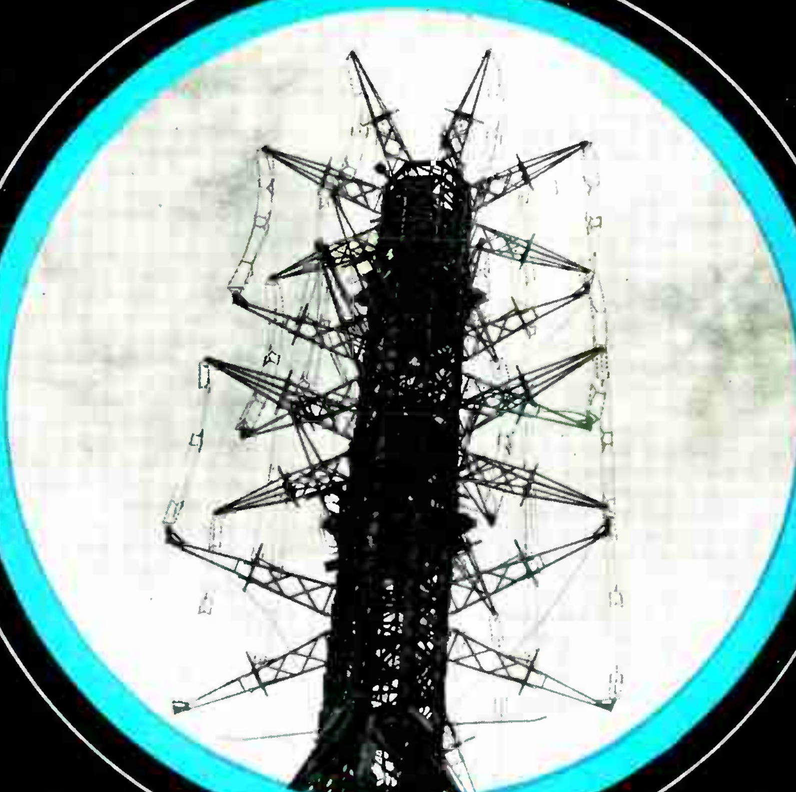
Wireless World

RADIO and ELECTRONICS



APRIL 1946

1/6

Vol. LII. No. 4

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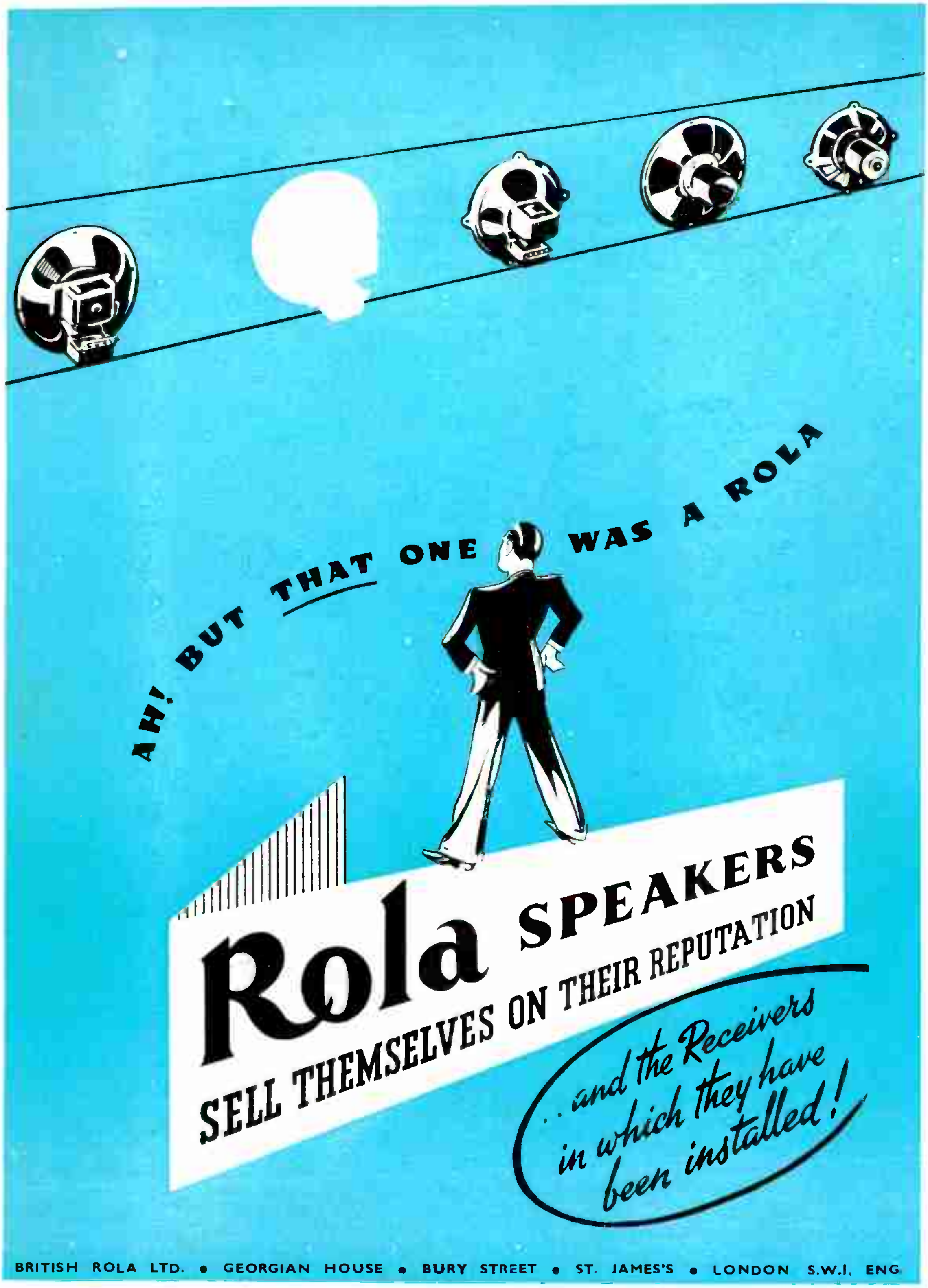
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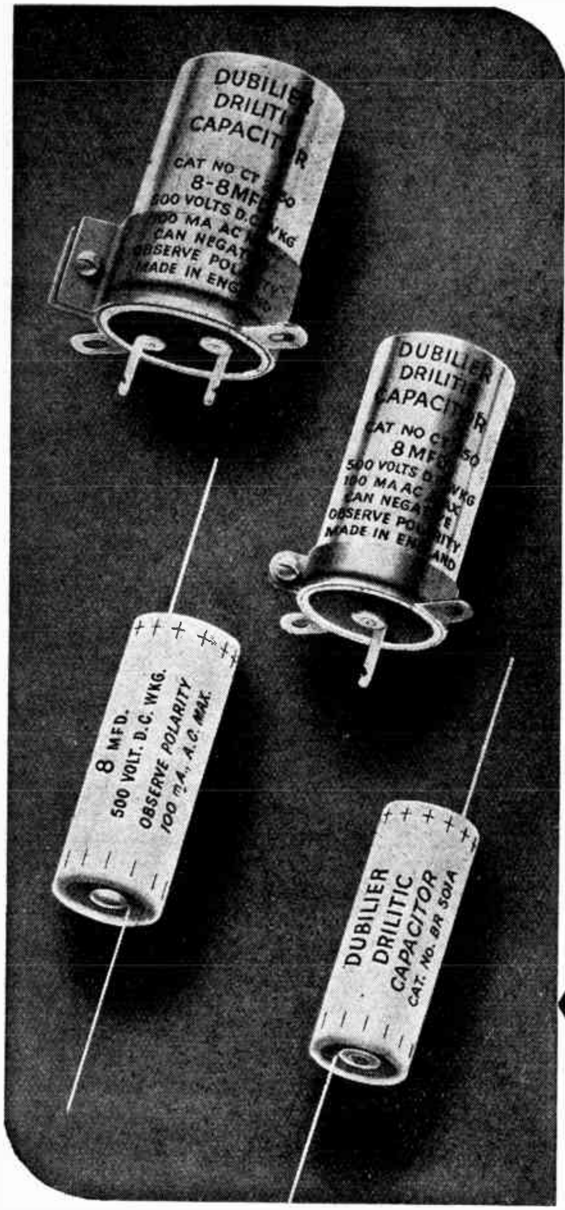

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8	150	5/8	1½	110	BR815	2s. 9d.
8	500	3/4	2	100	BR850	4s. 0d.
8	500	1	2	100	CT850	4s. 6d.
16	500	1	2	110	CT1650	6s. 6d.
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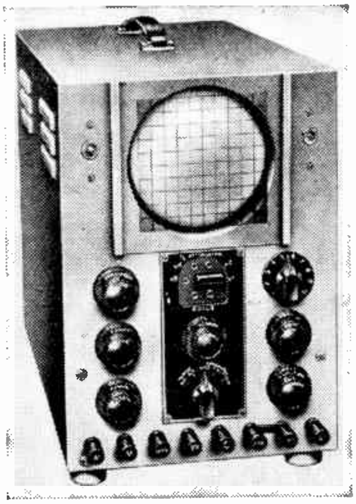

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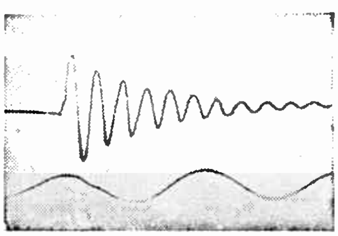

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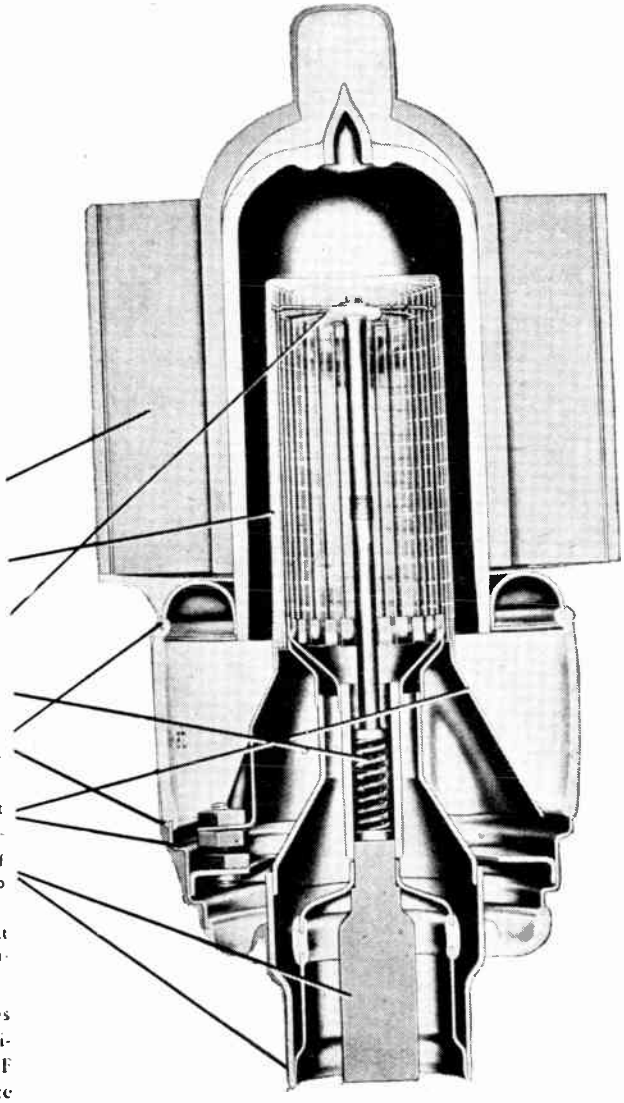

The external anode, conservatively rated at 2500 watts dissipation, has enclosed fins so as to facilitate the required forced air cooling.

Non-emitting vertical bar grid does not cause anode shadows ordinarily created by heavy supports in the grid structure.

Thoriated tungsten filament. Note unusually large filament area, and close spacing.

Filament alignment is maintained throughout life of the valve by special Eimac tensioning method.

New glass-to-metal seals do not have the RF resistance common to iron alloy seals, nor the mechanical weaknesses of the feather-edged types.

Grid ring terminal mounts a cone grid support which acts as a shield between plate and filament.

A coaxial filament stem structure forms the base of the valve. This makes possible proper connections to the filament lines.

Grid and filament terminal arrangements make it possible to install or remove the 3X2500A3 without the aid of tools.

The new mechanical and electrical features of the Eimac 3X2500A3 external anode triode make it valuable for use on the VHF as well as low frequencies. More complete data and information yours for the asking.

TYPE 3X2500A3 — MEDIUM MU TRIODE

ELECTRICAL CHARACTERISTICS

Filament: Thoriated Tungsten	
Voltage	7.5 volts
Current	48 amperes
Amplification Factor (Average) 20	
Direct Interelectrode Capacitances (Average)	
Grid Plate	20 μμfd
Grid Filament	48 μμfd.
Plate Filament	1.2 μμfd.
Transconductance (iB = 830 ma., EB = 3000 v.)	20,000 μmhos

1123

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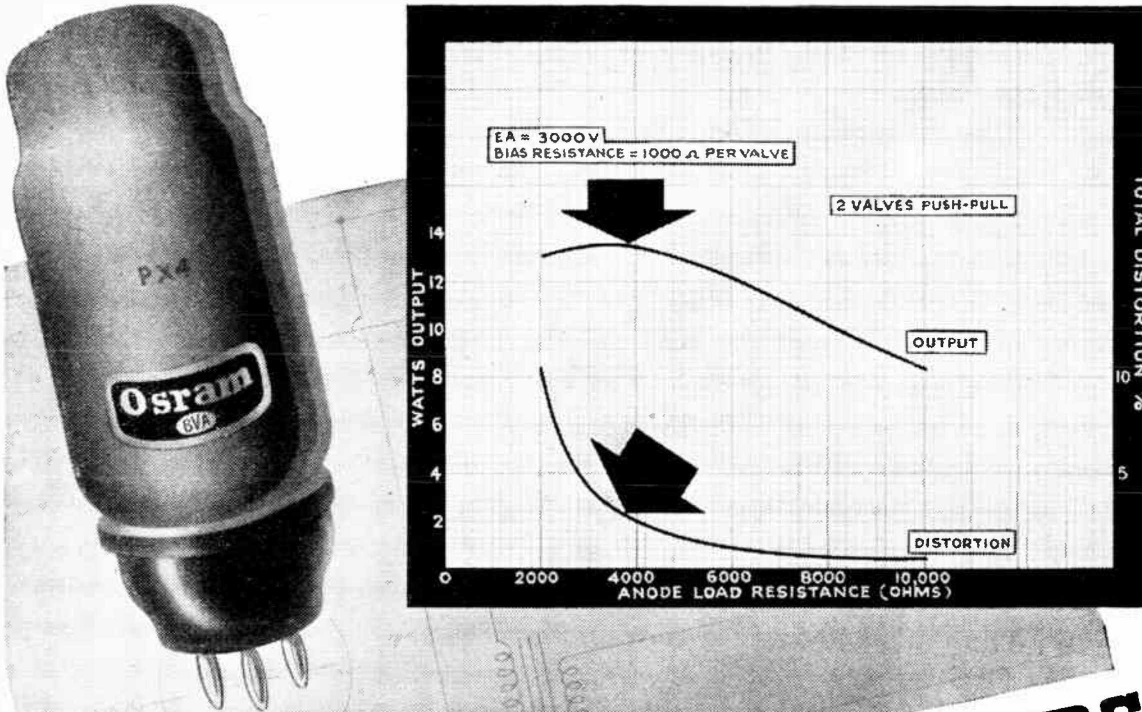

POINTERS FOR DESIGNERS

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A low impedance power triode, the OSRAM PX4 has achieved an almost unique popularity as an output valve (usually in push-pull pairs) for high quality Audio Frequency amplifiers at moderate power. Its outstanding features include :—

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- Very low harmonic content — only 2% distortion in push-pull at full output.
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A detailed technical data sheet is available on request.

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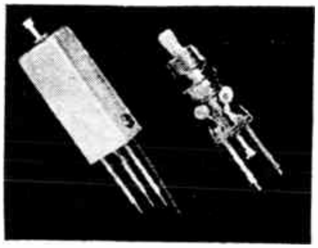

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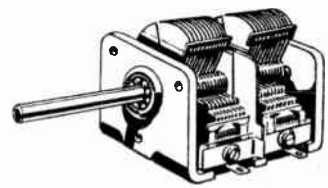

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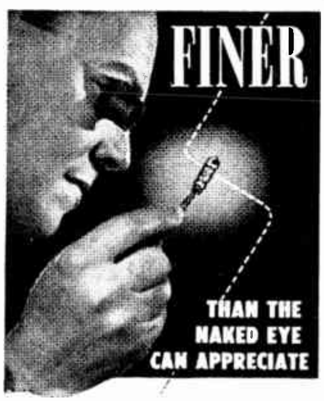

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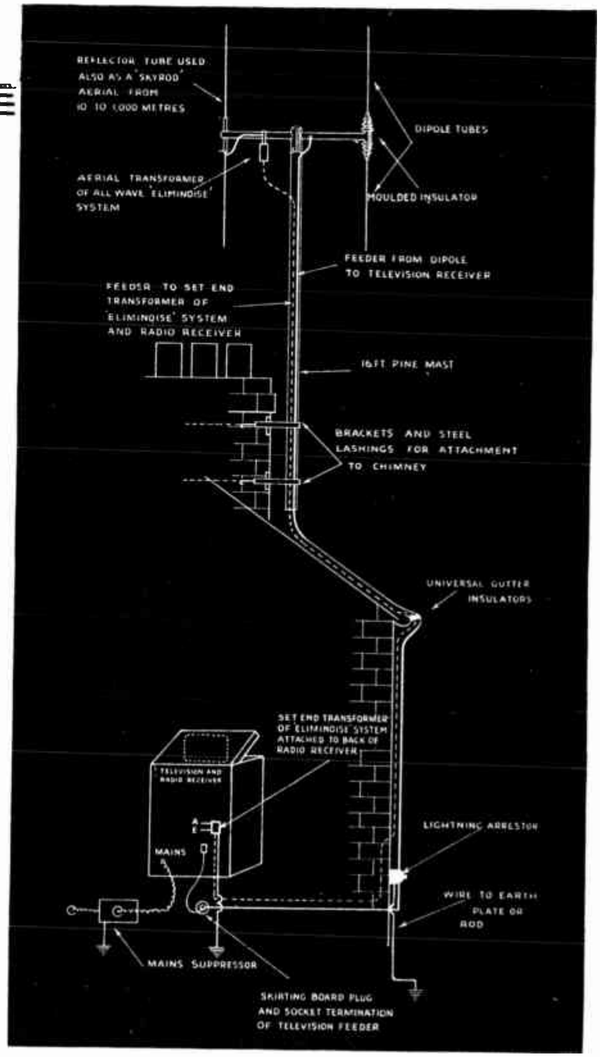

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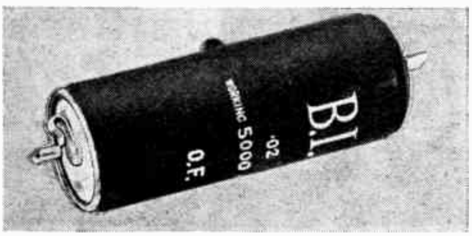

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Wireless World

Radio and Electronics

36th YEAR OF PUBLICATION

APRIL 1946

Proprietors:
ILIFFE & SONS LTD.

Managing Editor:
HUGH S. POCOCK, M.I.E.E.

Editor:
H. F. SMITH

Editorial, Advertising and Publishing Offices:
DORSET HOUSE,
STAMFORD STREET,
LONDON, S.E.1.

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As many of the circuits and apparatus described in these pages are covered by patents, readers are advised, before making use of them, to satisfy themselves that they would not be infringing patents.

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Wireless World

Radio and Electronics

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Monthly Commentary

Lessons from U.S.A.

AN article from a contributor in America, printed in this issue, gives food for thought, especially as it comes at a time when the new B.B.C. Charter is under consideration. Of course, there is no serious suggestion at the present time that we should adopt the American system of financing broadcasting by advertising revenue, but, in spite of the wide difference between conditions in the two countries, we here can learn something from the problems of transition from war to peace which are facing broadcasting in the U.S.A. At the start, one conclusion is inescapable; in that country so many conflicting financial and commercial considerations come into operation that purely technical factors must play a secondary part.

In America the over-riding consideration is "how can the public be made to pay for any technical development?" Here the problem is much simpler; having decided that a certain development is in the public interest, it can be put into use at once, provided B.B.C. revenue is sufficient. On these latter grounds there should be little difficulty; a correspondent whose letter is published elsewhere in this issue makes a good case in support of the opinion that the projected £1 licence fee should provide a large surplus of revenue. Even in 1937 there was no difficulty in financing a full-dress television service—which is still "around the corner" in America.

Arguing on the same lines, there seems no reason why we should not have ultra-short-wave broadcasting quite soon. The eternal problem of the chicken and the egg need not worry us; the service could be started without waiting for listeners to equip themselves with special receiving equipment before the transmissions start. But before we are committed to this new venture we should like to know a little more about the uses to which U-S-W broadcasting might profitably be put.

Many responsible critics of British broadcasting urge that one of its weaknesses is over-centralization; that new life would be infused into it if we were to have a multiplicity of stations catering for local groups and for listeners with rather specialised interests. Though we hear such views with respect, we are far from convinced that they are correct. Broadcasting of any kind—certainly medium-frequency broadcasting—seems a most unsuitable medium of distribution for material of merely parochial interest. On purely technical grounds, U-H-F, with its restricted range, is more suitable, but even here we think that the whole idea is out of sympathy with the true concept of radio distribution. But in this matter, again, we might learn much from studying the activities of the American low-powered "small-town" stations. It is perhaps significant that the number of such independent stations (not taking network programmes), seems to be declining.

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B.B.C. and Government

TIMIDITY is widely held to be an inherent shortcoming of a public-service corporation like the B.B.C. The fear of giving offence overrides the desire to please. Although that weakness can be exaggerated, we believe that it is responsible for a certain colourlessness in the way that the B.B.C. handles many highly controversial topics, particularly those of a political nature. It has long been considered abroad that the Corporation reflects the views of the British Government; not unnaturally, that opinion has been strengthened by the effects of the war, during which a large measure of official control was inevitable. As a result, it is necessary to consider both the susceptibilities of the home listener and the probable reactions of the foreigner to something that the latter will certainly regard as Government-inspired. The programme director would be rather more than human if he always resisted the urge to play for safety.

To some extent the matter is just another regrettable hangover from the war. But it goes rather deeper than that, and we hope that the new B.B.C. Charter will emphasise the principle of freedom of expression for broadcasting.

Post-War Components—
sures silent operation. Mumetal screened microphone transformers suitable for single-hole chassis mounting are made by this firm, and also by Parmeko.

Woden screened microphone transformer.

A very wide range of transformers and chokes is offered by Parmeko. Type 5080 is designed for radio receivers and small amplifiers and includes power transformers from 15 to 250 VA, chokes and audio output transformers handling up to 65 watts of A.F. power. In the Type 5081 series the power transformers are rated up to 2 kVA and the output or modulation transformers up to 750 watts. Small power transformers up to 15 VA for pilot bulbs, etc., are included in the 5082 range which is primarily an audio-frequency group comprising intervalve transformers, microphone input transformers, tone control and small smoothing chokes. Finally, the Types 5084 and 5085 are set manufacturers' components for sub-chassis wiring with power handling capacities from 4 to 60 VA.

The "Astronic" interlock coil winding bobbins produced by Associated Electronic Engineers provided a wide choice of sizes for transformer manufacturers. No cement is used and the cheeks are locked mechanically to the centre former. For export the bobbins can be packed flat, when they occupy only one sixth of their normal volume. Pressed steel clamping assemblies are also available and the firm produces a range of complete transformers using these components in sizes from 5 VA to 5 kVA.

