Wireless World

MAY 1951 VOL. LVII. No. 5

Questions About E.H.F. Broadcasting

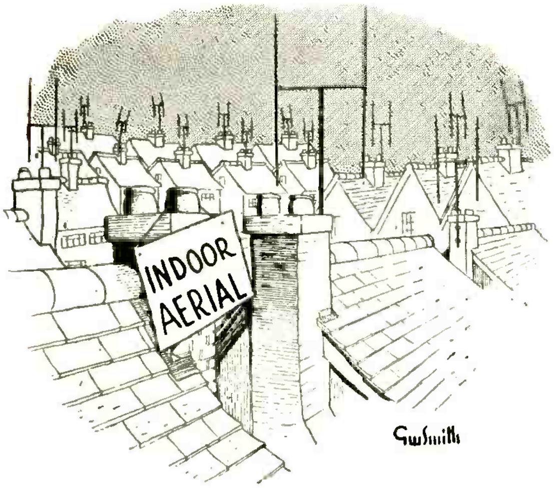
FEW of our readers will quarrel with the opinion that Great Britain cannot be given a full three-programme broadcasting service through the medium- and long-wave channels at present allocated. Even if the frequencies now monopolized by overseas transmissions were devoted to domestic purposes, there would still be some gaps to be filled. We cannot expect more m.w. and l.w. channels and so are forced to the conclusion that the use of extra-short wavelengths is essential for full coverage of these islands. That is why we so warmly welcomed the recommendation in the Beveridge Report that e.h.f. broadcasting should be developed as a matter of urgency. But can the National economy stand a full-dress e.h.f. scheme, or, if it cannot, is it worth while going ahead with piecemeal development? Can the radio industry, with its present commitments in the way of equipment for defence, produce sufficient receivers for public use to justify a start being made at once, and if so, on what scale? If the answer to all these questions is more or less favourable for an early start, we are still left with the over-riding problem as to whether amplitude or frequency modulation is to be used.

The comparative a.m./f.m. tests from the B.B.C. experimental station at Wrotham were, of course, instituted to give the answer to this last problem. Tests have now been going on long enough for conclusions to be reached, but as yet no official statement has been issued. However, the best-informed technical opinion inclines strongly to the view that the decision will be emphatically in favour of frequency modulation. This opinion is based not only on independent observations of the received signals, but also on information published on propagation tests from the Wrotham station. The tests, incidentally, seem to have been highly satisfactory, and to have shown that a modern high-power station on 90Mc/s, working with an effective aerial system, can have a service area that will bear comparison with that of an m.f. station.

As the subject of e.h.f. broadcasting was made a major issue in the Beveridge Report, the B.B.C. announcement on the system of modulation may possibly not be made until the Report is debated in Parliament. In the meanwhile, we will assume it will be f.m., but that does not settle all our problems even if we accept that f.m. is the best distribution system from the strictly engineering point of view. (That must obviously be the basis on which the B.B.C. report will be made.) Broadcasting, however, is at least as much a matter of reception as of transmission, and before we are committed irrevocably, more should be made public on the subject of receiver design, production, maintenance and especially economics. In fact, we encounter a whole new set of questions. What is the relative cost of f.m. and a.m. receivers? Can an f.m. receiver be properly maintained inexpensively and with the equipment likely to be available to the average technician? Unfavourable answers to these questions might swing us back to a.m., which offers at least the theoretical possibility of reception with cheap convertor units working with existing receivers. But can such convertors combine cheapness with adequate frequency stability?

As we see it, the answers to these questions and to many kindred ones that arise can only be given by the radio industry. The B.B.C. has done its part in providing means for a first-class comparison between the relative engineering merits of the competing systems of transmission; the only test of its kind ever to be made on such a large scale. We hope the industry, collectively and individually, will equally come to the fore in providing the reliable data on reception problems without which the final decision cannot be made with confidence.

Although *Wireless World* was at one time highly critical of proposals that seemed likely to saddle this country with an f.m. system of broadcasting before the merits of that system were proved, we are not "pro" or "anti" any particular method of modulation. All we want is to have some established facts to place before our readers, both with regard to transmission and reception. We hope that a detailed B.B.C. report on the Wrotham experiment, and also facts about receiver design and economics, will be made available at the earliest possible moment.



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Indoor Television Aerial

Construction of a Slot Dipole for Reception

By H. PAGE,* M.Sc.

THE expansion of the television service brings with it the prospect of a forest of unsightly aerials sprouting up from chimney stacks in all parts of the country. Is this really necessary?

To obtain satisfactory reception it is essential that the aerial should provide a signal of high strength, free from electrical interference, at the receiver. High outdoor aerials are particularly suitable for this purpose; the strength of the wanted signal increases with aerial height and, in addition, the distance from sources of interference such as motor cars and domestic appliances increases. The high outdoor aerial, preferably made directional to discriminate against the main source of electrical interference, or against local reflections, offers the best solution to satisfactory television reception. The various forms of long wire aerials, and vertical rod aerials with one or more parasitic elements, fall into this class.

Indoor aerials have not previously been considered satisfactory except at short distances from the transmitting station, because they are either relatively insensitive to the signal or do not discriminate against interference. The author has for some years been using a rather uncommon form of indoor aerial, designed to be installed in the loft of a house—the region of highest signal strength indoors. It is in some ways superior in performance to the usual outdoor aerial with reflector installed at the same height, and can be used successfully up to considerable distances from the transmitting station. In view of the rapid growth of the television service and the need to avoid the use of outdoor aerials wherever possible, on aesthetic grounds, readers may be interested to know about this aerial and to decide the potentialities for themselves.

Description of Slot Aerial

The aerial, shown in Fig. 1, consists of a horizontal slot, approximately half a wavelength long, cut in a vertical sheet of conducting material—wire netting is satisfactory—the output leads being connected across the mid-points of the long sides. A horizontal slot responds to vertically polarized waves, maximum signal being received in the two directions normal to the plane of the conducting sheet. No novelty is claimed for the slot aerial, for it has been widely used in the past for the centimetric wavelengths; but, as far as the author is aware, it has not previously been proposed for television reception.

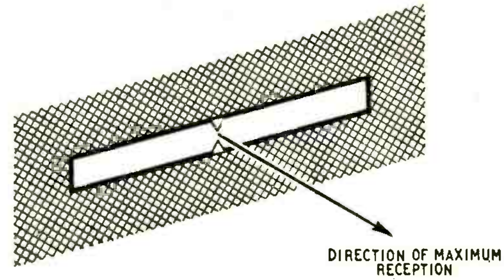
One difficulty about accommodating a vertical rod aerial array in the loft of a house is lack of vertical height. Using a slot aerial, however, space is required in the horizontal direction where it is usually readily available. It is necessary to erect the sheet on the correct bearing, that is, normal to the direction of the transmitting station. However, since the radiation pattern is fairly broad, it is quite satisfactory to have this adjusted to within about $\pm 10°$.

Performance

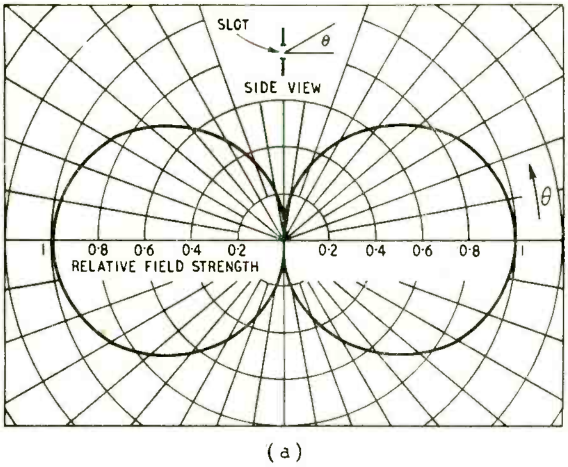
The slot has a figure-of-eight radiation pattern in the vertical plane and a figure-of-eight pattern with small minima in the horizontal plane. These patterns have been measured using a small-scale model, carrying out tests at correspondingly higher frequencies.

Fig. 2 (a) shows the vertical-radiation pattern, this shape being unaltered over the 10 per cent frequency band required for television. Fig. 2 (b) shows the horizontal-radiation pattern, the blocked-in portion indicating the variation over a 10 per cent frequency band. Compared with more conventional aerials the change in directional pattern with frequency is remarkably small, and the minimum is sharper—the

Fig. 1. This sketch shows the general form of the slot aerial.



* B.B.C. Research Dept.



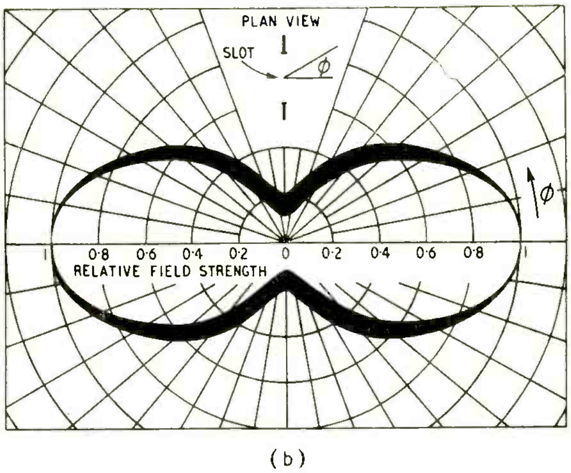


Fig. 2. Vertical (a) and horizontal (b) radiation patterns of slot aerial. The shaded area indicates the change which occurs with a 10% change of frequency.

ratio of maximum to minimum pick-up varies between 14 db and 18 db relative to the main lobe.

Evidently the slot aerial is most suitable for discrimination against interference arriving at right angles to the direction of transmission. As the main lobe is fairly broad it may be worth while to adjust the direction of the slot to reject local interference rather than for maximum pick-up.

It is possible to derive the theoretical gain of the aerial from Fig. 2 (b), making the reasonable assumption that the vertical-radiation pattern does not change with azimuthal angle. The gain over a vertical half-wave dipole is found to be 4 db—a little higher than that of the conventional H-type aerial. Moreover, this gain is substantially unchanged over the working frequency band—a consequence of the relatively small changes in the radiation patterns.

The impedance of the aerial also changes relatively slowly with frequency, being similar to that of a centre-fed dipole of the same shape as the slot.

From the point of view of constancy with frequency of the radiation patterns, gain and impedance, the slot is, therefore, a wideband aerial. The only advantage of the conventional H aerial is that it is a relatively simple mechanical structure, and so can be erected well above loft level. Unless this is done, and advantage taken of the increase in wanted signal strength with height (or of locating the aerial far from the sources of interference), it is difficult to justify the use of an outdoor aerial.

It is interesting to note that, if the slot were cut in an infinite sheet, the ideal case usually considered in theoretical investigations, neither the radiation pattern nor the aerial gain would be as favourable for this application.

Construction

The method of construction of the slot aerial, and the dimensions for the London wavelength, are shown in Fig. 3. The corresponding dimensions for the Midland service are, of course, obtained by scaling in the same ratio as the wavelengths. The slot is 10ft long and 1ft wide in a sheet of wire netting 14ft long and 5ft wide. The slot dimensions are important, but the size of the netting is not very critical, and can be changed if more convenient; a large reduction in size should, however, be avoided. The edges of the slot are bonded with wire to preserve the shape. At the centre points of the long sides, two triangular pieces of metal are fixed, to taper in to the transmission line which connects the aerial to the receiver; the impedance of the slot at the point of connection is approximately 600 ohms. This can be connected through the usual type of balanced transmission line, which has a characteristic impedance of about 100 ohms, directly to the television receiver. It is, however, preferable to match the two impedances, using a quarter-wavelength line transformer having a characteristic impedance of 250 ohms, between the

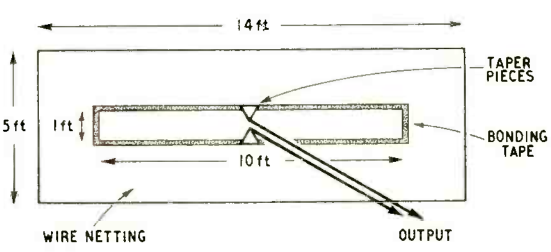


Fig. 3. Dimensions of slot aerial for the London area.

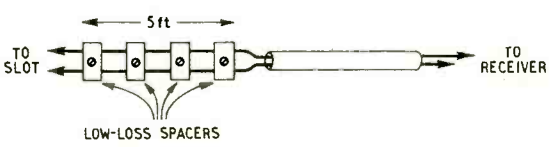


Fig. 4. Quarter-wave matching transformer made by ncreasing the wire spacing at the end of the feeder.

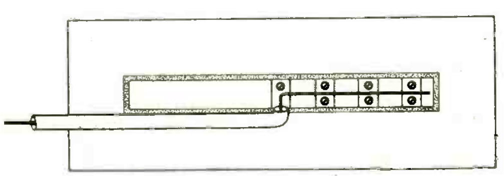


Fig. 5. Method of connecting a coaxial cable to the slot aerial.

slot and the 100-ohm line. Balanced lines of this impedance are available, but a convenient arrangement is to strip back the sheath and screening of the 100-ohm line and increase the spacing between the wires. This is shown in Fig. 4 and the spacing (between wire centres) should be four times the wire diameter, while the length of this widely-spaced section should be a quarter wavelength.

If an unbalanced connection to the slot aerial is required, in order to use a coaxial cable connection to the receiver, a simple modification makes this possible. An open-circuit wire or rod, half the length of the slot and of any convenient diameter, is fixed by insulators, as shown in Fig. 5, and connection is made between either side of the slot and the centre. The impedance in this case is 150 ohms, which is sufficiently near to the ideal for direct connection to the normal unbalanced cable. The latter should run along the slot edge, to which the screen is bonded, and then to the receiver.

Some difficulty may be experienced in handling a roll of wire netting in the confined space of a loft. Strings joining the longer sides of the slot at intervals along its length, and between the apices of the triangular connection pieces, will be found useful in preserving the shape of the slot. If nails are fixed in the rafters and joists, the netting can be temporarily hooked on to them and gradually manœuvred into position. The flatness of the netting is not important, but metal pipes or other conductors near the slot should be avoided.

The author has used this type of aerial at two sites 25 miles and 45 miles from Alexandra Palace; in one case the roof was tiled and in the other slate. At both sites direct comparison was made against an outdoor half-wave dipole at the same height above ground level; a signal gain of approximately 3 db was measured when using the slot, indicating that the loss due to absorption in the roof is negligible. Moreover, in the case of the tiled roof, measurement of the received field strength over a long period indicated no changes associated with weather conditions, which might be expected to affect the absorption. No similar measurements were carried out in the case of the slate roof but the consistency of reception at a distance of 45 miles from Alexandra Palace, apart from the fading normally to be expected at this distance, leads to the same conclusion.

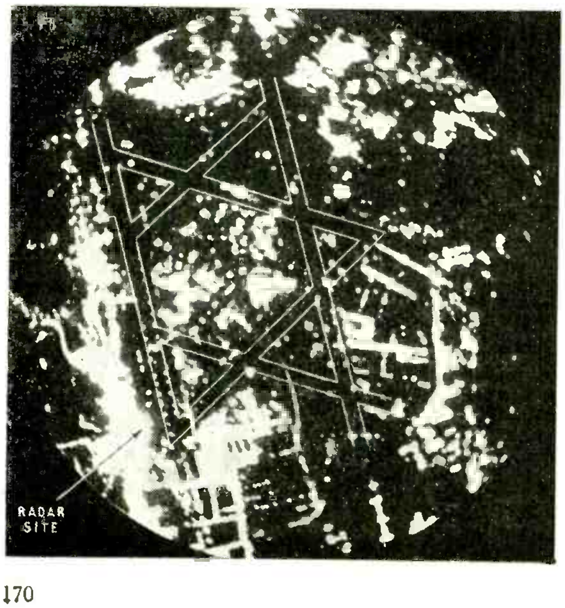
Further improvements of both the radiation pattern and aerial gain may be obtained by using more complicated arrangements, but these will not in general be practicable in the loft of the average house. The simple slot aerial described appears to offer the best compromise between complexity and performance.

AIRFIELD SURFACE MOVEMENT INDICATOR

New Ground Control Navigation Aid

THE majority of navigation aids now in use on the civil airways are concerned with aircraft in flight, but a new equipment recently demonstrated by Cossor Radar at London Airport is primarily concerned with the movement of aircraft and vehicles on the runways and perimeter tracks.

P.P.I. display of London Airport as seen on the screen of the Cossor A.S.M.I. equipment. Runways have been sketched in for easy interpretation.



In the interests of safety it is important that runways be clear of obstructions before any aircraft be permitted to land or take off, and in conditions of poor visibility all parts of the airport may not be clearly visible from the control tower.

The A.S.M.I. (Airfield Surface Movement Indicator), as it is called, operates on a wavelength of 3 cm and uses a curved rectangular scanner measuring 12 ft wide. The "aerial" is a small horn at the end of a waveguide and located in front of the scanner. This, combined with a pulse width of 0.1 microsecond, gives a beam $\frac{1}{2}$ deg only in azimuth and 15 deg in elevation, and very high discrimination is possible.

Display is of the P.P.I. kind on a 15-in c.r. tube. The centre of the radial time base can be shifted to any part of the tube face in order to provide the maximum display area in cases where the A.S.M.I. equipment is located at one corner, or to one side, of the airfield.

With the scanner mounted on the roof of a van the whole of London Airport was clearly displayed on the tube, definition being such that the runway lighting lamps were easily discernible. A small car showed up well and even the driver walking away from the car was noticed by keen-sighted observers.

All buildings are naturally visible as permanent echoes and, as the photograph of the P.P.I. screen reproduced here shows, it would not be easy in this case to pick out a small moving object on one of the runways. It was suggested at the demonstration that the "p.es" be blacked out by means of a positive transparency superimposed on the screen. Moving objects would then be more readily discernible.

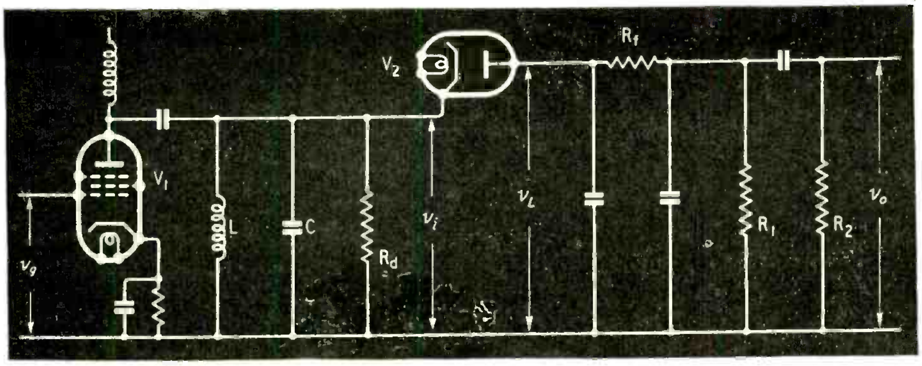


Fig. 1. Circuit of typical diode detector with the r.f. stage feeding it and showing its load circuit.

Diode Detector Distortion

A Common Misconception

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

MUCH has been written about the distortion which the diode detector can introduce when its a.c. and d.c. loads are unequal. The treatment of the effect of the loads is usually incomplete, however, and as a result the importance of the load ratio is often magnified out of all proportion with reality.

The usual analysis shows that there is a maximum depth of modulation which can be allowed in the signal applied to the diode detector if distortion is to be avoided, and that this depth of modulation depends on the ratio of the a.c. to the d.c. loads. This result shows that, for ordinary values of components, serious distortion occurs whenever the modulation depth exceeds some 70–80 per cent. Now, ordinary listening tests show that this serious distortion does not, in fact, occur; very serious audible distortion can be observed with grossly unsuitable component values, but not with normal ones.

There is nothing wrong with the theory on which the expectation of distortion is based. The distortion occurs and is audible if the modulation depth of the signal input to the diode exceeds the calculated value. However, what is usually overlooked is the fact that the modulation depth of the signal applied to the diode is appreciably less than that of the incoming signal. The modulation depth is reduced by the action of the diode circuit itself and the lower the ratio of a.c. to d.c. loads, the more is it reduced. There is an automatic compensating action on the diode input circuit which makes the requirements for the avoidance of distortion much less severe than is commonly supposed.

This beneficial effect of the diode on its input circuit is no new discovery.[1] For some obscure reason, however, it is usually overlooked. It comes about because the diode detector has a lower input impedance to a changing r.f. voltage than to one of constant amplitude. As a result the input tuned circuit is more heavily damped for the modulation than for the carrier; the gain of the preceding stage is lower for the modulation than for the carrier, and so the modulation depth of the signal applied to the detector is less than that of the incoming signal. A finite ratio of a.c. to d.c. diode loads limits the modulation which the detector can deal with without distortion, but at the same time it reduces the modulation depth of the signal applied to the detector. The net result is that the requirements for the avoidance of distortion are much less severe than is commonly supposed.

Consider the diode circuit shown in Fig. 1. With an unmodulated carrier of peak value v_i applied to the diode the steady voltage developed across the d.c. load $R_f + R_1$ is $v_L = \eta v_i$ where η is the rectification efficiency and, for normal conditions, is 0.9 or more. The current in the d.c. load R_{dc} is, therefore, $i = v_L/R_{dc} = \eta v_i/R_{dc}$.

With a modulated input of modulation depth m, the input voltage varies during the modulation cycle from $v_i(1 - m)$ to $v_i(1 + m)$; that is, it changes by $\pm m v_i$ about the unmodulated value v_i. The load voltage correspondingly changes about the unmodulated value $v_L = \eta v_i$ by $\pm m \eta v_i$.

The current must change accordingly, but the current now flows in the a.c. load $R_{ac} = R_f + R_1R_2/(R_1 + R_2)$, so the change of current is $\pm m\eta v_i/R_{ac}$ about the unmodulated value $\eta v_i/R_{dc}$. Since the current through the diode cannot reverse, this result is true only if the change of current during modulation does not exceed the unmodulated current. Therefore we must have

$$\frac{m\eta v_i}{R_{ac}} \leqslant \frac{\eta v_i}{R_{dc}} \text{ or } m \leqslant R_{ac}/R_{dc}$$

This is the relation which is usually employed to compute the capabilities of the detector. Typical practical values are: $R_f = 50\text{k}\Omega$, $R_1 = 220\text{k}\Omega$, $R_2 = 470\text{k}\Omega$. Therefore, $R_{dc} = 270\text{k}\Omega$ and $R_{ac} = 200\text{k}\Omega$. The maximum modulation depth for the avoidance of distortion is, therefore, 0.73.

This is considered poor because, although it is really the maximum depth of modulation at the detector input, it is taken, incorrectly, to be the maximum for the incoming signal.

The input impedance of the detector is easily

[1] "The Properties of a Resonant Circuit loaded by a Complex Diode Rectifier," by F. C. Williams, *Wireless Engineer*, November 1938, p. 600. See also "Radio Receiver Design," by K. R. Sturley, Vol. 1, p. 363 (Chapman & Hall Ltd.).

computed. With an unmodulated signal the power in the load circuit is $(\eta v_i)^2/R_{dc}$. This same power would be absorbed by a resistance $R_{i(dc)}$ shunted across the tuned circuit and would be $v_i^2/2R_{i(dc)}$. The factor 2 arises because the r.m.s. value of v_i is $v_i/\sqrt{2}$. Therefore

$$R_{i(dc)} = R_{dc}/2\eta^2$$

By a similar process of reasoning the input resistance for the modulation is

$$R_{i(ac)} = R_{ac}/2\eta^2$$

Now the amplification of the stage V_1 with an unmodulated input is

$$\frac{g_m}{\frac{1}{r_a} + \frac{1}{R_d} + \frac{1}{R_{i(dc)}}}$$

where r_a is the a.c. resistance of V_1, g_m its mutual conductance and R_d is the dynamic resistance of the tuned circuit alone. For the modulation the amplification is given by the same expression with $R_{i(ac)}$ substituted for $R_{i(dc)}$.

Since $R_{i(ac)}$ is less than $R_{i(dc)}$ the amplification in the second case is less than in the first. This is equivalent to a reduction in the depth of modulation m of the signal applied to the diode compared with that m_s of the signal applied to V_1. The ratio of the amplifications under the two conditions gives the ratio of the modulation depths and so

$$\frac{m}{m_s} = \frac{\frac{1}{r_a} + \frac{1}{R_d} + \frac{1}{R_{i(dc)}}}{\frac{1}{r_a} + \frac{1}{R_d} + \frac{1}{R_{i(ac)}}} = \frac{1 + R/R_{i(dc)}}{1 + R/R_{i(ac)}}$$

where $R = \frac{r_a R_d}{r_a + R_d}$

Inserting the values of the input resistances in terms of R_{ac} and R_{dc}, this becomes

$$\frac{m}{m_s} = \frac{1 + 2\eta^2 R/R_{ac}}{1 + 2\eta^2 R/R_{dc}}$$

Combining this with the earlier formula for the maximum depth of modulation at the detector input we get for the maximum depth in the incoming signal

$$m_s \leqslant \frac{R_{ac}}{R_{dc}} \cdot \frac{1 + 2\eta^2 R/R_{ac}}{1 + 2\eta^2 R/R_{dc}}$$

Now if the dynamic resistance of the tuned circuit, in shunt with the a.c. resistance of V_1, is 200kΩ and we reckon the detector efficiency as 100 per cent, we get for the previous values

$$m_s \leqslant 0.73 \frac{1 + 400/200}{1 + 400/270} = 0.73 \times 1.12 = 0.82$$

This is a very appreciable increase in the maximum modulation depth.

It is clear from the equation that if $2\eta^2 R$ is large compared with R_{dc}, the permissible modulation depth tends to unity irrespective of the actual value of R_{ac}/R_{dc}. In the limiting case of no tuned circuit losses and a valve V_1 of infinite a.c. resistance, the circuit is completely self-compensating and the a.c./d.c. load ratio can be anything without introducing distortion. In practice this cannot be approached.

In order to minimize detector distortion the proper steps can clearly be seen to be:

(1) Make R as high as possible. This entails the use of a valve of high a.c. resistance for V_1 and a tuned circuit of high dynamic resistance. This does not necessarily require a high-Q circuit, for R_d can be made large with a low Q by using a high L/C ratio. Nevertheless, a high Q will usually be an advantage. In practice it will probably be difficult to make R greater than 200kΩ, and it may often be less.

(2) Make R/R_{dc} as large as possible. According to the discussion of this article there is no limit to the extent to which R_{dc} can be reduced. However, not everything about detector design has been considered. It is actually necessary to make R_{dc} and R_{ac} as high as possible compared with the resistance of the diode. Unless this is done a different form of distortion will arise through a gradual curvature of the input-output characteristic and the efficiency will be appreciably below unity. In general, R_{dc} should not be much below 200kΩ for the ordinary diodes, but can be of the order of 100kΩ for the low-resistance types such as the EA50 and 6AL5.

(3) Make R_{ac}/R_{dc} as large as possible. Since this depends on the grid leak R_2 of the following valve, as well as upon R_f and R_1, it involves making R_2 as large as possible. In its turn this depends on the type of following valve. When this is an output valve R_2 can rarely exceed 0.5MΩ, but with a small triode amplifier it can usually be 2MΩ. If it is a cathode-follower or a cathode-follower type phase-splitter the effective value may be 10–20 MΩ because of the negative feedback in this stage.

