Wireless World

RADIO, TELEVISION AND ELECTRONICS

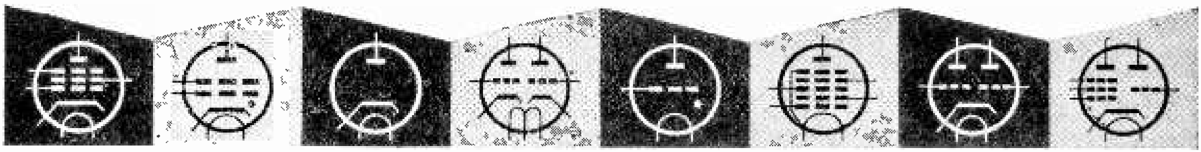
43rd YEAR OF PUBLICATION

Managing Editor : HUGH S. POCOCK, M.I.E.E.
Editor : H. F. SMITH

MAY 1953

In This Issue

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



VALVES, TUBES & CIRCUITS

5. DM 70—SUBMINIATURE TUNING INDICATOR FOR BATTERY OR MAINS RECEIVERS

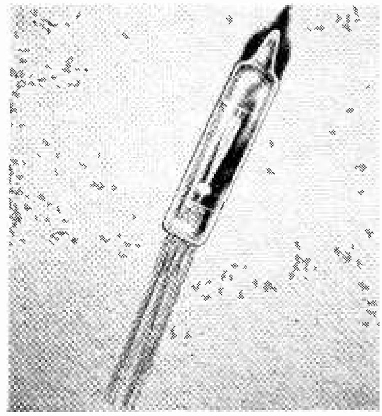


Fig. 1.—DM70, showing grid aperture.

An entirely new form of cathode ray tuning indicator, the Mullard DM70 is characterised by a compact subminiature bulb, a simple triode structure, a linear form of indication and a 1.4-volt 25mA directly-heated filament.

Whilst having electrical characteristics similar to a triode, the grid and anode together produce a visual indication of the voltage applied to the grid. These two electrodes consist of flat plates, the grid having an aperture shaped like an exclamation mark and the anode being coated with luminescent material on the face nearer the grid. The filament is located on the side of the grid remote from the anode and is parallel to the axis of the aperture. On viewing the anode through the grid aperture, a luminescent column is observed, the length of which is a maximum when approximately zero bias is present on the grid. Its length decreases from the " waist " of the aperture upwards as the bias becomes more negative. The valve is so constructed that the " dot " remains illuminated until the column has almost disappeared. The DM70 can be controlled by an undelayed a.g.c. voltage or by the demodulator circuit of a receiver to give maximum length of column when no signal is being received. On " tuning-in " to a carrier the length of column decreases, the minimum length indicating accurate setting of the tuning control.

In a particular receiver the h.t. voltage and the a.g.c. or demodulator voltage for maximum received signal are usually predetermined. Under these conditions control over the operating conditions of the DM70 may be obtained by correct choice of the filament voltage polarity. In the data given, the best method of filament connection has been indicated for each application, the " earthed " pin being at the same potential as the earthed side of the a.g.c. circuit. This is normally connected to the chassis of the receiver. The small bulb (10mm. diameter), solder-in leads and linear form of indication permit the valve to be mounted in several unconventional ways such as part of the moving cursor in the tuning dial. It then serves as an illuminated pointer, the " dot " assisting in this function and also acting as a pilot light in battery receivers.

In a subsequent advertisement it is hoped to deal with the application of this valve in both mains and battery receivers.

PRELIMINARY DATA

OPERATING CONDITIONS

Battery-operated receivers

	Pin 4 earthed	Pin 5 earthed	
V_b	90	67.5	V
V_a	85	60	V
V_g	0	0	V
I_a	170	105	μA
*Length	11	10	mm
V_g (for complete extinction)	-10	-7	V

Mains-operated receivers (Pin 5 earthed)

V_b	110	170	250	V
R_a	0.47	1.0	1.8	MΩ
V_g	0	0	0	V
I_a	105	110	105	μA
*Length	10	10	10	mm
V_g (for complete extinction)	-15	-23	-34	V

FILAMENT

V_f	1.4	V
I_f	25	mA

LIMITING VALUES

$V_{b(o)}$ max.	450	V
V_b max.	300	V
**V_a max.	90	V
V_a min.	45	V
†p_a max. ($V_a \leq 90$ V)	25	mW
†p_a max. ($V_a = 200$ V)	10	mW
I_k max.	300	μA
R_{g-f} max.	10	MΩ

BASE B8D

*Length of fluorescent column observed, measured from the top of the aperture. The maximum value is approximately 14 mm.

**In circuits without anode series resistor.

†Values of p_a max. for intermediate values of V_a may be determined by linear interpolation.

Reprints of this advertisement together with additional data may be obtained free of charge from the address below.

Mullard

MULLARD LTD., Technical Publications Department, Century House, Shaftesbury Avenue, W.C.2

MVM 228

Wireless World

MAY 1953 VOL. LIX No. 5

V.H.F. in Suspense

MANY hundreds of thousands of words have been spoken in both Houses of Parliament on the general topic of broadcasting since the Government issued a White Paper setting forth its intentions nearly a year ago. We have patiently read every relevant word in *Hansard,* but still admit to complete ignorance as to what are the Government's real intentions on the future of v.h.f. broadcasting.

The White Paper could hardly be more categorical (in para. 11) in saying that the completion of the B.B.C.'s plans, including the introduction of v.h.f., "must have first claim when labour and materials become available." That statement has not been unequivocally withdrawn by the Postmaster-General or Asst. P.M.G., though there are strong indications that the Government's support for v.h.f. has weakened.

As to the urgency of the matter there can be no doubt. Our correspondence columns—and a large number of unpublished letters from readers—bear witness to the growing inadequacy of medium-wave broadcasting. It is not defeatist to say that neither the B.B.C. nor anyone else can find any technical means of overcoming these troubles, and, for a radical improvement in the sound broadcasting service, we must turn to the higher frequencies.

Emergency Service

"IT can't happen here" is what the amateur radio transmitters have hitherto been told when they have offered to organize themselves to help against natural disasters like flood and tempest. But it *did* happen here, and amateurs, on their own initiative, took over the service of a Post Office coastal station which had been put out of action by the tidal inundations at the beginning of the year. Since then, the Radio Society of Great Britain has invited members willing to take part in an emergency scheme to register their names; we understand the response has been considerable.

In a country like this, of short distances and highly developed communications, it would be carrying caution too far to set up the complex kind of amateur organization that has worked so well in America. But it might be at least worth while to have the nucleus of a scheme, with a register of those willing to help.

New-style Patronage

IN the good old days the writer of fiction sometimes enjoyed the patronage of a nobleman of literary inclinations. The scientific writer, too, has long benefited from a kind of indirect subsidy on publication of his ideas through gifts made to his learned societies. But, till quite recently, the unassuming technical writer has had none of these benefits.

Things are changing. As we recorded in our pages a few months ago, a severely technical book may now command sales that arouse the envy of authors of best-selling "thrillers." The writing of technical books and articles is on the way towards being recognized as a job in its own right; there is already a flourishing Discussion Group concerned with the subject as well as a lecturership at University College, London. This is as it should be; in an increasingly mechanized and technical world there is a growing demand for the ever-wider dissemination of information on the widely diverse range of techniques in use. And the time is past when publication can be directed solely towards the kind of specialist who understands nearly as much of the subject as the author. Material has now to be presented more skilfully, and with sympathy towards those who may be working on the fringe of the specialized field concerned.

Just as the work of the technical writer is being accorded fuller recognition, so, in our particular sphere at least, he is beginning to enjoy the fruits of what we may call an up-to-date version of the old-style patronage of the arts. The Radio Industry Council, assuming the role of patron, recently presented six generous premiums and *ex-gratia* awards to writers of articles in published journals.

Components for Transistors

By G. W. A. DUMMER,* M.B.E., M.I.E.E.

Low Operating Voltages and Currents Make Extreme Miniaturization Possible

IT is already becoming apparent both in the U.S.A. and in the U.K. that a new range of components comparable in size to the transistor must be developed. A modern junction transistor is of the order of $\frac{3}{16}$ in square and the opportunity given for miniaturization is nullified if components of normal size, or even miniature ones, are used with transistors.

The normal valve and its associated components are comparable in size and a sub-miniature valve compares favourably with sub-miniature components, but there are at the moment few components comparable in size to the transistor.

The low voltage and low current needed to operate the transistor make possible almost wattless resistors and very thin dielectric capacitors, and the capacitors need withstand breakdown voltages of, say, 10-50 volts only instead of the normal 150-750 volts. Another factor which will aid the development of tiny components is that negligible heat is dissipated in the transistor itself, whereas the normal valve with its relatively large heater dissipation requires adequate ventilation.

Although transistor development is still in an early stage, and very few transistors (particularly junction types) are available for experimental use, it is not too early to consider the development of these new components which are entirely different from those in use to-day. The illustration (Fig. 1) shows some of the components which are being developed, compared in size with normal and miniature types. Some of these experimental components are described below:—

Fixed Resistors (*Grade* 2).—In designing a resistor to operate at, say, 20 volts and carrying a few microamps of current, wattage dissipation can be almost ignored and the component can be made extremely small. Experimental resistors have been constructed consisting of a 0.001-in diameter glass fibre, such as used in glass wool, coated with a carbon mix to form resistors of one megohm in a length of approximately one inch. These resistors are just barely discernible to the naked eye.

Fixed Resistors (*Grade* 1).—Experiments on a similar 0.001-in diameter glass fibre have shown that it is possible to coat the fibre with a platinum/gold solution which has a resistive value of 2,000 ohms per inch length. This is approximately 40 times the value obtained with nichrome or other high-resistance wire of equivalent diameter. The resistor produced by this method is extremely stable and has a noise value of the order of 0.02 microvolts per volt and a temperature coefficient of 0.025 per cent per degree C. The metallized glass-fibre resistor may be wound round a glass rod, or folded where high resistances are required. In actual fact and because of the low operating voltages, most resistors in transistor circuits are of the order of thousands or tens of thousands of ohms.

Resistors have also been made on flat glass plates by depositing a platinum/gold mixture on one surface and then firing in an oven at about 400 deg C, when the metal compounds are reduced to metal. Whilst in this stage, a meander or zig-zag pattern is scribed through the metal to produce a long resistance path. The plate is then fired at about 600 to 700 deg C (depending on the glass) to form a firmly bonded resistance coating. Resistors of several hundred thousand ohms have been produced at $\frac{1}{10}$th watt in a size $\frac{1}{8}$ in by $\frac{1}{8}$ in; end connections can be soldered directly. The stability of these resistors after one year's life is better than 1 per cent and they will withstand climatic cycling with less than 2 per cent change in resistance.

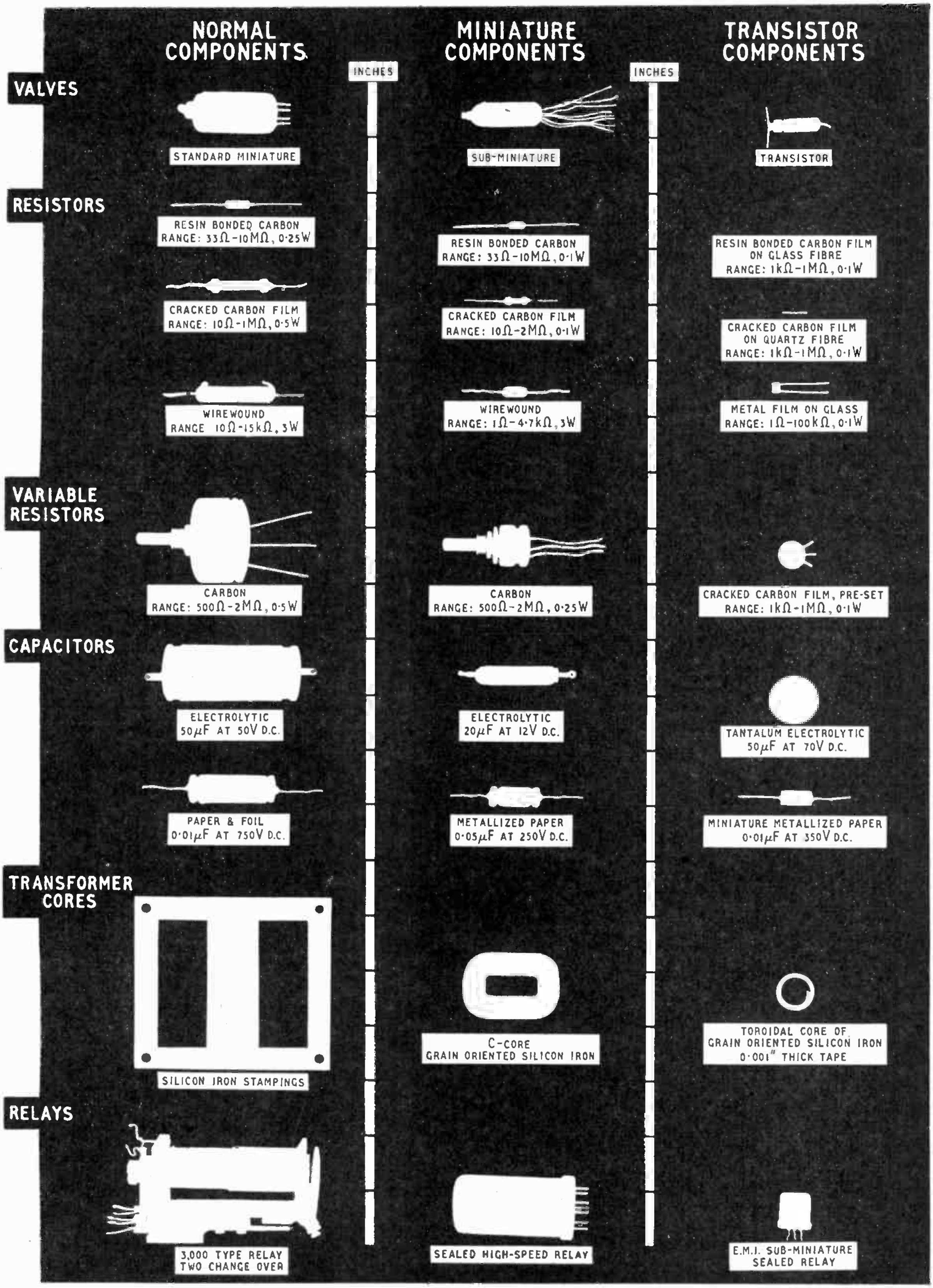
Pyrolytic carbon, or cracked carbon, resistors (high stability) have been manufactured experimentally by a leading resistor manufacturer in which the carbon film is deposited on a quartz fibre approximately 0.01 in in diameter instead of on the normal ceramic rod. These resistors have all the usual characteristics of the cracked carbon resistor and can be used for transistor applications. For values up to one megohm the length of (0.01-in dia) quartz fibre is about one half-inch. Carbon has been successfully cracked on quartz fibres varying in diameter from 0.003 in to 0.025 in.

Potentiometers. — Sub-miniature carbon-track potentiometers have already been designed for electronic equipment used in telemetering and guided missiles, and these are comparable in size to the new range of transistor components. The potentiometer has a cracked-carbon track deposited on a ceramic ring and made in values up to 10,000 ohms, above this value sprayed carbon tracks are used. This is intended to be used as a pre-set potentiometer requiring good stability once set. The size is $\frac{3}{8}$ in diameter by $\frac{1}{4}$ in deep.

Capacitors.—The low voltage operation of the transistor means that capacitors need not be designed

* Telecommunications Research Establishment.

See opposite page : *Fig. 1 Normal sized, miniature and transistor components are shown here on the same scale. The glass-fibre resistor is too thin to be visible on this reduction.*


NORMAL COMPONENTS
MINIATURE COMPONENTS
TRANSISTOR COMPONENTS
INCHES
INCHES
VALVES
STANDARD MINIATURE
SUB-MINIATURE
TRANSISTOR
RESISTORS
RESIN BONDED CARBON RANGE: 33Ω-10MΩ, 0·25W
RESIN BONDED CARBON RANGE: 33Ω-10MΩ, 0·1W
RESIN BONDED CARBON FILM ON GLASS FIBRE RANGE: 1kΩ-1MΩ, 0·1W
CRACKED CARBON FILM RANGE: 10Ω-1MΩ, 0·5W
CRACKED CARBON FILM RANGE: 10Ω-2MΩ, 0·1W
CRACKED CARBON FILM ON QUARTZ FIBRE RANGE: 1kΩ-1MΩ, 0·1W
WIREWOUND RANGE 10Ω-15kΩ, 3W
WIREWOUND RANGE: 1Ω-4·7kΩ, 3W
METAL FILM ON GLASS RANGE: 1Ω-100kΩ, 0·1W
VARIABLE RESISTORS
CARBON RANGE: 500Ω-2MΩ, 0·5W
CARBON RANGE: 500Ω-2MΩ, 0·25W
CRACKED CARBON FILM, PRE-SET RANGE: 1kΩ-1MΩ, 0·1W
CAPACITORS
ELECTROLYTIC 50μF AT 50V D.C.
ELECTROLYTIC 20μF AT 12V D.C.
TANTALUM ELECTROLYTIC 50μF AT 70V D.C.
PAPER & FOIL 0·01μF AT 750V D.C.
METALLIZED PAPER 0·05μF AT 250V D.C.
MINIATURE METALLIZED PAPER 0·01μF AT 350V D.C.
TRANSFORMER CORES
SILICON IRON STAMPINGS
C-CORE GRAIN ORIENTED SILICON IRON
TOROIDAL CORE OF GRAIN ORIENTED SILICON IRON 0·001" THICK TAPE
RELAYS
3,000 TYPE RELAY TWO CHANGE OVER
SEALED HIGH-SPEED RELAY
E.M.I. SUB-MINIATURE SEALED RELAY

to withstand the normal high breakdown voltages and therefore the thickness of the dielectric can be reduced to the extreme minimum. If a capacitor has to be designed to withstand, say, 20 volts only, both dielectric and metal electrode can be almost as thin as it is humanly possible to make them.

Experimental plastic films approximately 0.0001 in thick have been made by the following process: A metal film approximately 0.00005 in thick is evaporated on to a glass plate, then an extremely thin film of plastic, about 0.0001 in, is spun on to the metal and cured. Spinning ensures that there are no pin holes and that the coating is even. The metal-coated foil is then floated off the glass plate in an inert solvent and the capacitor foils thus produced rolled up in the usual manner.[1]

The advantages of the electrolytic capacitor are realized when used in transistor applications, as the maximum capacitance per unit area is obtained with the electrolytic capacitor if the operating voltages are low. This is due to the extremely thin dielectric (a few millionths of an inch). At a working voltage of 10 or 20 a capacitance of many microfarads can be encompassed within a very small space. The use of porous-foil electrolytic capacitors is being investigated and so also is the use of the tantalum electrolytic capacitors, as has been described previously.[2]

Transformers.—In the design of transformers in which the windings carry negligible current and the voltages are of the order of 10, it becomes possible to use extremely fine wire and the main limitation in the size of such transformers is principally the primary winding, especially in this country where 230 V is standard. In the U.S.A. small mains transformers have been designed for operation at 116 V, 60 c/s, a primary current of 0.014 A and a secondary of 8 V 50 μA. Including a half-wave rectifier, smoothing capacitors and smoothing resistor, the overall size is $1\frac{1}{4}$ in cube only. The core material used is "Hipersil" which permits a very high flux density and therefore aids miniaturization. Transformers designed for these low output voltages and currents are inefficient at normal mains frequencies and emphasize the need for further development of miniature batteries.

Audio Transformers.—Here again, transformers have been designed in the U.S.A. to carry 10 mW of audio power with a superimposed direct current of 0.1 mA (transistor collector current) and contained in a cube of $\frac{3}{8}$-in sides. "Ferrite" cores have many advantages for transistor components and will undoubtedly be used a great deal in transformers, particularly for carrier frequencies.

Batteries.—The development of miniature batteries capable of delivering the small powers required for long periods is probably the next stage in the operation of transistor circuits. Little work has been done on transistor batteries in the United Kingdom, but batteries have already been made in the United States which can last for reasonable periods and are comparable in size to the range of components described here.

Miscellaneous Components.—The development of new types of relays, switches, etc, may follow, but it is too early yet to decide detailed requirements. A miniature sealed relay is being developed by E.M.I. with a single-pole change-over contact, in size $\frac{1}{2}$-in cube only, which may prove a useful transistor component. Possibly some of the sub-miniature items developed for hearing aids may also find applications in this field.

Assembly Techniques.—It is not possible to assemble these tiny components in the usual way with chassis and panel fixings and one solution is to use

[1] See British Patent App. No. 13452/51 (R. J. Heritage, 2/50 in Canada Sep. No. 631,572, 1952, and U.S.A. Sep. No. 290,083, 1952).
[2] *Wireless World*, December, 1951, p. 510, "Electrolytic Capacitors," by G. W. A. Dummer.

Fig. 2 On the left is shown a multi-vibrator using sub-miniature valves and components while on the right is a similar circuit using transistors and special components.

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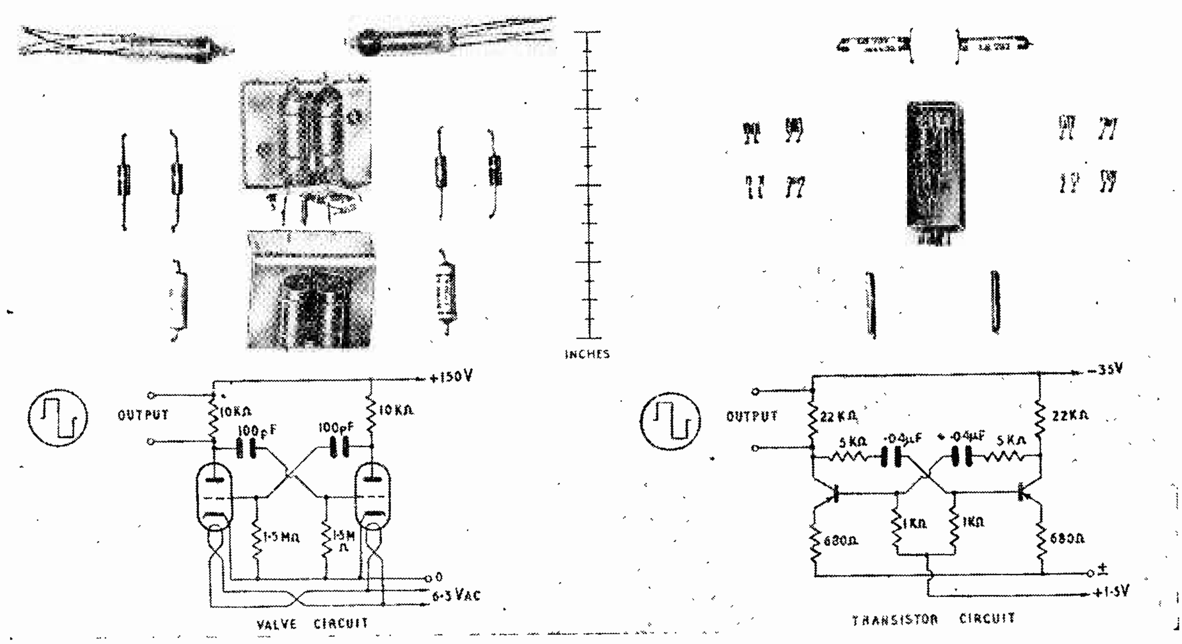


the potted techniques and casting resins of the polyester or ethozyline types. The method of assembly is to fit the components and the transistors in a jig using stout wires as supports. The assembly is tested whilst in this frame. A potting solution is then prepared, usually by mixing 1 part catalyst, 1 part accelerator and 100 parts polyester resin (with 25 parts powdered mica filler to prevent cracking of the casting at low temperatures). The assembly is then placed in a suitable mould coated with mould release agent and the casting resin poured in. There is usually an exothermic reaction which raises the temperature of the resin and the embedded components, but the use of the 1 part accelerator and 1 part catalyst results in a comparatively long gelling time (about five hours) and the exothermic reaction temperature is then cut down to about 10/20 deg C. After this period the casting may be removed from the mould and although it will continue to polymerise for some weeks, it is ready for use.

Conclusion.—There is a new field of development in this range of sub-miniature components, but there are many problems to be solved; handling and mechanical tolerances will be particularly difficult. The close mechanical tolerances required in the manufacture of these precision devices will present a tremendous problem, particularly in production. In addition, there will be such difficulties as preventing the corrosion of fine wires in transformers, relays, etc, and the compatibility of the component materials with the potting resins.

There seems little doubt however, the work of this type must be done if components for transistors are to be developed and made in the United Kingdom and this article described some of the research and development effort which has already been carried out. An example of the work now being done is exemplified by the transistor multi-vibrator unit with its component parts and circuit compared to a similar circuit using valves and normal miniature components and shown in Fig. 2. The transistor assembly is an example, also of the potted technique.

Research on Insulating Materials

Items of Interest from the Recent I.E.E. Symposium

OF the many groups of materials essential to radio and electronic technology, few are as important or require to be as versatile as insulants. Not only must they be non-conductors, to keep currents in their allotted paths, but in radio-frequency applications must show low losses in alternating fields. They may be called upon to provide high or low permittivity (dielectric constant), to show stable electrical characteristics over a wide range of temperatures, and, in this age of nuclear fission, to withstand irradiation by gamma rays or bombardment by high-energy particles !

Not so long ago the electrical or radio engineer was content to tabulate the qualities of the available dielectric materials and to select the appropriate grade for any given occasion, as one might select a cheese or wine. Nowadays a recondite literature of basic physical theory is available on the subject, and the time may not be far distant when it will be possible to predict the dielectric performance of materials with some confidence, or even to synthesize new materials to a specification.

Some insight into the breadth and depth of this subject was provided by the specialist papers in the Symposium on Insulating Materials, held last March at the Institute of Electrical Engineers, and attended by representatives of 10 countries.

Typical of the modern approach to dielectrics was the paper by L. Hartshorn, J. V. L. Parry and E. Rushton. "Dielectric Losses in Some Representative Insulating Materials," which describes the exploration of the properties of silicones, hydrocarbon plastics, and phenol- and aniline-formaldehyde resins over a frequency range from 10 c/s to 2,400 Mc/s, and gives a physical picture of the origin of irregularities in the $\tan\delta$ and loss curve in terms of the characteristic relaxation times of various elements of the molecular structure. Over the frequency range 1 kc/s-10 Mc/s, the power factor of silicones of widely different viscosities and molecular chain length is sensibly zero, certainly less than 0.0001, but at frequencies below 100 c/s it rises steeply and there is a peak above 100 Mc/s. As this is independent of chain length over a range of 24 to 356 intermediate Si-O links it seems likely that the higher resonance is a phenomenon associated with the time-constant of the silicon-oxygen link, and that the low-frequency rise is due to the ends of the chain which carry three CH_3 groups.

The hydrocarbon dielectrics polystyrene and polyethylene, and polytetrafluorethylene (p.t.f.e.), in which the fluorine atoms do not destroy the electrical symmetry of the molecule, have been investigated in detail and show low but measurable power factors which do not vary greatly, or in any characteristic way, with frequency. Such variations as are observed are thought to be due to traces of impurity, and the figures obtained in commercial samples do not necessarily represent the ultimate intrinsic performance of these substances.

Water Absorption

The performance of phenolic resins, which are much used in electrical engineering, is dominated by water absorption. In phenol-formaldehyde the loss increases and the permittivity falls steadily with frequency. Moisture content increases the loss without affecting the shape of the curve plotted against frequency, and the form of the curve is retained with a vacuum-dried specimen. From this it is concluded that OH groups in the resin are responsible for a loss similar to that of the absorbed water, and that one added water molecule is equivalent to about two original OH groups. Aniline-formaldehyde, on the other hand, shows a broad peak of power factor at room temperature centred at about 200 kc/s, which corresponds to a relaxation time equivalent to that of ice at -5°C. It seems probable, therefore, that the effect of water is determined by the nature of the bond with the insulating material, and that it may vary over a whole range of conditions from liquid water to the equivalent of ice.

Investigations on "Kel F"—a modified form of p.t.f.e., in which chlorine atoms are substituted for some fluorine atoms in the molecular chain, giving improved mechanical working properties—has provided experimental support for Fröhlich's* model of polarization in solid dielectrics, and gives good agreement with the calculated shape of the power factor/frequency curve, at least for the main peak. Equally striking is the correlation between calculated and measured loss curves for some benzene derivatives described in a paper by A. Turner.

Several speakers underlined the need for exploration of the region below centimetre wavelengths—the present limit with cavity-resonator and transmission-line techniques—in order to verify the existence, at higher frequencies, of changes in permittivity and loss predicted by theory. One possible method of investigating permittivity in the millimetre band is to use a free-field spectrometer in which electromagnetic horns with lenses take the place of the optical collimator and telescope. The technique is complicated by diffraction effects arising from the fact that apertures are of necessity comparable with the wavelength, but these can be allowed for and, by the methods described by W. Culshaw in the paper on "A Spectrograph for Millimetre Wavelengths," measurements of permittivity accurate to within ± 0.5 per cent can be obtained.

An interesting survey of ceramic dielectrics was given by P. Popper in a paper "Ceramic Dielectrics and their Application to Capacitors for Use in Electronic Equipment." The physical basis for the high permittivities obtained in crystalline ceramic aggregates are surveyed and an outline is given of the methods which have been used to modify the original characteristics obtained with titanium oxide. Nearly twenty useful materials are now available to the condenser manufacturer for meeting various requirements as regards permittivity, power factor temperature coefficient and electric strength. In general, ceramic dielectrics can be divided into two groups, those which do or do not develop a hysteresis loop on the application of an alternating field. It is not always realized that the electrostrictive properties of the former group of "ferro-electrics," which can be usefully exploited in pickups and microphones, is an embarrassment when such materials are used for their high permittivity in capacitors, and suitable precautions must be taken to avoid mechanical resonance. The paper described low-loss, high-stability capacitors for use in tuned r.f. circuits, and the manner in which the temperature coefficient of capacitance can be adjusted to offset the temperature coefficient of inductance of the associated coils. It also underlines the advantages of small size to be gained by the use of ferro-electric ceramics of high permittivity in bypass condensers, where losses and temperature effects are less critical. Due to the small physical size, the inductance of leads can be kept below 0.01μH.

The symposium also covered the range of insulating materials used at supply frequencies and discussed many of the newer laminated plastics. Subsequently, the papers will be published in a special issue of the *Proceedings I.E.E.*, Part IIa, No. 3.

* "Theory of Dielectrics" by H. Fröhlich (Clarendon Press, 1949).

Audio Shows

THIS year's "P.A." exhibition organized by the Association of Public Address Engineers will be held at the Horseshoe Hotel, Tottenham Court Road, London, W.1, for two days (May 5th and 6th) instead of one as in the past. At this fourth annual A.P.A.E. show, which will be open on both days from 10.0 to 6.0, there will be the following 18 exhibitors: Cosmocord, G.E.C., Goodmans, Grampian, Grundig, Leak, Lowther, Lustraphone, M.S.S., Magneta, Pamphonic, Reosound, Reslosound, Rola, Trix, Truvox, Vitavox and Whiteley.

Throughout each day there will be 20-minute demonstrations of public address equipment. Admission to the show is by ticket, available from the honorary secretary, Alex J. Walker, 394, Northolt Road, South Harrow, Middx, or by trade card. Production of this issue of *Wireless World* will also permit admission.

During the week-end of May 16th-17th, the fifth annual exhibition of sound recording and reproducing equipment, organized by the British Sound Recording Association, will be held at the Waldorf Hotel, Aldwych, London, W.C.2, from 10.30 to 6.0. Non-members are admitted by purchasing a 1s 6d catalogue.

The following 24 firms are exhibiting at the B.S.R.A. show, and many of them will be demonstrating loudspeakers and disc, tape and wire recording and reproducing gear: Acoustical Manufacturing, British Ferrograph, C.J.R. Electrical, C. T. Chapman, Cosmocord, E.M.I., Garrard, Goodmans, Grundig, Leak, Leevers-Rich, London Office Machines, Lowther, M.S.S., Minnesota Mining, Reproducers (Electronic), Reslosound, Rogers Developments, Simon, Sugden, Thermionic Products, Vitavox, Wharfedale and *Wireless World* and *Wireless Engineer*.

SCHOOL BROADCASTING

SIXTY broadcast receivers and twenty loudspeakers which have been tested and approved as suitable for use in schools are detailed in a list recently issued by the School Broadcasting Council for the United Kingdom.

The receivers, all of which have been tested under school conditions, are grouped in two sections; the first includes 40 sets "whose design is specially suitable for schools," while the second gives receivers, which, although designed primarily for domestic use, are approved for school use.

All the receivers are stated to be generally suitable for use in classrooms, and those sets capable of providing the output necessary for schools where reception is required in an assembly hall or where a number of loudspeakers are to be used simultaneously are marked. The manufacturers listed as making equipment "specially suitable" for schools (and, in brackets, the number of approved types available) are: Audix B.B., Ltd. (5), Clarke & Smith Manufacturing Co. (7), Communications Systems, Ltd. (2), F. W. Coomber & Son (5), Dictograph Telephones, Ltd. (2), E. K. Cole, Ltd. (3), Gramophone Co., Ltd. (2), Grampian Reproducers, Ltd. (1), Hadley Sound Equipments (1), Magneta Time Co. (5), A. F. Merriot, Ltd. (1), Sound Sales, Ltd. (1), Tannoy Products (1), Trix Electrical Co. (3), Ultra Electric, Ltd. (1).

The loudspeakers given in Part III of the list have been approved for use as extension speakers.

Copies of the list, together with further information on school broadcasting equipment, can be obtained free from the Secretary, the School Broadcasting Council for the United Kingdom, 55, Portland Place, London, W.1.

Portable P.A.

Negative Feedback Amplifier with Alternative Input Arrangements

By E. GRIFFITHS, Grad.I.E.E.

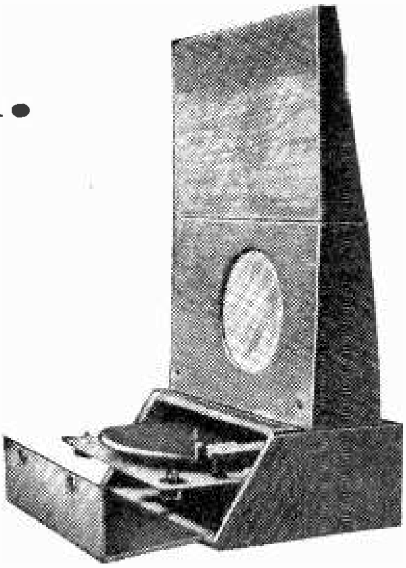


Fig. 1. The portable P.A. units opened and assembled for use.