An interesting miniature output transformer suitable for use in personal portable sets has been added to the range of "Hyperloy" transformers made by Wright and Weaire.

Chassis Fitments. — Metal chassis manufacture demands considerable skill and knowledge of the behaviour of metals. This work is one of the specialities of J. and H. Walter, who manufacture chassis of all kinds in steel, aluminium, copper and brass.

Specialised items of presswork and stampings and the host of small parts used in the manufacture of radio apparatus and components are produced for the radio industry by Carr Fastener.

That metal cabinets for housing such apparatus as PA amplifiers, battery chargers, laboratory gear and test equipment need not be unattractive is very conclusively proved by the modern designs prepared and manufactured by Alfred Imhof.

Retaining devices for holding valves firmly in their holders are now becoming generally available. Those made by Electrothermal Engineering are fabricated from woven glass material, plastics and steel springs, while a simple saddle-type retainer is produced by Long and Hambly. This firm also make rubber and synthetic rubber masks and supports for CR tubes, rubber grommets and a variety of rubber- and metal-bonded items, some of which are for use as shock-proof mountings.

A metal base retainer is now made by Belling-Lee for the all-glass type valves such as the EF50.

Plugs and Sockets.—There has been a general improvement in the resilience characteristics of the materials employed in plugs. The new ceramic co-axial models developed by Belling-Lee are of the type used as R.F. outlets on H.F. and V.H.F. receivers and transmitters. They are fully screened and designed for use with solid dielectric and air-spaced cables.

Examples of the miniature types are included among Clix, Belling-Lee and Bulgin products.

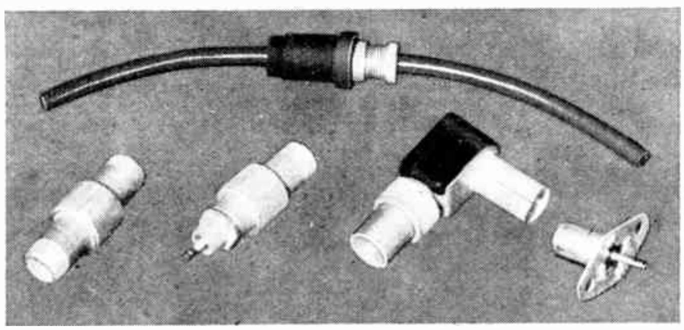
Valveholders.—The main improvements effected to valveholders are in manufacture and have been directed to increasing the resilience in the sockets and decreasing the contact resistance, sometimes by the use of silver-plated springs.

These features are now to be found in all the latest Clix, Belling-Lee and Celestion models.

The chassis style is now almost universal, and high-grade insulators, such as ceramics and silica-loaded polystyrene are now being pressed into service for valveholder plates, the last mentioned being used for the B9G 9-pin models made by Clix.

The Belling-Lee range also includes a 9-pin model for the new all-glass valves, as well as special types of top-cap connectors of anti-corona design.

Switches.—The trend of switch development is by no means obvious on a casual inspection for it is confined more to details than to the general form. A better understanding of the metallurgical problem involved in contact design has led to improvements in the materials employed, with the result that springy contacts can be relied upon to retain their springiness for longer periods.



Selection of Belling-Lee co-axial plugs and sockets.

In general form the switches fall into three categories. There are the rotary stud switches employed chiefly in attenuators and high-grade potentiometers. The developments here are the adoption of a floating mounting for the wiper arm and the use of contact studs moulded into the insulant to avoid their loosening with age.

The well-known Q.M.B. switches are now commonly made with open sides, permitting access to the interior for cleaning.

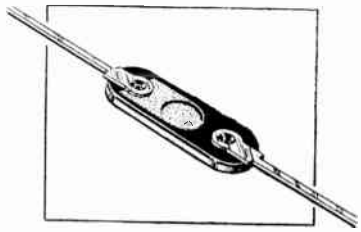
Rotary wafer-type switches are now almost universally employed for wave-band switching and in appearance are little, if any, different from the pre-war patterns. Detailed improvements in materials have been made, however, and the types now in production should give much better service.

Some near-miniature types are made and should find great application in compact equipment. Push-button operated types, too, are made with a great variety of contact arrangement and are finding their way into test equipment as well as broadcast sets.

Cables and Wires.—By reason of the bright and clean colours in which it is obtainable, the most striking of the new radio materials is connecting wire with polyvinyl - chloride insulation. This plastic is remarkable in being unaffected by water, salt solutions, inorganic acids and alkalis, and oils. It will also withstand a wide range of temperature. The exact figures vary somewhat with the grade but a typical range is $-25°$ C to $+70°$ C.

P.V.C., as it is usually abbreviated, is now very commonly used for insulated connecting wires and is made with both solid and flexible conductors. It is also frequently employed as an outer protective covering for coaxial cables. Most of the wire and cable manufacturers now adopt this insulant. Although it is also made in the form of insulating sleeving, the older fabric types of sleeving are by no means dead, and silk-base tubing in both tropical and non-tropical grades is made by Symons in sizes ranging from 0.75 mm bore.

For radio-frequency cables the most usual insulant is now polyethylene, which is available under various trade names, such as Polythene and Telcothene. The coaxial type is probably the most widely used, but twin screened feeders are also made. A solid or stranded centre conductor is embedded in polyethylene which is surrounded by the outer conductor. In the non-flexible types this takes the form of a lead sheath, but in the flexible it is copper-braiding covered by P.V.C.



Standard Telephones Uniplate selenium rectifier.

The twin types have two conductors embedded in polyethylene and the whole is usually covered with a copper-braided screen. The impedance is around 70 ohms for coaxial and about 80-130 ohms for the twin types.

Cable development has not been confined to the communications and radar patterns, for special kinds are now made for radio-heating purposes. B.I.-Callender's, for instance, produce a water-cooled coaxial cable in which the centre conductor is a tube carrying the cooling water. The main purpose of this is to convey the water to the work circuit in a neat and tidy manner rather than to cool the cable itself, although the cable may be expected to heat up somewhat since it carries up to 300 A.

For some applications, particularly on centimetre waves, special cable connectors are needed to avoid an impedance mismatch. These are obtainable in moulded polyethylene from the cable manufacturers.

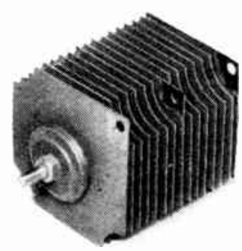
Protected moulded rubber junction sleeves are available for more ordinary purposes from Hellerman Electric, who also have special tools for use with them.

Metal Rectifiers.—An entirely new range of small selenium rectifiers, described as the Sentercel Uniplate series, has been introduced by Standard Telephones. Their main application is in A.F. and V.F. circuits, but there are also assemblies for incorporating in measuring instruments. Four sizes are available, with ratings of 1 to 40mA. Television and CRT types are also included in the Sentercel series.

To the Westinghouse range of Westalite selenium rectifiers has now been added some new models designed primarily for use in A.C./D.C. apparatus. They are half-wave rectifiers, and are intended to be used in the same manner as a valve rectifier. Three sizes are made with current handling capacities of 30, 60 and 120mA.

Vibrators.—Vibrators were, of course, well-known before the war when they provided the standard means of obtaining the H.T. supply in car sets. They have been widely used by the Services and considerable detail development has taken place which has resulted mainly in increased reliability. These improvements have been chiefly in spring and contact materials and in methods of manufacture.

Six-volt and 12-volt types are the most common, but the Wimbledon Engineering Co., include 24-volt types in their range. All types have a maximum input current rating of 5A, so that the power rating is proportional to the input voltage.

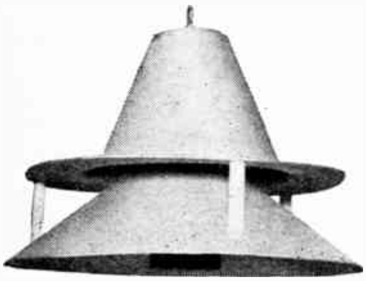


Westalite AC/DC rectifier, Type HT 250/120.

British N.S.F., the Plessey Co., and Wright & Weaire also market ranges of vibrators; this last film also produces a Vibrapower unit, consising of a transformer, vibrator socket and the RF filtering.

Loudspeakers. — The phenomenal performance of modern

Post-War Components—
magnet steels has influenced the design of loudspeakers in many ways, not the least important

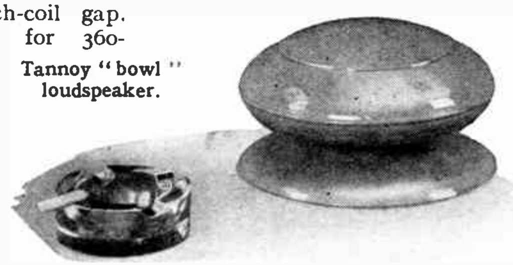


"Circorn" loudspeaker unit (Film Industries).

being the reduction in physical size. Goodmans are producing a range of 5-in and 6-in shallow-angle moving coil units for midget and car radio sets which take up little more space than a saucer. At the other end of the scale they have a series of cinema and PA speakers up to 18-in diameter and 50 watts power handling capacity in which the permanent magnets are little heavier than those required for pre-war 10- or 12in cones.

In some of the Celestion loudspeakers using the new magnet steels it had been found possible to dispense with clampiug bolts for the magnet end-plates; deliberate mishandling fails to produce the slightest relative movement between the parts. Celestion have also designed a system of dust-proofing which permits an air relief behind the corrugated centring diaphragm. By flanging the relief holes and disposing them correctly it has been found possible to trap all magnetic dust particles before they can find their way into the speech-coil gap.

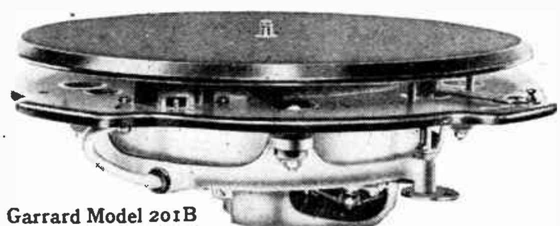
New loudspeakers for 360-degree sound distribution have been introduced. In the Tannoy Type LS/394/CIR bowl loudspeaker the unit is mounted in an ellipsoidal casing suspended from a cone reflector and can be quickly detached for inspection or cleaning. Two standard sizes are available with 4-in and 8-in units respectively. In the Film Industries "Circorn" the efficiency of horn loading has been combined with 360-degree radiation.



Tannoy "bowl" loudspeaker.

Gramophone Equipment.—The range of Garrard gramophone motor units has been extended and now includes a heavy duty transcription motor—model 201B. This is a governor-controlled induction motor which can be run at 78 or 33⅓ rpm. Special precautions have been taken to ensure constancy of speed, and the main thrust bearing is an optically-finished ball race. The motor windings are designed to reduce stray fields. A 12-in turntable is used, but there is a model with an extended speed indicator plate for 16-in discs.

The Garrard Model V radiogram units employ a new coil spring suspension designed to eliminate acoustic feedback. The Model RC60 record-changer plays up to eight mixed records, the time of the record-changing cycle being only six seconds.



Garrard Model 201B transcription motor.

A record-changer of unusual design was shown by Plessey. In this the records are stacked on retractable pawls on a vertical centre spindle of simple design.

Cosmocord are now supplying piezo-crystal recording cutters in addition to a range of magnetic and crystal pick-up reproducing heads and tone arms.

Materials.—One of the most obvious developments is in the increasing use of ceramic materials. At one time confined almost entirely to aerial insulators, ceramics now find wide application to small pressed insulators of nearly every kind. They are used for supporting the stators of variable capacitors, and, in a few cases, for insulating the rotors also; for the bases of trimming capacitors and switch plates; for valveholders and coil formers, to mention only a few of their applications.

They are now widely employed as the dielectric in small capacitors and different types are obtainable giving either positive or negative temperature coefficients of capacitance. The latter are commonly used in oscillator circuits to offset the normal positive coefficient and give to the circuit as a whole a zero coefficient. Whereas the positive coefficients of ceramic materials are in the neighbourhood of $100\text{-}300 \times 10^{-6}$ per °C, the negative are around -800×10^{-6} per °C.

Inductances are obtainable in which the "wire" consists of a metal coating fired on to a ceramic former. This same technique is adopted for sealing elements. A bush has a deposited metal coating and can be soldered in place.

As an alternative, metal-glass seals for hermetically sealed components are coming into favour. In these a bead of glass carries a lead-through wire and an external metal flange, both of which are sealed to the glass by a technique similar to that adopted by the valve manufacturer. The flange is soldered into a hole in the metal case of the component. Ferranti have a copper-glass seal, other firms have Kovar-glass types, and T.C. & M. Co. use Telcoseal—a material developed for this work.

The older insulators have by no means been ousted by the latest developments and many of them have been considerably improved. Mycalex, for instance, is not only easily machined, but can now be moulded. It is a mica-glass compound which will withstand temperatures up to 400° C without deformation. Micanite consists of mica splittings bonded with insulating cement and is obtainable in large sheets and in flexible form. It can also be moulded.

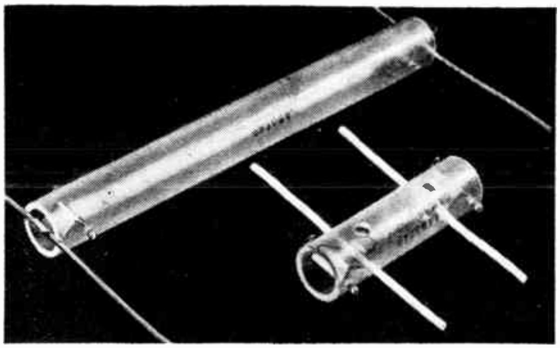
For that most important process in all wireless assembly, soldering, the use of resin-cored solder is now very common. It is usual to employ an activated form of resin, but different forms of core and different solder alloys themselves are available to suit various kinds of work. Multicore Solders produce a solder having three cores of Ersin flux, but most firms adopt a single core. Dubois and B.I.-Callender's both manufacture the latter, and B.I.-C. also market a range of fluxes separately.

In discussing switches it was said that one of the improvements had been in the spring material. One of these materials is beryllium copper, an alloy which becomes as hard as steel with suitable heat treatment. Its outstanding quality is its fatigue strength, particularly under corrosive conditions, but it also has high wear resistance when running against hard steel; making it particularly useful for cams. It is produced by T.C. & M. Co. who also manufacture the well-known magnetic alloys, Radiometal, Mumetal and Rhometal.

Magnetic & Electric Alloys also produce Mumetal and Rhometal as well as Laminic and Permalloy, and various types of Silcor and Vicor among the silicon alloys.

Permanent magnets have undergone great strides in recent years and some alloys now have phenomenal characteristics. The Mullard Ticonal, for instance, has a saturation value of B of 17,000 gauss and a normal working value of 10,000 gauss.

Aerial Equipment.—Active preparations are being made for the resumption of the television service and many reflector dipole aerials are now available. The "Aerialite" adjustable universal reflector makes use of flexible cable conductors stretched on a diagonal wooden frame. The advantage is that the length can be adjusted easily to any required wavelength present or future.



Transmission line spreaders (Labgear).

In the "Antiference" television dipole, Type WD3R, a simple swivel mounting facilitates the work of erection. The dipole elements are detachable and the various parts can be taken up the ladder in easy instalments.

A 50-ft. "Skytower" lattice mast has been designed by Belling and Lee for mounting their "Skyrod" aerials. The lattice structure is of galvanised steel and is divided electrically by porcelain compression insulators.

For amateur transmitters, Labgear have introduced a rotatable beam antenna suitable for mast mounting. Reflector and director elements are placed on either side of the dipole which is folded to compensate for the change of impedance introduced by the parasitic elements. Spreaders for spaced transmission lines are another new product of this firm. They are made from light extruded tubing of low-loss insulating material and are provided with snap-action clips for ease of assembly.

LIST OF MANUFACTURERS

Showing at R.C.M.F. Exhibition

A.B. Metal Products, Ltd., Hatton Works, Feltham, Middx.
Aerialite, Ltd., Castle Works, Stalybridge, Cheshire.
Aeronautical & General Instruments, Ltd., Purley Way, Croydon, Surrey.
Antiference, Ltd., Plender Place, Plender Street, London, N.W.1.
Associated Electronic Engineers, Ltd., Dalston Lane, Stanmore, Middx.
Associated Technical Manufacturers, Ltd., Vincent Works, New Islington, Manchester, 4, Lancs.
Automatic Coil Winder & Electrical Equipment Co., Ltd., Winder House, Douglas Street, London, S.W.1.

Belling & Lee, Ltd., Cambridge Arterial Road, Enfield, Middx.
Bird, Sydney S., & Sons, Ltd., Cambridge Arterial Road, Enfield, Middx.
Bray, Geo., & Co., Ltd., Leicester Place, Blackman Lane, Leeds, 2, Yorks.
British Electric Resistance Co., Ltd., Queensway, Ponders End, Middx.
British Electrolytic Condenser Co., Ltd., 52, Vicarage Lane, Ilford, Essex.
British Insulated Callender's Cables, Ltd., Surrey House, Embankment, London, W.C.2.
British Mechanical Productions, Ltd., 1, Church Road, Leatherhead, Surrey.
British N.S.F. Co., Ltd., Dalton Mill, Dalton Lane, Keighley, Yorks.
British Rola, Ltd., Georgian House, Bury Street, London, S.W.1.
Bulgin, A. F., & Co., Ltd., By-pass Road, Barking, Essex.
Bullers, Ltd., The Hall, Oatlands Drive, Weybridge, Surrey.

Carr Fastener Co., Ltd., Nottingham Road, Stapleford, Notts.
Celestion, Ltd., London Road, Kingston, Surrey.
Colvern, Ltd., Mawneys Road, Romford, Essex.
Cosmocord, Ltd., 700, Great Cambridge Road, Enfield, Middx.

Daly (Condensers), Ltd., West Lodge Works, The Green, London, W.5.
Dubilier Condenser Co. (1925), Ltd., Ducon Works, Victoria Road, N. Acton, London, W.3.
Du Bois Co., Ltd., 15, Britannia Street, Kings Cross, London, N.W.1.
Duratube & Wire, Ltd., Faggs Road, Feltham, Middx.

Electrothermal Engineering Co., Ltd., 270, Neville Road, London, N.7.
ERG Resistors, Ltd., 1021a, Finchley Road, London, N.W.11.
Erie Resistors, Ltd., Carlisle Road, The Hyde, London, N.W.9.

Ferranti, Ltd., Hollingwood, Lancs.
Film Industries, Ltd., 60, Paddington Street, London, W.1.
Fox, P. X., Ltd., No. 2 Factory, Hawksworth Road, Horsforth, Yorks.

Garrard Engineering & Manufacturing Co., Ltd., Newcastle Street, Swindon, Wilts.
Goldsman, J. L., Ltd., 5, Torrens Street, City Road, London, E.C.1.
Goodmans Industries, Ltd., Lancelot Road, Wembley, Middx.

Hellerman Electric Co., Ltd., Goodtric Works, Brewer Street, Oxford.
Hunt, A. H., Ltd., Bendon Valley, Garratt Lane, London, S.W.18.

Imhof, Alfred, Ltd., 112/6, New Oxford Street, London, W.C.1.

Post-War Components—

Jackson Bros. (London), Ltd., Kingsway, Waddon, Surrey.

Labgear, Ltd., Willow Place, Fair Street, Cambridge.
London Electrical Manufacturing Co., Ltd., 459, Fulham Road, London, S.W.6.
Long & Hambly, Ltd., 51, Highgate Hill, London, N.19.

Magnetic & Electrical Alloys, Ltd., 101/3, Baker Street, London, W.1.
Micanite & Insulators Co., Ltd., Empire Works, Blackhorse Lane, London, E.17.
Morgan Crucible Co., Ltd., Battersea Church Road, London, S.W.11.
Mullard Wireless Service Co., Ltd., Century House, Shaftesbury Avenue, London, W.C.2.
Multicore Solders, Ltd., Commonwealth House, New Oxford Street, London, W.C.1.
Mycalex & Co., Ltd., Ashcroft Road, Cirencester, Glos.

Painton & Co., Ltd., Kingsthorpe, Northampton.
Parmeko, Ltd., Percy Road, Aylestone Road, Leicester.
Plessey Co., Ltd., Vicarage Lane, Ilford, Essex.

Reliance Electrical Wire Co., Ltd., Staffa Road, Leyton, London, E.10.
Reliance Manufacturing Co. (Southwark), Ltd, Sutherland Road, Higham Hill, London, E.17.
Reproducers & Amplifiers, Ltd., Frederick Street, Wolverhampton, Staffs.
Ripaults, Ltd., Southbury Road, Enfield, Middx.

Sifam Electrical Instrument Co., Ltd., Leigh Court, Hr. Lincombe Road, Torquay, Devon.
Spicers, Ltd., 19, New Bridge Street, London, E.C.4.
Standard Telephones & Cables, Ltd., Connaught House, Aldwych, London, W.C.2.
Static Condenser Co., Ltd., Toutley Works, Wokingham, Berks.
Steatite & Porcelain Products, Ltd., Stourport-on-Severn, Worcs.
Stratton & Co., Ltd., 2/5, Station Street, Birmingham, 5.
Symons, H. D., & Co., Ltd., Park Works, Kingston Hill, Surrey.

Tannoy Products (Guy R. Fountain), Ltd., Canterbury Grove, London, S.E.27.
Taylor, Tunnicliffe & Co., Ltd., 124, High Holborn, London, W.C.1.
Telegraph Condenser Co., Ltd., Wales Farm Road, North Acton, London, W.3.
Telegraph Construction & Maintenance Co., Ltd., 22, Old Broad Street, London, E.C.2.
Telephone Manufacturing Co., Ltd., Hollingsworth Works, W. Dulwich, London, S.E.21.

United Insulator Co., Ltd., 12/20, Laystall Street, London, E.C.1.

Varley Dry Accumulators, Ltd., By-pass Road, Barking, Essex.
Varley (Oliver Pell Control, Ltd.), Cambridge Row, Woolwich, London, S.E.18.

Walter Instruments, Ltd., Exhibition Buildings, Earls Court, London, S.W.5.
Walter, J. & H., Ltd., 2, Caxton Street, London, S.W.1.
Wego Condenser Co., Ltd., Bideford Avenue, Perivale, Middx.
Welwyn Electrical Laboratories, Ltd., 70, Bridge Road East, Welwyn Garden City, Herts.
Westinghouse Brake & Signal Co., Ltd., 82, York Way, Kings Cross, London, N.1.
Wimbledon Engineering Co., Ltd., Garth Road, Lower Morden, Surrey.
Wingrove & Rogers, Ltd., Broadway Court, Broadway, London, S.W.1.
Woden Transformer Co., Ltd., Moxley Road, Bilston, Staffs.
Wright & Weaire, Ltd., 740, High Road, Tottenham, London, N.17.

CLASSIFIED LIST OF PRODUCTS

Shown at R.C.M.F. Exhibition

Aerial Equipment. Aerialite; Antiference; Belling-Lee; Labgear; Ripaults; T.C. & M.

Alloys. Magnetic & Electrical Alloys; T.C. & M.

Attenuators. Aeronautical & General; Labgear; Painton.

Bobbins. Associated Electronic Engrs.

Cables and Wires. Aerialite; Associated Tech. Mfrs.; B.I.-Callenders; Duratube; Reliance Electrical Wire; Ripaults, Standard Telephones; T.C. & M.

Capacitors, Fixed. British Electrolytic Condenser; B.I.-Callenders; British N.S.F.; Bulgin; Daly; Dubilier; Erie; Ferranti; Hunt; London Elect. Mfg.; Mycalex; Static Condenser; T.C.C.; T.M.C.; United Insulator; Wego.