As an example of what can be done, let R_2 = 2.2 MΩ and fix the filter resistor R_f arbitrarily at 50kΩ. Let R_1 be 100kΩ, and R 200kΩ. Then R_{dc} = 150kΩ and R_{ac} = 145.6kΩ. Assuming further that $\eta = 0.95$ we get

$$m_s \leqslant \frac{145.6}{150} \cdot \frac{1 + (400 \times 0.9)/145.6}{1 + (400 \times 0.9)/150}$$

$$= \frac{145.6}{150} \times \frac{3.47}{3.4} = 0.99 \text{ to slide-rule accuracy.}$$

In conclusion it should be noted that the results given here apply only to a single-tuned circuit coupling between the r.f. valve and the detector. This can, of course, be a transformer instead of the choke-fed arrangement of Fig. 1. The results do not necessarily apply to a coupled-pair of tuned circuits of the band-pass type, however. A similar effect does occur with such circuits but the formulæ given here do not apply to this case.

BOOK REVIEW

Time Bases (2nd Edition). By O. S. Puckle, M.B.E., M.I.E.E., Pp. 387+xxi, with 257 diagrams. Chapman & Hall, Ltd., 37 Essex St., London, W.C.2. Price 30s.

THIS second edition of a well-known book is to be welcomed for the addition of a great deal of information about modern time-base technique.

The most important of the additions are a considerable expansion of the section on linearization, the chapter on Miller-capacitance time bases, and the additions to "Push-Pull Deflection." There is also much new material about differentiating and integrating circuits, simple computing systems, frequency division and counting.

The book is largely non-mathematical. In the few places where a mathematical analysis does occur it is nearly always of quite simple type.

The time bases described are nearly all for electric deflection. Some magnetic-deflection circuits are included but they are much less fully treated. The book provides a vast amount of information about circuits and methods suited to the c.r. oscilloscope. The saw-tooth generators which are so fully treated are, of course, applicable to any method of deflection, but the information about ways of obtaining the current saw-teeth needed for magnetic deflection is meagre.

The book is well produced and few misprints were noticed. It is one which can be confidently recommended to engineers and students alike. W. T. C.

Festival of Britain

Radio Equipment to be shown in the Main Exhibitions

THE aim of the South Bank Exhibition, which will be opened by H.M. the King on May 3rd, is to present a broad review of British practice in the arts, sciences, technology and industrial design. As would be expected, therefore, radio and electronic equipment will be featured in a number of the pavilions. Radio equipment is also included in the Land Travel Exhibition (which visits Manchester from May 5th-26th), the Festival ship *Campania* (visiting Southampton, May 4th-14th, and Dundee, May 18th-26th), and the Exhibition of Industrial Power which opens in the Kelvin Hall, Glasgow, on May 28th.

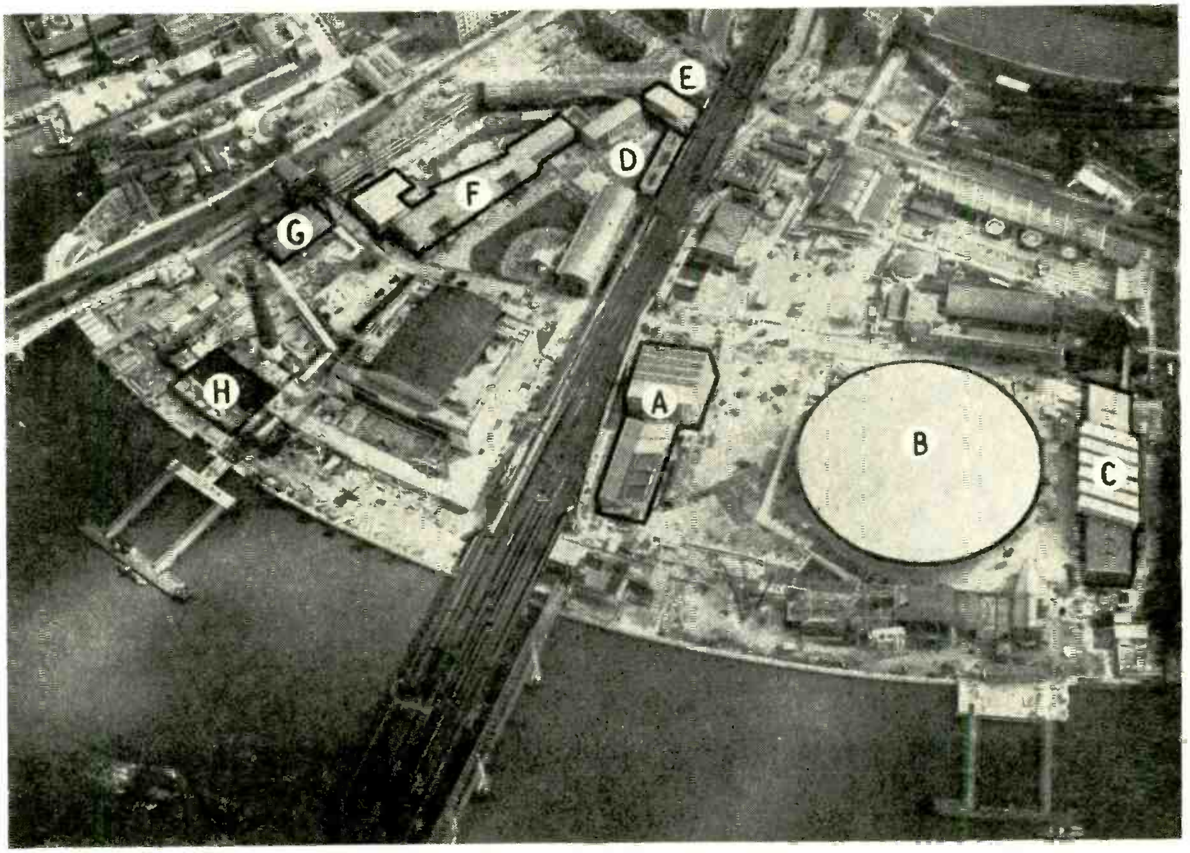
We give below a list of most of the modern radio gear chosen by the Festival authorities for inclusion in the four main exhibitions. In addition a considerable amount of historic apparatus has been borrowed from manufacturers, the B.B.C. and G.P.O. for the Transport Pavilion (South Bank), the aim of which is to give a comprehensive review of British developments in communications.

SOUTH BANK EXHIBITION

Manufacturer	Products
Ardente	Loudspeaking intercom. with loud-hailer.
Audix B. B.	Schools' radio equipment.
Automatic Telephone & Electric Co.	6-channel portable v.h.f. transmitter/receiver, and v.h.f. radio telephone.
B.I. Callender's Cables	Television cable and coupler.
Birmingham Sound Reproducers	Mobile battery amplifier.
British Ferrograph Recorder Co.	Magnetic-tape recorders and reproducer.
Bullers	Aerial insulator for Rugby.
Bush Radio	Television receiver (TUG 24).
Cathodeon	"Photocon" television camera tube.
Central Rediffusion	Radio relay installation.
Cinema-Television	Equipment for Telecinema Cathode-ray tubes and gas-filled photocell.
Cole, E. K.	Airborne search radar; Television receivers TSC 113, TS 114 and TC 140; 4-station "Festival" receiver (A147); and Export radiogram, ARG 90.
Columbia	Records.
Cossor Radar	G.C.A. remote console and airborne "Gee" receiver.
Decca Navigator Co.	Decca Navigator gear and charts.
Decca Radar	Radar display unit (159A) and scanner.
Decca Record Co.	Record player; Long-playing records; Pickup with interchangeable heads; and Mains/battery portable (DD46).
Edison Swan Electric Co.	Apparatus for measurement of the ratio of charge to mass of an electron.
E.M.I.	Studio magnetic-tape recorder (BTR-1B); Battery-operated radiogram.; and Projection television receiver (built in).

(*Continued on following page*)

On this view of the South Bank Exhibition site taken a month before the opening day has been indicated the sections and buildings in which radio and electronic equipment will be exhibited and demonstrated. A, Transport; B, Dome of Discovery; C, Power and Production; D, Television; E, Telecinema; F, Homes and Gardens; G, Schools; and H, Sport, nearby which is the Shot Tower carrying the lattice paraboloid for the "radio telescope." (*Courtesy Aerofilms*)



Manufacturer	Products
Emitron Television	"Emitron," "Super Emitron" and "C.P.S." television camera tubes; Multiplier phototube; Television cameras, microwave link equipment and console monitor for 625-line demonstration; and Hospital television equipment.
English Electric Co.	16-in. glass/metal c.r.t.
Ever-Ready Co.	Tropical receiver, Model "J."
Evered & Co.	"Azdar" rectangular wave guides.
Ferranti	Airborne distance measuring equipment; Airborne "Consol" receiver; Television receivers T1405 and T129; and Broadcast receiver 148.
Fielden (Electronics)	"Tektor" proximity detector.
Films & Equipments	Multi-way connectors for radar.
Fitton, R. N.	Experimental a.m./f.m. receiver designed for the B.B.C.; "Ambassador" receiver 650/CR; and Television set TV.2/TM.
Furzehill Laboratories	Beat frequency oscillator, Model 2232.
Garrard Engineering Co.	Transcription-type turntable (201B/2); Three-speed record changer (RC80); and Single 3-speed record player (M).
General Electric Co.	V.H.F. radio-telephone for railway locomotives; Communications receiver (BRT 400); Fixed-frequency v.h.f. receiver (BRT 186); cavity magnetron; and 900-Mc/s tuned circuit for television relay.
Goodmans Industries	12in. twin-cone loudspeaker "Axiom 22."
Gramophone Co.	Records.
Grampian Reproducers	15-W receiver-amplifier (Model 461); Direct disc recorder; and Sound reproducing equipment.
Hunt, A. H.	Capacitors.
Industrial Radio Co.	Marine receiver "Consol 66."
International Marine Radio Co.	Medium-wave telegraph transmitter (IMR. 51); Short-wave telegraph transmitter (IMR.53); Emergency marine transmitter (IMR.61); Radio-telephone transmitter/receiver (IMR.43/36); Marine communication receiver (IMR.42); Auto alarm (IMR.28); and Emergency receiver (IMR.60).
Invicta Radio	Mains/battery portable (Model 550).
Johnson Matthey	Waveguides.
Kelvin & Hughes	Waveguide assembly.
Kolster-Brandes	Broadcast receivers FB10 and FR10.
Marconi Instruments	Universal bridge, TF868; Output power meter, TF893; and moisture meter, TF874.
Marconi International Marine Communication Co.	Marine direction finder; Radar scanner; and Lifeboat radio equipment (Type 110A).
Marconi's Wireless Telegraph Co.	Components for universal racking system developed for British aircraft radio; v.h.f. portable simplex telephony transmitter-receiver (H.19); Airborne h.f. transmitters (AD.107) and h.f./m.f. receivers (AD.94); Automatic d.f. receiver (7092A); Marconi-B.C.C. mobile v.h.f. simplex transmitter-receiver; Hand microphone; and Marconi-Brown telephone headset.
McMichael Radio	Portable receiver.
Metropolitan-Vickers	Marine navigational radar.
M.S.S. Recording Co.	Cellulose Nitrate coated recording disc; and Twin channel direct recorder.
Muirhead & Co.	"Mufax" facsimile receivers and "Mufax" picture monitor.
Mullard Electronic Products	Miniature valves; Radar-sonde transponder; and Broadcast set (MAS277).
Murphy Radio	Television receivers V150 and V176; Baffle console receiver; Portable mains receiver (U144); Export receiver (A.160); Radiogramophone (172); and Apparatus demonstrating the waveform of a chosen line from a television picture.
Parmeko	Monitor loudspeaker unit for the B.B.C.
Philco (Overseas)	Radiogramophone "Richmond."
Philips Electrical	Television receiver (385U).
Plessey Co.	Motor cycle radio-telephone equipment; and components.
Pye	O.B. television camera; Television studio control and monitoring equipment; Fixed station v.h.f. transmitter/receiver; Broadcast receivers A.39J, 49 and a portable; Export radiogramophone (PE39RG); and Television receiver (BV30).
Radio Gramophone Development Co.	3-speed radiogramophone (1O46G3).
Radio Heaters	R.F. induction heater.
Redifon	Trawler direction-finding loop (DFL 5); 100-W marine transmitter for m.f. telegraphy and h.f. telegraphy/telephony; Marine d.f. receiver (R81); General purpose marine receiver; Emergency receiver (R55); Trawler control unit and speech amplifier (RC.12/A 137); and Remote control unit for v.h.f. equipment (RG 20).
Roberts' Radio Co.	Portable receivers.
Salford Electrical Instruments	Radio-sonde balloon transmitter and ground station.

Manufacturer	Products
Sargrove Electronics	Photo-electric automatic mechanism for sorting and batching.
Scanners	Microwave generator and receiver.
Simon Sound Service	Domestic tape recorder.
Sound Sales	Schools' trolley equipment (A/12).
Standard Telephones & Cables	Single-ended 160-kW water-cooled triode (3Q/331E); Time-sharing multiplex radio-telephone link terminal (D.P.1.); 140-channel v.h.f. transmitter-receiver (S.T.R.12); Instrument landing system receivers, localizer and marker beacons; Remote console for G.C.A.; Cathode-ray engine indicator; and Portable battery chargers.
Stratton & Co.	"Eddystone" receivers 680 and "All-World Six."
Telegraph Construction Co.	Polythene cables and micro-wave components.
Ultra Electric	Communication control equipment (UA.17).
Union Radio Co.	Automatic ionospheric recorder.
Vidor	Portable receivers CN396 and CN411.
Vitavox	Hand microphone (B50).
Walter's Electrical	Morse Key (Type 5KK).
Whiteley Electrical Radio Co.	Loudspeakers 50/6C and 50/5C; Sectioned model of "Stentorian" 12in. Concentric duplex loudspeaker; and Radio-sonde balloon transmitter.

LAND TRAVEL EXHIBITION

Advance Components	Signal generator, Model E.
Allan, Richard, Radio	Loudspeaker ("Baby Bafflette" 660).
All-power Transformers	Power supply unit (1120).
Amplivox	Headphones (Type 1900).
Automatic Coil Winder Co.	25-range Avometer.
Bush Radio	Portable (BP10).
Cole, E. K.	"Ekco Princess" portable and pencil soldering iron.
Decca Record Co.	Mains/battery portable, DD46.
E.M.I.	Absorption wavemaker.
Fitton, R. N.	Corner console television (TV2/CR).
Henley's	"Solon" soldering irons.
Imhof, Alfred	Television screen surround, for building receiver into wall.
Kolster-Brandes	Television receiver (EV.30).
Labgear	Low-power high-stability oscillator.
Metropolitan-Vickers	Miniature oscilloscope, Type 244.
Multicore Solders	"Ersin" Multicore solder.
Motor & Air Products	Television enlarging lens.
Panda Radio Co.	Rotary dual 20/10-metre aerial array, mounted on steel tower.
Q-Max (Electronics)	Communications receiver (Q5/10X).
Reslosound	Ribbon microphone.
Roberts' Radio Co.	Portable receiver.
Romac Radio Corp.	Personal receiver (236).
Standard Telephones & Cables	Cross section of polythene insulated co-axial cable.
Stratton & Co.	Communications set "Eddystone" 750.
Telegraph Construction Co.	Co-axial feeder cable and Selsyn cable.
Teleradio	100-watt amateur transmitter.
Universal Electronic Products	Tuner units.
Walter's Electrical	Morse key.
Webbs Radio	Great circle map.
Whiteley Electrical	Loudspeakers.

"CAMPANIA" FESTIVAL SHIP

Ace Radio	Broadcast receiver (33).
Decca Navigator Co.	Decca Navigator.
Decca Record Co.	Long-playing records; Dual-speed "Deccalian" record player; and "Double Decca" portable.
Gramophone Co.	H.M.V. television receiver (1807A).
Kelvin & Hughes	Marine radar equipment (Type 2).
Marconi Instruments	Moisture Meter TF933.
Marconi International Marine Communication Co.	"Oceanspan" telegraphy transmitter; "Reliance" medium-wave telegraphy transmitter; "Electra" and "Mercury" receivers; "Lodestone" direction-finding equipment; "Oceanic" broadcast receiver; and "Vigilant" auto-alarm.
Murphy Radio	Television receiver and component parts; Portable (B.165); and Export set (152).
Pye	Export receiver (PE.37).
Redifon	Marine communications receiver (R.30).
Thorn Electrical Industries	"Ferguson" broadcast receiver (208U).

KELVIN HALL, GLASGOW

Cinema-Television	Industrial electronic metal detector.
Ferranti	Broadcast receiver (248).
Kelvin & Hughes	Demonstration of marine radar using simulated signals from a model.
Marconi	Marine d.f. equipment and echometers.
Murphy Radio	Broadcast receiver (168M).
Radio Heaters	Portable short-wave therapy unit.
Redifon	7-kW r.f. induction heater (IH.39).

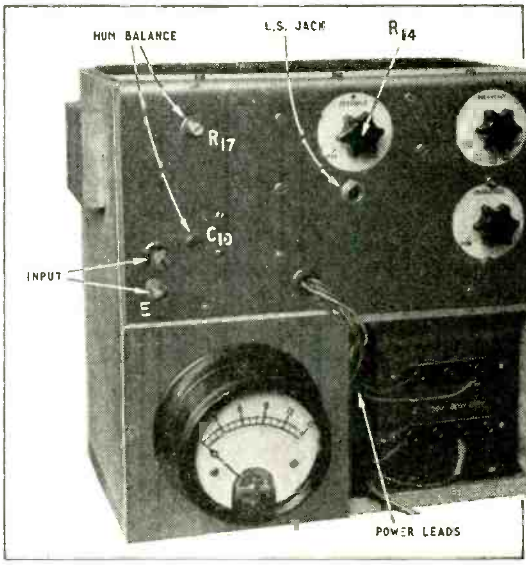
Sensitive Null Detector

Selective A.F. Bridge Amplifier Giving Visual and Aural Indication of Amplitude Variation over 10μV to 10V Range Without Manual Gain Adjustment

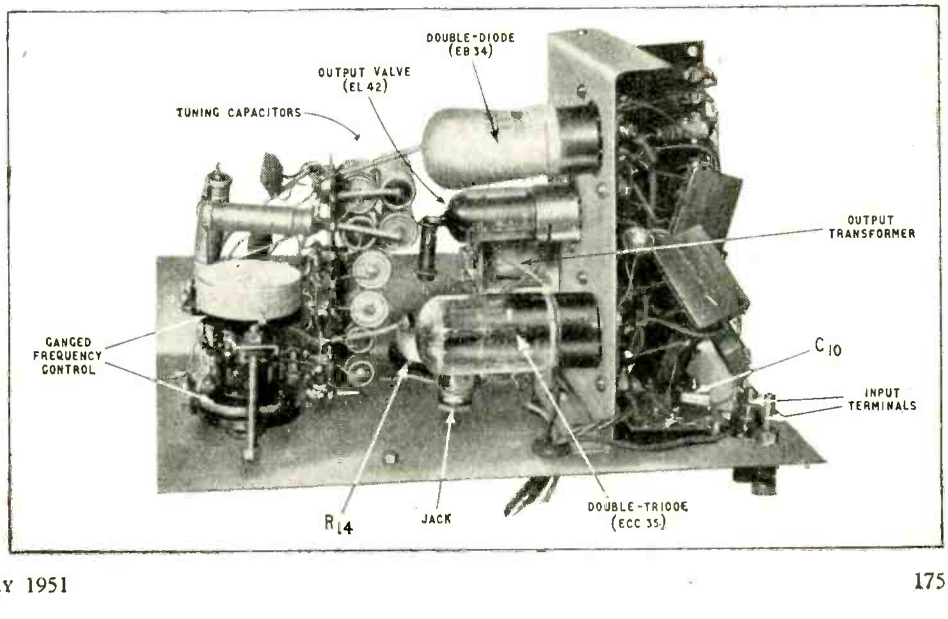
By M. G. SCROGGIE, B.Sc., M.I.E.E.

THE usual instrument for detecting the balance point in bridges and other null systems of measurement is a pair of phones. It is a simple and inexpensive device, and, in conjunction with the human ear, is a quite remarkably sensitive detector of a.f. currents in the frequency range around 1,000 c/s. Its limitations emerge, however, when it is necessary to perform measurements at much lower or higher frequencies, or in noisy situations, or with great accuracy. The combined sensitivity of phones and ear at, say, 50 c/s is so poor as to be practically useless, and it becomes necessary to substitute a visual detector preceded by amplification. A surprisingly small amount of background noise is sufficient to put phones out of effective action; and in really noisy places no amount of amplification solves the problem, for the "threshold of pain" intervenes; again, a visual indicator is necessary. Even in a haven of quietness, and at the most audible frequencies, it is not always possible to detect the null point with phones so precisely as to reap the full benefit from highly accurate bridge standards. A standard accurate to 0.05 per cent is hardly worth having if one cannot estimate balance within a ±0.2 per cent range of its scale. Again, amplification is needed.

It is easy enough to make up an amplifier, but if it is just any amplifier it will certainly not be an unmixed blessing. The lower levels of signal that can be explored by it are likely to be obscured by hum. Even if the wave form of the signal source is beyond reproach, harmonics are generated in the bridge itself when measuring iron-cored components. Until one is somewhere near balance, the amplification is a positive nuisance. A manual gain control is a partial solution, but is one more knob to adjust, and the shock of accidentally going right off balance when



Above : Complete unit, with amplifier in top half and power unit and balance indicator below.



Amplifier chassis of the detector unit.

maximum gain is in force is unpleasant, to say the least. Automatic gain control does not necessarily solve the problem, because the range of signal that may have to be handled is so large that when flattened out enough to be easy on the ear it becomes very difficult to tell whether adjustment of the bridge is bringing one nearer balance or farther off.

The object of the design to be described was to provide ample sensitivity free from all these drawbacks, over the widest possible range of measurement. It was considered necessary to be able to tune the detector to at least 50 c/s and 1,000 c/s, and preferably also to 400, 796 (i.e., $2\pi f = 5{,}000$) and 1,592 ($2\pi f = 10{,}000$). The effective range of signal input was to be about $10\,\mu$V to 10 V, without manual adjustment. This obviously meant a.g.c., and to keep the amplifier sensitive to *changes* of amplitude over such a range it was decided to give it a time constant such as to indicate the direction of change by a transient effect, at any point on its characteristic. Visual indication was clearly a necessity, but as it is usually preferable, whenever possible, to keep one's eyes on the bridge adjustments, use of loudspeaker or phones should also be available.

A cathode-ray tube has the special qualification as a visual indicator that if great care has been taken to avoid phase shift in the amplifier at any of the working frequencies it is possible not only to observe changes in amplitude but also in phase, and thereby to tell whether it is resistance or reactance that most needs adjustment in order to reach balance. The gain required to give a really sharp balance indication on a c.r.t. is very large, however; and its minimum to maximum range of indication is limited. The requirements laid down are difficult to combine with absence of phase shift, and the apparatus as a whole would be elaborate and expensive; so the c.r.t. system was rejected.

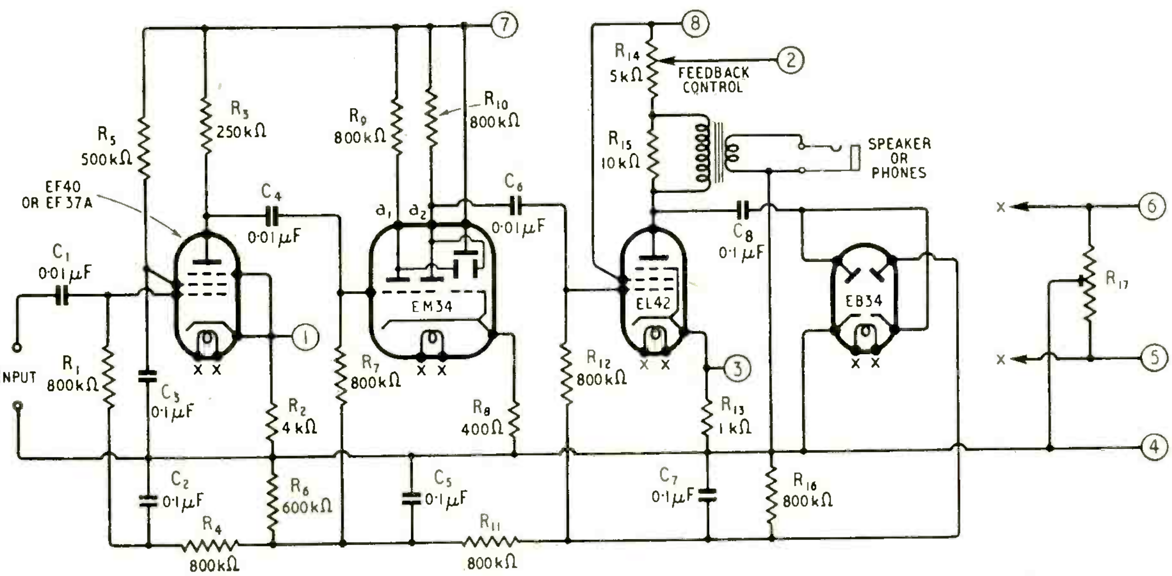
A simpler, smaller and more sensitive visual indicator is the "magic eye" and as a further economy the triode section can be used as a voltage amplifier to drive the output valve needed to work a loudspeaker and provide a.g.c. and tuning facilities. By the time an entirely satisfactory design had been produced along these lines it suddenly became apparent that the milliammeter which was being used to monitor the output valve was much more clearly visible than the tuning indicator, and at the present time is obtainable at a lower price—accuracy being completely unimportant. So an alternative design was developed accordingly. Since there may be reasons for preferring the "eye" in particular cases, or in other ways of varying the details to fit in with items in stock or special requirements, both circuits are given here, and the accompanying comments are devoted mainly to pointing out where departure from them brings trouble and where it does not.

Three-unit Circuit

To simplify the diagrams, the tuning circuit is shown separately (Fig. 3), and so is the power unit (Fig. 4). Any power unit capable of supplying the necessary heater current for the valves and about 14 mA at 250 V will do, provided that the smoothing is reasonably good and the output impedance is kept fairly low by not less than about $32\,\mu$F.

The circuit of the "eye" type amplifier is shown in Fig. 1. The EM34 indicator has the particular advantage of two "scales," one of about $4\frac{1}{2}$ volts and the other of about 15, which helps it to cover the full signal range effectively. It may be worth mentioning, however, that within a rather narrower range a 6E5 worked reasonably well. In the output stage the octal-based EL33, on account of its high gain, was especially suitable. It is now on the replacement list, however; the B8A-based EL41 is electrically equivalent for this purpose, and is physically much smaller.

Fig. 1. "Magic eye" version of the bridge amplifier. The indicator valve (EM34) serves also as a voltage amplifier to drive the output valve. The amplifier as shown here has a nearly flat frequency characteristic, but with the frequency-discriminating feedback circuit (Fig. 3) connected to points 1-4 it can be tuned over selected frequency bands. Points 4-8 are connections to the power unit (Fig. 4). A voltage-doubler rectifier provides a.g.c. bias, which also operates the indicator.



