$$\mathbf{Z} = Z \angle \phi.$$

The conversion to magnitude and phase from the complex form is

$$Z = \sqrt{R^2 + X^2}$$
$$\text{and } \phi = \tan^{-1} X/R.$$

And the reverse conversion is

$$R = Z \cos\phi$$
$$\text{and } X = Z \sin\phi.$$

So still another form is

$$\mathbf{Z} = Z(\cos\phi + j\sin\phi).$$

And yet another, which I am not going to try to explain now, but just mention to excite curiosity among any who have not yet encountered it is

$$\mathbf{Z} = Ze^{j\phi}$$

In any of these, of course, R and X may be more or less complicated expressions, as in the equation for Fig. 2. The important thing is to be able to recognize a complex number when you see it, even when heavily disguised by this sort of elaboration. And, as we saw in connection with Fig. 5, the same codes (or notations) can be used for currents and voltages. Whereas our impedance picture is just a "still," showing a fixed phase relationship, the steadily increasing phase angle of an alternating current can be indicated by substituting for ϕ something that increases steadily with time. But that is another story.

Oh! I nearly forgot! The complex gain of an amplifier: what is it? If you have followed everything so far you will probably be able to guess the answer. Suppose when a 0.1-V signal is applied to the input of an amplifier the output is 15V. Then the voltage amplification or gain is 150 times. But that is only its magnitude, which is just part of the information, and not enough if one is considering using negative feedback, for instance. The phase is equally important, or how does one know that it wouldn't be positive feedback—or neither one nor the other? In other words the gain or loss of an amplifier or anything else that deals with a.c. is a two-part quantity, and can be expressed as (among other things) a complex number. This idea is the basis of feedback amplifier design—but I had better not start on that just now!

If you would like a little test question on the foregoing, here it is. What is the resonant frequency of the circuit shown in Fig. 6, if resonance is defined by current being in phase with applied voltage? Answer next month.

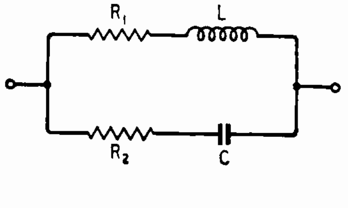


Fig. 6. An example to work out. What is the resonant frequency?

Magnetic Powder Cores

Manufacturing Techniques and Applications in Radio and Telephony

By D. F. W. CHAMPION,* B.Sc.(Eng), Grad.I.E.E. and E. G. WILKINS,* B.Sc.

DURING recent years, magnetic powder cores have been increasingly used in telecommunications. These cores consist essentially of ferromagnetic particles, each coated with an insulating material, and the whole compacted to form a solid mass having considerable mechanical strength. It is apparent that the permeability of such a core, when measured under direct current conditions, is considerably lower than for the solid magnetic material. Under conditions of alternating flux, however, the position is complicated by induced eddy currents in the material which have the effect of lowering the measured permeability. This effect is more marked at higher frequencies. The circulation of eddy currents is restricted by subdivision of the material: at power frequencies laminations are satisfactory but at higher frequencies insulated powder must be used. As a general rule, at audio frequencies large particles and small amounts of insulation are used whilst at higher frequencies small particles and much larger amounts of insulation are necessary.

The manufacture of these cores involves quite complicated processing and it is not proposed to attempt a detailed account here. An outline of some techniques may be of interest, however, and for this purpose it is convenient to divide the processing into two parts, namely, the preparation of the magnetic powder and the preparation of the core from that powder.

One of the earliest methods used for the production of iron powder for use in magnetic cores was electrolytic in character. Ferrous sulphate was electrolysed using mild steel anodes, the iron being deposited on cathodes of polished steel sheet. The resulting iron was brittle and readily broken down in suitable grinding equipment. This powder was used for loading coils and although it was later superseded by nickel-iron alloys, electrolytic iron is still in use to-day for certain other applications. It must be pointed out, however, that various heat treatments and other processes are carried out before this powder is pressed into a core.

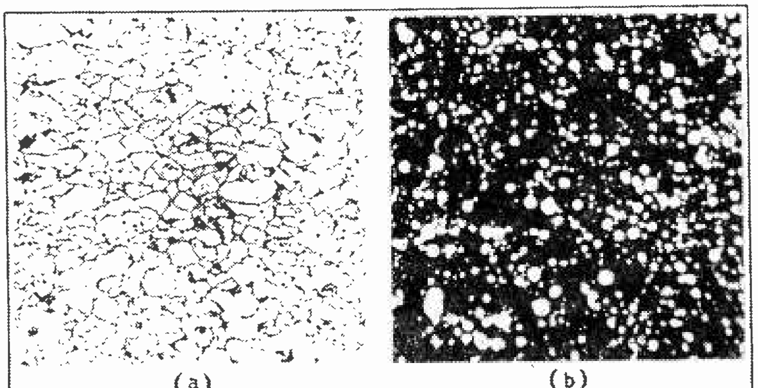
A later method, still in use to-day, was the introduction of an embrittling agent into nickel-iron and other alloys. The pure cast metal is too ductile to be readily broken down to a powder, but the use of such an agent results in a sufficiently brittle mass.

Both iron and its alloys can be produced by reduction from oxides, although in the case of alloys elaborate processing is necessary to obtain an alloy rather than a mixture of the component metals.

Finally, there is the carbonyl process. Iron pentacarbonyl, which is liquid at room temperature, is decomposed by heating in an enclosure. Iron is deposited on the walls of the enclosure in the form of almost spherical particles of approximately 5 microns diameter. This powder is of additional interest as it is an anomaly to the general conception of soft magnetic materials. Whilst most of these are mechanically soft, the so-called carbonyl iron is relatively hard.

Having outlined some of the methods of preparing magnetic powder we now turn to the next stages, namely insulation and core fabrication. Two main types of insulation are in common use, namely, plastic or resinous and ceramic. The former type is used where permeability and hysteresis loss are not critical, that is to say, in cores for use at radio frequencies. The insulating material is dissolved in some suitable organic solvent and mixed with the metal powder in a heated mixing machine. Ultimately the solvent evaporates, leaving a granular powder which is then pressed to form the core using pressures approaching

Fig. 1. Cross-sections of (a) high-permeability nickel-iron alloy core (× 200), and (b) low-permeability carbonyl iron core (× 500).



(a) (b)

* Research Laboratories of the General Electric Company.

25 tons per sq inch. The pressed cores are then heated to near 200°C, thus polymerizing the insulating material, which also serves as a binder.

For many applications cores are required to have higher permeabilities and lower hysteresis loss than can be achieved by this method of insulation. The use of a ceramic coating, applied to the powder in a manner similar to the above, enables one to press cores at much higher pressures (up to 120 tons per sq inch) and to relieve the strain so introduced by heat treatment at temperatures up to 700°C. In this instance the mechanical strength of the finished core is mainly due to the interlocking of the particles of magnetic materials owing to plastic deformation at the high pressures used. The heat treatment of the core is a very important part of the processing. The rates of both heating and cooling are critical as well as the control of the temperature at which annealing is carried out. Cross-sections of a carbonyl iron and a nickel-iron alloy core are shown in Fig. 1.

Core Losses

Before going on to describe the types of powder core used for various applications, the question of core losses will be discussed. These losses include hysteresis loss, the magnitude of which is proportional to the area of the ferromagnetic hysteresis loop, eddy current losses induced in the material by the applied field, and residual or viscosity loss, the source of which is not fully understood at present.

These characteristics of a magnetic material are most readily deduced from measurements on a wound toroid. This shape is preferred since leakage field is a minimum and the mean magnetic path may be readily determined. Several systems exist for describing, classifying and measuring such losses and the following is a typical example.

The total effective resistance of a coil wound on a toroidal specimen and measured under conditions such that the induction is low (say 10 gauss), can be represented by the equation:—

$$R_{total} = R_{dc} + R_e + R_v + R_h$$

where the suffixes *dc*, *e*, *v* and *h* denote that the resistances are due to copper loss, eddy current loss, viscosity loss and hysteresis loss respectively. It can be shown for the low flux densities under consideration that the equation can be re-written in the form:—

$$R_{total} = R_{dc} + L\left(ef^2 + vf + hf\frac{NI}{l}\right)$$

where L is the inductance in henrys of a winding of N turns on a toroid having a mean magnetic path of length l centimetres, and f and I are the test frequency in kilocycles per second and current in amperes. By measuring this total effective resistance at several frequencies and currents it is practicable to separate out the values of e, v and h for the specimen. Typical values of the coefficients e, v and h are given in Table 1, together with permeabilities calculated from the inductance of a single layer winding on the specimen. It must be appreciated that the values of e deduced include the eddy current losses in the winding.

The measurement of the eddy current loss of the core alone (*e.c.* in the table) is usually carried out at a frequency of several megacycles per second where the eddy current loss is predominant and the loss in the actual winding may be accurately calculated and allowed for.

The many different forms of construction and properties of powder cores ensure that they are versatile components suitable for use over a wide range of frequencies and operating conditions. The following remarks are confined to their applications in the field of telecommunications.

The inherent high capacitance and low inductance of a telephone cable severely limits the distance over which it is possible to transmit intelligible signals, and it was suggested by Heaviside in 1887 that the addition of inductance to the cable would reduce considerably both distortion and attenuation. Many years later it was demonstrated that loading coils wound on low-loss cores inserted in series with the cable at intervals would produce the desired effect.

The type of core used in telephone loading coils must conform to a rigid specification. The effective resistance of the coil must be as small as possible over the whole frequency band in use; it must be stable with regard to inductance and losses with time and after the application of large signalling currents; it must have a high insulation resistance, and be electrically symmetrical to prevent the introduction of cross-talk.

Experiments soon showed that, on one hand, the air-cored coil had a prohibitively large d.c. resistance, whilst stampings had very high losses and poor stability. Hence a compromise between the two was sought. The earliest loading coil cores used were made by winding insulated iron wire into a toroidal core. Further development produced, in 1915, a core made of electrolytic iron powder insulated with shellac and pressed into a solid core, but the high losses of these cores stimulated work which led to the introduction of nickel-iron alloy powder in 1930. Since low values of induction are gener-

TABLE I
Core Loss Coefficients

Material	Binder % by volume (approx.)	Nominal forming pressure tons/sq inch	Typical core losses				
			u	*e*	*v*	*h*	*e.c.*
Annealed electrolytic iron	5	50*	90	10	40	500	—
..	1	50	90	8	30	1250	—
80/20 Nickel iron	35	100*	12	—	1.5	3.5	0.04
”	17	100*	50	1.0	4.0	19.0	0.30
”	5	100*	120	2.0	7.0	60	—
Ternary alloy with nickel and iron in approximately 80/20 ratio..	35	100*	12	—	1.5	3.0	0.04
	17	100*	50	1.0	4.0	14.5	0.30
	5	100*	140	2.0	8	40	—
Carbonyl iron—							
Grade MC ..	30	20	14.5	—	14	13.5	0.02
Grade ME ..	30	20	11.0	—	2.0	1.0	<0.02
Grade MF ..	30	20	9.0	—	1.0	<0.3	<0.02
Iron from oxide reduction ..	30	20	19.0	—	14	34	0.06

* These cores are heat treated at a high temperature to relieve strain.