THE equipment described in this article was designed to give an output of 8 watts with less than 1% distortion and it is intended principally for use in small halls. A major requirement was lightness with reliability and the circuit design is such that a reasonable output can be obtained in the event of a valve failing.

Commercial gramophone equipment appears to fall into two classes, the record player and amplifier in one heavy box giving an output of about 3 watts into a small loudspeaker and large equipment consisting of several separate units. Both are equally inconvenient for carrying about on buses and it has been found more convenient to have two boxes of more or less the same size and weight. The equipment described here consists of one box measuring 15in × 13¼in × 6½in containing the turntable motor and pick-up and the other measuring 18in × 12in × 6½in housing the power pack, amplifier and a 10-in loudspeaker. Fig. 1 shows the playing arrangement and it will be seen that the loudspeaker box sits on the playing desk, the front of which pulls open drawing the turntable assembly forward for easy access. The back of the loudspeaker box hinges up to give an extended baffle and thus prevents the bass boom which would occur in a small cabinet of these dimensions if the back were closed. The loudspeaker is also mounted non-centrally so that the front to back length is different in each direction. Fig. 2 shows a rear view of the loudspeaker unit, the power pack being on the right and the amplifier on the left. The mains cable and connectors are wound on the two hooks above the loudspeaker and the space between the two units is utilized for carrying various adaptors. There is also sufficient clearance for a few records to be carried in the lid of the box.

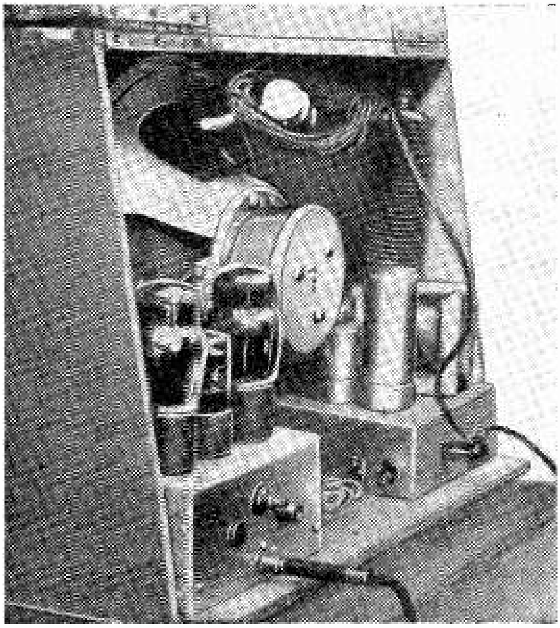


Fig. 2. Rear view of the amplifier unit showing the power pack on the right.

Amplifier.—The circuit diagram of the amplifier is shown in Fig. 3 and it will be noticed that both single-ended and push-pull inputs are provided. The former may be used with a radio tuning unit or pre-amplifier, but the latter was found more suitable for the crystal pick-up used with this equipment. Auxiliary contacts on the input jacks are used to switch the feedback connections so that the feedback is suitably arranged for the particular input in use.

The phase reversal for single-ended connection is obtained by a method which is novel as far as the author is aware and has the advantage of giving phase splitting with negligible loss of gain. Fig. 4 illustrates the principle adopted to obtain voltages of equal and opposite polarity.

In the example shown an input of 1 volt is assumed with the polarity indicated. To obtain parallel-connected feedback[1] a voltage must be applied in series with the grid resistor. If in addition, this self-balancing feedback voltage can be arranged to equal the input voltage, then this feedback voltage may also be used to drive the grid of V_2. With the simple basic circuit shown, the input resistance has an effective value of R/2 and this point may have to be

[1] "Negative Feedback' by E. Griffiths, *Wireless World*, March 1950.

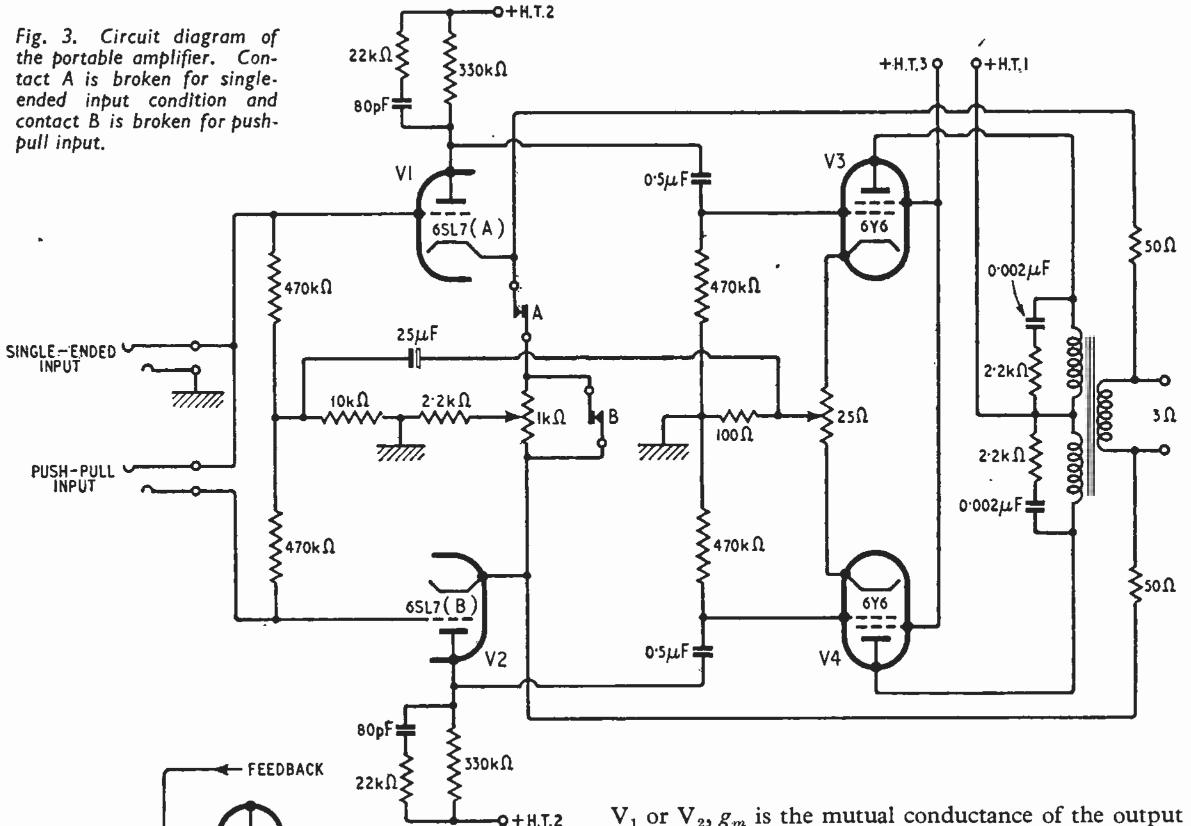
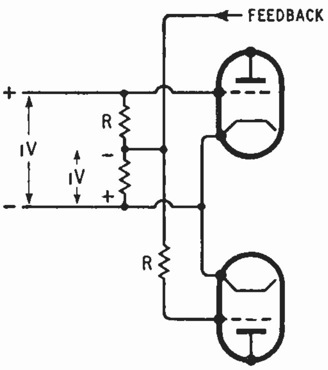


Fig. 3. Circuit diagram of the portable amplifier. Contact A is broken for single-ended input condition and contact B is broken for push-pull input.



Left: Fig. 4. The phase-splitter used in the amplifier for push-pull operation.

allowed for. The obvious way of deriving this feedback voltage is to use a tap on the following grid resistor. This is however not a good arrangement since any push-pull amplifier should be designed in such a way that the grid voltages are compensated against gain variations so that a balanced output voltage is obtained.

It is well known that a common cathode resistor in a push-pull stage has a compensating voltage developed across it and if the common cathode resistance is made sufficiently large this can be used for providing phase reversal; unfortunately when only a limited h.t. voltage is available the d.c. voltage drop across this resistance cannot be spared. If however, a smaller resistance is used, the voltage across this may be fed back to a previous stage and the amplification of the latter stage used to provide the phase reversed voltage. This is, in effect, what is done in the circuit described here. If reference is made to Fig. 3 it will be seen that the a.c. voltage across the common cathode resistance of the output valves is parallel-connected back to the grid circuit of the driven valve. An analysis of this circuit (Appendix I) shows that when A is the gain of V_1 or V_2, g_m is the mutual conductance of the output valves and R is the common cathode resistance of V_3 and V_4, the ratio of the grid voltages applied to the input valves is given by :—

$$\frac{e_2}{e_1} = \frac{g_m RA}{1 + g_m R(A + 1)}$$

Hence if $g_m R = 1$ (a typical value) and $A = 40$, $e_2/e_1 = 40/42$, i.e. an unbalance of about 5 %. The ratio of the driving voltages of the output valves is given by :—

$$\frac{e_3}{e_4} = 1 + \frac{1}{g_m R(A + 1)} = 1 + \frac{1}{41}$$

or an unbalance of just over 2 % for the values given above.

An inspection of the original equations will show that the amplifier is inherently self balancing, the output unbalance being affected mainly by the gains of V_2 and V_4. When the push-pull input connection is used the phase reversal arrangement will not be operative if perfect balance is obtained in the amplifier, this is however unlikely and the circuit then provides a balancing voltage to the input which corrects for amplifier unbalance.

Overall negative feedback is obtained from the secondary winding of the output transformer and is fed back across the cathodes of the input valves when the push-pull input is in use and in series with the cathode of the driven valve when the single-ended input is used. The changeover is done by auxiliary contacts on the input jacks, but there is no reason why a single input connection with a changeover switch should not be employed. The basic circuits are shown in Fig. 5(a) and (b). The re-arrangement of the negative feedback connection is desirable because if this is not done when changing to single-ended input, the balancing resistor must cancel the feedback voltage in addition to providing the grid voltage for V_2. This will require an unbalance voltage of about 2.5 volts across the common cathode resistance of the output valves and this is rather too much to expect.

The effective grid-cathode capacitance is reduced by applying negative feedback across the cathodes of the input valves and this allows high value grid resistors to be used with high-*mu* triodes without loss of top. The 6SL7 is operated with a very low anode current so that negligible current flows from the cathodes through the loudspeaker coil when the feedback is applied in series with the cathode resistor.

The gain of the amplifier with full feedback is 1, and hence an input level of approximately 5 V is necessary to obtain an output power of 8 watts. The gain without feedback is 21.5 db and hence a gain variation of 20 db could be obtained by reduction of the amount of feedback. This has not been done in this design since 5 V is readily available from a radio tuning unit and ample gramophone volume is available from a crystal pick-up.

Two variable controls are provided, one for balancing the feeds of the output valves and the other for adjusting the relative proportion of feedback between the two sides of the amplifier. The latter control is adjusted so that no a.c. voltage appears across the common cathode resistor of the output valves when tone is applied to the push-pull input. If distortion measuring equipment is available an alternative method is to adjust this control for minimum distortion at an output level of 8 watts.

The output transformer construction is described in Appendix II, and it will be seen that a 3-ohm load is used with the secondary windings connected in parallel or a 12-ohm load with the windings in series. With the latter arrangement the feedback factor has to be reduced and a loss pad must be inserted between the secondary of the output transformer and the switching circuit as shown in Fig. 6. The anode load on each output valve is about 80 % of that recommended for single-ended working. This enables the same output power to be obtained for a smaller voltage swing on the primary and hence reduces the amount of third harmonic distortion generated. The transformer primaries are shunted with a CR combination which helps to preserve a constant load impedance at high frequencies.

With full feedback the amplifier response was only 0.2 db down at 30 c/s and 16 kc/s, the output impedance being less than 1 ohm measured at the secondary of the output transformer.

Power Pack.—The heaviest section of most amplifier equipment is the power pack and weight has been saved in this unit by eliminating the usual mains transformer and heavy-duty smoothing choke. A filament transformer is used however to avoid the need for series connection of the heaters.

The power supply unit shown in Fig. 7 delivers 210 V. from 210-V. mains and it is reasonable to suppose that this arrangement used on 230-V. mains would allow an output power of 10 watts from the amplifier with less than 1% distortion. To save the weight of a large smoothing choke the anodes of the output valves are fed from across the reservoir capacitor. It will be recalled that the common cathode voltage of the output valves is used as feedback to the input circuit (for phase inverting) and hence any hum current in the output valves will produce a hum voltage in the output if the two halves of the 6SL7 are unbalanced. The 6Y6 has a relatively low anode resistance and hence the hum voltage at the anodes must be kept as small as possible, for this reason a 64-μF reservoir capacitor is used. With this arrangement the amplifier hum level is approximately 1 micro-

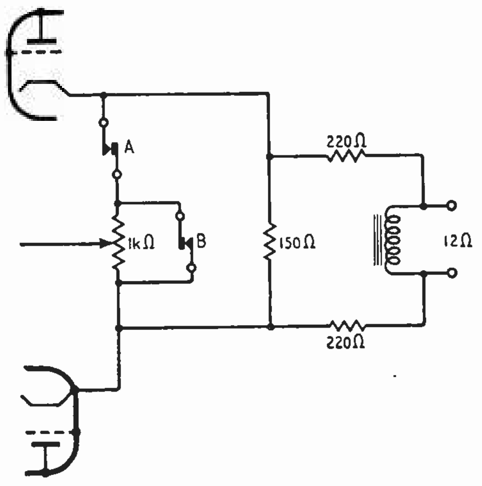


Fig. 6. Modification to negative feedback circuit for 12-ohm output.

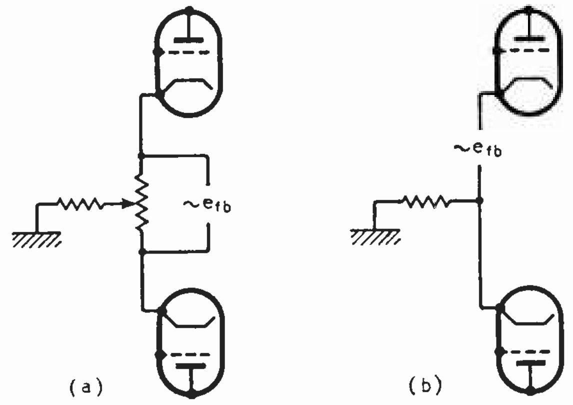


Fig. 5. Method of applying negative feedback (a) for push-pull operation (b) for single-ended input.

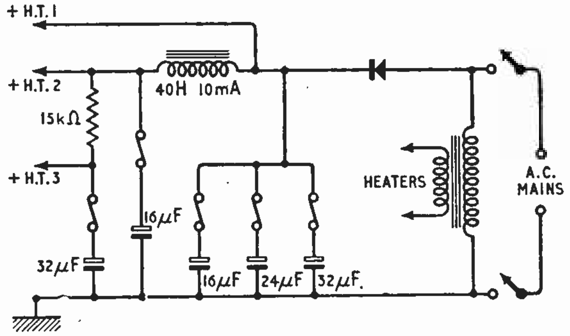


Fig. 7. Details of the power supply unit. An S.T.C. metal rectifier Type RM4 can be used.

watt. The smoothing choke passes the anode current for the 6SL7 and the screen current for the output valves, a total of 5 mA, hence a small and light choke can be employed. All capacitors in the power pack are separately fused so that failure of a capacitor will have no serious effect on the operation of the amplifier.

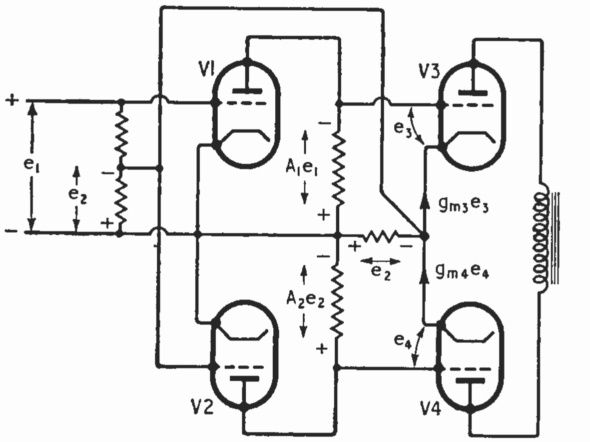
Cases.—The cases are made from a resin-bonded material faced with mahogany, the total thickness being approximately ⅜ in. All joints are dovetailed, pinned and glued with the exception of the front surfaces which are pinned and glued. The underside of the playing desk is screwed to the sides for easy access to the motor for oiling and adjustment. Small ball-catches are used to hold the lid of the loudspeaker section in position when closed. Experience with the equipment has shown that it has met all that has been required of it so far and it has stood up well to being carried about on buses several times weekly for two years.

APPENDIX I

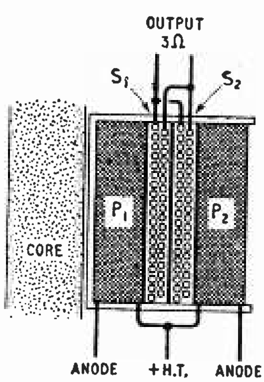
Fig. 8 shows a simplified circuit of the amplifier with the voltages in various parts of the circuit marked on the diagram. The symbols used are:

A_1 Gain of V_1
A_2 Gain of V_2
g_{m3} Mutual conductance of V_3
g_{m4} Mutual conductance of V_4
e_1 Grid-cathode voltage of V_1
e_2, e_3, e_4 Grid-cathode voltage of V_2, V_3, V_4 respectively

$$e_2 = g_{m3}e_3R - g_{m4}e_4R \quad \dots\dots (1)$$
$$e_3 = A_1e_1 - e_2 \quad \dots\dots (2)$$
$$e_4 = A_2e_2 + e_2 \quad \dots\dots (3)$$



Above: Fig. 8. Magnitude of the voltages in different parts of the circuit.



Left: Fig. 9. Disposition of the windings on the output transformer.

Substituting from equations (2) and (3) in (1) and re-arranging terms the ratio of the grid voltages on the input stage are given by:—

$$\frac{e_2}{e_1} = \frac{g_{m3}A_1R}{1 + g_{m3}R + g_{m4}(A_2 + 1)R} \quad \dots\dots (4)$$

Substituting from equation (4) in (2) and doing a little mathematical juggling:—

$$e_3 = \frac{A_1[1 + g_{m4}(A_2 + 1)R]}{1 + g_{m3}R + g_{m4}(A_2 + 1)R}e_1 \quad \dots\dots (5)$$

$$e_4 = \frac{g_{m3}(A_2 + 1)A_1R}{1 + g_{m3}R + g_{m4}(A_2 + 1)R}e_1 \quad \dots\dots (6)$$

whence

$$\frac{e_3}{e_4} = \frac{1 + g_{m4}(A_2 + 1)R}{g_{m3}(A_2 + 1)R} \quad \dots\dots (7)$$

Equation (5) shows the negligible loss of gain that occurs with this method of phase splitting. The fact that equation (7) is independent of A_1 does not of course mean that A_1 can be any value, since from equations (5) and (6) the actual magnitude of the grid driving voltages is dependent on A_1. It does however mean that the ratio of the grid driving voltages is independent of the phase angle of A_1. In addition since $(A_2 + 1)$ appears in both the numerator and denominator of equation (7) the effect of the phase angle of A_2 is very much reduced so that phase shift in the coupling circuit between V_2 and V_4 has little effect on the phase balance of the output grid voltages. The ratio of the currents in each half of the output transformer is given by:

$$\frac{g_{m3}e_3}{g_{m4}e_4} = 1 + \frac{1}{g_{m4}R(A_2 + 1)} \quad \dots\dots (8)$$

And hence the output unbalance is independent of A_1 and g_{m3}, which determine the magnitude of the output voltage only. A low unbalance thus requires a high value for A_2 or/and $g_{m4}R$. Again since A_2 appears as a small fraction of the unbalance factor in equation (8) the effect of the phase angle of A_2 is small.

APPENDIX II

Output Transformer

Core:—1-in stack of Silcor III—M.E.A. No. 29 laminations 0.020-in thick. E's and I's inserted from opposite directions in the bobbin alternately.
Windings (see Fig. 9):—P1, No. 34 s.w.g. enam 1,200 turns total, layer-wound with 0.002-in transformer paper between layers, 120 turns per layer.
S1, Two layers of No. 20 s.w.g., 33 turns per layer with 0.002-in transformer paper between layers.
S2, As S1.
P2, As P1.
All layers should occupy full width of bobbin.
Two layers of 0.005-in Empire Cloth to be inserted between all sections.
A transformer to this specification was wound for the author by the Cabot Radio Co. Ltd., 28 Bedminster Parade, Bristol, 3.

BOOKS RECEIVED

B.S. 1928: 1953 Lateral-cut Gramophone Records and Direct Recordings. Dimensions of grooves, centre holes, etc., and recommendations for labelling commercial pressings; dimensions, flatness, and thickness of lacquer in blanks for direct recording. Pp. 12, British Standards Institution, 24, Victoria Street, London, S.W.1. Price 2s 6d.

Rundfunk-Fernsch-Jahrbuch 1953.—Survey of German broadcasting and television activities with details of u.h.f. stations, wavelengths and powers. Also contains a German edition of "World Radio Handbook for Listeners." Pp. 208, illustrated. Kultur-Verlag GmbH, Passauer Strasse, 4, Berlin, W.30. Price DM7.

TRANSISTORS

4—*Introduction to the Junction Transistor*

By THOMAS RODDAM

IN the first article of this series the *n-p-n* junction transistor was mentioned very briefly. The time has now come to study the properties of the junction transistor in more detail. Most of the discussion will be based on the Bell Telephone Laboratories' *n-p-n* transistor, Type M 1752, but some of the discussion and the method of expressing the characteristics apply to the RCA *p-n-p* junction transistor.

The constitution and appearance of the *n-p-n* transistor were shown in Figs 7 and 8, page 73, of the issue of this journal February 1953. It consists, as was seen, of a sort of railway sandwich, with a very thin layer of *p*-germanium between two bits of *n*-germanium bread. The actual method of preparation of the Bell units is a secret, just like a railway sandwich, but there are two methods known to be possible for making junction transistors. At a guess, the first is the one used by Bell, though I repeat it is just a guess.

The first way of producing a junction transistor is to grow a single crystal according to a special programme. It sounds really very easy: you take a pot of molten germanium, dip a crystal of germanium into it and then slowly pull the crystal upwards. The temperatures are controlled so that the liquid germanium solidifies where it is lifted upwards by surface tension, and if all goes well you have a single crystal growing. If the bath is filled with *n*-germanium the crystal will be *n*-germanium. After growing some *n*-germanium you shift the crystal end to a *p*-germanium bath, and deposit a layer, still in the same single crystal, of *p*-germanium. Then back to *n*-germanium again. Cut into neat slices and serve, with appropriate contacts. The only trouble is that the process of getting a single crystal, even without changing mixtures, is remarkably difficult, and needs very complicated control equipment.

The other way of making junction transistors has been described for *p-n-p* transistors. It depends on the fact that certain impurities, in very small quantities, convert *n*-germanium into *p*-germanium. The impurity used is indium. A small block of *n*-germanium is provided with a gold-plated area on each side, to make the indium wet the wanted area uniformly. Indium is then applied to the gold-plated areas and the material is heated until the indium melts and covers the gold-plated contact area. The indium now begins to diffuse into the germanium, producing two *p*-layers, one on each side, which move towards each other inside the block. After the right length of time at the right temperature, a good *p-n-p* junction transistor is obtained.

As you can see, these processes are the sort which may be at their best in large-scale production, when elaborate control devices can be used. But just how far that work has gone, no one seems willing to say, although quite a number of American companies are building new factories for transistor production.

What will they get for their money when they start making really large numbers of junction transistors? The *n-p-n* properties can be easily summarized. It is relatively quiet, and at 1,000 c/s has a noise level only 10-20 db above ordinary Johnson noise. This is about 30 db better than the current point transistors, although these have been improved by 15 db since the old Type A. The junction transistor is inherently stable, because the current amplification factor is slightly less than unity. This quantity α is equal to $(r_m+r_b)/(r_c+r_b)$ and for the ordinary

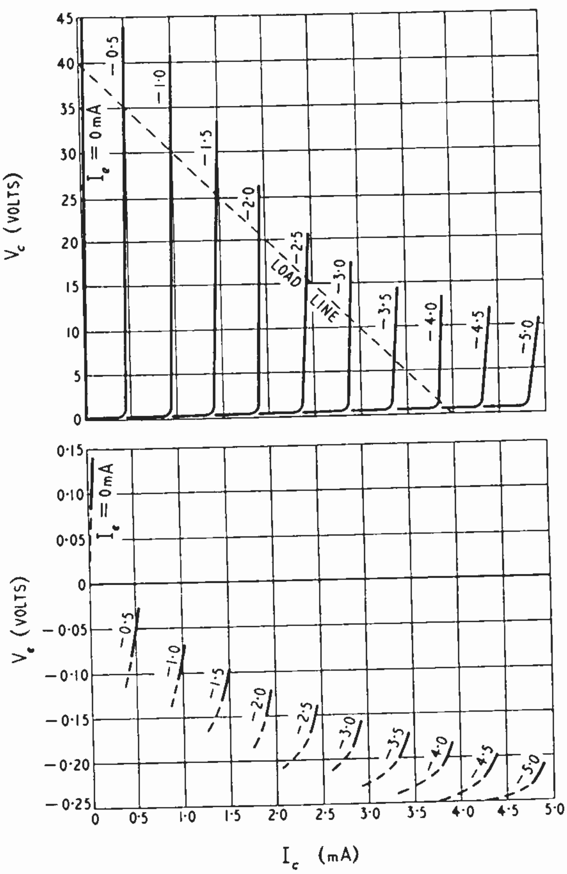


Fig. 1. Static characteristics of an n-p-n type junction transistor.

Type M1752 is about 0.95. Both r_m and r_c are so much bigger than r_b that we can take $\alpha = r_m/r_c$ with $r_m < r_c$. Substituting this inequality in the various equations of the earlier articles will show that there is no possible negative resistance condition, so that amplifiers are a lot easier to design.

The junction transistor is very efficient, having almost ideal static characteristics. We shall come back to this. It is rugged and non-microphonic, gives a high gain, although the frequency response may be limited. In this way it is rather like a pentode, which will give a very large gain if matched, but which has such a high impedance that a matched load is seriously shunted by the self-capacitance of the valve.

The characteristics of an *n-p-n* transistor are shown in Fig. 1. Notice first that the collector voltage is positive, not negative. This is because the centre region is of *p*-germanium, whereas in the point transistor (Fig. 4, p. 71, February 1953 issue) the centre region is of *n*-germanium. Similarly the emitter is held slightly negative. I am not going to say that this is more convenient, because although it means we can use supplies originally intended for ordinary valves, it also means that the curve tracer we designed for point-type transistors must be modified for *n-p-n* junction transistors.

The most striking feature of the characteristics is the steep linear slope. It is possible to swing, without distortion, over almost the whole length of the load line. The actual load line shown is for a resistance of 10,000 ohms, and a good working point on this load line would be 20 volts, 2mA, a total power from the supply of 40mW. It is possible to drive the transistor down to V_c=0.1 volt and up to zero emitter current, where V_c=39.5 volts. Moving the working point slightly, to V_c=19.8 volts the available power output corresponds to a peak swing of 19.7 volts, or an output power of 19.4mW. For Class A working the maximum possible output for a 40mW input is 20mW. To get 19.4mW is well within 5 per cent of the theoretical limit.

The current in the base circuit of a transistor is the difference between the collector current and the emitter current. For the junction-type transistor this base current is very small. As a result the current gain from base to collector is very high, of the order of 20-50 times. The base input circuit, with earthed emitter, becomes of particular importance, especially as there is no longer a stability problem, as there was with the point transistor. It appears that a rather different physical picture is useful to the designer, too. When the transistor is connected as an amplifier, the circuit, in its barest bones, will be that shown in Fig. 2(a). In Fig. 2(b), the potential energy distribution for electrons in the absence of a signal is shown. The positive bias on the collector

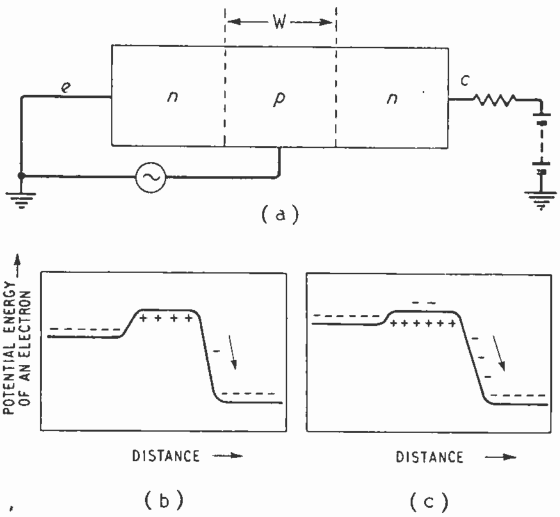
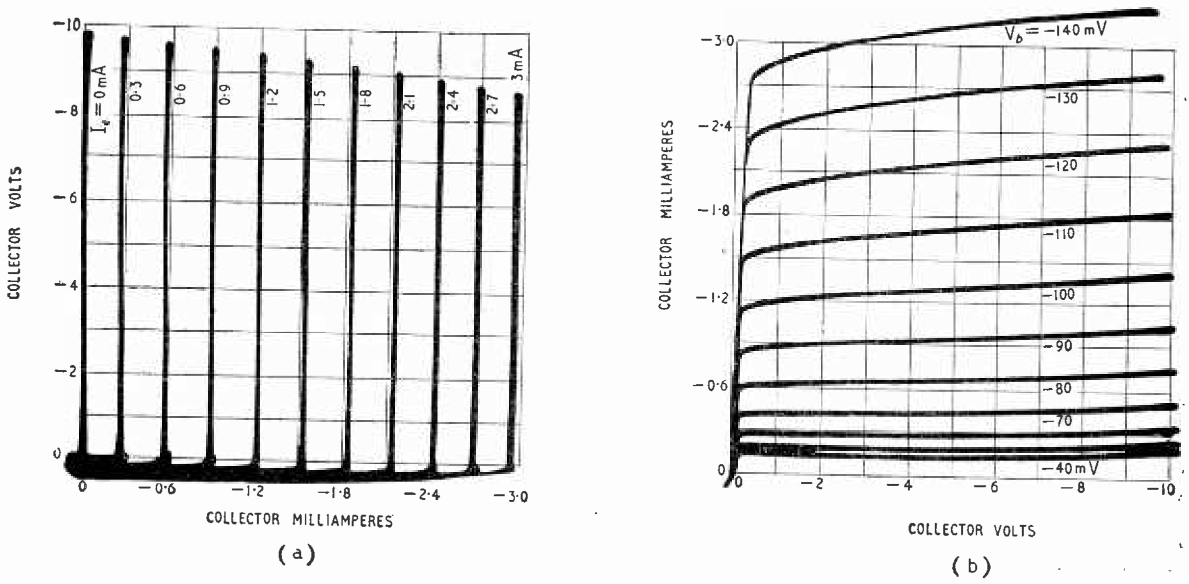


Fig. 2. (a) Earthed-emitter n-p-n *junction transistor biased as an amplifier. (b) Potential energy distribution of electrons with no signal and (c) with the base made positive.*

Fig. 3. Characteristics of a p-n-p *junction, taken on an automatic curve tracer. (a) With emitter current and (b) base voltage as a parameter.*



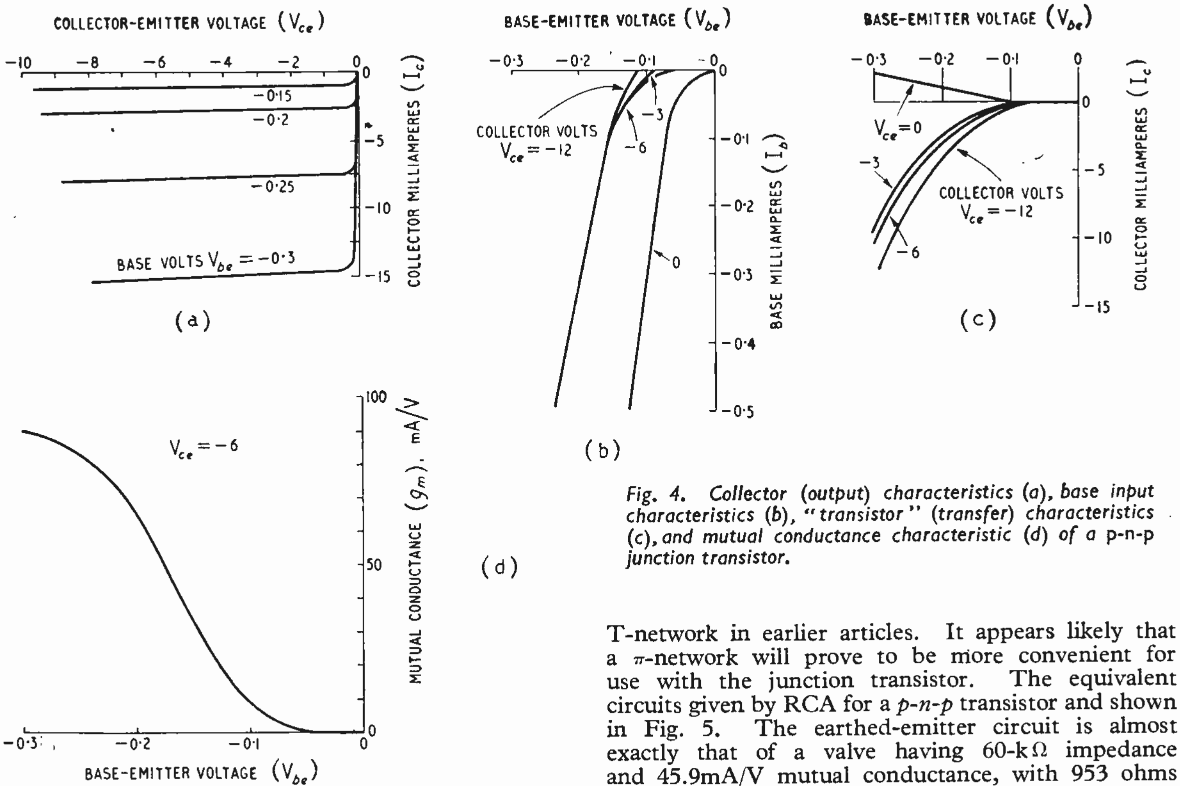


Fig. 4. Collector (output) characteristics (a), base input characteristics (b), "transistor" (transfer) characteristics (c), and mutual conductance characteristic (d) of a p-n-p junction transistor.

produces a reverse bias across the *p-n* base-collector junction. If the base is made to move positive the diagram is changed to the form shown in Fig. 2(c), and more electrons diffuse across from the emitter into the base, just as in a pentode more electrons move into the space between grid and screen when the grid is driven positive. If the base is thin, that is W is small compared with the diffusion length of the electrons, they can cross the base to the collector junction and rush downhill to the collector. The collector current is thus controlled by the height of the emitter-base step. It seems very reasonable, therefore, to use an ordinary valve approach to the earthed emitter junction transistor, and to determine a mutual conductance in the form of *d* (collector current) /*d* (base voltage). A typical value is 50mA/volt, which looks very high in valve terms.