Capacitors, Variable and Pre-set. Aeronautical & General; Sydney Bird; Erie; Jackson; Labgear; Mullard; Plessey; Stratton; United Insulator; Walter Instruments; Wingrove & Rogers.

Ceramics. Geo. Bray; Bullers; Steatite; Taylor, Tunnicliffe.

Chassis. Imhof; J. & H. Walters.

Chokes, Iron-cored. Aeronautical & General; Bulgin; Ferranti; Labgear; Parmeko; Plessey; Reproducers & Amplifiers; Stratton; Varley; Wright & Weaire.

Chokes, R.F. Aeronautical & General; Bulgin; Labgear; Plessey; Stratton; Varley; Wright & Weaire.

Coils, R.F. and I.F. Aeronautical & General; Bulgin; Labgear; Plessey; Stratton; Varley; Wright & Weaire.

Connectors. Belling-Lee; British Mechanical Productions; B.I.-Callenders; Bulgin; Carr Fastener.

Crystals, Quartz. Standard Telephones.

Ear Phones, Crystal. Cosmocord.

Fuses and Fuseholders. Belling-Lee; British Mechanical Productions; Bulgin; Carr Fastener.

Gramophone Motors, Units, Record Changers. Garrard; Plessey.

Instruments, Measuring and Test. Automatic Coil Winder; Ferranti; Labgear; Sifam.

Insulators. Belling-Lee; Geo. Bray; Bullers; Steatite; Stratton; Taylor, Tunnicliffe.

Insulating Materials and Sleeving. Associated Tech. Mfrs.; Duratube; Hellerman; Long & Hambly; Micanite; Mycalex; Spicers; Symons; T.C. & M.

Interference Suppressors. Antiference; Belling-Lee; Dubilier; Morgan Crucible.

Jacks. Bulgin; Plessey; T.M.C.

Laminations, Iron-core. British Rola; Magnetic & Electrical Alloys; T.C. & M.

Loudspeakers. British Rola; Celestion; Film Industries; Goodmans; Plessey; Reproducers & Amplifiers; Tannoy.

Magnets, Permanent. Mullard.

Microphones. Cosmocord; Film Industries; Tannoy.

Pick-ups. Cosmocord; Garrard.

Plugs and Sockets. Belling-Lee; British Mechanical Productions; Bulgin; Carr Fastener; Long & Hambly; Painton; Plessey; T.M.C.; Wright & Weaire.

Potentiometers and Rheostats. British Electric Resistance; British N.S.F.; Bulgin; Colvern; Dubilier; Erie; Fox; Goldsman; Morgan Crucible; Painton; Plessey; Reliance Mfg.; Varley, Welwyn Laboratories.

Recording Heads, Crystal. Cosmocord.

Rectifiers, Metal. Standard Telephones; Westinghouse.

Relays. Labgear; Standard Telephones; T.M.C.

Resistors, Fixed. British Electric Resistance; British N.S.F.; Bulgin; Colvern; Dubilier; Erg Resistors; Erie; Goldsman; Morgan Crucible; Mullard; Painton; Varley; Welwyn Laboratories.

Rubber, Moulded. Long & Hambly; Painton.

Solder. B.I.-Callenders; Du Bois; Multicore.

Switches. A.B. Metal Products; Aeronautical & General; British Electric Resistance; British N.S.F.; Bulgin; Painton; Plessey; T.M.C.; Walter Instruments; Wright & Weaire.

Thermal Switches and Cut-outs. Belling-Lee; Bulgin; Varley.

Thermostats. Electrothermal.

Transformers, A.F. Aeronautical & General; Associated Electronic Engrs.; British Rola; Bulgin; Celestion; Ferranti; Goodmans; Labgear; Parmeko; Plessey; Reproducers & Amplifiers; Varley; Woden; Wright & Weaire.

Transformers, I.F. and R.F. Bulgin; Labgear; Plessey; Stratton; Wright & Weaire.

Transformers, Power. Aeronautical & General; Associated Electronic Engrs.; Belling-Lee; Bulgin; Ferranti; Labgear; Parmeko; Plessey; Varley; Woden; Wright & Weaire.

Valve Bases, Holders, Top Connectors, etc. Aeronautical & General; Belling-Lee; British Mechanical Productions; Bulgin; Carr Fastener; Celestion; Electrothermal; Plessey; Stratton; United Insulator.

Valve Retainers. Belling-Lee; Electrothermal; Long & Hambly.

Vibrators. British N.S.F.; Bulgin; Plessey; Wimbledon Eng.; Wright & Weaire.

PULSE MODULATION

Important New Factor in Communications

By "CATHODE RAY"

A THING we are hearing about quite a lot nowadays, and will certainly hear much more about before long, is pulse modulation. When pulses are mentioned one tends to think, if not of doctors, then of radar. They also come, though incidentally, into television. They are beginning to come into radio communication of many different kinds, and that is what you may be finding rather confusing. Perhaps the best thing is to take a general view of the whole subject.

Until recently, "modulation" to most people has meant amplitude modulation of a carrier wave. It is the sort that has always been used by the B.B.C. In America it is now strongly challenged by frequency modulation, to which is closely related a third method —phase modulation. All of these have their counterparts in pulse modulation, so we had better be sure first of all that the distinctions between them are quite clear.

Fig. 1 (*a*) is how a brief sample of plain unmodulated carrier wave is represented. Below, at (*b*) is one cycle of a simple audio-frequency modulating wave. (In practice there are generally far more carrier-frequency cycles per audio-frequency cycle than are shown here, but one does get so tired of drawing them). Amplitude modulation of (*a*) by (*b*) is shown at (*c*). Deeper modulation, corresponding for example to sound of the same pitch but greater volume, is illustrated at (*d*). If the modulating waveform is more complicated than (*b*), the variations in amplitude of the carrier correspond. So far we are on familiar ground.

Frequency and phase modulation are more difficult to show clearly in an amplitude/time diagram, which may partly be why they are less generally understood. Phase modulation is represented by (*e*), and for convenience the unmodulated carrier (*a*) is repeated just below it, so that the phase shifts (that is to say the amounts by which the modulated cycles start earlier or later than they would if unmodulated) can be measured by the lengths of the horizontal kinks in the lines joining corresponding cycles. These phase shifts can be seen to be proportional to the varying height of the modulating waveform (*b*), it being conventionally assumed that distance *above* the base line in (*b*), and phase *advance* in (*e*), are *positive*; and vice-versa. The maximum phase displacement in (*e*) happens to be half a cycle, or 180 deg. To double the depth of modulation, all the phase shifts would have to be doubled, giving a maximum displacement of one whole cycle.

It is easy enough to guess that in frequency modulation the modulating waveform is made to vary the *frequency* of the carrier wave, instead of its amplitude or phase. Unfortunately, in the sort of diagram we have been using, frequency is not shown directly, but it can to some extent be estimated (Fig. 1 (*f*)) because frequency and phase are close relations. For example, if the frequency of a wave is raised by some fixed amount, a steadily increasing phase advance begins, and lasts as long as the frequency rise. The cycles are thus packed more closely. To anybody who has gone as far as the first few lessons of the Calculus, the relationship between phase and frequency shifts, such as those due to the correspondingly named methods of modulation, is something quite simple and definite: frequency shift is rate of change of phase shift, and, conversely, phase shift is frequency shift integrated with respect to time. But it is not at all necessary to have studied any calculus or be able to put the matter in these particular terms to see what

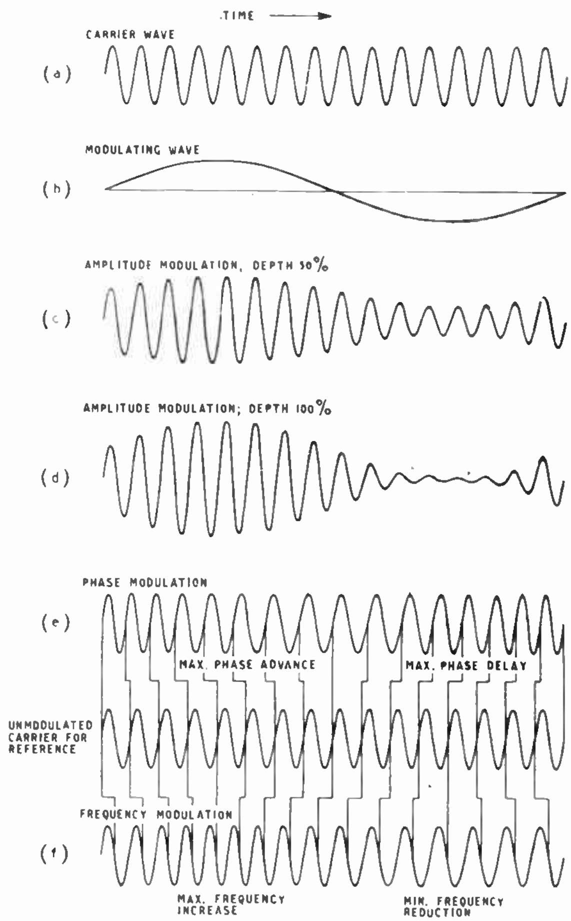


Fig. 1. Comparison of different ways of modulating a continuous carrier wave.

Pulse Modulation—

phase and frequency modulation mean. It is clear from Fig. 1 (*e*) and (*f*) that when either is present both must be, but they cannot both at the same time *correctly* represent the modulating waveform. For example, Fig. 1 (*e*) may be regarded as either phase modulation or frequency modulation: if the former, then it is an undistorted representation of the modulating waveform (*b*); if the latter, then it is a distorted representation of (*b*), but one could draw another waveform, of which it would be a faithful frequency-modulated version. I'm afraid that sounds rather involved, but I hope not too much so to follow.

Another important feature of phase and frequency modulation is that as the amplitude is normally constant the transmitter can work at full power all the time, and many of the things that cause distortion and noise in amplitude modulation receivers are avoided.

Readers (except, of course, you) have no doubt been thinking exclusively in terms of modulation derived from telephony, sound, speech, music or what you will. You, with exceptional perspicacity, have realized that Fig 1 (*b*) stands not only for these but for morse and other "on/off" signals. To emphasize the point, and also to give a further demonstration of the different

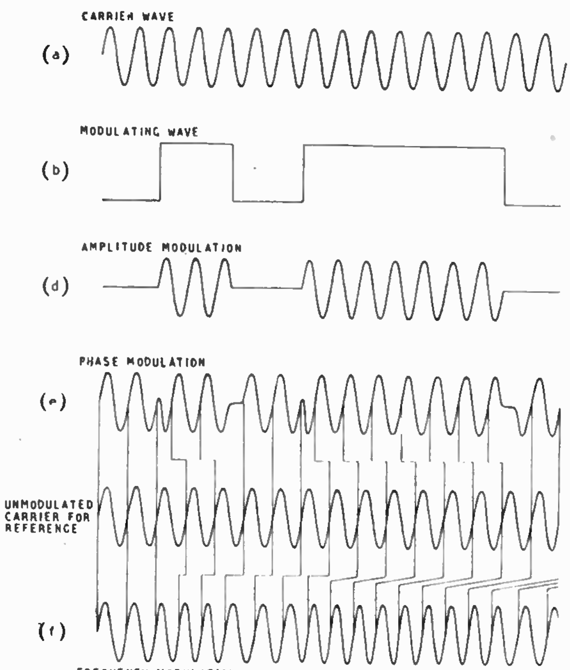


Fig. 2. The same series as in Fig. 1 but with a morse modulating waveform (*b*) instead of a single sine wave. (*c*) is omitted, because modulation by morse signals is almost invariably 100 per cent. Phase and frequency modulation are shown for comparison, but the latter is seldom used now for morse, and the former is of little or no practical importance. Note that as the modulating wave has a D.C. component a phase shift is likely to accumulate when the frequency is modulated.

sorts of modulation, the Fig. 2 series does for a morse "A" what Fig. 1 does for one audio frequency sine wave.

So much for the three main methods of modulating continuous carrier waves. For reasons which will be gone into soon, it is sometimes advantageous to complicate the issue by pulse modulation. This is not just a fourth name to add to the list of types of modulation we have already compiled, although it may sound like it. What makes things still more confusing is that "pulse modulation" has two meanings, which we shall consider presently, but first—what is a pulse? It is a very short-lived current or voltage, usually repeated at more or less regular and relatively long intervals. Fig. 3 (*a*) is a typical amplitude/time diagram of a train of pulses. There is general agreement that in order to qualify for the name "pulse" the ratio of length to period, p/P in Fig. 3 (*a*),

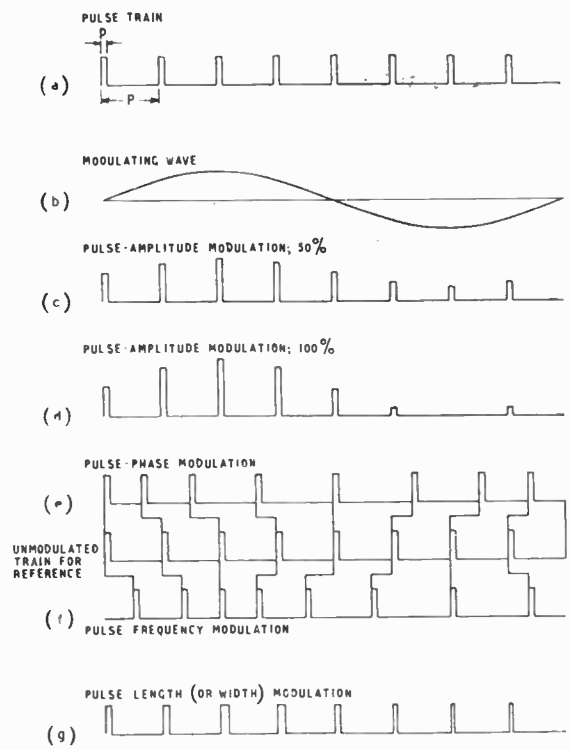


Fig. 3. All except the last of these ways of modulating pulses can be compared with modulation of a carrier wave in Figs. 1 and 2. Method (*g*) is used in the Pye system of combined vision and sound with a single transmitter.

must be "small," but so far as I know an official dividing line between pulses and, say, rectangular waves or morse dots has never been laid down. It is commonly of the order of 1 : 100 but may be much more or less.

In passing, it may be noted that both phase and frequency methods are less liable to *over*-modulation than the amplitude method, which suddenly reaches its limit when the amplitude touches zero as in Fig. 1 (*d*).

The number of pulses per second is the *pulse recurrence frequency.*

In the first meaning of pulse modulation a train of pulses such as is shown in Fig. 3 (*a*) is substituted for a train of high-frequency waves (Figs. 1 (*a*) or 2 (*a*)) as raw material available for modulation. Fig. 3 (*c* — *f*) corresponds with Fig. 1 (*c* — *f*) in showing the results of such modulation. These, and Fig. 3 (*g*) I will comment on later; in the meantime, according to the second meaning of pulse modulation a train of pulses (Fig. 4 (*b*)) is used to modulate our familiar continuous carrier wave (Fig. 4 (*a*)), the result being shown at (*c*). In this sense it is merely a case of amplitude modulation of a carrier wave, and Fig. 4 (*a* — *c*) corresponds with Figs. 1 and 2 (*a* — *c*), especially Fig. 2.

The products, Fig. 4 (*c*), are often called pulses, but this is asking for confusion with Fig. 4 (*b*). In the absence of any lead from authorities, I intend to call the things shown at (*c*) *wave pulses*.

Pulse modulation as illustrated in Fig. 4 is the sort used in radar, and calls for no further comment here. Pulse modulation as used in communications may be confined to what is shown in Fig. 3, but more often is a combination of the two, finally yielding modulated wave pulses. There are two ways of arriving at this result: either the modulated pulses shown in Fig. 3 (*c* — *g*) can be used in place of Fig. 4 (*b*) to modulate a carrier wave; or the uniform wave pulses, Fig. 4 (*c*), can be modulated. The latter method suffers from practical limitations, so the former is the one generally used; it is just a matter of design, anyway, so we are not going to bother about the processes of production but will concentrate on the final product—a series of wave pulses, modulated by the audio-frequency "intelligence" it is desired to convey.

Compared to the simpler modulated carrier wave, the modulated wave pulses may be considered to be the result of sampling, just as in a factory every hundredth unit (say) coming off a production line may be sent up for inspection. Such samples are taken to represent the bulk production, and any gradual changes ("modulation") in the dimensions or other qualities of the product are reflected in the samples. This procedure is justifiable (both in the factory and in the pulse modulator) provided that changes are not liable to occur rapidly between one sample and the next. Applied to modulation this means that it would never do for several cycles of the modulation frequency to occur between successive pulses; there would be nothing, in those great blank spaces, to represent them. In extreme cases, and with special care in design, it is possible for the pulse recurrence frequency to be not much more than double the modulation frequency, but things are easier if it is much greater.

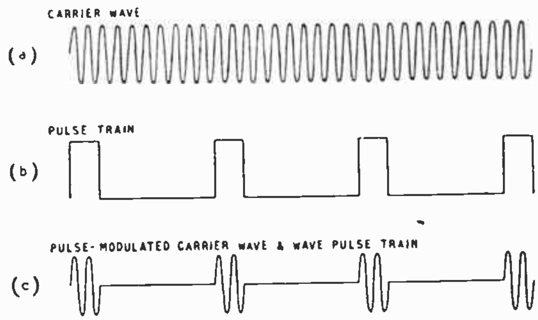


Fig. 4. Modulation of a carrier wave by pulses. In practice the relative frequency of the carrier wave is many times greater than shown, so that although the pulses are generally narrower each wave pulse seldom contains less than about 100 cycles.

When the modulated pulses are in turn used to modulate a carrier wave there must be another and even bigger step-up in frequency. Each wave pulse consists of carrier-frequency cycles, and in practice they cannot be made, like Venus, to start life full grown. When the transmitter is "switched on" by the pulse it takes a considerable number of cycles to build up to full amplitude, and a further number to die away at the end, besides the main body in between. It tends to be difficult if there are much fewer than a hundred cycles per pulse. Remembering that the periods between pulses may last a hundred or more times as long as the pulses themselves, we see that the carrier frequency may easily be of the order of 10,000 times the pulse frequency, which in turn is at least several times the *highest* modulation frequency. From this it appears that to handle speech or music by a pulsed carrier-wave system the carrier frequency is likely to be at least of the V.H.F. order. On the other hand, for morse signals, in which the highest modulation frequency is much lower, there is a wider choice for both pulse and carrier frequencies.

Summing up; you take the highest modulation frequency, multiply it by at least 2½ and preferably much more to get the pulse frequency, multiply that by the ratio p/P (Fig. 3 (*a*)) and again by the number of carrier cycles in tach wave pulse, and that gives ehe carrier frequency.

An alternative to the sampling way of looking at pulse modulation (and one that fits some cases better) is to imagine the continuous carrier to be swept up into heaps at regularly spaced intervals, like fallen leaves along an avenue. Any modulation that the original carrier carried will appear also in the heaps or wave pulses; again provided that the heaps are not spaced too widely in relation to the modulation frequency. Fig. 5, a picture of a row of heaps, tells us that the fall of leaves was below average at the left-hand end and above it at the right, but it cannot indicate the variations from tree to tree, because they are smoothed out in the sweeping process.

Now we shall examine the different ways in which pulses can be modulated. (It goes without saying that any of the rows of pulses in Fig. 3 can be supposed to represent *wave* pulses). First there is amplitude modulation (Fig. 3 (*c*) and (*d*)), which hardly needs explanation. The only thing you may be worrying about is what happens at the receiver. What about all the

Pulse Modulation—

long gaps in between the pulses? Well, of course, we have already stipulated that they must not be long in relation to the shortest cycles of music or morse or whatever is ultimately put out by the receiver, and therefore after the wave pulses have been rectified into pulses (Fig. 3 (*d*)) by the detector they can be smoothed out by a filter to yield a reconstituted modulation waveform (Fig. 3 (*b*)). In fact, there is nothing special about the receiver at all, unless the pulse frequency is near its lower limit, necessitating a rather more elaborate filter than one finds in the ordinary receiver.

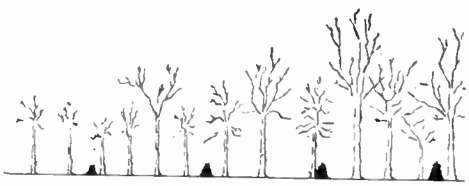


Fig. 5. The varying density of fallen leaves along an avenue is reflected in the relative sizes of the heaps when they are swept up at regular intervals, provided that the variations are gradual compared with the heap frequency.

Phase modulation, too (Fig. 3 (*e*)), corresponds closely with its continuous wave counterpart (Figs. 1 (*e*) and 2 (*e*)). As a matter of fact, it is easier to see in a diagram, because the pulses are more obvious " marks " than any points on sine waves. In practice, phase modulation may be arranged to make all the shifts *delays*, instead of as shown.

Pulse frequency modulation is shown at Fig. 3 (*f*). Unlike CW frequency modulation, it doesn't seem to have been used much, if at all; whereas the reverse situation exists with phase modulation. Although there is no law to the effect that in frequency modulation the variation in frequency must amount to many cycles per second each side of normal whereas in phase modulation the maximum variation must be less than one cycle, it generally seems to work out that way. There are technical reasons why wide variations of frequency suit CW systems and narrow variations of phase suit pulse systems.

Pulses can be modulated in a fourth way, not available to CW; it is shown in Fig. 3 (*g*). This is often called pulse *width*, but perhaps more appropriately pulse *length*, modulation. Our road sweeper, faced with gradual variations in leaf density, could deal with the situation either by making the evenly-spaced heaps of differing heights (amplitude modulation) or alternatively, adopting a standard height, could accommodate the varying quantities of leaves by corresponding variations in the lengths of the heaps. (He might also be intrigued by the problem of keeping the size of the heaps constant and adopting either phase or frequency modulation, but if so he would obviously be misemployed as a road sweeper.)

To dispel a possibly growing suspicion that all this is a mere outlet for doing simple things in a complicated way, it may be as well at this stage to consider the reasons why. There is no need to justify the use of wave pulses (unmodulated) in radar; it is fundamental to the echo method of range finding. The use of synchronizing pulses in television is equally obvious. But for communications, either morse or phone, which can quite well be done by modulating a carrier wave directly, it may seem an unnecessary complication to insert pulses as an intermediate stage. One reason for doing so is that the spaces between the pulses may be occupied by something else. A good example is the new Pye method of making one television transmitter do for both vision and sound.* In between successive lines of vision there is a short interval—10 microseconds to be exact—to allow the scanning beam to flash back to the beginning of the next line. This interval constitutes the line synchronizing pulse, but inside it there is room for a modulated pulse to carry the sound. Pulse length modulation (Fig. 3 (*g*)) is the type adopted, with a mean length of 3 microseconds, varying between 1 and 5 at maximum depth of modulation. To the receiver, these are equivalent to amplitude modulated pulses.

Another example is the Army Set Type 10†, in which the spaces in one set of speech-modulated pulses are interlaced with seven other sets, thus enabling eight conversations to go on at once over the same carrier wave. Pulse length modulation is again the favoured method. At the receiving end the sets of pulses have, of course, to be sorted out, but that is just a matter of routine circuitry.

The G.P.O. have been experimenting with a similar system but with pulse amplitude modulation‡.

All of these examples come into the category of *multiplex*; that is to say, methods of making one line or carrier wave bear several communications at once. Pulse multiplex is described as a *time allocation* system, because each communication gets the whole channel to itself in turn, like the three mythical sisters with only one eye between them, in contrast to *frequency allocation* systems, in which all share the same channel all the time but each must be on a different sub-carrier frequency.