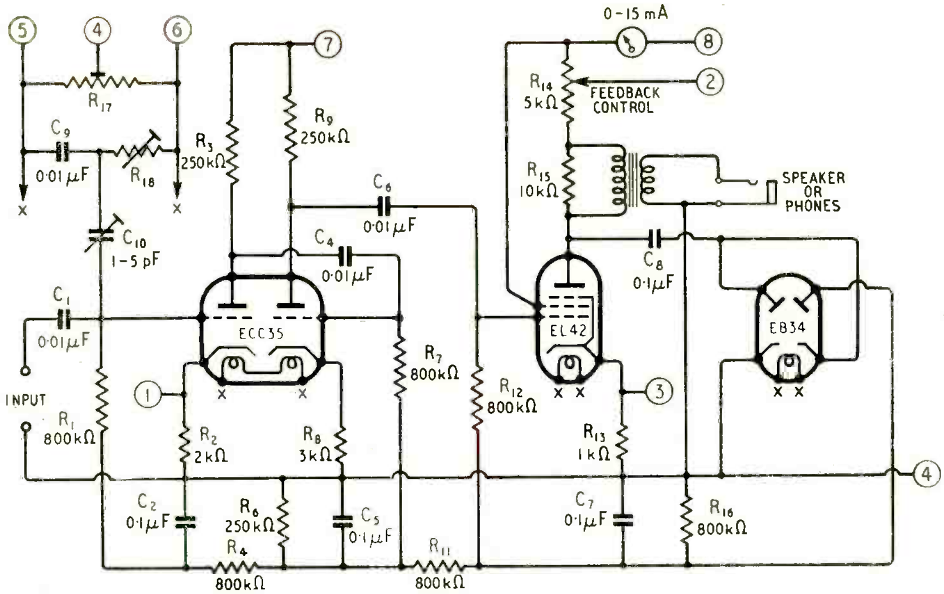


Fig. 2. Alternative version of the amplifier, with a milliammeter in the output stage as indicator. Components corresponding to those in Fig. 1 have the same numbers. The pre-set components in the top left corner are for enabling full gain to be used in the 50 c/s band without mains interference.

A still smaller valve, taking far less heater current (0.2 A instead of 0.7 A) is the EL42; and for these reasons it was used, with some slight sacrifice of performance.

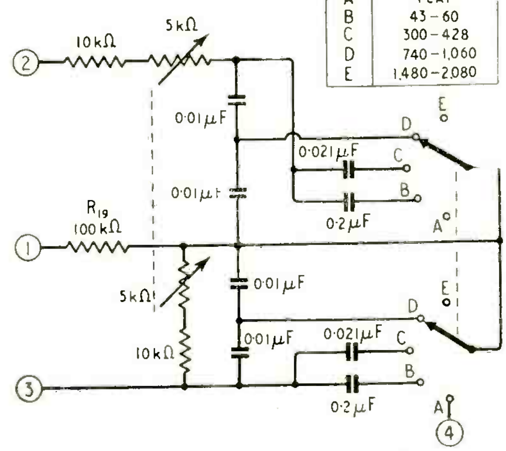
A suitable octal first-stage valve for low noise and hum is the EF37A; the B8A equivalent is the EF40. Almost any double diode can be used for the a.g.c. rectifier. A pair of Westectors worked quite well, but with some loss of sensitivity, and possible risk owing to the high peak voltages liable to appear, so were not retained; and the germanium diodes obtainable were rather too low in backward resistance.

When the signal level is large, so that the valves are nearly cut off, the output waveform is a negative-going pulse, which is largely ineffective for producing negative a.g.c. bias if a single diode is used. The voltage-doubling circuit shown uses this pulse and greatly improves both sensitivity and a.g.c. characteristics. It will be noted that in the "meter" circuit (Fig. 2) there is the minimum of time-delaying smoothing between this rectifier and the grid of the output valve, the object being to secure a momentary upward or downward indication on the meter whenever the bridge is adjusted, before the bias has time to reach the previous stages and make the a.g.c. fully effective. In the "eye" circuit the indicator is necessarily the second stage, so the visual "transient" is not quite so marked, though of course the audible effect is the same.

At frequencies of 50 c/s and below, one has to provide against feedback via the a.g.c. line causing slow oscillation. To avoid having to make the a.g.c. unduly sluggish, it was necessary to cut down C_4 and C_6 to 0.01 µF, causing the increase in feedback at low frequencies to be offset by a decrease in gain. It was for stability, too, that it was found desirable not to make use of the extra gain that could be obtained by transferring C_6 to a_1.

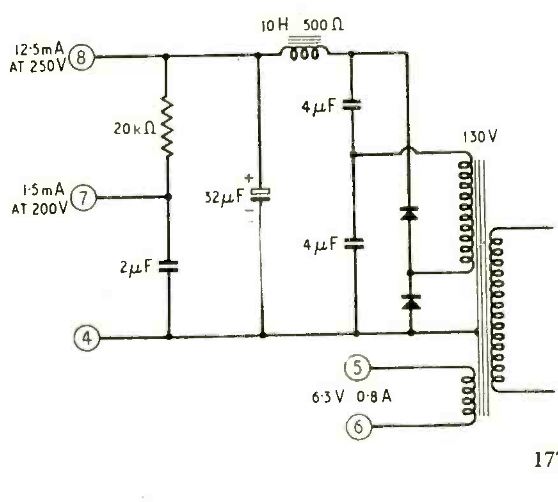
The frequent choice of 0.8 MΩ was occasioned by an ample stock of that value; there is no reason to suppose that substitution of 1 MΩ throughout would have any drastic effect. One resistor whose value really is critical, however, is R_6. It controls the shape of the a.g.c. curve; and to obtain a satisfactory sensitivity to small signals, combined with a steady

BAND	FREQUENCY (c/s)
A	FLAT
B	43–60
C	300–428
D	740–1,060
E	1,480–2,080



Above: Fig. 3. Tuning circuit covering four selected frequency bands as an alternative to a flat characteristic. Typical selectivity curves shown in Fig. 5.

Below: Fig. 4. A suitable power unit. The centre-tapped voltage-doubler selenium rectifier is rated at 260 V, 30 mA output.

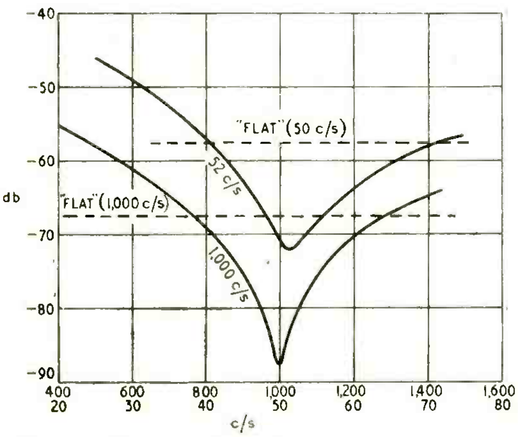


slope and no reversal at large signal amplitudes, it is advisable to ascertain the best value by using a variable component initially.

So effective is the a.g.c. that a manual gain control was omitted, but if the bridge introduces a large amount of hum it is desirable to shunt the input by the lowest resistance that leaves sufficient signal; for the selectivity is effective only at low signal inputs, so can be swamped if the interference level from the bridge is substantial.

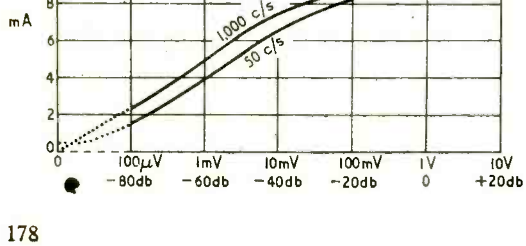
Direct connection to the detector terminals of the bridge necessitates one of them being "earth." The modern trend is towards T networks and inductively coupled bridges, in which both source and detector can be earthed, but where this is not the case and it is necessary to connect one of them through a suitably screened transformer it is generally simpler to make it the source, as a detector transformer may need a Mumetal screen in addition, to exclude hum.

Seeing that audible indication is not primarily relied upon in the 50 c/s band, there is hardly any limit to the cheapness of the output transformer that can be used. Its impedance at the higher frequencies is limited by a 10 kΩ shunt, so that the signal current through R_{13} and R_{11} does not vary widely with frequency. It should be noted, however, that the step-



Above: Fig. 5. Selectivity curves at two spot frequencies, with the feedback control at a stable setting, showing input required to give 1.5 mA deflection. Decibels are reckoned from 1 volt as zero. The "flat" gain in the 50 c/s band is deliberately less, to avoid instability via the a.g.c. line.

Below: Fig. 6. Automatic gain control curves, showing downward deflection of meter in the Fig. 2 circuit. With either circuit R_6 is the critical component in determining the shape of these curves. Note that the slope is rather steeper for small signals, where it is needed to give clear indication near balance. Hum interference caused a small deflection with zero input at 50 c/s.



down ratio should be quite large (say 90:1 for a 2-Ω speaker) to minimize the effect of loudspeaker connection on feedback and frequency. The voltages across R_{13} and R_{11} provide negative and positive feedback respectively when a fraction of them is applied to the cathode of the first value via R_{19}. The Wien frequency-selective system (Fig. 3) causes negative feedback to prevail except at and near the frequency to which it is "tuned," when the feedback is positive and can be adjusted close to the oscillation point by R_{14}. As Fig. 5 shows, the sensitivity at the chosen frequency can be increased up to about 20 db, and decreased substantially at frequencies well off tune, giving a very useful discrimination against harmonics and bridge noise.

These curves, and the a.g.c. characteristics in Fig. 6, although very similar for the "eye" circuit, actually refer to a "meter" type unit. Since this does not require the cathode-ray valve, the same amount of gain in the first two stages can be obtained more economically by using a double triode, provided that it has a sufficiently high μ. The ECC35 is just about right, but other types can be used if a smaller gain is acceptable.

Use of a double triode introduces one disadvantage to set off against a certain amount of simplification and economy; in all of those tried there was a substantial amount of hum—of the order of 1 mV under working conditions—due apparently to internal capacitance between heater and grid leads. It could not be suppressed sufficiently by the usual potential divider only (R_{17}) and seriously reduces the usable sensitivity in the 50 c/s band. It is true that the beat effects can be removed by using the mains also as bridge source, but, thus hidden, the hum is even more undesirable, because in general it causes an apparent balance which is off the true balance and so leads to errors in measurement.

At the cost of a little elaboration the hum can be balanced out if R_{17} is supplemented by a phasing device consisting of C_9, R_{18} and C_{10}. The latter component is a pre-set capacitance of a few pF (say 1-5) and R_{18} can either be a pre-set variable, or fixed after the correct value has been found by trial with a variable. These adjustments can be made very precisely by feeding in rather less than a millivolt of signal at about 52 c/s and adjusting for minimum slow beat.

Tested on a wide variety of bridges, the amplifier has proved its worth. It is particularly valuable for measurement of inductance, giving a really sharp balance under conditions where 'phones are practically useless. The irritation of having to wait until each incredibly slow aircraft has gone is completely removed, and it is a great pleasure to be able to do anything to the bridge without fear of one's ears being shattered. With the selectivity in use, discrimination against harmonics is so effective that the source can be switched from "Sine" to "Square" almost unnoticeably.

It is, of course, essential to enclose the amplifier (excluding the power unit) in a screened box, and the grid input lead from the bridge must be screened. For the indicator in the Fig. 2 version the largest available milliammeter was obtained (actually an ammeter with the shunt disconnected) and the original dial replaced by a blank one marked as boldly as possible with arbitrary scale divisions so that the movements of the pointer can be seen easily without having to be close to it.

LETTERS TO THE EDITOR

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

Valve Symbols

IN the January issue of *Wireless World* "Diallist" regrets that the preamble to BS1409: 1950 suggests that the valve symbols contained therein "are intended for use mainly in manufacturers' catalogues and such like," whereas he would vastly prefer that they should be adopted by "all British writers, teachers, . . ." etc.

Now this is a very laudable ideal, but is unfortunately impossible of fulfilment. The main reasons for this state of affairs are, I would suggest:

(1) The symbols are intended to cover nearly all the contingencies which can arise in the specification of multi-electrode valve parameters and are, on that account, somewhat complicated, double suffixes being very common. Multiple suffixes are the very devil in printing and duplication processes and few teaching establishments could cope with the preparation of literature using such symbols.

(2) The symbols are specifically designed to define the characteristics of any single valve. However, we must, of necessity, use the valve with its fellows and it is here that the difficulties of the system are most apparent.

For example, if we consider the problem of describing the passage of a signal through a multi-stage amplifier in terms of the circuit parameters, we would be mainly concerned with control grid and anode voltage variations. In such a description we would normally define a system of symbols; e.g., let voltage on grid of V_1 be v_{g1}, let voltage on grid of V_2 be v_{g2}, and so on.

If, however, we use the B.S. symbols we must resort to the clumsy device of specifying the particular valve on each occasion; thus v_{g_1} of V_1, v_{g_1} of V_2, etc.

(3) It is almost impossible to use the symbols algebraically in the derivation of an expression. To prove this conclusively, it is only necessary to apply the symbols to, say, the determination of the unbalance expression for a see-saw phase-splitter or to the operating equations of a sanatron time-base.

(4) My personal grudge, from a teaching point of view, is that it is no longer possible with this system to speak unambiguously of "the R_a of the valve"; in oral teaching it becomes necessary to distinguish between the a.c. resistance and the external load.

The introduction of a standard system of symbols for specification purposes is itself a major advance which will be welcomed by all right-thinking electronic engineers. If, however, the system is called upon to shoulder a burden for which it was never designed, we run a grave risk of obscuring its undoubted merits for its original purpose.

The B.S. Committee is therefore quite right to place a restriction on the recommended applications of the symbols.

At Sea. E. JEFFERY.

American Insularity

HAVING recently had the opportunity of several discussions with American engineers and technicians in the electronic field, I was particularly interested by the recent letter, by A. T. Colbeck, in the November, 1950, issue. In most of these discussions I was surprised by the small extent to which our trans-Atlantic colleagues were aware of British efforts in the fields of radar and telecommunications. Investigation showed, however, that this could in no wise be attributed to insularity on the part of the individual but rather to the lack of information presented to him during his perusal of technical literature. Indeed, individuals to whom I spoke were only too ready to give praise, where praise was due, to that British work with which they were familiar.

This state of affairs has arisen, in my opinion, by virtue of the high degree to which America has cultivated the art of advertisement. By comparison, articles dealing with our own progress, published in the technical press of the United States, stand a good chance of being overlooked. Let us hope that the advent of the Festival of Britain, together with the 1951 Radio Exhibition, will do much to change the position. A. CRIBB.

R.E.M.E., Korea.

I AM an Englishman living in this part of New York, and I think that you might be interested in an experience which I had last night. I took my small boy's radio in to my local dealer, for overhaul. The repairman worked on it, and we chatted together. He told me that he was in London during the war, and that he was a subscriber to *Wireless World*. The talk got on to international relations, and we agreed how much better it would be if the papers of our two countries stopped criticizing so much, and gave each other a little credit for our accomplishments, whatever they may be. By that time he had finished with the set, and had put in a new valve, but he refused to take any money for what he had done. "Chalk it up to international relations," he said. That, I would like to say, is the spirit that is needed in these days, not only between our two countries, but, between all countries. I would like you to print this letter, if possible, not only to increase mutual understanding, but to let him know, when he reads it, that his action, and the thought behind it, was not unappreciated.

TERENCE R. BOND.

East Meadow, New York, U.S.A.

[This letter seems to sound a note on which correspondence on this subject may appropriately be closed.—ED.]

Radio in the Jungle

I HAVE read the interesting article by "Pronto" in the February issue and agree with the fundamentals. During the last war I was engaged on communications of this kind in India and Burma, when it was clearly evident that no existing military sets were suitable for the task. Either the lightweight sets had very reduced range, especially on R/T, because normally speech is not required to have long range, or the larger sets could have met the requirements for signals, but were too heavy to be used in the field.

Efforts were made to provide special sets for this purpose associated with hand generators; these generators which had h.t. and l.t. windings, providing d.c. up to 70 watts total, were found suitable, particularly for transmitting. A type GN58 manufactured with regulator for the American Signal Corps was satisfactory and weighed about 30lb, made up of:—generator 22lb, legs, cranks, etc., 8lb. Although this is fairly heavy it compares favourably for life, weight and volume with equivalent power derived from dry batteries, which are not reliable under tropical conditions. While it is agreed that pedal generators are fatiguing after a day's march, it is relatively easy for two people to turn the hand generator—one on each handle. Also the hand generator could be clamped to a tree at suitable height. It is felt that serious consideration should be given to the design and use of this source of power.

Concerning the aerials for communications with 6 watts and up to 200 miles, on the frequencies 2 to 10 Mc/s, we found that the most successful type was the ½-wave dipole, although the ½-wave end-fed was reasonable, the former type appeared to give better transfer of r.f. power with more consistent results.

For this type of set it is considered that 5 watts output is necessary for communication with the above conditions. Experience showed that reduction below 5 watts gave serious deterioration under many conditions, while increasing it to 10 watts did not give much noticeable improvement.

Coventry, Warwickshire. D. R. SABEN.

Capacitors in See-Saw Circuit

ALTHOUGH the use of capacitors instead of resistors in a See-Saw Circuit is mentioned by Cocking* and others†, it is the writer's opinion that the advantages of using them are not fully appreciated. These advantages are:

(1) Capacitors having a tolerance of ±1 per cent are easily and cheaply obtainable while resistances cannot normally be produced to this tolerance.

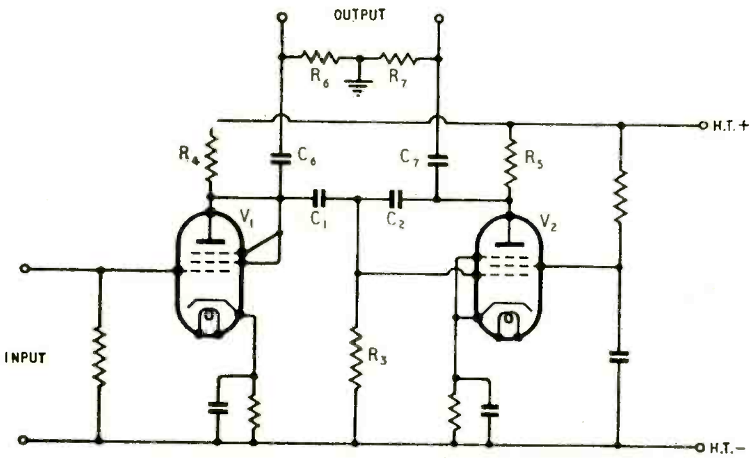
(2) No adjustable member (e.g., a potentiometer) is required and therefore the cost is reduced and maladjustment cannot occur.

(3) The short- and long-term accuracy of the amplitude balance is increased because of the reduced tolerance and avoidance of maladjustment.

(4) The phase balance is excellent.

The circuit details are shown in the figure, in which the following component values may be employed: C_1, C_2, 100$\mu\mu$F; R_3, 3MΩ; R_4, R_5, 10,000Ω.

With these components the phase balance is zero at frequencies from 50 c/s to 10 kc/s while the error at



20 c/s is only 20 degrees provided that the impedance of the output coupling network R_7 C_7 is high compared with that of R_5. The values of R_6 and C_6 should be the same as those of R_7 and C_7 in order to preserve the anti-phase condition. Although the phase of the potential at the anode of V_1 is altered by the addition of R_6 C_6, it remains a reference potential and that at the anode of V_2 will be in anti-phase, at least for the upper frequencies, in the absence of R_7 C_7. Careful design of this latter network can reduce the inevitable error to negligible proportions.

J. K. DRAPER.

E.M.I. Engineering Development, Ltd.,
Hayes, Middx.

* W. T. Cocking, *Television Receiving Equipment*, 1st edition, p. 51.
† Cosmos Report R.1730, October, 1937.

Cathode Follower Circuit

ALTHOUGH the cathode follower has had many applications, I have not seen it used following a diode detector, where, under certain conditions, its use may justify the expense of an extra valve. The advantages are, of course, its high input and low output impedances. This means:

A.C. shunting of the diode load resistor is virtually eliminated, with a consequent reduction of distortion. If the cathode follower grid leak is 1MΩ, then the input impedance may approach 10MΩ.

The diode load can be chosen high enough to give good detector efficiency, without raising serious a.c. shunting problems.

A relatively low value of potentiometer can be used for gain control across the cathode load. (Make sure the time constant CR is adequate). This is helpful when variations of high-frequency response at different volume control settings are encountered with conventional values, particularly when a high capacity circuit is being fed. This is often unavoidable if long screened leads are used.

London, N.8. S. H. FINN.

Electrical Dangers

I WAS both pleased and surprised to read Mr. Crampin's letter in your February issue. I have made a study both of electric shock and electric safety and I am pleased that a low supply voltage for domestic use was advocated in the letter. The need for a value around the 100-volt mark for alternating current supplies is easily seen from statistics of accidents in factories.

To say that anyone can touch the element of an electric fire and so risk electrocution may be true, but I wish here to strongly disagree with Mr. Crampin about earthing. The reason for earthing the metal cases of electric appliances is well known and the precaution is sound, but if anyone can touch a current-carrying part the designer of the appliance is to blame. An appliance designed without regard to safety measures—including earthing—is a danger to the consumer and should be abolished. I believe that we in England have the most dangerous electric fires in the world, and unfortunately unlike members of our Commonwealth and the Scandinavian countries, we have no legal minimum standard of air heater design. More people are injured and killed each year by them than by gas and even coal fires. For this reason, the appearance of a special safety electric fire, made by Ferranti, has been most welcome to me and I sincerely hope that other firms making fires —safety or otherwise—will try to equal its specification.

T. J. WYNN.

Bradford, Yorks.

Television Relay Loss

REFERRING to Mr. Lawson's letter on this subject in the December, 1950, issue: At a recent meeting of the British Institution of Radio Engineers I myself raised the same query, and was answered to the effect that the television broadcast from the Radio Exhibition at Castle Bromwich was transmitted down the link to Alexandra Palace, thence back to Sutton Coldfield for transmission to Midland viewers. The signal, therefore, traversed the link *twice* before Midland viewers received it. Apparently the excellent picture quality was due to the use of new cameras of the latest type.

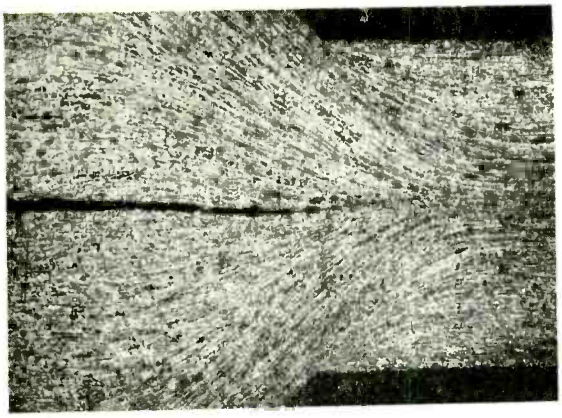
Another point apparently not common knowledge is the fact that the radio link is not now being used and that television programmes are transmitted between London and the Midlands by means of the underground co-axial cable.

G. L. HARRY.

Leamington Spa,
Warwicks.

Jointing Aluminium

Versatile Low-Temperature Methods Requiring No Flux



Microphotograph of a cold pressure weld, the pressure having been applied to the right of the shoulder.

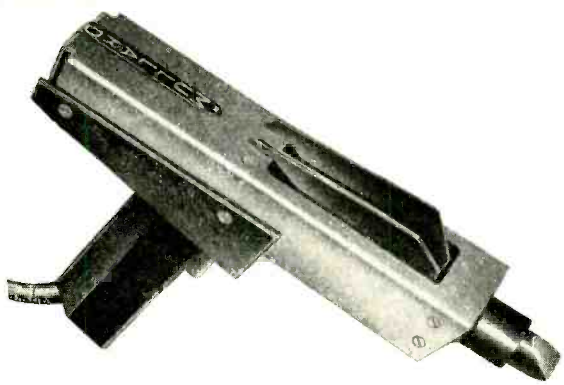
ALTHOUGH aluminium is probably one of the most useful metals in the radio industry, it has always suffered from the disadvantage of being rather difficult to join. Admittedly the established methods, such as brazing, oxy-acetylene-, arc-, resistance- and spot-welding are, up to a point, satisfactory, but all require the application of considerable heat and this is not always a good thing in certain kinds of work. It is, therefore, of some interest that two new low-temperature methods have recently made their appearance in Britain—both, incidentally, coming from radio and electrical companies.

The first is cold pressure welding, developed by the Research Laboratories of the General Electric Company, for making homogeneous welds solely by pressure at room temperature. No flux is used, the tools are simple and inexpensive and no special machines are needed beyond those commonly found in industrial machine shops. The process merely involves pressing the two pieces of aluminium together until they flow at the surfaces; then the molecules of the separate pieces come into such intimate contact that they run together and form a true weld.

Careful cleaning of the two surfaces is, of course, necessary to achieve this and scratch-brushing has been found the most suitable method. It is interesting to note, however, that there is no such thing as an indifferent weld caused by contamination: either the metal is perfectly clean and there is a perfect weld or it is dirty and there is no weld at all. Also, it is immaterial whether the requisite pressure is applied as a slow squeeze or a sudden impact. Another feature is that the electrical conductivity of a pressure-welded aluminium joint is not less than that of a solid aluminium member of equal cross-section.

Pressure welding is remarkably versatile, and a variety of different joints can be made by the use of dies specially designed for them. It is possible, for instance, to spot-weld by a series of indentations, to join perimeters by a ring weld, to make tubes for aluminium-sheathed cable by a continuous seam weld, and to join aluminium wires and meshes. The process is also successful with copper, and aluminium-to-copper welds can be made with equal facility.

Soft-soldering of aluminium is the other new low-temperature method of jointing, and this has been made possible by the ultrasonic soldering iron developed by Mullard Electronic Products. Hitherto, the difficulty with soldering aluminium has always been the highly refractory film of oxide which forms so easily on the metal and prevents the solder from flowing. Fluxes that react with the oxide have been tried, but are not very successful as the film re-forms immediately after the reaction has ceased. With the ultrasonic soldering iron, however, the oxide film is broken up by a 20-kc/s vibration coming from the soldering bit itself, after which the solder flows on to the metal in the usual way. The removal of oxide by this method is so effective that no flux is required at all. The same principle can be applied to the tinning of aluminium by immersion, only here the ultrasonic power energizes the bath of molten solder and, through this, attacks the oxide film as soon as the metal is dipped.



Ultrasonic soldering iron for soft-soldering aluminium.

For generating the necessary ultrasonic power the soldering iron employs a magneto-striction transducer. This consists of a stack of iron-alloy laminations wound with two coils, one of which, the driving coil, is connected to the output of an amplifier, whilst the other, the pick-up coil, is connected to its input. Thus a feedback loop is formed with the soldering iron as an integral part of it, and oscillations at the natural frequency of the magneto-striction element are maintained by the gain of the amplifier. Ultrasonic vibrations generated in this way are then conducted by a solid bar to the soldering bit, which is made of nickel silver and is heated by a resistance-wire element in the usual way.

There is also a fluxless method of tinning aluminium with solder of 90% tin and 10% zinc, but the metal has to be cleaned very carefully and the result is not always satisfactory.

WORLD OF WIRELESS

B.B.C. Cuts ♦ Radar Claimants ♦ "Sound" Shows ♦ Standardization

Television Regress

IT was announced by the Postmaster General in the House a few weeks ago that in view of the present defence programme it had been decided to postpone indefinitely the building of the five low-power television stations planned for Southampton, Plymouth, Newcastle (Pontop Pike), Aberdeen and Belfast. The remaining three high-power stations at Holme Moss, Kirk o' Shotts and Wenvoe will be completed as planned.

B.B.C. expenditure during 1951 on extending the television service has been estimated by the P.M.G. to be approximately £215,000, whilst the Post Office will spend some £350,000 in providing the necessary radio and cable links.