It is interesting to compare the characteristics shown by the two methods. Fig. 3 shows the collector characteristics of a *p-n-p* junction transistor (reversed polarity) plotted on an automatic curve tracer with emitter current as parameter and with base voltage as parameter. The same transistor was used for both sets of characteristics, but in the base-voltage set the curvatures are much more easily observed. Another set of characteristics is shown in Fig. 4, and apart from the fact that they are upside-down they can be seen to resemble the ordinary pentode characteristic quite closely, except that the base impedance is not infinite. The mutual conductance curve, showing the dependence on bias, is unpleasantly curved, but as you can see, values as high as 90mA/volt are obtained. This represents a g_m/I_e ratio of 22 at a standard working point, compared with the corresponding g_m/I_k ratio for a 6AG5 pentode of 0.55.

For circuit design work we have used an equivalent T-network in earlier articles. It appears likely that a π-network will prove to be more convenient for use with the junction transistor. The equivalent circuits given by RCA for a *p-n-p* transistor and shown in Fig. 5. The earthed-emitter circuit is almost exactly that of a valve having 60-kΩ impedance and 45.9mA/V mutual conductance, with 953 ohms connected from grid to earth. This means that if we match this transistor to a 60-kΩ load the voltage gain from base to loaded collector will be $45.9 \times 60/2 = 1380$. To find the gain in decibels we must make an allowance for the change of impedance: the simplest way of calculating this is to include the effect of a suitable step-down transformer. As one input impedance is 950 ohms, this transformer will be 60,000 : 950 (impedance ratio). The gain of the circuit in decibels is then $20 \log 1380\,(950/60{,}000)^{\frac{1}{2}} = 20 \log 174$. This gain, just under 45db, is reduced by the feedback between collector and base, and the maximum power gain is given as 40db, while the input and output impedances are also reduced to about one-half their values when r_{bc} is neglected. The gain quoted for *n-p-n* transistors by Bell is 50db.

If we make use of the results from the previous articles, we can insert in the T-network the values given by Wallace and Pietenpol (*Bell System Technical Journal and Proc. I.R.E.*, July 1951):

$r_e + r_b = 266$ ohms
$r_e = 25.9$ ohms
$r_c - r_m = -13.1 \times 10^6$ ohms
$r_e + r_c - r_m = 0.288 \times 10^6$ ohms

The input impedance, as shown in the last article, is

$$r_e + r_b + \frac{r_e(r_m - r_e)}{r_e + r_c - r_m + R_L}$$

Putting $R_L = 0$ and $r_m/r_c = \alpha$ this is approximately

$$r_b + r_e \cdot \frac{1}{1-\alpha}$$

Now α is very nearly unity: Fig. 6 shows a typical distribution for α over a batch of 118 *p-n-p* transistors. The highest value of α I have seen in published data is 0.9965, for which $1/(1-\alpha)$ is about 300. In

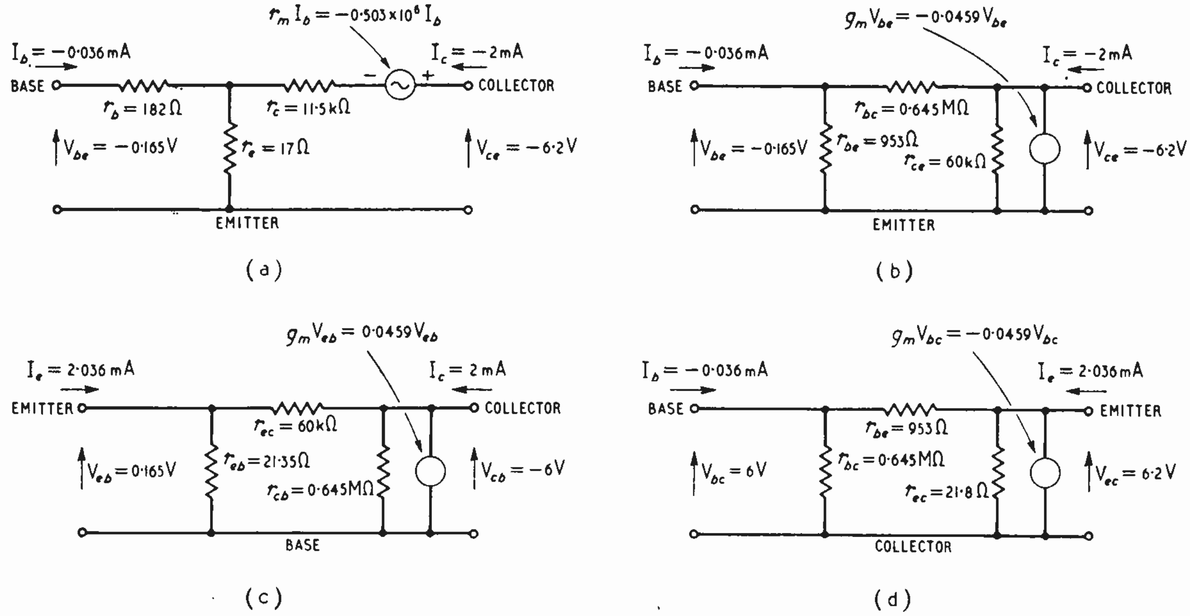


Fig. 5. Equivalent circuits for a p-n-p *(RCA) transistor: (a) T-network, (b) π-network, (c) common base circuit, (d) common collector circuit.*

these circumstances you will see that the input impedance is a rather delicate matter.

We can revert to these detailed calculations at some later date. For the present let us look at one of the most striking features of the junction transistor. The curves in Fig. 7 show the characteristics of the *n-p-n* transistor at extremely low levels. A rather nice working point would seem to be $V_c=0.16$ volts, $I_c=60\mu$A, $I_e=50\mu$A and $V_e=0$. The dissipation is then 10μW and the output power will probably be of the order of 3μW. This is a level of about −26db referred to 1mW, not a very low level by many standards, but an oscillator producing this level will operate from a battery consisting of two coins and a piece of wet blotting paper. I have not yet had time to construct an oscillator using an *n-p-n* transistor and operating at this low level, but with the relatively clumsy point transistor an oscillator, which I shall describe later, giving about 10mW has been run for some 200 hours from an ordinary 4.5-V flat torch battery.

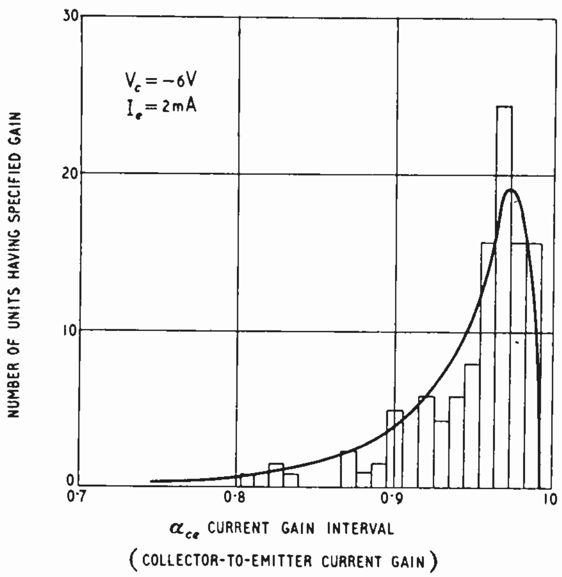


Fig. 6. Distribution of collector-to-emitter current gain for a batch of 118 p-n-p *transistors.*

These very low level characteristics of the junction transistor do not have very great immediate application, because at the moment most of us are trying to fit transistors into existing patterns of equipment. For example, we may be replacing one valve unit by a transistor unit, keeping to the same supplies and the same performance.

We shall begin to make enormous advances as soon as we can design a system completely for transistors. All our problems will be passed back to the system engineers for reconsideration. Let us glance at a typical case : we now assume that it is best to concentrate the gain in a broadcasting network at the transmitter, and bang out hundreds of kilowatts to save a valve in each of myriads of receivers. Now, however, we can provide an extra 20 decibels of gain in each receiver by using a transistor consuming 10μW, instead of a valve consuming 2W. Even a million receivers will only use 10 watts, so from the power efficiency viewpoint we should complicate the receiver, not the transmitter. This is not the last word on this question, of course : in fact it is hardly the first word, but it serves as a very simple example of the new thinking the systems engineers will be doing.

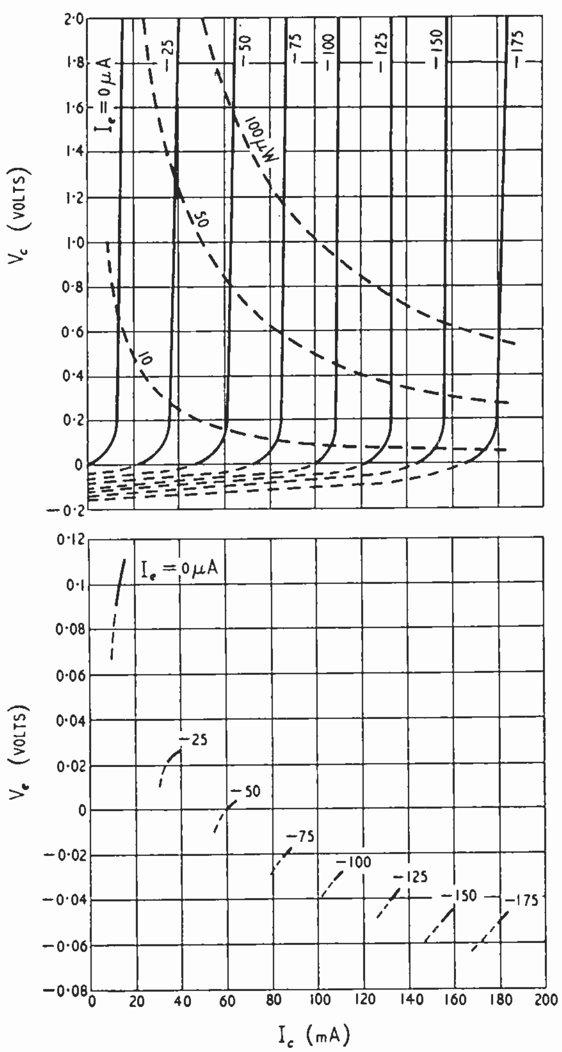
To round off this rapid survey of the junction transistor, let us look at some of the typical amplifier arrangements we can use. The earthed-emitter circuit appears to be the most generally useful form for simple amplifiers. We shall start off by taking the circuit shown in Fig. 8. The base is floating, and the collector current and emitter current are exactly equal. Now when the emitter current is zero, the collector current has a value I_{co}, a very important quantity in junction transistor circuit design. As I_e is increased, I_c increases, with $dI_c/dI_e=\alpha$. Assuming a linear characteristic, the value of I_c is $I_{co}+\alpha I_e$. We know, however, that $I_e=I_c$ so that $I_e=I_c=I_{co}+\alpha I_e$ and $I_c=I_{co}/(1-\alpha)$

From Fig. 7, I_{co} is rather less than 20μA and α is about 0.96, so that I_c will be about 500μA, which at a collector voltage of 20V gives quite a reasonable working point on Fig. 1. The main difficulty here is that a small change in α will give such a large change in working point. I shall discuss this question in more detail later.

Following on from this basic idea we can move the working point by two expedients. These are shown in Fig. 9. In the first circuit we allow some of the base self-bias to leak away through the base resistor. The base is thus less positive, and the collector current is reduced. In the second circuit a small extra positive bias is applied to the base by the current pulse through R and the emitter. As a result the collector current is increased.

Additional bias can be provided by reducing the base resistance to zero and adding resistance in the emitter lead. This makes the base slightly negative with respect to the emitter. In appearance and in behaviour this resistance in the emitter-earth lead behaves like the conventional cathode bias resistance in a valve circuit. The gain of a junction transistor in the earthed-emitter circuit is inversely proportional to r_e so that an external addition to the emitter resistance produces a gain reduction, due, of course, to negative current feedback.

For reasons which will be made clearer in a later article, we usually have to combine these various types of biasing in order to get a reasonably stable working point for different specimens of transistors. The circuit of Fig. 10 shows a typical arrangement of a simple *n-p-n* transistor amplifier. Across the transistor itself the voltage drop is 25 volts, at a current of 2mA. The resistance R_1 is chosen to use up all the available battery voltage. Using a 60-volt battery and allowing 1,000 ohms for the transformer we should use $R_1=16.5\text{k}\Omega$. This puts the emitter at +33 volts



Left: Fig. 7. Static characteristics of n-p-n *junction at very low levels.*

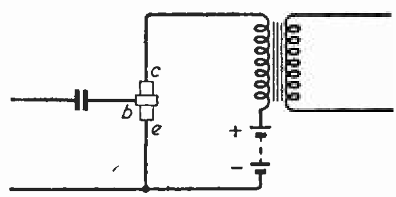


Fig. 8. Practical arrangement of earthed-emitter amplifier.

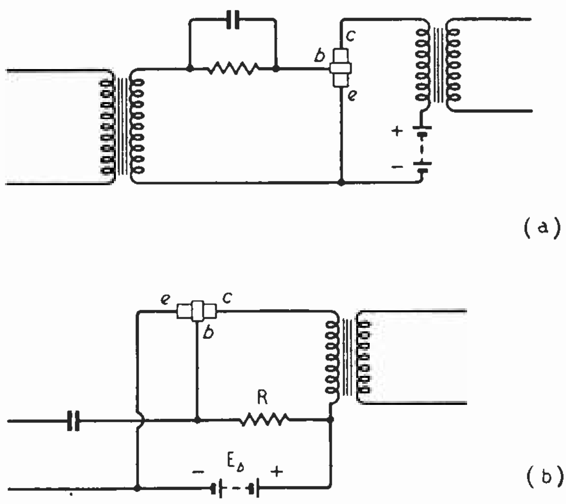


Fig. 9. Modifications to the circuit of Fig. 8 to obtain (a) lower collector current by introducing a capacitor and leak to reduce the base self-bias and (b) higher collector current by adding R to increase the positive base bias.

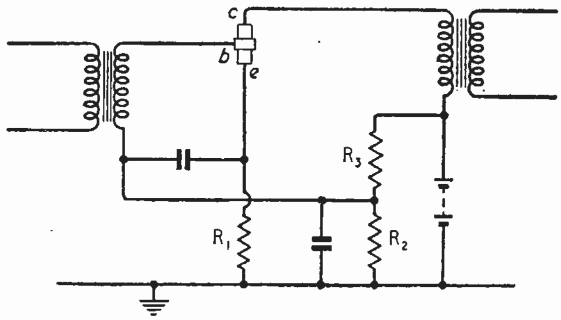


Fig. 10. Simple n-p-n *junction transistor amplifier, showing biasing arrangements for stable operation.*

above earth, so we now choose R_2 and R_3 to bring the base to about +33 volts, too. To save arithmetic, take R_2=33kΩ and R_3=27kΩ. All these feeding resistors are decoupled, so that although the negative feedback effect is very large, when it is a question of fixing the working point, there is no loss of gain. A reasonable collector load is about 10-15kΩ and this defines the output transformer. The input transformer . . . well, all you can do at present is to let the circuit warm up for half an hour, measure the impedance and design to suit. In general, I have found that it is necessary to assume an input impedance of about 1,000 ohms, and tolerate the increase which takes place with warming-up. This is expensive in gain. An alternative is to step up to about 10kΩ at the input, when a gain of about 25-30db can be obtained.

Apart from the differences in α and I_{co} which have been mentioned above, in some of the *n-p-n* transistors I have tested that elegant straight line characteristic has bent over at somewhere between 5 and 25 volts. This puts a rather low limit on the maximum output power.

This scamper over the junction transistor story will have left the reader thinking in terms of milliwatts and microwatts. To conclude, therefore, we may notice that a power transistor has been described showing characteristic curves up to 10 amps emitter current and 3 amps collector current. Nearly 100 watts of Class A power can be obtained from this unit, with 10-20db gain. The area is one square centimetre.

References and acknowledgements. Figs. 1, 7, 8 and 9 are based on Figs. 4, 5, 17, 18 and 19 of " Some Circuit Properties and Applications of *n-p-n* Transistors " by R. L. Wallace, Jr., and W. J. Pietenpol," *B.S.T.J.* July, 1951 and *Proc. I.R.E.* July 1951. Fig. 2 is based on Fig. 22 of " Transistor Electronics " by W. Shockley, *Proc. I.R.E.*, Nov. 1952; Figs. 3 and 6 on Figs. 4 (b), (d) and Fig. 12 of " A Developmental Germanium *p-n-p* Junction Transistor " by R. R. Law, C. W. Mueller, J. I. Pankove and L. D. Armstrong, *Proc. I.R.E.*, Nov. 1952; Figs. 4 and 5 on Figs. 2 (b), 3 (a), (b), 4, 5 and 6 of " Junction Transistor Equivalent Circuits and Vacuum-tube Analogy " by L. J. Giacoletto, *Proc. I.R.E.*, Nov. 1952.

LETTERS TO THE EDITOR

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

Broadcast Transmitter Distortion

I AM indebted to Ian Leslie's letter (your April issue) for a solution to a problem with which I have been troubled for some time.

Numerous enquiries amongst other associates who, like myself, have gone to considerable expense in purchasing first-class equipment, have revealed similar defects in B.B.C. transmissions.

My equipment includes two expensive high-fidelity speakers, a well-designed tuner and a " quality " amplifier, all of which are beyond reproach. Notwithstanding this, the speakers rattle at times like old tin cans.

We have tolerated bad quality and unnecessary interference of all descriptions long enough and it is about time some tangible solution was found. Experiments carried out for years at Wrotham will, apparently, go on indefinitely before anyone institutes a better broadcasting system.

I have a feeling that we have slipped up badly in allowing the B.B.C. to make increased use of recorded programmes; we rarely get "live" transmissions, but are forced to listen for the majority of the time to inferior recordings.

Land-line transmissions, particularly in the north, leave much to be desired. The lines are often noisy and quality in the upper register is frequently poor.

In an effort to effect some improvement may I suggest:

1. That listeners should insist on the number of recorded transmissions being reduced to a minimum and never resorted to when it is possible to use a "live" broadcast.

2. That the B.B.C. discontinue using compression and find a more satisfactory remedy for cutting out interference from adjacent transmitters.

3. That more supervision be exercised over land-line transmissions.

4. That television transmitters, covering as they now do some 80 per cent of the listening public, be employed to transmit sound when not required for television.

Although receivers, amplifiers and loudspeakers have been considerably improved in recent years, it is deplorable that the quality from B.B.C. transmitters, except on rare occasions, by no means approaches the standard achieved 20 years ago.

Skipton, Yorks. A. YATES.

Flashing Beacons

I WOULD like to refer to the letter from John Baggs in the April issue of *Wireless World* on the subject of interference with radio and television reception from flashers used to control the lighting of zebra beacons.

My company considers that it should be known that the flashers manufactured by us comply with BSS800, and have been fully approved by the General Post Office for effective suppression. Tests have shown that no interference will be experienced from these flashers even after a year or so's wear when, as Mr. Baggs states, the contacts may become pitted.

It may also be of interest that every flasher is being individually tested before despatch on G.P.O.-approved radiation interference test equipment, to ensure that no Venner flasher will be guilty of spoiling radio or television programmes.

Venner, Ltd., New Malden, Surrey. J. H. RAWLINGS.

Lamp Interference

A NEIGHBOUR of mine who owns a television receiver has complained of chronic interference on vision and sound for a considerable time. On seeing the picture I immediately exclaimed "Oh! valve diathermy apparatus, of course!" There was a single hum bar with the characteristic herringbone pattern above and below it towards the top of the picture. I was even more confirmed in my diagnosis when I realized that we were only a stone's throw from a hospital.

The G.P.O.'s aid was enlisted, and the engineer insisted that it was nothing to do with the hospital (which fact we ourselves confirmed with the authorities). He discounted the possibility of diathermy altogether and said he believed the radiation to be coming from an ordinary domestic vacuum lamp in the neighbourhood. He always found it extremely difficult to trace such interference when hundreds of lamps were on in the vicinity.

If such heavy interference is possible from these lamps, how is the herringbone pattern, which I should imagine would require a wide band of frequencies, actually produced?

Weymouth, Dorset. K. ROBINSON.

"Vision A.G.C."

HAVING an interest in television a.g.c. systems, I would like to raise one or two points about the article in your April issue. First, you state that the video output is maintained constant against variations of $\pm$20db. That may be correct, but you do not state that the contrast control is the only means of adjusting the mean level in order to achieve this. This, to my way of thinking, is important, for two reasons:

(a) If the contrast control is set too low, the signal increase produced by "aeroplane flutter" will be most manifest by an overload effect at the grid of the first i.f. stage. This in turn results in a decrease of picture contrast. (This effect occurs when sensitivity is increased in an attempt to offset loss of signal at low contrast setting.) The result of this mode of setting up is a reverse flutter effect of a somewhat abrupt nature and at its best is quite disturbing.

(b) When contrast is used as a major control, i.e., where signal strength is low and sensitivity is at maximum setting, the amount of black level stabilization that actually takes place is dependent on the contrast setting, being least at maximum contrast and greatest at a point equivalent to about two-fifths contrast. Actual measurement shows that the range of anti-flutter gets progressively poorer as inputs fall below 120μV peak white.

The article states quite correctly that the system will be of most value in fringe areas, where fading is more troublesome. Unfortunately any a.g.c. system, especially a gated system, suffers from having to rely on the "reserve" sensitivity of the receiver plus the sensitivity of the a.g.c. gating, etc., and if contrast is controlled by a variation of either characteristic a loss of a.g.c. is suffered except at one critical setting of the contrast control. This setting is not only difficult to adjust, but also varies with input signal strength.

The article also states that the system is sufficiently fast to counteract flutter up to 50 c/s, above which the eye "couldn't care less," so to speak. It is true that the eye will not respond to a change in 0.02sec, but I must insist that the a.g.c. does not respond either. The system's rate of operation is limited by the circuit values used, and on test the a.g.c. action gets noticeably worse above 15 c/s, subject to the "gain" of the pulse amplifier—again depending on contrast control setting. Furthermore, above 10 c/s low-frequency beats are produced, and these cannot be attenuated by the a.g.c. unless the a.g.c. can first remove the "parent" flutter frequency. Therefore, unless all flutter above 10 c/s is removed, the resultant beats are present.

However, generally the article is of great interest and I look forward to seeing something more on a.g.c. in the near future.

Southend-on-Sea, Essex. HENRI T. PICHAL.

Cathodic Protection

I HAVE noted with interest the reference to cathodic protection by "Diallist" in your February issue, and since I specialize in this subject, you will perhaps permit me to make the following brief observations:—

(1) Under-water corrosion, even in the Persian Gulf, is not due to direct chemical attack, as your columnist suggests, but is electro-chemical in character.

(2) The galvanic anodes used to form the primary cell do not consist of aluminium but are made of a special magnesium alloy.

(3) In addition to the galvanic system utilizing reactive anodes, there is a further system in use in the Persian Gulf. This system makes use of relatively inert anodes through which externally generated current is applied.

(4) Cathodic protection by means of the two systems referred to has been adopted not only for protecting jetties in the Gulf but British design and British equipment is employed in many countries for the protection of such widely diverse structures as the hulls of ships, tanks, and underground pipelines. In this country alone there are several hundred installations.

(5) The reference to the effect on fish seems to be very greatly exaggerated. W. GODFREY WAITE,

F. A. Hughes and Company, London, W.1.

V.H.F. for Voyagers

TRAVELLING from Holland to England with a colleague during the recent storm period, I had the following experience of ship-to-shore communication in the North Sea.

At the Hook of Holland, due to the storm we were unable to leave the ship, and the ship was unable to leave the port for a period of twenty-four hours. The natural reaction of all passengers under such circumstances is to send a message to their destination to relieve anxiety. However, at the Hook, as in so many ports of the world, ships are barred from using their medium-frequency radio equipment within three miles of the land. The ship on which I was travelling, in common with all ships on the Harwich-Hook of Holland run, is not fitted with v.h.f. radio-telephony.

After some time, and after much shouting through the gale to the shore, we were able to organize ship-to-shore communications by means of a 30ft bamboo pole with a bag on the end of it. Written messages were placed in this bag by passengers and transferred to the shore for despatch by telegraph to England.

During the crossing to Harwich on the following day, it was still impossible for passengers to send telegrams via the ship's wireless installation. This was due to congestion of available medium-wave channels, priority being accorded to safety-of-life messages on these channels. Attempts to use the radio-telephone channels were only slightly more fruitful, in this case one or two of the passengers' calls were successful after about two hours' delay.

Is it not time that v.h.f. ship-to-shore communication was established on all Channel and North Sea routes in the interests of passengers' convenience and safety?

Cambridge. A. G. CLARKE.

WORLD OF WIRELESS

More Television Stations ✦ New Navigational Aids ✦ Personalities ✦ News in Brief

B.B.C. Television Plans

SIR IAN JACOB, director-general of the B.B.C., stated recently that the Corporation hopes to erect 10 low-power television stations when the present scheme for five medium-power stations is completed. These are, of course, provided for in the Stockholm v.h.f. frequency plans which allow for two more television stations in the present band and 28 in the 174-216 Mc/s band. It should, however, be pointed out that since it has not yet been decided how the v.h.f. broadcasting bands will be utilized in this country, the British delegation to the conference entered a reservation in signing the agreement, which makes the signature effective only so far as the 41-68 Mc/s band is concerned.

The proposed chain of 20 stations will bring television to 98 per cent of the population. Although these projected stations will be of low power, they will not be "boosters" in that that they will not rely on their direct reception of the signal radiated by the nearest high-power transmitter.

On the question of colour, Sir Ian stated that it may come in two or three years, but it would have to be a compatible system using no more than the present bandwidth. It would probably be introduced by equipping one studio and one O.B. unit for colour, which will be used only on occasions when colour would be an advantage.

It is understood that arrangements have been completed for the B.B.C. to acquire a site at the Crystal Palace for the erection of the high-power transmitter which will replace the Alexandra Palace station when the lease of the building expires in 1956.

Radar Plotter

OBSERVATION of a radar screen is not sufficient to determine if another ship is steering a collision course with respect to the vessel on which the observations are made. It is constantly being stressed that it is essential to keep a good radar plot, and hitherto it has been necessary to do this on a chart or plotting sheet. Decca have now produced a screen which enables direct plotting on the radar display without the serious parallax error which was previously caused by the normal screen being some distance from the actual tube face.

A half-silvered mirror is placed between the tube and the Perspex plotting surface. The curvature of this surface is opposite to that of the p.p.i., so that the reflection of any mark made on the plotter will coincide with the radar echo on the tube when viewed from any angle. The plotting screen is edge-illuminated so that wax pencil marks show up clearly on the radar screen, but when the light is switched off the marks are not visible on the p.p.i.

The "Deccaplot," as it is called, fits over the face of the standard Decca 12in display unit.

Mobile Decca Chains

AN OBVIOUS, yet little publicized, use of the Decca Navigator system is described in the March issue of *Decca Navigator News*. To cover a desired area of a few thousand square miles in a part of the world not served by one of the existing permanent chains, transportable low-power transmitters are set up. Their principal use so far has been for hydrographic surveys, but the transportable chains have also been employed successfully on oil exploration in the Persian Gulf.

PERSONALITIES

Professor Willis Jackson, D.Sc., D.Phil., M.I.E.E., who in July will be assuming the directorship of research and education with the Metropolitan-Vickers Electrical Co., has been elected a Fellow of the Royal Society. The citation refers to his "studies of the electrical behaviour of dielectrics and of the performance of transmission lines and wave-guides." Professor Jackson at present occupies the Chair of Electrical Engineering at the Imperial College of Science and Technology, London, where he has been since 1946.

(Left) P. D. CANNING

(Right) W. A. ROBERTS

P. D. Canning, the new chairman of the Radio and Electronic Component Manufacturers' Federation, has been with the Plessey Company since 1933, and was for some years responsible for development and production of transmitting equipment and for radio installation work. Since 1948 he has been acting as liaison between the company and trade associations. He is also serving his second term of office as chairman of the R.I.C. Technical Direction Board.

W. F. Randall, B.Sc., M.I.E.E., the new vice-chairman of the R.E.C.M.F., has been a director of the Telegraph Construction and Maintenance Co. since 1945. He joined the company in 1922 to undertake research work on cable and loading materials and from this research emerged mumetal. When the h.f. plant was set up for the production of mumetal he was put in charge.

Appointments of engineers-in-charge of the two low-power television stations at Pontop Pike (Newcastle) and Glencairn (Belfast), both of which are to be equipped temporarily with mobile stations, are announced by the B.B.C. **J. P. Brett,** who is appointed to Pontop Pike, has been with the Corporation since 1944 and for the past two years has been at Holme Moss, latterly as a senior maintenance engineer. **C. Duddington,** who also holds a similar position at Holme Moss and was previously at Alexandra Palace and Sutton Coldfield, is appointed to the Belfast station. He joined the B.B.C. in 1946 at the Lisnagarvey, Northern Ireland, transmitting station.

G. T. Clack has resigned, because of pressure of work, the honorary lecture secretaryship of the Television Society, which he has held for the past four years. Prior to his appointment he was for some time responsible for the lectures for the Society's engineering group. Mr. Clack is a senior laboratory engineer at the Bush Research Laboratory, which he joined in 1938, and is at present primarily engaged on technical liaison work.

W. A. Roberts, A.M.I.E.E., a senior member of the B.B.C. Engineering Division, who was a member of the Broadcasting Commission which visited the Gold Coast recently to advise on the setting up of a statutory broadcasting corporation, has been appointed to the Colonial Office to advise on the further technical development of broadcasting in the Colonial territories. He was at one time assistant to the B.B.C. chief engineer. Mr. Roberts will make a series of tours to the Mediterranean and East Africa, Central Africa, the West Indies, South-East Asia, the South Pacific, and West Africa.

J. H. Williams, who has been in the radio industry since 1922, first with Marconiphone and then with Cossor's, has become joint managing director, with William Harries, of Regentone Radio and Television Ltd., and the Radio Gramophone Development Co., Ltd. On leaving E.M.I., Ltd. (which took over Marconiphone), he joined Cossor's in 1939 and became joint managing director in 1943. He resigned from Cossor's in 1947 and has since been acting as a consultant in the industry.

Richard R. C. Rankin, O.B.E., A.M.I.E.E., who, as announced in our March issue, has succeeded Dr. C. F. Bareford as a director of Telcon Telecommunications, Ltd., was erroneously stated to be a director of Mullard Ltd. He is technical manager of Mullard Equipment, Ltd. (of which he is also a director), and of the Equipment Division of the parent company, Mullard, Ltd.

OUR AUTHORS

G. W. A. Dummer, who writes in this issue on components for use with transistors, joined the Telecommunications Research Establishment in 1939, and, with E. Franklin, designed the first p.p.i. to be used in radar. During the war he was in charge of a group designing synthetic radar trainers. Mr. Dummer subsequently became responsible for component development and panclimatic testing. He is at present in charge of a Component Development Division, an Engineering Research Division and a Testing Division at T.R.E. He is doing fundamental work, on printed and potted circuit techniques, and, with D. L. Johnston, read a paper on this subject before the I.E.E. in January this year.

R. F. Hansford, joint author of the article on radar repeaters in this issue, studied communication engineering at the Portsmouth Municipal College and during the war was at the Admiralty Signal and Radar Establishment, developing navigational radar gear. After the war he was in the Research Department of the Sperry Gyroscope Co. until 1952, when he joined Decca Radar, Ltd., to take charge of its newly formed Radar Applications Division. He is a founder member of the Institute of Navigation and was for a number of years its technical secretary.

G. J. Dixon, who, with R. F. Hansford, contributes the article on p. 218, was a wireless mechanic in the R.A.F. prior to joining the Decca organization in 1946. He is now a member of the staff of the Decca Radar Research Laboratories and is at present in charge of a radar link development project.

H. E. Styles, author of the article in this issue on a sensitive two-valve receiver, is superintendent of laboratories in London Transport Executive. A chemist by profession, he gained a 1st class honours B.Sc. (Chemistry Special) degree at London University.

Charles A. Marshall, author of the article on the design of a television converter, graduated from Manchester University in electrical engineering in 1944. The following year he joined the Philips group of companies as a technical assistant at Mitcham Works, Ltd. In 1948 he transferred to the Mullard Research Laboratories as a development engineer in the television laboratory where he has been mainly concerned with the design of r.f., i.f. and video sections of both 405- and 625-line receivers. He is at present working on the problems involved in the application of valves in television tuner units for multi-channel working in the 174-216 Mc/s band.

OBITUARY

It is with regret that the death is announced of **Frank Powell Best,** M.Sc. (Cantab), B.Eng., B.Sc., technical manager of the Marconi International Marine Communication Co. and the Marconi Sounding Device Co., on March 26th at the age of 52. In 1924 he joined the Radio Communication Co., which four years later was amalgamated with the Marconi Marine Co. He became deputy technical manager, but in 1934 transferred to Marconi's W.T. Co. to assist in the development of equipment for marine use. In 1939 Mr. Best returned to the Marconi Marine Company as technical manager, and a year later was also appointed technical manager of the Marconi Sounding Device Co. He was chairman of the technical committee of the International Maritime Radio Committee (C.I.R.M.).

It is with regret that we record the death of **H. L. Bowen,** a technical executive of Mullard's Valve Division, soon after his arrival in the U.S.A. He had been chairman of the technical committee of the British Radio Valve Manufacturers' Association since 1949 and during his stay in America he was to represent the Association at the Joint Electron Tube Engineering Council Conference held in Atlantic City in March. Mr. Bowen recently celebrated his 25th year with the Mullard organization. He was a member of various committees of the British Standards Institution and was also a member of the Valve Standardization Committee of the International Electro-technical Commission (C.E.I.).