Another reason for pulse modulation is that in the centimetre wave bands the available generators—principally magnetrons—like to work at full power or nothing, so do not lend themselves to amplitude modulation. Neither do they like frequency modulation. Pulse length modulation suits them admirably, however.

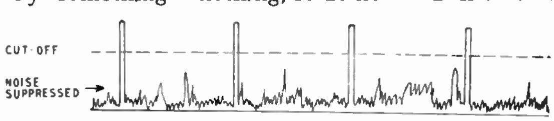


Fig. 6. Because pulses of very high intensity can be generated from moderate mean power, they can be made to cut through noise or other interference. But this is not quite the whole story.

A third object of pulse modulation is noise reduction. Benefit is obtained in this respect by

* " Television Developments," *Wireless World*, December 1945.

† *Wireless World*, December, 1945.

‡ " Multichannel Communication Systems," *Wireless Engineer*, November and December 1945.

going on to centimetre waves, for a start, and that inclines one to pulse modulation as just mentioned. Then, for a given power input to the transmitter, a wave pulse can be given a vastly greater amplitude than a continuous carrier, and is thereby able to compete more effectively with noise. If the pulse occupies, say, one hundredth of the pulse period P (Fig. 3) the pulse power is one hundred times the mean power. That is why radar transmitters are able to radiate pulses of kilowatts while the transmitter input averages only watts. This high power is likely to stand well above interference, noise, etc., which can be cut off in the receiver by a limiter (such as an over-biased valve) which allows any peaks above a certain level to get through (Fig. 6). There is a catch in this, however, because pulses occupy a much wider band of frequencies than a carrier wave, so the receiver cannot be made nearly so selective, and that offsets a lot—but usually not all—of the advantage of power.

Aid to Secrecy

Yet another reason for using pulses is secrecy. Pulse modulation increases the number of things that an eavesdropper may have to get just right before he can intercept and decypher the message. In addition to normal coding the pulses can be "scrambled" in various ways. By the time he has caught on, the code may be changed.

One of the snags of pulses has already been mentioned—the wide frequency band needed. Roughly, if each pulse lasts 1/*n*th of a second, it makes the carrier wave spread out at least *n* cycles per second on each side. That is liable to interfere with other services, and it necessitates an unselective and therefore interference-prone receiver. We have already seen, too, that pulse systems need a high carrier frequency. So everything tends to the same conclusion: pulse modulation is unsuitable for low radio frequencies, but its advantages are greatest and its disadvantages least at high radio frequencies, especially in the centimetre wave region.

WORLD OF WIRELESS

GOVERNMENT SURPLUS

It seems that facilities for the purchase of ex-Government surplus radio equipment by members of the Radio Society of Great Britain are not to be granted. Protracted negotiations between the R.S.G.B. and Government departments have culminated in the asking of questions in Parliament. It has been officially decided that "generally it is preferable that the needs of radio amateurs should continue to be met through trade channels. . . . Surplus radio sets and components have been sold to the trade by competitive tender and further such sales will be made."

EXTRA AMATEUR FREQUENCIES

The "10-metre" band has been extended to cover 28-30 Mc/s. British Isles amateurs have also been granted the 1800-2000 kc/s band, subject to possible withdrawal and the use of 10 W max power.

U.S.-U.K. TELECOMMUNICATIONS

Some two months having elapsed since the conclusion of the U.S.-British Commonwealth Telecommunications Conference at Bermuda and no statement having been made as to the findings of the Conference, Garry Allighan raised the question in the House of Commons on Feb. 21st.

The communiqué issued by the British Information Service in Washington at the conclusion of the conference has now been made available in this country. It states:—

"By the agreements reached at the Conference . . . a great step forward has been taken to bring order out of the chaotic telecommunications system; and ensure a balanced combination of cable and wireless services for the world. . . .

"The interest of the United States is primarily in the radio field, with a lesser interest in cable communication; while in the British Commonwealth the emphasis is on cables. But the United States delegation accepted the British view that the reckless and unrestricted use of new radio circuits would unbalance the world system and deprive the United States themselves of the certain services and the security of the Commonwealth cable systems."

Reduction of all telecommunication rates between the U.S. and nations of the British Commonwealth were also agreed upon. The gold franc as the measure of telecommunication charges has been abandoned as impracticable and a dollar basis agreed on.

A protocol has been signed discouraging the principle of one country obtaining exclusive concessions for conducting the external tele-communications for another.

TELEVISION SETS

The Board of Trade announced on March 7th that licences had been issued to fourteen manufacturers to produce 78,300 television receivers.

Licences have also been granted for the production of a total of 937,100 broadcast sets for the home market and 583,380 for export.

During the last five months of 1945 nearly 73,000 sets were manufactured. Of this number 12,000 were for export.

"AIRMET" BROADCASTS

Weather reports, forecasts and navigational warnings for civil aviation are now broadcast daily from Daventry on 245 kc/s (1,224 metres). Transmissions are continuous from 0700 to 1800 G.M.T. in winter and from 0600 to 2100 G.M.T. in summer.

Navigational warnings providing urgent information regarding the unserviceability of aerodromes, radio facilities and air light beacons are given during the first 10 minutes of each hour. Weather reports and forecasts follow every ten minutes. Each transmission is prefaced by "This is Airmet."

RESEARCH

The need for a central electronic research organisation supported by the Government and engaged on regular work for the Services, but with freedom also to study and meet industrial demands, is stressed by Charles Davy, writing in *The Observer* for March 10th. Doubt is expressed by the writer as to the possibility of any one industry being competent or having the necessary incentive to undertake "comprehensive electronic research."

The article has been written to answer the question: "What is going to happen to the scientific research units built up under Government direction during the war?" which has been brought to the fore by a decision to reduce the staff at

World of Wireless—

the Royal Aircraft Establishment at Farnborough. After outlining briefly some of the projects in hand, or in view, at the Telecommunications Research Establishment at Malvern, he expresses the hope that T.R.E.—perhaps rechristened Electronics Research Establishment—might become the centre of electronic research.

WHAT THEY SAY

RADAR PATENTS.—The patent situation in radar is said to be so complicated that no company on earth could safely proceed to manufacture radar with any confidence that it would be immune from suits of infringement.—*Paul A. Porter, Chairman, U.S. Federal Communications Commission.*

ADMINISTRATIVE TECHNICIANS.—Refresher courses would provide an opportunity for engineers whose main duties were administrative to bring their technical knowledge up to date, and would prevent any tendency towards control of staff by seniors whose knowledge of modern techniques is inadequate.—*A speaker at the I.E.E. discussion on "Post-Graduate Courses in Electrical Engineering."*

MANUFACTURING COSTS.—The [American] Office of Price Administration is attempting to force what they call a "reconversion formula" down the unwilling throats of the parts manufacturers .. The O.P.A. contends that this "reconversion pricing formula" is fair because war-born technological advances have created so many improvements in manufacturing efficiency that any increase in labour and material prices can be fully absorbed by the manufacturer.—*The Editor, "Parts Jobber," New York.*

PERSONALITIES

Lord Louis Mountbatten has accepted election as President of the British Institution of Radio Engineers for the year 1946-47, in succession to Leslie McMichael. He has been a member of the Institution since 1935 and was elected Vice-President in 1938.

Vice-Admiral J. W. S. Dorling, C.B., R.N. (retd.) has been appointed Director of the Radio Industry Council. He has been connected with radio since 1912 and during the first world war was chiefly concerned with high-power continuous-wave installations in shore stations and warships. During the years between the two wars he served as Fleet Wireless Officer, Director of Signal Department, Admiralty, and Captain of H.M. Signal School, Portsmouth.

T. W. Bearup, who has been Assistant Manager of the Australian Broadcasting Commission since 1943, is now acting as its London representative. He will also supervise A.B.C.'s New York office.

M. J. Smith, O.B.E., B.Sc., has been appointed Electrical Engineer to the Copper Development Association. As a Wing Commander in the R.A.F. he was Senior Training Officer at the R.A.F. School of Electrical and Instrument Training.

L. R. Vincent rejoins Ritchie Vincent and Telford, consultants, of Harrow, as Managing Director, having been released from his appointment as Technical Specialist (Communications and Broadcasting), Ministry of Information.

Vice-Admiral J. W. S. Dorling, C.B., R.N. (retd.) the Radio Industry Council's first Director.

IN BRIEF

Ten Million.—It was announced by the G.P.O. on February 20th that the number of wireless licence holders in Gt. Britain and Northern Ireland was 10,266,300. This figure includes 47,300 licences issued free to the blind. It is of interest to note that the 5,000,000 mark had been reached in the first ten years of broadcasting—by 1932.

Another Record?—C. G. Allen asks if he set up another record at his station, G8IG, on Saturday, March 9th, when he worked, on 10 metres, all continents in 4¼ hours and the British Empire in 5 hours 20 minutes. His log was: 0845, W4KDA (Okinawa); 1100, VK4LP (Australia); 1138, XABY (Greece); 1203, SU1USA (Egypt); 1230, W3BDL (New Jersey); 1300, HK4AX (Colombia); 1405, VE4EK (Canada).

Canadian FM.—Canada's first broadcast FM transmitter started operating a few months ago from Mount Royal, Montreal. The transmitter, employing a frequency of 48.8 Mc/s with a power of 25 W, uses the call VE9CM.

A.R.R.L. Bulletins giving the latest official information regarding U.S. amateur activities are broadcast regularly by the League's headquarters station W1AW at West Hartford, Connecticut. The frequencies used are 3.555, 7.145, 14.280, 28.245 and 56.968 Mc/s and the times of operation are 0100, 0200 and 0300 G.M.T., Tuesday to Saturday. Transmissions on each of the above frequencies open with a bulletin in morse at 15 w.p.m., which, with the exception of that on 28.245 Mc/s, is followed by 'phone announcements.

Burma.—English transmissions from the short-wave station of the Burma Broadcasting Service are now radiated on 6.04 Mc/s from 0015-0100 and 0515-0600 G.M.T. and on 11.85 Mc/s from 0200-0230, 0615-0645 and 1230-1400.

Servicing Examination.—Applications to sit for the next examination of the Radio Trades Examination Board must be received by the Secretary of the Board at 9, Bedford Square, London, W.C.1, not later than March 31st. It will be held at various centres on May 4th. Copies of the papers set by the Board for the last two examinations may be obtained from the Secretary, price 2s per set.

Radar Stations.—Experimental licences for stations undertaking development and research of radar navigational aids are now being issued by the American F.C.C.

Policing the Ether.—The checking centre of the International Broadcasting Union, which was removed from Brussels during the war and set up at the Union's headquarters in Geneva, has now returned to its original home in the Belgian capital.

New I.E.E. Group.—The Council of the I.E.E. has sanctioned the formation of a Radio and Measurement Group at the Institution's North-Eastern Centre.

Research Endowment. — A new laboratory is to be constructed at McGill University, Montreal, equipped with the latest apparatus for research in radio, radar, atomic energy and other scientific fields. The money is to be provided out of an endowment to be known as the Eaton Electronics Research Laboratory Fund.

Our Cover.—The reconditioned television aerial arrays on the 300ft mast at Alexandra Palace are illustrated on this month's cover. The vision aerial is uppermost. Test transmissions are still being radiated from 11.30 to 12.30 and 4.0 to 5.30 on 45 Mc/s (vision) and 41.5 Mc/s (sound).

W.W. Index.—Copies of the Index for Vol LI, 1945, of *Wireless World* will shortly be available from our Publishers; price 1s 1½d by post.

Back Numbers.—Our Publishers are anxious to obtain copies of *Wireless World* for December, 1945, and January and February, 1946. Readers who are prepared to dispose of these back issues are asked to communicate with our Publishers.

"Code of Practice" for Valves.—A new edition (1945) of British Standards publication B.S.1106, issued during the war and reviewed in this journal in September and October, 1943, has just been published. The precautions necessary to ensure reliable operation and long life in all types of electronic valves other than cathode-ray tubes are dealt with, and copies can be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1, price 2s, postage paid.

"Radio Valve Vade Mecum."—Many readers have asked if this valve data book of British, Continental and American valves, by P. H. Brans, of Antwerp, mentioned in our February issue, is obtainable in this country. We understand that arrangements have now been made to distribute a limited number and that copies will be obtainable from A. F. Bird, 66, Chandos Place, London, W.C.2, price 12s 6d, postage 7d.

Installing Car Radio.—Useful hints on the installation of car radio receivers, including the suppression of vehicle-generated static as well as all types of ignition interference, are contained in a booklet written by S. L. Robinson, A.M.Brit.I.R.E., and issued by Masteradio, Ltd., 193, Rickmansworth Road, Watford. Copies are available to radio dealers free of charge.

"Britain Can Make It."—A committee has been appointed to assist the Council of Industrial Design in arranging for the submission of radio, television and gramophone designs for the "Britain Can Make It" Exhibition in September. The members of the committee are: G. J. Freshwater (E.M.I.), H. J. Dyer (Philips), G. P. Wickham-Legg (Bush) and A. Middleton (Ferranti).

An Appeal has been made by Field-Marshal Lord Chetwode to the radio and electrical industries in aid of the Victory (Ex-Services) Club, a social, cultural and welfare centre which is to be established as industry's memorial to those who fought in the 1939-45 war. Enquiries should be addressed to M. A. Browning, 15, King Street, London, S.W.1.

Rehabilitation.—Cable and Wireless and Marconi's have each promised £1,000 towards the training and research sections of the Roffey Park Rehabilitation Centre, Horsham, Sussex.

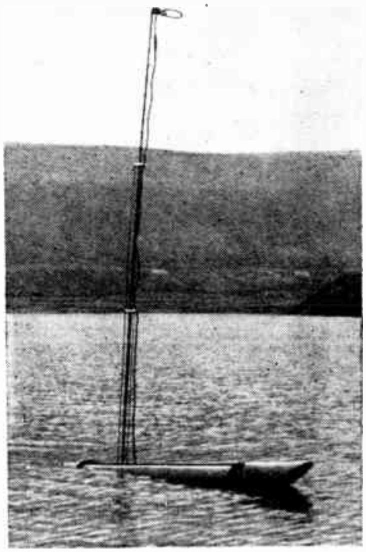
Webb's Radio.—Through a printer's error the two lines heading the Webb's Radio advertisement in our March issue were transposed. The heading should have read "The hub of the 'ham' world."

H.M.V. Works.—Among the Government factories recently allocated by the Board of Trade to various firms for civilian production is one at Treorchy, Wales, to be used by the Gramophone Co.

Bulgin has issued a brochure outlining the war work undertaken by their factories. Whereas the output of components in 1940 was 1,994,503, by December, 1944, it had risen to 4,378,979.

Philco.—Among the latest allocation of Government factories to industry is one at Ossett, Yorks, which is to be taken over by the Radio and Television Trust—Philco's new name.

Ekco are to open 5, Vigo Street, in the vicinity of Regent Street, as their London showrooms.



THE JELLY FISH or radar marker buoy. When launched into the sea two operations, one mechanical and the other electrical, are automatically performed. The first is concerned with the buoyancy and extension of the telescopic aerial and the second, accomplished by the action of a "sea-cell" and "corrosion cell", provides power for, and switches on, the radar gear and arms the buoy for self-destruction. The bulk of the development on the buoy was done by Ferranti.

CLUBS

Merseyside.—Recent attendances at the meetings of the Merseyside Section of the R.S.G.B. have been so great as to necessitate the duplication of the monthly meetings. They will now be held on the second Wednesday at 6.30 and the last Saturday at 2.30 each month. Details of the Section's activities may be obtained from R. A. Spears (G8AZ), 72, Rocky Lane, Broadgreen, Liverpool, 16.

Manchester.—New members will be enrolled at a meeting of the recently formed Whitefield and District Radio Society, at the Stand Grammar School, Higher Lane, Whitefield, Manchester, at 8 on April 1st. The Society's Hon. Sec. is R. Purcell, 28, Stanley Street, Prestwich, Manchester.

Leicester.—The next meeting of the Leicester Radio Society will be held at 7.30 on April 9th at the Charles Street United Baptist Church (entrance in side passage). A review of the "Historical Development of Radio" will be given by C. F. Atkinson.

Liverpool.—The Liverpool District Short-wave Club is now holding weekly meetings on Wednesdays at 8 at St. Barnabas Parish Hall, Penny Lane, Liverpool. Hon. Sec., T. W. Carney (G4QC), 9, Gladeville Road, Aigburth, Liverpool, 17.

B.S.W.L.—The first post-war transmission to be arranged by the British Short-wave League will be radiated from the Ankara short-wave station, TAP, on 9.465 Mc/s at 2130 G.M.T. on Sunday, April 14th. Reception reports should be sent to Box A3, B.S.W.L., 53, Madeley Road, London, W.5.

Short-wave Enthusiasts are invited by Arthur E. Bear, European and Colonial Representative of the International Short-wave Club, to communicate with him at 100, Adams Gardens Estate, London, S.E.16, for details of membership. Members receive the Club's publications, "On the Air" and "Short-wave News Letter."

MEETINGS

Institution of Electrical Engineers

Radiolocation Convention.—The four-day convention arranged by the I.E.E. opens on March 26th at 5.30. The meetings on each of the following days will begin at 9.30 a.m.

Radio Section.—A symposium of papers on "Naval Gunnery Radar" will be read by J. F. Coales, M.A., J. G. Calpine, M.A., D. S. Watson, B.Sc., R. V. Alred, M.A., C. A. Laws, H. W. Pout, B.Sc.Eng., H. A. Prime, W. D. Mallinson, B.Sc.Eng., and T. C. Finnemore on April 3rd.

Discussion on "Interference Problems arising from Industrial Electronics," opened by M. R. Gavin, on April 16th.

"Nuclear Physics and the Future," Thirty-seventh Kelvin Lecture by Prof. M. L. Oliphant, F.R.S., on April 25th.

The above meetings commence at 5.30 and will be held at the I.E.E., Savoy Place, London, W.C.2.

Cambridge Radio Group.—"A Method of Increasing the Range of V.H.F. Communication Systems by Multi-Carrier Amplitude Modulation," by J. R. Brinkley, at 6 on April 2nd at the University Engineering Laboratory, Trumpington Street, Cambridge.

British Institution of Radio Engineers

London Section.—"The Electron Gun of the Cathode-Ray Tube—Part II," by Hilary Moss, Ph.D., at 6.15 on April 17th at the Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1.

North-Eastern Section.—"Ship's Distress Automatic Alarm Apparatus," by H. Armstrong, at 6 on April 10th at Neville Hall, Westgate Road, Newcastle-on-Tyne.

Institute of Physics

Electronics Group.—"Velocity Modulation Tubes," by Dr. J. H. Fremlin, at 5.30 on April 9th at the Royal Society, Burlington House, Piccadilly, London, W.1.

Institution of Electronics

North-West Branch.—"Recent Advances in Electronics Applied to Medicine," by G. Parr, at 6.30 on March 29th at Reynolds Hall, College of Technology, Manchester.

Radio Society of Great Britain

"Amateur Transmitter Design," by Capt. R. L. Varney (G5RV), at 6.30 on April 12th at the I.E.E., Savoy Place, London, W.C.2.

CONTRAST EXPANSION

Some Practical Results Using Negative Feedback

By J. G. WHITE

IN the September and October 1945 issues of this journal, a review was made of various forms of contrast expander, and details were given of a proposed new circuit using variable negative feedback to produce expansion of the volume range as received. Since then it has been possible to carry out some experiments with the circuit. In addition, a method has been devised to overcome the effects of current feedback in the first stage, which, as predicted, reduces the degree of expansion attainable for any given set of component values. This modification will be explained before details are given of the experimental results obtained.

Eliminating Current Feedback.—In Fig. 1 (*a*) is shown a simple RC coupled amplifier in which R_2 and C are the anode decoupling components. Current negative feedback occurs because the cathode resistor R_1 is unbypassed. By connecting the low-potential end of C to cathode instead of to earth, as shown in Fig. 1 (*b*), the alternating component of the anode current is returned to cathode direct, and, provided that R_2 is much larger than R_1, as will normally be the case, the signal voltage across R_1 will be negligible. The gain of the stage will therefore be unaffected by the omission of the cathode bypass condenser.

When the circuit of Fig. 1 (*b*) is used, however, it is essential that the hum content of the HT supply be low. R_1 is connected between grid and cathode of the valve and any voltage produced across it by ripple on the HT current will be amplified and so increase the hum level of the amplifier.

Except that the modification just detailed has been included, the circuit of Fig. 2 will be seen to correspond in general to that of Fig. 9 (October issue). The signal voltage developed across R_1 is now proportional only to that across the anode load of V_2. However, not only is it introduced into the input of V_1, but also into that of V_2. Examination of the circuit will show that in each case the feedback is negative. Thus, subsidiary feedback still occurs, but, unlike the current feedback of the circuit in Fig. 9, it varies in the same ratio as the main feedback when the impedance of V_3 is changed.

Assuming the same terminology as applied to the amplifier in Fig. 7 (October issue) the expression for the gain of the amplifier in Fig. 2 may be written

$$M_2 = \frac{M_0}{1 + \beta M_0 + \beta \dfrac{\mu_2 R'_5}{R_4 + R'_5}} \qquad \text{(1)}$$

When V_1 and V_2 in Fig. 2 are RF pentodes, equation (1) may be written

$$M_2 \doteqdot \frac{g_{m1} R_3 g_{m2} R'_5}{1 + \beta g_{m1} R_3 g_{m2} R'_5 + \beta g_{m2} R'_5} \qquad \text{(2)}$$

In practice, β is unlikely to exceed 0.04, so that the subsidiary feedback may be neglected in the majority of cases, and the expression given in the original equation (1), (October issue) may be used with sufficient accuracy to meet normal design requirements.

Experimental Circuit—An amplifier was assembled in accordance with the circuit of Fig. 2, Mazda SP41 valves being used in all three positions, V_1 and V_2 as pentodes and V_3 as a triode. A variable source of bias was applied between control grid and cathode of V_3 and measurements of gain were made with various values of anode load for V_1 and V_2. Each measurement was carried out with the anode decoupling condenser of V_1 connected alternately to the common earth line and to the junction of R_1 and R_7.

A triode-connected SP41 has a high mutual conductance and a short grid base; thus, widely different values of anode resistance may be obtained within a comparatively small range of control grid volts. With the particular valve used, the AC resistance was about 10,000 ohms at a bias of 1 volt negative, and rose to some 5 megohms at 8 volts negative. As this latter value is exceedingly high compared with R_1, the gain of the amplifier under these conditions is not reduced to any great extent and the expansion range obtainable is greater than with the values of impedance suggested in the original article.

The mutual conductance of the

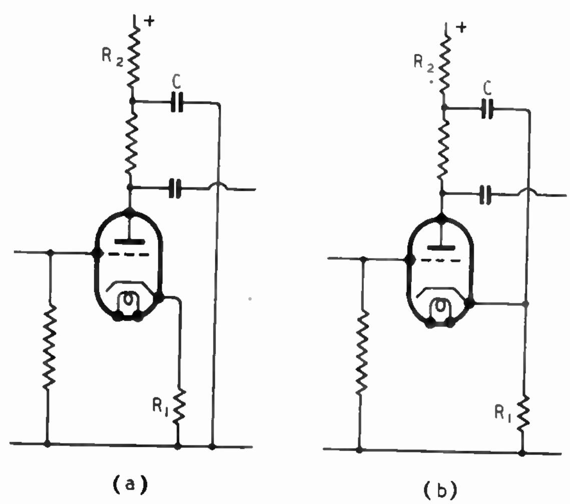


Fig. 1. Current feedback in (*a*) is eliminated by returning the alternating component of the anode current direct to cathode (*b*).