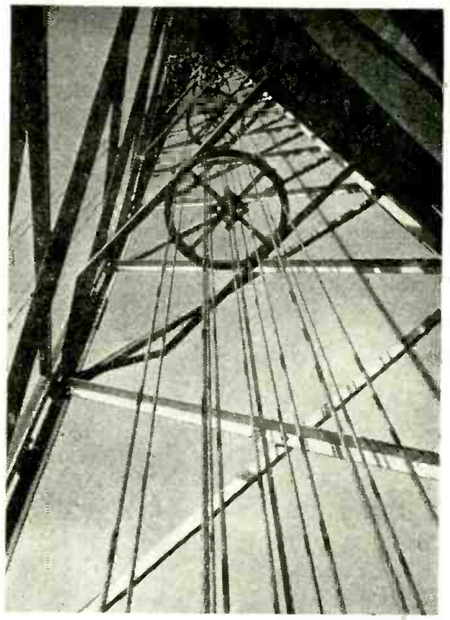
The original estimated expenditure of the B.B.C. on the development of television during the next three years was £4.25 million. This will now be reduced.

Radar Claims

PRIOR to the opening of the public hearing of the radar claims by the Royal Commission on Awards to Inventors on April 11th, the chairman and members of the Commission visited the R.A.F. Station at Bawdsey, Suffolk, the scene of the earliest radar experiments. The claims of Sir Robert Watson-Watt were heard first, and others submitting claims include A. F. Wilkins, Dr. E. G. Bowen, R. Hanbury Brown, Dr. A. G. Touch, Dr. K. G. Budden, D. Taylor, Wing Cdr. E. J. Dickie, Dr. B. J. O'Kane, W. A. S. Butement, P. E. Pollard, L. L. K. Honeyball, H. Dewhurst, R. H. A. Carter and Mrs. G. F. Herd.

The hearing will be continued from May 22nd to 25th and, if necessary, in June.

W. F. TAYLOR, O.B.E. (see "Personalities").



The 725-ft mast radiator of the new 150-kW Third Programme transmitter at Daventry is fed across an insulator at the 460-ft level by this open-wire unbalanced transmission line with four inner and eight outer conductors.

B.S.R.A.

TWENTY-TWO companies have again taken space at the exhibition of sound recording, reproducing and audio-frequency equipment organized by the British Sound Recording Association, to be held at the Waldorf Hotel, Aldwych, London, W.C.2, on May 19th and 20th. The exhibition will be open each day from 10.30 a.m. to 6 p.m.

Admission of non-members will be by programme, price 1s at the exhibition or 1s 2d by post from the secretary, R. W. Lowden, "Wayford," Napoleon Avenue, Farnborough, Hants.

A number of manufacturers will be giving demonstrations of high-quality disc, tape and wire recording and reproducing gear during the show.

Ignition Interference

IT will be recalled that in compliance with the provisions of the Wireless Telegraphy Act, 1949, an advisory committee was set up by the Postmaster General on July 26th last year to consider the question of ignition interference. Questions were raised recently in the House regarding the progress of the investigation and it was stated by the P.M.G. that the committee had met only twice—September 13th and November 17th—and had not yet made any recommendations.

British Standards

AS part of the celebrations to mark the golden jubilee of the British Standards movement, an exhibition, supported by practically the whole range of British industry, will be held at the Science Museum, South Kensington, from June 18th to 28th.

The benefits derived from standards, standardization and simplification will be graphically presented, and each industry will show how standards have simplified production, reduced costs and maintained quality, and how in turn they have benefited the users of that industry's products.

The exhibition will be opened at 11.30 on June 18th by the President of the Board of Trade. Admission to the exhibition, which will be open daily (except Sunday) from 10.0 to 7.0, will be free.

S.R.E. Exhibition

THE second annual exhibition and conference organized by the Association of Public Address Engineers will be held at the Horseshoe Hotel, Tottenham Court Road, London, W.C.2, on May 31st from 10.30 a.m. to 10.0 p.m. During the exhibition, which is being supported by twenty manufacturers, a demonstration will be given of sound-reproduction equipment used for an actual two-way transmission between the hotel and the liner *Caronia* some 600 miles out at sea.

Admission to the exhibition will be by ticket, obtainable free by bona fide sound technicians from Alex. J. Walker, 394, Northolt Road, South Harrow, Middx.

OBITUARY

George F. Mansbridge, O.B.E., whose name has been associated with the manufacture of fixed capacitors for many years (he applied for his first patent in this field over 50 years ago), died on March 23rd, aged 83. He retired from the board of the Dubilier Condenser Co. two years ago.

PERSONALITIES

Prof. G. W. O. Howe, D.Sc., Technical Editor of our sister journal *Wireless Engineer*, will deliver the inaugural Clerk Maxwell Memorial Lecture during the television engineering session of the forthcoming Brit. I.R.E. Convention. This session, which will be held at King's College, Cambridge, from August 21st to 24th, is planned to embrace every aspect of television engineering from cameras to receiver design.

W. F. Taylor, O.B.E., director of the Telegraph Condenser Co., is the new chairman of the Radio & Electronic Component Manufacturers' Federation. He has been with T.C.C. since 1925, and during the war took over the management of the company's works at Acton and the various dispersal units which were established to boost production.

Harold Hunt, who has been with E. K. Cole, Ltd., since 1931 and in recent years has been engaged on the development of broadcast receivers and communication equipment, has been appointed chief of development and engineering, responsible to A. W. Martin, the company's chief engineer. Prior to joining the company he was successively with A. Reyrolle & Co. and in the research laboratories of H.M.V.

HAROLD HUNT.

P. G. A. H. Voigt, B.Sc., A.M.I.E.E., who is now part-time instructor in electronics at the Ryerson Institute of Technology, Toronto, Canada, gave a demonstration of high-quality reproduction to the Wireless Association of Ontario on March 15th last. The equipment used included the American *Audio Engineering* version of the Williamson amplifier, Voigt moving-coil pickup with diamond stylus, and the latest Voigt rematched diaphragm loudspeaker with 22,000-gauss field magnet. Decca "London" records were used in the test. The audience, which filled the lecture hall to capacity, included Frank Murphy, who now lives in Toronto.

Charles I. Orr-Ewing, O.B.E., M.P., who was in charge of B.B.C. television outside broadcasts prior to joining A. C. Cossor, Ltd., as technical commercial adviser two years ago, has been appointed a director of the company. He is also a director of Cossor Radar, Ltd. Before joining the B.B.C. in 1938 he was with H.M.V.

Prof. John A. Ratcliffe, O.B.E., M.A., Reader in Physics at Cambridge University, who during the war was superintendent at T.R.E., has been elected a Fellow of the Royal Society. Prof. Ratcliffe was appointed a member of the Television Advisory Committee in 1949.

Morris Reed, Ph.D., M.Sc., M.I.E.E., who was appointed chief radio engineer of Mitcham Works, Ltd.—a subsidiary of Philips—in 1948, has been made a director of the company. From 1929 to 1946 he was with Siemens Bros., and for two years prior to joining Philips was general manager of R.F. Equipment, Ltd.

IN BRIEF

Licences.—An increase of 45,050 television licences during February is recorded by the Post Office. The total number of sound and vision licences current in the U.K. at the end of February was 12,376,300.

Performing Rights.—The question of fees charged for the public performance of gramophone records was recently raised in the House and the President of the Board of Trade stated in reply that the question of performing rights in recordings would be included in the general review of copyright which it is hoped to begin at an early date.

Amateur Exhibition. — The fifth annual amateur radio exhibition to be organized by the Radio Society of Great Britain will be held at the Royal Hotel, Woburn Place, London, W.C.1, from November 28th to December 1st.

Zworykin Prize.—The American Institute of Radio Engineers announces that Dr. Vladimir Zworykin has given a prize which will be awarded annually for twenty years, beginning in 1952, to the member of the Institute who has made the most important technical contribution to electronic television during the preceding year.

Aeronautics.—A two-year course in aeronautical engineering, with special stress on the application of electronics in this field, has been arranged by the College of Aeronautics, Cranfield, Beds. The five main sections of the course, which begins in October with a yearly intake thereafter, are applied electronics, communications, aerials, servomechanisms and electrical systems.

T.I.D.U.—The Technical, Information and Documents Unit, which for a number of years has been attached to the Board of Trade, is now part of the Information Services of the Department of Scientific and Industrial Research. For the present the Unit will remain in Lacon House, Theobalds Road, London, W.C.1, where the large collection of unpublished German documents of technical interest and post-war American and O.E.E.C. reports can be inspected.

Electro-physiology. — The Electro Physiological Technologists' Association, formed about eighteen months ago to cater for those engaged in clinical and research work in electro-physiology (such as electro-encephalography), will be holding its annual general meeting on May 19th at Hurstwood Park Hospital, Haywards Heath, Sussex. Non-members are invited and can obtain particulars of the Association from the Secretary, G. Johnson, at Hurstwood Park Hospital.

"How Television Works" is the title of a new 10-minute film produced by G-B Instructional Ltd., of Imperial Studios, Boreham Wood, Elstree. Designed for the age group 13 upwards, it covers the link-up from studio to receiver photographically and explains the mechanism of scanning by means of animated diagrams. The fading of photographic pictures into working models, when explaining the pick-up tube and cathode-ray tube, is particularly well done. Although the treatment

SOVIET MAGNETOPHONE. Twin-console reproducers, each containing a two-stage recording amplifier and a three-stage play-back unit, produced in the U.S.S.R. and recently demonstrated in this country. Based on the German Magnetophon, it uses standard 6.5-mm tape, recording at 77 cm/s and has a frequency response flat within 1.5db between 50 and 10,000 c/s.

is not rigorous enough for technical students, the film provides an excellent introduction for the interested layman and would probably go down well as a B.B.C. television programme. It is available in 35mm (and 16mm in May) on one reel and can be hired for 7s 6d (for the first day) or bought for £12 10s.

Changing Outlook.—When speaking at the Radio Industries Club luncheon the Minister of Supply told this story. A four-year-old child taken to the cinema for the first time said, "Look, daddy; big television."

Jordan Telecommunications.—A long-term licence to operate a wireless telegraph station in Amman, Jordan, has been granted by the Jordan Government to Cable and Wireless, Ltd. A mobile station has been in operation in Amman since May, 1948, on a provisional licence and efforts are now being made to establish a permanent station in Jordan. The mobile station was transferred from Jerusalem prior to the surrender of the British Mandate in Palestine.

Navigation Prize. — Under the Thomas Gray Memorial Trust the Royal Society of Arts is offering a prize of £50 to any person of British nationality who may bring to its notice "an invention, publication, diagram, etc., which in the opinion of the judges is considered to be an advancement in the science or practice of navigation proposed or invented by himself in the period January 1st, 1946, to December 31st, 1951." Further particulars are available from the R.S.A., John Adam Street, London, W.C.2.

Veterans' Reunion.—The fifteenth reunion luncheon of Marconi veterans will be held at Caxton Hall, London, S.W.1, on May 5th. The luncheon will be followed by the annual general meeting.

Colonial Appointment.—The appointment of Edward J. K. Banks, B.Sc., as assistant controller of radio communications in Malaya is announced by the Colonial Office. Since 1949 he has been engaged on the development of e.h.f. transmitters with British Telecommunication Research, Ltd., prior to which he was successively at the G.E.C. radio and television works, Coventry, and at Plessey's where he was senior circuit and project engineer in the company's microwave laboratory.

"Communications Receiving Equipment."—All the reprints of the article giving modifications to the R1155 for civilian use (July, 1946), having been sold, the opportunity has been taken to combine with it two related articles on band-pass converters (October, 1950, and February, 1951). This 12-page reprint, "Communications Receiving Equipment," is now available from our Publisher, price 1s (postage 1½d).

R.E.C.M.F.—The chairman of the Radio and Electronic Component Manufacturers' Federation for the ensuing year is W. F. Taylor (T.C.C.) and the vice-chairman, P. D. Canning (Plessey). They succeed L. H. Peter and H. V. Slade respectively.

Indian Exhibition.—As announced last month, an international exhibition of radio and electronics is to be held in Bombay next February under the auspices of the recently formed Radio and Electronics Society of India. A delegation is visiting the Continent and this country to solicit the support of the radio industry. The delegates, headed by Y. A. Fazalbhoy, managing director of General Radio and Appliances, Ltd., of Bombay, were in this country during the R.E.C.M.F. exhibition and will be returning for a week on May 4th. They will be staying at the Savoy Hotel, London, W.C.2.

Y. A. FAZALBHOY.

Plastics Convention.—During the forthcoming plastics exhibition, organized by our associate journal *British Plastics*, a ten-day convention, planned to appeal to the technologist within the plastics industry, the users of plastics and the general public, will be held. The exhibition and convention open at Olympia on June 6th. A programme of the convention, giving summaries of the papers to be read, is obtainable from *British Plastics*, Dorset House, Stamford Street, London, S.E.1, from whom free tickets for specific sessions of the Convention and for the exhibition are also obtainable. Radio-frequency heaters are among the equipment being exhibited.

QSL Cards.—E. R. Martin (G2MN), of R. Martin & Co., Bridge Street, Worksop, Notts, who are producing the QSL cards for the amateur radio station, GB3FB, which will form part of the Festival of Britain Land Travel Exhibition, informs us that they are printing special QSL cards for the personal use of amateurs. On the face of the card is a view of the South Bank Exhibition overprinted with the call sign.

Metal Polishing.—Designers and production executives will be interested in the book "Industrial Polishing of Metals" recently published for our associate journal *Metal Industry* by Iliffe & Sons, Ltd., price 21s.

"By any other name . . ."—The Decca Radar house journal, which was introduced in May, 1950, under the title of *Decca News*, has been renamed *The Scanner*. The fourth issue, dated February-March, 1951, contains an article describing the Decca schools for training in operation and maintenance.

INDUSTRIAL NEWS

South African Agency.—F. P. Moore, a director of S.M.D. Manufacturing Co. (Pty), Ltd., of Natal, South Africa, is visiting the continent and the U.K. in an endeavour to secure machinery, plant and raw materials for the manufacture of small transformers and chokes and capacitors. The company is also interested in securing agencies for communications and radar equipment. Mr. Moore's address from May 9th to the end of June will be 18, Herringston Road, Dorchester, Dorset.

S.I.M.A.—Among the British radio and electronic instrument makers who will be exhibiting at the International Trade Fair at Toronto (May 28th—June 8th), where the Scientific Instrument Manufacturers Association has taken space, are:—Everett Edgcumbe, Fielden, Kelvin-Hughes, Southern Instruments and Tinsley.

R.F. Heater.—What is claimed to be the most powerful r.f. heater in Europe has been installed recently by Philips Electrical at de Haviland Propellers Ltd., Hatfield, Herts, for hardening purposes. It has a maximum output of 150 kW (continuous) and 200 kW (intermittent) and the nominal operating frequency is 275 kc/s. The valve complement of the equipment, which measures approx. 7 ft high, 4½ ft wide and 12 ft deep and weighs 3 tons, consists of an oscillator, grid bias valve and six rectifiers.

Partridge.—The managing director of Partridge Transformers Ltd.—Arthur L. Bacchus—is touring the United States where there has been a great demand for the company's products.

S.R.E.—In the note on the installation of Philips sound-reinforcing equipment in the Glasgow Banqueting Hall in our last issue mention should have been made of the fact that the work was carried out by C. W. Cameron, Ltd., of 59, Oswald Street, Glasgow, C.1.

MEETINGS

Institution of Electrical Engineers

Radio Section.—Symposium of Papers on the Sutton Coldfield television station: "The Sutton Coldfield Television Broadcasting Station" by P. A. T. Bevan, B.Sc., and H. Page, M.Sc.; "The Vision Transmitter for the Sutton Coldfield Television Station" by E. A. Nind, B.Sc. (Eng.), and E. McP. Leyton; and "Vestigial-Sideband Filter for the Sutton Coldfield Television Station" by E. C. Cork, B.Sc. (Eng.), at 5.30 on May 9th at the I.E.E., Savoy Place, London, W.C.2.

British Institution of Radio Engineers

London Section.—"The Resistance Wire Strain Gauge in the Measurement of Physical Quantities" by J. L. Thompson at 6.30 on May 24th at the School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

Merseyside Section.—Annual general meeting followed by a technical film "Atomic Physics" at 7.0 on May 4th at the Electricity Service Centre, Whitechapel, Liverpool.

North-Eastern Section. — Annual general meeting followed by a technical film at 6.0 on May 9th at Neville Hall, Institute of Mining and Mechanical Engineers, Westgate Road, Newcastle-on-Tyne.

Institution of Electronics

Midlands Branch.—"Some Recent Applications of Electronic Techniques in Industry" by R. J. F. Howard (British Electronic Products) at 7.0 on May 8th at the Warwick Room, Imperial Hotel, Temple Street, Birmingham, 2.

Trends in Components

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

The annual private exhibition of radio components and accessories, organized by the Radio and Electronic Component Manufacturers' Federation, was held in London from 10th-12th April. Our description of exhibits in each category is followed by a list of makers.

CAPACITORS

ALTHOUGH nothing startlingly new in capacitors was seen this year, it does not follow that development in this field has come to a standstill. One had to look a little more deeply to appreciate the full significance of the improvements embodied in the 1951 production programme.

Some new models there are, of course, the Polar (Wingrove and Rogers) type C90 variable capacitors being an example. This unit is made in two- and three-gang types and is mounted in a sturdy "U"-shaped cadmium-plated frame without lateral supports. The vanes are aluminium, the spindle is brass and the insulation ceramic. Ball bearings are used front and back and a revival of an earlier idea is the inclusion, as a built-in feature, of a 6-to-1 ratio epicyclic drive. In the latest model the drive is embodied in the front bearing so that concentric spindles are not required. These new capacitors are made with or without the reduction drive and in capacitances up to 528 pF swing.

A new method of sealing fixed capacitors has been developed by the Telegraph Condenser Co. It is described as "Plimoseal," and the capacitor, be it moulded mica, tubular or metal-cased, is dipped in the compound which sets glass hard and is impervious to moisture.

Some new ceramic dielectric trimmers have been added to the Erie range of components. They have chassis-fixing bushes and are made in 1-12pF with a positive coefficient of temperature and 3-50pF with a negative coefficient. They are fully tropicalized.

Sydney S. Bird (Cyldon) has introduced a small insulated mica dielectric compression-type trimmer capable of operation at moderately high voltages, such as are met with in television sets to-day. It can be panel mounted as it has a moulded adjusting knob and is made in capacitances up to 1,000 pF for 1,500 V d.c. and up to 3,000 pF for 250 V d.c. working.

Changes were slight in most other directions. Daly had a new range of small etched-foil electrolytics in PVC-covered metal cases. Dubilier had a television suppressor unit consisting of two 500pF capacitors and two r.f. chokes assembled as a compact unit for fixing to small domestic electrical appliances. A somewhat similar device, but for inserting the mains lead to the appliance, was shown by the Telephone Manufacturing Company.

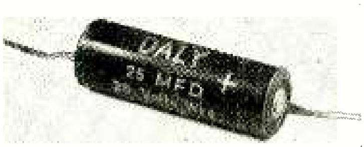
Makers*: Bird (T, V); British N.S.F. (P); Bulgin (T); Daly (E); Dubilier (C, E, M, P, T); Erie (C); Hunt (E, M. P); Jackson (T, V); London Electrical Manufacturing (C, M); Mullard (T); Plessey (E, T, V); Stability Radio (M); Static Condensers (P); Telegraph Condenser Co. (C, E, M, P, T); Telephone Manufacturing Co. (M, P); Walter Instruments (T); Wego (C. M. P); Welwyn Electrical (T); Wingrove & Rogers (T, V).

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

COILS AND TRANSFORMERS

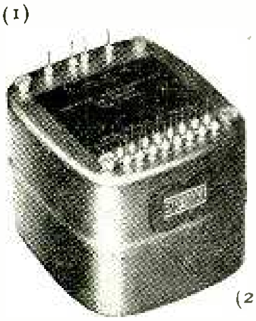
Radio Frequency.—Few changes in the design of r.f. coils are noticeable and both air- and iron-cored types are still manufactured. I.F. transformers are normally individually screened but signal- and oscillator-frequency coils are more usually only partly screened and that in groups. Although quite commonly fitted as individual items to a receiver, a sub-assembly is sometimes used for the tuner. This usually incorporates the coils, trimmers, switches and interstage screening; types for two to nine wavebands were shown by Weymouth.

Wright & Weaire were showing a range of coils which depart considerably from the normal practice. Silver-plated wire is moulded on the inside of an alcothene former on the outside of which any coupling coils are wound. An adjustable contact



(1)

(1) The latest Daly miniature electrolytic of 25µF/25V size with PVC outer covering. (2) Partridge Transformers output transformer. (3) Miniature insulated compression type mica trimmer made by Cyldon. (4) Although very little larger than a matchbox, the Polar C9002 12 twin capacitor gives 2 × 528pF capacitance swing and embodies a 6 to 1 reduction drive.



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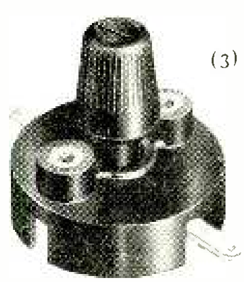

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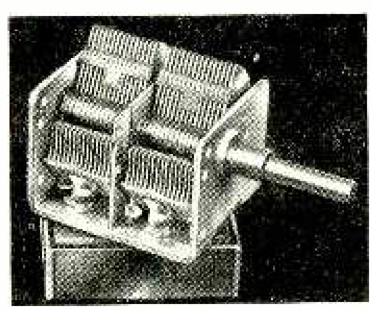

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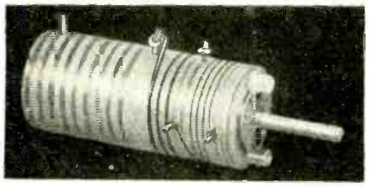
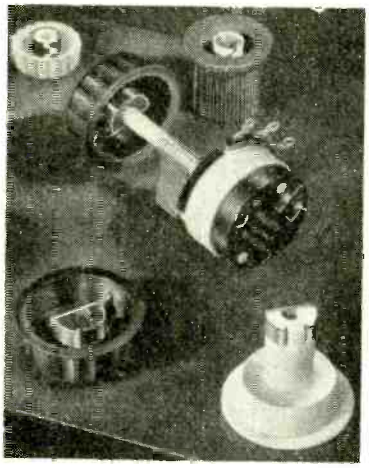


Wright and Weaire short-wave coil wound inside the former.

Ring and D-shaped clips by Simmonds Aerocessories, providing frictional connection between control knobs and their shafts.



to the inner winding is provided by an alcothene plug carrying a silver contact.

The general tendency with television r.f. coils is to adopt iron-dust-core coils individually screened. Small square cans are used which are little bigger than a modern miniature valve and in the coupled-circuit types the trimmers are accessible one from above and the other from below the chassis.

Makers: Advance, Automatic Coil Winder, Igranic, Oliver Pell, Plessey, Weymouth, Wright & Weaire.

Mains and A.F.—The use of C cores using grain-oriented material is increasing and Partridge Transformers showed a range of a.f. transformers embodying this technique. An output transformer in the C.F.B. series is claimed to introduce only 0.05 per cent distortion when handling 16 W at 50 c/s. Types with a bandwidth of as much as 15 octaves were shown.

This form of core is also used in the Ferranti H series of transformers and chokes which are made for 50-c/s use in sizes up to 1 kVA. They conform to the Inter-Services Specification RCS214. The Parmeko Neptune series also conform to this specification and also have C cores. A saving of up to 30 per cent in volume and weight as compared with shell-type cores is claimed.

Impregnation is now generally adopted and hermetic sealing is used for quite a number of types.

Makers: Acoustic Products, Advance, Automatic Coil Winder, Bulgin, British Electric Resistance, Electro Acoustic Industries (Elac), English Electric, Ferranti, Goodmans, Igranic, Partridge & Mee, Partridge Transformers, Plessey, Rola, Taylor, Truvox, Oliver Pell, Vitavox, Wright & Weaire, Weymouth, Woden.

RESISTORS

MOST of the work carried out on resistors appears to have been directed towards improving the stability of the various carbon types now in current use. It is difficult to itemize these improvements, as many are quite slight and entirely undetectable, yet they reflect in the long-term performance of most of the makers' products.

There have been some investigations by Painton into the stability of the higher ohmic values of the high-stability type resistor. This, it will be recalled, uses a carbon film deposited on an insulator of some kind, glass or ceramic being the most popular.

A new development is a wire-wound resistor on an oval former, it being claimed that more of this shape can be packed into a given area than is the case with circular types. Various finishes are employed, British Electrical Resistance use vitreous enamel, while Erie adopt a "Silvertex" coating which is a silicon base enamel said to have the protecting properties of vitreous enamel, but baked at a lower temperature.

Interference suppressor resistors for motor cars have been given some attention by Morganite and a number of newer types are now available. Standardization in ohmic values, at 5,000, 10,000, 12,500 and 15,000 ohms, for the various models should help production generally.

Makers*: Advance (A); Belling-Lee (S); British Electrical Resistance (P, V, W); British N.S.F. (P); Bulgin (P, W); Colvern (P, W); Dubilier (C, HS, M, P, S, V); Egen (P, W); Erie (C, P, S, W); Igranic (W); Morganite (C, P, S); Mullard (HS, NC); Oliver Pell Control (W); Painton (A, HS, P, V, W); Plessey (P); Standard Telephones (A, NC, S); Taylor (P, W); Welwyn Electrical (HS, V, W).

**Abbreviations:* A, attenuators; C, composition; HS, high stability; NC, negative coefficient; P, potentiometers; S, suppressors; V, vitreous; W, wire-wound fixed and variable.

VALVES

IN view of recent criticisms on the unreliability of valves, it was interesting to note the appearance of a range of "trustworthy" types specially developed by Brimar for use in aircraft, telecommunications, instruments and Service equipments. Improvements lie mainly in better mechanical construction and more rigorous testing, so that by reducing the likelihood of mechanical failure the valves have been given a higher expectation of life.

Prominent among cathode-ray tubes was the new English Electric steel-bodied tube T901, shown here for the first time. It has a 16-inch screen, 6.3-V heater, 14 kV on the anode and a deflection angle of 70 degrees. Tubes with rectangular screens were the other main development and examples were shown by Brimar and Ferranti.

The idea of mounting quartz crystals inside valve-type envelopes has been taken a step further by Pye, who showed a miniature crystal oven with the crystal, heater and thermostat all contained in an evacuated B7G envelope. On the S.T.C. stand was a crystal for working at the unusually high overtone of 100 Mc/s.

Makers: Edison Swan, Ferranti, General Electric Company, Mullard, S.T.C.

METAL RECTIFIERS

TELEVISION applications figured prominently in the displays of metal rectifiers this year, and emphasis was placed on the use of low-current tubular types for e.h.t. supplies. S.T.C. showed a new selenium range of considerably lower price and smaller size than previously produced, with inputs up to 17 kV, current ratings of 1 and 5 mA and alternative wire or screw connections. Westinghouse featured the well-known 36EHT and 36K ranges and also showed their 16HT and 16K models which provide for low-current applications up to 4,120 volts.

The trend towards smaller h.t. rectifiers was reflected in the appearance of a new addition to S.T.C.'s RM range, the RM0, which measures only $\frac{7}{8}$in × $1\frac{3}{16}$in. It is designed primarily for use in television preamplifiers and similar equipments and is rated at 125 V input and 30 mA mean d.c. output when used for half-wave rectification.

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

TELEVISION COMPONENTS

THE use of Caslam in television scanning components has now been extended to deflector coils, and Plessey showed types having a magnetic circuit of this material. Being a solid, it lends itself to easier assembly than laminations and its low losses make it suitable for "efficiency" scanning circuits. Another solid for the same purpose is Ferroxcube, which was shown by Mullard, while Salford exhibited Gecalloy dust-iron.