IN BRIEF

Receiving Licences. — During February the number of television licences increased by 69,531, bringing the total to 2,072,980. At the end of the month 10,794,918 "sound" receiving licences—including 180,375 for car sets—were current in the British Isles bringing the total to 12,867,898.

Four-day Components Show?—If the R.E.C.M.F. is guided by the consensus of opinion at the annual general meeting of the Federation and by the success of this year's show, the 1954 components exhibition will be extended to four days instead of the present three.

French Audio Journal.—A monthly journal *Revue de Son* made its debut with the April issue and will cover all aspects of sound reproduction. The publishers are Editions Chiron, 40, Rue de Seine, Paris 6, and the price is 180 francs per copy.

R.E.C.M.F. Council.—As a result of the ballot at the annual meeting of the Radio and Electronic Component Manufacturers' Federation, the following firms were elected to the council (the representative's name is in brackets):—Automatic Coil Winder (R. E. Hill), British Moulded Plastics (J. H. Bridge), Garrard (Hector V. Slade), Hunt (S. H. Brewell), Multicore (R. Arbib), Painton (C. M. Benham), Plessey (P. D. Canning), Reliance Electrical Wire (C. H. Davis), Telegraph Construction (W. F. Randall) and Telephone Manufacturing (W. A. Jackson). At the first meeting of the council, P. D. Canning and W. F. Randall were elected chairman and vice-chairman respectively. In addition to the re-election of A. F. Bulgin, E. M. Lee and L. H. Peter as vice-presidents, S. Wilding Cole and Hector V. Slade were also elected vice-presidents.

Radio-controlled Models.—The annual international contests for radio-controlled model boats and aircraft, organized by the International Radio Controlled Models Society, will be held at Southend-on-Sea, Essex, on July 25th (boats) and 26th (aircraft). Further details and entry forms are obtainable from R. Ing, 36, Sunny Gardens Road, Hendon, London, N.W.4.

Electron Optics.—A science meeting of the Physical Society on "Recent Research in Electron Optics," arranged by Dr. O. Klemperer of Imperial College, will be held at the College, Imperial Institute Road, London, S.W.7, on May 15th and 16th. It will be divided into the following sections: electron lenses, correction of aberrations, electron guns, focusing in electron accelerators, electron optics in television tubes and valves, and electron spectrometry. Application forms to attend the meeting are available from the Physical Society, 1, Lowther Gardens, Prince Consort Road, London, S.W.7. Closing date for applications is May 7th.

Gramophiles.—A National Gramophone Conference is being organized by the National Federation of Gramophone Societies at High Leigh, Hoddesdon, Herts, for the weekend of May 29th to June 1st. During the conference high-fidelity recording and reproducing equipment will be demonstrated. Full details may be obtained from G. E. Palmer, 106, Streatfield Road, Kenton, Harrow, Middx.

Pye-U.S. Agreement.—"Joint research and development in the field of industrial and broadcast television cameras and studio equipment" is provided for in an agreement recently signed by Pye, Ltd., and General Precision Laboratory, Inc. (New York), who have been associated for the past three years in the development of studio equipment. Each company will manufacture and market its own equipment, but the "combined engineering knowledge of the two firms will be pooled." Pye and G.P.L. are also stated to be co-operating on theatre television.

British Plastics.—Among the 20 or more papers to be read at the convention which runs concurrently with the British Plastics Exhibition at Olympia, London, from June 8th to 18th, are a number of interest to the radio and allied industries. Of particular interest is "Plastics in the Telecommunications Field" by R. C. Mildner, H. F. Wilson and E. I. Cooke, of the Telegraph Construction and Maintenance Co. It will be read on June 17th. There will be 80 or more exhibitors at the show, which is sponsored by *British Plastics.* Admission to the exhibition, which is open from 10-6 is price 2/6. Further information and free tickets for the convention can be obtained from *British Plastics*, Dorset House, Stamford Street, London, S.E.1.

Radar Exports.—Decca's annual report records that during the past year, over £1M worth of the company's marine radar equipment was exported. The report adds that Decca radar is believed to be "more extensively fitted than any other marine radar equipment in the world."

Dover Harbour R/T.—The port of Dover is to be equipped by Rees Mace Marine, Ltd., with Pye v.h.f. radio-telephones for harbour control. The central station will be installed in the signal tower on the eastern arm of the harbour. Tugs operated by the harbour board will be equipped with multi-channel v.h.f. sets to enable them to communicate either with the signal tower or with other ships.

Cintel large-screen (24×24ft) television equipment is being installed in the Festival Hall to enable a paying audience of 3,000 to see the B.B.C. broadcast of the Coronation procession and service in Westminster Abbey.

Glass Exhibition.—The proposed Glass Industries Exhibition planned to be held in London this month, and to which we drew readers' attention in our February issue, has been postponed indefinitely by the organizers, B. & C. D. Trade Exhibitions, Ltd.

New Relay Company.—British Relay Wireless and Television, Ltd., is the name of the company recently formed to integrate the sound and vision relay services operated by the British Relay Wireless Group and Link Sound & Vision Services, Ltd. The latter company was formed jointly by Pye, Ltd., and Murphy Radio, Ltd., who will be shareholders in the new company.

R.G.D.—The Radio Gramophone Development Co. which was taken over by W. Harries, chairman and managing director of Regentone Radio & Television, Ltd., last year, has moved from Hampton Court to Eastern Avenue, Romford, Essex (Tel.: Romford 5991).

MEETINGS

Institution of Electrical Engineers

Radio Section.—"Recent Work in France on New Types of Valves for the Highest Radio Frequencies" by Dr. R. Warnecke and P. Guenard at 5.30 on May 13th at Savoy Place, London, W.C.2.

North Lancashire Sub-Centre.—Annual General Meeting, followed by an informal lecture on "The Nervous System as a Communication Network" by J. A. V. Bates, M.A., M.B., B.Chir., at 7.0 on May 6th at the Harris Institute, Corporation Street, Preston.

Television Society

London.—"A Delayed Trigger Oscillograph" by R. Anderson and J. R. Smith (Plessey) on May 7th.

"A Directly-driven Line Scan Circuit" by Emlyn Jones and K. Martin (Mullard) on May 29th.

Both meetings will be held at 7.0 at the Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2.

British Institution of Radio Engineers

London Section.—"Recent Advances in the Application of Electronics to Chemical Instrumentation" by G. I. Hitchcox at 6.30 on May 6th at the London School of Hygiene & Tropical Medicine, Keppel Street, London, W.C.1.

Merseyside Section.—Annual General Meeting followed by "The Development of the Radio and Electronics Industry in India" by G. D. Clifford at 6.45 on May 7th at the Electricity Service Centre, Whitechapel, Liverpool.

Royal Society of Arts

"Training for Science and Technology" by Sir Richard Southwell, M.A., LL.D., D.Sc., F.R.S., at 2.30 on May 13th at John Adam Street, London, W.C.2.

British Sound Recording Association

London.—Annual Covention on May 15th at the Waldorf Hotel, Aldwych, London, W.C.2. Discussion with demonstrations of high quality and stereophonic (sound) reproduction, to be opened by three leading authorities on the subject.

Institution of Production Engineers

Shrewsbury Section.—"Electronics as an Aid to Productivity" by R. McKennell at 7.30 on May 27th at the Shrewsbury Technical College.

MARITIME FREQUENCY CHANGES

AS already announced, the marine radio-telephone distress and calling frequency for small craft will be changed from 1650 kc/s to 2182 kc/s on May 1st. This change is in conformity with the plans for the maritime mobile frequency band 1605-2850 kc/s drawn up by the Extraordinary Administrative Radio Conference at Geneva in 1951. The implementation of the plans also necessitates changes in the working frequencies of the U.K. coast stations and we give below their radio-telephony (R/T) frequencies and also the frequencies they will employ for telegraphy (W/T).

Under the new frequency arrangements, British ships will be divided into two categories, (a) fishing vessels, and (b) coasters and deep-sea ships. Both classes will use the new R/T distress and calling frequency and for communication with coast stations they will adopt one or more working frequencies from the following numbered channels:—coasters and deep-sea ships, (1) 2009, (2) 2016, (5) 2527 and (6) 2534 kc/s; fishing vessels, (3) 2104, (4) 2111, (7) 2548, and (8) 2555 kc/s. A ninth channel (3373 kc/s) is reserved for fishing vessels working Wick Radio.

		R/T Service (kc/s)	M.F. W/T Service (kc/s)
Wick	(GKR)	1827, 2705, 3617	432, 1615, 2842*
Stonehaven ..	(GND)	1855, 2691	458, 1618
Cullercoats ..	(GCC)	1841, 2719	484
Humber ..	(GKZ)	1869, 2628, 2684	441, 1618
N. Foreland ..	(GNF)	1848, 2698, 2733	418
Niton	(GNI)	1834, 2628	464
Jersey	(GUD)	1657.5	516
Land's End ..	(GLD)	1841, 2719	438, 522
Burnham ..	(GRL)	1855, 2670	476
Seaforth ..	(GLV)	1715, 2754	447
Portpatrick ..	(GPK)	1883, 2607	472
Oban	(GNE)	1848, 2740	1622
Malin Head ..	(EJM)	1841, 2593	421, 1618
Valentia ..	(EJK)	1827, 2614	429, 1612
Parkeston Quay	(GUQ)	—	429
Folkestone ..	(GUR)	1827	—
Newhaven ..	(GUV)	1855	—
Cork Harbour ..	(EJC)	—	516
Guernsey ..	(GUC)	1642.5	—

* Fishing vessels only.

The following three frequencies are reserved for the use of deep-sea ships for R/T communication with coast stations:—2090, 2097 and 2146 kc/s.

For inter-ship radio-telephony communications, the frequencies 2226, 2231 and 2306 kc/s are reserved for fishing vessels; 2241, 2246 and 2301 kc/s for coasters and deep-sea ships and 2421 kc/s for deep-sea vessels in the Atlantic and Mediterranean.

"Fishing vessel" frequencies are reserved exclusively for use by these craft, but the category "coaster and deep-sea ships" will include tugs, pilot vessels, cross-channel passenger boats, yachts and miscellaneous craft.

Ship frequencies for ship-shore telegraphy (A1 and A2) for fishing vessels are 1623, 2042 and 2496 kc/s. The inter-ship W/T calling and traffic frequencies are 1606 and 1609 kc/s.

The telegraphy distress frequency is still 500 kc/s and all coast stations, with the exception of Oban, keep a continuous watch on this frequency.

Correction

Fig. 4(b) in "D.C. Restoration in Television," in the March issue shows the waveform sloping the wrong way during the narrow pulses. In parts such as DF it is shown as sloping upwards to the right whereas it should, of course, slope downwards

THE "BELLING-LEE" PAGE

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

Three Moot Points.

There are a lot of "Doubting Thomases" in the world, but we suppose that must be, so long as it is good law to "let the buyer beware."

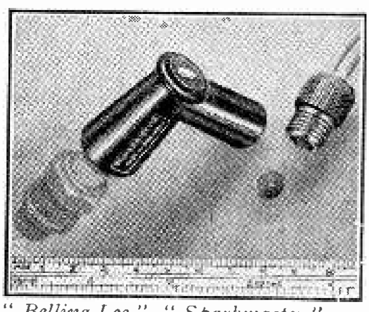
This month we have three good cases for discussion.

(1) Statements that ignition suppressors are harmful to cars.
(2) Multi-array television aerials are no good.
(3) No necessity to protect centre insulators of a dipole.

Let us take these one at a time.

(1) Within the last few months the editor of a widely read paper writes that the fitting of ignition suppressors is detrimental to the starting of motor cars.

Without going into details as to what car or cars, or of what vintage, we can only say that we cannot find evidence to support this. During the past year or so, two important papers on the subject have been read to learned societies—April 1952 to The British Institution of Radio Engineers, "Current Radio Interference Problems," by E. M. Lee, B.Sc., and February 1953 to a joint meeting of The Institution of Mechanical Engineers and The Institution of Electrical Engineers, "Ignition Interference with Television Reception," by A. H. Ball,



"Belling-Lee" "Sparkmaster" Sparking Plug Suppressor L.762.

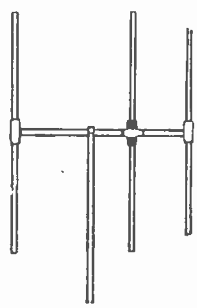
A.M.I.E.E. and W. Nethercott, B.A., B.Sc.

The authors of those papers, and the discussion that followed, made it clear that in general there was no detrimental result. Mr. A. H. Ball is a Research Engineer with Messrs. Joseph Lucas Ltd., and would not recommend anything that would reflect badly on their electrical equipment. Mr. Nethercott is head of the department dealing with electrical equipment at the Electrical Research Association.

Nor would the A.A. and R.A.C. give this thing their blessing if their members were going to be in trouble through following their recommendations.

This Company has sold many thousands of pounds worth of these suppressors and will not be able to help itself from selling them probably in millions. We appreciate that there may be a little trouble with a very small percentage of decrepit cars, but in general, for one to decry ignition interference suppression is equivalent to Canute trying to keep back the tide.

(2) We read that a multi-array television aerial has no advantage over an "H." Let us say here and now, that very often better results would be obtained by raising an



"Belling-Lee" "Junior Multirod."

"H" on a really high mast, but generally it is easier to erect a 3 or 4-element array. Now, leaving out the claims of various manufacturers, the text books on the subject tell those interested just what can be expected, i.e. a practically constructed "H" has a gain of over 5 db over a dipole, and a 3-element array over 8 db. One correspondent stated that all the gain in a multi-array was lost in matching. In fact the insertion loss of a matching transformer in any soundly designed aerial is of the order of 0.1 db.

(3) Elsewhere we read that there is no necessity to protect the centre insulator of a dipole. The very first television aerials manufactured for sale in this country were made by "Belling-Lee." The centre of the dipole then was open to the elements. We well remember holding a wet sponge over the centre termination without noticeable results; a snowball was also frozen on, and still all was well. Many thousands were sold like that before the war. Many stood up all through the war and some may still be in service. In certain sheltered locations however, where there are heavy deposits of soot, a semi-conductive film tends to "short" the terminals. Sometimes heavy rain will wash away the deposit. We agree that clean water is not harmful, but a leaky centre insulator may be, if it allows an accumulation of semi-conductive sludge.

Horizontal Polarisation.

Readers of this page would surely be horrified to see a friend of theirs with an aerial looking like figure 1. In the first place, we do not believe in knocking the chimney about, property owners may rightly object. Secondly, when we can

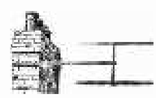


Fig. 1.

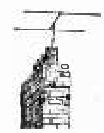
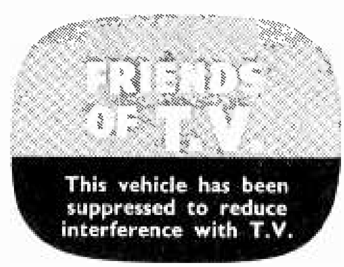


Fig. 2.

drop the pole clear away down at right angles from the crossarm, let us do it. Fig. 2 shows an ideal arrangement.

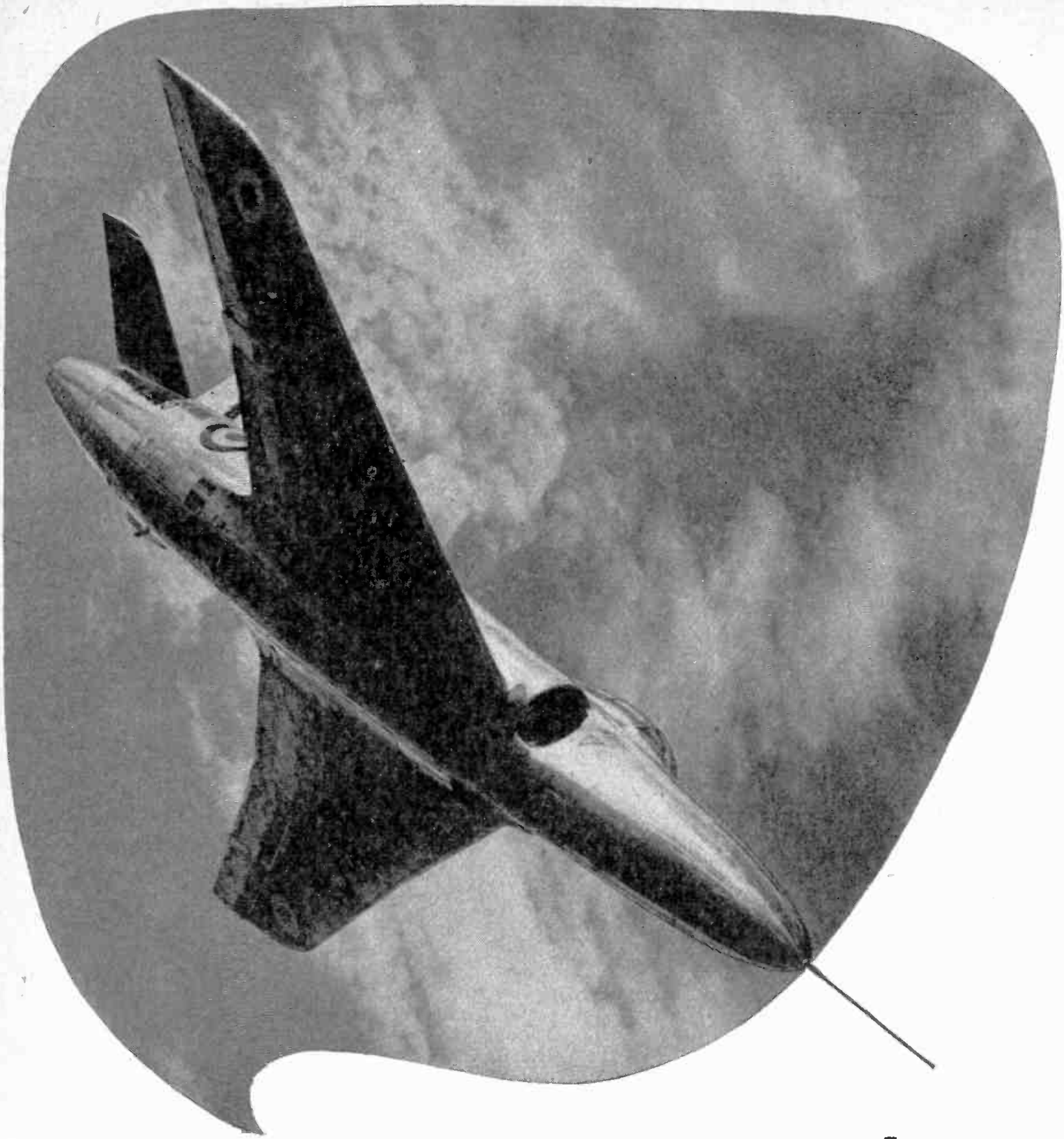
Are You ?



This attractive little windscreen transfer, shown here full size, light blue above and black below, is given free with every "Sparkmaster." The resistor that reduces plug burning; eases starting from cold; reduces pinking and suppresses interference with television.

Written 28th March 1953

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



there are times when . . . .

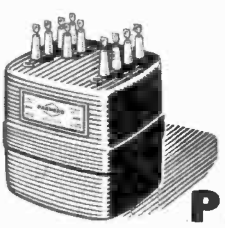
. . . an airman feels on top of the world. The carpet of cloud makes him feel like a god of myth, high-stepping with power at his finger's control.

He may climb with effortless ease ; he may dive like a dolphin at play ; and he may pause to review the qualities of those who placed him on high.

Aerodynamicists, designers, craftsmen, and crew—confidence in these gives the pilot confidence in himself, in his instruments.

Serving those instruments in their turn are Parmeko transformers, earning—by their steady, infinite reliability—the trust of those who plan.

Parmeko are proud of their part in the chain of confidence that keeps them flying.



PARMEKO *of* LEICESTER

Makers of Transformers for the Electronic and Electrical Industries.

MODERNIZING THE

Wireless World Television Receiver

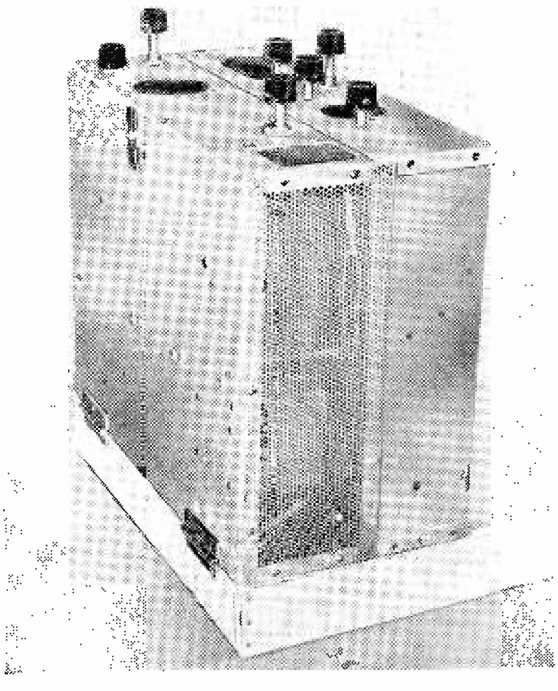
Part 1—General

IT is now some years since the *Wireless World* Television Receiver was described. Since then there has been considerable technical development and a definite change in the requirements of viewers. Larger and brighter pictures are now demanded. The 9-in tube operating at 5 kV no longer meets the needs of most people; a 12-in tube at 8–10 kV is nearer the mark.

The general tendency of development is towards still larger pictures using 14–16-in tubes working at up to 14 kV. In order to keep the cabinet dimensions reasonably small the deflection angles of the latest c.r tubes have been increased since this permits the use of a larger screen without a corresponding increase in the cabinet depth. These two factors, the increase of operating voltage and the increase of deflection angle, have enormously increased the volt-amperes needed for deflection. As a result a great deal of the technical development of recent years has been concentrated on the time-bases and it is probably only here that major advances have been made.

It is interesting to review critically the performance of the *Wireless World* Television Receiver and judge it by to-day's standards, rather than those of 1947 when it was described. Its only major defect of performance is in giving a somewhat smaller and less bright picture than fashion now dictates. In the receiver proper, by which is meant the circuits from aerial to tube which handle the picture signal, the performance can hardly be improved even to-day.

Two alternative receiver units were described; one, a straight set for double-sideband reception of London only, the other, a superheterodyne for vestigial-sideband reception of any British television station. The straight set falls below a modern standard of performance in only one particular; its sound-channel rejection is rather low. The superheterodyne is free from this and on performance will stand comparison with more recent designs. The only thing that could be brought against it is the fact that its intermediate frequency is rather close to one of the amateur bands, but this seems to be more a theoretical criticism than a practical one for very few cases of interference have been encountered.



The time-base units closed in their normal position.

The scope for improvement in this superheterodyne is thus rather limited and a new design would aim at obtaining the same performance in a simpler way rather than at improving the performance itself. The main fault of this superheterodyne is, in fact, its rather complex mechanical form. The aim in any redesign would be to simplify the construction and to make the unit smaller by taking advantage of the smaller valves and components now available.

On the time-base side, the greatest fault of the original design was a tendency to poor linearity in the frame scan. This was later put right by a simple corrector circuit. The greatest difficulty experienced by constructors, however, was undoubtedly with the line time-base. The factor of safety in the design was very small and variations in components and valves made it difficult to scan the full picture width in all cases. It made it difficult because it necessitated extremely critical adjustment of inter-dependent controls.

In all other respects the design proved an exceedingly good one. Synchronizing held over long periods without adjustment and even interlacing proved remarkably rigid. The fly-back e.h.t. system using a voltage-doubler with metal rectifiers turned out to be completely free from trouble.

Basically, therefore, one would not wish to make any major change in the design save to fit a larger tube operating at a higher anode voltage and to make the line time-base less critical of adjustment. However, this does actually entail a complete redesign of both line and frame time-bases and of the deflector coils!

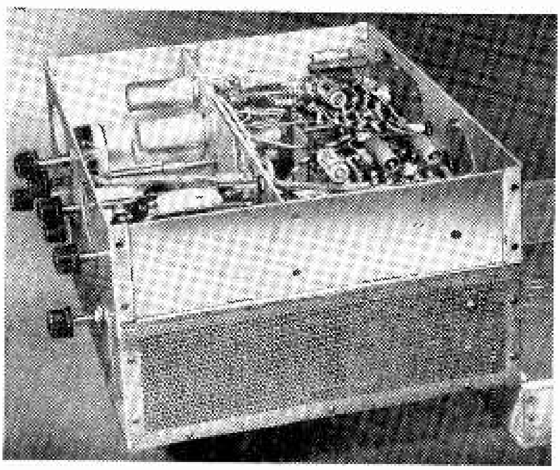
Before going into this in detail it may be remarked that the redesign, which it is the purpose of these articles to describe, has been carried out for a c.r. tube of medium deflection angle of around 53°. *It is not* *suitable for tubes of 70° angle.* Such tubes need nearly twice the deflection power.

It may be asked here why the redesign was not carried out for a wide-angle tube and the answer is that at the time it was started there were no such tubes. When they appeared it was felt to be better to carry on with the existing type than to stop and start again with the new one, for this would have entailed considerable delay.

Deflector Coils

In considering a redesign of the original receiver the line time-base was obviously the place to start for, its output being bare for a tube at 5 kV, it would obviously be inadequate for any higher operating voltage—and a higher voltage is needed for a bigger tube. When it was decided, some time ago now, to redesign the time-bases it was evident that the first essential was to improve the efficiency of the deflector coils themselves. An investigation was therefore carried out into the factors which affect this efficiency.[1] The quality of a deflector coil was expressed as the product of the inductance in millihenrys and the square of the peak-to-peak saw-tooth deflection current in amperes, the standard of deflection being 7.5 inches on a Mullard MW22-7 tube operating at 5 kV. The original deflector coils gave a figure of 2.9 mH-A^2 for the line.

It proved possible to obtain a figure of only about one-third of this which means that it is possible to obtain the same deflection for one-third of the input power at the same e.h.t. voltage or for the same input power at three times the voltage. There is much more to a deflector coil than sheer efficiency, however: it must produce a rectangular raster and introduce negligible deflection defocusing. In addition, it must be possible to make it without undue difficulty and using only materials that are obtainable. Taking all these factors into account it turned out that an efficiency of about double the original design was all that could reasonably be obtained.



Here the units are shown hinged down for access to the frame time-base.

[1] "Deflector Coil Characteristics," by W. T. Cocking, M.I.E.E., *Wireless World*, March, April and May 1950, pp. 95, 147 and 176.

[2] "Deflector Coil Construction," by W. T. Cocking, M.I.E.E., *Wireless World*, December 1952, p. 480.

Full constructional details of coils to this design have been published[2] and at first sight it would appear that no alteration would be needed to the time-bases, for with the greater efficiency of the coils the line time-base has sufficient output for scanning at 8-9 kV with something in hand. However, there is more to it than this. Under these conditions the e.h.t. obtainable with a voltage-doubler would be a little under 5 kV and something like a 5-stage multiplier would be needed to obtain 8-9 kV. It is doubtful if the regulation of this would be good enough.

Apart from this, it was considered very desirable to simplify the adjustment of the time-base and to remove the 10-kc/s whistle produced by magnetostriction in the core of the line-scan transformer. This transformer normally runs very hot so that the obvious remedy for the whistle—to enclose the transformer in a box packed tightly with sponge rubber—is impracticable. It was decided, therefore, completely to redesign the time-base.

The new form of deflector-coil construction led also to a need for redesigning the frame time-base. Originally, a high-inductance frame deflector coil was used, but in the new design this required such fine wire that it seemed unlikely that the coil would survive the bending process. It was felt, therefore, that it would be necessary to use a low-inductance coil. This meant a transformer for feeding it and this in turn meant a much more elaborate linearity-correcting system and so entailed a redesign of the frame time-base as a whole.

It is not always realized how interdependent the two time-bases are. It is surprising how some apparently minor change reacts to demand compensating alteration elsewhere.

Time-Bases

Space does not permit an account of all the work put into developing new time-bases. It is sufficient to say that the main difficulties with the conventional forms were all centred around the line-scan transformer. This component is a critical one, especially in the modern high-efficiency forms of circuit. It must have very low electrical losses, very high insulation, very low self-capacitance, etc., and the core material should not be magnetostrictive. Leakage inductance, too, must be kept very low if ringing is not to occur and produce vertical bars on the picture.

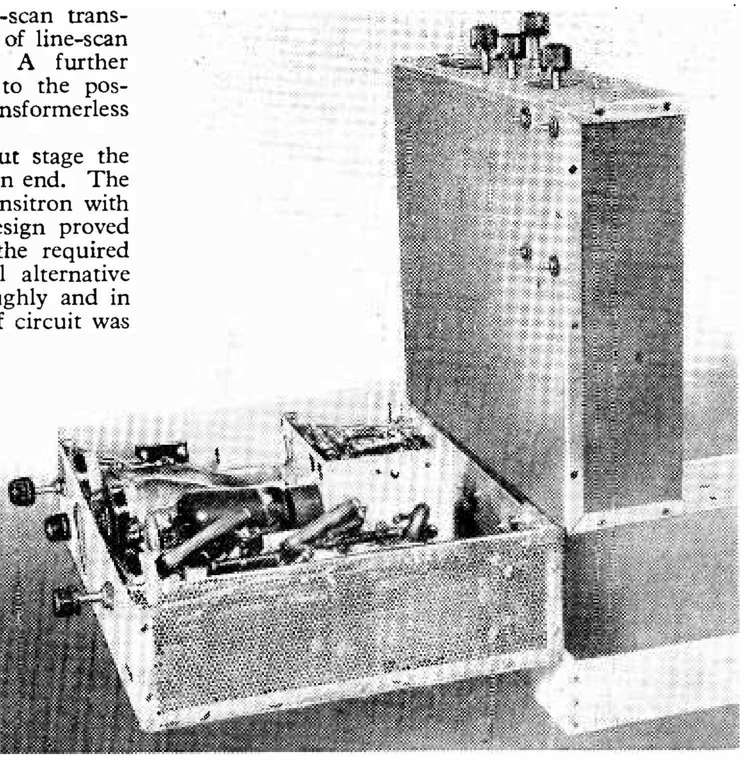
In addition to this, when the redesign was started suitable components and materials looked as if they might be rather hard to obtain because of rearmament. Actually, the position is much better than expected and as things have turned out it would have been possible to have used materials that have not been used. Because of the expected difficulties, however, the decision was made to use only parts and materials which would probably be readily obtainable wherever it was possible to do so. In addition, it was decided to describe the construction of all special components.

This last decision virtually ruled out a line-scan transformer of an efficient type, for it seems hardly practicable to make such a transformer without using wave-wound coils and these need machine winding. There were also doubts about the availability of suitable core materials.

After a good deal of experimental work it was decided to take the bull by the horns and remove all these difficulties by eliminating the line-scan transformer altogether. This led to a review of line-scan circuits[3] and also of e.h.t. systems.[4] A further development[5] which then occurred led to the possibility of obtaining h.t. boost in a transformerless circuit.[6]

Having thus obtained a suitable output stage the designer's troubles were by no means at an end. The output stage must be driven and the transitron with intermediate amplifier of the original design proved to have too slow a fly-back to enable the required e.h.t. voltage to be developed. Several alternative arrangements had to be tried out thoroughly and in the end a two-valve multivibrator type of circuit was chosen. It was chosen in preference to a single-valve transitron (not the Miller integrator transitron) mainly because it synchronized better. It was chosen in preference to the blocking oscillator because it is free from two defects of the latter. These are the need for a transformer, which may "sing," and the large voltage pulse fed back into the sync circuits, which is liable to upset interlacing.

As developed the new time-bases comprise a two-valve multivibrator with a single pentode output valve for the line scan and a blocking oscillator and pentode output valve for the frame. For mechanical convenience the sync separator (two valves) is included with the time-bases. Somewhat newer valve types have been chosen and, except in the output stages, all valves are of the same type, EF91. It would have been possible to reduce the number by using one or more double triodes, but the saving in cost would not be large. It is outweighed by the convenience of there being fewer valve types which need be kept by as spares. In particular, it is desirable to avoid having only one valve of a given type in a set, for when there are several alike it is possible to change a valve suspected of being faulty with another. Of course, in the case of output valves it is often too uneconomical to do this.



In this photograph the line time-base is exposed.

Purpose of the Units

The time-base units will be fully described in further articles. In the meantime it may be as well to make their purpose quite clear. They have been designed primarily to enable the owner of the original *Wireless World* Television Receiver to modify it for a 12-in or 15-in tube and obtain with it a picture of a brightness which meets present-day standards. The frame and line time-base units need rebuilding for this and many of the existing valves and components are suitable, but not necessarily all of them. A new deflector-coil assembly is required. This was described in the December 1952 issue[2] and the type of assembly required is the one having 30-mH line coils and 10-mH frame coils.

The redesign is *not* for a wide-angle tube but for types such as the G.E.C. 6705A and the Mullard MW31-16. These tubes actually represent quite diverse types, for the G.E.C. has a triode gun, whereas the Mullard has a tetrode gun and an ion trap. In spite of this the changes needed in the circuit to accommodate them are quite small and will be made clear.

The new time-bases require a few minor alterations in other parts of the equipment, mainly to the power unit and the focus-coil circuit, for the h.t. voltage needed is now lower and the focus current required is higher. These alterations will also be described in these articles.

So much for the position of those who already have a *Wireless World* Television Receiver. Something must also be said about those who do not. The superheterodyne type of receiver is still regarded as a satisfactory one and a reprint of the articles describing it is still available.[7] This reprint includes coil winding data for the London and Birmingham channels only. Details of the coils for the other channels were given in a later article,[8] and the relevant part of this is being made available. When the present series of articles is completed it will constitute, together with the article on deflector-coil construction (December 1952), the reprint "Superheterodyne Receiver Construction" and "Superheterodyne R.F. Coil Data," the full description of a complete television receiver having an up-to-date performance.

(To be continued)

[3] "Efficiency Line-Scan Circuits," by W. T. Cocking, M.I.E.E., *Wireless World*, August, September and October 1951, pp. 302, 347 and 425.
[4] "Ringing-Choke E.H.T. Systems," by W. T. Cocking, M.I.E.E., *Wireless World*, November and December 1951, pp. 444 and 513.
[5] "Reactive Time Bases," by A. B. Starks-Field, B.Sc., *J. Brit. Inst. Radio Engns.*, 1951 Convention Paper.
[6] "Simple Line-Scan Circuit," by W. T. Cocking, M.I.E.E., *Wireless World*, August 1952, p. 305.
[7] "Superheterodyne Television Unit" (London and Birmingham Areas). Iliffe.
[8] "Further Notes on the *Wireless World* Television Receiver," *Wireless World*, July 1951, p. 286.