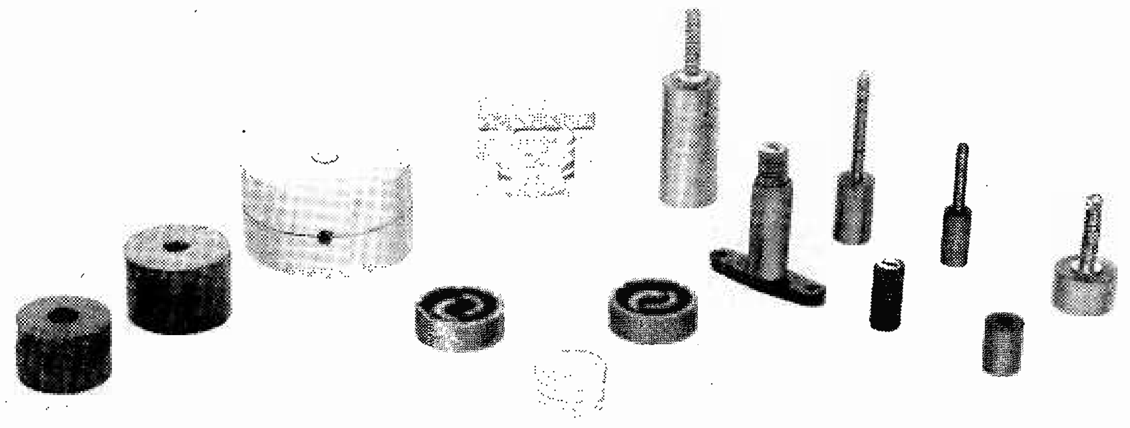


Fig. 2. Powder cores for use at radio frequencies.

ally the rule, the loss separation outlined above may be used to specify the maximum permitted losses. The initial permeability, or rather the permeability at very low inductions, must be as high as possible consistent with low values of hysteresis, eddy current and viscosity losses. Nickel-iron alloys and ternary alloys containing nickel and iron in the approximate ratio of 80/20 are most commonly used for powder cores in this frequency range. The particle size is in the region of 15 to 50 microns. The highest permeability available at present is 140; in such cores the volume of insulation occupies about 4 per cent of the total whilst in cores of the lowest permeability of 14 some 30 per cent of the volume is occupied by insulation.

Telephone Circuit Applications

The selection of a core for a loading coil depends on the type of telephone circuit in which it is to be used. For high quality transmission, as required for broadcast or music lines, low-permeability low-loss cores are used. For main trunk cables and minor trunk cables cores of high permeability and low losses (particularly hysteresis loss) are necessary, whilst for town and exchange lines the higher permeability core with its larger losses is satisfactory. The toroidal core is always preferred for this application because of its small external field. The wound cores are sealed in cylindrical containers and stacked in vertical columns in a steel loading coil pot, which may contain up to 400 coils. They are then connected to a central stub cable and the pot is sealed ready for installation. The spacing of the pots along the telephone cable is usually about 2,000 yards.

Alloy powder and carbonyl iron cores are used extensively in filters for multi-channel carrier telephony systems. Here again, the cores must have extremely low losses combined with a very small temperature coefficient of inductance.

The application of magnetic powder cores in radio may be conveniently divided into two groups, namely, those used at radio frequencies and those used at lower frequencies in ancillary circuits.

The first serious attempt to manufacture cores for use at radio frequencies was the introduction of Ferrocart in Germany some twenty years ago. It was made by depositing a layer of insulated iron powder on to paper which was then rolled into tubes for use as plug cores, or a number of layers were formed into a block before being machined to a suitable shape. This material had a comparatively low permeability, less than ten in toroidal form, and was superseded in 1935 by cores made by methods similar to those in use to-day.

Because the predominant core loss at high frequencies is that due to eddy currents, the modern radio-frequency core is made of very fine powders having a particle size in the range 5 to 10 microns and about 30 per cent by volume of insulating material. Carbonyl iron is commonly used for the highest quality cores, whilst fine iron powder is used for those of lesser quality.

Although available in many different forms, the most widely used types of radio frequency core are the completely enclosed pot core and the plug core. The pot core may have an effective permeability of up to six and provision is usually made to adjust the inductance of the coil by about 5 per cent by the insertion of a plug in a central hole in the core. The plug core, used widely for such applications as tuning coils and i.f. transformers, is usually fitted with a screwed brass insert or a thread is ground into the core itself so that the inductance may be varied by changing the relative positions of the coil and core. Plug cores may have effective permeabilities up to eight, but for the screwed cores the figure is usually in the region of two. Certain types are suitable for applications at frequencies over 50 Mc/s.

Cores for Television

The rapid developments in television receivers during the post-war years have resulted in several new applications of the powder core, the most noteworthy being in components for line time-base circuits. The trend towards the use of energy recovery systems has necessitated the use of efficient output transformers and deflection yokes. The output transformer not only matches the deflector coils to the output valve but also supplies the e.h.t. for the cathode ray tube from the flyback pulse, and very often the heater current for the e.h.t. rectifier. As well as having low magnetic losses, a core material for this application must have a reasonably high permeability to keep the

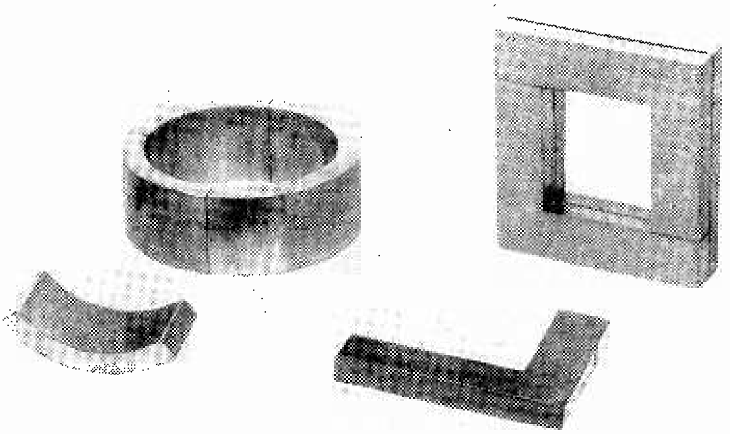


Fig. 3. Television cores: (left) deflector coil yoke; (right) line time-base output transformer core.

copper used to a minimum, and to reduce leakage inductance to a tolerable amount. One such time-base output transformer core is shown in Fig. 3. It consists of four L-shaped cores which are assembled with staggered butt joints. The windings are usually placed on one limb. The technical advantages of this type of core are that it is more efficient and easier to assemble than stampings, it may be operated at quite high flux densities and it is extremely quiet in operation.

Deflector Coil Yokes

The powder-core technique has also been successfully applied to the manufacture of deflector coil yokes which have hitherto used stampings or iron wire. There are two designs available, the castellated type and the plain ring in segments (shown in Fig. 3) which are finally clamped or cemented together. The major advantage of the castellated form of yoke is that undue care need not be taken in winding the coils since the field distribution is almost wholly controlled by the shape of the internal teeth.

The material used for these television applications is usually a pure iron of large mean particle size (about 100 microns) with a relatively small amount of insulation. The insulation may be either ceramic or resinous and amounts to about two per cent of the volume of the core. In order to enhance the permeability of the core in a given direction, some manufacturers use iron particles processed in such a way as to render them plate-like.

The propagation of radio interference may be by direct radiation from the offending equipment, by radiation from wiring connected to the equipment, or by conduction along the wiring directly into the receiver by way of its power supply. The first method may only be cured by screening the equipment itself, but the last two causes of interference may be remedied by the use of suppressors in the wiring.

The employment of magnetic cores in suppressor coils results in a reduction in both the volume of the coil and the amount of copper, and hence copper losses. Early suppressor cores were of the laminated variety, but, because of the low permeability of these cores at radio frequencies caused by eddy current shielding, the open type of construction proved essential, giving an effective permeability of less than ten.

Compared with other applications, the requirements of cores for interference suppressors are not very stringent. The essential feature of such a coil is that it should have a high impedance over a wide frequency range, which implies that a fall in permeability with increasing frequency is not detrimental to its performance. The losses in the core are comparatively unimportant since, although they cause a drop in the maximum impedance of the coil at its self-resonant frequency, they result in a broadening of the impedance-frequency curve.

The characteristics of a core suitable for suppressor coils are that it should preferably have a permeability of greater than fifty in toroidal form with polarizing fields of about fifty oersteds, and this permeability may fall above a frequency of 200 kc/s. Alloy powder cores have been used very successfully for this application, but in general, lower grade cores similar to the pure iron type described above adequately meet these requirements.

By suitable selection of materials, it is possible to satisfy many requirements by the use of powder cores. Apart from the obvious advantage of low losses, these cores have the merits of being prefabricated to precise dimensions, of having excellent stability and linear magnetic characteristics and of being usable at high inductions.

INDUCTANCE OR CAPACITANCE?

IN a lecture to the British Sound Recording Association last month, A. N. Crowhurst, A.M.I.E.E., discussed the basic principles of equalizers, filters and tone controls and showed how a required characteristic could be broken down and synthesized from a combination of simple "step" circuits, resonant sections, etc.

In the discussion which followed, several speakers commented on the fact that the lecturer had in many instances included inductances in his circuits and asked if this were not a retrograde step, since the tendency for some time had been to use only resistive or capacitive elements in the interest of simplicity, immunity from hum pick-up and (*sic*) less phase distortion. It was pointed out that as far as phase displacement was concerned, inductance differed from capacitance only in sign and not in magnitude, and that hum pick-up was a matter of design and could be overcome by the use of "binocular," "astatic" or toroidal windings.

Support for the lecturer's case for a more extended use of inductance in equalizer design came from other experienced designers in the audience, who pointed out that in the sizes of the order of millihenrys, which are common in filter design, an inductive component is often more reliable and cheaper than an equivalent capacitive element.

Suppression of Ground Reflections

By MICHAEL LORANT

Applications of Optical Methods to Microwave Communication Systems

A METHOD for alleviating one of the difficulties confronting the users of line-of-sight microwave communications — service interruptions resulting from ground-reflection effects—has recently been devised by the U.S. National Bureau of Standards through the application of optical methods and theories to microwave techniques. In particular, a method based on the Huygens-Fresnel diffraction theory has been developed for the suppression of the ground reflections in microwave systems.