Permanent and electro magnets for focusing were to be found on the Plessey stand and the former were also shown by Eclipse and Electro Acoustic Industries. Two models of Elac ion-trap magnets were shown, for Cossor and Mullard tubes.

Moulded plastic implosion guards were exhibited by Thermo-Plastics, while Long and Hambly showed c.r. tube masks having a lacquer finish.

Makers: British Moulded Plastics, Electro-Acoustic Industries (Elac), Igranic, Long & Hambly, Mullard, James Neill (Eclipse), Plessey, Salford Electrical Instruments, Thermo-Plastics.

SWITCHES AND RELAYS

APART from a new s.p. toggle-switch with a neon indicator matching its appearance (Diamond "H" Switches) very little has occurred in this field since last year. However, the "Ledex" rotary solenoid made by N.S.F. still continues to attract a great deal of attention because of its unusual screw principle. This is an electromagnetic mechanism of considerable power and efficiency which can be arranged to turn a large bank of rotary switch wafers in sharp positive steps. Another popular favourite, also shown last year, was the "Minibank" rotary switch, made by AB Metal Products. It measures only $\frac{3}{4}$in (diameter) by $\frac{13}{16}$in (depth behind the panel) and is completely sealed.

Makers: AB Metal Products, BERCO, Bulgin, Diamond "H" Switches, Electrothermal Engineering, Erie, N.S.F., Oliver Pell Control, Painton, Plessey, S.T.C., Taylor, T.M.C., Walter Instruments, Wright & Weaire.

CHASSIS FITTINGS

AN interesting new development in miniature valveholders, shown by Clix and McMurdo, was the use of nylon-loaded Bakelite for body mouldings. This is an improvement on the normal fibrous loading material, as nylon is characterized by its low moisture absorption and so goes a long way towards keeping the resistivity up and the losses down. Moreover, the development bridges a gap in quality which has long existed between ordinary Bakelite and the more expensive PTFE.

The versatility of spring steel for simple fastening methods was well demonstrated on the Simmonds Aerocessories stand.

Prefabricated cabinets were again displayed by Widney-Dorlec, and the range of parts has now been extended to include sloping fronts and to make the system adaptable to standard rack construction.

Makers: Antiference, Associated Electronic Engineers Ltd., Belling & Lee, BERCO, British Mechanical Productions, Bulgin, Carr Fastener, H. Clarke & Co., Colvern, Electrothermal Engineering, Guest Keen & Nettlefold, Hellermann, Igranic, Imhof, Long & Hambly, McMurdo, Painton, Plessey, Reliance, Erwin Scharf, Simmonds Aerocessories, Taylor, T. C. & M., Thermo-Plastic, T.M.C., Tucker Eyelet, Walter Instruments, Walter J. & H., Widney-Dorlec, Wingrove & Rogers.

AERIALS

MAKERS of aerial equipment have been overhauling their products with the view to eliminating redundant models and telescoping types where possible. As a result Belling and Lee have introduced a single new co-axial cable plug to take cables of from $\frac{5}{32}$in to $\frac{5}{16}$in diameter, so covering both 50-ohm and 75-ohm sizes, also local and fringe-area types.

A novelty in aerials, at least so far as this country is concerned, was the latest Antiference combined television-f.m. aerial. Advantage is taken of the difference in polarization of the two transmissions to mount two half-wave dipoles at right angles on a common centre unit of their "Antex" weatherproof type. The vertical dipole is for television and the horizontal for f.m. They are quite separate electrically and each has its own feeder.

Makers: AB Metal Products, Aerialite, Antiference B.I. Callenders, Belling & Lee, Telegraph Construction & Maintenance.

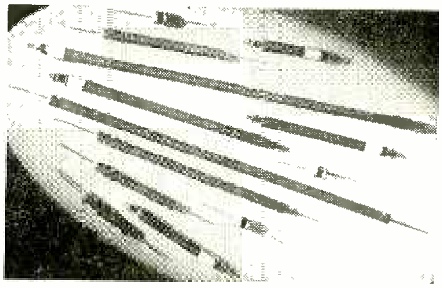
VIBRATORS

EXAMPLES of both synchronous (self - rectifying) and non-synchronous (interruptor) vibrators were on view and the power ratings of these were noticeably high. The heavy-duty 220-V model shown by J. & H. Walter, for instance, will handle anything up to 440 watts.

Makers: Plessey, J. & H. Walter, Wright & Weaire.

SOUND REPRODUCTION

GRAMOPHONE pickups have been through a period of consolidation in design, and detail improvements are apparent. For example, the lightweight movements in the Goldring (Erwin Scharf) range are now supplied with a new damping material of zero temperature co-efficient which is also resistant to atmospheric changes. Production models of "turnover" pickup heads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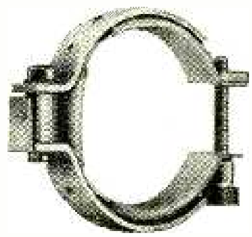
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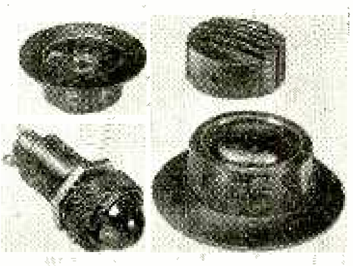
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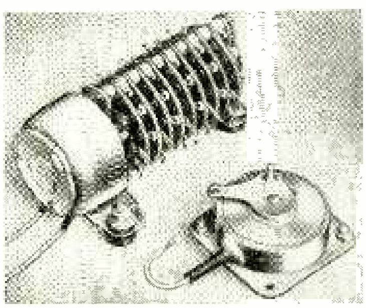
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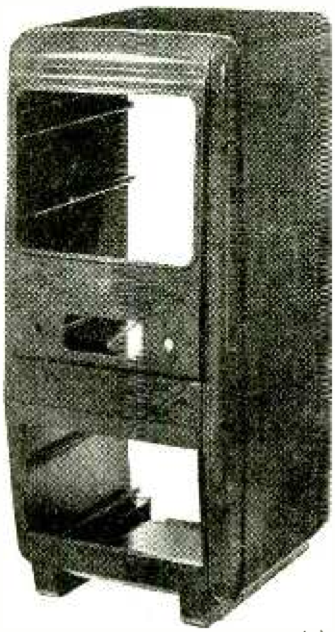
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(1) Representative group of selenium tubular rectifiers by S.T.C. (2) Elac ion trap magnet. (3) Three new control knobs and a signal lamp, made by Bulgin. (4) Rotary solenoid relay by British N.S.F. (left) as a circuit selector and (right) for actuating a high-torque arm. (5) British Moulded Plastics console television cabinet, standing 36 in high, made for Sobell Industries.

with stylus radii on one side for 78-r.p.m. and on the other for micro-groove records were shown with magnetic movements by Garrard and piezoelectric crystal by Cosmocord. Interchangeable heads are favoured by Decca.

The loudspeaker situation, too, is one of stabilization, with a tendency for firms to specialize in one particular sphere, e.g., domestic high-quality, public address, receiver manufacturers' types, etc. Very few additions to existing ranges were noted, but Goodmans have introduced an oval-diaphragm type for car radio and similar applications where small dimensions are essential. It is claimed that this new Model T22/470 has the bass response of a much larger unit and that the high frequencies are distributed over a wide angle.

A new form of spindle attachment in the British Ferrograph (Wright and Weaire) tape recorder gives positive retention for the spools with quick release, and the recorder can now be operated with safety in a vertical position. A third tape speed has been added of only $1\frac{7}{8}$in/sec giving a playing time of four hours on a 1,200ft reel of tape.

Makers*: Acoustic Products (LS, D); Birmingham Sound Reproducers (GM, GU, RC); British Rola (LS); Celestion (LS); Cosmocord (E, M, PU); Decca (DR, GU); Edison Swan Electric (E, LS, PU); Electro Acoustic Industries (LS); Garrard (GM, GU, RC); Goodmans Industries (LS); Plessey (GM, GU, RC, LS, PU); Reslosound (LS, M); Erwin Scharf (PU); Truvox Engineering (LS); Vitavox (LS, M); Wright & Weaire (MR).

**Abbreviations:* D, diaphragms; DR, disc recorders; E, earphones, headphones; GM, gramophone motors; GU, gramophone units; RC, record changers; LS, loudspeakers; M, microphones; MR, magnetic recorders; PU, pick ups.

MATERIALS

NEW techniques in coil winding are opened up by the introduction of thermoplastic-covered instrument wires by B.I. Callenders Cables and the London Electric Wire Company, under the trade names of "Bicaloc" and "Lewmexbond" respectively. Normal enamel-covered wires are given a thin outer coating of thermoplastic material and are wound in the usual way. Heat treatment and subsequent cooling effectively bonds adjacent turns and the coil is then self-supporting without the need for formers or even taping. One obvious application is for the deflector coils of cathode-ray tubes, and there are many problems in radio and light electrical engineering for which this method provides an elegant solution.

Permanent magnet performance can be improved by as much as 25 to 50 per cent if the metallurgical structure of the magnet can be influenced to grow columnar crystals extending throughout the length of the magnet. This fact was demonstrated at the Physical Society Exhibition last year by the Permanent Magnet Association and the decision to include these magnets in the R.E.C.M.F. show is based on the encouraging progress which has been made in the past twelve months towards normal commercial production. Consistent improvement in the performance of Alcomax III and IV has resulted in the quotation of revised figures in the latest data sheets.

The range of cored solder types seem, if possible, wider than ever and Multicore were showing six standard tin-lead alloys, from 20 to 60 per cent tin, in nine gauges from 10 to 22 s.w.g. and in two flux percentages. Enthoven are supplying coloured rosin cores (in red, blue, green and yellow) with the object of facilitating inspection for unsoldered joints in complex circuits.

Among rubber products, or perhaps more precisely elastomers, two items were noted. Long and Hambley have developed a new finish for their television tube masks involving a latex - based lacquer. Hellermann Electric are making a wide range of grommets, sleeves and mouldings in an elastic form of p.v.c. known as "Helvin." One application is for cathode ray tube covers to reduce factory handling risks from implosion.

Makers*: Associated Technical Manufacturers (C, CO, IS, PVC, W); Birmingham Sound Reproducers (MT); Bray (CE); B.I. Callenders Cables (C, IS, W); Bullers (CE); H. Clarke (Manchester) (CF, IM, IS); De La Rue (IM, IS, W); Du Bois (S); Duratube & Wire (C, IS, PVC, W); Edison Swan Electric (C); H. J. Enthoven (S); Fine Wires Ltd. (CO, W); G.E.C. (MT); Hellermann Electric (IS); London Electric Wire Co. (IS, W); Long & Hambly (RP); Magnetic & Electrical Alloys (M, L); Mullard Electric Products (M, DC); Multicore (S); Murex (M); Mycalex (IM); Permanent Magnet Assoc. (M); Plessey (CE, DC); Reliance Electrical Wire (B, C, CO, IS, PVC, RP, W); Salford Electrical Instruments (DC); G. L. Scott (L); Suflex (B, C, CO, IS, PVC, W); H. G. Symons (IM, V); Taylor Tunnicliff (CE); Telegraph Construction & Maintenance (C, CO, IM, M, W); Telephone Manufacturing Co. (DC); Thermo-Plastics, Ltd. (B).

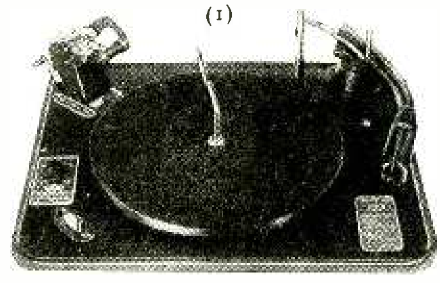
**Abbreviations:* B, braiding; C, cables; CE, ceramics; CF, coil formes, bobbins; CO, cords; DC, dust cores; IM, insulating materials; IS, insulating sleeving; L, laminations; M, magnets and magnetic alloys; MT, magnetic recording tape; PVC, polyvinyl chloride tapes, wires, etc.; RP, rubber products;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

(1) Garrard type 80 record changer for 45, $33\frac{1}{3}$ and 78 r.p.m records.

(2) Combined television/f.m. aerial made by Antiference. Separate feeders are employed.

(3) Goodmans oval-diaphragm loudspeaker, Type T22/470.

(4) Decca transcription-type two-speed gramophone turntable.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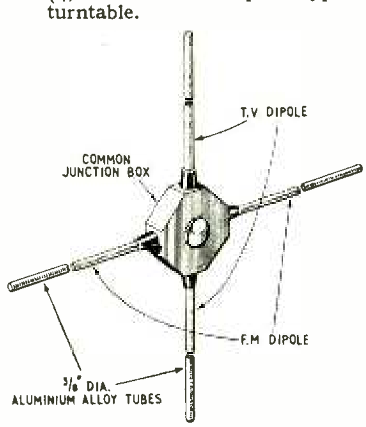

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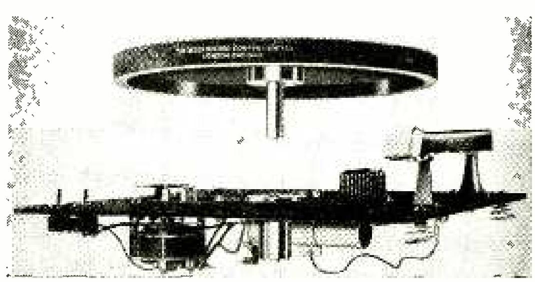
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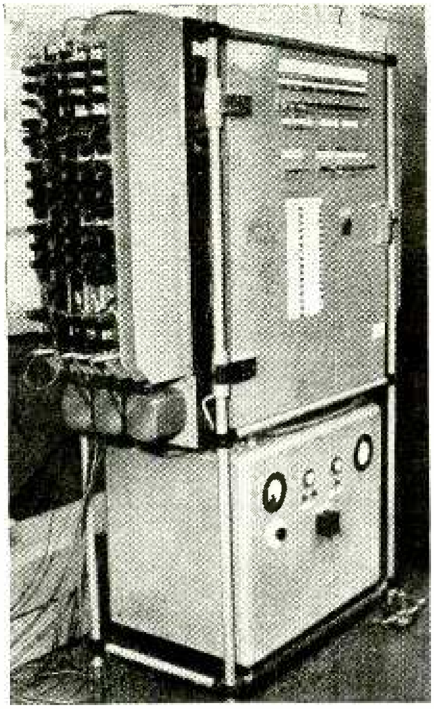
Physical Society's Exhibition

Apparatus for Research and Development

The sixth post-war exhibition of the Physical Society was held in London from 6th-11th April. This review deals with exhibits of radio and electronic interest.



N.P.L. digital computor.

RESEARCH

SEVERAL firms exhibited different forms of automatic equipment for plotting aerial-radiation diagrams. An important use of the Ferranti system is in designing aircraft aerials. A scale model of the aircraft is used and the aerial is energized to radiate a proportionately reduced wavelength. The model is rotated slowly and the table of the recorder rotates in synchronism while the recording pen moves under the control of the receiver output. In the Belling-Lee apparatus the diagram is displayed in Cartesian co-ordinates on a c.r. tube, the X deflection being obtained from a potentiometer attached to the rotating mast of the aerials under test. Similarly, in the Ekco centimetre-wave apparatus it is the receiving aerial which rotates.

G.E.C. Research Laboratories showed a voltage-controlled swept-frequency oscillator covering 30-140Mc/s. It is intended, in conjunction with a c.r. display, for the visual alignment of amplifiers. It is a phase-shift oscillator with four cathode-follower stages and one amplifier giving a gain slightly above the attenuation of the phase shifter.

An electronic digital computer was shown by the N.P.L.; intended primarily for testing chassis of the ACE it can perform simple sums like addition, multiplication and division.

The Elliott swept-frequency impedance meter operates at 9,400Mc/s. The amplitude and phase reflected by the component under test are measured in a waveguide having two directional couplers. The reflection coefficient is displayed on a c.r. tube over which a Smith chart is placed.

T.R.E. showed a system of matching a dielectric to free space which is analogous to "blooming" in optical work. The surface of the dielectric is provided with narrow slots having a depth of a quarter wavelength. R.R.D.E. exhibited a four-channel electronic switch for use with non-recurrent waveforms; it can be used with any oscilloscope.

The Metropolitan-Vickers high-speed recurrent-waveform monitor can display waveforms with frequencies up to 300Mc/s and gives a stable display even when the wave jitters with respect to its driving pulse. A sampling technique is used, the gating width being only 0.001μsec. About 100 samples are needed to produce the displayed wave in dotted form.

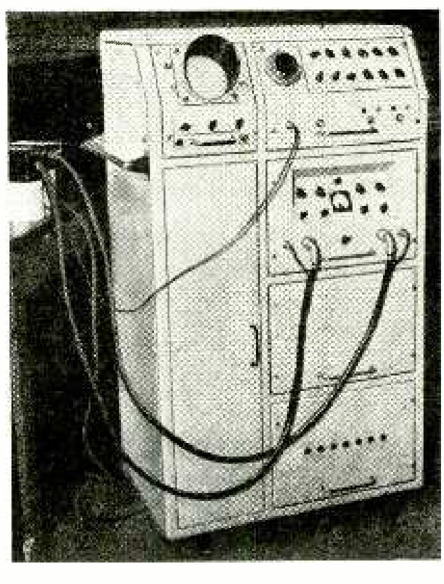
INDUSTRIAL ELECTRONICS

MANY physical effects are utilized in the control of industrial processes, but few systems are without some form of electronic link in the chain between cause and effect, and each year sees new extensions to the already wide field of electronics in industry.

Ball-type grindings mills, for example, which are dependent on critical levels of material for efficient operation, are normally controlled by skilled operators who judge the rate of feed required by the character of the sound emitted by the mill. The judgment of the operator may be affected by health, and to provide a more objective control Standard Telephones and Cables have developed an acoustic mill feed controller (Type 74701-A). The sound picked up by a microphone is amplified and passed through filter circuits which select the predetermined critical frequency bands. The output is applied to a marginal relay which operates normally in the floating condition; top and bottom contacts operate when the noise level is higher or lower than the optimum, and control the field current of the mill feed motor. A large indicating meter may be used where more critical manual control is required.

The servo-controlled self-balancing capacitance bridge developed by Fielden is used in a new type of recording pressure gauge named the "Manograph." The mechanism is similar to that of the "Servograph" but the recorder pen, instead of following the movements of a meter pointer, is controlled by a ring electrode which encircles one limb of a manometer "U" tube containing any suitable conducting liquid.

Metropolitan-Vickers high-speed waveform recorder.



Many methods ranging from β-ray absorption to simple pocket magnetometers have been devised for measuring thickness of materials.

Sheets of material of constant density can be checked for thickness (and vice versa) by passing them between a radioactive source (usually thallium 204) and an ionization chamber, the output of which is amplified and applied to a meter calibrated directly in density-thickness (usually mg/cm^2). Equipment for permanent installation in mills was shown by Baldwin, Ekco and Electronic Instruments. A self-contained battery-operated portable model was shown by Baldwin.

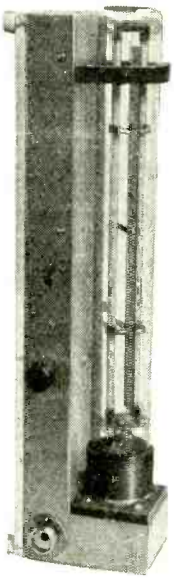
The technique of flaw detection by ultrasonic methods involves considerable skill in the interpretation of results and also the expenditure of much time if records are to be made for assessment of the relative importance of different flaws. Normally flaws are shown by vertical peaks in a horizontal time-base scale on a c.r. tube, and a fresh record must be taken for each position of the exploring probes. Glass Developments, Ltd., were showing a new continuous scanning method in which the condition of the whole specimen is presented in a single display. Distance from the surface is indicated, as before, in the horizontal axis, but the position of the flaw is shown by intensity modulation of the electron beam. Vertical deflection is controlled by the movement of the probe along the specimen and a two-dimensional picture on the lines of a television raster is obtained.

ELECTRONICS, NON-INDUSTRIAL

THE impact of atomic research on the electronics industry was made very evident by the large showing of instruments for detecting and measuring radiation, and amongst the annual parade of monitors, counters, scalers, ratemeters and the like were one or two items of more than usual interest. The scintillation counter shown by Ekco, for instance, causes the radioactive specimen to activate some kind of phosphor material—the scintillations from this being converted into pulses by a photo-multiplier tube and then registered electronically in the usual way. A multiple Geiger-Muller counting apparatus was demonstrated by Nucleonic and Radiological Developments. Ten G-M tubes with samples were automatically selected in time sequence and the resulting counts were registered by a pen recorder, the idea being not only to save time but to avoid the contamination which occurs when the same G-M tube is used for different samples in turn.

Smallest of all the detecting in-

(1) Oscillator with jointed quartz crystal working at 100 c/s, made by Salford. (2) Acoustic mill feed controller (S.T.C.). (3) Portable beta-ray thickness gauge (Baldwin Instruments). (4) Ultrasonic scanner for flaw detection (Glass Developments Ltd.). (5) Mullard electronic polarograph. (6) Portable radioactive ore detector by Ekco, with cover removed.



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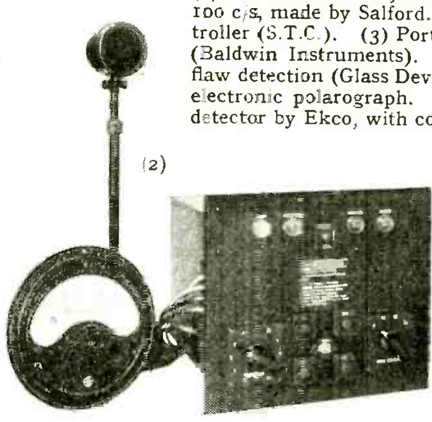

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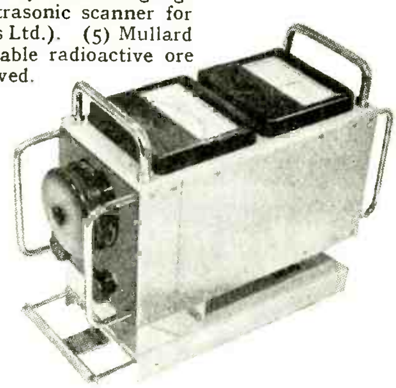

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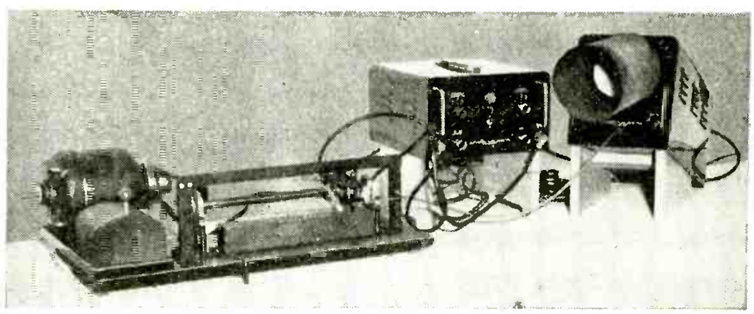

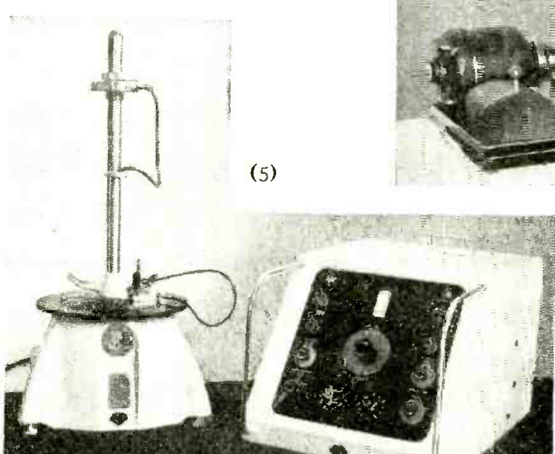

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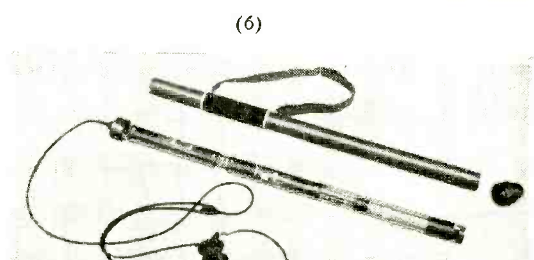

struments was the new type of "fountain-pen" pocket dosimeter containing an ionization chamber and electroscope; examples were shown by Baldwin, Cintel and the Commissariat à l'Energie Atomique. Other new medical instruments were an arterial blood-pressure recorder by Southern Instruments (with a variable-capacitance pickup device controlling a frequency-modulated amplifier), and a portable electro-encephalographic equipment by Ediswan—both of them working into pen recorders.

Measurement of inorganic fluctuations was also represented—by the Pye geophone, a low-frequency vibration pickup for registering earth movements. In the field, the outputs of several geophones are fed into a 12-channel "suitcase" amplifier, and one of the miniature amplifier channels from this was also on view. Passing from *terra firma* to *aeris mobilis*, the Meteorological Office showed an interesting photoelectric hygrometer for automatically measuring the frost-point of the air. Light scattered from a deposit of natural frost on a cooled metal "thimble" is collected by photoelectric cells, and these control a heater coil in the thimble so that the frost deposit is kept constant; another resistance coil then measures the temperature.

One of the most consistently useful of electronic aids is the d.c. amplifier, and at the exhibition four different types were represented. The first was the straightforward direct-coupled amplifier with, in some cases, automatic drift correction; the second contained a "chopper" mechanism for converting the d.c. into a.c.; the third caused the d.c. variations to amplitude-modulate a carrier frequency; while the fourth used a mirror galvanometer to produce an unbalance current between two photocells.

VALVES AND C.R. TUBES

OUTSTANDING among the various special-purpose valves on show were two new stabilizers—one for current and the other for voltage. The constant-current barretter shown by Siemens had a tungsten filament in hydrogen (giving about ten times the life of an iron-wire filament), and a system for preventing the filament from losing heat—thereby increasing its resistance with voltage and obtaining a flatter characteristic. The bulb is divided into two sections (one containing the filament) by a mica disc, so that although the pressures in the two halves can equalize there is very little transfer of heat from the filament.

Corona discharge in pure gas was the principle of the new voltage stabilizer demonstrated by Nucleonic and Radiological Developments. The stabilizing voltage was virtually the same as the striking voltage (420V), the initial current was quite small (about 10μA), and an increase of the supply voltage to 800 produced only a 7-V rise in the stabilized voltage. Types with stabilizing voltages up to 1,000V are also available.

Other items of interest were a co-axial-type silicon crystal for use up to 10,000Mc/s, shown by G.E.C., a 100-c/s quartz crystal oscillator by Salford, and a double-beam c.r. tube (20th Century Electronics) having common time-base plates but entirely separate guns and deflection plates.

COMPONENTS

AS might be expected, the components exhibited were mainly of the precision type. Precision moulded silvered-mica capacitors having an insulation resistance greater than 200,000MΩ over a temperature range of -40° C to 100° C were shown by Johnson, Matthey. A variable capacitor of 320pF swing was shown by Mullard. It has PTFE insulation, bi-metallic temperature compensation and brass vanes in a stress-relieved strain-free housing. It has an s.l.f. law to within 0.1%.

British Electrical Resistance have a hermetically sealed potentiometer of 5W rating in which Perbunam washers provide the seal. They also have a range of oval vitreous resistors.

Sine/cosine potentiometers, unsealed, are produced by Kelvin Hughes; a wide range of resistance values is available, while Unit resistance boxes are made by George & Becker.