Remote Display of Radar Pictures

Design Requirements and Performance of a Centrimetric Radio Link

By R. F. HANSFORD* and G. J. DIXON*

IN the past many radar stations have had to be operated from bad sites because the choice of site has been governed by the need to have the displays at a particular place. Conversely, when radar performance has been of paramount importance, it has often been necessary to set up the radar station, together with operating staff, at a place many miles distant from the place where the information was needed. In the one case radar performance has suffered, in the other there is often the difficulty of conducting the operation from the wrong place or of reporting all information by a lengthy telephone procedure; in both cases the result has necessarily been a lowering of operational efficiency.

There has for a long time been a requirement for a means of transmitting the information from the radar site to a remote position, where it may again be displayed on a radar indicator without loss of detail or performance. The development of the Decca Radar Link Type 2 has recently been completed in order to meet this requirement.

In addition to allowing greater freedom of siting radar installations, an effective radar link has a number of other valuable applications. It can be of great operational advantage to relay the information from a chain of air warning and fighter direction radars back to a central control room, where all the radar displays can be co-ordinated. Similarly, the central display of information from a chain of coastal defence radars has great advantages. In civil applications, the relay of pictures from ground controlled approach radars and air traffic control radars directly into the airfield control tower, where the picture is wanted, will greatly aid the efficiency of airfield control procedure; and the harbourmaster of a modern port may now have in his own building the p.p.i. display of the radar information from a chain of radars sited along a difficult estuary.

The need for a radar link has been appreciated for some time past but the delay in the provision of suitable equipment has, to a large extent, been caused by the difficult nature of the problem. The remote display of radar information demands the transmission of video signals, synchronizing pulses and data on the angular position of the scanning antenna. It is obviously desirable that these should be transmitted over a common carrier, and means have to be devised for a suitable form of modulation which will permit reliable separation at the receiving end.

* Decca Radar Limited

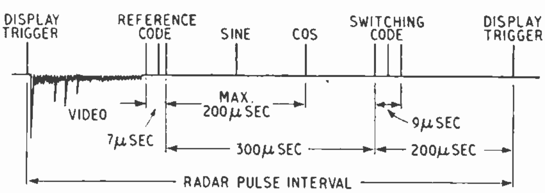
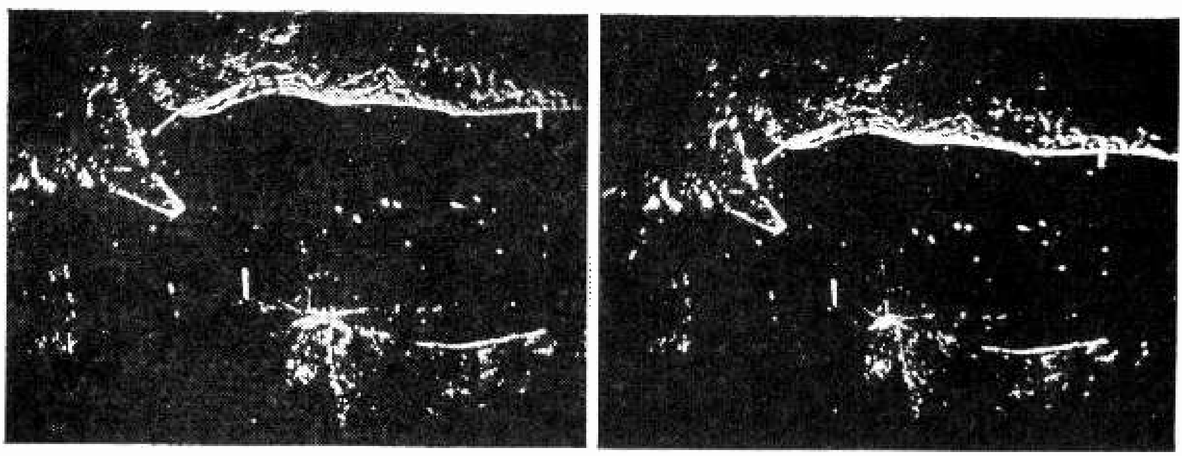


Fig. 1. Modulation waveform carrying p.p.i. video signals, bearing information and synchronizing pulses.



Photographs of p.p.i. display (left) at the harbour radar installation at Southampton Water and (right) at the end of a 5-mile link giving a simultaneous display at Warsash.

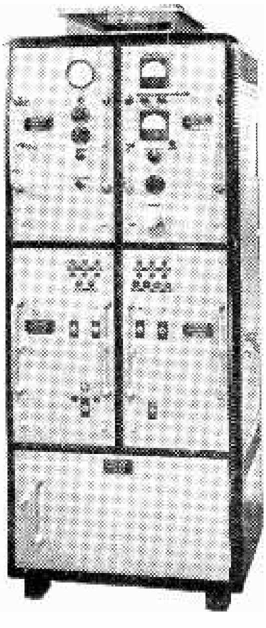
A modern radar installation is capable of very high order accuracy and an effective radar link must do nothing to lower the accuracy of information.

In examining the problems of synchronizing pulse separation and accuracy of the displayed picture the considerable complication introduced by fading along the transmission channel has to be very carefully considered. Over a long transmission path both rapid and slow fading to a considerable depth may be experienced under certain atmospheric conditions; if part of the transmission path is over water a further change in signal strength will be encountered with the rise and fall of the tide. Provision of a reliable service demands that under extremes of these conditions synchronism should be maintained, and that accuracy shall remain unimpaired. The accuracy requirements are particularly stringent in the case of the angle information.

In the past, attempts have been made to avoid the difficult problem of transmitting the angle information by driving the radar scanner with a synchronous motor, locked to the mains supply, and by driving the p.p.i. rotation also from a synchronous motor. Such a system is unsatisfactory if the radar scanner fails to rotate completely evenly as, for example, if it is buffeting into a high wind, or if any roughness has developed in the mechanical turning gear. A variant of this method which avoids the use of mains synchronism is to transmit a control frequency over the radar link (this may for simplicity be the radar repetition rate), to count this frequency down to a usable value at both the transmitting and receiving ends, and to drive the scanner and display deflection coils from it. Although a more elegant method, it suffers from the same disadvantage as the system mentioned earlier.

The direct transmission of angle information has been attempted by deriving from the aerial rotation two voltages proportional to the sine and cosine of the scanner angle, and transmitting these two voltages over the radar link. If this is done by amplitude modulation of the carrier it will be clear that any fading along the transmission channel will introduce serious errors. The use of automatic gain control could minimize the effect, but could not be relied upon to hold the received signal steady enough to ensure the required angle accuracy, which in the case of a p.p.i. display should be better than one in 360. An alternative method would be to transmit these voltages by frequency modulation of the carrier or sub-carrier, but difficulties are likely to be experienced in being able to develop for the receiving end a discriminator circuit which could be relied upon to maintain the necessary linearity. A further method which avoids fading errors is to transmit the information by a system of pulse time modulation which has the advantage of making use of time base circuits from which the required high degree of linearity may readily be achieved. It was thus decided to employ this method and exhaustive tests with the completed radar link have shown it to be reliable and capable of a high order of accuracy.

The equipment consists normally of a link transmitter, which is situated at the radar site, and a link receiver at the display position. When the information must be transmitted over a greater range than can be covered with a single transmitter and receiver, or



Link transmitter cabinet.

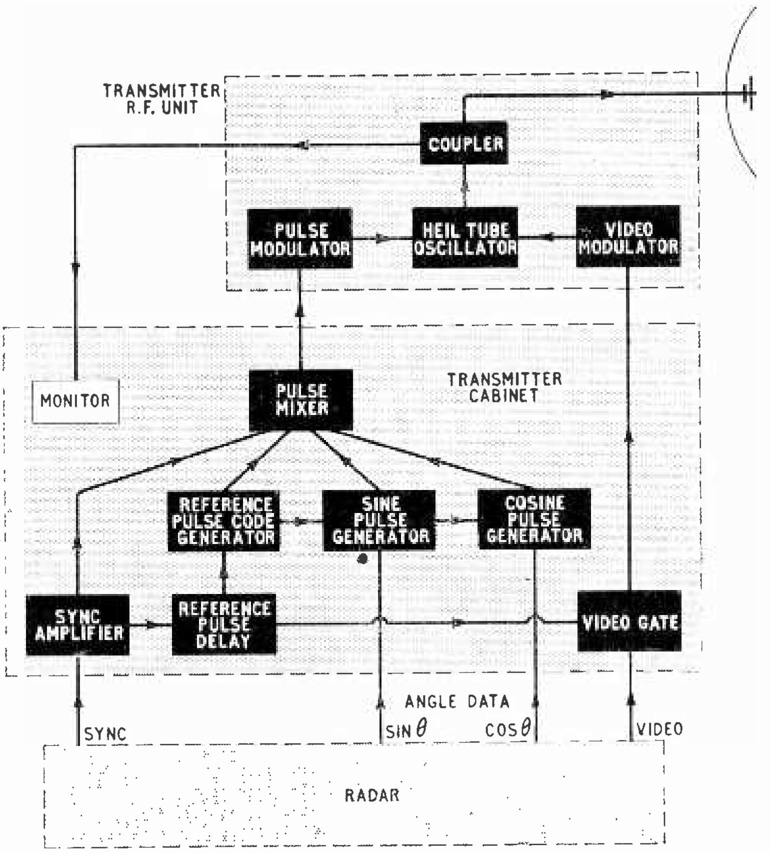


Fig. 2. Block schematic diagram of link transmitter.

when intervening hills or large buildings render a clear transmission impossible, then one or more link repeaters can be added.

The transmission takes place on a wavelength of approximately 9 centimetres (approximately 3,300 Mc/s) and employs a transmitter power of 0.5 watt.

The carrier is amplitude modulated to a depth of 80 per cent and negative modulation is employed for the video signals; pulse time modulation is used for conveying the synchronizing pulses and the bearing information, these pulses being transmitted by positive modulation of the carrier, in order that they may readily be separated from the video signals (see Fig. 1). The fact that the bearing information is transmitted by a varying time of occurrence of two pulses ensures that the accuracy of the received bearing information is completely independent of any fading which may occur along the transmission channel.

The link transmitter consists of two parts, a transmitter cabinet containing the control and modulation units, and a transmitter aerial with the r.f. unit carried in a watertight box at the rear.

The transmitter cabinet unit accepts from the radar the synchronizing, video and bearing signals; the manner in which these are converted into the requisite form of modulation for the carrier may best be understood by the block schematic diagram of Fig. 2. The synchronizing pulse is fed into the synchronizing amplifier, where it is sharpened and fed both into the pulse mixer and to the reference pulse delay unit.

The reference pulse delay provides a delay which is equal to or a little greater than the required operating time of the video information, and is used both to operate the video gate, which closes down at the end of the video period, and also to trigger the reference pulse code generator. The latter produces three pulses with characteristic spacing which are fed into the pulse mixer and which are used as the reference pulses for the angle data pulses. The reference pulse code is fed to the sine pulse generator which is also fed with a voltage from the radar proportional to the sine of the angle of scanner rotation; this unit produces a pulse at a time t_1 after the reference pulse proportional to sine θ, where θ is the angle of scanner rotation. The sine pulse is fed both into the pulse mixer and into the cosine pulse generator. The cosine pulse generator produces a pulse at a time t_2 after the sine pulse such that t_2 is proportional to cosine θ.

If necessary, an additional characteristically coded set of pulses may also be fed into the pulse mixer (by a unit which has been omitted from the block schematic for the sake of simplicity) which may be used to operate any desired switching sequence; for example, turning on a heading marker once per aerial rotation.

The combined pulses from the pulse mixer are fed up to the link transmitter r.f. unit. The video pulses from the radar are passed into the video gate where, as previously mentioned, they are permitted to pass during the required video period and are shut off for the interval during which the various synchronizing and angle pulses are being formed. The output from the video gate is also passed up separately to the transmitter r.f. unit.

The transmitter cabinet also contains monitoring meters, a wavemeter and a monitor oscilloscope with which the waveforms at various points in the modulation process can be checked. All chassis may be withdrawn on runners for ready maintenance, and are all of the modern vertical chassis type to ensure maximum cooling.

The transmitter r.f. unit is housed in a watertight box mounted on the back of the aerial and contains thermostatically controlled heaters, both to keep the unit dry and to ensure an even operating temperature to assist frequency stability. The transmitter valve is a velocity-modulated valve of the Heil tube variety, and has an unmodulated output power of approximately 0.5 watt. It is positively modulated by the pulse modulator and negatively modulated by the video modulator. The valve may be remotely tuned by means of a magslip motor driven from a complementary magslip in the transmitter cabinet. Coupling

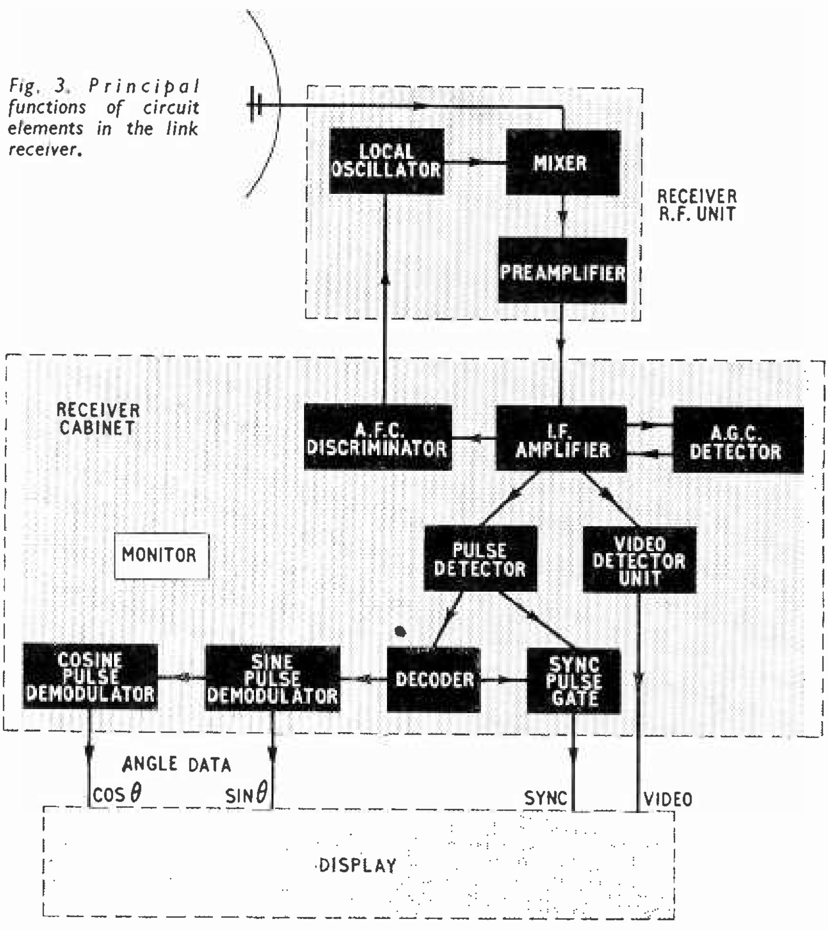


Fig. 3. Principal functions of circuit elements in the link receiver.

units are included so that test signals are sent back to the transmitter cabinet, in order that measurements may be made of transmitter frequency, power and modulation.

The aerial itself consists of a paraboloid, 4ft 6in in diameter, with a dipole feed. The beam width is approximately 5 degrees and horizontal polarization is normally employed. The position of the dipole may readily be adjusted over small limits as an aid to the final alignment of the beam.

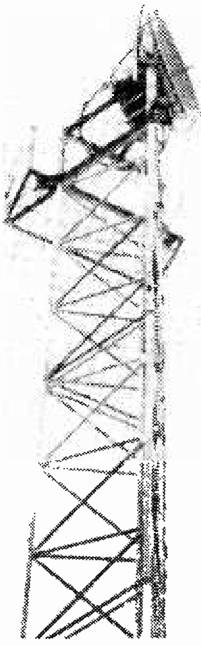
An exactly similar aerial system is used at the receiver end and the early stages of the receiver are contained in a watertight box on the back of it; the remainder of the receiver and the demodulation units are contained in the receiver cabinet. The receiver block schematic diagram is shown in Fig. 3.

The receiver is a superheterodyne with a reflex klystron as a local oscillator; this, with a crystal mixer and the first stages of the i.f. amplifier, are mounted on the back of the aerial. The local oscillator may be tuned initially by means of a magslip system; a.f.c. is then applied from a discriminator circuit to ensure that, once aligned, the receiver will remain accurately in tune with the transmitted signal.

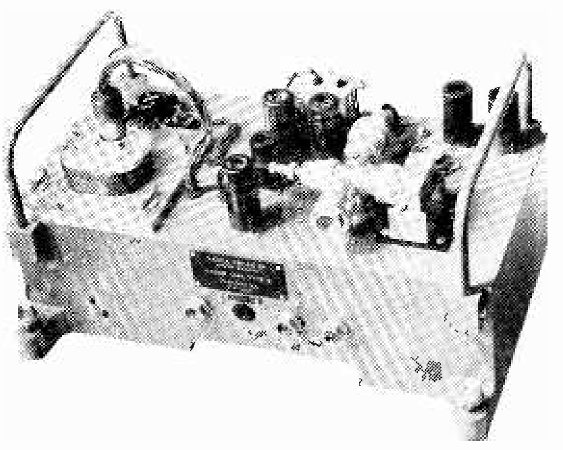
The receiver cabinet contains the main amplifier and modulation circuits, the a.f.c. discriminator and a.g.c. circuits. The signal from the pre-amplifier is fed down into the i.f. amplifier which has an a.f.c. discriminator circuit (referred to above) and three separate detector units. The video detector unit is arranged (by virtue of a biased amplifier stage) to respond only to negative modulation. It therefore provides the video information and ignores the synchronizing and angle pulses; the output from this unit is distributed directly to the remote display. The a.g.c. detector is responsive to the d.c. level of the carrier and is thus a suitable signal to feed back into the i.f. amplifier for gain control. The pulse detector unit responds to positive modulation of the carrier, and thus provides the synchronizing and angle information and ignores the video.

The output of the pulse detector is fed into the decoder which, by means of coincidence circuits, identifies the reference code pulses. The reference code pulses are fed to the sync pulse gate, where they are used after an appropriate delay to open the gate shortly before the expected arrival of the sync pulse; thus the display synchronizing pulse alone is passed through. The reference code pulses and the angle pulses are also fed into the sine pulse demodulator which produces a voltage proportional to the time between the reference code pulses and the sine pulse; this voltage is thus proportional to the original sine θ voltage fed in at the transmitting end and can be fed out to the display to control the time base circuits. The sine pulse and cosine pulse are also fed into the cosine pulse demodulator, which develops a voltage proportional to the time difference between them and is thus proportional to the original cosine θ voltage fed into transmitter; this is also fed off to the display to control the time base circuits. An additional decoder unit (not shown in the block schematic) is also available for detecting the presence of the switching code pulses and its output may be used to operate any switching circuit in the display.

The rack includes a signal distribution unit suitable for feeding up to three displays and providing outputs of synchronizing, video and bearing information. As with the transmitter cabinet, full test facilities are included, both meters and an oscilloscope



Paraboloid aerial and waterproof r.f. unit mounted on an 80-ft mast.



Transmitter r.f. unit removed from its watertight housing.

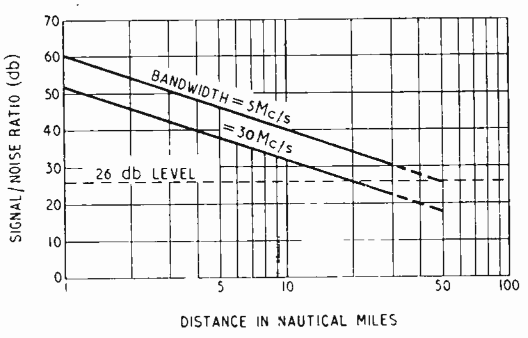


Fig. 4. Variation of signal/noise ratio with distance between transmitter and receiver in the radar link.

being provided. Vertical chassis construction is again employed and all chassis are mounted on runners.

The above equipments will provide reliable transmission of the radar data over a distance which may be up to 20 or 30 nautical miles, providing suitable terrain clearance for the transmission path can be obtained. At these distances it is usual to maintain a signal-to-noise ratio of 26 db. The signal-to-noise ratio will also be dependent upon the bandwidth employed. The performance in this respect, at various distances, is shown in Fig. 4 for two different link bandwidths.

When it is desired to transmit the information over greater distances, use may be made of the radar link repeater which has been developed. This may also be required in some cases for shorter distances when a clear transmission path cannot be obtained. The link repeater consists of two parabolic aerial units, one fitted with a receiver r.f. unit and the other with a transmitter r.f. unit. A single cabinet couples the two aerial units. The transmission takes place on a frequency different from that of the received signal. Although similar to the terminal equipment in external appearance, it is somewhat simpler since the pulse time modulation and demodulation circuits, used in the terminal equipment, are not required.

Further repeater stations may be used if required to extend the distance over which the link is required to operate; each separate transmission path may be up to approximately twenty nautical miles, under normal circumstances.

It is often required to use the link with radars of widely differing characteristics; consequently the radar link equipment has been designed to achieve a high degree of flexibility. Wherever practicable sub-unit construction has been adopted in order that the characteristics of the link may be changed as required by the use of alternative sub-units. The link has been used with radars of pulse lengths ranging from 1 to 0.06 microsecond. To achieve maximum signal-to-noise ratio with a 1-μsec pulse a bandwidth of 5 Mc/s was employed with a video response which was flat up to 2 Mc/s. Maintenance of high resolution with the 0.06-μsec pulse demanded the employment of an overall bandwith of 30 Mc/s, with a video response flat up to 14 Mc/s.

The version of the link described above is suitable for use with a p.p.i. type radar, which employs a fixed-coil type of deflection system with the scanner rotation being reproduced by controlling the amplitude of time base fed into the two pairs of coils. Some radars use a mechanically rotating deflection coil with the display, and in this case a slightly different version of the link is required. Here a mechanical rotation is accepted from the radar end and is converted into electrical signals by means of a magslip resolver. At the receiving end the two voltages are used to control a servo system which provides a rotating shaft output which can be used to drive any rotating coil equipment in the display.

Not all radars are of the p.p.i. type; for example, a ground controlled approach radar uses two displays, one a range-bearing display and the other a range-elevation display. The link can readily be arranged to deal with this type of equipment by using what was originally the sine pulse channel to convey the elevation angle data and what was originally the cosine pulse channel to convey the bearing angle data.

The link is now finding application in a variety of different radar fields, but it may be of interest to cite one example of the use of the link with a radar of extremely high discrimination. The pair of photographs on page 218 show (left) the p.p.i. picture obtained on a Decca harbour radar on the shores of Southampton water, and (right) the display derived via a radar link at Warsash about five miles away. This radar has a discrimination of 0.5 degree by 12 yards (a 0.06 microsecond pulse is employed), and it will be seen that the link reproduces the picture with negligible loss of quality.

The bearing accuracy has been carefully assessed and is better than one degree.

Manufacturers' Literature

Television Receivers; table model T.174 and console T.174C, both a.c./d.c. working with 17-in rectangular c.r. tube and edge-lit panel for pre-set controls. Illustrated leaflet from Sobell Industries, Langley Park, Slough, Bucks.

Capacitors for television receivers; paper and electrolytic types for smoothing h.t. and e.h.t. supplies; stacked mica and ceramic types for r.f. and i.f. decoupling and by-passing. Technical bulletin No. 28 from The Telegraph Condenser Company, North Acton, London, W.3.

Tape Unit, Motek model K3, with push-button controls and electrical braking system. Main features listed in a leaflet from Modern Techniques, 138, 142 and 144, Petherton Road, London, N.5.

Valve Wall Chart, 1952/53 edition, including data on germanium crystals, c.r. tubes and specialized glassware, with base diagrams, lists of equivalents and prices. From Mullard, Century House, Shaftesbury Avenue, London, W.C.2. Also a list giving the Mullard valve complements of television receivers, available to the trade either as a wall broadsheet or a booklet.

E.H.T. Concentric Connectors; demountable and moulded types with insulation adequate up to 10kV. An illustrated booklet with detailed drawings of all the parts involved, from The Plessey Company, Ilford, Essex.

Coaxial Cables; helical-membrane and solid-dielectric Telcon types described in an illustrated brochure containing electrical data, information on materials used and installation instructions. From the Telegraph Construction and Maintenance Co., Telcon Works, Greenwich, London, S.E.10.

Megohmmeter, essentially a stable d.c. valve voltmeter, capable of measuring up to 100 million MΩ, the meter giving a full deflection for an input voltage of 1V. Very full technical description in the Technical Review of Brüel and Kjær, Nærum, Denmark.

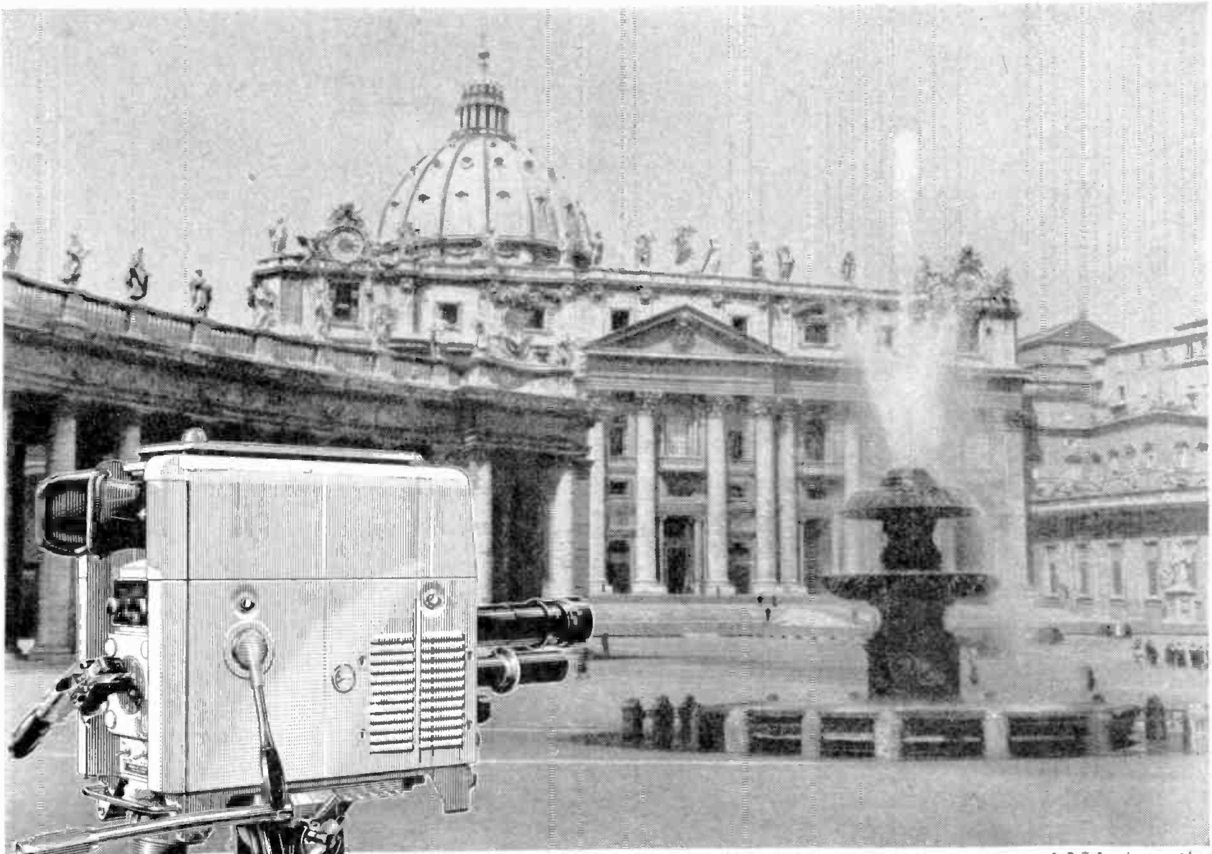
Photo Electric Cells and multipliers; monoscopes; cathode ray tubes for television, radar and oscilloscopes. Data sheets collected in a folder, also containing leaflets on other electronic apparatus made by Cinema-Television, Worsley Bridge Road, Lower Sydenham, London, S.E.26.

Special Adhesives; a quick-reference folder showing the best types for making joints between different materials, including metals, wood, glass and ceramics, plastics and rubber. From Aero Research, Duxford, Cambridge.

Repair Service for radio and electronic components; a leaflet giving details and listing the types of components handled, from W. Forrest, 349, Haslucks Green Road, Shirley, Birmingham.

Stabilized Power Supply with d.c. output adjustable in three ranges: 250-300 V at 0-200mA; 300-350 V at 0-200mA; 350-400 V at 0-150mA; and stabilization against changes in both mains input and load. Specification on a leaflet from The Edison Swan Electric Company, 155, Charing Cross Road, London, W.C.2.

Marconi Television for Italy



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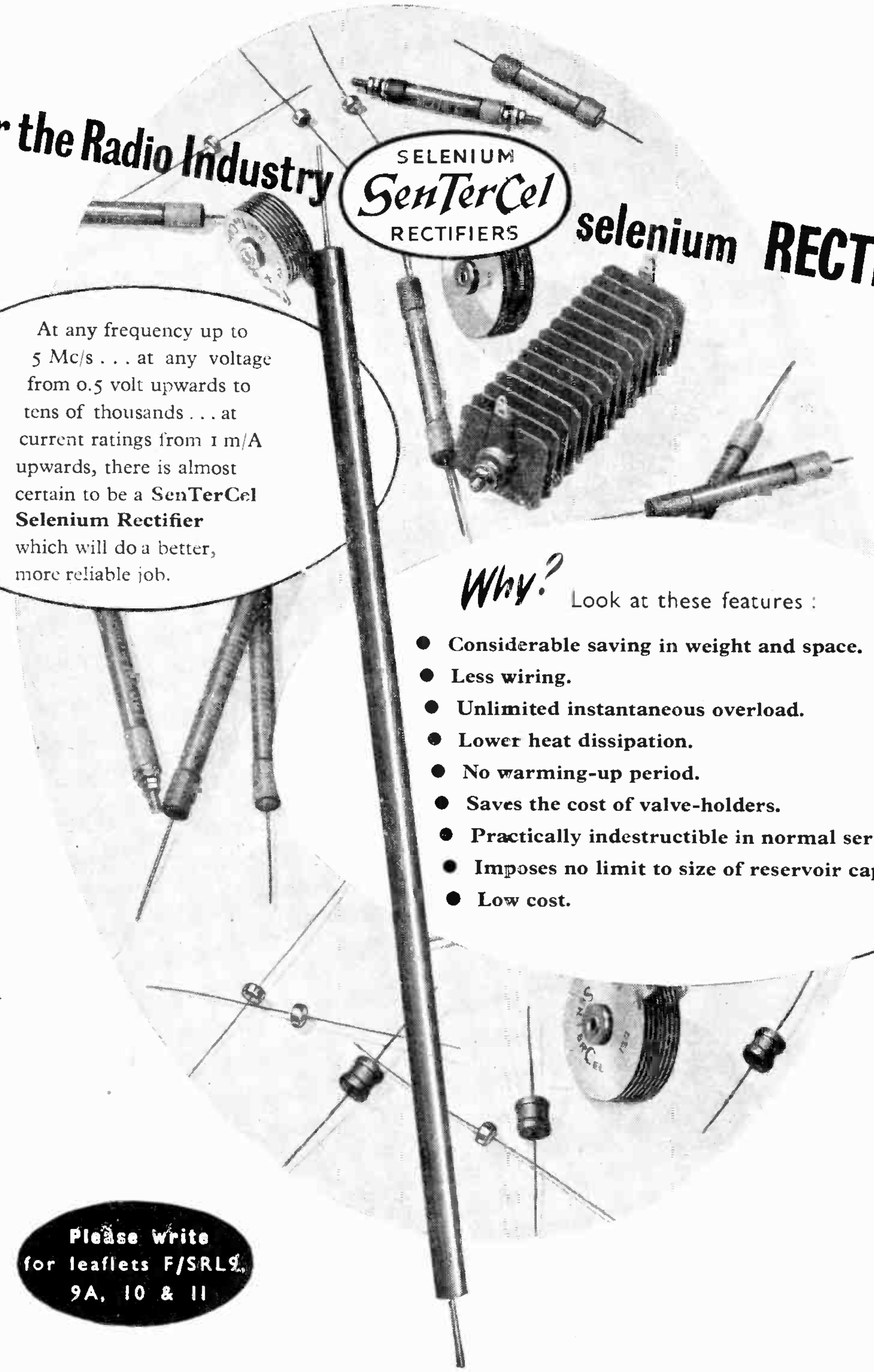

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For Sets Which Cannot be Tuned to Different Stations

RSHALL,* B.Sc., A.M.I.E.E.

new television receivers
days are capable of being
iere are large numbers of
ve this facility, particularly
r of England. It must be
tuneable receiver is quite a
and has only appeared since the
Sutton Coldfield transmitter. Before
receivers were designed for the Alexandra
smitter (Channel 1) and the possible need
ging to other channels was not anticipated.
quently, people who own non-tuneable sets are
an unfortunate position if they move to another part of the country and want to receive a new station. Likewise if they happen to be in a fringe area and a booster station working on a different frequency is installed for their benefit.

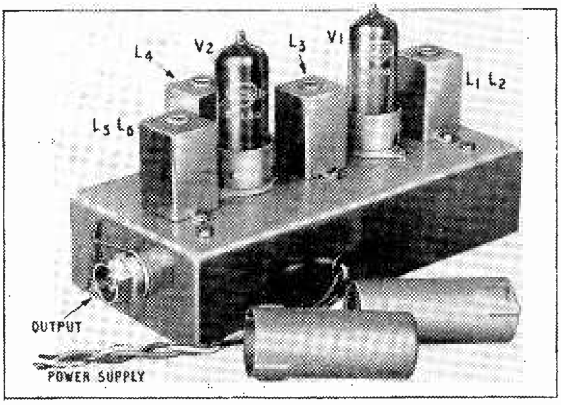
Probably the most convenient way out of the difficulty is to add a frequency converter to the set, and in this article the author puts forward a suitable design. At the moment, the viewers perhaps most in need of a converter are those in the Brighton district who would like to change from Channel 1 to their new booster station on Channel 3 in time for the Coronation. For this reason the circuit constants given are for this particular requirement, but later on the author hopes to give values for some of the other frequency conversions that may be needed.