Interruptions may occur when the direct wave from the transmitter and the ground-reflected wave destructively interfere with each other at the receiver. Although it is possible to set the receiver at a point of constructive interference, subsequent atmospheric changes usually shift the spatial interference pattern (the so-called lobe pattern) so that an interference minimum frequently occurs at the receiver.

In the new method reflected wave-suppression is achieved by setting a small screen of the proper size on the ground at the "reflection point" in the path. The reflected wave at the receiver is then substantially diminished, to an extent depending on the smoothness of the ground plane. The screen is designed to block only a small part of the re-radiation from the ground to the receiver; the remainder of the reflected radiation adds up to zero at the receiver. The direct wave undergoes little or no modification.

The new wave-suppression technique is based on the optical principle that the wave field transmitted from a point source to a point receiver under free-space condition becomes zero if half of the first

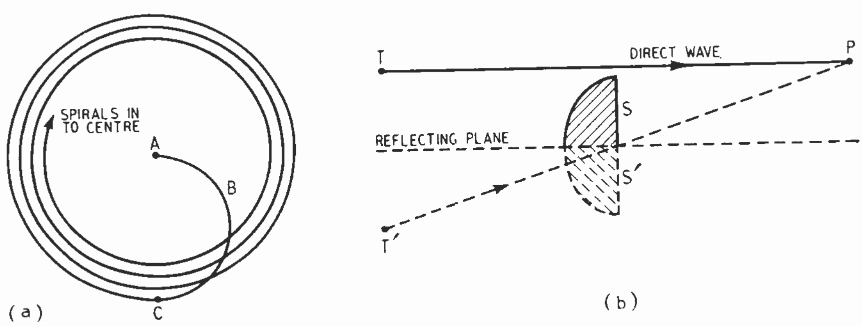
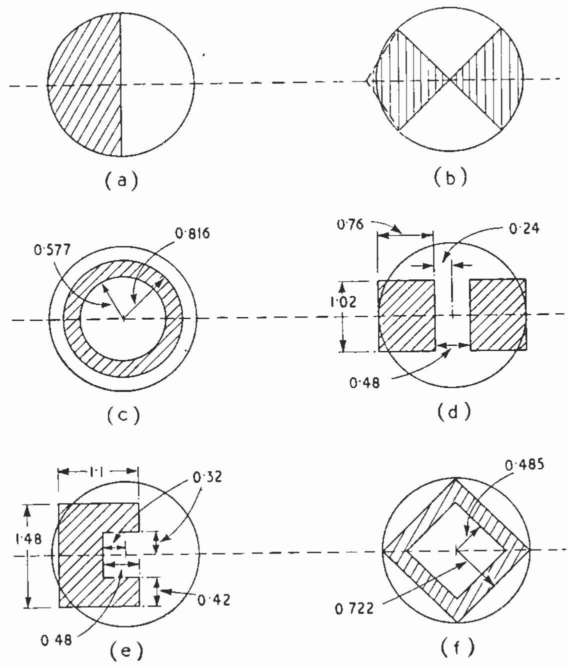


Diagram illustrating the application of optical principles to microwave techniques for the suppression of ground reflections. Attempts are made to nullify the effect of the ground at the receiver by placing an opaque screen at about the midpoint of the path between the transmitter and the receiver. The screen is erected so as not to interfere with the direct ray from the transmitter (T). The ground-reflections are considered as originating at an image transmitter (T′) below the reflecting plane and are radiating toward the receiver (P) along a path that passes through the screen (S) and its image (S′).



Drawings of zonal screens to give suppression of microwave ground-reflections. The dimensions of the screens are given in fractions of the radius of the first Fresnel zone : the outside circle of each drawing represents the periphers of the first zone. The dashed line through the centre of the circles denotes the ground plane. In practice only the upper half of the screen is constructed ; suppression is accomplished through the combined effect of the actual screen and its image. Screen (b) indicates how the semi-circular screen (a) can be cut into sub-sectors and still suppress the reflected wave. Screen (c) is an annular ring that nullifies only one-third of the zone area but is fully effective because it is opaque to the midphases of a zone. The remaining two-thirds of this zone would also be a screen. Screen (d) is composed of two rectangles which are structurally convenient and produce a broad null area. Screens (e) and (f) offer convenient variation for isolated application in which permanent structures may be utilized.

Fresnel zone is blocked so that the remaining diffracted contribution of the zone is halved in amplitude and unchanged in phase. The reduced contribution of the first zone is then cancelled by radiation from unblocked zones.

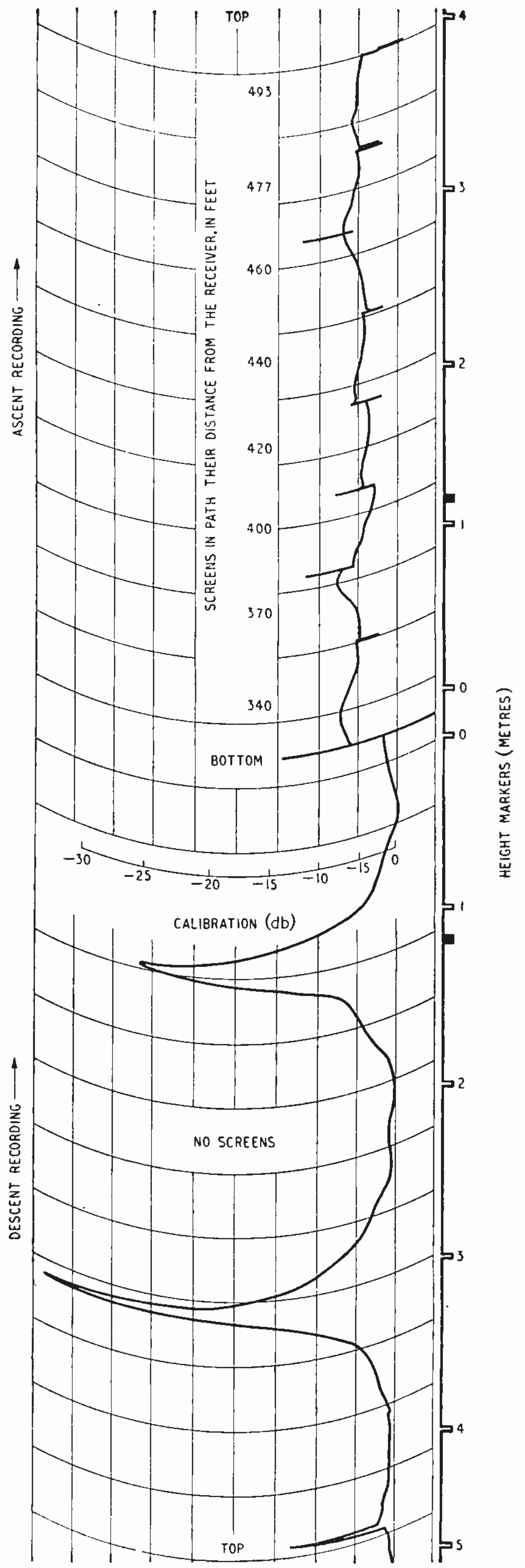
One of the screens developed by the Bureau takes the form of an opaque quarter-circle. The screen is erected where the reflected ray from the transmitter strikes the ground. The plane of the screen is perpendicular to the path, and its radius is equal to that of the first Fresnel zone in this plane. Thus, the quarter-circle blocks one half of the first Fresnel zone for the ground-reflected wave; according to optical theory, the remaining contribution from this zone is cancelled and the effect of the image source is effectively eliminated at the receiver.

To obtain experimental confirmation of the reflected-wave suppression, the investigators used a 4,500-Mc/s transmitter. Horizontally polarized signals were radiated from a horn set about 14ft above the ground and received with a similar aerial about 800ft away on a 50ft tower. The received power was recorded as a function of height of this aerial.

One of the experimental wave suppressors is composed of two triangular screens with edges of 7.3, 6.6, and 5.4 feet. When the path was not obstructed by the suppressor, the receiver recorded a well-defined interference pattern of minimum and maximum signal strengths as the receiving aerial was raised and lowered on the tower. But when the triangular screens were placed in their proper position, the influence of the reflected wave was substantially eliminated at the receiver. The field strength of the remaining direct wave was 6 db less than that of the signal at a point of maximum interference when no suppressing screen was used. By moving the receiving aerial above and below its normal operating position it was possible to determine whether the reflected wave was really suppressed or merely shifted in phase.

In practice, microwave radio relay paths are usually 20 or 30 miles long, and the transmitters generally operate at a frequency of about 4,000 Mc/s (wavelength 7.5 cm). Under these conditions, the first Fresnel zone is 80 to 100 feet in radius at the middle of the path, and the radius of the main suppressed area at the receiving point is about 8 to 10 feet. Fortunately, the aerials commonly used for these microwave systems are about 8 feet in radius. To accomplish nearly complete suppression, the screen is positioned on the path to within a few feet of the centre. For a first zone of 80 feet, a satisfactory screen is a rectangular structure made of fine mesh wire netting mounted on poles 40 feet high.

A number of experiments using differently shaped screens have indicated that troublesome reflections can be eliminated by small screens erected in the path or by utilizing obstacles permanently located near the proper position in the path.



Receiver-recording of signal strength versus height and time of a microwave radio relay with and without the zonal screens. Without screens and when the aerial is lowered from 4 to zero metres the interference of the reflected ray creates a well-defined pattern. With two triangular suppressing screens and with the aerial at 4 metres, the influence of the reflected wave is mostly eliminated.

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FURTHER NOTES ON THE

F.M. FEEDER UNIT

Circuit Modifications for EF91 R.F. Valve; Avoidance of Parasitic Oscillation in Frequency-changer and I.F. Amplifier

By S. W. AMOS,* B.Sc. (Hons). A.M.I.E.E., and G. G. JOHNSTONE,* B.Sc. (Hons).

SINCE the publication of the original articles on the f.m. feeder unit in the September and October, 1952, issues, some correspondence has been received concerning the performance and construction of the unit. The points raised are discussed here for the benefit of other prospective constructors.

(1) The pre-emphasis circuit of the B.B.C. f.m. transmission is 50 μsecs. The values of the components R_{19} C_{24} specified in the original article give approximately 75 μsecs de-emphasis, implying a small relative loss at the upper audio frequencies. To avoid this loss, the values of R_{19} and C_{24} should be amended; 47 kΩ and 0.001 μF are suitable.

(2) It has been pointed out that the quarter-wave section of feeder used in the balance-to-unbalance coupling at the dipole has a dielectric consisting mainly of air; its electrical length is therefore equal to its physical length and should be 2 ft 6 in.