SP41 valve under working conditions is higher than that assumed for the EF 50, and, when R_3 and R_5 were 50,000 ohms and 5,000 ohms, respectively, an overall gain of 6,300 times was obtained without feedback. Using the circuit of Fig. 9 (October issue) the maximum and minimum gains with 8 volts and 1 volt negative on the grid of V_3 were 2,240 and 200 times, respectively. This represents an expansion of 21 db. When current feedback was eliminated by use of the circuit of Fig. 2, the extremes of gain obtained were 5,600 and 200 times respectively, giving an expansion of 29 db. The elimination of current feedback is therefore well worthwhile. It will be noted that the minimum gain is the same in each case (within the limits of experimental accuracy). That this may be expected is apparent from equations (7) and (8), in which the term for current feedback diminishes in importance as β increases, becoming negligible for high values of βM_0.

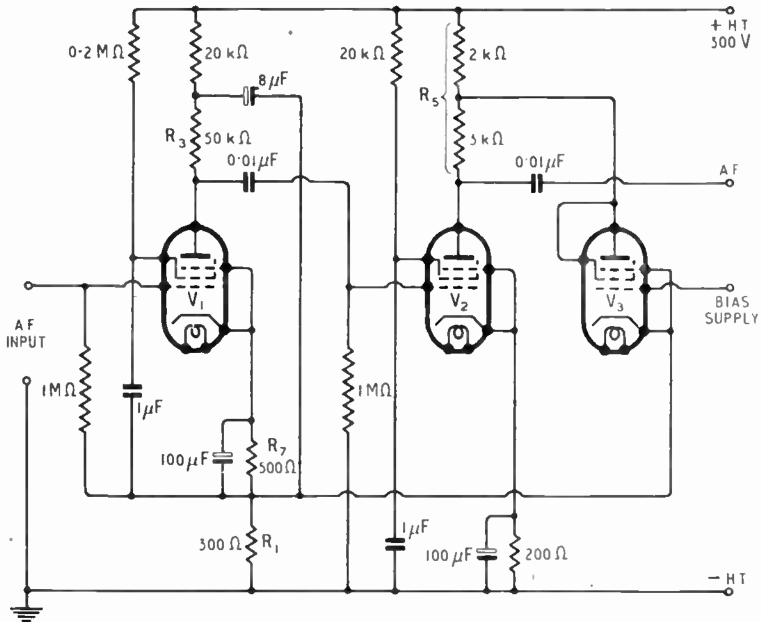


Fig. 2. Revised circuit of negative feedback contrast expander.

The output waveform was examined on an oscilloscope and, with an output of 30 volts RMS maintained across R_5 by increasing the input as the gain decreased, no distortion was noticeable with any degree of feedback in the range quoted above. This output is sufficient to load a push-pull output stage consisting of two PX4 or PX25 valves through a phase-splitting stage.

Other values of anode load were substituted, and similar measurements were carried out. In each case the advantage of eliminating current feedback was apparent in the results obtained. Representative curves illustrating these results are shown in Fig. 3, which indicates the general shape of the expansion curve.

Replacement of the 3,000 ohm resistor next to the anode in R_5 by one of 5,000 ohms, permits an output of 40 volts RMS to be obtained with no noticeable distortion of the waveform. As βM_0 is unaffected by this change, the expansion is unaltered although the overall gain is increased.

Control Circuit.—We now have an amplifier with gain variable over the required range and a satisfactory level of distortion. It only remains to produce the control bias from the signal and to apply it to the grid of V_3 so that the desired effect may be obtained. Unlike most other valve-operated expanders, this circuit requires a negative bias increasing as the signal amplitude increases. Thus the problem is similar to that of producing AVC bias and similar circuits may be employed.

The question of time-constants is one which has been dealt with at some length, notably in D. T. N. Williamson's article in *Wireless World*, September, 1943. The provision of a suitably slow decline in gain is quite straightforward, and it may easily be arranged to be variable at will. Difficulties arise, however, when an attempt is made to produce the rapid rise in gain which is generally agreed to be desirable.

If the time-constant of the circuit is too long, a sudden crescendo will be drawn out and the programme will lose the necessary qualities of attack and brilliance.

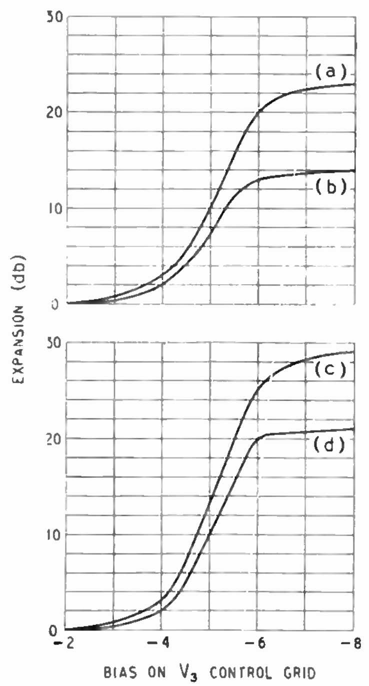


Fig. 3. Measured expansion curves for various working conditions. (*a*) and (*c*), with voltage feedback only; (*b*) and (*d*), with current and voltage feedback. For curves (*a*) and (*b*), R_3 is 15,000 ohms and for curves (*c*) and (*d*), 50,000 ohms. R_5 consists of 3,000 ohms (nearest anode) and 2,000 ohms in series giving a gain at zero expansion of 200. If 5,000 ohms is substituted for the 3,000-ohm resistor the expansion curve is not affected, but the gain at 0 db is 280.

Contrast Expansion—
If the time-constant is too short, the gain of the amplifier will vary at the frequency of the applied signal, with unpleasant results that must be heard to be fully appreciated. Thus, a compromise is necessary and is a feature common to the majority of expansion circuits. In addition, with the amplifier under consideration, another factor makes a very short time-constant difficult to use.

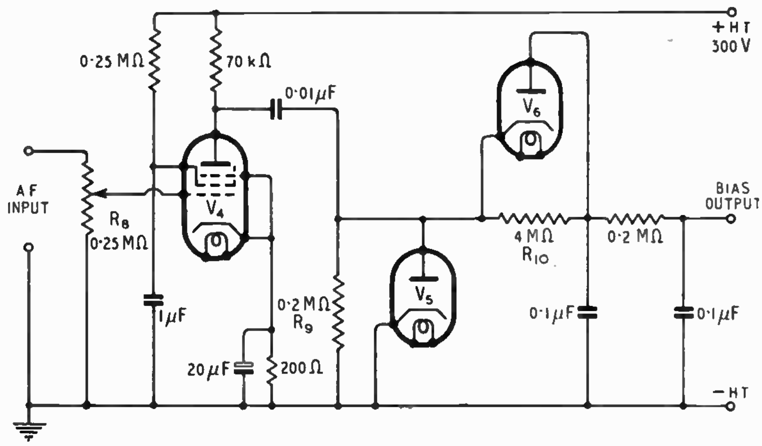


Fig. 4. Circuit for providing control bias for the expansion amplifier.

Examination of the circuit of Fig. 2 shows that any superimposed audio frequencies applied with the control bias to the grid of V_3 will appear in the cathode circuit of that valve, and therefore of V_1, amplified by a factor approximately equal to the product of R_1 and the mutual conductance of V_3. At low gain, that is, when the bias on V_3 is at a minimum, this factor is appreciable, and the result is that very quiet passages are distorted. The effect may be reduced either by increased filtering of the control bias, which reduces the rate of rise of gain, or by setting the initial bias of V_3 at such a point that the gain from its grid to cathode is negligible. The latter method may restrict the expansion range.

The theoretical circuit of an auxiliary amplifier and rectifier to produce the control bias is shown in Fig. 4, and has proved satisfactory when used with the amplifier of Fig. 2. V_4 is an SP41 type valve and V_5 and V_6 may be the two sections of a 6H6 type duo-diode. The time of rise of gain is appreciably less than 0.05 second and the time of fall is about one second. By making R_{10} variable, it is possible to adjust the rate of fall of gain to suit the programme which is being heard. The audio-frequency component passed to the grid of V_3 is negligible, no measurable AF voltage appearing across R_1 when the grid of V_1 was connected to earth. This result was obtained without increasing the initial bias on V_3. The control bias developed across C_1 was measured for a range of AF inputs to V_4, and this is plotted in Fig. 5. If it is considered desirable to reduce the effect of the initial curved portion, the DC output may be taken from a tapping on R_9 instead of from the junction of R_9 and the anode of V_5. This necessitates a higher voltage across R_9, but the curve of Fig. 5 shows that this may easily be achieved. If the tapping on R_9 be made adjustable, a method of varying the degree of expansion is obtained which is preferable to using R_8 as the control, because the input to the diode V_5 may then always be maintained at a high value. The effect on the discharge time-constant of the circuit as the tapping is adjusted may be neglected.

The value of the initial bias on V_3 will largely determine the shape of the expansion curve for the amplifier, and attention may now be directed to the curves in Fig. 3. It will be seen that, as the control bias increases, the rise in gain is at first very slight and then becomes very high. Thus a change of bias from − 2 to − 4 volts may produce an increase in gain of 2 db. and a further change from − 4 to −6 volts, an increase of 18 db. Assuming a linear rectifier system, this means that changes of input level to the amplifier of 6 db. and 9.5 db., referred to the signal input corresponding to a bias of − 2 volts, appear at the output as changes of 8 db. and 27.5 db. respectively. The effect is completely to ruin the reproduction of any broadcast programme or record by the completely unnatural contrasts introduced.

It is desirable that the expansion be more nearly linear, and this may be achieved by increasing the standing bias on V_3 to the value at which the expansion curves begin to rise rapidly, i.e., about 3.5 to 4 volts negative. The simplest method of doing this is to increase the current in R_1 by connecting a resistor between HT positive and the cathode of V_3. If the resistor is made variable, it may be adjusted quite simply to the correct value. The control grid of V_3 is connected to earth and the resistor decreased in value until a slight increase in volume is apparent. The resistance may then be increased slightly and left at that value. This same adjustment obviously may also be used to introduce delay if this is con-

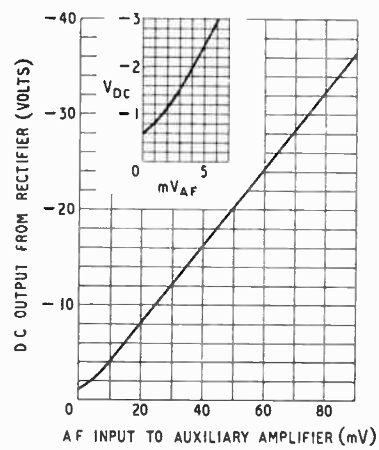


Fig. 5. Characteristic of control bias circuit.

sidered desirable, but that is a matter which must be decided by the individual listener.

The oscillograms in Fig. 6 are included to illustrate the action of the expander, and show a 6 db. increase in input producing a 12 db. increase in output. This degree of expansion was chosen solely to provide an illustration of the action of the circuit, and is not intended to represent any specific input conditions which may be encountered in normal use. The difference in the rates of rise and fall of gain are readily seen.

It is hoped that the practical results detailed above will interest readers of the original article, and reassure those who, with Dr. Parnum,* foresaw the possibility that an unacceptable degree of distortion might be introduced because V_3 is a non-linear resistance. Most of the work described had been completed before Dr. Parnum's valuable comments were received, but further experiments were carried out to ascertain as far as possible the distortion introduced by this characteristic of V_3. Apparatus of the standard necessary to make reliable quantitative results possible was unfortunately not available, but it is felt that an estimate of not more than 2 per cent. total distortion at the outputs quoted earlier is fully justified by the observations made. This is no doubt partly due to the very small value of β at maximum gain, which ensures that only a negligibly small fraction of any distortion due to the non-linearity of V_3 appears across R_1. A check was also made that distortion does not increase at intermediate levels, where β is considerably larger.

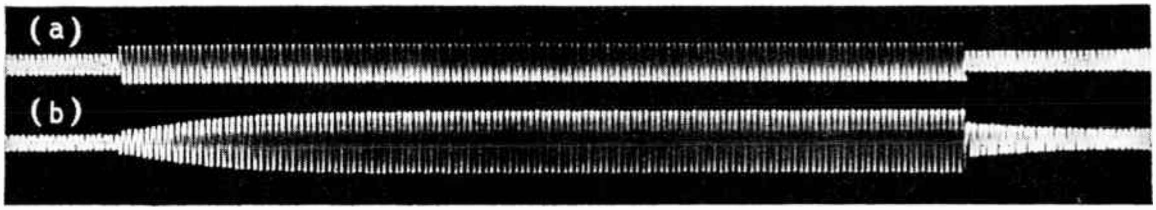


Fig. 6. Oscillogram at 80 c/s showing difference in rates of rise and fall of gain. (*a*) input increased 6 db, (*b*) output increased 12 db.

In conclusion, an error which unfortunately occurred in the second part of the original article must be pointed out. The last line of the second column on page 309, following equation (3), should read " If R_1 is much *less* than R_{a2}."

The writer is indebted to Mr. P. L. Stride for suggestions and assistance in carrying out the practical work on which this article is based.

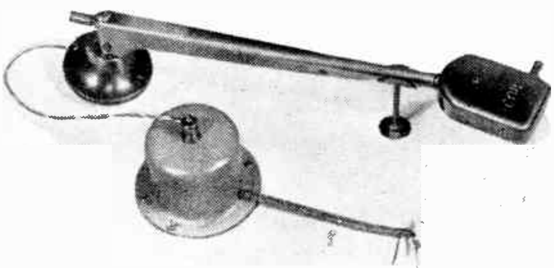
* See page 136 of this issue.

NEW MOVING-COIL PICK-UPS

THE "Coil" pick-up is now being made by Wilkins and Wright, Holyhead Road, Birmingham, 21. It employs a circular coil working between shaped pole-pieces and a centre core similar to a d'Arsonval galvo.; the coil is suspended by a stretched flat metal strip. No rubber is used and the damping medium is thick grease. It is designed to take miniature chromium-plated needles such as the "99" or "Silent Stylus." The weight of the head is counter-balanced by a coil spring inside the pick-up arm which can be adjusted to give weights at the needle point ranging from ¼ to 1 oz. A screened coupling transformer and bass equalizer unit is supplied for mounting between the pick-up and the amplifier. The output is 0.05 V (average) into an impedance of 100,000 ohms, and the makers state that the response is flat within 3 db between 30 and 9,000 c/s. The price complete is £5 15s exclusive of purchase tax.

The output transformer and bass compensating filter are incorporated in the arm of the "Valradio" pick-up.

In the "Valradio" pick-up the coil is in the form of a long ellipse and is lightly rubber-damped. The whole pick-up head measures only one inch cube. It is mounted in a long tone arm which contains the bass compensating circuit, and the Mumetal shrouded output transformer is carried in an extension and acts as a counterbalance; the weight at the needle point is ½ oz. The pick-up is designed to take special needles, but ordinary needles can be used. The makers state that the response from 25 to 12,000 c/s is constant within ±2 db and the output is approximately 50 mV. The price, including 50 needles, is £5 15s plus purchase tax (£4 0s 6d), and it is obtainable from Wolsey Television, 107, Brixton Hill, London, S.W.2.



No organic damping material is used in the movement of the "Coil" pick-up made by Wilkins and Wright.

SHORT-WAVE CONDITIONS

Expectations for April

By T. W. BENNINGTON

(Engineering Division, B.B.C.)

THE feature of short-wave conditions during February was the effect upon propagation of the very large sunspot group—the one which received all the publicity—which, appearing on the sun's east limb on January 29th, crossed the central meridian on February 5th and reached the west limb on February 11th. It then survived the journey across the "reverse" side of the sun and reappeared on the east limb on February 27th, being due on the central meridian again on March 6th, but it now appears to have considerably decreased both in size and in activity.

First, as to the *general* conditions during February. These, themselves dominated by the influence of the above sunspot group, were such that the *average* maximum usable frequencies for this latitude were somewhat higher than for January, both for noon and midnight. During those periods of the month, however, when the sunspot group "faced" the earth, its *general* effect was to increase the atmospheric ionisation considerably and so to give rise to very "high-frequency" conditions. Thus, between February 1st and 10th, and again from February 27th to the end of the month, maximum usable frequencies were much *above* the average and some remarkably good communication was achieved on the higher frequencies. Conditions on the higher frequencies were also good from 15th to 17th.

Now for the *disturbing* effects produced by the solar activity. A very remarkable number of "Dellinger" fade-outs occurred in connection with the large sunspot, some 20 or more of these having been reported from various parts of the world during the month, whilst the "hissing" phenomenon was several times observed. These fade-outs were reported as occurring mainly between February 1st and 14th and from February 27th to the end of the month.

After the sunspot crossed the central meridian the expected ionosphere storm occurred. It appeared to start on February 6th, but, strangely enough, cleared up again very quickly, restarting with great severity about 11.00 G.M.T. on February 7th and lasting till about 13.00 G.M.T. on February 9th. This period therefore made a break in the first period of "high frequency" conditions above referred to. Another disturbance occurred during the period February 20th-22nd.

Forecast.—Conditions during April—apart from ionosphere storm effects—should be such that somewhat higher night-time and somewhat lower daytime frequencies than during March will be generally usable. The daytime frequencies will, of course, be usable over a longer period than during March, and, furthermore, there will be a tendency for peak usable frequencies to occur later in the day. Sporadic E—that unpredictable phenomenon which often makes possible communication on frequencies much higher than those usable by way of the *regular* layers—should begin to increase in the frequency of its occurrence in April, but more about this in the forecast for May, when this phenomenon should begin to become really prevalent.

Now a word of explanation about the tables of predicted best frequencies for use during April which are given below for various directions from this country. For certain significant times of day the unbracketed figures give the best frequencies, in terms of the broadcast bands. These are based on the *average* predicted MUF for the month, and indicate the frequencies which could reasonably safely be used by a communication or broadcasting organisation which has to operate services on *every day* throughout the month. But it is known that the *average* MUF is exceeded on many days during the month, and, furthermore, it is possible roughly to estimate the amount by which it will be exceeded during a given percentage of the total time; that is, unless some very exceptional variations in solar activity occur. Whilst attempted operation on such higher frequencies would not be a useful expedient for regular services there are others whose interest lies, not in the continuous operation of a service, but in the exploitation of a particular frequency band. Furthermore, because the power at the disposal of such experimenters is usually limited, the very highest frequency will practically always yield the best results *while and if it is open*, because the absorption is there the lowest.

In order to meet these requirements a figure in brackets is therefore included for each significant hour, indicating the highest frequency likely to be usable for about 25% of the time during the month, for communication by way of the *regular* layers, *not* by way of Sporadic E.

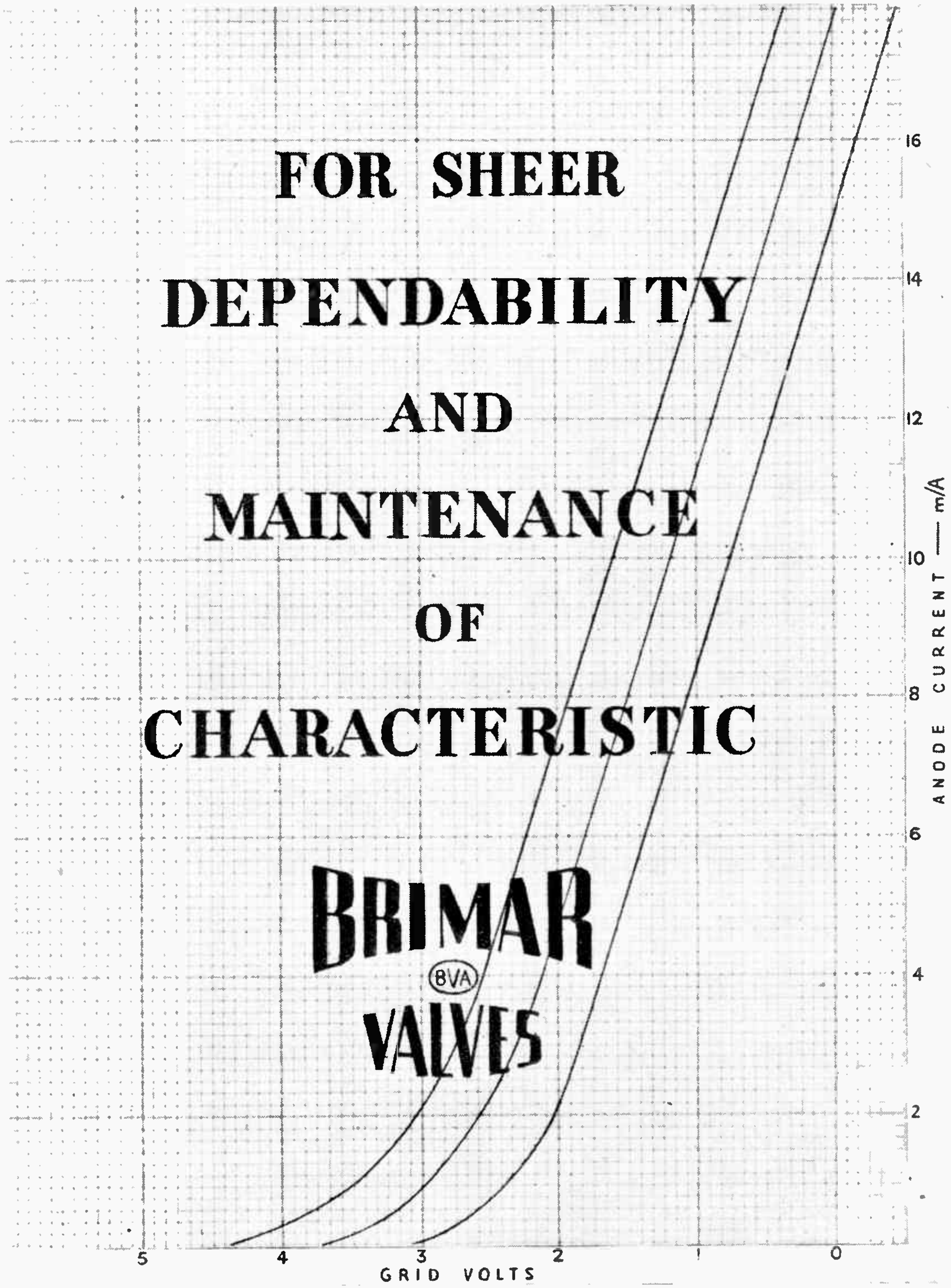
Montreal: 0000, 11 or 9 Mc/s (16 Mc/s); 0300, 9 Mc/s (14 Mc/s); 0900, 11 Mc/s (16 Mc/s); 1100, 15 Mc/s (21 Mc/s); 1500, 17 or 15 Mc/s (24 Mc/s); 2000, 15 Mc/s (22 Mc/s); 2200, 11 Mc/s (17 Mc/s).

Buenos Aires: 0000, 11 or 9 Mc/s (14 Mc/s); 0400, 7 Mc/s (13 Mc/s); 0800, 11 Mc/s (17 Mc/s); 1000, 17 Mc/s (24 Mc/s); 1400, 21 or 17 Mc/s (28 Mc/s); 2100, 17 or 15 Mc/s (23 Mc/s); 2200, 11 Mc/s (17 Mc/s).

Capetown: 0000, 11 Mc/s (17 Mc/s); 0600, 15 Mc/s (21 Mc/s); 0700, 17 Mc/s (25 Mc/s); 0900, 21 Mc/s (30 Mc/s); 1800, 17 Mc/s (24 Mc/s); 2000, 11 Mc/s (17 Mc/s).

Chungking: 0000, 9 Mc/s (13 Mc/s); 0400, 11 Mc/s (17 Mc/s); 0700, 15 Mc/s (22 Mc/s); 1100, 17 or 15 Mc/s (24 Mc/s); 1500, 15 Mc/s (21 Mc/s); 1700, 11 Mc/s (17 Mc/s); 2000, 9 Mc/s (14 Mc/s).