In designing a television frequency converter there are quite a number of factors which have to be taken into consideration. For example, a great deal depends on which channel is being converted and which channel the receiver is tuned to. One must realize that the television receiver is acting as an i.f. amplifier which follows the frequency changer stage in the converter unit. As with all superheterodyne design the i.f. must be carefully considered if interference is to be avoided. If the television receiver itself is a superhet then we have in effect a double superheterodyne. This combination may give a set of interfering signals which can be predicted—but never cured! In a television system there is a further complication in that we are concerned with two transmissions—sound and vision. In any frequency changing process which occurs in a converter unit the relative position of these carriers in the spectrum must not be disturbed; the sound carrier must always be at a lower frequency than that of the vision carrier.

In most frequency changers one is free to make the oscillator frequency either higher or lower than the incoming signal frequency, but this is not so with the television converter. Only the low oscillator frequency can be used if the two signal frequencies, vision and sound, are to be kept in their correct positions. For example, take the present case of converting from Channel 3 to Channel 1, that is, vision from 56.75 Mc/s to 45 Mc/s and sound from 53.25 Mc/s to 41.5 Mc/s. Working on the vision frequencies, if the oscillator frequency were made high it would have to be 101.75 Mc/s, so that the difference frequency (101.75 − 56.75) would come to 45 Mc/s. But with this oscillator frequency the 53.25-Mc/s sound transmission would be converted, not to the required 41.5 Mc/s, but to 101.75 − 53.25 = 48.5 Mc/s. If, on the other hand, the oscillator frequency is made low, it becomes 11.75 Mc/s, and this converts the sound frequency from 53.25 Mc/s to the required 41.5 Mc/s. The same situation occurs if one wishes to convert from a lower-frequency channel to a higher one; only the "oscillator low" condition will keep the vision and sound frequencies in their correct relative positions.

With the converter oscillator at a lower frequency than that of the incoming channel there is the inevitable danger of oscillator harmonics falling in that channel. They may even fall in the original receiver channel, which means that a considerable amount of filtering will be required between the converter and the receiver. Second-channel or image interference may also occur if there is insufficient rejection in the pre-mixer stages.

The problem is therefore identical with that encountered in any superheterodyne design except that the i.f. is fixed and no choice is possible for the oscillator frequency. These represent severe design limitations and each conversion from one channel to



Top view of the chassis showing the disposition of the valves and coils.

* Mullard Research Laboratory.

another must be considered separately. It is, however, fortunate that the conversion from Channel 3 to Channel 1 can be done without the need of any special filter circuits. The oscillator frequency is 56.75 − 45.0 = 11.75 Mc/s. This has harmonics at 23.5, 35.25, 47.0 and 58.75 Mc/s—all of which are outside the two channels under consideration. (Here it should be explained that 47 Mc/s *is* outside Channel 1 if a lower-sideband receiver is used. The system cannot be made to convert a lower-sideband transmission to an upper-sideband transmission suitable for an upper-sideband receiver. Hence the older type of upper-sideband receiver cannot be converted in this way. As the output at 47 Mc/s is only small the converter should also be suitable for receivers of the double-sideband type.) The second channel band is from 29.75 to 33.25 Mc/s which is relatively free from high power transmissions.

There is, of course, the possibility that the 11.75 Mc/s oscillator frequency may interfere directly with the i.f. stages of the receiver, as some of the older sets have i.fs which are in this region. The only solution for this will be to insert an 11.75-Mc/s filter between the converter and the receiver, and the author hopes to give details of a suitable circuit later on.

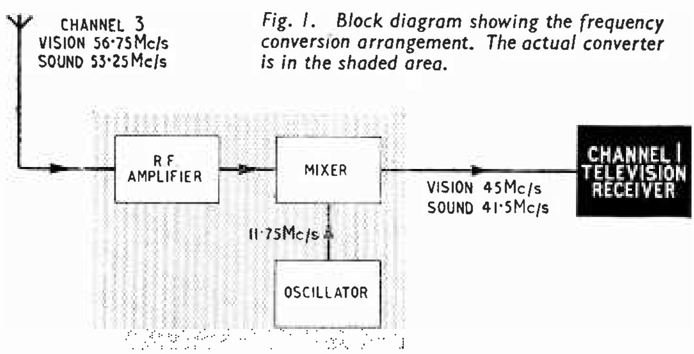


Fig. 1. Block diagram showing the frequency conversion arrangement. The actual converter is in the shaded area.

Coming now to the ac system is shown in the bloc Fig. 2 is the complete circuit input from the coaxial 80-Ω c transformer L_1L_2 to the grid amplifier. Further r.f. selectivi tuned circuit associated with L_3 passed to the grid of the mixer va valve is used in an oscillator oscillator output (at 11.75 Mc/s) i C_9. With this circuit a conversion approximately 0.9mA/V can be achie adequate for the purpose. With the va optimum oscillator voltage is injected w current in R_5 is 2.2μA. The value of C_8 have a relatively high reactance at osc quency to prevent the r.f. coil L_3 shu oscillator signal. The i.f. output from the m is taken via the tuned transformer L_5L_6 to t input of the Channel 1 receiver.

Winding data for the coils is given in Fig. the coils are close wound with 32-s.w.g. enam copper wire on Aladdin 0.3in diameter formers. numbers in circles refer to the pin numbers stamp on the base of these formers. The coils should b soldered to the vertical spills inserted through the numbered holes. The winding direction is the same in all cases, i.e., looking from the base of the coil former the windings go in an anti-clockwise direction towards the top of the coil former. (If the pin numbers and the number of turns are correct, then the winding direction will be automatically correct.) The dust iron cores should be waxed in position after the unit has been trimmed. It is also a good plan to place a small piece of thin string down each former before the core is inserted so that the core is not a loose fit in it.

The prototype model was constructed

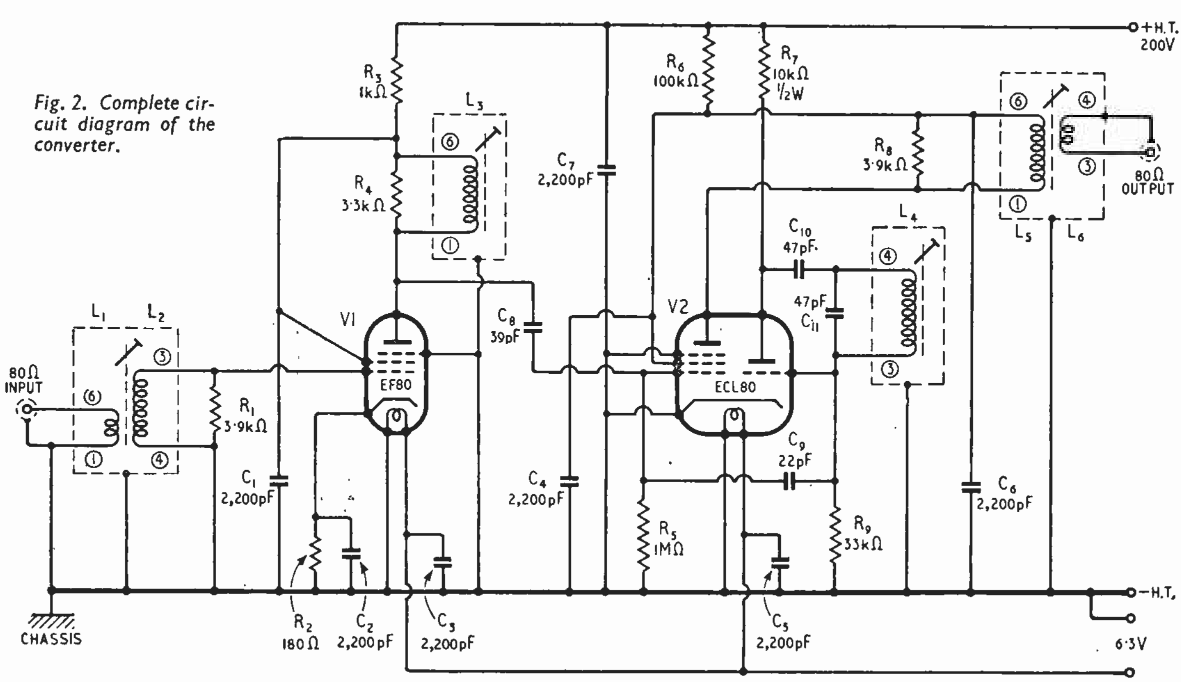
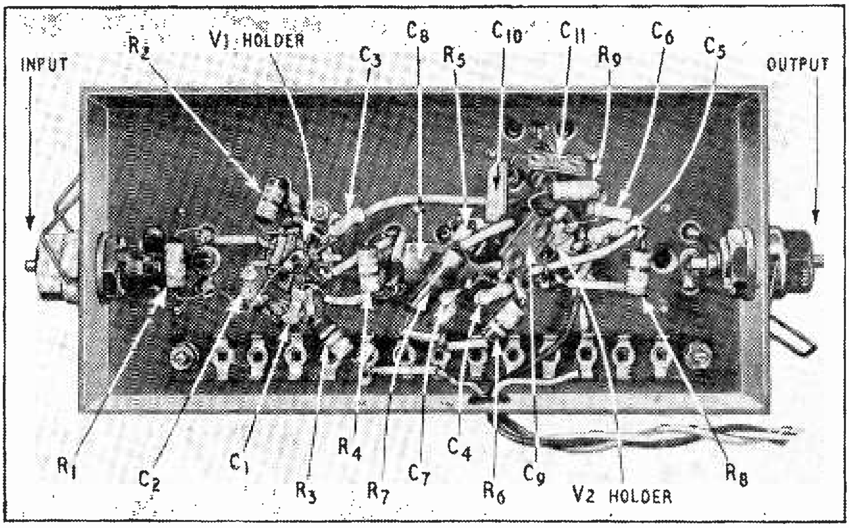


Fig. 2. Complete circuit diagram of the converter.

on an aluminium chassis measuring approximately 7in × 3in × $1\frac{1}{2}$in. The valve-holder for V_1 is mounted with the line between its fixing holes at an angle of 60 deg to the major axis of the chassis. V_2 is mounted in line with the major axis of the chassis. Normal r.f. wiring precautions should be adopted, e.g., all leads should be short and direct and the earthed electrodes on the valveholders should be connected by individual leads to the chassis. The use of low self-inductance decoupling capacitors for C_1-C_7 is of extreme importance.



Underside view of the chassis. Leads should be as short and direct as possible.

The h.t. voltage should be 200V and the total h.t. current 22mA. On V_1 the anode and screen voltage should be 183V and the cathode voltage 2.4V. On V_2, the triode section should have an anode voltage of 140V and anode current of 6mA, while the oscillator grid current measured at the bottom of R_9 should be 160μA. The anode and screen voltage of the pentode section should be 30V and the grid current at the bottom of R_5 should measure 2.2μA. The conversion gain of the circuit is 18db. Relative to the 56.75-Mc/s vision transmission, the rejection of 45 Mc/s is 17db, while the second channel rejection of 33.25 Mc/s is 35db.

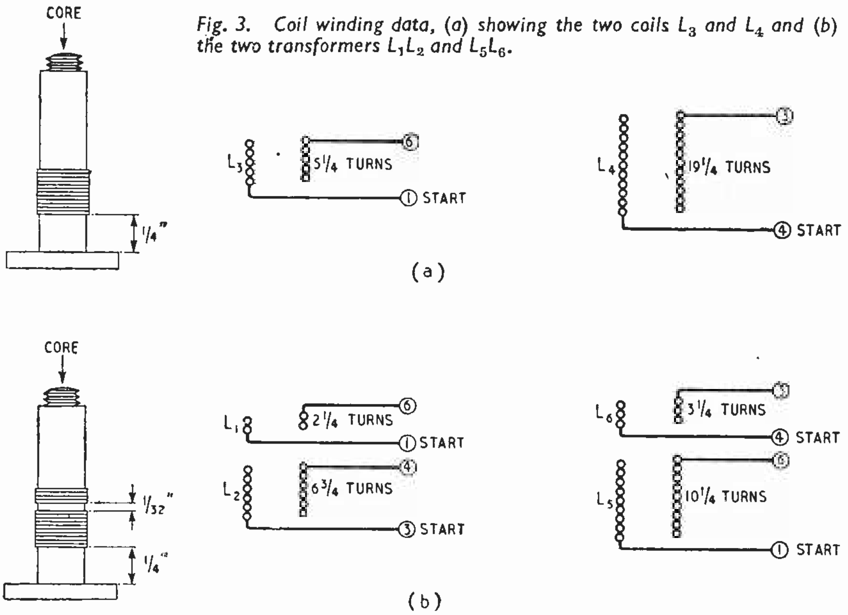


Fig. 3. Coil winding data, (a) showing the two coils L_3 and L_4 and (b) the two transformers L_1L_2 and L_5L_6.

Now for the trimming procedure. The unit should be allowed to warm up for about ten minutes before trimming is started. A correctly tuned Channel 1 television receiver should be connected to the output of the converter and an 80-Ω generator to the input. Any convenient method of noting the output from the sound and vision sections of the receiver can be adopted. To begin with, adjust all cores so that they are just about to enter the coil windings from the top. Then, with an input of 44 Mc/s, disconnect R_7 from the h.t. line and trim L_5L_6 for maximum vision output. With an input of 53.25 Mc/s, re-connect R_7 and trim L_4 for maximum sound output. Check that an output can also be obtained at the second channel sound frequency of 29.75 Mc/s. Next, with an input of 55 Mc/s, trim L_3 for maximum vision output; and then, with an input of 56 Mc/s, trim L_1L_2 for maximum vision output. Finally, on a B.B.C. Channel 3 transmission a final adjustment for maximum sound output can be made on the oscillator coil L_7.

As already stated the converter has an effective conversion gain of 18db, so the effective sensitivity of the receiver will be increased by this amount. Many simple one-valve converter units actually introduce a loss during the channel changing process, which is detrimental to their value. This converter does not have this disadvantage and the addition of the r.f. valve improves the noise factor of the system. The additional gain means that a distribution attenuator system could follow the converter so that several receivers could be fed from it.

Fig 4 shows two response curves which have been measured. The first is that of a typical television receiver which was tuned to Channel 1. The second curve was measured with the converter in front of the receiver. No deterioration in performance was indicated by these measurements.

Viewers on the south coast who have been operating high-gain Channel 1 receivers may find that the converter will supply too great a signal when the Channel 3 transmitter comes into operation. In general, any extra attenuation that may be required should be introduced between the converter and the receiver and not before the converter. On the other hand, receivers which are very close to the transmitter may need an aerial attenuator if cross-modulation effects are to be avoided. The important thing to remember is that the receiver should not be operated at maximum gain with the converter output attenuated to suit the receiver. This is almost sure to result in a noisy picture. For a start the receiver should be operated at about half its normal gain and direct connection made between the converter and the receiver. If an "over-contrasty" picture is received then it will be in order for an attenuator to be introduced. Much will depend on the type of aerial, the site, and the distance from the transmitter, and only these general guiding principles can be given.

On the question of aerials the recommendations of the aerial manufacturer should be followed if the optimum results are to be expected. Television aerials *will* work on channels for which they are not designed but at much reduced efficiency. Many south coast areas have installed elaborate beam arrays and it is these aerials which unfortunately fall off rapidly in performance when they are not being used on the correct channel. The sound-to-vision ratio may also be altered. However, a Channel 1 aerial may prove satisfactory in many cases and it will certainly be worth a trial before a new aerial is erected. The aerial system may have to be reorientated for maximum signal pick-up.

The converter requires an h.t. supply of 200V at 22 mA and a 6.3-V heater supply at 0.6A (alternatively the valve heaters may be connected in series to a 12.6-V supply at 0.3A). Although the television receiver itself may be able to supply the above power, the author does not recommend that this technique be adopted. It would indeed be very dangerous to take the power from an a.c./d.c. receiver of the type which is now almost universally used in this country. It is therefore strongly advised that a separate power supply be made up for this converter; a suitable design is shown in Fig. 5. All the r.f. decoupling that is required is contained within the converter unit so the length of the leads between the converter and the power supply is not critical.

The author would like to thank Maitland Radio, of Edinburgh, for assistance given in testing the converter on the Kirk o' Shotts transmission.

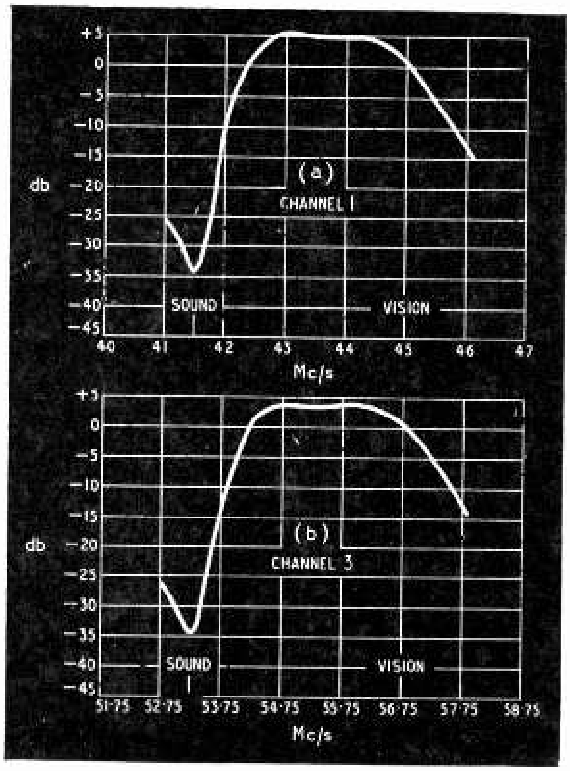


Fig. 4. Response curves of (a) a typical Channel I receiver and (b) the receiver and converter.

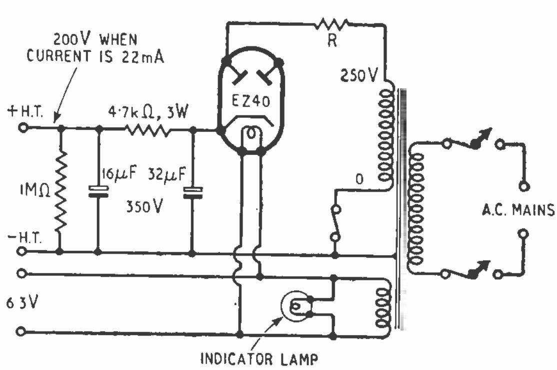


Fig. 5. Circuit of a suitable power supply. The value of R should be chosen so that with the resistance of the transformer secondary it comes to at least 80Ω.

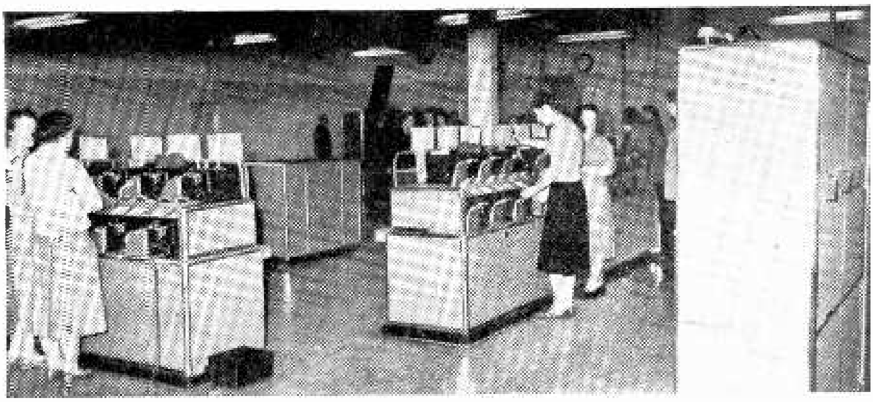
A.R.R.L. 1953 HANDBOOK

Standard Radio Textbook for Amateurs

THE Radio Amateur's Handbook produced by the headquarters' staff of the American Radio Relay League for radio amateurs has become the recognized standard textbook for everyone interested in radio as a hobby all over the world. It has been in continuous publication since 1926.

The 1953 edition is divided into 27 chapters covering, among other things, radio and electrical laws and circuits, thermiomic valve principles, high and extra-high frequency communication principles and practice, aerials of all kinds and descriptions of a wide variety of equipment for home construction. There is a comprehensive valve data section covering modern and not-so-modern transmitting and receiving valves and c.r. tubes. Particular attention is given to the suppression of transmitter harmonics and spurious radiation as American amateurs have their TVI and BCI problems as well as us and the suppression measures described are applicable to all amateur transmitters.

The handbook contains 548 pages of text with 1,200 illustrations, 95 charts and tables and 60 pages of valve data. Copies are obtainable from the Modern Book Co., 19-23, Praed Street, Paddington, London, W.2, at 31s, including postage, or from The Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.1.

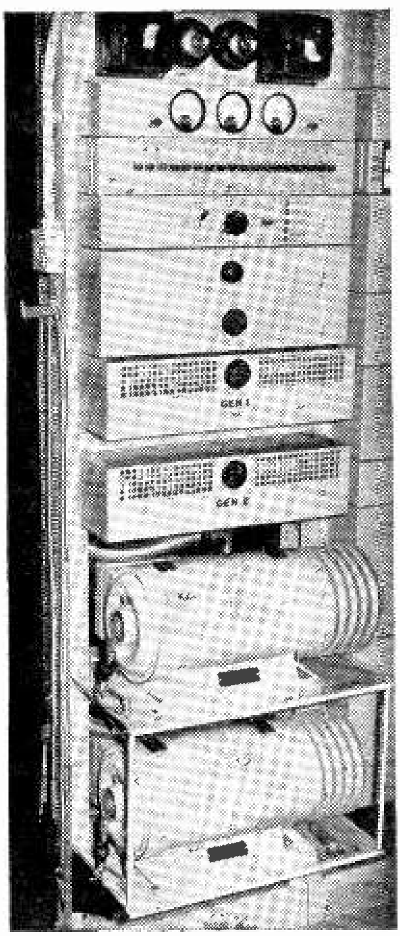


Part of the main equipment hall in the M.C.A. communications centre, at Croydon.

Below : One of the equipment racks in the G.P.O. control room showing two of the multi-frequency generators used to operate the teleprinter circuits.

Civil Aviation Communications Centre

Radio and Landline Clearing House for Aircraft Operational Messages



THE swift, accurate and economical handling of operational messages between airports, air traffic control centres and operating companies is an essential requirement of civil aviation and will increase in importance as fast jet airliners take over more of the regular air services. As flying speed increases messages announcing their departure and expected time of arrival at the destination or intermediate airports must be speeded up and the immediate aim of the Ministry of Civil Aviation is to ensure that such messages shall reach their destination within at least one-fifth of the flying time between departure and arrival.

In order to speed up the ground communications and so achieve this desired end a new communications centre has been opened at Croydon airport by the M.C.A. A network of teleprinter, radio-teletype and W/T circuits radiate from this centre to various parts of Europe, Scandinavia, South America, Canada and the U.S.A. It forms part of an extensive ground communications system set up between member states of the International Civil Aviation Organization and is the clearing house for operational messages originating or destined for the United Kingdom.

The new signals centre was planned with the following requirements in mind: (a) transmission time to be reduced wherever possible by employing automatic equipment; (b) manual transmission of messages restricted to the absolute minimum; (c) limit the number of retransmissions; and (d) mechanize the handling of messages wherever possible.

When land lines are available messages are sent by automatic teleprinters and W/T circuits are operated wherever possible by radio-teletype equipment. Some circuits still have to use hand-operated W/T owing to lack of suitable equipment at the distant end.

At the time of our visit W/T was used on circuits to Africa, Asia, some Mediterranean areas, India, Spain and South America; duplex radio-teletype on circuits to Iceland, Newfoundland, U.S.A., India and Egypt and landline teleprinters for all internal communications and to France, Italy and Scandinavia.

Teleprinter receiving equipment which records the message in the form of perforations on a paper tape has been available for some time and this tape can be used for automatic retransmission, but it suffers from the drawback that scrutiny of a message to establish its destination and content requires operators trained to interpret the perforations. This means a large staff of highly skilled personnel.

A printed copy could be attached to the message, but handling is then inconvenient and there is the danger of the perforated tape becoming separated from its printed copy. A solution to this problem has been found in the use of partially perforated tape on which the message is printed in ordinary typescript so that the operators need not be trained in interpreting the perforations. The layout of the equipment is such that the functions of individual operators are simplified as much as possible. All incoming circuits terminate on "printing-perforators" mounted three in a rack. The racks are grouped in rows to conserve space and to allow one operator to deal with several circuits during quiet periods. The receiving operators tear off the message tapes and dispose of them by pneumatic tubes to either a "circulator" in the case of messages with a single destination or to a "tape multiplication pool" if there are several destinations. This may well be the case if the message relates to a long-distance flight involving several intermediate stopping places, as these must be informed as well as the destination without appreciable loss in transit time.

In the case of a multi-addressed message the tape is fed into a machine which produces simultaneously six copies of the original and if more are required it is fed through again until the required number have been made. Messages are usually quite short so that multiplication takes but a minute or two and the tapes of a multi-addressed message are then fed into appropriate machines for retransmission to the various destinations.

With the new centre in operation further advancement towards speedy communications can only come by more mechanization. For example, at present the manually-operated W/T circuits are centred at Birdlip where the teleprinter slips have to be deciphered; this is done mechanically, of course, and the messages are then retransmitted by hand in morse.

The first step will be to transfer the hand-operating to Croydon, so saving some of the retransmission time at Birdlip. Later the hand-operated W/T will be replaced by teletype circuits, but this depends on the speed with which the necessary equipment can be installed at the distant terminals, a matter outside the control of the M.C.A.

Draughtsmen or "Delineators"?

CIRCUIT diagrams cannot be expected to tell their own stories if the men who draw them do not understand what they are supposed to convey. For this reason draughtsmen should have a sound basis of technical knowledge and preferably should be radio technicians who have changed over to this sort of work. It is a mistake to employ mechanical draughtsmen for the job because they are realists, concerned with the actual shape of things in the metal, whereas the good "circuit delineator" is essentially a kind of impressionist.

These views were expressed at a recent discussion meeting of the Brit. I.R.E. on "The Standardization of Symbols and the Arrangement of Electronic Circuit Diagrams." Some speakers, indeed, went so far as to suggest that radio draughtsmen were sometimes unnecessary, and described various systems of "prefabrication" by which circuits could be compiled by the technicians themselves. One of these was called "sticky symbols," the symbols being printed in quantity on sticky paper and cut out and stuck on squared paper. Another system used magnetized metal symbols which could be juggled about on a sheet of iron. When assembled the diagrams were reduced and copied photographically.

L. H. Bainbridge-Bell, who opened the discussion, stressed the importance of drawing circuit diagrams to bring out their function rather than drawing them just to look pretty. He also advocated the use of standard configurations for familiar things like multivibrators and oscillators so that they could be instantly recognized wherever they were. Several speakers put forward some rather unusual suggestions on this topic. One felt that valve stages should be drawn wherever possible as four-terminal networks. The two input terminals would go to grid and earth, while the two output ones would come from anode and earth, the anode load and h.t. supply being shunted in series across them. The h.t. line would actually run somewhere below the earth line, and while some speakers thought this a bad thing others felt that a strictly logical positioning of the d.c. power lines in a circuit gives them too much importance. On this topic, mention was made of the German idea of a "three-dimensional" circuit diagram, drawn in perspective, which achieved separation of power and signal lines by representing them in different planes.

Another unconventional idea, put forward by Mr. Bainbridge-Bell, was the use of curved and sloping lines. He felt that they were especially justified when the connections were important to the circuit, for they drew attention to themselves. There was no reason, in fact, why a curved or sloping line should not slash right across a lot of other circuitry if by this means the connection could be made more direct. In practice the line did not become confused with those it crossed. It was not really essential to have right-angled connections in circuits at all, but draughtsmen were addicted to them because their T-squares and set-squares made them so delightfully easy to draw. Another thing that sometimes led to confusion was equal spacing between lines that have to run parallel for any distance—the eye is never quite sure which one it is supposed to be following. The lines should be arranged in small groups according to their functions and relationships.

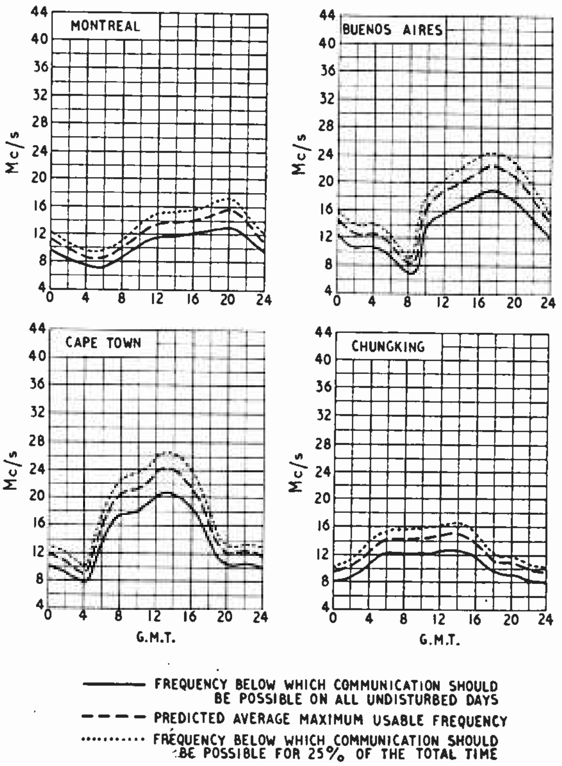
On the subject of annotating components, one speaker thought that components should be numbered according to their position in the chassis, not their position on the circuit diagram. This, he said, would be a great help to the servicing technician.

Short-wave Conditions

Predictions for May

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

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



Designing a Tape Recorder

3—The Complete Instrument : Construction and Adjustment

By
J. M. CARTER, B.Sc.*

THE circuit diagram of a complete instrument is shown in Fig. 7. All the wiring and switches shown in the upper section are contained in the "Wearite" Tape Deck which is connected to the amplifier shown in the lower section by means of octal plugs and sockets and the two screened leads which attach to the head matching transformer and equalizing network respectively.

It will be seen that a combined record/playback head is employed and switched either to T_1 on playback or to the anode lead from the output valve V4 on "Record." The head has four coils, two of which, in series, form the signal winding and two the bias winding. On "Playback" and "Record," both windings are in series, but in the latter connection the bias volts are connected across the bias winding by the main switch on the Tape Deck. It should be noted that, although not indicated in the diagram, the switch section which does this is of the "make before break" type and that the switch tag which connects on "Record" is strapped to the adjacent tag corresponding to the "Wind back" position. This, of course, is to ensure that the bias lead to the head is not broken before the oscillator volts have sunk to zero.

As previously mentioned, the earth connection to the head is kept separate from the Deck chassis and connected to a single-point common earth with the first stages in the amplifier. The three mains connections to the motors form part of an arrangement whereby use is made of the mains transformer primary taps to act as an auto-transformer and always maintain the capstan motor volts at between 240 and 250V irrespective of the supply voltage. Otherwise, the motor switching system is that previously described in Part 1.

Mention might here be made of the motor starting, stopping and brake release system employed. These functions are effected by means of the main operating bar which runs diagonally across the underside of the Deck, and the knob which protrudes through the small panel at the bottom left-hand corner. Pulling this bar towards the front of the panel operates the main motor switch, across which is the 0.1μF capacitor for noise suppression, and simultaneously pulls the brakes off the reel brake drums. The bar is held in the "on" position by the brake release solenoid, which is energized from the h.t. feed to the amplifier, and also acts as a second choke for this. To stop the tape running this solenoid is shorted by the "Press to Stop" switch, or by the contacts of the automatic stop switch, Sw4, located immediately to the left of the erase head. This allows the bar to return under its spring tension, switching off the motors, disengaging the pinch roller and applying the brakes to the reel drums.

A section of the main switch is provided to substitute automatically an equivalent load resistor (R_{27}) for the internal speaker in the "Record" position. This, of course, is primarily intended to prevent acoustic feedback taking place when using a microphone; if a radio or similar source is used the internal speaker may be reconnected to work at reduced volume by joining pins 2 and 4 with a 10-Ω resistor on the external feed socket. This also has smoothed-h.t. and l.t. connections for supplying a small tuner unit for radio recording. The circuit diagram shows a 2.5Ω internal speaker, and a jack for a 15Ω external speaker (which automatically disconnects the muting). If it is desired to use a 2.5Ω external speaker this should be connected between the live terminal of the external speaker jack and pin 4 on the external feed socket.

The amplifier circuit follows closely along the lines already described in Part 2, with the addition of bass and treble controls to the equalizing circuit, and provision for equalizing the response at $3\frac{3}{4}$ in/sec by means of the two-pole switch linked to the speed-change control on the deck. As the tone controls are in the equalizing section, on "Record" they are automatically disconnected by the jack plug, and therefor inoperative. The oscillator and peak level meter have a common h.t. supply which is switched on the Deck (tags 4 and G), and both operate only on "Record."

Layout

No specific drawings regarding the general layout of the amplifier are given, because it was thought that most people would have their own ideas as to which type of chassis, or various sub-chassis, would suit their own particular cabinet requirements. This being so, a few general recommendations on the disposition of the components may prove helpful. The most important point is to keep the record/playback head, and also the first two valve stages, away from the immediate vicinity of all iron-cored inductors carrying any appreciable a.c. This means, of course, especially the mains transformer and smoothing choke, and the output transformer also should be

* Wright and Weare, Ltd.

kept away from these prolific sources of hum.

Microphonic effects can be largely avoided by some form of rubber mounting for the first two valves, and the EF40, having low hum, noise and microphony, should be selected as first valve. As always, grid leads should be kept as short as possible and covered screened sleeving will be necessary for the long grid leads in the first stages. Unless the microphone jack is well screened in the chassis a separate screening for this may be necessary. The oscillator circuit should be kept as far removed as possible from the main amplifier section, as 51-kc/s pick-up, especially on the grid leads of the last valves, is prone to occur. Finally, the pre-set variable resistances and potentiometers R_5, R_{21}, R_{25}, R_{33} and the cores of L_2 and L_1 should be readily accessible for adjustment when the equipment is completely assembled.

For the complete testing and setting up of the equipment, the following instruments are necessary:

(1) Audio oscillator having a range of 40 c/s to 55 kc/s, with a pure waveform between 400 and 1,000 c/s.

(2) Valve voltmeter measuring from 0.5 to 50 volts.