Plessey showed extremely compact tantalum electrolytic capacitors for operation over the range -60° C to 200° C. A capacitance of 55μF at 80V working is typical.

TEST AND MEASURING GEAR

At the Physical Society's and R.E.C.M.F. Exhibitions

Though test and measuring equipment predominated at the exhibition of the Physical Society, a certain amount appeared also at that of The Radio and Electronic Manufacturers' Federation. Apparatus is dealt with in this review irrespective of the exhibition at which it appeared.

SIGNAL SOURCES

IT is interesting to observe that in this electronic age one of the earliest methods of generating a constant frequency still performs a useful function. The particular device in mind is the electrically maintained tuning fork, a 50-c/s version of which has recently been introduced by Dawe Instruments for use where no other suitable reference of frequency can conveniently be used. It is operated by a 4-volt battery and utilizes a carbon button microphone. Its accuracy is 0.1 per cent, stability 0.01 per cent and it gives 18 V r.m.s. output.

Signal generators of one kind or another are now beginning to make their appearance at the other end of the frequency spectrum and Metropolitan Vickers now have a klystron oscillator unit covering 8,500 Mc/s to 9,500 Mc/s.

A signal generator for use on the "X" band is made also by Elliott Bros.; again a klystron is employed, but in this case the signal is frequency-modulated about a mean value of 9,400 Mc/s.

To the range of precision equipment made by Standard Telephones has been added a waveform generator designed for testing television relay systems. It provides synchronizing pulses to B.B.C. standards and also a signal in the form of a pulse, the width of which is variable from 2 to 83 μsec. The amplitude of the sync and of the pulse signal can be varied independently and picture signals from an external source can be injected and mixed with sync and black-out pulses.

A much simpler form of television test set is included among the latest Avo instruments. It is basically two instruments, a signal strength meter for direct measurement of signals picked up by the aerial, and a square-wave generator for modulating an existing signal generator covering the television frequencies. Two frequencies are provided, giving the familiar vertical and horizontal bars.

Among the more specialized forms of signal sources is an r.f. generator giving the choice of a number of spot frequencies from an oscillator having a single crystal only. It is a Marconi development and utilizes their "FMQ" technique and is intended as a source of drive for a multi-channel v.h.f. transmitter. In one form 25 spot frequencies of 12-kc/s bandwidth at a carrier frequency of 225 Mc/s are available.

OSCILLOSCOPES

THE Nagard 103 instrument is called an oscillometer because of the special provision which is made for measuring voltage. Also, it has a time base which is calibrated in frequency to within 2 per cent and in time to 5 per cent. It is arranged in two fitting cases, one of which is the power supply and the other the housing for the c.r. tube and the controls; it also accommodates the time bases and amplifiers as sub-units of which several alternatives are available. A 6-in tube is used with an edge-illuminated graticule which is ruled on both sides to prevent parallax.

The Marconi Instruments Q scan is a portable instrument which has the usual oscilloscope facilities but is designed primarily for the visual alignment of television receivers. There are both X and Y amplifiers, but the latter can be switched to act as a time base which is used to frequency-modulate an r.f. oscillator. This has a mean frequency which can be adjusted over the normal range of television signal and intermediate frequencies.

The Elliott oscilloscope is of the ultra-high-speed type with sweeps ranging from 0.05μsec to 2.5msec. With the tube operating at 10kV writing speeds up to 20,000km/s can be obtained.

Of the more general-purpose types the Cossor 1049 double-beam oscilloscope now has a 4-in flat-faced tube operating at 2kV. The time base gives sweeps of 150μsec to 1.5sec and can be used repetitive, triggered or single stroke. The Mullard wide-band oscilloscope can be used with a triggered sweep and can resolve pulses of 2mμsec duration.

MISCELLANEOUS TEST EQUIPMENT

A SMALL but useful piece of test gear included in the current range of sets made by Marconi Instruments is a wide-range absorption wavemeter. With eight plug-in coils it covers 100 kc/s to 100 Mc/s. The dial is directly calibrated in frequency. It embodies a 0-50 μA meter and a germanium crystal.

There are quite a number of new single and multi-range test meters available this year. Avo have a new Model 8 Avometer providing some 50 ranges and a sensitivity of 20 kΩ/V on d.c. and 1 kΩ/V on a.c. A useful feature is the inclusion of a press switch which reverses the connection to the movement to facilitate measurements without changing over the test leads, where changes of polarity may be involved.

Taylor Electrical have a new universal meter, the Model 88A, for a.c. and d.c. volts up to 5 kV, current up to 10 A and with facilities for capacitance, inductance and resistance measurements. It also has a buzzer for continuity testing. The sensitivity is 20 kΩ/V on d.c. and 2 kΩ/V on a.c.

There is a 0-7.5 kV voltmeter among the Sangamo Weston range of meters; also a new electronic r.m.s. voltmeter reading up to 750 V, the lowest scale being 0-1.5 V. The input resistance is 1 MΩ and it has first-grade accuracy up to 10 kc/s. A large 6-in scale is employed. The final indicator is a thermo-couple and a 10-mA moving-coil meter, so despite its high sensitivity it is by no means a delicate instrument.

A high-frequency bridge for impedance measurements over the range 20-100 Mc/s has been developed by the General Electric Company. It makes use of a continuously variable ratio arm taking the form of a semi-circular copper rod inductor of high stability with a sliding contact. It is intended primarily for measurements on aerials and feeder systems.

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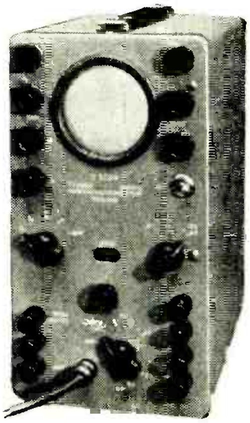

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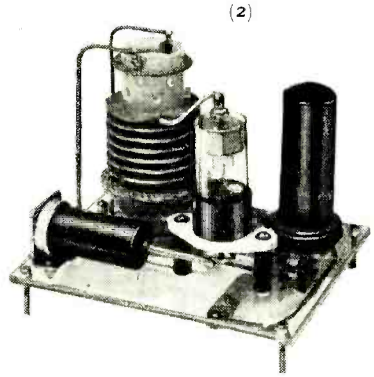

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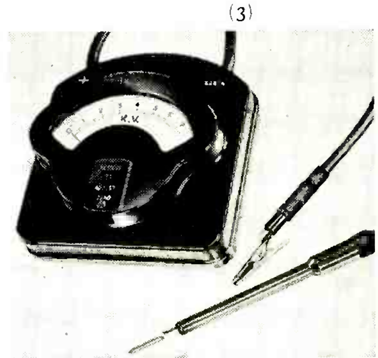
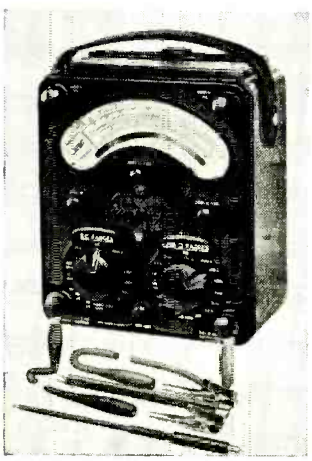


(1) Marconi Instruments Q-scan television alignment oscilloscope. (2) Radio-frequency e.h.t. generator suitable for c.r.t. supplies, by Brandenburg Designs. (3) Sangamo Weston 7.5 kV voltmeter.



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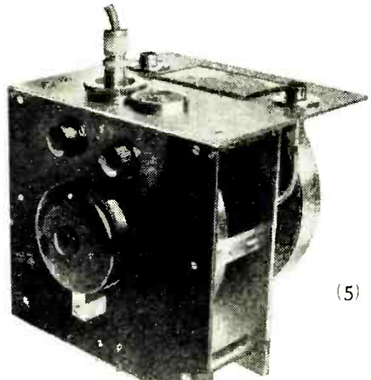

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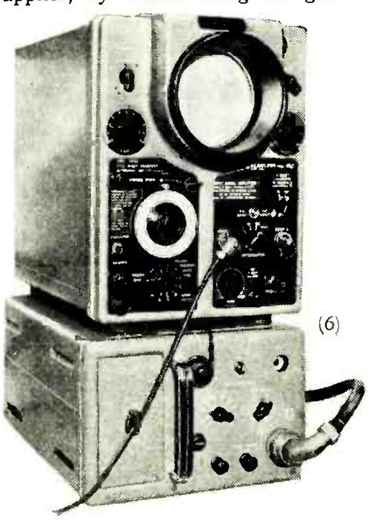

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(4) New Model 8 Avometer. (5) High frequency impedance bridge made by G.E.C. (6) Nagard oscillometer.

Frequency Modulation

1—Simple Introduction

By "CATHODE RAY"

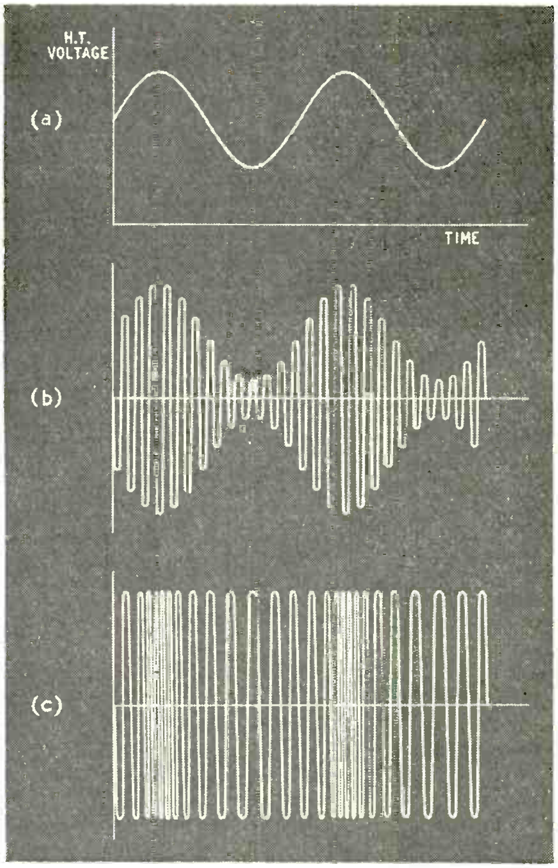


Fig. 1. Varying the h.t. voltage of a transmitter up and down as shown at (a) makes the r.f. amplitude vary in the same way (b), and is a simple example of amplitude modulation. Manipulating the frequency control in the same way produces frequency modulation (c).

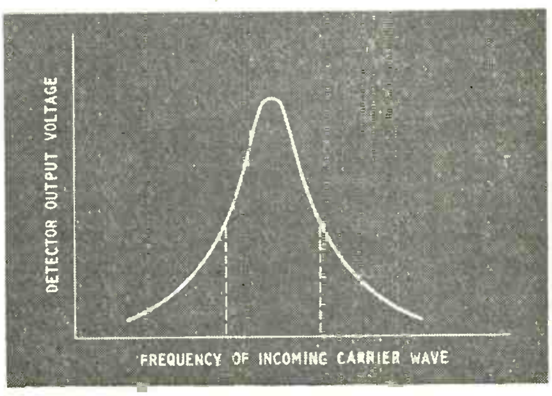
ALTHOUGH I wrote under the same title not so very long ago (September 1948) some readers may have been too young then, or did not consider f.m. had become a "live issue," or perhaps were frightened or baffled by my vector diagrams. And those who did read it have probably forgotten all about it by now and would be glad of a recap., seeing that f.m. broadcasting is so much in the limelight these days. This first article is intended to be a really simple outline. Anybody who wants to pursue the subject further can do so next month (and probably the month after that).

If you had a radio transmitter and amused yourself by turning the h.t. voltage rapidly up and down, as in Fig. 1 (a), you would vary the amplitude of the radiated waves in time with your movements. The resulting r.f. waveform would be something like Fig. 1 (b). You would be causing amplitude modulation, though the modulation frequency would admittedly be rather lower than usual. If for a change you tried the same trick on the oscillator tuning knob, twiddling it to and fro in the Fig. 1 (a) manner, you would cause frequency modulation, and the r.f. waveform would look like Fig. 1 (c). Instead of the amplitude varying and carrier-wave frequency remaining constant it would be the other way about. In practice, of course, the variations (of amplitude or frequency) are caused by the audio-frequency or other signal voltages. With a little speeding up of the time scale, Fig. 1 (a) can be taken as representing these. At the receiving end the carrier-wave variations are translated back into a copy of the original a.f. The only essential difference in the f.m. receiver is that it must respond to frequency variations, preferably with as little distortion as possible. Any ordinary a.m. receiver can receive f.m. after a fashion if it is tuned so that the carrier frequency comes on the slope of the resonance curve instead of at its peak (Fig. 2). The increases and decreases in carrier frequency then cause increases and decreases in detector output voltage. To obtain the benefits that f.m. has to offer, however, other changes in design are necessary.

What are these benefits? They can be stated very briefly: better signal-to-noise ratio.

So far everything is perfectly clear and simple. It is when one asks how much benefit f.m. gives that complications begin. The variety of statements —all more or less true—that are used in answer to this question can only be compared with what one gets during a General Election. Some enthusiasts

Fig. 2. An ordinary a.m. receiver can be used to receive f.m. (though not very satisfactorily) by mistuning it so that the unmodulated carrier-wave frequency comes on the slope of the receiver's resonance curve, at either of the dotted positions. The variations in carrier frequency due to modulation then cause roughly corresponding variations in detector output voltage.



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have claimed that f.m. is about 1,000 times better than a.m.; on the other hand it has been said that f.m. is no better, if even as good. The reason for such apparent contradiction is that it all depends on how the comparisons are carried out. To make any sense of claims for or against f.m. it is necessary to have a reasonably clear picture of its theory.

Let us start with an unmodulated carrier wave. Its frequency (which of course is r.f.) can be denoted by f_c. Then there is the modulation frequency, which for the sake of example we shall assume to be a.f. (it might of course be v.f.), to be denoted by f_m. It now the carrier is amplitude-modulated, the well-known result is that side frequencies are formed, f_c+f_m and f_c-f_m. The total bandwidth is therefore $2f_m$. Since the carrier is usually modulated at frequencies all over the a.f. band, there are continuous groups of side frequencies called sidebands. The loudness of the programme is represented by the depth of modulation—the amount by which the amplitude of the carrier wave is varied compared with its unmodulated amplitude (Fig. 3). When the variation equals the unmodulated amplitude, so that the carrier fluctuates between twice its unmodulated amplitude and zero, the depth of modulation is 100%; and since the amplitude cannot be made less than zero that is the limit.

The obvious way of adapting Fig. 3 to illustrate depth of frequency modulation would be to write "frequency" instead of "amplitude." Then 100% modulation would mean that the carrier wave frequency was varying from zero to double, which would be more than a trifle inconvenient. It would of course be quite absurd. On this scale of reckoning, the depth of frequency modulation is always very small. The term actually used is *frequency swing*, which is the amount modulation causes the carrier frequency f_c to vary above and below its normal. For example, a frequency swing of ±10 kc/s would cause a 100-Mc/s carrier wave to wobble between 99.99 and 100.01 Mc/s. The greater the frequency swing the louder the programme. The practical limit is not fixed by any natural boundary, as in a.m., but by the bandwidth that the transmitter is allowed to occupy, which is a matter of decision. This maximum allowable frequency swing, is, according to a British Standards definition, *frequency deviation*. But the term is often used to mean frequency swing. Personally I think this is a pity, because the distinction is a useful one, and I am going to stick to the standard terms, abbreviating them by f_s and f_d respectively.

The Inventor's Dream

How is the deviation, or maximum allowable swing, decided? Reducing it reduces the a.f. voltage output obtainable from the detector, but that can be made up (within reason) by a.f. amplification. Nowadays, when every kilocycle of bandwidth is precious, it would seem an excellent idea to make it as little as possible. Every now and again a would-be inventor hits on the perfectly marvellous scheme of making it much less than the highest modulation frequency, so abolishing at one stroke the difficulty with a.m. that the bandwidth occupied is twice f_m. If f_d were made, say, 1 kc/s, the frequency of the carrier-wave would be varied between limits only 2kc/s apart and yet we could receive audio frequencies up to 15kc/s if we liked, and at the same time pack two or three times as many stations into the medium waveband! Unfortunately this is only a dream, as was proved as long ago as 1922 (though that didn't stop all the dreamers by any means). It is by no means easy to see why it doesn't work, so at this stage it must be just accepted as a fact that the bandwidth with f.m. is greater than either $2f_m$ or $2f_d$.

We shall see later how the choice of f_d affects the working of the system. It is generally considered in relation to f_m. In fact there is a special name for the ratio of f_d to the highest f_m—*deviation ratio*. This is sometimes confused with the ratio of f_s to any f_m being considered, which is called the *modulation index* and usually denoted by M.

Important Distinctions

To make the meanings of these terms clearer let us take an example—an f.m. broadcasting station in which audio frequencies are included up to 10kc/s. In some f.m. stations the deviation f_d is made less than the highest f_m, but in broadcasting (for reasons I shall explain later) it is generally several times greater. The number of times greater is the deviation ratio, so if in this case we decided to make f_d 50kc/s the deviation ratio would be 5. But the bandwidth occupied by the transmitter at any particular moment depends not on the highest f_m that *could* exist or on the greatest frequency variation or swing (f_s) that would be allowed, but on the actual f_m and f_s. The ratio of these two, f_s/f_m, is the modulation index. If a note of 2kc/s were being broadcast at half the maximum modulation depth (25kc/s), M would be $25/2 = 12\frac{1}{2}$. The thing to remember is that deviation ratio is part of the specification of an f.m. transmitter, like its power and its carrier frequency, but modulation index refers to what the transmitter is actually doing at the moment. Except when broadcasting a tuning note (or nothing at all) M is continually varying.

Since practically the whole point of using f.m. is to obtain quieter reception, another important matter to be clear about is the nature of the noises to be overcome. There are two main kinds. One is the continuous hissing or rushing sound that is always heard when a large amount of amplification is in use. It is due to random movements of electrons in circuits and valves, which can only be stopped altogether by reducing their temperature to —273°C, and nobody has ever quite managed that, even at enormous expense. The amount of this kind of noise can be calculated fairly exactly. It depends on the temperature, but the difference between winter and summer is too small to be important. It depends on the resistance of the circuit, or anode current and type of valve. And the noise power is distributed uniformly over all frequencies, so the noise one gets is proportional to the frequency bandwidth accepted by the receiver or amplifier. Since it can't be stopped, the usual method is to have so much signal power that one doesn't need to use enough amplification to hear the noise. It is shouted down. Random noise gives no trouble when listening to a 100-kW station within 20 or 30 miles on a good aerial. It is when listening to a weak or distant transmitter on a poor aerial (such as a portable) that it becomes a nuisance. This is where f.m. gives an advantage over a.m. Oddly enough (seeing that this noise is proportional to bandwidth) the advantage increases with the bandwidth of the system, and as spare bandwidth is now non-existent on the medium frequencies it is necessary for f.m. stations to work at very high frequencies. Released from the pressure of the medium waves, where top and perhaps even middle audio frequencies have to be drastically cut to avoid interference, the quality of reproduction can be much improved. F.m. enthusiasts in the past have sometimes claimed credit for this, but of course it is really due to v.h.f. and is obtainable equally with a.m.

The other kind of noise includes everything else—chiefly atmospherics and "man-made" electrical noises. These are more or less unpredictable, depending on circumstances and conditions. But nearly all of them become less and less troublesome as the reception frequency is raised, so that at the 100Mc/s or thereabouts used for f.m. almost the only kind to worry about is motor-car ignition noise. And that really is a worry. It takes the form of sharp pulses at each spark in the engine, so is commonly referred to as impulsive noise. Random noise is a continuous background, generally well below the programme level (or it wouldn't be worth listening to); impulsive noise is not continuous, but when heard its pulses have peaks generally far greater in amplitude than the programme signal level. So a valuable improvement can be gained by cutting the peaks down to the signal level.

It is more obvious how this can be done with f.m. than with a.m., because the signal amplitude with f.m. is constant (Fig. 1(c)), and it doesn't matter even if the signal peaks are trimmed off. So it is perfectly simple to use a limiter in front of the detector to do so and thereby remove the worst of the noise pulses. But one must not imagine, as so many have done, that because of this an f.m. receiver cuts out impulsive noise completely. As we shall see later, the pulses frequency-modulate the signal and get in that way. Nevertheless f.m. does help a lot. But here again many persons have allowed their f.m. enthusiasm to run away with their judgment. Although it is not so obvious how pulse limiting can be applied to a.m. (Fig. 1(b)) so as to be effective, and yet to avoid the severe distortion that would result from clipping the signal peaks, it can be done. But because even a high-fidelity a.m. receiver can be tuned fairly sharply on the v.h.f. waves, people made the mistake of comparing a ± 15kc/s band a.m. receiver with a ± 100kc/s f.m. receiver. Whereas a wideband set preserves the sharp brevity of the noise pulse, so that most of its power is above audible frequency, and it is soon over, the more highly selective a.m. tuner draws it out into a much broader shape, so that it passes through into the a.m. part of the receiver. When a fair comparison is made, using an equally wide band in both sets and the best available noise-limiting technique, there is remarkably little difference between f.m. and a.m. An important point with f.m. is that freedom from impulsive noise depends much more on accurate receiver tuning than with a.m.

Transmitter Power

The question of freedom from noise is bound up with the transmitter power. As we have noted, noise can always be thrust farther into the background by using more power. That generally means a larger transmitter. But one of the advantages of f.m., contributing to better signal/noise ratio, is that considerably more power can be radiated without enlarging the transmitter. The limiting factor is the highest peak that has to be handled, and with a.m., as you can see from Fig. 3, this is twice the unmodulated or average amplitude. If it were changed over to f.m., the peak amplitude could be maintained all the time (compare Fig. 1(c)), so its average current or voltage would be doubled. The power is equal to current × voltage, so would be four times as great. Other things being equal, then, an f.m. transmitter delivers a stronger signal than a.m. Alternatively, to deliver the same strength of signal with a.m. necessitates a larger and more expensive transmitter. In broadcasting, however, the cost of the transmitter is much less important than the cost of the receiver. Taking the system as a whole, it is no economy to save £20,000 on the transmitter if it is thereby necessary to spend an average of 5*s.* more on each of 100,000 receivers served by it; the result is a net loss of £5,000. It remains to be seen how the relative cost of a.m. and f.m. receivers works out. One would expect f.m. to be more, but of course it is difficult to make an exact comparison because the performance cannot be exactly the same in every respect, so the verdict depends a good deal on who makes it.

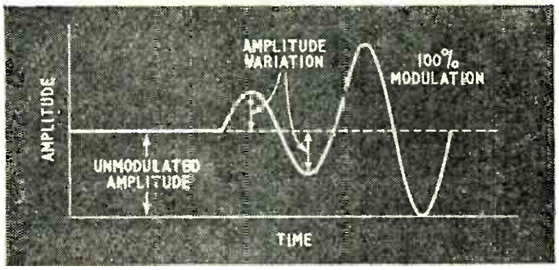
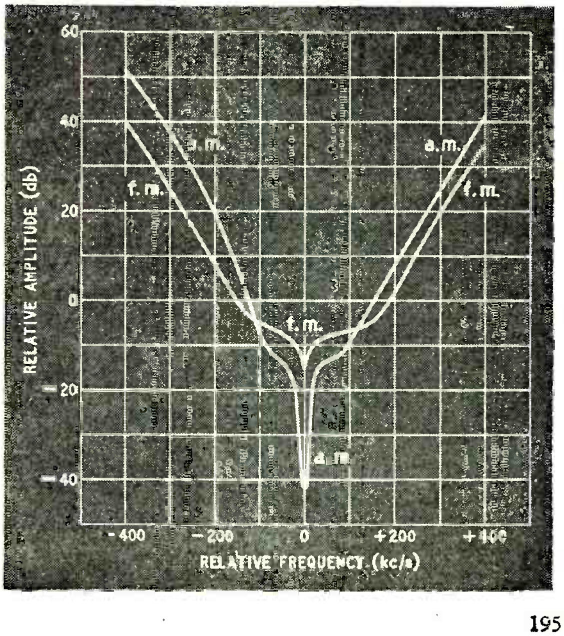


Fig. 3. Explanation of modulation depth in a.m.

Fig. 4. Showing how the strength of a signal required to cause just-audible interference varies with the frequency relative to that of a signal tuned-in. A.m. interference with an a.m. receiver is worse than f.m. interference with an f.m. receiver when the frequency difference is audible, but over 100 kc/s the position is reversed.



How about interference between stations—that great curse of medium-frequency broadcasting? Moving to the v.h.f. band leaves behind the great hurly burly, but if everybody does that won't the v.h.f. band in turn become the congested one, like some of the by-pass roads we have known? Well, in the first place there is considerably more room. The apparently narrow band between 3.00 and 3.05 metres alone, for example, is wider in frequency than the whole medium-wave band and long-wave band together. Not only so, but whereas the ionosphere reflections from a powerful medium-wave transmitter can cause interference far beyond its service area, v.h.f. waves are not reflected, so the same frequency can be used by another station only one or two hundred miles away. The use of f.m. helps here, because one of its peculiarities (called the "capture effect") is that if two stations are being received on the same frequency one of them has only to be two or three times stronger than the other to make it quite inaudible. In areas where both come in at nearly equal strength, neither can be heard properly.

Owing to the much greater width of the v.h.f. band, and the ability to use the same frequency channels over and over again at different places, each transmitter is allowed about 200kc/s instead of the miserable 9kc/s in the medium and long bands. If this sounds as if there is not much need for selectivity, you must remember that what counts is the ratio to the carrier wave frequency. A band of 200kc/s centred on 100Mc/s is only 0.2% of the carrier frequency, compared with 0.9% for 9kc/s on 1Mc/s. That being so, one has to consider the possibility of interference from a transmitter on another frequency—especially "adjacent-channel" interference. In this respect the advantage seems to be with a.m. Fig. 4* shows the results of a comparison between the two methods of modulation, when care had been taken to keep everything else the same. The "a.m." curve shows that when an interfering signal is within a few kc/s of the wanted one it can just be heard even when it is far weaker (about 40 db). An f.m. station has to be about 25 db stronger to produce the same interference. At about 100 kc/s off-tune there is no difference. But at 200 or more kc/s, a.m. interferes less, by about 10 db.

Next month I propose to go into the curious affair of f.m. sidebands, and why and how f.m. receivers can give quieter reception.

*M. G. Nicholson, *Wireless Engineer*, July 1947, p. 198.

MAGNETIC DICTATION MACHINE

AN interesting dictation machine, making use of rectangular sheets of coated magnetic recording paper, has recently become available in this country. It is known as the "Dictorel," and is made by the Belgian firm of A.C.E.C., whose London office is at 56, Victoria Street, S.W.1.

The leading edge of the recording paper is reinforced and provided at each end with a metal tag which engages with recessed hooks on the recording drum. These ensure accurate location of the paper, which is longer than the circumference of the drum and overlaps the leading edge. The recording head, which is driven parallel to the axis of the drum by a lead screw, makes a helical magnetic track 1mm wide with a pitch of 1.27mm; the recording speed is 8cm/sec.

"Dictorel" Type 402 magnetic recorder.

The paper is held continuously against the drum by three fixed external spring strips, which are felted and provide sufficient friction to keep the paper in register against the retaining hooks. No click can be heard as the trailing edge of the paper passes the sound head, and it was demonstrated that if the sheet is removed and replaced exact re-registration of the tracks at the overlap is automatically achieved.