A *moderate* amount of ionosphere storminess is usual during April, and although one cannot be at all certain, it would appear at the time of writing that during the periods 3rd-6th, 14th-18th and on 30th conditions are likely to be more disturbed than on other days.


FOR SHEER
DEPENDABILITY
AND
MAINTENANCE
OF
CHARACTERISTIC
BRIMAR
BVA
VALVES
16
14
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ANODE CURRENT — m/A
5
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GRID VOLTS

VORTEXION
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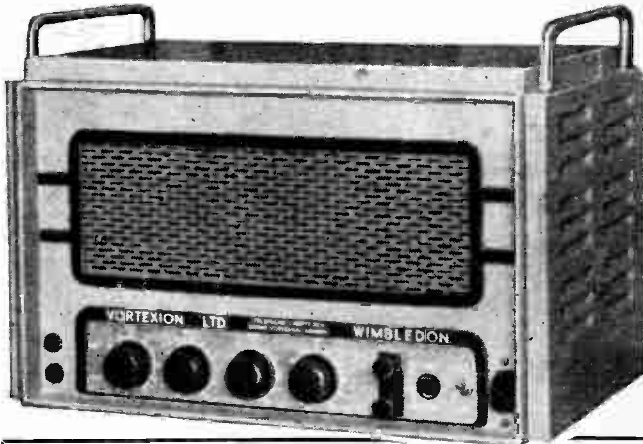

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Design Data (3)

WIDE-BAND AMPLIFIERS

II.—Single-Circuit Couplings : Stagger Tuning

IF the band-width of a multi-stage amplifier employing single resonant circuits as intervalve couplings, is too narrow, it can be broadened either by increasing the damping of the circuits or by staggering their individual resonance frequencies about the mid-band frequency. It is found that the latter method leads to a considerably higher gain per stage and is consequently usually to be preferred.

The possible ways of achieving stagger-tuning are very large, for each circuit has two variables—its damping and its degree of mistuning. The most generally satisfactory result is obtained, however, when the amplifier is divided into pairs of stages, each pair having identical response characteristics. Each pair of stages comprises two valves and two couplings employing single tuned circuits, one being mistuned to one side of the mid-band frequency and the other being mistuned to the other. The circuits are equally damped, but need not have identical capacitance or resistance, nor need the valves be the same.

Such a circuit with coincidence tuning gives a performance calculable by the formulæ of Design Data No. 2. If the circuits are tuned away from coincidence in opposite directions the response curve broadens and the amplification falls. There is a critical degree of mistuning beyond which the response curve becomes double-humped and similar to that given by a pair of over-coupled tuned circuits. This critical degree of stagger is analogous to critical coupling in such a pair of coupled circuits. Only the case of this critical stagger is considered here

Higher gain for a given band-width can be secured with greater stagger, especially if the pair of stages is combined with a third tuned to the mean frequency. The system then becomes much more critical in its adjustment, however, and more liable to be seriously affected by small changes in circuit constants, notably the input capacitance of the valves. It is usually better, therefore, to adopt critical stagger.

Practical Example

The formulæ given enable the circuit values to be calculated and their use is best illustrated by an example. Suppose $C_1 = C_2 = C = 30$ pF., $g_{m1} = g_{m2} = 8$ mA/V, $n = 5$ Mc/s, $f_m = 13$ Mc/s; and $S = 1.414$ (-3 db.), then from equation (2) or the curve $nCR = 225/k$. From (3) $f_r = 12.75$ Mc/s, and from

(9) $k = 1 - \dfrac{(5/12.75)^2}{8} = 0.908$; therefore, $nCR = 248$ and $R = 1.65$ kΩ. From (4) $L = 5.0$ μH and from (5) $y = 0.2975$.

$$\text{Consequently } a^2 = \frac{2 + 0.2975\sqrt{4 - 0.0886}}{2 - 0.0886} = 1.355 \text{ and } a = 1.16.$$

Then (7) gives $R_1 = 1.92$ kΩ; $R_2 = 1.425$ kΩ; $L_1 = 6.77$ μH; $L_2 = 3.69$ μH, $f_{r1} = 11$ Mc/s; $f_{r2} = 14.8$ Mc/s; lastly $A = 69.2$.

This should be compared with the gain of two coincident-tuned stages with the same capacitance values, band-width and valves. The figure given in Design Data No. 2 was 26.3 times, so that stagger tuning in this instance gives 62 per cent. more amplification per stage.

If four stages are used with the same overall response, the drop per pair of stages is 1.5 db., so that $S^2 = 1.414$, and $nCR = 200$. Consequently $R = 1.33$ kΩ, and $A = 51.5$ per pair, or 2,650 times overall. This compares very favourably with the 182 times of four stages with coincidence tuning.

Equation (10) can be used to determine the response at other frequencies. Thus if we wish to know the response at $13 \pm 3.5 = 16.5$ and 9.5 Mc/s, $m = 16{\cdot}5 - 12{\cdot}75 = 3.75$ Mc/s and $9.5 - 12.75 = -3.25$ Mc/s in the two cases. Then $x = 1.294$ and 0.745, giving $x^2 + 1/x^2 = 2{\cdot}276$ and $2{\cdot}352$.

Then in the first case the relative response is

$$-10 \log\left[1 + \frac{2.276 \times 2.09 - 4}{0.088} + \frac{(2.276 - 2.09)^2}{0.0077}\right] = 11.46 \text{ db.}$$

and in the other

$$-10 \log\left[1 + \frac{2.352 \times 2.09 - 4}{0.088} + \frac{(2.352 - 2.09)^2}{0.0077}\right] = -12.6 \text{ db.}$$

This is the attenuation of two stages at a frequency 3.5 Mc/s different from the mid-band frequency of 13 Mc/s.

Effect of Mid-band Frequency

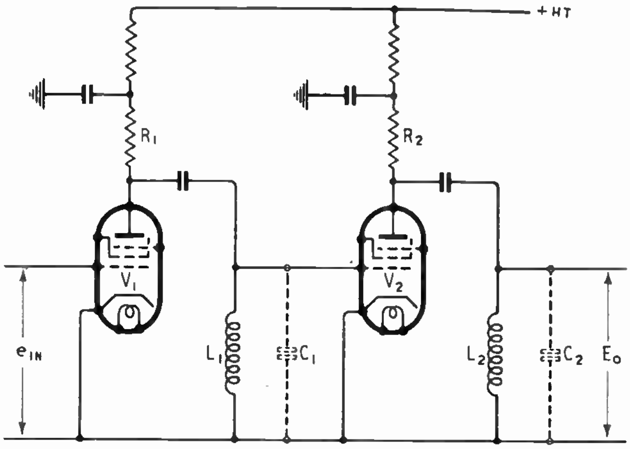
The circuit constants and performance are to a first approximation independent of the mid-band frequency. When n becomes an appreciable fraction of f_m, however, the values are affected slightly and the amplification increases somewhat as the frequency is lowered. This is not immediately apparent for in equation (8) $A \propto k$ and k decreases with decreasing frequency. However, in equation (2) $R \propto 1/k$, and $R^2 = R_1 R_2$ appears in equation (8); consequently, in reality $A \propto 1/k$. The effect of k is to increase the gain of two stages by about 10 per cent. at 13 Mc/s, as compared with, say, 45 Mc/s, so that it is quite small.

It would not influence the choice of intermediate frequency as long as this is above 7 Mc/s and there are usually objections to a lower value. It is usually permissible to take $k = 1$, and therefore to ignore it.

In order to reduce computation, a curve is included to show the relation between the attenuation at the

Wide-band Amplifiers—
edges of the pass-band and nCR (for $k = 1$). It must be remembered that the data all applies to a pair of valves with two tuned circuits — one resonant at f_{r1} and the other at f_{r2}.

Design Data (3): Wide-Band Amplifiers II



Let f_m = required mid-band frequency
n = required band-width
$f_1 = f_m - n/2$ = lower limit of pass-band
$f_n = f_m + n/2$ = upper limit of pass-band
$f_r = f_m\sqrt{(1 - n^2/4f_m^2)} = \sqrt{f_1 f_2} = 159/\sqrt{LC}$
= frequency of maximum response
f_{r1} = resonance frequency of circuit 1
f_{r2} = resonance frequency of circuit 2
m = frequency difference from f_r

S_n = Ratio $\dfrac{\text{response at } f_r}{\text{response at } f_1 \text{ and } f_2}$

S_m = Ratio $\dfrac{\text{response at } f_r}{\text{response at } (f_1 + m)}$

g_{m1} = mutual conductance of V_1
g_{m2} = mutual conductance of V_2

Units

Frequency (Mc/s); mutual conductance (mA/V); inductance (μH); capacitance (pF); resistance (kΩ).

Given f_m, n, S_n, C_1, C_2, g_{m1} and g_{m2}, to determine R_1, R_2, L_1, L_2 and A :—

$$C = \sqrt{C_1 C_2} \quad \ldots \quad (1)$$

$$nCR = \frac{225}{k}\sqrt{(S_n^2 - 1)} \quad \ldots \quad (2)$$

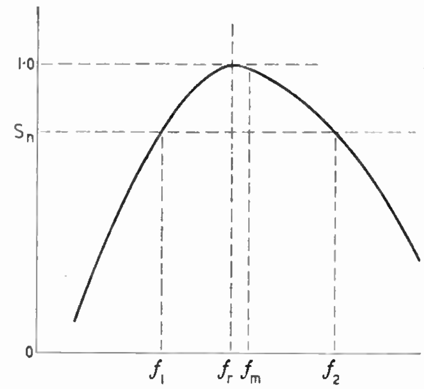
$$f_r = f_m\sqrt{(1 - n^2/4f_m^2)} \quad \ldots \quad (3)$$

$$L = \frac{24{,}400}{f_r^2 C} \quad \ldots \quad (4)$$

$$y = \frac{159}{f_r CR} \quad \ldots \quad (5)$$

$$a^2 = \frac{2 + y\sqrt{(4 - y^2)}}{2 - y^2} \quad \ldots \quad (6)$$

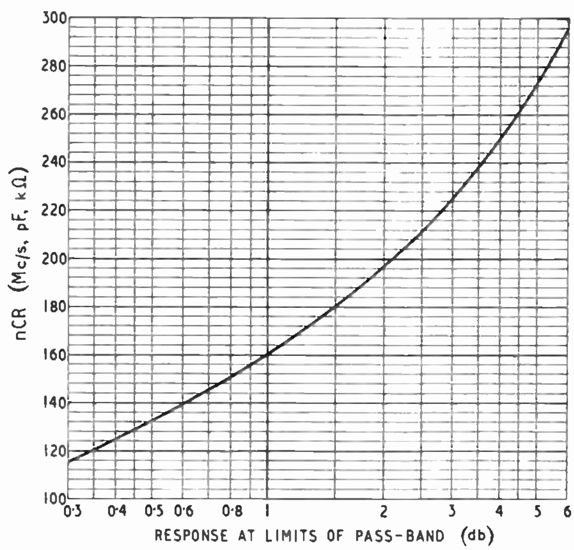
$$\left.\begin{array}{ll} R_1 = RaC/C_1 & f_{r1} = f_r/a \\ R_2 = RC/aC_2 & f_{r2} = f_r a \\ L_1 = La^2C/C_1 & \\ L_2 = LC/a^2C_2 & \end{array}\right\} \quad (7)$$



$$A = e_0/e_1 = \frac{g_{m1}R_1 g_{m2}R_2}{2} \cdot k \quad \ldots \quad (8)$$

where k = a correction factor

$$= 1 - \frac{n^2/f_r^2}{8\sqrt{(S_n^2 - 1)}} \quad \ldots \quad (9)$$



Relative response at any frequency $= -10 \log S_m^2$

$$= -10 \log \left[1 + \frac{1}{y^2}\{(x^2 + 1/x^2)(a^2 + 1/a^2) - 4\} + \frac{1}{y^4}\{x^2 + 1/x^2 - a^2 - 1/a^2\}^2\right] \quad \ldots \quad (10)$$

where $x = 1 + m/f_r$

PHASE RELATIONSHIPS

"180 Degrees Out of Phase" or "Reversed Polarity"?

By C. E. COOPER

EXPLANATIONS of phase difference between grid and anode signals of a valve stage, which include the subterfuge of an imaginary generator, are apt to leave the student, at least, with a somewhat hazy idea of the effect being explained. Such subterfuges are not essential to a completely accurate explanation, as the writer hopes to show.

It is worth while considering first the case of a valve with no anode load impedance, i.e., where the anode-to-cathode voltage does not fluctuate in accordance with a signal voltage applied between grid and cathode. This point is of some small importance, since otherwise, as will later be shown, the phase relationship between I_a and V_g sig. is dependent upon both the nature of the load and the valve amplification factor.

If we consider a resistor placed between grid and cathode, the current through this resistor will be in phase with the voltage across it, i.e., electrons will flow from the cathode end of the resistor towards the grid end at the highest rate at the instant at which the grid end is most positive.

Inside the valve, electrons will flow from the cathode towards and past the grid at the highest rate at the instant at which the grid is most positive (or most nearly positive, i.e., least negative). Thus, in the no load condition where I_a is varied only by V_g sig., the current past the grid, i.e., the I_a sig., is exactly in phase with V_g sig., if we neglect the time taken for the electrons to travel. This time is so small that it may be ignored unless the input signal is reversing its polarity in less than, say, one twenty millionth of a second.

Dealing now with the case of a valve with a load impedance, the I_a sig. will develop a signal voltage across the load, causing the anode to cathode voltage to fluctuate. These fluctuations will also affect I_a, which is controlled by both V_a and V_g, in the ratio of the valve amplification factor. To maintain the simplest possible explanation for the moment, let us now consider only the case of a pentode valve of such high amplification factor that the control over I_a exerted by V_a is negligible by comparison with that exerted by V_g.

Considering such a valve in its steady state or DC conditions, with a resistive anode load, there will be a certain voltage dropped across the resistor. The valve anode is negative to the HT+ terminal by this voltage, and positive to its cathode by this amount less than the HT voltage.

When an input signal is applied, at the peak of the half-cycle which makes the grid positive to cathode, the I_a will be highest, and the voltage dropped across the load resistor will be greatest. This means that the anode becomes least positive to cathode and most negative to HT+, so that the maximum change of V_a in a negative direction occurs at the instant of maximum change of V_g in a positive direction, from which arises the usually accepted, but erroneous statement, that V_a and V_g are in antiphase (with a resistive load).

Naturally, the writer is now required to justify the word "erroneous."

Fig. 1 (a) shows a waveform having a large amplitude, short duration positive half-cycle and a small amplitude, long duration negative half-cycle. Fig. 1 (b) shows the same waveform 180 degrees out of phase with the first. A positive peak is still a positive peak, but occurs at a different instant of time. This is certainly not what would be obtained from a valve whose input was represented by Fig. 1 (a).

What would be obtained is shown in Fig. 1 (c), where the large amplitude, short duration half-cycle occurs at the same instant of time as in Fig. 1 (a), but where it has now become a negative half-cycle. This is not a phase reversal, but is instead tantamount to a reversal of polarity or direction of connection.

This point may perhaps be clarified by a brief consideration of Fig. 2. With the circuit shown in Fig. 2 (a), there is a certain phase relationship between V_p and

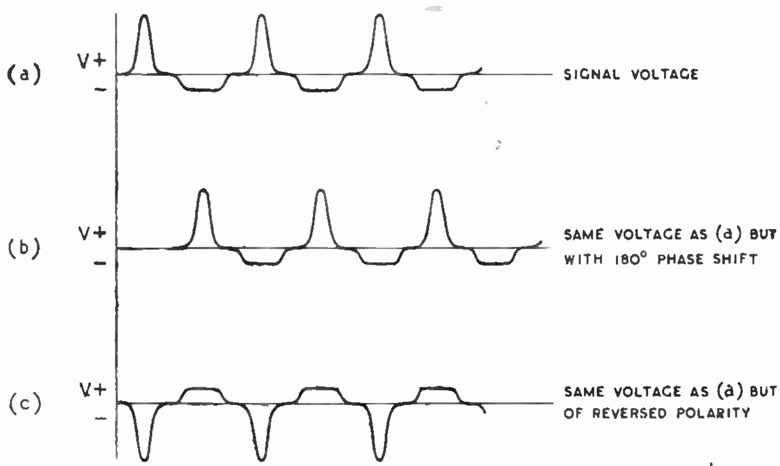


Fig. 1. Illustrating the difference between "phase" and "polarity."

Phase Relationships—

V_s, and therefore the same relationship between V_p and V_{xy}. In Fig. 2 (b) the connections to x and y have been reversed, resulting in exactly the same effect as would be produced by the addition of a valve stage to Fig. 2 (a). This reversal of connections can, however, hardly be said to have changed the phase (or time) relationship between V_p and V_s.

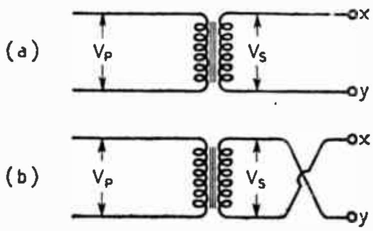


Fig. 2. Reversal of the secondary connections of a transformer has a similar effect to the introduction of a valve stage.

We may take the matter a stage further, and consider the input voltages to a Class "B" push-pull stage, where it is normally stated that the two inputs need to be in antiphase. Bearing in mind that a Class "B" (cut-off biased) valve can amplify only the positive half-cycle of an input signal, it should be realised that the application of the signals shown in Fig. 3 would only result in sinusoidal output, though the inputs are far from being sine waves. What, in fact, the two valves require are signals of opposite polarity, or direction, not signals with a time difference.

The next step is to consider a reactive load, still dealing with the high-mu valve, where I_a is virtually unaffected by V_a.

I_a is in phase with V_g sig., and this I_a flows through both valve and anode load without any change of phase (a general rule of series circuits, irrespective of the nature of the impedances). Thus if the load is inductive, the signal voltage across it will lead the I_a sig. by 90 deg. This genuine time change will now add to the reversal of polarity. The net result for an input signal of similarly shaped positive and negative half-cycles would be exactly similar in effect to V_a sig. lagging by 90 deg. on V_g sig.

For dissimilar half-cycles, in circuits where this is of importance, the only accurate view is of V_a sig. being 90 deg. leading on, but of opposite polarity to V_g sig.

It is worth while considering the case of an inductively loaded amplifier from the viewpoint of changes in steady state conditions, instead of from the viewpoint of signal voltages. With no signal input, there will be a certain steady anode current through the inductor. Assuming this inductor to have negligible resistance, there will, however, be no voltage drop across it, so that V_a will equal the HT voltage. A stationary magnetic field will have been built up round the inductor by the current through it.

If the grid is now made more negative, I_a, and therefore the current through the inductor, tends to fall. This reduced current cannot maintain the previous strength of magnetic field, some of the flux of which therefore collapses back into the inductor, inducing an EMF between its ends. The direction of the EMF is such as to oppose the change (of I_a) producing it, resulting in the anode being made positive to HT+. Thus V_a will rise above the HT voltage, a possibility which does not often seem to be realised. In fact, where I_a is suddenly considerably reduced, with a considerable amount of inductance in the anode circuit, V_a can momentarily rise as high as eight or more times the HT voltage.

Where the load is capacitive, as would be the case with a parallel tuned circuit resonant to a frequency lower than that of the input signal, the voltage across the load will lag on the I_a signal. This phase lag will be in addition to the polarity reversal, since making the grid more negative will always result in the anode becoming more positive, even though a time difference exists between the instants of maxima in the two directions.

In conclusion, mention may be made of the case where the amplification factor is sufficiently low that V_a exerts appreciable control over I_a. With a resistive load, where V_a sig. and V_g sig. are in phase but of opposite polarity, the effect is merely a reduction of working mutual conductance. With a reactive load, where V_a sig. will not be in the same phase as V_g sig. the net result will be that I_a sig. is no longer in phase with V_g sig.

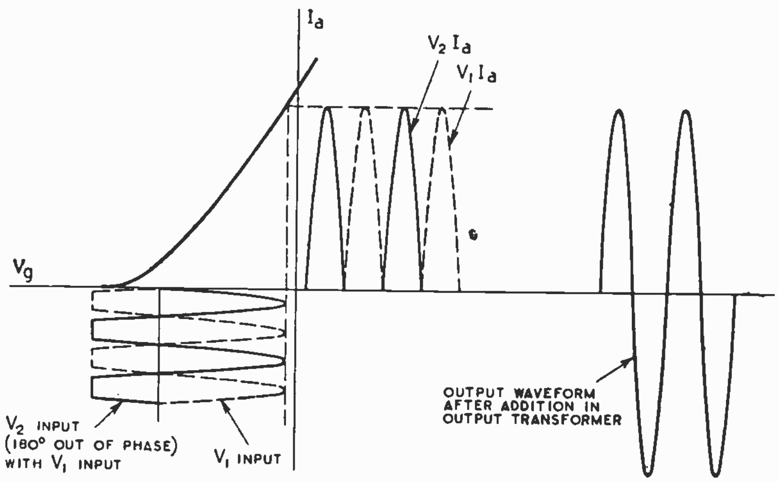


Fig. 3. "Distorted" signals with 180-degree phase difference applied to the grids of a Class B stage might result in a pure sine wave output.

This phase difference, which cannot exceed 45 deg., will be greatest when the amplification factor is lowest and the voltage developed at the valve anode is highest, a low mu indicating considerable anode control over I_a, and a high load compared with R_a indicating anode signal voltage being large.

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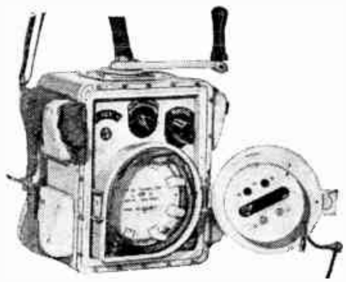

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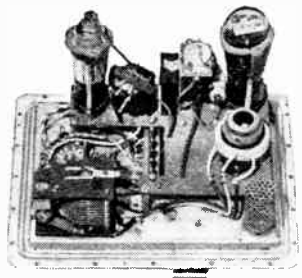

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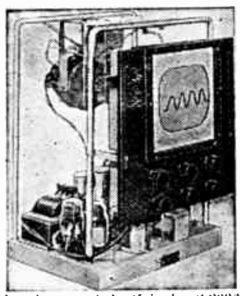

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RADAR CABLES

Recent Developments in Conductors for Very High Frequencies

By E. W. SMITH, Ph.D., M.I.E.E.
(The Telegraph Construction and Maintenance Co., Ltd.)

THE key to progress in radar technique has always been the use of increasingly high frequencies for the exploring wave.

It is evident that all the numerous current-carrying components in the equipment have had to keep pace with these increases of frequency so that none imposed undue limitations. It is here proposed to review the development of the cables which, among other components, have performed a vital function throughout. While the rate of this development has been most marked in the period 1935-1945, there is a background, as in radar itself, of theory and manufacturing experience, going back a hundred years to the days when the first cables insulated with extruded plastics were made for submarine use.

Dielectric Loss in Cables.—The chief objective in the drive for better cables has been the reduction of the power factor of the dielectric, for ten years or so ago the lowest figure obtainable in otherwise suitable dielectrics was about 0.005. We can express the attenuation constant in high-frequency cables as $R/2Z + GZ/2$, where R is the high-frequency resistance of the conductors, Z the characteristic impedance of the cable, and G the conductance (= power factor × admittance) of the dielectric. Analysis shows that, for the average cable, Z varies inversely as the square root of the dielectric permittivity, and that this permittivity can only be improved over comparatively narrow limits, and is usually independent of frequency. We know, however, that the resistance R varies approximately as the square root of the frequency, while G usually varies directly as the first power of frequency. It will thus be seen that as frequency rises, the dielectric loss can very easily outstrip that due to the resistance of the conductors. An example of this in a pre-1935 cable is shown in Fig. 1, from which it will be seen that the dielectric loss alone could be about 0.7 db./100ft. even at the low frequency of 30 Mc/s, and no less than 5 db./100ft. at 200 Mc/s.