(3) Some of the units constructed have suffered from parasitic oscillation in the frequency-changer or i.f. amplifier. These oscillations usually manifest themselves as "dead" carriers, but in one particular unit they caused a continuous hiss in the a.f. output. The oscillations are produced by a Lecher-wire mechanism between the leads to valve electrodes. Oscillation in the i.f. amplifier can be eliminated by connecting additional miniature 0.001-μF ceramic capacitors in parallel with the existing 0.01-μF decoupling capacitors C_{16} and C_{17}. The cause of oscillation in the frequency-changer is associated with the lead from the valve screen-grid to the 4-μF smoothing capacitor C_{15} and can be cured by insertion of an additional resistor R_{22} in series with the screen-grid as shown in Fig. 1. The value of the resistor is not critical and 330 Ω has been found satisfactory.

Some correspondents have suggested the use of an EF91 valve in place of the EF95 as r.f. amplifier. This suggestion has the advantage that all the valves in the unit would then be of the same type. An EF91 can be used by adopting the slightly modified circuit given in Fig. 2. The aerial coil requires modification to allow for the lower input resistance and higher input capacitance of the EF91 and a coil of four turns spaced to occupy 0.5 in on the Aladdin former, with two turns wound over the earthy end for aerial coupling, has been found satisfactory. The copper screen separating the control-grid and anode circuits of the r.f. amplifier should be retained but, because of the different pin connections of the EF91, should be soldered to the cathode and suppressor-grid

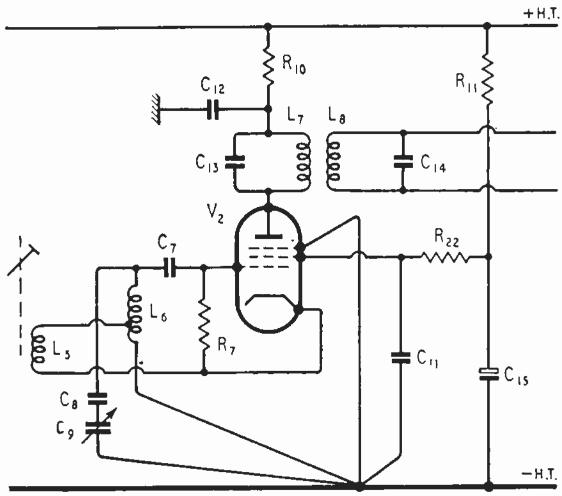


Fig. 1. Frequency-changer circuit showing the additional decoupling resistor, R_{22}, mentioned in the text in the screen-grid lead.

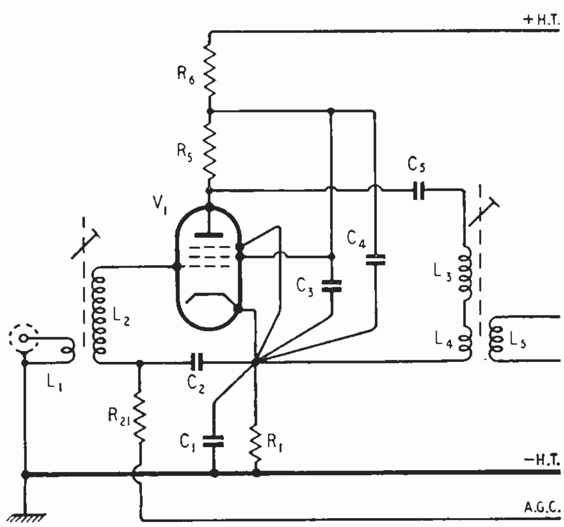


Fig. 2. The r.f. stage modified for use of the EF91 valve.

* B.B.C. Engineering Training Department.

tags (numbers 2 and 6 respectively) and, of course, the centre spigot of the valveholder. This is illustrated in the drawing of a suggested layout in Fig. 3. To keep the copper screen in its original position with respect to the chassis, the r.f. valveholder must be rotated through an angle of approximately 45 degrees with respect to the position illustrated in the photographs of the original article. The screen-grid of the EF91, can, with advantage, be returned to the h.t. line and the screen-grid potentiometer originally used is no longer necessary. A decoupling circuit consisting of a 4.7-kΩ resistor and 0.001-μF capacitor is included in the anode and screen-grid feeds as shown in Fig. 2. No change is required in the coupling circuit between r.f. valve anode and frequency-changer grid.

For weak signals giving no appreciable a.g.c. voltage, the substitution of the EF91 for the EF95 gives approximately 6 db loss in a.f. output, but where there is a good signal from Wrotham the change of valve produces no significant fall in a.f. output.

During alignment of the i.f. transformers it is sometimes found that there are two positions of the dust-iron core giving a peak in the detector output. To find the correct peak, it is advisable to start with the core well out of the winding, and remote from the coupled winding, and advance it until the first peak in output is obtained. This is the correct alignment point. If the core is advanced farther the output begins to fall due to mistuning but a second peak may be obtained due to the increase in the degree of coupling between the primary and secondary windings.

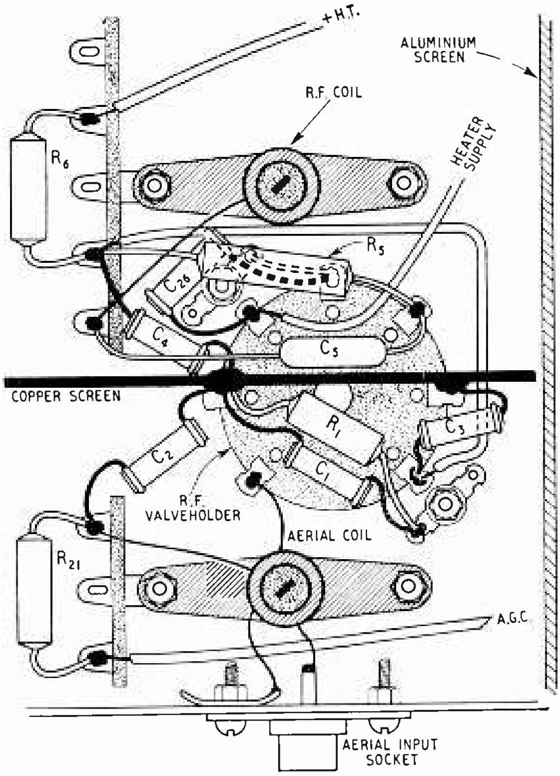


Fig. 3. Since the performance of v.h.f. equipment depends as much on the component layout as on the circuit, the actual disposition of components in the modified r.f. stage using the EF91 valve is shown here.

Meter Protection

Design and Performance of Fine-wire Fuses

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

THE delicately constructed, but nevertheless robust, moving-coil milliammeter may be damaged permanently in two ways. An overload, in itself insufficient to burn out the coil or its leads, may damage the movement, due to the force involved when the pointer strikes the stop. A greater overload will burn out the coil and usually damage the movement.

Any protective device must include three essential properties: it must carry the full-scale current for several thousand hours, clear the heaviest overload without damaging the coil and clear the heaviest overload *before* the pointer hits the stop. It is obvous that such a device must possess very low thermal inertia in order that it should operate very quickly when the overload is applied.

Curve (a) of Fig. 1 shows the time taken for the pointer to reach full-scale deflection as a function of the overload. The instrument used in all the experiments was a 2½-in moving-coil type with 10-mA f.s.d. The shape of this curve appears to be fairly typical of various makes of the same type.

During the preparation of this curve it was ascertained that brief overloads of about 300 per cent, while causing the pointer to hit the stop somewhat vigorously, did not appear to cause damage to the movement or its balance, or to the calibration accuracy. Such an overload, *if sustained*, might damage the coil by heat. Overloads in excess of 300 per cent would probably cause damage, but experiments in that direction were not pressed home as in any event the fuse should be capable of clearing such an overload before damage occurred.

The curve (a) shows that f.s.d. is reached in about 0.1 second at rated current. At 300 per cent overload f.s.d. is reached in about 0.04 second. It is clear that a protective device must be capable of clearing this latter overload in less than 0.04 second.

Ideally, the device should clear instantly at all over-

* Belling & Lee, Ltd.

loads however small, that is, before the pointer reaches the stop; but the initial experiments indicated the latitude which could be safely introduced in practice.

It was subsequently ascertained that a very simple cartridge-type fuse employing an exceedingly fine platinum wire element would give adequate protection under all fault conditions because of its very low thermal inertia, which conduces to rapid blowing.

Wire to carry 10-mA f.s.d. current continuously, but to fuse under the prescribed overload conditions, is about one-twentieth the diameter (0.002in) of an average human hair. It is a practical impossibility to draw wire down to 0.0001in and to store it on reels.

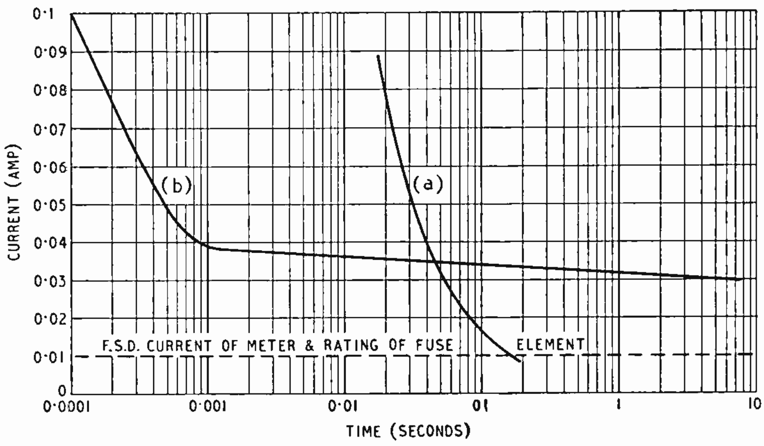


Fig. 1. (a) Time taken for pointer of a 2½-in meter to strike the stop after the application of currents in excess of the full-scale deflection current of 10 mA. (b) Blowing time of platinum fuse element as a function of current.

Use is therefore made of a unique method of manufacture invented and developed by W. H. Wollaston, F.R.S. (1766-1828) who was a very close friend of P. N. Johnson, the founder of the well-known firm of assayists, refiners and fabricators of precious metals Johnson, Matthey & Co.

The technique consists of fitting a rod of platinum into a silver tube, the outer diameter of the tube being of the order of 20 times the diameter of the rod (Fig. 2). This "billet" is progressively drawn through reducing dies until the requisite final diameter of the platinum is reached. Using a factor of 20 times the composite wire has an overall diameter of 0.002in which corresponds to 47 S.W.G. and is relatively easy to handle and store. After assembly the silver is dissolved away in a weak solution of nitric acid, which does not attack the platinum, and the desired fine platinum wire remains.