Each sheet gives 12 minutes recording time, and the machine is fitted with a built-in loudspeaker and the usual remote control facilities for starting and stopping. A back-stepping control moves the sound head back one turn of the spiral trace, equivalent to 4 seconds, for each movement of the foot pedal or press button. For long repeats the head can be moved back quickly by hand.

Four valves are used in the equipment and the frequency of the erase and bias current is 30 kc/s. About 1 watt output is available for the loudspeaker, and the quality of reproduction on speech is very good. Power consumption is approximately 45 VA at 110, 130 or 220 V, 50-60 c/s. The dimensions are about $15\frac{3}{4}$in × $13\frac{1}{2}$in × 6in high, and the price is £85, with accessories for dictation, or £82 with equipment for transcription. Spare recording sheets cost £2 3s for 10, or £3 18s for 20.

BOOK RECEIVED

Applied Electricity. By Edward Hughes, D.Sc.(Eng.), Ph.D., M.I.E.E. Student's book covering the syllabus of the Ordinary National Certificate in Electrical Engineering and other examinations of a similar standard. Pp. 394 + xxviii; Figs. 269. Longmans, Green & Co., Ltd., 6 & 7, Clifford Street, London, W.1. Price 10s 6d.

The 1,000-Line Will o' the Wisp

Lines : Bandwidth : Ghosts

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

ONE meets not a few people who are firmly convinced not only that television with scanning of the 1,000-line order will be with us quite soon, but also that its coming will bring about an almost revolutionary improvement in the images provided by the domestic receiver. Some hold these views so strongly that they do not think it worth while to install 405-line sets in their homes : " Why buy what will soon become a museum piece when we are on the verge of such vast advances in technique ? " To those who ask me when the advent of 1,000-line television is to be expected in the home my reply is one which will not, I am sure, go unchallenged by readers of *Wireless World*. It consists of just the one word : Never.

By that I do not mean that definition of the kind theoretically obtainable by the use of such a system will never be achieved in television broadcasting and reception. It certainly will be achieved some day—but probably not by the scanning methods which we now use, because we know of nothing better. Again, I do not contend that television systems with 1,000 scans to the image will never be developed. It is possible that they will, for use in theatres and cinemas. An 819-line service is, in fact, already in being in France. The crux of the matter is whether these so-called high-definition systems have anything to offer to the viewer in his own home ; for the future of television is far more closely bound up with the home than with the hall or the theatre. Like sound broadcasting, it makes its strongest and widest appeal by virtue of its ability to provide entertainment in one's own house. Would 1,000-line television, if it came, improve domestic reception as dramatically and as radically as it would improve that in theatre or hall ? That is an important question. It is one to which I have given a great deal of thought, besides spoiling much paper with calculations, the results of which may be of use to those who want a ready means of comparing the possibilities of existing or proposed television systems. The rather shattering conclusion which emerges is that 1,000-line television has nothing whatever to offer to the ordinary viewer ! The term " 1,000-line," by the way, is used in a general sense and to save the trouble of writing repeatedly " of the order of 1,000 lines " ; the total of the scanning lines used in any interlacing system must, of course, be an odd number. Another point in favour of using the round figure 1,000 is that it simplifies calculations, without materially affecting the accuracy of the results obtained.

In any system of television one of the most important considerations is frequency : the range of modulation frequencies required and the carrier frequency. As the reader knows, the carrier frequency is largely determined by the width of the channel needed by a transmission : the greater the modulation bandwidth, the higher is the carrier frequency called for, if the transmission is to give and to receive sufficient elbow room.

The equation for the minimum range of modulation frequencies for balanced definition given in a previous issue of *Wireless World** may be conveniently rearranged in the form :

$$f_{min} = \frac{arpn}{2} L^2 \times 10^{-6} \text{ Mc/s} \quad .. \quad .. \quad (1)$$

where f_{min} = minimum modulation bandwidth to provide balanced definition
a = aspect ratio
r = ratio of whole line to active portion
p = ratio of active lines to total scanning lines
n = number of images per second
L = number of scanning lines.

Now in Europe, as well as in all countries in other parts of the world in which the periodicity of a.c. mains supplies is 50 c/s, n is a constant, its value being 25. All systems now use the 4 : 3 aspect ratio ; hence a also is a constant with a value of 1.33. The remaining factors r and p differ so little from system to system that they, too, may be regarded as constants, at all events for something a good deal better than round-figure working. The values here are 1.2 and 0.93 respectively. Hence we have for transmissions with 25 images per second :

$$\frac{arpn}{2} = \frac{1.33 \times 1.2 \times 0.93 \times 25}{2} = 18.55$$

This gives the delightfully simple expression

$$f_{min} = 18.55L^2 \times 10^{-6} \text{ Mc/s} \quad .. \quad .. \quad (2)$$

The minimum modulation range for 1,000 lines leaps to the eye ! Since 10^{-6} and 10^6 cancel out it is 18.55 Mc/s.

Carrier Frequencies

The total modulation range for the vision channel of a transmission is not twice the modulation bandwidth in modern systems, for one sideband is partially suppressed. For reasons outside the scope of this article complete suppression of this sideband is impracticable ; but under working conditions about 75 per cent of one sideband can be fairly sharply cut off.

This means that the vision bandwidth of a balanced 1,000-line transmission is approximately 18.55 + 4.64 = 23.19 Mc/s. We may take the whole width of the sound-plus-vision channel required, including the necessary gap between it and the channel next above it, as not less than 26 Mc/s, which is getting on for 3,000 times that needed by a sound broadcasting transmission and over six times that called for by a 405-line television transmission. Only one balanced

*Television " Goodness Factor," *Wireless World*, March 1949.

1,000-line transmission could, in fact, be made on the entire 41-68 Mc/s range of frequencies now allotted to the B.B.C. for television.

For 1,000-line television, then, carrier frequencies very much higher than those now in use would be essential; frequencies probably of the order of 300-400 Mc/s. And once we get up into carrier frequencies of hundreds of megacycles per second and wavelengths measured in decimeters we begin to encounter problems in reception of new kinds.

The shorter the length of an electromagnetic wave, the more closely does its behaviour resemble that of light waves. Radio waves, for instance, are increasingly prone to reflection and to scattering as their length is reduced. It was precisely for that reason that shorter and shorter waves were used as radar developed, for the scattering of electromagnetic impulses by the "target" and their return as echoes are the basis of radar. But even in radar the shortening process cannot in the light of present knowledge be continued usefully beyond a certain point; otherwise scattering is caused not only by the wanted target, but by such a variety of unwanted targets—clouds, rough seas and so on—that clutter blinds the receiver.

Scattering, reflections and echoes can and do produce interference with television reception on 40-70 Mc/s. Far worse trouble is to be anticipated with carrier frequencies of 300-400 Mc/s. If the idea of wavelengths of one meter or less has conjured up visions of neat little dipoles, or H- or inverted V- or X-aerials in his mind, the reader must prepare for a disillusionment: it seems certain that elaborate, highly directional arrays would be needed if ghost images were to be avoided.

Reflections

Let us see how it works out. With a 1,000-line transmission the duration of a complete scanning line is $10^6/(10^3 \times 25) = 40\ \mu$sec. That of the visible portion of the line is $40 \times 0.84 = 33.6\ \mu$sec. With a 20×15in image (it would hardly be worth while to have anything smaller for 1,000-line reception) the speed of the spot over the screen is 33.6/20, or 1.68 μsec per inch. Hence a ghost displaced by 1/10th inch is produced by a reflected signal reaching the receiving aerial with a delay of 0.168 μsec. How much longer than the direct path from transmitter to receiver must the path of a reflected signal be to produce such a ghost? The velocity of e.m. waves through air is 1,000 yards per 3.05 μsec. The distance travelled in 0.168 μsec is thus $10^3 \times 0.168/3.05$ = approx. 55 yards: a reflection following a path 55 yards longer than the direct path produces a ghost displaced by 1/10th inch. Unless the image is viewed at a distance of nearly 29 feet (which would completely annul the beneficial effects of its higher definition) the displacement of such a ghost image subtends more than one minute of angle and is therefore within the resolving powers of ordinary eyes. In other words, at normal viewing distance one such ghost would destroy the horizontal definition.

One does not need to do much thinking in order to realize (1) that at comfortable viewing distances a ghost with a much smaller displacement would spoil the image; (2) that if the receiver is only, say, 10 miles from the transmitter a reflection from something very close to the direct path of 17,600 yards will give rise to a secondary signal with a path-difference sufficient to produce a ghost; (3) that in any kind of built-up area not one but many ghosts are to be expected, due to reflections from a variety of sources, including other television aerials; (4) that since the angles between the unwanted echo paths and that of the wanted direct signal may be very small indeed the directivity of the aerial serving the individual home would have to be of a kind difficult to achieve even with the most complex of arrays—particularly in view of the wide pass-band required.

So far as one can see, the only means of ensuring "clean" reception in any house, save that remote from other buildings, hills, pylons and tall trees, and itself destitute of all chimney stacks except the one carrying the television receiving aerial, would be to receive the transmissions at a master station, equipped with a complex aerial array and erected on a carefully chosen site, and to "pipe" them to the homes of subscribers.

But over what can they be piped? And what kind of subscription in terms of £ s. d. would be called for from the householder? To design and install transmission lines able to deal faithfully with bandwidths of the order of 26 Mc/s would be a formidable and a costly business, particularly because they would have, as a rule, to be of considerable length, since the site chosen on account of its freedom from sources of echoes for the master receiving station might be expected to be at some distance from any built-up area. One cannot make any exact estimate of the subscription which the "pipee" would have to pay; but it would undoubtedly be something rather heavy.

Suppose that all these problems had been solved, that we could transmit and receive 1,000-line images faithfully, that it had become possible to manufacture suitable big-screen television sets at prices within the reach of the ordinary man: should we then be so much better off as many imagine?

Let us see what a balanced 1,000-line image has to offer. The number of modulation cycles per whole line is $f_{mod}/n\mathrm{L}$ and that of the cycles per visible portion of line is $f_{mod}/nr\mathrm{L}$, where f_{mod} is the modulating frequency in cycles per second. Taking n and r as constants as before, we have: modulation cycles per visible portion of line $= f_{mod}/30\mathrm{L}$. Each whole cycle of modulation corresponds to two picture elements. Hence the number of picture elements per visible line is $f_{mod}/15\mathrm{L}$ and the number of picture elements per inch is $f_{mod}/15s\mathrm{L}$, where s is the width of the image in inches. Calling the width, or horizontal diameter, of the picture element x, we have

$$x = \frac{15s\mathrm{L}}{f_{mod}} \text{ inch} \qquad \ldots \qquad (3)$$

From (3) we can find the minimum distance at which an image of a given number of lines can be viewed satisfactorily on a screen of given width. Notice that these calculations apply to any transmission, whether it is balanced, with $f_{mod} = f_{min}$, or unbalanced, with $f_{mod} < f_{min}$. In the latter case $x > y$, the height of the picture element, and therefore subtends a greater angle at the eye. The discrimination of normal good eyesight is accepted as being about one minute of angle. Since cotan $1' = 3438$, the minimum viewing distance d is $3438x$, or

$$d = \frac{15s\mathrm{L} \times 3438}{f_{mod}} \text{ in.}$$

Using the tangent of $1'$ (which is 0.00029), we can simplify the expression to the form:

$$d = \frac{15s\mathrm{L}}{f_{mod}\,(\mathrm{Mc/s}) \times 290} \text{ in} \qquad \ldots \qquad (4)$$

For a given viewing distance in inches the maximum screen width in inches is :

$$s_{max} = \frac{f_{mod}\,(\text{Mc/s}) \times 290d}{15L} \text{ in} \quad \cdots \quad (5)$$

The smaller living rooms towards which we tend to-day do not usually allow the viewing distance to be much greater than 8-9 feet ; let us call it 100 inches to simplify calculation.

From (5) we find that at 100 inches the maximum screen width for a 1,000-line image is 29.2 inches—say a 30 × 22½ inch image—which would probably be overlarge for comfortable viewing at such close quarters and would seem to point to a televisor, no doubt of the projection type, which might be a piece of furniture of rather unwieldy size. Alternatively, (4) shows that a 24 × 18 image built up by 1,000 scanning lines could be viewed, if one wished to do so, at approximately 5½ feet.

If prospects for 1,000-line television are so barren, what of the 625-line standard, to which all Europe save this country and France, is now apparently committed ? The word " save " is used advisedly, for the projected 625-line systems are shown by cold, hard figures to be but poor pale travesties of television as it could and should be. From (2) above f_{min} for a 625-line transmission is : $18.55 \times 625^2 \times 10^{-6}$ Mc/s, or approximately 7.25 Mc/s. The accepted standard modulation bandwidth is 4 Mc/s ; hence the " goodness-factor," f_{mod}/f_{min}, for such services is 4/7.25 = 0.55 — little more than half what it should be. And even that is likely to prove an ideal rather than a reality; for, as readers know from experience, a pretty good receiver is needed to do justice to the 3-Mc/s portions of the B.B.C.'s faithfully transmitted test patterns . . . I will not labour the point.

The more one thinks over the subject, and the more paper one spoils with calculations, the stronger becomes one's conviction that, so long as scanning of the present type remains the sole practicable television method, progress is not to be made by increasing the number of lines. Research should be concerned, rather, with making the best use of the ranges of modulation frequencies which can produce in transmitter and moderately priced receiver a goodness-factor having the closest possible approach to unity. And that, in the light of present knowledge and technical achievement, leads inescapably to a scanning system, where 50-c/s mains supplies are involved, of the order of 400 lines. If we and the French could split our differences by adopting a common standard of (on our part) 405 + 16 = 421 lines and (on their part) 441 − 20 = 421 lines—an alteration which most existing receivers in both countries could take in their stride since it involves no more than line-hold adjustment—we might even yet show the rest of Europe that television progress in the immediate future is, and must be, closely linked with the adoption of a faithfully transmitted and faithfully received modulation bandwidth of the order of 3 Mc/s.

Radio on the Airways

Types of Navigational Aids Used on the Main Airlines

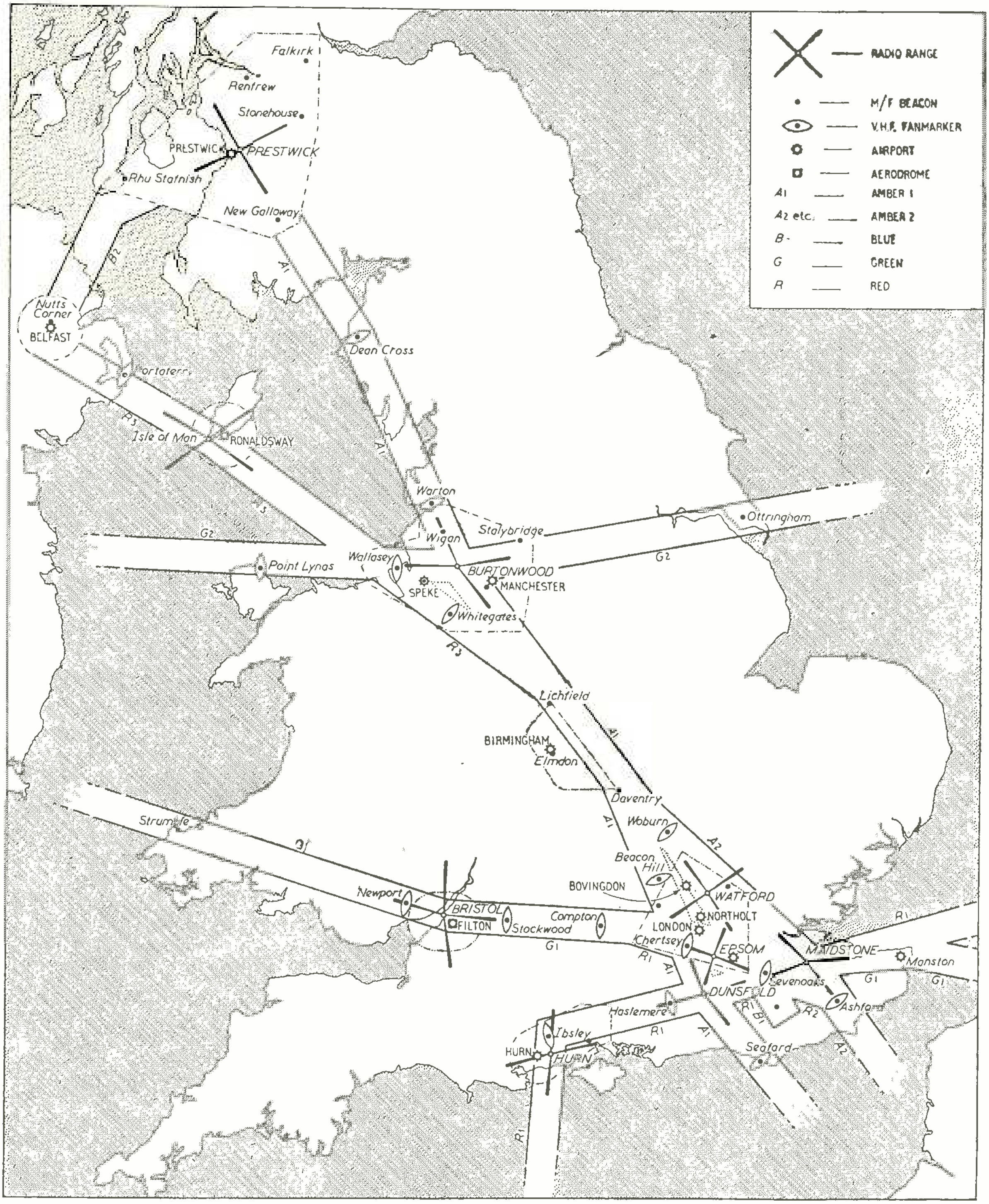
SINCE the inauguration of regular air traffic to and from this country there has always been a tendency for aircraft to follow fairly well-defined paths in the air. Navigation in fine weather offers no difficulties, but in conditions of poor visibility assistance from the ground in some shape or form has always been a pressing need. Radio has served this purpose, in one way or another, reasonably well, but with the ever-increasing density of air traffic it became apparent that some way would have to be found of controlling the flow of traffic to and from the main airports, and that the control would have to become effective, when conditions required, quite a considerable distance away from these termini.

Thus there came into being a scheme which involved the laying down of a number of main trunk air routes, or airways as they are known, and equipping them with various radio aids to navigation so that pilots of aircraft, carrying only the barest minimum of radio apparatus, can safely negotiate the air lanes under all, or at least most, weather conditions.

These airways have, for identification purposes, been given the names of Red 1, Red 2, Amber 1, 2 and 3, Green, Blue, and so on, according to the direction they follow. As the map in Fig. 1 on the following page shows, they give direct access to most parts of the Continent, the Americas, and, so far as possible, avoid the main centres of population.

Radar also fits into the general picture, but its present use is limited to the immediate vicinity of the major airports. But here we are concerned only with the actual radio aids to navigation which the pilot in the aircraft (or his navigator) use to guide them into, and along, the airways. The principal equipments installed for this purpose are medium frequency omni-directional beacons, radio ranges, v.h.f. fan markers and " Z " markers. V.H.F. radio telephony also plays an important part in the scheme.

The m.f. omni-directional beacons, which operate in the 200- to 400-kc/s frequency band, are used as markers for the entrance to the airways; Strumble, Nutts Corner (Belfast), New Galloway, Ottringham and others located on or near the coast, to mention a few only, exemplify this application. These beacons radiate a tone-modulated signal which is periodically interrupted to give the identification letters of the station in morse characters. These beacons can often be heard at considerable distances, although for operational purposes they are rated as 10-, 25-, 50-, or 100-mile beacons, these being the service ranges as a radii from the stations for a signal strength of 60 mV ± 10 mV per metre at the service boundaries. As the map shows the omni-directional beacon is used also to mark the course of the airways, but this function is more effectively performed by the radio range. It provides a well-defined path to follow and gives immediate warning of any deviation from the correct course and special equipment is not needed, the ordinary communications receiver being all that is required in the aircraft. D.F. equipment, or a radio compass, is needed to obtain the same information from the ordinary omni-directional radio beacons.



(Courtesy Ministry of Civil Aviation

Fig. 1. Map of the principal air routes in the United Kingdom with the type and position of the radio beacons installed and contemplated.

Radio range operates also in the medium frequency waveband and produces a signal which, while audible from all points of the compass, gives indication of a definite course in four directions only. Two types of radio range are in general use; one employs two crossed loop aerials (usually rectangular in shape) arranged at right angles to each other, while the other has vertical towers with the towers acting as the actual radiators. Both types give the same kind of signal in the receiver, but the transmitters are quite different.

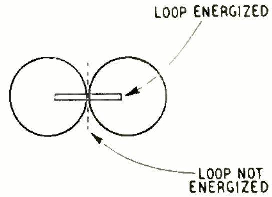
The crossed loop installation radiates a tone-modulated 1,020-c/s signal, each loop being energized alternately by a switching and keying system. If fed with the same power, each loop will have a "figure-of-eight" polar diagram in the horizontal plane, as shown in Fig. 2, and when energized alternately, and in suitable phase relationship, the radiation pattern round the station takes the form of two "figures-of-eight" at right angles, producing four zones of equal-strength signals spaced 90 deg. apart and bisecting the angles formed by the crossed axes of the individual loop patterns, as shown in Fig. 3.

In order to detect the equi-signal paths with an ordinary receiver the loops are not only energized alternately, but each is keyed to radiate a distinctive signal. One is keyed with the morse letter N and the other with A. The duration of the dots, dashes and spaces are so proportioned that if the two signals are received at exactly the same strength they interlock and give a continuous tone in the pilot's headphones.

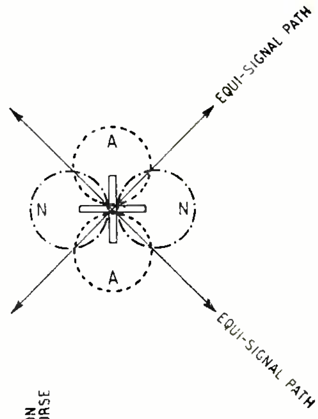
At other points round the beacon either the A or the N signal will predominate and at a suitable distance there will be regions where either A or N only will be audible. The pattern in Fig. 4 shows the kind of signal that should be heard at different points of the compass round a radio range when each loop is so energized that it radiates a symmetrical pattern with equi-signal paths exactly at 90 degrees to each other.

The principle of A and N interlocking signals is not new and it has been used in the past to produce path indication by navigational aids, but possibly this brief description of its application to radio range may serve to refresh the memory as the system has not been discussed at any length in recent times.

The other type of radio range used on the airways has vertical tower radiators, four such towers being arranged in a square with a fifth in the centre. Fig. 5 shows the type of towers employed. The four corner aerials are connected to one transmitter with diagonally opposite ones forming a separate aerial system similar to the four vertical sections of the crossed loops. Each system is fed alternately from a transmitter with unmodulated signals keyed in the one case with the morse letter A and in the other with the letter N. Interlocking occurs as already described and while it produces four equi-signal paths they could not be detected without some very special equipment. To overcome this, the fifth, or centre, tower is continuously energized by a separate transmitter having a frequency different from the other of 1,020 c/s. Heterodyning of the two signals in the aircraft's receiver produces the distinctive modulation tones of the crossed loop system. The pilot would not know by the sound of the received signal from which type of range it came but for the identification signals which are radiated periodically. The A and N signals are interrupted at intervals and an identification signal in morse characters substituted.

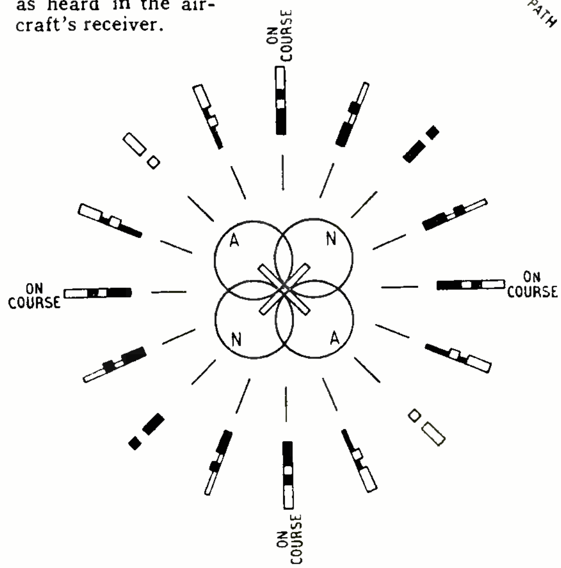


Left: Fig 2. Theoretical radiation pattern for one of the crossed loops of a radio range beacon.



Right: Fig 3. With the two loops (or four towers) of a radio range energized alternately and keyed with the morse letters A and N, four equi-signal regions are produced.

Below: Fig. 4. The all-round signal pattern of a radio range beacon. Both the crossed loop and the tower installations produce the same signal pattern as heard in the aircraft's receiver.



As the map shows, the four course markings of a radio range are rarely at right angles, but at some angle that throws some, or all, of its equi-signal paths along an airway. This is not accomplished by any change in the position of the loops, or towers, as once the station is erected any subsequent changes in courses brought about by additions or modifications to airways would be an expensive undertaking. In practice the aerials are erected quite symmetrically and the course path produced by the way in which the aerials are energized.

With the tower installations this can be done solely by electrical methods, it being necessary only to adjust the phase angle of the currents in the four towers. A goniometer system of feeding power to the aerials is employed and variations in phase are easily achieved by inserting suitable delay networks in the feed lines to each.

With the loop system conditions are somewhat different as the physical form of the loop precludes any simple method of varying the phase relationship in opposite limbs of a loop; this must be 180 degrees unless some external influence intervenes. The fact that external bodies can modify the polar diagram of a loop is taken advantage of when it is required to shift the equi-signal paths of the system.

In radio range it is done by erecting an auxiliary aerial so that it couples closer to one vertical section of a loop than to the other. This causes a shift in the equi-signal paths and the amount of displacement is governed by the magnitude and phase of the induced current in the auxiliary aerial.

The extent to which the four paths can be shifted is well exemplified by the diverse courses needed to meet the requirements of the airways' scheme. If at any subsequent time it is required to shift the course of an airway the radio range can be modified to suit merely by resiting the auxiliary aerial (or substituting different delay networks in the goniometer), which is a relatively simple matter.

The average power of a radio range of the loop type is 100 watts r.f. output with 100 per cent tone modulation. Higher power is used for the tower installations, the central tower (the carrier frequency) is supplied with about 400 watts and the keyed towers (equivalent to modulation) with 275 watts or so. The last-mentioned equipment thus has a greater operational range than the loop installation.

Whilst a radio range tells a pilot whether or not he is keeping a true course along the airway, it does not give him any indication of his actual position. It is the same as direction finding on to a single station or beacon; one can get direction, but not position.

Position information is provided by a series of vertically radiating marker beacons, the radiation pattern being broad at right angles to the course of the airway, but narrow along its length. That relic of Victorian times, an opened fan standing vertical with its base on the ground and at right angles to the airway, will give a fairly good idea of the kind of radiation pattern achieved. And these beacons are appropriately termed fan markers and they have a power of about 100 watts.