What is the practical significance of losses of this order? The reader will remember that the height of the aerial masts in the original "CH" system was given as 350ft. for transmitting and 240ft. for receiving. The conductance loss in a connection, say, 300ft. from aerial to operating hut by cable of power factor 0.005 would be appreciable (2 db.) at 30 Mc/s and serious (15 db) at 200 Mc/s, while the use of such a cable at 3,000 Mc/s would be quite out of the question. It should be remembered that cable losses help to determine the signal/noise ratio and therefore cannot be compensated for *ad lib.* by increasing amplifier gain.

Air Dielectric Cables.—Before the advent of polythene, by the aid of which the solution of most radar cable problems was eventually found, considerable attention was paid to air dielectric cables.

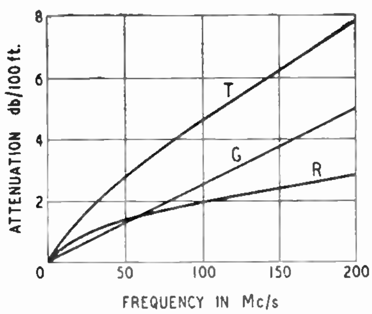


Fig. 1. Loss in a 0.3 inch diameter coaxial cable using dielectric with power factor 0.005. R, loss due to series resistance; G, loss due to shunt conductance; T, total loss.

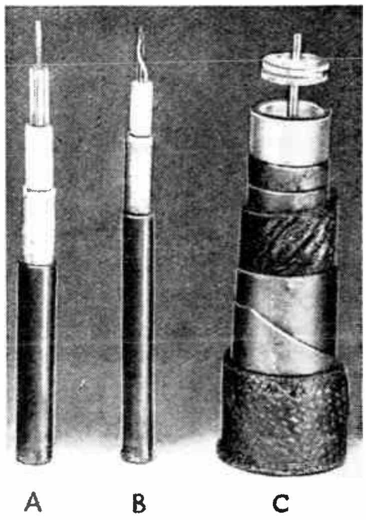


Fig. 2. Three types of air dielectric cable. A, "fin" type; B, "spiral thread" type; C, "disc-spaced" type.

Three types of air dielectric cable are illustrated in Fig. 2, in which A shows the "fin" type, B the "spiral thread" type, and C the "disc spaced" type. Type A was originally made by extruding first the star-shaped fin on to a flexible conductor and then applying the enclosing cylinder of dielectric in a separate operation. In 1935, with this combination of air and materials of the old type, the power factor discussed above was halved, while the effective dielectric constant was reduced from about 3 to about 1.5. Similar electrical results were obtained with Type B, and these types were both characterised by desirable flexibility and robustness.

With Type C it was possible to make the spacing discs of relatively hard inflexible dielectric, and a particularly suitable one, namely polystyrene, had been available for some time. In the cable illustrated the outer conductor consists of an extruded lead sheath, which when required is protected with a steel tape or wire armouring. Owing to the very low loss of polystyrene and the small amount of this material

Radar Cables—

used, the power factor of this type of cable is of the order of 0.0002, while the effective dielectric constant is about 1.1. For a 300ft. connector the dielectric loss would be quite negligible at 30 Mc/s, practically neglible (0.3 db.) at 200 Mc/s and quite tolerable (5 db.) at 3,000 Mc/s, although for frequencies of this order modifications in the normal disc spacing might be required.

The disc-insulated cables were thus electrically suitable for radar use when the art was in the early stages of development, and in fact are still incorporated in many systems. Their disadvantage is in their relative inflexibility, and in the vulnerability of their somewhat delicate construction. As will be seen later, most stringent mechanical requirements must be satisfied by most cables before they are approved for radar use.

Polythene Insulated Cables.—Readers will be familiar with the properties of polythene (polyethylene), the plastic dielectric material invented by Imperial Chemical Industries, and first produced in appreciable quantities in 1938. It has already been recorded that the construction of polythene insulated cables was undertaken by the Telegraph Construction and Maintenance Company as soon as the material was available. Actually "Telcothene," a mixture of polythene and polyisobutylene (a material of similar electrical characteristics) was used. In 1938 and early 1939 several types of radar cables were made with this dielectric. Very soon the demand grew to such an extent that the Ministry of Aircraft Production sponsored an auxiliary T.C.M. factory, solely for radar cable production, and in 1940 obtained the co-operation of other cable-making firms so that the enormous demands could be satisfied and freed, by the dispersal of plant, from the danger of serious interruption by enemy action.

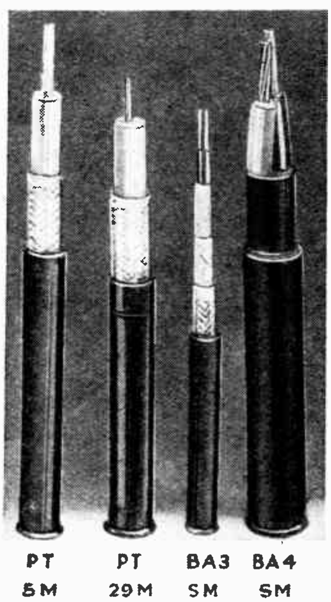


Fig. 3. Examples of coaxial and balanced twin feeder cables.

Types of Radar Cable.—It must not be imagined that the invention of polythene solved all radar cable problems at a stroke. A good deal of work in the processing of the material had to be carried out before its full value could be realised in practice. Thus the prevention of oxidation and the avoidance of air inclusion and of irregularities in extrusion had to be ensured, and it was in the solution of such problems that a long experience of plastic extrusion proved most valuable. By 1940, however, most of the desired refinements in production had been attained, and at this time an inter-Service committee was formed to standardise the variations in cable sizes and characteristics which were required. This committee framed specifications covering between 30 and 40 different cables, based mainly on a pre-war series of coaxials, known to many as "PT" types, and on a corresponding series, "BA" types, of balanced twin feeders. Fig. 3 shows, approximately half size, two examples of each type.

Generally speaking, the coaxial types have single or 7-strand centre conductors, insulation applied in two or three layers, outer conductors composed of a braid of fine copper wires, and sheaths of extruded PVC (polyvinyl chloride). On most of the balanced twin types the two separately insulated conductors are twisted and filled with the polythene-polyisobutylene dielectric to circular section.

The most important refinement desired in coaxial cables is regularity in diameter. If this dimension varies along the length of the cable, even by a few thousandths of an inch, reflections will occur and standing waves of undesirable magnitude will be set up. While great progress has been made in uniformity of diameter, work in this direction is still in progress, for dimensional tolerances even as low as ±0.001in. would be well worth attaining.

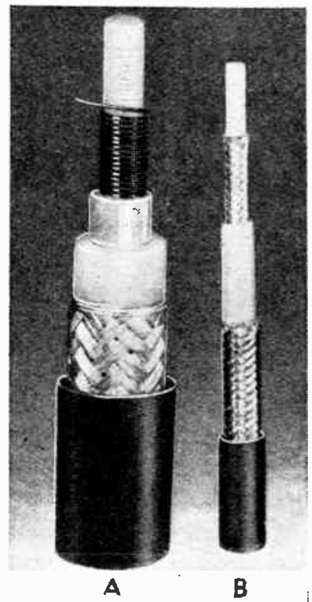


Fig. 4. Special coaxial cables. A, "delay" cable with helical centre conductor and B, "low impedance" cable with braided cylindrical centre conductor.

In balanced twin cables, the degree of electrical balance to earth of the two conductors is of similar importance. A notable feature in such cables is a double screen, the inner screening component being a helical wrapping of metallised paper, and the outer one a braid of fine wires. Prior to the introduction of this construction by T.C.M. in 1942 the stability and ageing properties of twin cables left much to be desired.

Special Types.—The impedance of the polythene insulated coaxial cable is normally about 70 ohms, and that of the twin 90-100 ohms. Departures from these average figures have, however, been required for special purposes, and two extreme cases may be mentioned here. One is the "delay" cable, in which a helix of wire takes the place of the single central wire in a coaxial cable, and the other the "low impedance" cable in which the centre conductor, as well as the outer, is a braid of fine wire. These are illustrated in Fig. 4.

The chief features of the "delay" cables are their high characteristic impedance and low propagation velocity. Several types are made, the impedances ranging from 130 to 2,000 ohms and the velocities from one-seventh to one-hundredth that of light. These cables are mainly used to produce artificial echoes for calibration purposes.

Mechanical and Electrical Testing.—Mechanical testing of solid dielectric cables includes tension, bending, twisting, hot deformation, and "cold crack" tests. Tension is applied to short lengths to see that the dielectric tightly embraces the centre conductor and is in turn firmly held within the outer braid. To determine the effects of bending, the cable is wound and unwound several times, the diameter of the winding being normally ten times that of the cable itself. Twisting tests comprise twists and untwists on a short, straight sample through a specified angle. In the hot test the cable is kept under load for 16 hours at a temperature of 70 deg. C.; the temperature generally chosen for the "cold crack" test is −30 deg. C.

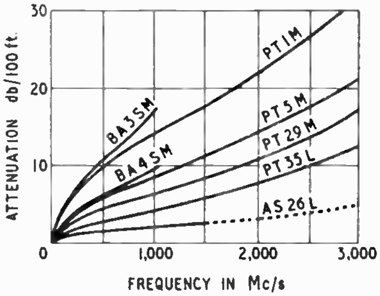


Fig. 5. Losses in radar cables, diameters 0.13in. (PT1M) to 0.8in. (PT35L).

The radio-frequency characteristics of radar cables are determined by "resonant line" and "standing wave" methods, details of which have appeared in recent papers.* Fig. 5 shows a few typical results. In addition to RF tests, all cable is subjected to DC measurements to determine conductor and dielectric resistances, the latter being usually at least 10^5MΩ—100ft. A high-tension test at 50 c/s is also applied, the voltage chosen being such that the maximum stress in the dielectric is 90 kV(peak)/cm. Radio-frequency characteristics must remain unaffected by this application, and by the mechanical treatment outlined above.

* *Journal Brit. I.R.E.*, Aug., Sept., 1945. *Wireless Engineer*, Nov. and Dec., 1944.

BROADCASTING IN U.S.A.

Report on Post-war Trends

By A. DINSDALE

As shown in this article from a correspondent in U.S.A., the problems of war-to-peace transition in American broadcasting and television are very different from those prevailing under the British system of distribution.

IN considering post-war radio prospects in the United States we must start with the listener. His problem is the simplest and therefore the easiest and quickest to dispose of. All the listener asks is: "When do I get a new radio?" The manufacturers' easy answer to that one is: "As soon as the current strike situation is cleared up, and we can get materials and parts." (First it was "reconversion." Now it's strikes.) Privately, the manufacturers are still debating just how much provision to make for F.M. and television. Even more important from their point of view are the ceiling prices they will ultimately be permitted to charge. American production of consumer goods for domestic consumption will not get under way in real earnest until these two vital factors, wages and prices, have been settled.

Until such time as new radios become available, the average listener can manage to get his old set fixed, now that service men are returning, although certain parts and some types of valves are still in short supply, or unavailable.

Some listeners, while pondering the possibilities of a new radio receiver, are asking "What about television? Is it ever going to come around that corner? And what's this F.M. thing I keep hearing about? Is it any good?" But it must be reported that the majority of listeners appear to be apathetic towards both these developments.

That just about disposes of the listener. From here on, this report is going to get complicated, as it must delve into the grim realities of Big Business.

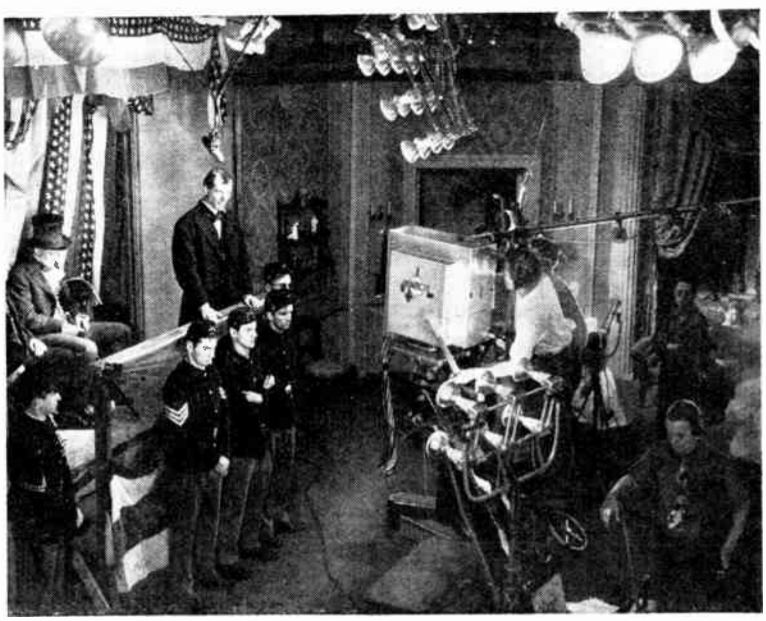
Radio is Big Business.—First of all, you must never for a moment lose sight of the fact that American broadcasting is conducted on a commercial basis. Generally speaking, the principal function of a station manager is to see to it that as much of the station's time is sold as possible. In America, radio is just as much an advertising medium as newspapers, magazines or posters. You probably know that already, but it is necessary to emphasize it.

During the war years, the demand for radio time increased by leaps and bounds. One of the principal causes of this was the increasing shortage of newsprint for the papers. Another potent factor was the vast increase in radio's power as an advertising medium. Everybody listened constantly and attentively for the latest war news.

According to the new 1946 Broadcasting Yearbook, the total spent on radio advertising (including station time and talent) in the United States in 1945 (American radio's 25th year) is estimated at $383,450,000, an increase of 7.5 per cent over 1944. That puts radio up in the category of Big Business.

The effects of radio's sensational rise are many and varied. In the first place, at the end of 1945 there were 1,004 standard broadcasting stations in the United States, compared with 943 in 1944. I might explain that the term "standard broadcasting station" has come to be used to describe an A.M. station, as distinct from F.M.

One immediate effect of the radio bonanza is apparent in the numbers of applications on file before the Federal Communications Commission. The F.C.C. was swamped with over 500 applications for new standard broadcasting stations, more than 800



A scene in the studio of the American National Broadcasting Company's television station during the transmission of a programme. Only "a small handful" of Americans have sets with which to receive these transmissions.

applications for new F.M. stations, and between 40 and 50 applications for television stations. The figure for television applications was much greater at one time, but many applications were withdrawn for reasons which will be made clear later. In addition, the F.C.C. has before it hundreds of applications from existing stations for increases in power and/or changes in frequency. In the face of this apparently hopeless situation, many would-be station owners are shopping around, trying to buy existing stations. Naturally, prices have risen to astronomical heights, with few stations for sale.

Goodness only knows how room can be made for 500 additional A.M. stations, although much has already been done by the use of directional antenna systems, arranged so that at night a station's signal can be cut off in the direction of a nearby station on the same frequency, thereby protecting it from interference.

Frequency Modulation.—Radio manufacturers obviously face a tremendous post-war boom, both in transmitters and receivers. There is a demand for new transmitters both as replacements and for new stations. There is a stupendous market for replacement receivers. But this, apparently, is not enough. Hence the pressure for F.M.

This pressure for F.M. has been brought to bear on station managers and owners by transmitter manufacturers. It went on relentlessly all through the war years, increasing in tempo as the war drew to a close. I know. As a station manager I was exposed to it. Manufacturers bombarded owners and managers with the constantly reiterated argument that of course they wanted to be first in their locality to exploit this new post-war development. "Place your order now, and be first on our list when we are able to deliver."

American broadcasting is a competitive business. Every station tries to outdo its competitors with all sorts of stunts to attract new listeners. Just as some newspapers run circulation-building stunts, so American broadcasting stations strive to build listeners. The more listeners you have the more advertising you can attract. Or you can raise your rates. So F.M. has been "sold" to owners as a means of attracting new listeners.

But the catch is that it costs from $50,000 up to build and equip an F.M. station, and until somebody buys a new receiver you have no listeners. The comparatively few F.M. receivers sold before the war are now useless, due to a recent change in the F.M. band, which is now 88-104 Mc/s. But it's the old story of the chicken and the egg. Which came first? Unless somebody puts up an F.M. transmitter there is no incentive for a listener to buy an F.M. receiver. But while waiting for people to buy receivers the station owner has to bear the expense of keeping his F.M. transmitter operating as a sort of auxiliary to his A.M. transmitter. In time, enough people will have bought F.M. receivers (or combination receivers capable of receiving both A.M. and F.M.), so that the station owner will have an audience sufficiently large to attract advertisers. When that happens the owner should begin to get his investment back. At least, that is the theory. Will it work out?

Suppose you own the only station in town. Suppose, for the sake of argument, you have just two listeners. Either they both ignore F.M. and continue to listen to the A.M. station, or they both listen to F.M. and abandon the A.M. station. More likely, they will divide their listening between the two stations. Thus, instead of increasing your audience, all you have done is *split your audience*, reducing by half the potential advertising value of both stations. You just *can't* increase your audience, because everyone ever likely to own a radio has one already, and has established his listening habits.

If there's more than one station in town, competition will force the other fellows to build F.M. stations, too, and anyone interested in the novelty of F.M. will continue to listen to the auxiliary of the station he usually tunes in.

From a revenue point of view,

(*Continued on page* 134.)

Broadcasting in U.S.A.—

one advertiser put it to me like this: "Look, Dinsdale. I've got just one advertising dollar to spend. Go ahead and build an F.M. station if you've a mind to. And when you get it built you can put my advertising on either station, or split it between them, according to your judgment of what'll do me the most good. But don't come and ask me for a *second* advertising dollar for your F.M. station. I just haven't got it."

That is the dilemma facing American station owners and managers to-day. They want to keep in the van of progress, but it means a heavy investment, both in first cost and in operation, and they cannot see clearly where the return is coming from, or when. Splitting the audience between A.M. and F.M. may force a reduction in advertising rates of both stations, with a consequent heavy reduction in overall yield from an increased investment.

In large metropolitan areas like New York or Chicago, the case is different. In such areas there are many would-be radio advertisers who simply can't get on the air because (1) there aren't enough A.M. stations to accommodate them, and (2) the rates are too high. In metropolitan centres there is room for some F.M. stations to accommodate these people. With range, and thus marketing area, limited to the horizon, the rates can be low enough so that service can be extended to thousands of new advertisers.

Why F.M., Anyway?—At this point one is forced to ask the question: "Why introduce F.M., anyway? The only one sure to profit is the manufacturer of transmitters and receivers. The position of the station owner is most dubious, to say the least of it, and the listener doesn't seem to care." So let's take a look at the listener again.

F.M. is being sold to the American public on two counts: (1) It is interference-free (but the word "practically" is now being inserted); (2) it provides unequalled tone quality.

Let's examine this interference-free claim. Since F.M. is limited to the horizon, we can compare an F.M. signal to that provided in the same area by an A.M. station—that is, the so-called primary service area, where the signal strength is not less than a half millivolt. As things stand to-day, with a reasonably good receiver, properly installed, there is no interference to speak of in the primary service area of an A.M. station, unless a thunderstorm is raging in the immediate vicinity. If you get beyond the primary service area of an A.M. station you'll get plenty of interference natural and man-made. But at the same distance from an F.M. station you'll get no signal at all. So wherein lies the value of the argument?

Let's consider quality. I will make the flat statement that if you walk into any number of American homes to-day you'll find that in 95 per cent. of them the tone control on the radio is turned *down*, to cut out the high frequencies. If you ask about it, you will be told vaguely that they like it better that way. With the tone control up, the radio sounds "harsh," "raspy," or it interferes with conversation or reading.

In that last you have it. The radio is on only to provide a pleasant background. It is only really listened to when a comedy programme comes on, or a news broadcast, or a favourite commentator, or a dramatic programme. And for such programmes high quality is not necessary. Only a few music lovers take the trouble to buy the best in radios, and then get the most out of them.

An educational campaign? Futile. About 12 years or so ago, set manufacturers improved their receivers so that they would reproduce up to 7,500 cycles. They spent millions to advertise the fact. A number of so-called "high-fidelity stations," like WQXR in New York, explained and explained and *explained* this business of high quality, and demonstrated it for years by playing the highest quality recordings they could get. In fact, they forced improvements in recording quality.

And what happened? People still turned down the tone control as soon as the first novelty wore off.

So now along comes F.M., with transmitters capable of putting out even higher quality, and receivers capable of reproducing it.

However, you can't take out what you don't put in. By that I mean that F.M. transmitters are capable of putting out much higher quality than is readily available to them. At first, much of the programming will come from high-quality electrical transcriptions and some records. But even the highest quality transcriptions that it is now possible to make cannot equal F.M.'s potentialities. Network programmes, received by the station over ordinary telephone lines, will not sound much better than they do over A.M. The cost of a network of high-quality concentric cable would be prohibitive. In the end, networks of F.M. stations will have to be fed network programmes by means of chains of F.M. relay stations.

However, it is the opinion of top network executives that, eventually, service in metropolitan areas will be by F.M. exclusively. Existing A.M. stations in such areas will be scrapped, with the exception of a limited number of high-power A.M. transmitters which will be moved out to the wide open spaces to serve rural areas where the population density is so low that F.M. service would be uneconomical. However, it is expected that about ten years will elapse before this change takes place.

The major factor in forcing this change will be economic. The time will come when broadcasters, one by one, will find it uneconomical to operate two transmitters, one A.M. and one F.M., and they will either scrap the A.M. or move it out into the country.

Gradually, there will be still another economic change. With the range of F.M. limited to the horizon, the number of radio homes which can be covered will be greatly reduced, especially in the case of the higher powered A.M. stations. That means a reduction in circulation, which in turn means that advertising rates will have to be reduced. Yet, first costs and operating expenses will remain about the same. Add to that a vast increase in the total number of broadcasting stations when F.M. becomes general, and the result is that the total radio advertising revenue will be spread among many more stations, so that the average revenue per station will be greatly reduced. This factor may discourage many station owners and become the controlling factor which will limit the total number of stations.

The vast potential increase in the number of stations possible with F.M. has already attracted trade unions and other organizations with a special cause to plead, and they are busily filing applications for "non-commercial educational" F.M. stations.

Television's Future.—Television's future in America can be summed up in one word—Uncertain.

Technically, black-and-white images, seen under the best conditions, are good. I've just checked on them in New York. The Columbia colour television is very good. To get the colour, they use a revolving colour disc at the receiver, synchronized with a similar disc at the transmitter. I described this system in its original form in *Wireless World* several years ago.

Programme material cannot be so highly praised. Frankly, producers are still experimenting, searching for the proper material and methods of presentation for television. "Televiewers" are limited to a small handful. Only a few thousand receivers were distributed before the war, and these must be modified before they can be used on to-day's limited transmissions. This is so because, as in F.M., frequency assignments have been changed. A start is being made now on the 60-78-Mc/s band, and eventually, television will move to the 160-288-Mc/s band. Columbia is experimenting with its colour system on frequencies above 450 Mc/s. New television receivers are not yet on the market, although a few of the bigger manufacturers are beginning to advertise combination receivers capable of handling A.M., standard band and short-wave; F.M. and television; they incorporate a phonograph turntable with automatic record-changer. As to delivery, it is hoped that this may be "some time this year." No one ventures to quote even an approximate price for these new "all-in" sets.