The idea was developed originally for cross-sights in optical instruments, such as telescopes, and while the acid technique was satisfactory for this purpose great difficulty was encountered in applying it to fuse manufacture.

The only way of supporting such a fine wire in a standard $\frac{5}{8}$in × $\frac{3}{16}$in glass cartridge with metal end-caps was to use a short length of about 0.1in connected between two stout backing-wires supported in an insulating block (Fig. 3).

Before acid-stripping the wire it was soldered to the backing-wires at the junctions A, B. After dipping the assembly into an acid bath for sufficient time to remove the silver coating, and then neutralizing the remaining traces of acid with an alkali and finally washing, it was found that continuous corrosion took place at the soldered junctions and the connection failed or was intermittent after a few weeks.

It was subsequently ascertained that when a liquid is drawn into minute crevices by means of capillary action it is impossible to mix other liquids with it. A simple experiment was performed to demonstrate this property and the details are worth describing

A piece of transparent glass capillary tubing, as used for example in clinical thermometers, is touched into a weak solution of nitric acid to which a few drops are added of pH indicator which changes colour when a solution changes from acid to alkaline—a process which may be reversed many times. Bromothymol blue was used in this experiment; the colour is orange in an acid solution and changes to deep blue when the solution is made alkaline. It is very sensitive so that the solution need only be very weakly acidic or alkaline for the change to take place.

When the capillary tube is touched into the acid solution the orange-coloured fluid rises immediately and fills the bore, and can be seen against a white background. The end of the tube is now touched into a solution of ammonia (which is strongly alkaline). It will be noticed that the column of acid is only neutralized for a short distance along the bore as shown by a deep blue coloration. There is a clear boundary between the blue (alkali) and the orange (acid) and the tube may be sealed and kept for many months without any diffusion of the one fluid into the other.

This is the explanation as to why the acid continues its action in the minute capillaries formed in the process of soldering the junctions of the element and is not neutralized by the subsequent alkaline treatment. A wax or other protective coating is useless because a capillary still exists where the wire enters it.

A new method of approach was attempted by making use of a phenomenon well known in electroplating. The electrodeposition of one metal upon another consists of immersing the object to be coated into a solution containing, as an essential ingredient,

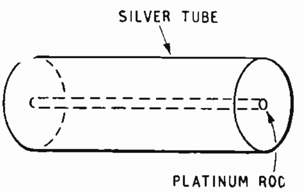


Fig. 2. Silver-platinum "billet" which is the first stage in the production of Wollaston wire.

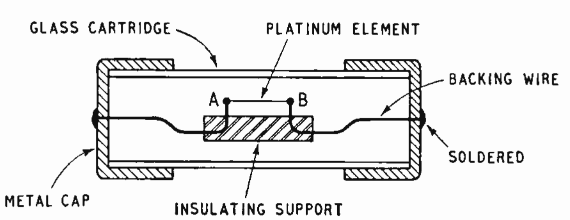


Fig. 3. Experimental 10-mA fuse employing Wollaston wire.

a dissolved salt of the metal to be deposited. The object is connected to the negative pole of a d.c. source and the positive pole to an anode comprising a plate or block of the metal to be deposited.

Presumably all readers are familiar with this general process but may not appreciate that difficulties arise when one attempts to secure an even electroplating on an irregularly shaped object containing hollows, sharp bends, or bores.

For example, it is difficult to electroplate the inner bore of contact sockets. The ability of the plating process to deposit metal in inaccessible places is referred to as the "throwing power" of the process. In short, those parts of the object which can "see" the anode in an optical sense will receive the heaviest deposit.

Now the process of electroplating may be reversed merely by reversing the polarity of the d.c. source, whereupon the plating is stripped from the object and returned to the parent anode (now the cathode). From this it follows that it is just as difficult to *extract* metal from a hollow, or a bore, as it is to deposit it.

This observation led to the development of a low-rating cartridge fuse using Wollaston wire as the element, in which the silver coating is removed by electro-stripping, and the stripping is confined to a small central portion of the wire purely by making use of the "throwing" phenomenon.[1]

Fig. 4 shows a section of the assembled fuse. The cartridge is constructed from a ceramic tube of very small bore with a central cross-hole or window and is fitted with the usual metal end-caps. The coated Wollaston wire is threaded through the bore with a very fine needle and soldered to the caps.

At this stage the assembly is connected to the positive pole of a d.c. source and is suspended in an ammoniacal solution of silver-nitrate in which is also suspended a silver cathode connected to the negative pole. The silver on that part of the Wollaston wire crossing the window is stripped so rapidly that by the time it is completely removed there has been negligible action upon that portion of the wire remaining in the narrow bore of the ceramic cartridge.

Due to the neutral behaviour of the remaining traces of ammonium-nitrate after drying there is no corrosive action, so that one is left with a robust fuse capable of being mass produced and in which the length of platinum element is controlled by the diameter of the window. These latter characteristics determine the resistance of the fuse and the prospective current which it can clear without maintaining an arc or shattering the cartridge.

Fuses based upon this method of construction, and with a window diameter of approximately 0.1in, will possess a minimum resistance of approximately 40 ohms for a 10-mA rating.

So far the ratings have been restricted to the range

[1] U.K Patent No. 647049.

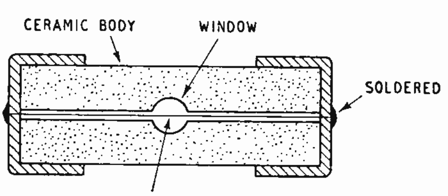


Fig. 4. Section of fuse in which the wire is prepared by an electro-stripping process.

10 to 25 mA. While it is a simple matter to extend the range in the higher direction great difficulties arise when attempts are made to obtain ratings less than 10-mA. The platinum wire when stripped becomes so fragile that the lightest air draught is sufficient to break it. There is also some difficulty in drawing a composite billet down to final platinum diameters of less than 1/10,000in.

It is appreciated that there are certain applications in which the resistance of the fuse will affect the ultimate calibration of the instrument. In this event it is wise to include a small pre-set resistance with the fuse so that the circuit can be adjusted to the correct calibration when a fuse has to be replaced.

The normal application of milliammeters is such that a series resistance of 40 ohms ±, say, 25 per cent, can be tolerated without affecting other parts of the circuit.

Curve (b), Fig. 1, depicts the blowing time as a function of current of a typical 10-mA rating. It is at once apparent that, for overloads in excess of 300 per cent, the fuse blows long before the needle can reach f.s.d. In fact, the accompanying table shows that moderate overloads cause the fuse to blow before the needle has a chance to move more than a few divisions. For example, on a 300 per cent overload (i.e., 0.04A) the fuse blows in less than one-thousandth of a second, whereas it takes 0.04 sec for the pointer to reach f.s.d.

TABLE

Percentage Overload	Percentage F.S.D.	
5,000	0.2	
2,500	0.3	
750	0.5	
500	1.0	
250	2.0	
200	4.0	
150	50.0 to 100	Critical region
125	Greater than 100	
100	,, ,, 100	
0	Exactly 100	

There is a certain critical overload condition at which the fuse blows just as the needle reaches f.s.d. but, as pointed out earlier, at this overload and at lower overloads which enable the pointer to "hold" against the stop continuously, the amount is insufficient to damage either the coil or its associated mechanism.

The conclusion to be reached is that simple cartridge-type fuses containing an element of fine wire, preferably platinum on account of its indefinite life under normal conditions, can successfully protect the popular type of moving-coil milliammeter over a wide range of overload conditions. Connection can even be made to the 240 volts mains supply, at the consumer's outlet socket, without damage to the meter, and with a clean rupture of the fuse element.

The critical range over which there may be some possible damage to the movement of the meter is between 100 and 150 per cent overload although no damage was caused during the tests.

Even if occasional damage were to result, the statistical probability of a fault providing an overload of between 100 and 150 per cent, when there is such a very large range to embrace, is extremely low and might require the existence of many hundreds of random faults before the condition was met.

Simple Capacitance Checker

Resonance Method Using Grid Dip Oscillator Circuit

By T. R. SMITH*

THIS apparatus was built to provide a simple means of checking the values of small capacitors and the minimum and maximum values of variable capacitors and trimmers. Further uses would no doubt be found in practice.

In operation the device is similar to a grid dip oscillator except that the frequency is fixed (see Fig. 1). Permanently coupled to the oscillator is a variable tuned circuit which, when tuned to resonance, will cause a drop in grid current. A Colpitts type oscillator is used, as the most easily obtainable coils are of the two-terminal type. The range of the instrument is determined by the maximum value of C_1 and, as the inductance of L_1 equals that of L_2, C_1 also fixes the series capacitance of C_4 and C_5. These values are also, of course, dependent upon the L/C ratio required to give satisfactory oscillation.

If an unknown capacitor is now connected at C_x, C_1 will have to be reduced in capacitance to bring the circuit back to resonance. The amount by which it is reduced will be equal to the value of the unknown capacitor. Thus if C_1 has a calibrated dial it is possible to read directly the value of the unknown capacitor. In practice this is made easier by the addition of a small capacitor C_2 as shown in the complete circuit diagram Fig. 2.

Adjusting the Circuit

The components may be arranged in any convenient manner, care being taken to keep the wiring rigid in the tuned circuits. The position of L_1 relative to L_2, however, is important and it should be adjusted so that the dip in grid current is just discernible when C_1 is tuned through resonance. The coils should then be fixed securely in this position and mounted rigidly. The amount of grid current flowing through the meter can be adjusted by varying the value of R_1, a convenient deflection being approximately half scale.

The component values quoted will be suitable for most small triodes, but as individual coils differ variation in the resistance of R_1 and R_2 may be necessary to obtain satisfactory oscillation.

The power requirements are quite small, and although a conventional power supply could be used the arrangement shown works quite well in practice. Care must of course be taken to ensure that the neutral line of the mains supply is always connected to chassis. As a further precaution the unit might be housed in an insulated box.

Method of Calibration

Calibration is carried out as follows. C_1 and C_2 are set to maximum capacitance and both dials marked "0." C_3 is then adjusted for minimum grid current on the meter. A close-tolerance capacitor of 50 pF is then connected at C_x and, with C_2 left at "0," C_1 is adjusted for minimum grid current. This point on the dial of C_1 is marked "50." Further capacitors are now connected at C_x so that calibration points at 50-pF intervals can be marked. This procedure is continued until the minimum capacitance of C_1 is reached. Close-tolerance capacitors of the correct values can be used, e.g., 50, 100, 150, 200 pF, etc., or 50-pF capacitors can be added together to give the required value, although this last-mentioned method may introduce a slight error compared with the first. Capacitor C_2 is treated in a similar manner, except that its dial is calibrated at 10-pF intervals.