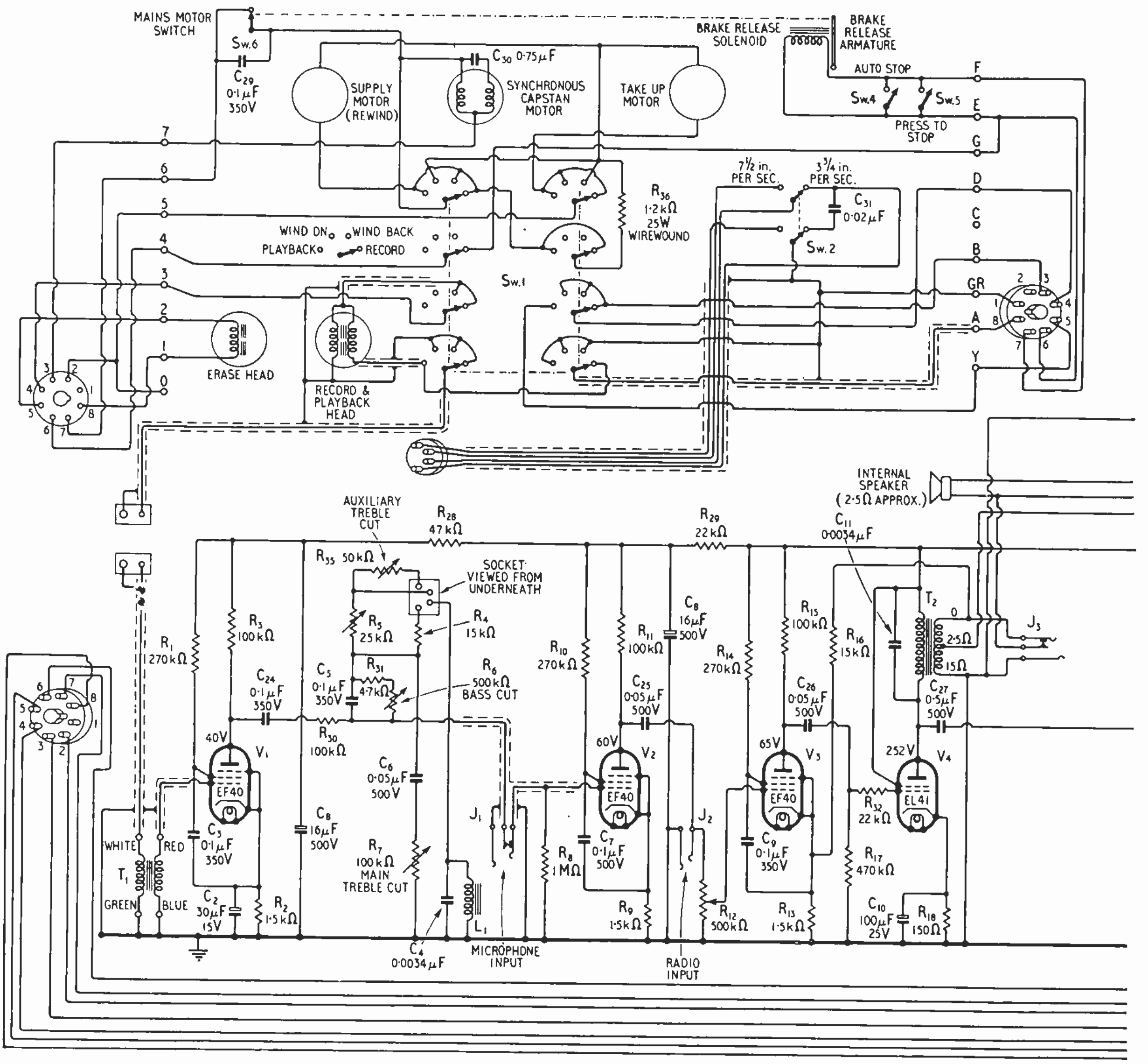
(3) Cathode ray oscilloscope.

(4) Universal voltage and current meter.

(5) Distortion meter.

For amateurs who do not possess, or even have access to the latter, a rough estimation of the distortion is possible using the cathode ray oscilloscope and audio oscillator.

Once it has been ascertained that the equipment appears to be working normally, e.g., the motors run when the starting knob is pulled on and the latter "holds in," indicating that the amplifier is drawing h.t. current through the solenoid, the amplifier gain should first be checked at 400 c/s and to do this the following dispositions made. Load the Deck with tape by dropping this through the slot in the head



cover, with the main knob set to "Wind on." Then switch to "Playback'; this will ensure that the automatic stop switch is held open and that the solenoid (which also acts as a choke) is not shorted out. Set the universal meter to measure a.c. volts and connect this, together with a cathode ray oscilloscope, to the anode of V4 (pins 3 and 7 on the external feed socket). A small calibrated voltage from the audio oscillator is now required for injection at the various points specified below. If an accurate attenuator is not available, fixed carbon resistors connected as a potential divider can be made to serve.

1. Overall gain (primary of T_1), 350,000—450,000.
2. Gain from microphone input (2nd stage jack), 6,000-8,000.
3. Gain from radio input (3rd stage jack), 210-240.

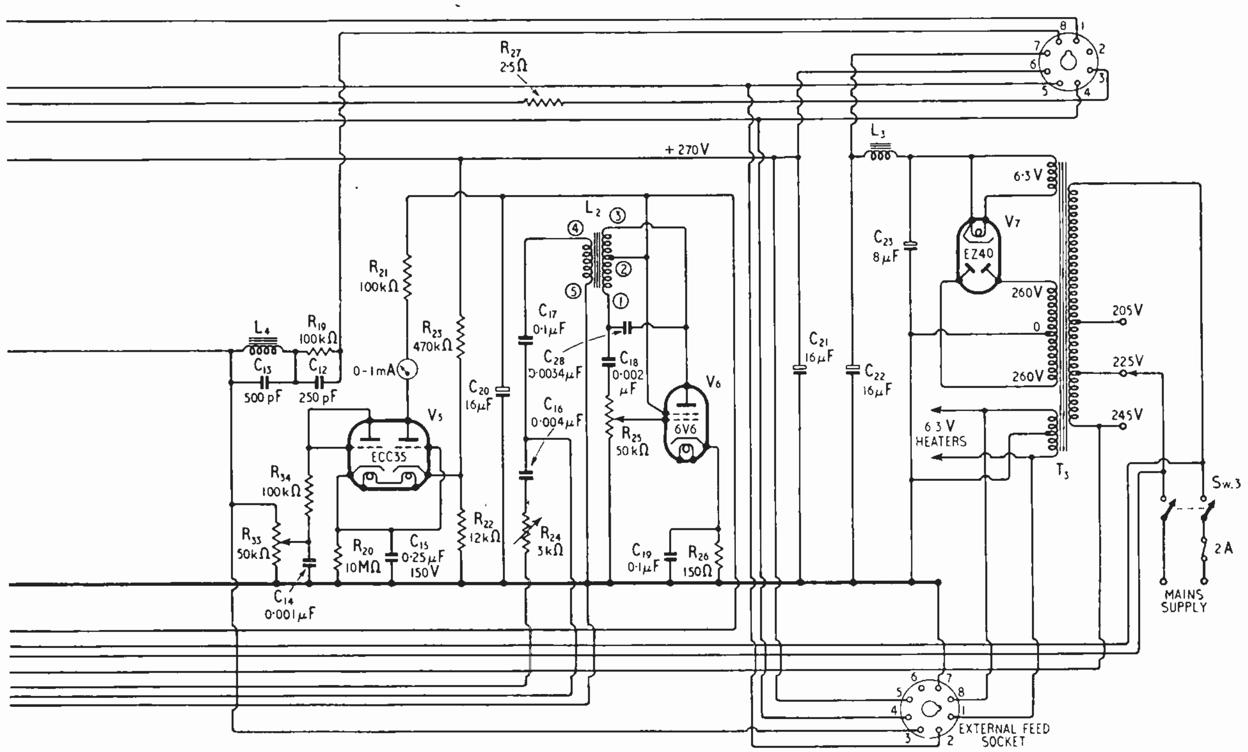
An a.c. anode voltage of 150 corresponds roughly to 3W output from an EL41, and the waveform, when viewed on an oscilloscope, should be good up to this figure. To avoid any errors in gain measurement, however, the a.c. voltage at the anode should be kept below 130. It is also convenient now, to make a rough check of the amplifier equalization at 7½ in/sec. With the audio oscillator set to 400 c/s and again connected to the primary of T_1, and with the bass and treble controls at maximum, adjust the volume control to give a reading of 25V on the universal meter, then proceed to check if the equalization corresponds to that shown by the figures given in Table 1. Assuming that the mains and head matching transformers are rotatable, as recommended in Part 2, the next step is to adjust these for minimum hum. Leaving the meter and oscilloscope connected as before, set the volume and bass controls to maximum and the treble control to minimum and proceed to find the best position for the transformers. If the best position with the motors running results in an increase in hum when they are stopped, this means that hum is being "bucked out," and whilst a small amount of this "bucking" is permissible a large amount is undesirable and indicative of poor layout.

The waveforms seen on the oscilloscope will prove a useful guide to what is happening, and a slight tilting of the Mumetal "wing" on the head pressure pad arm will sometimes prove of assistance. In the final analysis, hum should certainly not exceed 1.5 volts with the motors running. This, of course, is not the figure which will apply in estimating the signal/noise

TABLE I

FREQUENCY (c/s)	A.C. volts at ANODE	
	7.5in/sec	3.75in/sec
60	>75	>75
400	Set to 25	Set to 25
2,000	Set to 12 (R_5)	15–17
Top peaked frequency (10kc/s/12kc/s)	>52	>35

Fig. 7. Complete circuit diagram of Wearite Tape Deck and recommended associated electronic equipment. Unless otherwise stated, fixed resistors are of ½-watt rating. Resistors R_3, R_{11} should be of high-stability type, and R_6, R_7 and R_{12} should be of the log-law type. Capacitors C_4, C_{11}, C_{12} and C_{13} are silvered mica. Coils and transformers to the required specifications are available from Wright and Weaire as follows: L_1 (55mH), Type 727; L_2, Type 579; L_3 (10H), Type 1497; L_4, Type 666; T_1, Type 977; T_2, Type T1428; T_3, Type T1395D. Igranic Type P72 jacks are suitable for J_1, J_2 and J_3. SW_3 is a 250V, 5A toggle switch.



ratio, as with the fully-recorded tape the volume control will require to be set back to avoid overload distortion in the amplifier.

To check the oscillator, turn the volume control to zero and the main switch to "Record," and first set the oscillator frequency to 51 kc/s. This may be done by taking a lead from the grid of V6 to the "Y" plate of the oscilloscope and feeding the full output of the audio oscillator to the "X" plate, the time base being switched off. The frequency of the audio oscillator may then be varied until a stationary ellipse or, alternatively, a Lissajous figure, is seen, indicating that its frequency is the same as, or some known multiple of that of the oscillator in the equipment. Adjust the core of L_2 until the frequency is 51 kc/s. If now a valve voltmeter is also connected to the grid of V6, the grid drive may be adjusted by means of the potentiometer R_{25} to the maximum value possible, without incurring distortion in the figure seen on the oscilloscope. As a rough guide the grid drive will usually be between 10 and 13 volts, with the tap point of the potentiometer approximately 11 kΩ above earth.

The oscillator being now set, the filter coil L_4 should next be tuned. The adjustment is most easily observed at the anode of V4. If the valve voltmeter or the oscilloscope is connected to the h.t. isolated side of C_{27}, and the grid of V4 is earthed to prevent any stray 51 kc/s pick-up partially masking the effect, the core of L_4 may be tuned with an insulated screwdriver to give a minimum reading on the valve voltmeter. With the latter next transferred to terminal strip tags 3 and 1 (earth) on the Deck, the bias volts should now be set to 12 by adjusting R_{24}. This will have a final value of approximately 1,200Ω. Finally, check the erase voltage across the erase head pins; it should be between 28 and 36 volts.

To set the peak recording level to some pre-determined point on the meter, proceed as follows. Reconnect the oscilloscope and the universal meter (a.c. volts) to pins 3 and 7 on the external feed socket and connect the "X" plate of the former to the full output of the audio oscillator, an attenuated output from which should be fed to the microphone jack. Turn the main switch to record and adjust the volume control to give a reading of 12 volts at 400 c/s. Now adjust R_{33} until the recording level meter indicates peak level (a two-thirds deflection is a convenient point to choose for this), and record a short passage at 7½in/sec at this setting. Wind back and then play back with maximum bass and treble. The ellipse which will be seen on the oscilloscope should show about 5 per cent distortion and enough output at maximum volume should be obtained to overload the amplifier and cause "squaring off" of the ellipse at each end. If the ellipse does not show any appreciable distortion, the recording level should be progressively increased (each time re-setting R_{33} to indicate peak level on the meter) until the required result is obtained. On the other hand, if the ellipse has more than 5 per cent distortion at a 12V recording level it is possible that the bias is of the wrong value, and a test for optimum bias should be instituted as follows. Record a 200-c/s note at bias values of 13, 15 and 17 volts, and at a low level of approximately 4V. Playback with all controls fully clockwise (at maximum) and note the output voltage for each different bias recording. The bias setting which gives maximum output is the correct value, and the bias should be finally set to this. It may be found that if a large bias value is required the frequency response will fall away much more quickly at the high frequencies, and if this effect is very severe it may be necessary again to reduce the bias and effect a compromise solution. In most cases, however, a level of between 12 and 14 volts at the anode will be found correct.

The final adjustments may now be made and concern the frequency response. If the circuit diagram (Fig. 7) is examined it will be seen that on the 7.5 in/sec speed an additional variable resistance (R_{35}) is switched across the treble boost inductor L_1. The purpose of this is so to limit the treble response at the top peaked frequency that a flat response with the main tone controls at maximum is obtained, the main treble control acting only as a "cut." At 3.75 in/sec this resistor is switched out and any peak occurring in the response at the top end must be reduced by the main treble control. In addition, when testing the frequency response with pure tones of constant amplitude, the recording level should be kept low to avoid overloading the tape, due to the recording pre-emphasis at the higher audio frequencies. This effect, of course, is not present to the same extent when music and speech are recorded as then an audio "spectrum" is being dealt with, in which the energy content of notes at various frequencies is widely different.

To check the frequency response at 7.5 in/sec connect the valve voltmeter (5-volt range) across a 15-Ω external speaker or equivalent load, plugged into the appropriate jack in the instrument. At a level of roughly 6 volts, record a complete frequency sweep from 60 to 13,000 c/s, pausing at 60, 400, 2,000, 6,000, 9,000, 10,000, 11,000, 12,000 and 13,000 c/s for a few seconds. On playing back, with the volume control set at a convenient deflection on the valve voltmeter, adjust R_5 at 2,000 c/s and R_{35} at the top peaked frequency to give the same output as that obtained at 400 c/s. The response should be within ±3 db from 60 to 10,000 c/s. The same procedure can now be repeated at 3.75 in/sec and any necessary adjustments in value made to R_1 at 2,000 c/s. A response of ±3 db from 60 to 5,000 c/s should be obtained.

(Concluded)

CLUB NEWS

Birmingham.—May meetings of the Slade Radio Society include a lecture on receiver selectivity by G. Nicholson (G3HKC) at 7.45 on May 15th at the Church House, High Street, Erdington. The first of the season's direction-finding contests for the Harcourt Trophy will be held on May 17th. During the month visits will be paid to Elmdon Airport and the Research Department of the Dunlop Rubber Co. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

East Grinstead.—A series of lectures on fault finding are to be given at the weekly meetings of the East Grinstead and District Amateur Radio Club, which are held on Thursdays at 7.30 at Portland Hall, Portland Road, East Grinstead. The club also holds regular morse instruction classes. Sec.: L. E. Miller, 30, Forest View Road, East Grinstead, Sussex.

Manchester.—The title of the Amateur Radio Society of the Faculty of Technology of Manchester University has been modified in view of the wider interests now covered and is to be known as the Faculty of Technology Radio and Electronics Society. The present secretary is P. J. Green, Manchester University, Sackville Street, Manchester, 1.

B.A.T.C.—Five members of the British Amateur Television Club now hold television transmitting licences. A demonstration of a home-constructed 3-colour camera was given at the Ross-on-Wye Hobbies Exhibition on April 11th. Demonstrations are also planned for Dagenham, Manchester and Ely. Sec.: M. W. S. Barlow (G3CVO), Cheyne Cottage, Dukes Wood Drive, Gerrards Cross, Bucks.

Sensitive Two-Valve Receiver

High Gain Detector Directly Coupled to Small Output Valve with Negative Feedback

By H. E. STYLES, B.Sc.

THE author has, for some time, quite successfully employed a two-valve receiver based upon the "midget" design of S. W. Amos[1] but the necessity of using some form of aerial with this set is considered to detract somewhat from its value as a portable instrument. The three-valve version of the same receiver[2] would no doubt be free from this drawback, but an article by W. K. Volkers[3] dealing with the characteristics of pentodes operated with abnormally low screen potentials suggested that the difficulty might be overcome without recourse to an additional valve.

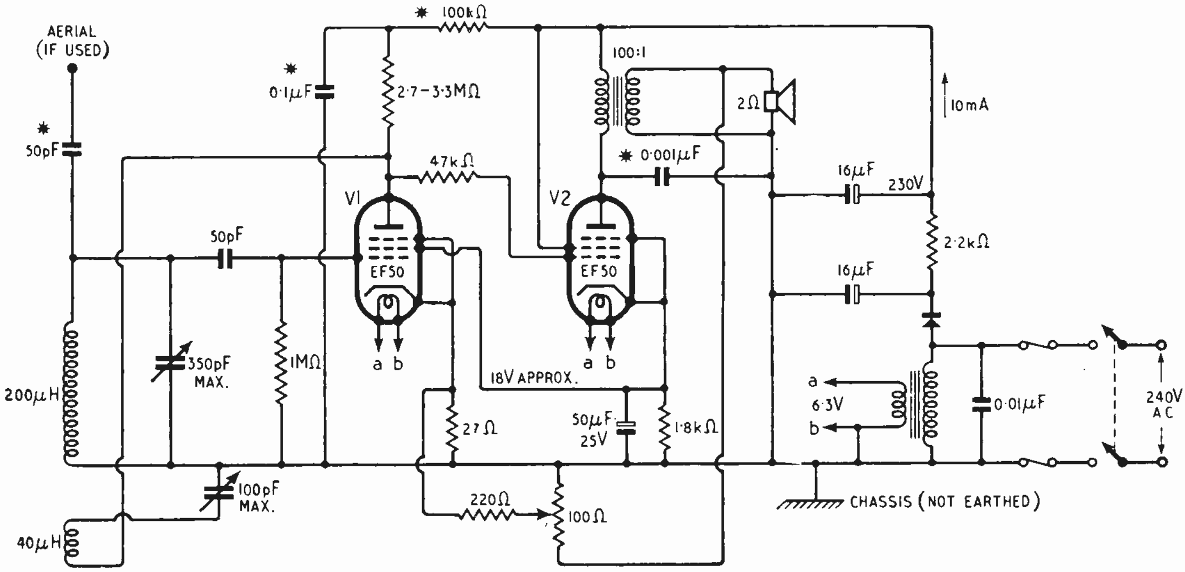
Experiments have been made to investigate this possibility and results obtained have far exceeded expectations. A receiver employing the circuit shown in the accompanying diagram has proved capable of receiving, in the Harrow district, not only the "Home" and "Light" programmes of the B.B.C. but also a number of continental stations, at good loudspeaker strength, using no more than the internal wiring of the set for signal pickup. Moreover, the circuit also permits the elimination of a number of components normally required, thus cheapening its cost.

[1] "Midget A.C. Mains Receiver" by S. W. Amos—*Wireless World*, March, 1949.
[2] "Midget Three-Valve A.C. Mains Receiver" by S. W. Amos—*Wireless World*, February, 1950.
[3] "Direct-Coupled Amplifier Starvation Circuits" by Walter K. Volkers—*Electronics*, March, 1951.

Circuit Design.—The essential feature of the circuit lies in the employment, as detector, of a pentode (EF 50) operated with a low screen potential and an unusually high value of anode load resistance. Under such conditions, the internal resistance of the valve is increased to a greater extent than its mutual conductance is diminished with the result that the amplification factor of the valve becomes very considerably enhanced. The high anode load resistance enables a considerable proportion of this enhanced amplification to be made available externally with the nett result that a very high stage gain can be obtained.

Several other advantages accrue from such conditions of operation. The anode current of the valve becomes reduced to a very small value as also does its anode potential. The latter enables direct coupling to the following stage to be employed without encountering the disadvantages normally attendant upon such method of inter-valve coupling. An economy of components thereby results from elimination of the usual coupling capacitor and grid leak, whilst removal of a possible source of phase change diminishes risk of instability arising from negative feedback.

With direct coupling, it is, of course, necessary to ensure that the cathode of the following valve is at a potential sufficiently above that of the anode of the first stage to provide an appropriate negative difference



*Circuit diagram of the receiver. Resistors can be ½W and capacitors 350V d.c. working. The 0·01-μF capacitor across the mains input must be capable of continuous operation at 250V a.c. Components marked thus * may be omitted for "local" reception. The cathode resistor for V_2 must be adjusted to fix the h.t. current at 10 mA.*

of potential between the grid and cathode of the second stage. Using an EF50 pentode for the latter, requiring a grid bias of only a volt or two, it follows that its cathode potential needs only to be maintained slightly above that of the anode of the preceding valve and such a potential proves to be quite suitable for the screen of the latter. It is, therefore, possible to connect the screen of the detector valve directly to the cathode of the output stage the potential of which is maintained steady by the normal bypass capacitor. The necessity for the usual detector screen resistor and capacitor is thereby obviated.

Connection of the detector screen to the cathode of the following valve serves also to provide automatic compensation for variations in supply voltages and valve characteristics. If for any reason the anode voltage of the detector increases, so also does that of the grid following valve. The anode current of the latter therefore rises causing a corresponding increase in cathode potential which, in turn, results in an increase of potential at the screen of the detector. The anode current of the latter is thereby increased with the result that the anode potential of the detector becomes reduced thus offsetting the rise in potential assumed to have initiated the changes outlined. The circuit thus provides a high degree of negative feedback so far as steady potentials are concerned, but this does not apply to alternating potentials which are bypassed by the capacitor in the cathode of the output stage.

The employment of an anode load resistance of the order of megohms necessitates avoidance, as far as possible, of shunt capacitance in order to obviate undue attenuation of high audio frequencies. Compensation for such loss can, however, be achieved by application of adequate negative feedback and a more serious difficulty arises from the need to ensure a sufficiency of radio frequency power output from the detector to enable satisfactory reaction effects to be obtained. This, rather than audio frequency attenuation, appears in practice to set a limit to the maximum value of anode resistance which can be employed.

A value of about three megohms has been found to be acceptable with a high tension supply at some 230 volts. Under these conditions the screen potential needed to ensure an anode potential of the same order proved to be about 18 volts, the anode current then being of the order of 70 micro-amperes. It is evident from the low value of the latter that the radio frequency power available at the detector anode must be severely limited and, to conserve this for reaction purposes, it is necessary to avoid losses as far as possible. In particular, the shunting effect of the input capacitance of the following valve must be minimized, whilst the use of normal radio frequency filtering in the detector anode circuit is precluded.

A series resistance of 50 kΩ in the grid circuit of the output valve provides a satisfactory solution to both these problems, the input capacitance of the valve then serving to attenuate radio frequency voltages without shunting the detector anode load.

A 1,000-pF capacitor connected between the anode of the output valve and earth serves the dual purpose of bypassing any radio frequency component present in the output and of eliminating excessive shrillness in reproduction when the negative feedback is reduced to zero. This capacitor is, however, by no means essential for stability and could well be omitted if reception of local stations only is desired. In such cases sufficient negative feedback will be required to obviate shrillness and prevent overloading.

By reason of the very small detector anode current, additional smoothing and decoupling for the detector stage can be attained by means of a 100-kΩ resistance and a 0.1-μF capacitor, though here again, these components may be omitted if operation without feedback is not required, as the small amount of hum arising from such omission can readily be eliminated by a moderate degree of negative feedback.

The latter is adjustable from zero to a maximum of about 1/1,000 by means of a potentiometer across the loudspeaker speech coil. The precise resistance of this potentiometer is relatively unimportant provided that it is sufficiently high to prevent any significant reduction of current through the speech coil.

Provision is made for attachment of an additional aerial, if desired, via a 50-pF capacitor connected to the grid end of the tuning coil. For safety reasons, this capacitor must be capable of withstanding the full mains voltage, as also must be the 0.01-μF capacitor shunted across the primary of the mains transformer supplying valve heater current. This capacitor serves to minimize modulation hum which cannot be eliminated by negative feedback. For purely local station reception the aerial series condenser need not be fitted as increased pickup, if required, can be obtained by connecting, internally, a few inches of wire to the grid end of the coil.

Receiver Adjustment.—The only adjustment to circuit values which may prove necessary is that of the cathode resistor of the output valve. This should be checked by measuring the h.t. current of the receiver, which ought to be about 10 mA. If the current is found to be too great the cathode resistor must be increased (and vice versa). A 5-kΩ variable resistor can be used for preliminary adjustment.

Connections to the detector anode and output valve grid should be kept as short as possible to minimize wiring capacitance, whilst reasonable care should be taken to avoid coupling between the detector input and the output from the second valve. No difficulties from instability have been encountered despite the very high overall gain, but acoustic reaction between the loudspeaker and detector valve may be troublesome with certain valves when feedback is reduced to zero. Selection of a suitably non-microphonic valve will obviate any serious difficulty from this cause, but the use of flexible valve mountings would probably help, whilst a sound absorbent shield round the detector valve may also assist. This can safely be applied owing to the low operating temperature of the valve. In any case, a small degree of negative feedback suffices to reduce overall gain to a level at which acoustic reaction is no longer troublesome without unduly reducing the sensitivity of the set.

Volume control can be effected by a combination of reaction and negative feedback, the effect of the latter being very considerable on account of the high gain available at zero setting of the control. Due to the very small signal input required adequate range of volume can be obtained by these means, though admittedly complete silence cannot be achieved without detuning (or switching off!).

The addition of an aerial consisting of 6in to 12in of wire results in astounding sensitivity, but the poor selectivity of the single-circuit tuner prevents full benefit being obtained, and the receiver is quite definitely not suitable for use with an aerial of appreciable size. Modifications to the aerial input circuit and additional screening might alter this position, but such possibilities have not been investigated.

Some Aerial Queries

Explaining How the "odd bit of wire" Fits into Theory

By "CATHODE RAY"

WIRELESS and radio are not necessarily the same thing. Last month I tried to show the difference between induction and radiation. Radio is communication by electromagnetic waves (of greater wavelength than heat), which have to be radiated. But what about the little crystal sets* that N.A.T.O. delegates carry with them, for listening to the speeches in their favourite language while moving around the building? Surely they are wireless? But they do not use radiation to any significant extent; they depend on induction, and their range is thereby limited.

Do you remember the graph (repeated here in Fig. 1) showing how rapidly the induction field strength falls as the distance from the source increases? Radiation, though relatively weak close to the source, can be detected at vastly greater distances because its fall-off is much more gradual. This greater uniformity of distribution is because radiation is an outward movement of electromagnetic energy that has broken loose from the source and has become independent. The energy of induction fields, on the contrary, returns to the source—if it is allowed. Our a.c. generator connected to a resistanceless coil alternately built up a magnetic field and then received the same amount of energy back during the other half-cycle, and (neglecting radiation, as one can at low frequencies) the net energy supplied by the generator per cycle was nil. But as the frequency is raised the time taken to build up and pull down the more distant parts of the field begins to amount to an appreciable phase shift, and the result is that more power goes out than comes back. This power is radiated, and some may happen to fall on a receiving aerial and do work in the receiver. But the sender wouldn't know about that, for it has lost touch with the radiated energy. The receiver, if beyond the effective induction zone close to the sender, is too far away to react on it.

Then what works the N.A.T.O. receivers, if all the induction energy returns to the source? Well, I said it all returns *if it is allowed.* But if a circuit—or a sheet of metal, or anything in which current can be induced—is coupled to the source (which is another way of saying it is within the induction-field or near zone) the currents so induced react on the source in such a phase as to cause less energy per cycle to return than went out. That energy is what is used up in the coupled circuit. An ordinary mains transformer is an extreme example, in which the coupling is very close. If the secondary coil is open-circuited, no current can be induced in it, so no energy is withdrawn from the primary (other than the small amount needed to cover incidental losses). But if the secondary is connected to a low resistance a heavy current flows through it, and this induces a current in the primary in phase with the applied voltage, so that the net result is practically the same as if a resistance load had been connected directly across the primary; energy is drawn from the mains. In the N.A.T.O. headquarters the coupling is very loose, so it makes little difference to the fixed primary coils when a receiver is brought in; nevertheless it does make some difference or the receiver wouldn't work.

Another thing to recall from last month is that the range at which the near or induction zone ends and the distant or radiation zone begins—the range at which induction and radiation fields are equally strong, marked by the intersection of the lines in Fig. 1 — is $\lambda/2\pi$, roughly one-sixth of the wavelength. The wavelength of Droitwich, 1,500 metres, is 4,910 feet, so $\lambda/2\pi$ is 780 feet. Now all but a very little of the total field energy of a circuit is within a radius not many times greater than the dimensions of the circuit. So if the source of a 1,500-metre field ($f=200$ kc/s) is a

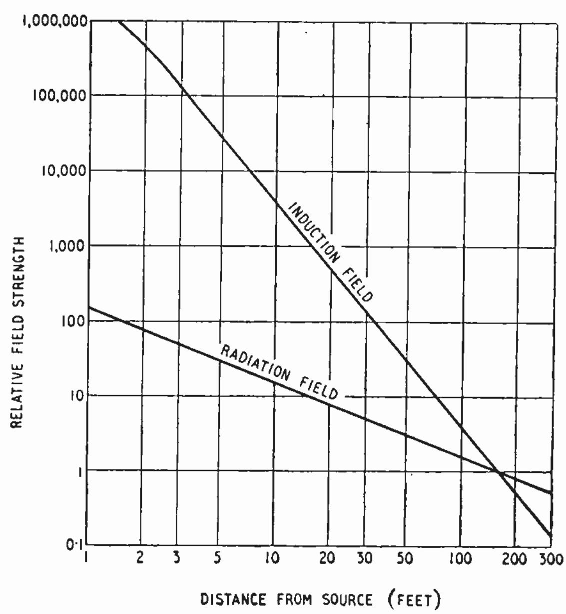


Fig. 1. Repeat of last month's graph showing how the radiation field strength, though weak compared with the induction field close to the source, falls off less steeply, and beyond $\lambda/2\pi$ is stronger than the induction. This particular graph refers to a 1-foot coil carrying 1 Mc/s current.

* *Wireless World*, February 1953, p. 69.

coil about an inch in diameter, the field strength 780 feet away is for most purposes negligible. Which means that the radiation is negligible. But if the 200-kc/s current were made to flow through a loop several hundred feet in diameter, the field 780 feet away would be quite considerable, and as half of it would be radiation field the radiation would be considerable.

If the same loop were fed with a 50-c/s current, for which λ is 6,000,000 metres or 19,700,000 feet, and $\lambda/2\pi$ is therefore 3,130,000 feet, and one compares this with the size of the loop, it is obvious that the radiation would be negligible. Yet even the 1-inch coil would be a good radiator if fed at 1,000 Mc/s, for at that frequency $\lambda/2\pi$ is less than 2 inches.

So we see that whether a circuit is a good radiator or not—in other words, whether it is an effective sending aerial or not—does not depend either on its size or on the frequency (or wavelength) alone, but on the ratio of size to wavelength. If the size is very small compared with the wavelength, then it cannot be a good aerial. If it is comparable with the wavelength—say at least one-tenth—then it *might* be a good aerial. But one has to take account of its shape, too. A parallel-wire feeder may be as long as you like, but it cannot radiate effectively if the spacing between the wires is very small compared with the wavelength, because the external field set up by one wire is nearly cancelled out by the opposite field due to the current in the other. It is only between the wires that the field can be really strong. The main purpose of a feeder is to transmit energy from one end to the other with as little loss as possible, and for this purpose energy radiated is energy lost. So the spacing must be kept very small compared with the wavelength; the shorter the wavelength the closer the spacing. The main purpose of a sending aerial being radiation, the spacing should be as large as possible. The limit is reached when the wires extend away from one another in opposite directions. A particularly good result is obtained when the length of each wire is quarter of a wavelength, as in Fig. 2. This is so not only because the $\lambda/2\pi$ distance is well within the strong part of the field, but also because the capacitance between the two wires resonates with their inductance so that a given generator e.m.f. causes maximum current to flow and builds up maximum voltage at the ends. The resulting magnetic and electric fields not only spread out well into the surrounding space but are at maximum strength.

This aerial, of course, is the well-known half-wave dipole, seen on countless roof-tops. What is good for sending is good for receiving. Resonance helps both, of course. And the e.m.f. induced is proportional to the length.

Length of the Aerial

You may ask, then, why stop at *half* a wavelength? Resonance is obtainable at greater lengths—multiples of half a wavelength. And in fact such lengths are sometimes used, but there are results of the extra length that are not always welcome. Even at television wavelengths, λ/π is (for London) about 12 feet, which feels a good deal longer when you are actually handling the aerial than when you are surveying it from the ground. Some local councils at least seem apprehensive about the possible results of attaching it to their houses. At the longer broadcasting wavelengths the question of exceeding the half-wavelength hardly arises. Droitwich's wavelength, as we have already noticed, is 4,910 feet, and even half of this would take some accommodating in or on the typical suburban dwelling. And I have not yet mentioned that ideally it ought to be far removed from any other objects, such as the earth!

So it is only for quite short waves that even a half-wave aerial is practicable. For very short waves one can consider full-wave or longer aerials, but then another effect comes in, which may or may not be desirable. I am not going into it in detail, because it is really a subject in itself, and I did deal with it some years ago—actually September, 1946. It is the directional effect caused by the combining of radiation from different parts of the aerial. With the simple half-wave dipole, all of it works to give maximum radiation all around its "equator"; that is to say, a vertical dipole is most effective in all horizontal directions. But with a full-wave dipole the radiation in these directions due to one half is cancelled out by the other half. Maximum radiation occurs at an angle upwards and downwards. (The same goes for reception as well as radiation.) Of course, if you want to shoot your radiation up at that particular angle, then the full-wave dipole is the thing. But if not, not.

The Ideal and the Practical

The question I want to deal with now is the relationship between this apparently ideal dipole aerial which we have arrived at (though not very rigorously, I fear!) by theory, and the sorts used for ordinary "steam" radio. Judging from inquiries received, the connection is not obvious to all.