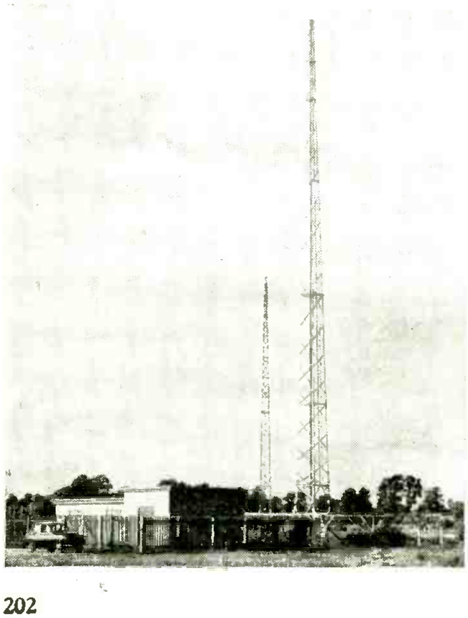
The desired radiation pattern is obtained by using four half-wave horizontal dipoles mounted in line end-to-end (or collinear), one-quarter wavelength above a reflecting curtain of wire-netting and by suitable relationship of the currents flowing in the four dipoles. The reflecting curtain is not a fundamental part of the system as the ground itself would serve the same purpose, but by using the wire-netting reflector any distortion of the vertical radiated pattern due to inequalities of the ground, or even differences in vegetation, is avoided. A typical aerial installation for a fan marker is shown in Fig. 6.

In order to obtain the fan-shaped radiation across the airway the aerial system is erected so that the four collinear dipoles point *along* the airway. It is what is sometimes called a broadside array backed by a reflector.

These fan markers are tone modulated and each radiates identification signals in morse, so that the pilot can tell not only which airway he is on, should there be any doubt and this is most unlikely except at intersections of two or more airways, but also his exact position along the airway.

One other type of vertically radiating marker is sometimes used on the airways. It is called a "Z" marker and has a vertical cone-shaped radiation pattern with the apex on the ground. It is used to fill in the region of "no radiation" immediately above a radio range. They avoid complete cessation of signals when the aircraft passes over the range and, while not normally troublesome as an aircraft on a steady course would soon run into the signal zones again, the absence of signals might be a little awkward for aircraft instructed to make tight circles round a particular range while awaiting its turn to proceed into the area under the operational control of an airport.

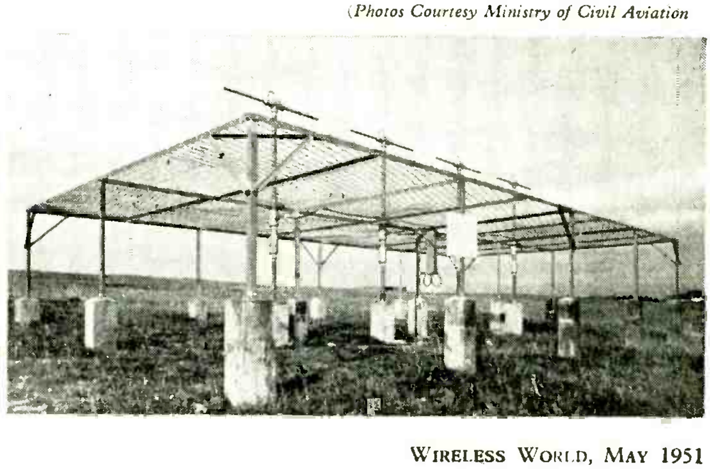
Although figures have been given here for the r.f. power output of the various radio beacons it does not mean that all use the maximum. The power output of all transmitters is variable over a wide range, the fan markers, for example, can be used with 12 watts output or 100 and all beacons are set up and operated with just the amount of power needed to give a reliable service under all conditions. The majority are unattended beacons so that equipment is duplicated and automatic change-over to the stand-by takes place in the event of a failure. Suitable warning is passed over land-lines to the parent station of the beacon so that immediate steps can be taken to rectify the defect.



Left : Fig. 5. Two of the tower radiators used for one type of radio range.

Below : Fig. 6. Aerial installation for a fan marker. These operate on a frequency of about 75½ Mc/s.

(Photos Courtesy Ministry of Civil Aviation



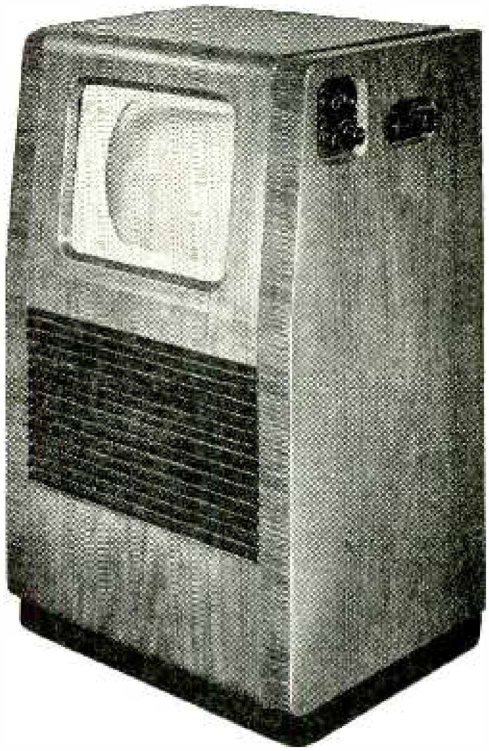
R.G.D. Television Receiver

Model L2351T

THIS receiver is of the console type with a 12-in tube and includes a four-station broadcast set as well as television. The L2351T is for London-area reception. It has three r.f. stages, a diode detector and one v.f. stage in the vision channel. Single-circuit couplings are used between the coaxial feeder and the first grid on the one hand and between the last r.f. valve and the detector on the other. Pairs of coupled circuits are used between the r.f. valves. The circuits are tuned to provide vestigial-sideband reception of the upper sidebands; that is, of those remote from the sound channel. As a result no special sound-channel rejector is needed and it suffices to tune the sound pick-out circuit for maximum sound-signal rejection in the vision channel.

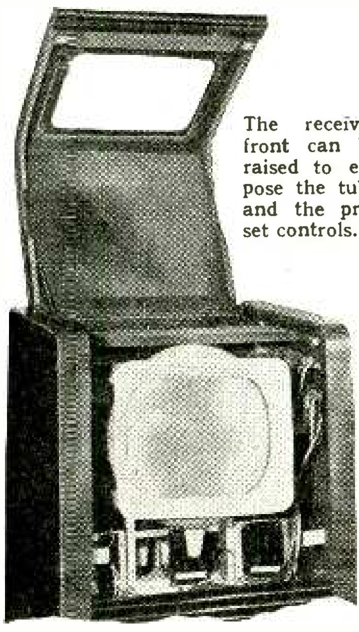
This circuit comes after the first r.f. valve which is common to both signals. The sound channel itself has two r.f. stages with coupled pairs of circuits, a diode detector, diode noise limiter and an output valve. The noise limiter is of the usual series type which needs no adjustment. A switch is provided, however, by means of which the time constant can be increased if required. This permits better noise suppression to be obtained when interference is severe, but at the expense of sound quality. The volume control operates by varying the cathode bias on the r.f. stages.

The vision-channel noise limiter is of an unusually complex form. The arrangement is shown in Fig. 1, in which V_1 is the v.f. valve. Its output is positive-going on the picture signal and that proportion developed across R_1 and the compensating inductance is applied to the grid of the c.r. tube through C_1. It is also applied through C_2 to V_2 and a somewhat larger amplitude of signal appearing across R_1 and R_2, directly to V_3. Both diodes are normally non-conductive.

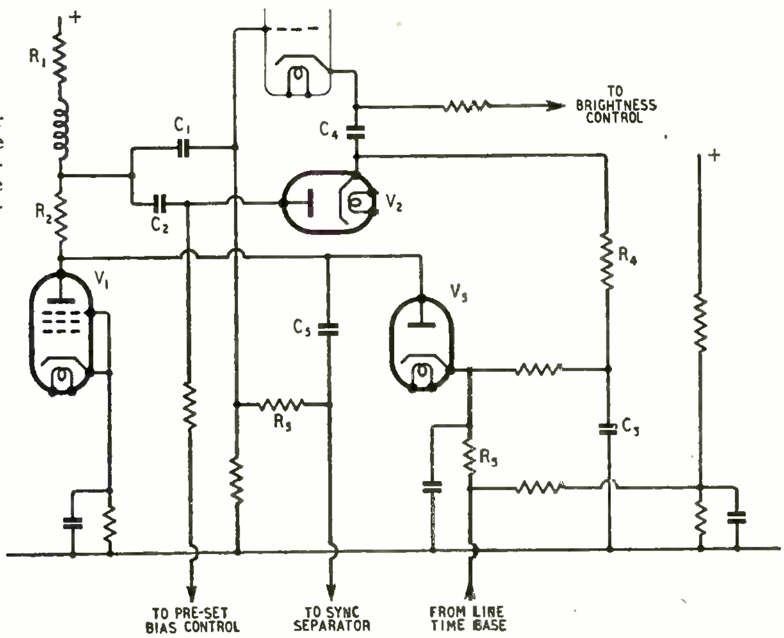


General view of the receiver showing the controls.

Fig. 1. Circuit of the vision-channel noise limiter.



The receiver front can be raised to expose the tube and the pre-set controls.



A negative-going pulse is applied through R_3 to the cathode of V_3. This pulse is derived from the line time base and has a duration roughly equal to that of a line sync pulse and coincides with it in time. V_3 therefore has impressed on it simultaneously the sync pulse to its anode and the larger time-base pulse to its cathode. It therefore conducts and the quantity of electricity passed is proportional to amplitude of the sync pulse, and hence to the signal, and it builds up a proportional bias across C_3 which is applied through R_1 to the cathode of V_2. The diode V_3 and its associated circuit are merely a means of obtaining a bias voltage for V_2 which is proportional to the output of V_1.

This bias voltage keeps V_2 non-conductive unless the input to it through C_2 exceeds the peak-white level, as on an interference pulse. V_2 then conducts and the interference is passed to the cathode of the tube through C_1. On interference, therefore, the signal is passed to grid and cathode simultaneously so that the grid-cathode p.d. is unaffected.

The sync separator is fed from the anode of V_1 through C_5 and this circuit also acts to give d.c. restoration, the resulting bias being passed back to the tube through R_5. The sync separator comprises a pair of diodes which provide initial limiting of the signal. They are followed by a pentode limiter from the anode of which the sync pulses are fed to the line time base through a differentiator. A further pentode is used to produce the frame sync pulses.

The time bases each have a thyratron saw-tooth generator and a pentode amplifier. An adjustable linearity circuit is fitted to the frame amplifier and the output valve is transformer-coupled to the deflector coil.

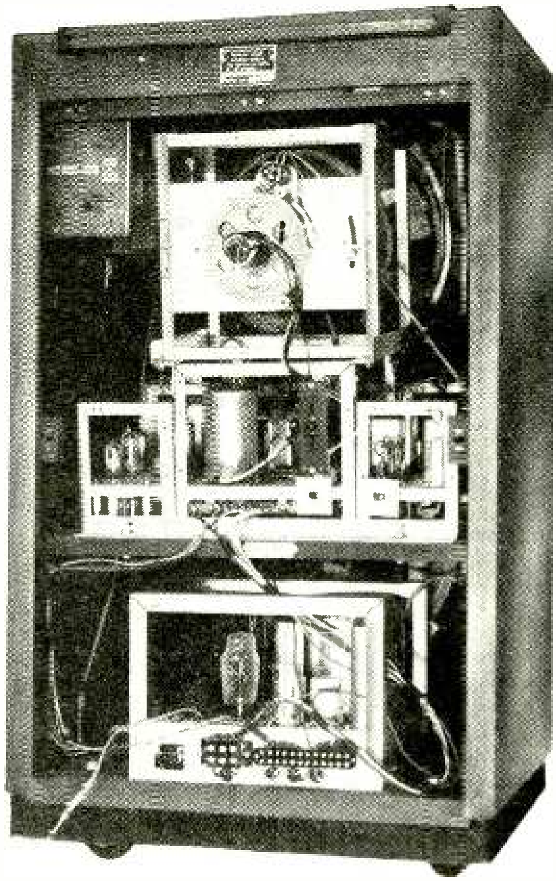
The line amplifier also comprises a pentode with transformer-coupling to the deflector coil. The linearity control is a variable resistor which, in series with a capacitor, is connected across the deflector coil. The deflector coil itself is of rather unusual type, for it has an iron core wound in toroidal fashion.

The e.h.t. of some 7 kV is produced by an r.f. oscillator and rectifier. The power supply comes from the mains through a transformer. The h.t. winding is tapped and two rectifiers are used to provide supplies at 260 V and 380 V, the latter being used for the time-base output valves.

The broadcast receiver is a separate unit with three valves and providing a choice of four pre-selected stations; its output is fed to the output valve of the television sound-channel receiver. It requires a separate aerial from the television one. Provision is made for the connection of a gramophone pick-up and there is a mains-outlet socket on the power unit from which the connections for a gramophone motor can conveniently be taken.

The mains controls are mounted on the side of the cabinet and comprise the mains on-off switch, contrast, focus, television-sound volume, broadcast-sound volume and station selector switch. When changing from television to broadcast it is necessary, in addition to operating the switch, to turn down one volume control and turn up the other.

By undoing two wing nuts inside the cabinet the top of the cabinet, with the upper half of the front attached, is released and can be lifted up for access to the interior. This enables the safety glass and the tube face to be cleaned and gives access to most of the pre-set controls. Since the whole of the back can be removed the accessibility is good.



Rear view of the set ; the broadcast receiver is the unit in the top left-hand corner.

On test, the set gave a very good performance, the brightness being adequate for daylight viewing under normal conditions. The synchronizing was exceedingly good, the settings of the hold controls being in no way critical. The 3-Mc/s bars in the test pattern were plainly evident. There was some evidence of circuit "ringing" when viewing the test card, but it was not sufficient to be noticeable on programme pictures.

The workmanship of the set is excellent and the appearance of the cabinet is pleasing. It is fitted with very easy ball "castors" and can be moved in any direction at a touch.

The construction is of unit form, the television set proper being in three units held together by a framework which also supports the tube. The broadcast receiver is a separate unit and the power unit is at the bottom.

There are 21 valves (counting double valves as one) plus the three of the broadcast receiver and the pre-set controls are: Sensitivity, Brightness, Sync, Line Hold, Line Amplitude, Line Linearity, Frame Hold, Frame Amplitude, Frame Linearity, Sound Interference Suppressor Switch, Vision Noise Suppressor, Vision Noise-Suppressor On-Off Switch.

The set is available with or without the broadcast receiver. Without it the price is 115 guineas plus £27 9s 5d Purchase Tax; the broadcast receiver costs £19 6s 8d.

The Birmingham-area model is type B2351T and is a superheterodyne but is otherwise identical.

SHORT-WAVE CONDITIONS

March in Retrospect : Forecast for May

By T. W. BENNINGTON*

DURING March the average maximum usable frequencies for these latitudes decreased slightly by day, and increased considerably by night. These are the normal seasonal variations from February to March, and the m.u.fs. should now continue to vary in these directions towards mid-summer.

Daytime working frequencies were only moderately high. There was a long period of ionospheric disturbance about the middle of the month, when the higher frequencies were generally unusable. During the rest of the month, while, for example, 28 Mc/s was occasionally usable to the U.S.A., the highest useful frequencies were more often of the order of 22 Mc/s by day, and about 9 Mc/s after midnight.

There was a considerable decrease in the amount of Sporadic E observed during March. Sunspot activity was, on the average, at about the same level as during the previous month.

March was, on the whole, a somewhat less disturbed month than February. A prolonged ionospheric storm did, however, occur from 5th-17th, but apart from that the only other day of disturbed radio conditions was March 1st. A Dellinger fadeout was recorded at 1137 hrs. on the 24th.

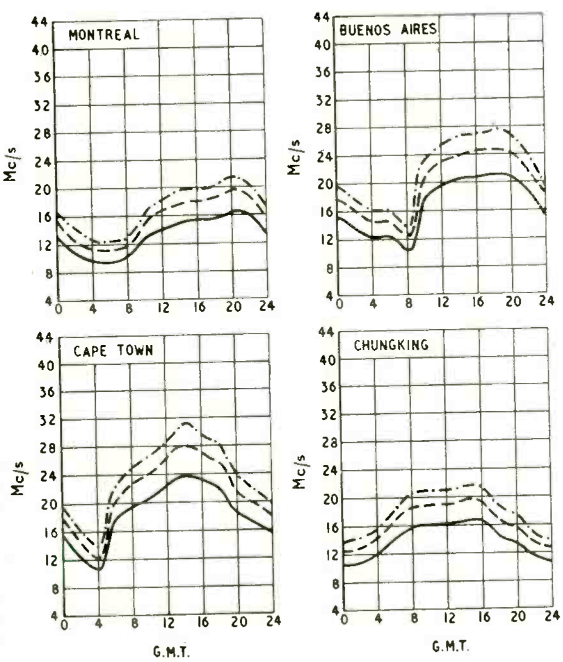
Forecast. — During May it is likely that the daytime m.u.f. for these latitudes will decrease considerably, and that the night-time m.u.f. will increase slightly.

The result of the ionospheric variations should be that the peak daytime working frequencies for long-distance communication will become lower over all circuits. Medium-high frequencies will, however, be usable for longer periods during the day and, over most circuits, frequencies as high as 9 Mc/s should be usable throughout the night. The highest regularly usable frequency for north/south circuits should be of the order of 22 Mc/s, and that for east/west circuits about 16-17 Mc/s.

There will probably be a considerable increase in the rate of incidence of Sporadic E capable of sustaining high frequency propagation, and this may often permit medium-distance communication on, perhaps, the highest of the short-wave frequencies. Normal communication over medium distances will be controlled for several hours around noon by the E or F_1 layers, and during these periods the working frequencies will not be lower, but higher, than during the previous month. Ionospheric storms are not usually particularly frequent or troublesome during May.

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

* Engineering Division B.B.C.



——— 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

RANDOM RADIATIONS

By "DIALLIST"

Automatic Monitoring

NOT LONG AGO I spent an interesting afternoon in the B.B.C.'s Designs Department seeing and hearing the recently developed Automatic Monitor at work and talking to two of its three joint originators, F. A. Peachey and C. Gunn-Russell. The automatic monitor—A-M for short—is designed to take over one of the most monotonous of human jobs, that of the engineer who sits at some distant point in a broadcasting network and makes the adjustments necessary to keep a signal as it reaches him as close as possible to what he imagines it must have been at its point of origin. The engineers doing this work at about a dozen points in the B.B.C.'s network must listen critically for long periods on end; a tiring business. Since there is no reference signal for comparison, the corrections they make must be to a great extent matters of personal taste and judgment, which is not altogether satisfactory. Even less satisfactory is the employment of a very considerable number of skilled engineers on tasks of this kind. The A-M will soon be taking over much of this work. The way in which it works is very briefly this. Most of the defects to which a signal is liable in its passage over a long cable can be made to appear as abnormal rises or falls in voltage. The A-M is supplied with a reference signal and makes continuous electronic comparisons between this and the line (or compared) signal. This is done by means of a bridge arrangement and a differential detector, to the valves of which both voltages are fed. So long as they are equal, or nearly so, nothing happens. But any serious unbalance is at once shown up by the ringing of a bell, served by a relay, and by movements of the pointer of a galvanometer.

The Next Step?

You will see that this does not quite eliminate the engineer. Someone has to be there to take action when A-M calls for it; normally, though, adjustments and corrections are needed only at fairly long intervals, so that the engineer can go on with his own work, leaving it only at those moments when A-M summons him. This is a big step forward, but I imagine that in time another development will be made. If A-M now operates, as it does, a relay which causes the bell and the galvanometer to indicate by their behaviour not only the existence of a fault but also what kind of fault it is, it should surely be possible to develop an electronic device which would interpret these signals *and* take the necessary action. It is a complicated problem and its solution will take time, but no doubt one day the fully automatic monitor will appear.

The Eutectic

I GATHER THAT a good many readers have been as puzzled as I was when I first came across the term "eutectic," which is always cropping up in articles on soldering. My own acquaintance with the mysteries of metallurgy being of the slightest, I consulted friends who do know something about it. From these I gather that the eutectic is the combination of the two metals forming an alloy with the lowest possible melting point. And that melting point appears to be always considerably below the melting point of either of the constituent metals by itself. The term melting point here means the temperature at which the metal becomes entirely liquid. The soft solders used for most purposes are alloys of tin (melting point 232° C) and lead (melting point 327° C). Suppose that you started with pure lead, went on adding tin to it and recorded the temperature at which each combination of the two metals became liquid. An alloy of 10/90 (that is 10% tin, 90% lead—the tin is always written first) would liquefy at a little below 320°, one of 20/80 at about 300°, and one of 30/70 at 275°. The fall in the melting point temperature would continue until the proportions were 63/37, when it would be 183°. From then onwards the addition of further tin would send the melting point up.

Back to Tubal Cain?

The eutectic of the tin-lead alloy is, then, 63% tin and 37% lead; eutectic solder has these proportions of the metals. The commercial soft solder used for so many radio jobs may be described as near-eutectic, for it is the 60/40 alloy which is found satisfactory from both manufacturers' and users' points of view. As S. J. Nightingale and O. F. Hudson have mentioned in their excellent book "Tin Soldiers," the craftsmen of the middle ages (and very probably those of much earlier times) discovered by trial and error how to make something very like eutectic for use in tinsmith's work. This was known as "two-and-one," that is, two parts by weight of tin to one of lead, or 66/34. Some families of tinworkers, no doubt, had their own special recipes, such as "seven-and-four" (64/36) or three-and-two (60/40), which were passed on from father to son. Where harder solders were needed these were close to the one-and-one (50/50) ratio. The traditional alloy for the hardest of the tin-lead kinds was "one-and-two," known as plumbers' solder and very like the 40/60 of to-day.

Knee-Deep in Terminals

My very best thanks to those kind readers who have sent me examples of what they consider ideal terminals for radio or general electrical purposes. At first they trickled in; then the trickle became a river and the river a flood. The last time I met the Editor he enquired whether I had safely received the hundredweight or so that he had sent on to me a few days before! It has not been possible for me to write personally to all who showered actual terminals or drawings or descriptions upon me; I am sure they will understand and forgive. Some of those who sent drawings or descriptions asked whether it would be worth their while to take out patents. Frankly, I doubt it. To be successful, a new idea in such things as terminals must offer something so obviously and outstandingly better than familiar types that it will completely outclass them. Only in that case is it likely to be worth while for a manufacturer to install the tools required for the new device and to write off his existing equipment as scrap. That is a point that inventors often fail to grasp.

MANUFACTURERS' LITERATURE

Components and Accessories by Clix catalogued in a booklet from British Mechanical Productions, Ltd., 21, Bruton Street, London, W.1.

E.H.F. Aerials; a folder of illustrated leaflets from G.S.V. (Marine & Commercial), Ltd., 395, High Street, Chatham, Kent.

Cold Pressure Welding; the latest developments described in a new illustrated brochure from The General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2.

Capacitors catalogue C263 available to manufacturers from A. H. Hunt, Ltd., Bendon Valley, Garratt Lane, Wandsworth, London, S.W.18.

Cables for broadcast relaying and sound distribution catalogued in a leaflet from The Telegraph Construction and Maintenance Co., Ltd., 22, Old Broad Street, London, E.C.2.

UNBIASED

By FREE GRID

Radio Mummy-Making

APPLIED science in all its branches has made enormous strides since the day when Mr. Sowerberry, the undertaker, took young Oliver Twist into his employ to initiate him into the mysteries of this very necessary calling. It does not surprise me, therefore, to learn from the pages of *Tele-Tech* (February, 1951) that diathermy—one of the many ramifications of radio technique—has been brought into use by Chicago undertakers, or morticians as they call themselves without regard to the sinister literal meaning of this horrible hybrid word which is so very apt in this famed city of gangsters and sub-machine guns.

Diathermy is being used for desanguinating and dehydrating defunct Chicagoans, thus embalming them and enabling them to be kept in prime condition for two million years. The only comment I have to make is that the whole business leaves a nasty taste in my mouth, more especially when I remember

" A nasty taste "

that Chicago is also the centre of the meat-canning industry.

Radiotelearchics in 1915

A FEW months ago (October, 1950) I told you that I had fitted my car with a v.s.w. transmitter whereby I was enabled by a very simple and obvious application of telearchics to open the garage doors and at the same time fill the house with light, warmth and the smell of sizzling kippers each night while still a mile or so from home. A correspondent, who with Micawber-like patience and persistence has read this journal steadily from the first number, tells me that he has been enabled to do this and more, also, solely by carrying out ideas put into his head by an item of news he read in the November, 1915, issue of *W.W.*

He stresses that in one respect he

" Desperate slimming measure "

did more for his comfort by remote radio control in 1920 than I did for mine thirty years later. He lives in a house not provided with a garage and has to rent one some distance away. But, in the depths of winter he has, since 1920, started his car engine by radio telearchics while still at home so that it is nicely warmed up by the time he gets round to the garage.

It was astonishing to me to read that car engines were started by remote radio control as far back as 1915, and yet on taking down the appropriate issue of *W.W.* from my library shelves I see that my correspondent is correct. I presume that the only reason why he waited from 1915 to 1920 to use this idea was the restrictions imposed during the war years.

I must say that I had forgotten this news item in *W.W.* Happily, I am not compelled to clutter up valuable ether space in this manner as my garage adjoins my house and I could, if necessary, start the car by ordinary electrical means, but do not actually do so as Mrs. Free Grid warms both the car and herself by using the handle in winter and summer as a voluntary and desperate slimming measure.

Amateur Radio in 1898

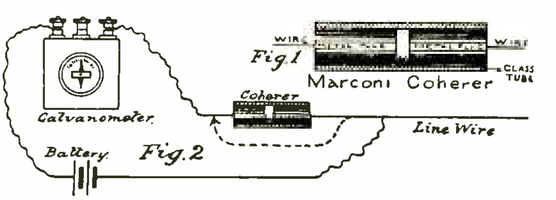
IN the February issue, when discussing the question of the publication of the first constructional article for a wireless set, I stated that I had personal knowledge of one which appeared in 1911 but felt that this was not the earliest. Actually, I expected, as a result of what I said, to hear of some article being published about 1907, but certainly not very much earlier. I have, therefore, been greatly astonished to learn from a reader that one appeared in the first issue of *The Model Engineer* which was born in January, 1898, and is still going strong. By permission of the Editor of that journal, we reproduce a diagram from the article which was entitled "The New Wireless Telegraphy: Some Interesting Experiments for Amateurs" and was given pride of place in the issue.

The article is not of the type giving complete constructional details such as we were used to in the twenties and thirties but deals with the construction of both transmitters and receivers in broad outline, giving the reader a choice of several different arrangements. A range of two *feet* is claimed using the make-and-break of an electric bell as a spark transmitter, while, with a six-inch induction coil, the range is more than quadrupled to three yards. These ranges seem a little conservative but it is only fair to point out that neither aerial nor earth were used and the writer states that for long-distance work these are necessary for both transmitter and receiver.

I think that the most surprising thing about the article is that it shows how hard the amateurs pressed on the heels of the professionals even in those early days; in later times, of course, notably in the years following the 1914-18 war, we find them leading the professionals as they bridged not only the Atlantic but the 12,000-odd miles between here and the Antipodes using wavelengths given to them by the "totalitariocrats" of St. Martin's-le-Grand solely because it was thought that these short waves were of not much practical use.

How closely the amateurs followed the professionals can be realized when it is recalled that the article in *The Model Engineer* was published only six months after the formation in July, 1897, of the first commercial wireless company, The Wireless Telegraph and Signal Co., which, like the amateurs, still flourishes in 1951, but as Marconi's W.T. Co.

I have little doubt that "amateur" wireless experimenters were at work long before 1897, but surely one is not justified in using the word "amateur" before professionalism has started.



1898 Constructional Diagram.