An alternative method of calibration, using only one close-tolerance 50-pF capacitor, is as follows. Connect the 50-pF capacitor at C_x and adjust C_1 for mini-

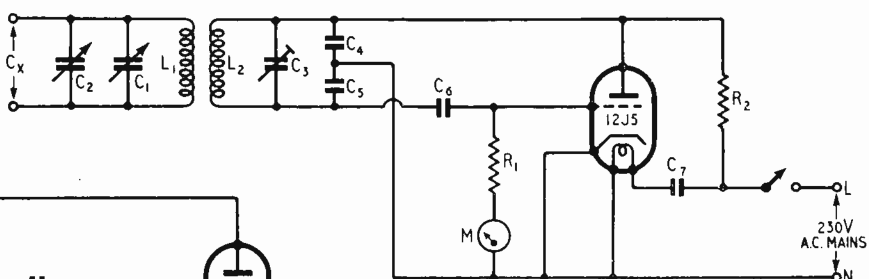


Fig. 2. Complete circuit diagram. $C_1 = 500pF$, $C_2 = 60pF$, $C_3 = 100pF$, C_4 and $C_5 = 1{,}000pF$, $C_6 = 300pF$, $C_7 = 2\mu F$ 400V working, $R_1 = 47k\Omega$ ½W, $R_2 = 20k\Omega$ ½W, L_1 and $L_2 = 2{,}000\mu H$ approx. (long-wave coils), $M = 500\mu A$ f.s.d.

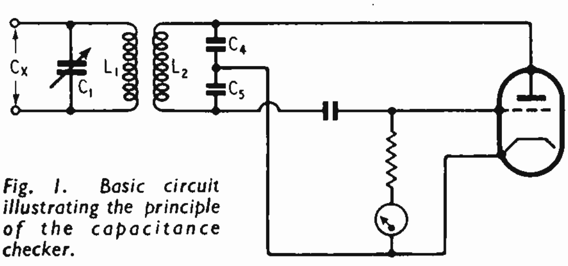


Fig. 1. Basic circuit illustrating the principle of the capacitance checker.

* Amateur radio station G3BMN.

mum grid current, marking the dial "50" as before. Remove the 50-pF capacitor and, leaving C_1 at its new position, connect at C_x a variable capacitor (preferably 500 pF) which is then adjusted to give mimimum grid current again. Reconnect the 50-pF capacitor across both C_x and the variable capacitor and reset C_1 for minimum grid current. The dial of C_1 is now marked "100." This procedure can be continued up the scale of C_1 until its minimum capacitance is reached. Calibration of C_2 is done in a similar manner, using a 10-pF close-tolerance capacitor and a variable capacitor of 50 pF.

In all cases the calibrating capacitors should be connected directly to the terminals C_x, so that maximum accuracy is obtained.

With the component values given the instrument will read up to a maximum capacitance of 500 pF in calibrated steps of 10 pF with sufficient accuracy for general requirements.

STOCKHOLM V.H.F. PLAN

WHEN summarizing in our October issue the plans for European v.h.f. broadcasting drawn up at the Stockholm Conference, we gave the number of frequencies assigned to this country, but did not draw any comparison with assignments to other countries. In a recent issue of its *Bulletin*, the International Broadcasting Organization (O.I.R.) published a critical review of the Conference in which is included a tabulated summary of frequency allocations, the essential details of which are given herewith.

The number of v.h.f. assignments—both television and sound broadcasting—provided for in the Stockholm plans are given in the last two columns and in the preceding two columns the number of stations for which each country made request. Although not directly related to the v.h.f. plans, the number of frequencies in the medium- and long-wave bands allocated at Copenhagen are given in the first column.

Countries	Copenhagen Plan	Countries' V.H.F. Requirements		Stockholm V.H.F. Plan	
		Television	Broadcasting	Television	Broadcasting
Albania ..	4	5	11	4	11
Austria ..	4	7	24	9	28
Belgium ..	4	5	22	4	25
Bielorussia	4	15	28	8	33
Bulgaria ..	4	11	24	7	23
Cyprus ..	—	—	—	—	1
Czechoslovakia	8	15	35	9	37
Denmark ..	3	—	—	8	41
Eire ..	2	—	—	5	10
Finland ..	7	7	54	14	58
France ..	18	45	183	50	178
Germany, East	3	9	38	6	22
Germany, West	6	33	95	27	246
Great Britain	13	36	118	40	189*
Greece ..	7	—	—	—	—
Hungary ..	4	15	34	8	35
Italy.. ..	11	9	18	15	188
Luxembourg	1	2	2	1	2
Malta ..	—	—	—	—	1
Monaco ..	1	2	3	2	3
Morocco and Tunis ..	8	5	—	5	—
Netherlands	2	5	20	4	25
Norway ..	12	—	—	34	124
Poland ..	9	23	57	24	75
Portugal ..	10	—	—	—	—
Rumania ..	6	18	40	11	40
Saar ..	1	2	3	1	3
Spain ..	9	4	6	21	81
Sweden ..	12	—	—	50	101
Switzerland..	4	9	20	13	39
Trieste ..	—	—	—	2	4
Turkey ..	4	—	—	43	87
U.S.S.R.† ..	24	100	183	76	187
Ukraine ..	10	52	94	33	90
Vatican City	1	2	2	2	2
Yugoslavia	8	16	—	22	88

* This figure includes the alternative assignments prepared for the U.K. providing for 110 a.m. stations or 79 f.m. stations.

† Territory West of the meridian 40° East

MANUFACTURERS' LITERATURE

Moving-coil Headphones, available as single earpiece, single headset or double headset, with impedance of 25Ω per earpiece. Leaflet describing construction and giving specification and response characteristic over 50 c/s-10 kc/s, from Standard Telephones and Cables, Transmission Division, North Woolwich, London, E.16.

Moulded Terminal Blocks; two-, three- and four-way connectors and twelve-way strips which can be cut up, all with nickel-plated brass terminals. Leaflet giving sizes and prices from Precision Components (Barnet), 13, Byng Road, Barnet, Herts.

Tape Unit, the Truvox Mark III, with three-motor drive, drop-in tape loading, push-button control and two speeds. Main features described briefly in a leaflet from Truvox, Exhibition Grounds, Wembley, Middlesex.

Components and Accessories; a 1953 catalogue from Watts Radio (Weybridge), 8, Baker Street, Weybridge, Surrey.

Chassis Fittings; developments and improvements described in No. 1 series leaflet (to go in catalogue folder) from A. F. Bulgin & Co., Bye-Pass Road, Barking, Essex.

Electrical Resistance Materials; a well-produced and illustrated new edition of booklet 1440, giving information on the principal base metal resistance alloys and on materials for specialized purposes. Tables give resistance per unit length for nominal diameters and percentage tolerances. From Johnson, Matthey & Co., 78-83, Hatton Gardens, London, E.C.1.

Export Table Radiogram, Ekco type TRG189, plays automatically all sizes of standard and long-playing records, covers medium and short wavebands in three ranges and is fed from 100/150 V or 200/250 V a.c. mains. Brief specification on a leaflet from E. K. Cole, Southend-on-Sea, Essex.

Components, Accessories and Test Gear; a very comprehensive indexed catalogue containing about 5,000 items from Arlt Radio Versand (Arlt Radio Export Company), Walter Arlt, Berlin-Charlottenburg 1, Kaiser-Friedrich-Str. 18, price 1 mark.

Portable Test Set for overall checking of v.h.f. multi-channel communications equipment as used in civil aircraft. Receiver sensitivity, transmitter output, modulation depth, etc., can be checked by a single engineer. Descriptive leaflet from Radio-Aid, 29, Market Street, Watford, Herts.

Television Aerials; a catalogue from A.B. Metal Products, 16, Berkeley Street, London, W.1.

Capacitors; a guide booklet giving information on standard forms of cases available and the capacitances and voltages they will accommodate for various ranges of working temperature. From Standard Telephones and Cables, Telephone Line Division, North Woolwich, London, E.16. Also a broadsheet on capacitors for marine radio interference suppression.

Electroplating Set, using flashlight batteries in a self-contained plating tool with a brush anode. Jars of gold, silver, nickel. copper, tin and zinc plating compound are provided. Descriptive leaflets from Scope Laboratories, 417, Keilor Road, North Essendon, Melbourne, W.5, Australia.

Horizontally Polarized Television Aerials for Pontop Pike and Belfast stations. Illustrated price list showing types available, from Wolsey Television, 75, Gresham Road, Brixton, London, S.W.9.

Storage Cathode-Ray Tube

By L. S. ALLARD* B.Sc., A.Inst.P.

Electrostatic "Memory" System for Digital Computing Machines

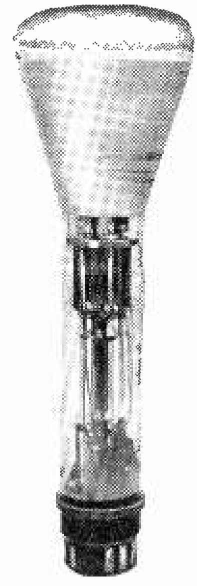


Fig. 1. The storage tube looks very much like an ordinary oscilloscope cathode ray tube.

DIGITAL computors need some form of storage mechanism to enable solutions of problems and instructions concerning succeeding operations to be retained. There are various means by which this can be achieved, including mercury delay lines, magnetic recording and electrical charge storage on an insulated surface. The last-named method was chosen for the digital computor now in use at Manchester University† and, in particular, cathode ray tubes were used as the storage medium.

The initial hopes of using ordinary commercially made cathode ray tubes as the storage medium did not materialize. When tried, such tubes were found to have two main defects: (a) random spurious pulses over the screen area (known as "phoneys"), and (b) small total storage capacity. A special tube, shown in Fig. 1, was therefore developed at the G.E.C. Research Laboratories to overcome these disadvantages. This is an electrostatic-deflection tube incorporating an electrostatically focused gun to give a very small spot and a fluorescent-screen storage surface.

In operation, the computor uses the binary scale and the two digits 0 and 1 are represented by charge distributions on the storage surface.‡ These different charge distributions can be established by various techniques, for example, by the spot being either defocused or focused, commonly known as defocus-focus, or by the focused spot being drawn out into a small line, known as the dot-dash system. Although the last-mentioned system was used originally, the reliability of the storage surface was impaired if there were any "phoneys" of amplitude greater than 50 per cent of the initial pulse at the beginning of the trace. The defocus-focus system is now used, and with this it is possible to operate a tube having a much larger amplitude of "phoney" signal.

The display cf these binary digits can be seen on the face of the storage tube since the electron beam is intensity modulated as it scans over a rectangular raster. A dot pattern is thus produced, a typical pattern consisting of 64 rows of 32 dots per row.