Let us start with the half-wave dipole, having a receiver coupled to its middle. For all-round reception it is both simple and good, provided that the wavelength is short enough for its installation to be a practical proposition. On medium or long waves results would be magnificent—and they would have to be, to be worth suspending hundreds or thousands of feet of dipole high above the earth! The problem of high suspension can be completely avoided, and the problem of length halved, by substituting the earth for the lower half of the dipole (Fig. 3). This dodge also solves another difficulty, by bringing the receiver to a more convenient spot. Actually, I shouldn't call it a dodge, because it is a perfectly respectable device, with a scientific proof and all that. Just as half a dipole standing on a mirror *looks* very like a whole dipole, so half a dipole standing on a perfectly conducting earth radiates or receives very like a whole dipole.

There are still two difficulties left. One is that the length has to be quarter of the wavelength of the station to be received (if one insists on working it at its best), and the other is that it is still too long anyway. Having had enough of the Home Service on 330 metres, for which a 270-foot vertical wire would be right, can one imagine oneself extending it to 1,230 feet to tune in the Light Programme? One solution of these difficulties is to use the tallest aerial that can conveniently be managed, and tune it to resonance by means of inductance and/or capacitance inserted between it and earth. In practice this means that for medium or long waves the aerial is much shorter than a quarter-wavelength, so it is much less effective as a picker-up—or a radiator. Another solution, and the one in general use nowadays, is not even to bother to tune the aerial. So reception is worse still. And since the radio trade has for years encouraged the public to believe that a receiver that needs any visible aerial at all—other than perhaps the odd bit of wire around the picture rail—must be a poor specimen, there should be little difficulty in understanding why broadcast reception is so often bad. When people bring me their complaints about it, nine times out of ten I know the answer before they have told me the symptoms—" Use an outdoor aerial." The " bit of wire "—and still more the mains connection on which so many rely—is not only bad at picking up radio transmissions because its vertical length is only a fraction of optimum, and because it is probably untuned, and because there are no precautions against r.f. losses, and because it is inside a house which does a considerable deal of screening, but it is an excellent picker-up of undesired noises, because it is close to their sources and may even be directly connected to them.

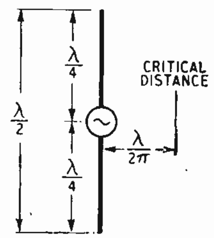
Reverting to television dipoles: the fact that the Pontop Pike and Glencairn transmissions need horizontal ones, in contrast to the vertical types that have been associated with the B.B.C. ever since 1935, brings before a wider public the matter of polarization. If the sending aerial is vertical, then its electric field is vertical, as a result of the difference of potential between top and bottom ends. The magnetic field is horizontal, as a result of the current flowing up and down. The polarization of the waves is their field direction, and in this case could be called either vertical or horizontal according to whether one had in mind the electric field or the magnetic field. One can't *see* either, so it is a great help that the electric field was chosen for naming the polarization, since it is the same as the aerial that one *can* see.

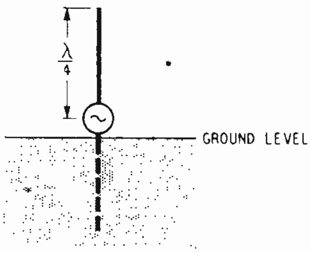
Reception is best when the receiving aerial is parallel to the sending aerial, and theoretically is nil when it is at right angles. That, of course, is why the low-power B.B.C. senders, working on the same wavelengths as the high-power ones, are differently polarized—to avoid interference. In practice, however, the waves undergo a certain amount of reflection and general pushing around *en route*, and seldom arrive with exactly the polarization with which they started. So maximum may be a little off perfect parallel, and minimum is unlikely to be quite nil.

Role of the Horizontal Top

That is part of the explanation of what some people find rather puzzling—that the ordinary all-wave domestic aerial is quite effective, even when it consists of a horizontal wire stretched from an upper window to a tree in the garden. Although the sender may radiate vertically polarized waves, by the time they reach the receiver they are more than likely to have an appreciable horizontal component. Another part of the explanation is that if the receiver is on an upper floor it receives the vertical component of the waves on its earth lead or the equivalent. Another aspect of this matter is that a horizontal top to an otherwise vertical aerial—the familiar domestic Γ type —does help even in a perfectly vertical field. It concerns what is known as effective height. The meaning of this can perhaps be better grasped with reference to a sending aerial. Suppose it consists of a vertical wire 100 feet high. The maximum current occurs at the lower end, because it has to charge the entire aerial. Half-way up, the current is less, because it has only the upper half of the wire to charge. And

Right: Fig. 2. The critical distance, $\lambda/2\pi$, being less than quarter of a wavelength, is relatively close up to a half-wave dipole, so the radiation field is far stronger than from a source that is small compared with the wavelength.





Left: Fig. 3. A dipole is still effective if the lower half is replaced by a conducting plane. The earth is a fair approximation to this.

the current tails off to nothing at the top. Clearly this aerial does not radiate as much as an imaginary aerial of the same height carrying the maximum current (which is what is delivered by the sender) all the way up. If the height of the imaginary aerial were reduced until its radiation was equal to that of the real aerial, its height would be the " effective height " of the real aerial. The effective height of the 100-foot vertical aerial, if operated as in Fig. 3, is something like 63 feet. Under more usual conditions it is nearer 50.

Now it is very much cheaper to erect an aerial 50 feet high, or even 63, than one 100 feet high, so anything that can be done to persuade the current to remain at nearer full strength all the way up is likely to save money. Horizontal extensions of the wire are less costly than vertical, and although they do not add directly to the vertically polarized radiation they do add to the capacitance of the aerial so that the vertical part is more like the ideal uniform-current aerial. In other words, the horizontal top increases the effective height.

There is a fable about a visitor who was regarded by his superstitious host with dismay because he could blow both hot and cold—hot to thaw his chilled fingers and cold to cool his soup. It is like that with television aerials; students are sometimes mystified because the unconnected dipole in an " H " can be used as a reflector, suppressing reception from the direction towards which it is mounted, or as a director which does exactly the opposite.

Of course both dipoles have currents induced in them by the incoming waves, so each affects the other. We are not so much interested in what the receiving dipole (A) does to the unconnected one (B) as what B does to A. Unlike A, B has no receiver to draw off the received power; almost its only resistance is radiation resistance, so most of the power it receives is re-radiated. The net signal received by A is made up of what it gets direct from the sender and what it gets indirectly from B. Whether it is greater or less than what it would be if B were not there depends on the phase difference. If the two lots are in phase, then obviously the net effect is stronger reception; and vice versa.

Now the phase difference is caused by two things: the spacing between A and B (in terms of wavelength), and the reactance of B. The part due to spacing is easy to find; the phase angle can be measured with a metre scale, if we know the wavelength. For the wavelength is simply the distance the wave travels during one cycle. So quarter of a wavelength ($\lambda/4$) is the distance travelled during quarter of a cycle, or 90°. The phase angle of the dipole itself is more tricky, because it is affected not only by its length (again, in terms of wavelength), but also to some extent by its thickness, and certainly by the other dipole. The length is, however, the main factor. When it is about $\lambda/2$—actually a little less—the dipole is in tune and its reactance is zero. Just as with an ordinary tuning circuit, the reactance and phase angle change very rapidly each side of resonance, so the length is quite critical. And that is the main reason why the effect of B can be reversed by making it, say, a little shorter instead of a little longer. And it also explains why reflector spacing varies considerably with different makes of aerial; one manufacturer may like to reduce the spacing and bring the phase angle right by a slight alteration to the length of the reflector. Although the change may leave the phase difference as before, the performance is altered in other respects by the closer coupling. It depends on whether he is aiming at maximum reinforcement of signals from one direction, or the most complete elimination of interference from another.

So many factors come into it that the whole thing is too complicated to attempt here, but I shall just show roughly how it is that an H aerial discriminates between waves coming from different directions. For simplicity let us assume that the spacing is $\lambda/4$ and that the re-radiated wave from B is 180° out of phase with the wave flowing past it. Then Fig. 4 (a) depicts the situation at an instant when wave coming in from the left is passing through zero at A and is at negative peak at B. The re-radiated wave from B is therefore at positive peak. Quarter of a cycle later, the incoming wave has reached its positive peak at A, and the positive peak from B arriving simultaneously reinforces it. The result is a gain. Now consider a wave coming from the right (b), again at the instant when it is zero at A and about to become positive. At B the phase is peak positive, so the re-radiation is peak negative, and in quarter of a cycle these two will have arrived at A simultaneously. So the effect of B is all loss.

Fig. 4. A rough explanation of how an unconnected reflector dipole B enables a receiving dipole A to tell the difference between left and right. It is assumed that the re-radiation from B is 180° out of phase with the incident wave.

VICTORIAN WIRELESS ENGINEER

THERE were not many wireless engineers in Queen Victoria's days, and still fewer who dated back to the 19th-century part of the reign. One of that select band was Andrew Gray, formally chief engineer of the Marconi Co., whose recent death at the age of 80 we record with regret. Andrew Gray, who joined the Marconi Company in 1899 (two years after its formation), was sent by Marconi at the turn of the century to install the world's first public telegraph service—between the islands of the Hawaiian group.

In 1901 he was appointed chief-of-staff of the company and was put in charge of both the training of engineers and the organization of the Marine Company's ship-shore installations. He was appointed chief engineer in 1910 and in 1928 became technical general manager.

G. M. Wright, the present engineer-in-chief of Marconi's, writes:—

It is indeed sad to hear of the severing of another link with the early days of wireless by the death of Andrew Gray, who worked for some years as a personal assistant to Marconi. He had previously served with the West India and Panama Telegraph Company as chief electrician and so brought to the rapidly developing art of wireless communication an invaluable background of practical telegraph experience.

The time of his early work saw the development of wireless in the form of ship installations, coast stations, and later high-power point-to-point telegraph services, in all of which he played a most important part.

The late Andrew Gray.

One of his major contributions was the design of a steel mast which could be pressed in sections, easily transported and erected, under supervision, by local labour. These masts were erected in all parts of the world and became the familiar landmark of a Marconi station. When the new Marconi works was built at Chelmsford two Gray masts 450 feet high were erected on the site and gave invaluable help to the company's research work.

Andrew Gray had that rare combination of qualities which goes to make the great engineer. He had a deep knowledge of his specialized branch of engineering, supported by a wide general technical background. Above all, he possessed the virtue of common-sense. He took deep interest in research and experiment and encouraged research engineers by his personal advice in discussions of their problems. In the period from the end of the first war until his retirement in 1932 he paid a visit at least once a week to the company's research department in order to keep in close touch with all that was going on, and to discuss problems.

He was a man of a most lovable character and his staff always took their personal troubles to him and never left without advice and help. Those who knew and worked with him will learn of his death with a deep sense of personal loss, and regret that he is no longer with us.

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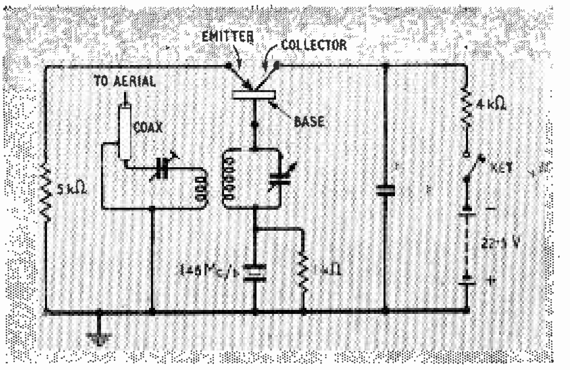
Transistor Transmitter

A Peep into the Future



Circuit of the crystal-controlled transistor transmitter described in the text.

WHEN it became known that a transistor could be made to oscillate, somebody, somewhere at sometime was bound to have an urge to try one in a radio transmitter. It is perhaps in keeping with the inquisitive spirit of amateurs that the first authenticated transmission using this device should be effected by an amateur, or more strictly speaking from an amateur-operated station.[1]

In the present state of transistor development only a privileged few have access to the kind of transistor likely to be any use in a radio transmitter and the author of the experiment[2] is fortunate in having access to some unusual types of transistor.

First mention of this transmitter was made in *QST* of February, 1953, and a description of the transmitter appeared the following month. It should be realized that the transistor transmitter is as yet a long way away, but it is technically interesting to know that this new device has distinct possibilities in the transmitting field, although no doubt limited to quite low-power work in the initial stages.

The two-metre band was chosen for this first transmission experiment for several reasons; first an exceptionally good aerial was available at K2AH for the 146-Mc/s band and secondly transistors were not supposed to be capable of stable oscillation at such a high frequency, although in the R.C.A. laboratories some special ones had been put together that behaved rationally as oscillators up to and above 300 Mc/s[3].

The circuit of the transistor transmitter is shown in Fig. 1. It is a simple keyed oscillator with crystal control and is what the author describes as basically a Colpitts. The quartz crystal is used in an unusual way, being employed as a frequency-selective by-pass element in series with the tuned circuit.

Quartz crystals can be used either as high- or low-impedance elements depending on the circuit in which they are employed and while the resonant frequencies of the two conditions are different the difference is so slight as to be almost indistinguishable and for all practical purposes they may be taken as one and the same frequency.

In this case the low-impedance or series mode[5, 6] is used and at the operating frequency the 1-kΩ resistor in series with the tuned circuit is by-passed by the crystal and the circuit oscillates. At any other closely related frequency the crystal exhibits a high impedance and oscillation does not occur.

An interesting sidelight on this experiment is that the crystal which is a 16-Mc/s unit intended for use on its 5th overtone (80 Mc/s) gave solid control of oscillation on its 9th overtone, 144 Mc/s.

Operating power for the transmitter was obtained from a miniature hearing-aid battery of 22½ volts, but the series resistors dropped the actual voltage at the transistor to about 8, which with a current of about 3 mA fixed the input power to the oscillator at 24 milliwatts. Of this an estimated 50 microwatts only reached the aerial.

Despite this low output communication was established with several amateur stations by c.w. at ranges up to 25 miles, which was by no means the possible limit, since signals were reported at RST559. An S5 signal is a good solid one and readable through quite a lot of interference, while the T9 report signifies a perfectly steady keyed note free from ripple or "chirp."

If a modulator with an output small enough to modulate the extremely low-power oscillator had been available the author of the experiment was quite confident that no difficulty would have been experienced in effecting R/T communication.

For this experiment the transistor used was one of the point-contact type. It is a current-controlled device whereas the thermionic valve is voltage controlled so that transistor circuitry will always be quite different from the more familiar valve technique, as this simple transmitter exemplifies.

[1] U.S. Amateur station K2AH operated by G. M. Rose.
[2] R.C.A. Tube Department, U.S.A.
[3] "Transistors Oscillate at 300 Megacycles," *Electronics*, November, 1952.
[5] "Series Resonant Crystal Oscillators," *Wireless Engineer*, June, 1946.
[6] "Series Mode Crystal Oscillators," *Wireless World*, July, 1952.

An Aural Anomaly

Is the Ear a "Pressure-operated Device"?

MEASUREMENTS involving the subjective assessment of sound levels have long been bedevilled by a curious discrepancy between the results obtained with earphones and those in which the sound is judged under normal conditions of hearing in a free field provided by a loudspeaker at some distance from the observer. To begin with, it was found that the minimum threshold curve obtained with earphones was higher than that given by direct listening; later, suspicion fell on the validity of earphone calibrations involving adjustment of loudness to equality with free fields of known strengths.

Experiments with probe-tube microphones, inserted in the ear canal to measure the sound pressure adjacent to the ear drum, have confirmed that when the loudness of, say, a 100-c/s tone from a closely fitting earphone is judged to be equal to that of the same tone coming from a loudspeaker, the pressure at the eardrum is of the order of 6db higher. Alternatively, for equal sound pressure at the eardrum, the loudspeaker sounds the louder.

Like all our senses, hearing is governed not by precise physical laws, but by general relationships derived from the average of many measurements on individuals. The responses of individuals are themselves by no means fixed, but vary with age, health and the acoustic environment. However, for the short period of time required for a change-over, it seems reasonable to assume constant sensitivity of the ear, and that equal pressures will produce equal sensation, irrespective of the origin of the pressure at the end of the ear canal. At frequencies of the order of kilocycles per second, where the wavelengths of sound are comparable with the dimensions of the ear canal, discrepancies in physical measurements might be expected from resonance and standing wave effects, but not at 100 c/s where the wavelength is 11 feet.

Possible Causes

A recent investigation* at Bell Telephone Laboratories by W. A. Munson and F. M. Wiener clears the air, but does not completely resolve the mystery. After repeating earlier experiments to make sure that the pressure measurements were not in error, the possibility that increase of static pressure on the ear drum might be the cause of change of sensitivity was investigated. A good seal between the outer ear and the earphone pad is important when measurements are involved, and under these conditions an increase in pressure between the outer and middle ears is to be expected as the result of rise of temperature. It is known that such a pressure difference causes a diminution of sensitivity, and evidence from experiments on animals points to a figure of 5 mm of mercury for the pressure required to effect a reduction of 8db in the potentials developed in the cochlea. But under normal conditions the pressure rise after applying an earpiece is found to be less than 1 mm/Hg; so pressure difference, though possibly contributory, is not decisive in explaining the loss of loudness.

Another possible physiological cause is the involuntary contraction of muscles in the middle ear, when sensitive areas of the outer ear are touched. This can cause significant attenuations and is known to affect low frequencies more than high. If this is the root cause of the discrepancy, equal loudness for equal pressures should be found when the comparison is made with the middle ear muscles also contracted when listening to the loudspeaker. Three methods were used by Munson and Wiener to this end; dummy earphones with normal pads, but with an aperture in place of the receiver, and unilateral stimulations of the opposite ear, either by plugging or by a 6-kc/s tone, 100db above the 100-c/s test tone level, the assumption being that, by the known principle of bilateral action in man, the muscles of the opposite ear would also contract. All three experiments produced negative results—the 6db difference in loudness still persisted.

The possibility of sound reaching the inner ear by paths other than through the ear drum and ossicles was considered, but it was concluded that the indirect sound amplitude resulting from, say, head vibration would have to be at least half that arriving through the normal channel to account for the observed difference, and that such indirect amplitudes were unlikely.

A difference in harmonic content between the two sources was also considered, and it was noted that the tone from the earphone appeared to be less pure than that from the loudspeaker; but measurements failed to reveal any difference sufficient to affect the apparent loudness. In any case the effect would be to increase the loudness of the earphone tone rather than to decrease it.

One other possibility is listed by the authors, but was not investigated, namely, that the seat of the loudness decrease is in the central nervous system. Having regard to the thoroughness with which the initial physical conditions were investigated it seems reasonable to assume that the discrepancy arises further along the chain of auditory perception; but a rational explanation must await more conclusive evidence of the exact mechanism by which we appreciate loudness. Work so far carried out has shown that there is no simple relationship between the cochlea potentials and the patterns of stimulation in the cerebral cortex by which we recognize the qualities of sound.

It seems likely that unsuspected trace stimuli could easily falsify the cerebral pattern, and what more probable than that the acuity of hearing under artificial binaural conditions from headphones is at a disadvantage compared with the more practised and experienced function of normal hearing in a free sound field.

In the paper referred to, it is not always clear when the experiments are monaural or binaural, but one experiment is of more than usual significance. Instead of removing the earpieces when listening to the free field, they were left on the head and the sound was allowed to reach the ears by leakage under the caps or by any other available path. In this experiment, to quote the authors, " . . . we hit the jackpot. Our tests showed no significant difference between pressures in the ear canal for equality of loudness of tones from the receivers and from the sound field."

But in this experiment the "binaural" conditions of listening to the free field were quite different from the untrammelled normal use of the two ears, and it seems reasonable to suggest that if means could be found of simulating true free-field binaural listening with tones originally only in the close-fitting headphones the pressure difference anomaly might disapper. But how to be sure that no trace element of falsehood remains to be detected by the highly developed analytical powers of the cortex?

Until the anomaly is resolved we can but endorse the authors' warning that "the calibration and use of receivers will be subject to an element of uncertainty that is very real and annoying." F. L. D.

* "In Search of the Missing 6db," *J. Acous. Soc. Amer.*, Vol. 24, No 3, Sept., 1952, p. 498.

NEW R.I.C. SPECIFICATION

Component Standard for Rotary Wire-wound Resistors

VARIABLE wire-wound resistors of the rotary type form the subject of a new components specification, RIC/121, issued by the Radio Industry Council, 59, Russell Square, London, W.C.1.

Like the other specifications in this series it is divided into three sections dealing with performance requirements, production tests and a schedule of types, values and sizes, and classifies the component into red, yellow and green groups according to the climatic conditions under which it is intended to be used. The latest specification consists of sections 1 and 2 only and section 3 will follow later.

It is laid down that resistance values should conform to the series 1, 2, 5, 10, etc., and tolerances should be ±5 or ±10 per cent. The specification covers resistors ranging from 0.5 watt to 80 watts and for working voltages of 350, 500 and 1,000 d.c.

This specification has been produced by agreement between B.R.E.M.A., R.C.E.E.A. and R.E.C.M.F., whose individual contributions to the subject have been co-ordinated by the Technical Specification Committee of the R.I.C. For the present it is intended for use within the radio and electronics industry, but it will be submitted in due course to the British Standards Institution for incorporation in a B.S. specification.

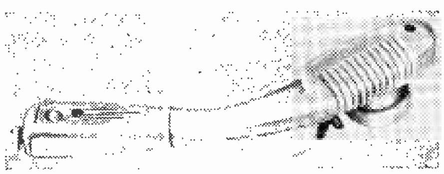
Copies of sections 1 and 2 (together) of this specification are obtainable from the R.I.C. at a charge of 5s post free. The cost of section 3 will be announced when it is available.

Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

New Crystal Pickups

TWO new crystal pickups have been introduced under the name "Studio" by Collaro, Ltd., Ripple Works, By-Pass Road, Barking, Essex. Both are turnover types with



Collaro "Studio" crystal pickups.

adjustable needle-point pressures and it is claimed that they will track with pressures as low as $7\frac{1}{2}$gm for 78 r.p.m. and 3gm for $33\frac{1}{3}$ r.p.m. records. Type "O," for use with normal radio receivers, has internal compensation for bass response and gives an output of the order of 0.6 V at 1,000 c/s. Type "P" has a constant-velocity type of response and is suitable for amplifiers with tone compensation and higher overall amplification. The output is 0.15 V at 1,000 c/s.

The crystals are protected from moisture and a guarantee is given for use under tropical conditions. Both types are mounted in tone arms with ball-bearing pivots, and the price of either type is £4 0s 6d (including tax). Cartridges are available separately at £2 6s (including tax).

Miniature Hearing Aid

MADE by a printed-circuit technique using silver on a ceramic base, the new "Telepak" hearing aid introduced by Bonochord, Ltd., 48, Welbeck Street, London, W.1, is housed in a polished plastic case which reduces noise arising from clothing friction, and measures $3\frac{1}{2}$in $\times 2\frac{1}{4}$in $\times \frac{3}{4}$in (weight, including batteries, $4\frac{1}{2}$oz).

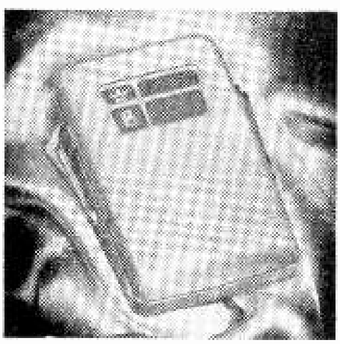
Volume and frequency-response characteristics are adjustable to individual requirements, and the maximum air-to-air gain is 60db.

An interesting feature is the provision of an induction pick-up attachment which can be used on a telephone instrument without direct connection, or for amplifying radio or television sound programmes if a single turn loop from the low-impedance output circuit of the set is installed round the listening-room. The price of the "Telepak" is £28 7s.

Record Player

DESIGNED to play all normal and long-playing records, the Philips Model 424A "Disc Jockey" is contained in a case 13in $\times 11\frac{1}{4}$in $\times 4\frac{1}{2}$in and weighs 7lb. It has a three-speed motor suitable for 110-V and 200-250-V, 50 c/s mains. The pick-up is of the double-stylus type and functions with a weight of $\frac{1}{3}$ oz at the point. As the total weight of the tone arm is only 3/5 oz, counterbalancing is unnecessary and the low mass ensures stability and freedom from groove-jumping on warped or eccentric records. An automatic stop switch for all types of run-off groove is provided.

The price is £11 11s (including tax) and the makers are Philips Electrical, Ltd., Century House, Shaftesbury Avenue, London, W.C.2.



Bonochord "Telepak" hearing aid.

Philips Model 424A record player.

RANDOM RADIATIONS

By "DIALLIST"

Components Show

THE R.E.C.M.F. SHOW or, to give its full title, the exhibition of British components, valves and test gear, organized by the Radio and Electronic Component Manufacturers' Federation, is a private show, with admission by invitation only. It is, of course, a miniature affair in comparison with the national radio exhibition; and that very fact gives it an intimacy which, to my mind, makes it one of the most enjoyable radio events of the year. Every stand is full of interesting things and you meet all kinds of interesting people. This note has to be written some days before the 1953 show opens. I know, though, that I shall enjoy every minute that I spend at the show. This annual array of new "bits and pieces," produced to meet the growing requirements of workers in industry and research, gives one some idea of the rapid progress made in radio and electronics—two of the most enthralling branches of human knowledge.

A Kindly Thought

YOU MAY RECALL that I described last month an ultra-simple "Wrotham" dipole, made by untwisting the last two-and-a-half feet of a twin flex feeder and training one wire to the right and t'other to the left. Since my home is within the 3 mV/m contour of the B.B.C.'s field-strength map, I felt that this might not give a.m. a fair chance, though it is likely to do all that is needed for f.m. I've therefore had a pukkha metal tubing dipole fixed to my tallest chimney stack as well. This aerial is over 40 feet above the surface of the nearest roadway. The flex dipole is about 20 feet lower. It will be interesting to compare the results given by the two. The receiver is not yet ready for action; nevertheless, I'm already getting quite a bit of entertainment out of the chimney-stack dipole. It catches the eyes of a lot of folk who pass by and not a few of them pause to give it a second, puzzled look. One man stopped me as I was going out the other day and said in the kindliest way: "I hope you won't mind my telling you, but your television aerial hasn't been put up properly. It should stick up like *this* and not lie flat like *that*." I thanked him gravely for letting me know.

"Sound" Broadcasting a Back-number?

NOT A FEW PEOPLE hold the view that "sound" broadcasting has had its day. It's only a matter of time, they say, until all broadcasting is of the sound-and-vision kind. But I make the bold and confident prediction that much reception, if not indeed the bulk of it, will continue to be of the "sound only" type. As I see it, the domestic receivers of the not-very-distant future will contain a three-position switch: sound-and-vision; vision only; sound only. And I believe that more often than not the switch will be turned to the third position. The things that I personally want to see by radio are not very many. Big national, civic and sporting events—YES. Plays, ballet and so on—occasionally. Orchestras and instrumentalists—not after a short preliminary glance just to find out what they look like. Singers—definitely NO. Unlike children, most singers, once they have got to work, should be heard, but not seen. Debates and discussions—again, NO, after the first few moments. Once you know what each of the participants looks like, you can follow the argument far better by just listening, instead of having your attention distracted by constant switches to close-ups, which are not always too prepossessing.

Ups and Downs

CHATTING RECENTLY with a wireless enthusiast of the younger generation, I mentioned one point which had puzzled not a few of the old hands in the late 'twenties and most of the 'thirties. As new broadcasting stations came on to the air, many were for some time received with outstanding strength in most parts of this country. The Swedish long-wave Motala, for example, gave an enormous signal when it made its *début* with (I think) 25 kilowatts. It was the same with Kalundborg and several other long-wave transmitters. But, within a comparatively short time—say, four or five years at the outside—signal strength showed a remarkable decline. That this was not due to any reduction in the power output was clear, for I wrote myself to several stations which had waned and received positive assurances that nothing of the kind had taken place. On the medium-wave band things were even more spectacular. Many new stations behaved like the astronomers' novæ, those stars which flame into sudden brilliance, remain conspicuous objects for a time and then fade away into insignificance.

What's the Reason?

Both the long- and medium-wave bands were then far less crowded.

You could, and did, receive dozens of European stations free from interference. Hence, many a transmission that is now marred, or even blotted out by mutual interference then came through clearly. That explains why you can't now obtain interference-free reception of foreign stations that were formerly first rate; but it does *not* explain why there should have been so great a decline in the signal strength of many that were once outstanding in this respect. I've talked the matter over with many transmitting and receiving experts. All agree that there is something of a mystery and many are with me in believing that the cause may be the occurrence of electro-chemical changes in the soil surrounding the earth contacts, produced by the flow of heavy, or comparatively heavy, r.f. currents.

Fast Work

Have you ever thought about the astonishing growth of wireless and of its many offshoots in just over 50 years? At the beginning of the century all that wireless could do was to send messages in rather slow morse over very short distances. Less than twenty years later long-wave communication systems spanned the world, communications over moderate distances were established on the medium waves and the coming of the valve had made wireless telephony practicable. Wireless telephony gave birth to broadcasting. It was still a textbook maxim that long distances demanded long waves and high-power transmitters, when the amateurs began to cause the pundits to raise incredulous eyebrows by asserting that their short-wave, almost fly-power transmitters managed very nicely, thank you, to keep them in touch with fellow amateurs in Europe, America, Africa, Australia and New Zealand. That led to a revolution in long-distance communications. Meantime, one promising young branch was just beginning to appear; this was television. Most folk heard nothing of another branch, radar, until it had become a strong healthy growth, using first the metre and then the centimetre waves. The unattended and entirely automatic radio link led to the high-power, unattended broadcasting station, such as that which transmits the Third Programme from Daventry. And so it goes on. No one, probably, will ever write the complete story of wireless, for any book which tried to tell it would fall far behind the latest developments by the time it was written, printed and published.

UNBIASED

By FREE GRID

Autopædarchics

THIS JOURNAL pioneered over a quarter of a century ago what is generally known as a "Baby Alarm." Consisting of a microphone suspended over the child's cot and connected to the broadcast receiver downstairs, it superimposes the child's cries on the broadcast programme. Since then the basic idea has been reproduced again and again in other journals with but a few trivial improvements. Indeed, until recently, I saw no scope for any improvement myself.

Wandering round a recent exhibition with my blonde—in the absence of Mrs. Free Grid—I came across an electric baby rocker. This consisted of a small "carry-cot" suspended from a metal stand to allow of easy rocking, the latter being done very simply by means of an electric motor plugged into the mains. Now

A practical demonstration.

I don't profess to be an expert in babyology, or pædetics as some people seem to call it nowadays, but even I could not help being struck by the fact that, since babies feed largely on a milk diet, continuous rocking would result in the formation of butter. This would, I feel sure, be contrary to the regulations of the Ministry of Food.

Eventually the manager of the stand was "contacted," to use the modern jungle jargon, and he hastily explained that the contraption was intended to be rocked by hand. The electric motor had been installed merely to show how the thing worked.

It occurred to me at once that, since a child only requires occasional rocking, it would be a simple matter to retain the services of the electric motor. This could be controlled by the child itself by means of a "baby-alarm" microphone, an amplifier and a series of relays, just as the voice of a person speaking on the transatlantic telephone is used for control purposes by means of the well-known "Vogad" arrangement, the principle of which "Cathode Ray" elucidated for us some years ago.

The rocking motor would be switched on by the child's initial bellow and kept going for as long as the baby continued its vocal efforts. Immediately the child had rocked itself into insensibility the device would be automatically switched off and the cradle would come to rest. I can see no technical objection to this autopædarchic arrangement; maybe there is a medical one.

Canning the Coronation

IT IS very unlikely that I shall be present in the Abbey at the coming Coronation. A literary critic, however, who forecasts posthumous popularity for my poetry, tells me that in his opinion I stand a very good chance of being present at the next one. As you may be aware, more than one poet whose work did not hit the headlines until long after his death has subsequently been disinterred and granted, what is usually termed in certain journalistic circles, "a niche in our National Shrine."

As it is, I shall probably see this year's Coronation in canned form, appropriately enough in Chicago, the Mecca of mummified meat which London-born settlers call, with nostalgic appositeness, Canning Town. I was astonished when I first heard that films of the Coronation would be seen on some television screens in the U.S.A. on the evening of Coronation Day and for the moment I thought that some scheme had been devised for firing the films across the ocean in one of our new long-range carrier rockets.

But, owing to the time lag, it is just possible for the films to go from the Abbey to New York by helicopter and fast transatlantic plane in time for the late evening programmes in New York and elsewhere. The films will be processed in the plane *en route* as was done in a specially fitted train that was used in 1911 to transport the film of another Royal occasion from Carnarvon to London.

I am disappointed at American lack of enterprise in making no attempt to get the Coronation scenes across the Atlantic radionically so that they might be seen live instead of canned. It is, of course, easy enough to think of wild-cat schemes like having a string of ships, each carrying a helicopter-borne television relay station, to provide the links in the transatlantic chain, but I do think the experts could have worked out something.

Even if the Atlantic be an impassable barrier it must be remembered that there is less than 60 miles of water separating Britain from the U.S.A. Would it not have been possible for President Eisenhower, with his well-known tact and flair for reconciling National differences, to arrange for an overland route with radio relays every 50 miles or so from Calais to the Siberian side of the Bering Strait whence it is a mere 38 miles to the shores of North America?

De Morituris

INVENTORS are popularly supposed to die destitute in garrets while hard-faced and unscrupulous financiers make millions out of their brain children. Undoubtedly this did sometimes happen in the days of long ago. I am, however, surprised to learn from the pen of the Editor of our leading photographic journal (who writes at length and with feeling in the January 7th issue of *Amateur Photographer*) that in 1920 Louis Ducos du Hauron, who forecast, if he did not actually invent, all modern processes of colour photography, died in destitution.

This rather startling revelation has left me with an uneasy feeling that somewhere at this moment there may be some wireless inventor lying hollow-cheeked and hungry in a dismal attic while we who use his inventions are smacking Lucullan lips over our caviare. The wireless counterpart of du Hauron was undoubtedly Campbell Swinton, inasmuch as in 1908 he accurately forecast, although he did not actually invent, our present system of television. So far as I am aware, however, he died in a reasonable standard of comfort.

There may be others who were not so fortunate and died in poverty, but we can obviously do nothing about it now as a posthumous plaque in Westminster Abbey is no substitute for an *ante-mortem* square meal. But there may be some who linger on and we can at least do something for them even if it be only to put them out of their misery. If, therefore, you know of any deserving cases please let the Editor or myself know so that we can remove this blotch on the wireless escutcheon. It seems a crying shame that there is no R.S.P.C.I. to look after the interests of indigent inventors with the same zeal that the R.S.P.C.A. looks after destitute dogs.

Te Moriturus Saluto.