As the beam scans over the previously deposited charges on the storage surface, current waveforms are capacitively induced in a "pick-up" plate which is fixed to the outside surface of the storage tube screen. These waveforms are shown in Fig. 2. By strobing, or selecting a particular portion of these waveforms, as in Fig. 2, positive and negative pulses can be made to represent the two binary digits.

To overcome any leakage defects of the fluorescent screen, it is necessary to regenerate the charge pattern at a frequency greater than 5 cycles per second. This is achieved by allowing the amplified output pulses to control the voltage waveforms applied to the modulator and focusing electrodes, while the beam is being scanned. By this means, the information inserted into the storage system can be maintained indefinitely. When the information is required for some other part of a calculation in the computor, the amplified output pulses can be re-routed to the appropriate circuits. It is customary to regenerate and abstract the necessary digits on alternate scans.

The presence of a "phoney" is indicated by a negative signal in the output lead at some random position on the storage surface. If the amplitude of this signal is too large it may be impossible to obtain a positive signal at this particular position during storage, and the tube is therefore unreliable.

It was originally considered that "phoneys" were

† "New Digital Computor," *Wireless World*, August, 1951, p. 333.

‡ Williams, F. C., and Kilburn, J., "A Storage System for Use with Binary Digital Computing Machines, *Proc. I.E.E.*, Part III, No. 40 (March, 1949).

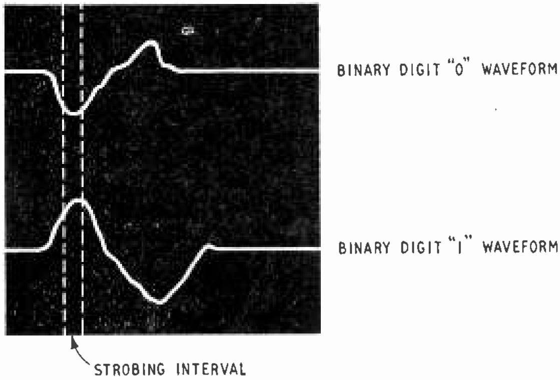


Fig. 2. Showing how positive and negative pulses are strobed to represent binary digits.

* Research Laboratories of The General Electric Company.

due to two factors: (a) particles of carbon from the internal conductive coating settling on the screen, and (b) pinholes in the screen allowing the electron beam to bombard the glass, which has a different secondary emission coefficient from that of the screen. The first of these factors was eliminated by using silver instead of graphite as the internal conductive coating, but the second was shown by experiment to be unconnected with the occurrence of "phoneys." The removal of these "phoneys" has been finally achieved by extremely careful preparation of the phosphor, and by absolute cleanliness while the screen is being deposited and until the bulb with its electrode system is sealed to the pump for evacuation.

In view of the difficulties encountered in preparing good screens, the possibility was considered of using insulated surfaces other than fluorescent powders, but no large-scale investigation into their preparation was made. Although such surfaces, produced by evaporation, would probably have yielded more uniform results, this advantage was outweighed by the desirable property of tubes with fluorescent screens acting as their own monitors and giving a bright display on the screen.

Atmospheric conditions, e.g., humidity, have been known to affect the operation of the tubes if they have been made of low-resistivity glass, such as soda glass. For this reason, high-resistivity lead glass is now used exclusively for the bulbs.

To improve the total storage capacity of the tube it was necessary to reduce the tube spot size. The main methods of achieving this were either to increase the tube e.h.t. or to redesign the electron gun to give an inherently smaller spot without increasing the tube e.h.t. Either of these methods has the effect of increasing the amplitude of any "phoneys" present. An increase in e.h.t., however, would also entail an increase in the voltage required to deflect the beam, so that the redesign of the electron gun was chosen as the best solution. A pentode electron gun is used, the first accelerating anode and second anode (focusing electrode) taking no current, while a small aperture in the final anode allows only a small fraction of the current leaving the cathode to arrive at the screen. The spot size in the redesigned tube operating at 1kV is about 0.3 mm, and approximately 2,000 digits have been stored on the tube face.

The cathode emission life in these tubes should be no worse than in standard commercial oscilloscope tubes. The rate of deterioration of the storage surface under typical operating conditions has not yet been accurately determined but information on this is being obtained from the behaviour of tubes in the Manchester University computor.

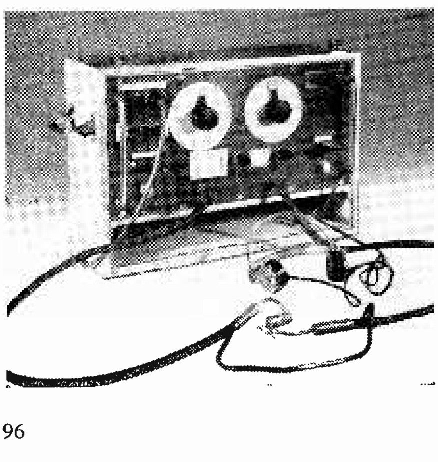
Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

"In-Situ" Impedance Bridge

THIS bridge is intended for measuring resistance and capacitance between 1 Ω and 10,000 MΩ and 0.1 pF and 1,000 μF respectively. It is an a.c. energized bridge with measurements made at 1,592 c/s, a frequency which, with the circuit employed, gives equal sensitivities on the separate resistance and capacitance dials.

E.M.I. Sales and Service "In-situ" impedance bridge Type QD215.



Transformers are used for the ratio arms and an important feature of the bridge is that under most conditions it is possible to measure a component without disconnecting it from adjacent wiring, even though other impedances may be connected in parallel with it. Hence the emphasis in its title on the "in-situ" feature.

When measuring resistance or capacitance alone the dial not in use should be set to zero capacitance or infinite resistance as appropriate, otherwise it may be impossible to find a balance. Balance, incidentally, is indicated by a null in the tone audible in the headphones. With mixed quantities balance on both dials must be effected.

The full range of resistance and capacitance covered by the bridge is divided into nine bands each covering one decade nominally.

Since the first capacitance range is 0.1 pF nominal, the bridge can be used for measuring inter-electrode capacitance in certain types of valve.

The bridge can be operated on an a.c. mains supply or on batteries as required. It contains four valves, two each in the tone generator and the balance detector circuit. Known as the Impedance Bridge (In situ) Type QD215, it is made by E.M.I. Sales and Service, Ltd., Hayes, Middlesex, and the price is £218.

High Temperature Solder

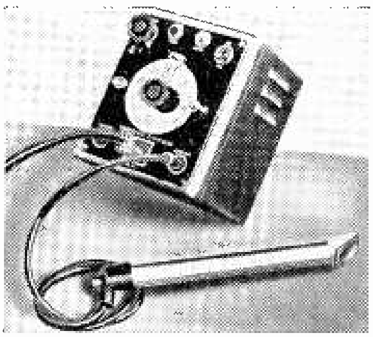
A NEW solder consisting of a tin/lead/silver alloy having a melting point of 296 deg C has been introduced by Multicore Solders for use where unusually high working temperatures may be encountered. Known as Comsol this new alloy has been produced with the co-operation of Johnson Matthey of Hatton Garden, London and as a solder is made in wire of No. 16 s.w.g. with the customary triple core of non-corrosive flux which characterizes this particular make of solder.

Despite the high melting point it is said that a soldering iron can be used if the bit temperature is maintained in the region of 350 to 400 deg C.

It is thought that Comsol solder may be particularly suitable for equipment subjected also to sub-zero temperatures and investigation into this aspect of its use is at present proceeding.

Laboratory Temperature Controller

THE rapid change of phase occurring in an a.c. bridge network at the point of balance is used to give a very quick response in a new electronic instrument for controlling the temperature of water or oil baths. The instrument works on the themostat principle, with a temperature-sensitive resistor to respond to changes of temperature in the bath and a heater to make appropriate corrections to keep the temperature constant. The resistor forms one arm of a 50-c/s a.c. bridge, the output of which is amplified and compared with a reference phase in a phase-sensitive rectifier. In this way the phase changes produced by temperature variations in the bath are arranged to operate a relay, which switches the heater on or off as appropriate. According to the makers, the temperature can be controlled to within ±0.02°C of the working point.



Mullard temperature controller showing the probe unit containing the temperature-sensitive resistor.

By changing the value of the resistors in the "standard" arm of the bridge, the working point of the instrument can be set anywhere within the temperature range 15-75°C. This is done by a four-position range switch. Fine adjustments of the setting are made by a potentiometer control. The overall range can be extended to as low as −50°C or as high as +80°C by using external "standard" resistors in place of the built-in ones.

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

Midget Loudspeaker

THE Elac 3½-in speaker, Type 3/13, is of a kind suitable for many special applications, and seems particularly well suited for use in a communications receiver when space is limited. The magnet is exceptionally large for so small a speaker; it is of Ticonal alloy, and weighs nearly 2½ oz. It provides a flux density of 9,500 gauss.

Midget loudspeakers are not necessarily less sensitive than the larger models at medium and high frequencies; indeed, the reverse can be the case, but their small physical size does impose a limit to the audio output obtainable at the low frequencies without distressing signs of overload.

This model will handle 1 watt, but its high sensitivity gives the impression that a much more powerful speaker is being used. As it is intended primarily for speech circuits the main acoustic output is in the 300- to 3,000-c/s range. There is a tendency to favour the higher speech frequencies, but for communications work this is not necessarily a disadvantage as it enables a little more i.f. selectivity than usual to be used without producing "woolly" speech.

The model used has a speech coil impedance of 3 ohms, but 15-ohm models are available also. No output transformer is fitted.

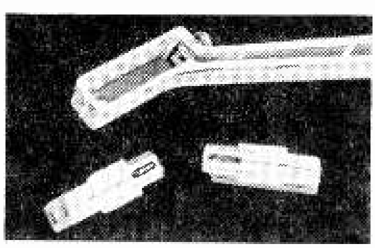
The price of the speaker is 24s 4d including purchase tax and a multi-range output transformer costs 6s 6d. The makers are Electro Acoustic Industries, Ltd., Stamford Works, Broad Lane, Tottenham, London, N.15.

Crystal Pickup

A NEAT combined clamp and contact device ensures rigidity in the mounting of the interchangeable heads used in Ronette "Miniweight" pickups, now distributed in this country by E. & G. Distributions Corporation, Ltd., 33, Tottenham Court Road, London, W.1. In types N50/3 and L50/3 for 78- and 33⅓-r.p.m. records respectively a frequency response up to 7,000 c/s is provided and the price of the arm and two heads is £4 19s 6d. For those with facilities for using a wider frequency range the N50/4 and L50/4 are available at £5 19s 6d with a response up to 14,000 c/s.

Standard and long-playing stylus radii are 0.0025 and 0.001in respectively and the weight on the point is 7.5 gm in both cases. The effective mass at 1,000 c/s is 40 milligrams.

Ronette "Miniweight" crystal pickup with frequency response up to 14,000 c/s.



RANDOM RADIATIONS

By "DIALLIST"

It's an Ill Wind . . .

THERE ARE FEW more interesting achievements than the turning to good account of effects previously regarded as nuisances. One well-known instance is the harnessing of the Miller Effect to do good work in the Miller capacitance reactor valve. Another, even more striking, has been brought to my thrilled ears by a young friend, who recently returned from visiting many of the oil centres of the vast tract which, for some queer reason, we now call the Middle East. A large part of the present region, including Turkey, the Levant and Egypt, used to be the Near East: if they're lumped into "middle," where is the Near East now? Anyhow, the news that interested me came from the Persian Gulf—and that is Middle East beyond all disputing. All wireless folk have theoretical knowledge and bitter practical experience of the evils caused by the polarization of primary cells. Can you think of any effect less likely to be induced to turn over a new leaf and to give useful service? Yet, that is just what has been done with primary cell polarization.

Cathodic Protection

At the oil ports of the Gulf great new jetties have been built and are still building. The material used is steel, which doesn't seem, at first flush, ideal for standing up to the chemical attacks of the warm salt water of the Gulf. Nor would it be, unless something were done about it. That "something" is to make the steel of the jetty the cathode or positive electrode of an enormous primary cell, of which the sea-water is the electrolyte. The anode of this huge cell consists of great chunks of aluminium, which is electro-negative to iron. By providing an external circuit with the right load resistance the cell can be kept permanently in a very high state of polarization, due to the maintenance of a "blanket" of hydrogen bubbles all over the surface of the steel. Consisting as they do of masses of neutral hydrogen molecules, the bubbles give almost complete protection from the effects of chemical action: any hydrogen atom which decides to abandon staid neutrality and to become an active positive ion is re-neutralized by the arrival of an electron from the cathode. The system has one interesting, if rather pathetic, by-product. All round the jetties are masses of motionless fish, all lying facing the anodes. Fish cannot help placing themselves parallel with the lines of force of an electric field which exceeds a certain strength; and they are compelled irresistibly to move away from the cathode.

The Gas Blowlamp

YOU MAY, OR MAY NOT, know the small gas blowlamp, several types of which are in the tool shops now. If you do, you will probably agree with me that, consciously or unconsciously, you have been led by hardy combination of cored solder and small, intensely hot flame to make more and more use of the blowlamp and less and less of the soldering iron. There are some jobs for which an iron is the only thing: you can't, for example, risk letting a flame play about when you're engaged in soldering wiring joints in radio, television or other electronic equipment containing components that are only too easily damaged by heat. Again, there are jobs, such as the tinning of a fairly large surface, for which it is often convenient to use both tools: the lamp supplies the extra heat needed, while the iron enables the solder to be guided over the surface. But for a very large number of sweating, jointing and seaming jobs the blowlamp is the handier and quicker tool.

Types, Uses and Possibilities

The gas blowlamps that I know are of two main types, each of which works *via* a length of ½-inch rubber tubing from a nozzle outlet in the ordinary domestic gas supply. Type No. 1 has a tubular metal body a little over ½-inch in diameter. The far end is closed by a flat disc, near the top of which is fixed a jet ⅛-inch in diameter. With no blowing, this would give a narrow yellow flame about 1½-inches long. Blowing is done automatically by drilling a small hole (No. 80 Morse drill) in the centre of the disc. Gas, issuing from this under pressure, carries air along with it and blows the flame at the orifice of the jet into a hot, blue flame, six inches or so in length. The flame of type No. 2, which has a plastic body and uses a jet based on the Bunsen principle, is smaller, though equally hot. Good as both are, I wish that, besides the standard patterns, which sell at about 4s apiece, there was available a *de luxe* model at, say, 25s. The ideal gas blowpipe is wanted on a heavy, broad-based stand that can't be upset easily; it can be clamped at any height and at any angle required.

Most important of all, the jet is provided with a miniature gas-tap, which enables the length of the blown flame to be reduced to as little as one inch when the occasion arises. I have seen and used such *de luxe* models—in fact *I am* using one. But all these have been made in amateur workshops and I don't know of one that is obtained commercially.

Come On Chaps !

HESITATING and rather feeble legislation always seems to us a pathetic business, particularly when it is admitted on all hands that there is a wrong to be righted and that strong action is long overdue. I am thinking now, of course, of this footling business of making the fitting of suppressors compulsory only on cars delivered after the middle of the present year. Why this tomfoolery—for one can use no milder term? The P.M.G. knows that all vehicles can be suppressed—and cheaply; for all Government vehicles have been fitted with suppressors for some time. There can be no hardship in compelling an owner to spend a few shillings in suppressing a vehicle that cost hundreds of pounds. The P.M.G. can be in no doubt as to what constitutes interference, for the advisory committee told him that. Very many car and lorry owners also have television sets and stand to benefit like everyone else from strict and swift legislation. Nobody wants it to be a matter of 10 or 15 years before snowstorms on the screen and machine-gun volleys from the loudspeaker cease to furnish unwelcome television "effects." Let's stop fooling about and deal firmly with this interference business.

The Buster Box

A FRENCH FRIEND has asked me for the English equivalent of the term *boîte à claquage*, which means literally "buster box." It's the professional (and amateur) jargon name for a continuously variable high-voltage generator, used for testing the dielectrics of capacitors and the insulation of conductors to destruction. I don't know any jargon equivalent in English, though I feel that if there isn't one, there ought to be, for it's so beautifully descriptive. Not one of the many friends that I've asked has been able to help. Readers of *Wireless World* have never yet failed to supply the answer to any query put to them in these notes; so I pass the ball to them feeling sure that if we have such a term I shall hear from them.

UNBIASED | By FREE GRID

Shamateur Radio

THE Editor of the *B.S.W.L. Review*, which is, of course, the official organ of the British Short Wave League, gave us his views in a recent issue of his journal (Dec., 1952) on the vexed question of amateur stations. Unlike the lawn tennis authorities, who are much worried by the free racquet racket by which it is alleged certain amateur players endanger their status, he does not suspect transmitters like myself who use factory-built equipment of clandestine commercial activities.

He makes it quite clear, however, that in his personal view we are mere "shamateurs" although he does not actually say so. If I read between the lines correctly, he takes the same contemptuous view of us as his forebears of twenty years ago did of broadcast listeners, about which I protested in the issue of February 10th, 1933.

Now I am not only an amateur transmitter but also an amateur photographer of some experience and perhaps I may be permitted to draw a parallel. I doubt if a single amateur photographer of to-day uses anything but a factory-built camera, but we would be as ashamed to hand our precious negatives over to the chemist for processing as an amateur transmitter would be to hire a professional wireless operator to manipulate his gear. The aim of us photographers is not to construct our apparatus but to

Shamateur or Superman ?

make perfect our technique and eventually to produce a masterpiece which will make even Sir Alfred Munnings pulverize his palette and put out his brushes for salvage as a preliminary to buying a camera.

I cannot help feeling strongly that exactly the same argument holds good in the field of amateur radio. There is no more shame in using a factory-built transmitter than in using a commercially made camera. My own interest in amateur transmitting is quite frankly the study of wave propagation and not in exercising my mechanical ingenuity.

In my opinion the true shamateurs are those who seem to go on the air solely to discuss personal matters including their YLs and OWs with fellow OMs of similar mentality. Usually these gossip-mongers use factory-built apparatus just as I do, but the reason is not because they are interested in any scientific aspect of transmitting. Their main object, apart from gossiping, seems to be to collect QSOs, and in that respect they are rather like the seaside snapshotter who has no real interest in photography but desires only to collect soot and whitewash monstrosities of Aunt Maria paddling.

There are exceptions, of course, who can take a serious interest in the problems of amateur transmitting and at the same time give a young lady all the attention she needs. I take off my hat to them; they are men indeed.

Heading for Hitlerism ?

THE Postmaster-General does his best by pamphlet and poster to persuade wireless pirates to abandon their evil ways but he words his warnings with lamentable looseness which gives licence to lawbreakers and leaves honest men bewildered. Recently I related how his posters left me completely in the dark about the type of licence required to cover the television set which I have installed in my car for use when parked by the roadside.

Now the P.M.G. has, by another pamphlet, reminded me that I may be on the wrong side of the law with regard to the portable set in my car. I don't nowadays have a car radio fitted as there simply isn't room for it now that I have installed television. Instead I use a portable set when I want to listen to "sound-only" programmes in the car. The P.M.G.'s precious pamphlet emphasizes condition No. 7 on the back of my wireless licence by calling my attention to the fact that my home-set licence only covers the *occasional* use of a portable set in the car (the italics are mine).

Words are funny things, and I daresay many of you know the story of the very literal-minded yokel who was a member of the village choir and wished to name his newly born twins Cherubim and Seraphim because, as he explained to the astonished vicar, they "continually do cry." Like the yokel who thus placed his own interpretation on the words of the *Te Deum*, the P.M.G. may have some special, but unwarranted, meaning of the phrase he uses.

Cherubim and Seraphim ?

"Occasional use" certainly isn't the antithesis of "continuous use" as some folk think, but even if it be taken as such, I break the continuity every time I take it up to bed to enable me to hear Big Ben sound the knell of parting day, if I may misquote Gray. If the correct meaning of use "on some special occasion" (O.E.D.) be taken, is the P.M.G. to decide what is a special occasion *to me* as condition No. 7 on the wireless licence clearly implies ? If so we are indeed heading for Hitlerism, for thought-control is the very stuff of which totalitarianism is made.

Concerning St. Thomas

TELEPATHY can, I feel sure, be explained on a purely radio basis. It is, in my opinion, simply a matter of transmission from one brain to another of electro-magnetic waves. As long ago as June, 1946, I said in these columns that it was as much a question of extra-short waves as is rhabdomancy, concerning which D'Orsay Bell had written in an earlier edition of *W.W.* Of course, I make no claim that my idea is original for in the July, 1945, issue you will find my views anticipated by "Radiophare," a pseudonym which, as stated in the Editor's introductory note to the article, conceals the name of a radio engineer whose identity, I may add, would surprise you.

Neither Radiophare nor myself made any attempt to give the wavelength of thought and I am so far steeped in ignorance that I did not realize that it had long since been measured. In a book published over a year ago, "About Yoga," by Harvey Day, which has only just fallen into my hands, I learn that an unnamed research worker at St. Thomas's Hospital has declared that he has actually *seen* thought waves. Their wavelength was measured on a special "sensitizer" which he invented and was found to be 0.000000003 metre. I will say no more but I cannot help remembering what the patron saint of this hospital is famous for.