Economics of Television.—Even more so than in the case of F.M., economics seems destined to play an important part in television. About the lowest figure I have heard quoted for a television station is $200,000. But it is generally agreed that the minimum cost of a fully-equipped television station is likely to be closer to $350,000. It is also agreed that the cost of operation for the first year is likely to be in the neighbourhood of $350,000. By the end of the second year, it can be hoped that a substantial number of television receivers will have been purchased within the service area of the station. But by that time, the television broadcaster will have spent *one million dollars.* Bear in mind that in America, television seems destined to become another advertising medium, like sound broadcasting. Where, after two years of operation, is a television broadcaster to find sufficient revenue to make his investment worth while? It is generally agreed that advertising rates over television will have to be several times those now charged for present radio advertising, and programme production costs will also be several times higher. Thoughtful persons in the radio industry are beginning to wonder just who will be able to stand such high advertising costs. In large cities, perhaps a few big department stores will be able to stand it, but the overall revenue possibilities are so doubtful that quite a number of would-be television broadcasters have withdrawn their applications.

Obviously, those who stand to profit most by the development of television are the manufacturers who expect to produce and sell transmitters and receivers. It may be that eventually they will have to shoulder the cost of television broadcasting and accept as their sole return the wide sale of receivers. But before that can happen, present restrictive laws will have to be modified.

So, all in all, I feel justified in saying that the future of television in America can only be described as uncertain.

Letters to the Editor

Expansion Circuits • The £1 Broadcast Licence Quality of B.B.C. Recordings

Contrast Expansion

I HAVE read with much interest Mr. White's articles on contrast expansion in the September and October, 1945, issues, but there is one important point on which I should like to be re-assured before accepting his final circuit as satisfactory. It is the amount of harmonic distortion introduced by the controlled valve (V_3, Fig. 9) being a non-linear resistance.

Suppose first that the output voltage at the anode of V_3 is applied to V_3 and R_1 in series, but that the voltage across R_1 is not fed back into the amplifier. Since the resistance of V_3 cannot be strictly linear, the current through the circuit will contain harmonics and so, therefore, will the voltage across R_1. When R_1 is connected into the cathode circuit of V_1, these harmonics will be amplified and will appear in the output. Simple analysis indicates that, if the harmonic percentage across R_1 (before connection to V_1) is p, the harmonic percentage in the output will also be not far short of p. From this point of view, therefore, the circuit is probably not superior to variable-resistance circuits not using feedback.

Mr. White claims that his expander will drive an output stage directly. The output stage of a quality amplifier will need something like 45V peak for full drive (this means nearly 20V applied to V_3). Since at full drive V_3 has maximum negative bias, its resistance will be in the most non-linear state, and I should have guessed that with 20V applied to the anode it would generate appreciable distortion, which will sound worst at maximum output. But the matter can only be settled by the figures, and if Mr. White can supply these (i.e., output distortion for given amounts of output voltage) I think he should do so, in order to prove his claims that the circuit will drive an output stage directly and that it introduces less distortion than other types (he remarks that push-pull variable-gain expanders do not remove the odd harmonics, implying that his circuit is superior).

Although this may not have been intended, the article gives the impression that the distortion produced by a variable-resistance valve is inherently reduced by placing the valve in the feedback path. This is obviously not fundamentally true; negative feedback will reduce the effects of non-linear components in the amplifying path, because this is its function, but it does so by using a feedback path which is strictly linear (usually a resistance divider). If the feedback path is itself non-linear then it will produce distortion even with a strictly linear amplifier.

These remarks are not meant to detract from the value of Mr. White's article, but rather to add to it. If the distortion figures are satisfactory, the circuit may well prove to be superior to all others on grounds of simplicity, ease of control, and relatively high gain.

D. H. PARNUM.

Helensburgh.

[These comments are referred to on p. 120.—ED.]

B.B.C. Finance

MAY I be allowed to point out some anomalies which seem to have escaped other commentators on B.B.C. finance?

First, the radio critics in the lay Press seem to have swallowed unquestioningly the extraordinary idea that the 10s licence fee would not now suffice to pay for the home (sound) broadcasting services, and that an increase to £1 is reasonable. Now the B.B.C. in 1938 had only 7s 6d out of each of a smaller number of licences than exist now, but was able to pay for the following: The home (sound) broadcasting services; the Empire service (on short waves); the London television service; capital expenditure on new transmitters and buildings; income tax (charged on that part of the Corporation's revenue which was devoted to capital expenditure). It is therefore my guess that 6s per licence would have covered the maintenance of the home (sound) broadcasting services before the war; allowing for the 50 per cent rise in prices since 1938 the B.B.C. would need 9s now. Out of a 10s licence fee this would still leave the Post Office 1s for cost of collection, compared this with 2d which is charged for issuing and cashing a 10s Postal Order. An increase in the licence fee to, say, 12s 6d. might be within the bounds of reason, but an increase to £1 is not. The additional 10s on the ordinary radio licence is therefore not required to pay for the services which the licensee receives, but is probably intended for one or more of the following purposes:—

(i) To pay for the overseas propaganda services, which ought to be charged directly to the Exchequer, on a par with the expenses of the British Council.

(ii) To pay for television, which the Government's Television Committee has shown cannot be paid for by the owners of television receivers.

(iii) To serve as a tax, pure and simple. (However unpalatable, this is fairly logical, since other forms of entertainment are taxed.)

It seems that many people have been misled by the fact that during the war the B.B.C. has had a total expenditure roughly equal to twice the proceeds of the 10s licence fee. But the reasons for this are now emerging from secrecy: the number of overseas programme hours, the numerous additional high-power stations to carry these programmes, the reorganisation of the home services to meet air-raid dangers. The wartime figures are therefore no guide to future requirements.

One other point deserves mention. In the past, the B.B.C. has financed all capital expenditure out of income; if a substantial step forward in B.B.C. services is required, whether for television or for U.H.F. sound broadcasting stations in sufficient number to provide real "freedom of the air," part at least of the capital expenditure might perhaps be met by a loan secured on the capital assets of the broadcasting system.

D. A. BELL.

London, N.21.

Too Many Recordings ?

SEVERAL of your correspondents have complained about the poor quality of the B.B.C. transmissions and the excessive use and poor quality of gramophone recordings.

An analysis of the Home Service programme for March 3-9 inclusive shows a total time of 121 hours and 5 minutes, of which 35 hours 5 minutes, or some 29%, was taken up by recordings, of which 14 hours 50 minutes were commercial pressings, and 20 hours 15 minutes B.B.C. recordings. It would therefore appear reasonable to say that the use of recordings is excessive.

Regarding the quality of recorded programmes, commercial pressings are far too often worn and even scratched, and in a number of instances badly presented. But the B.B.C. recordings are, in almost all cases, of really excellent quality, and I cannot help feeling that if the many armchair critics were not made aware of their origin by announcements or printed programmes, it would not occur to them that the programme was recorded. As regards this type of recorded programme, I disagree entirely, as do very many of my friends, with your correspondents, and consider that the B.B.C. have done, and are doing, a first-class job.

R. W. LOWDEN.

Camberley.

Soldering v. Spot Welding

"DIALLIST," in your March issue, is not quite fair to soldering. We cannot agree that it necessarily produces "too many dry joints," or that "the dry joint is a menace." Also, may we remind your readers that the merits of spot welding, which he seems to advocate as an alternative, have yet to be proved?

There may have been too many dry joints at one time, due to poor solder (incorrectly alloyed or made from reclaimed metal), poor flux, or, in cored solder, lack of flux in lengths of the solder wire. Multicore Solders, Ltd., endeavoured in 1938 to overcome these troubles by producing a cored solder which (a) was made from virgin metal; (b) incorporated non-corrosive activated rosin flux; (c) provided three flux cores, so the risk of absence of flux in appreciable lengths was negligible.

The results of introducing this solder was very encouraging, but after the fall of Malaya there was some increase in the incidence of dry joints in radio equipment. This was because the 45-55 alloy solder used to conserve tin supplies had a higher melting point than the 60-40 alloy mainly used before. Many electric soldering irons had too low a bit temperature for wartime solder. We investigated the matter in collaboration with manufacturers, and as a result of our efforts dry joints again fell to a reassuringly low level.

Cored solder of 60-40 alloy is again available, and if the radio industry will use it in the correct manner with a soldering iron bit temperature of about 250°C there is no reason for any dry joints in bulk production. In fact, it should be practically impossible to make one.

RICHARD ARBIB,
Multicore Solders, Ltd.
London, W.1.

CATALOGUES RECEIVED

PAMPHLET No. W9795 describing Pirelli-General radio-frequency cables, issued by the General Electric Co., Magnet House, Kingsway, London, W.C.2.

Abridged illustrated list of amplifiers, loudspeakers and microphones from Trix Electrical Co., 1-5, Maple Place, Tottenham Court Road, London, W.1.

Illustrated catalogue of dry electrolytic capacitors in aluminium containers from the Telegraph Condenser Co., Wales Farm Road, North Acton, London, W.3.

Folder giving characteristics, base connections and prices of Osram receiving valves in tabular form from the General Electric Co., Magnet House, Kingsway, London, W.C.2.

Leaflet describing the "Quixo" battery test meter made by Runbaken Electrical Products, Burtons Buildings, Oxford Road, Manchester, 1.

RANDOM RADIATIONS

By "DIALLIST"

A Sun Spot Effect

WHEN the two enormous spots were passing across the sun's face earlier in the year some very peculiar wireless effects were noticed. One of the queerest that came my way concerned not the short waves but the long waves. On rare occasions in the past I have known fading on wavelengths up to 900 metres or a little above though it has seldom been of a very severe kind over about 750-800 metres. During the sun-spot period I found Luxembourg on 1,200 metres behaving almost like a very distant short-wave station. Fading was very marked indeed, the transmission at times almost disappearing amidst the horrible distortion that so often occurs on distant short-wave stations or on stations at the lower end of the medium-wave band during high-speed fading. But fading was sometimes slow and rhythmic; at other times it was found to be a good deal more rapid. I wonder if readers noticed anything of the kind; perhaps some of them found fading on even higher wavelengths during that queer period. I only wish that the data of solar activity which one used to get before the war were now available. They should make interesting reading.

□ □ □

Standard Voltages

SO there is some chance that we shall have standard main voltages in the not-too-distant future. A good many people must have been surprised by the announcement by the Minister of Fuel and Power that it had been decided that the national standard voltage should be 240. This, I suppose, applies to A.C. and there is no suggestion that any alteration is to be made in the frequency. The original aim was to standardise 230 volts, 50 cycles, A.C. throughout the country, but in a good many districts (parts of Scotland for instance) the supply is 240 volts. The figures are in effect surprising. Out of nearly ten million consumers rather more than five and a half million now have supplies at 230 volts and two million, one hundred and seventy thousand supplies at between 240 and 250 volts. The present permitted variation is ±6 per cent., which, as the Minister suggests, probably means that many, if not all, of the 230-volt consumers have at one time or another been working their apparatus, even if they knew it or not, at 240 volts or more. The idea is that a good deal of apparatus designed for 230 volts will therefore prove satisfactory at 240 volts, and as something like seven and three quarter million consumers have hitherto had supplies at 230 volts or more, the choice of 240 volts means the smallest expenditure in replacing apparatus.

Worth Noting

The Minister stated that the cost of replacing or converting existing apparatus which would not work on 240 volts would fall upon the supply authorities when the change-over was made. I am no lawyer, but I think that I am right in saying that supply authorities become liable only if they have been informed of the apparatus that is in use in a particular house and have approved it. I imagine that most of us have any amount of electrical gadgets in our homes whose use has not been reported to our suppliers. I know I have! I suppose the sound thing to do is to make a list of what one has and to send it in with a formal report. Being myself on 200V I must remember to do so; much of my gear would not work as it stands on 240V.

□ □ □

"All-wave" Receivers

A FEW of the new receiving sets are beginning to find their way on to the market, and they are apparently being snapped up by an eager public as soon as they appear. This is not surprising, for the majority of listeners must own sets which are more than five years old, so that replacements are, to say the least of it, desirable. At present almost any kind of set will sell, so long as it works; but I do hope that manufacturers will remember that this cannot go on for ever. To have a ready market in this country the sets will have not only to be good performers on the local stations, but also, if they are of the "all-wave" type, to be easy to use on the short waves. Short-wave listening is so fascinating that it would have caught on as a popular hobby much more markedly than it did if only sets had been made reasonably easy to tune on their short-wave range. Well do I remember one set of bygone years on the tuning dial of which the rich 19-metre band occupied a space of less than one-eighth of an inch! As there were twenty-two stations working in this band at the time when the receiver made its bow to the public you can imagine that it was not exactly a fine short-wave performer in the hands of the average listener. If the "all-wave" set is to be a success the short-wave range must not be just stuck into it as a sales-talk trill. There is no reason why, with band-spreading of one kind or the other, short-wave tuning should not be made a perfectly simple business. I am sure that the public would be quite willing to pay a bit more for an "all-wave" receiver whose short-wave range was really usable by the ordinary man or woman. I am equally sure that a short-wave range as difficult to handle as some of those of past years is not really an attraction.

□ □ □

The Gas Blowlamp

THE little gas blowlamp which I described in these columns recently seems to have been known to only a few readers; those who did know it speak highly of its performances and of its usefulness. A brother of mine, who is not only the owner of a splendidly equipped workshop, but is also a skilled amateur mechanic, has made himself a *de luxe* model—a lovely thing. You may remember that the essentials of this blowlamp are as follows: a nozzle about ⅛in. in diameter is supplied with gas from the mains and gas, issuing from a minute aperture an inch or so away, carries air with considerable velocity into the flame at this nozzle. The result is an intensely hot "blown" flame from six to eight inches in length according to main pressure. The "super" model to which I refer is mounted on a heavy stand with a ball and socket joint. You thus have both hands free to hold the work and can direct the flame just where you want it. Another refinement made is to fit the nozzle with a control valve so that the amount of gas issuing from it can be regulated to a nicety. In this way a very hot flame can be obtained from about 1½-6 inches or more in length to suit the work in hand. I have shown this little tool to several people, some of whom were sceptical about its efficiency until they actually saw it in action. But that scepticism does not endure long when you show them how quickly a piece of steel can be brought to bright red heat in the flame. One of the most useful applications that I have found for the lamp is for sweating. You can do the work cleanly and quickly and there is no bother about pumping up to maintain pressure.

AMATEUR TRANSMITTER'S EXAMINATION

IN view of the changed status of the radio amateur it has been decided that those wishing to operate a transmitting station must either satisfy the Postmaster-General that they possess the required qualifications or alternatively sit for an examination which will be arranged by the City and Guilds of London Institute. The first examination will take place on May 8th, 1946, between the hours of 7 p.m. and 10 p.m. and it may be taken at one of several centres throughout the country, details of which can be obtained from most technical colleges; failing that, from the Superintendent of the Institute, 31, Brechin Place, London, S.W.1. Closing date for entries is March 31st, 1946.

A fee of 10s. will be charged by the Institute to cover examination costs. Local centres may also make a small charge for accommodation.

In addition, the Post Office will require applicants to pass a test in morse at 12 words per minute, which will be held at local Head Post Offices on payment of a fee of 5s.

The following abridged syllabus gives an indication of the subjects covered by the examination:—

1. **Electricity and Magnetism.**—Elementary theory of electricity conductors and insulators. (Ohm's Law, resistance and capacitance in series and in parallel.) Permanent magnets and electromagnets in radio. Self and mutual inductance, capacitance.

2. **Radio Principles** (elementary treatment only).—Alternating currents; series and parallel A.C. circuits incorporating inductance, capacitance and resistance. Coupled circuits, acceptor and rejector circuits. Simple theory of electromagnetic wave propagation.

3. **Thermionic valves and circuits.**—Principles and characteristics of modern valves, methods of use in receiver and transmitter R.F. and A.F. circuits and power supply equipment.

4. **Receivers.**—Essentials of a radio receiver, including T.R.F., superheterodyne and super-regenerative principles of operation (C.W. and telephony).

5. **Low-power Transmitters.**—Oscillator circuits, use of quartz crystals in oscillators for frequency control, frequency multiplication, R.F. power amplification, modulation and keying technique. Avoidance of interference (over-modulation, harmonic radiation and keying).

6. **Aerials.**—Simple types of receiving and transmitting aerials, feeder systems and simple directional arrays.

7. **Measurements.**—Measurement of frequency, use of crystal-controlled frequency meters, artificial aerials and their use in lining up transmitters. Measurement of anode current and voltage; computation of power input to individual stages in a transmitter.

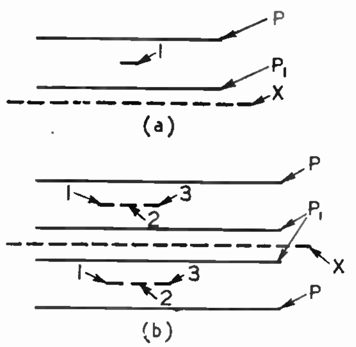
8. **Licence Conditions.**—Understanding of the conditions laid down for operation and procedure.

RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

TRANSMISSION LINE ELEMENTS

PAIRS of conductors, having distributed inductance and capacity, are commonly used as impedances and resonators in short-wave technique. A more recent application is to radiolocation, where it is necessary to transmit periodic pulses of high-powered energy, at regular intervals, and where the time constant of a transmission line element lends itself to the formation of suitable square-shaped modulating voltages.



"Delay" cable construction

An element which is geometrically short, but electrically long, and therefore well adapted for the purpose in view, is based on the combination of a conductor 1, in the diagram (*a*), of finite cross-section, placed midway between two infinite parallel conducting planes P,P_1. This is wound helically about an axis X to give the assembly shown in diagram (*b*), where 1, 2, 3, are successive turns of the inner conductor, and the parallel planes become two concentric tubes, P,P_1. Further similar windings can be built up around the two shown. The different inner layers are connected in series, and the tubes P,P_1 are connected together and earthed, to simulate the inner and outer conductors of a coaxial line.

The General Electric Co., Ltd., and C. R. Dunham. Application date May 26th, 1943. No. 570087.

TUNING SYSTEMS

ONE end of an inductance coil is enclosed in a movable sleeve which is connected, directly or through a capacity, to the free end of the winding. If the distance between the inner surface of the sleeve and the coil is small, compared with the distance between consecutive windings, a part of the current will flow through the capacity between the covered windings and the sleeve. The circuit is stated to be equivalent to the inductance of the uncovered windings, in series with a pair of Lecher wires formed by stretching out the covered windings, and the bending the straightened wire back on itself to form a Lecher pair, the two wires being separated by a distance equal to that between the sleeve and the coil.

If the Lecher wires are terminated by a load equal to their surge impedance, the transition resistance between the covered and uncovered parts of the coil is independent of the position of the sleeve. Also if the uncovered coil is shunted by a condenser, the resonance resistance of the loaded oscillation-circuit so formed can be made constant over a wide range of movement of the tuning sleeve. The invention is particularly applicable to ganged tuning control, and to the balancing of push-pull couplings.

"Patelhold" Patentverwertungs-und Elektro-Holding A. G. Convention date (Switzerland) December 17th, 1942. No. 570474.

INSULATORS

AROMATIC sulphones, mixed with known insulating materials such as those derived from vegetable and mineral oils, are found to possess unexpectedly favourable dielectric properties. When used, for instance, in the type of condenser built up from paper-spaced aluminium foil, the impregnating mixture gives a substantial increase of capacity and reduced power losses.

The preferred sulphones are produced by the addition of an SO_2 group to selected aromatic hydrocarbon radicals.

The British Thomson-Houston Co., Ltd., Convention date (U.S.A.) March 31st, 1942. No. 571498.

PIEZO-ELECTRIC OSCILLATORS

A SLAB of crystal, cut in the known A-T manner, will oscillate so that a number of parallel nodal lines are set up along its surface. The fundamental frequency of such a crystal can be varied to a small but useful degree by employing a pair of narrow exciting electrodes; but these in turn, limit the power that can be taken from the crystal.

According to the invention, the electrodes are made in the form of a number of parallel ribs, spaced apart by the distance that separates the nodal-lines. The ribs are originally placed directly over the nodes, and the maximum change of frequency is secured by adjusting them to lie half-way between. Thus to obtain the full advantage of the frequency-shift, the crystal surface need be very little larger than the effective area of the electrode.

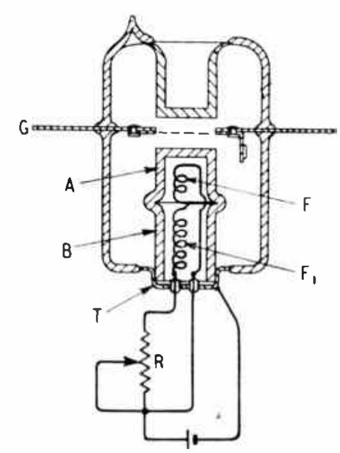
The General Electric Co., Ltd., and S. K. Lewer. Application date February 24th, 1943. No. 571623.

The British abstracts published here are prepared with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

ADJUSTABLE VALVE ELECTRODES

IN certain types of short-wave valves, such as the grounded-grid triode, the clearance between the grid and cathode may be less than one-tenth of a millimetre, and is a critical factor in performance. It is difficult to meet this requirement in mass production, and the invention provides means for making a final or vernier adjustment after the valve has been sealed off.

As shown, the indirectly-heated cathode comprises two coaxial tubes, the flat top of the upper tube A being coated with emissive material. The lower tube B is welded to a metal thimble T, and can expand when heated, so as to adjust the gap between



Thermal electrode adjustment

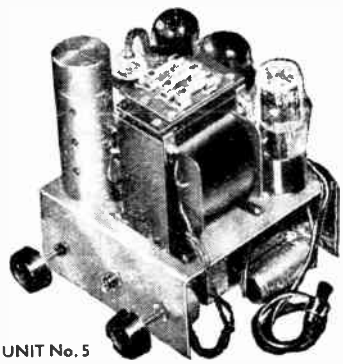
A and the grounded grid G. The heating filament is divided into two parallel branches F, F_1, the current through F_1 being adjusted by a resistance R, until the correct clearance is obtained. Once this is secured, the corresponding resistance is permanently included in the heating circuit. The tubular cathode structure may form part of a quarter-wave resonant-line input circuit.

G. Liebmann and Cathodeon, Ltd. Application date November 20th, 1941. No. 570834.

M. WILSON LTD

NEW UNIT SYSTEM OF RADIO DESIGN

Last month we announced our new series of **Radio Units**, which enable you to select any combination to satisfy your own desire with regard to range and power.



UNIT No. 5

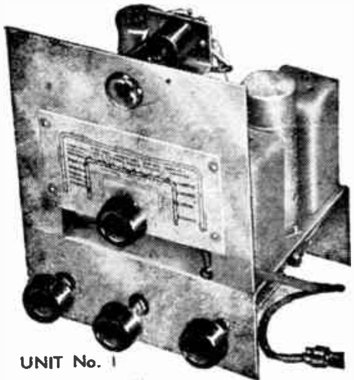
UNIT No. 1: A/C. Complete H.F. and I.F. stages, 3-waveband coil unit (16-50, 185-550 and 800-2,000 metres), 3-gang, ceramic insulated rubber-mounted condenser. R.F. stage with R.F. gain control, H.F. and Oscillator all A.V.C. controlled feeding into an I.F. stage of 465 kc/s. and fitted with I.F. gain control. Cathode-ray tuning indicator (tuning eye), dial lamps, dial and show-motion drive, pointer and knobs, mounted on 16 S.W.G. aluminium chassis with output plug. The Unit is complete in itself, ready wired up, calibrated and tested. All parts brand new, standard components, Octal valves.

UNIT No. 2: A/C. Complete L.F. Output and Power stages, comprising 2nd detector A.V.C. and 1st L.F. amplifier, feeding into output tetrode 4½ watt output complete with mains transformer 350-0-350 v., 80-100 mA., L.F. choke and 8in. P.M. speaker with multi-ratio transformer.

UNIT No. 3: As No. 1, but with 6-waveband coil unit, 5-2,000 metres.

UNIT No. 4: A second I.F. stage 465 kc/s.

UNIT No. 5: Second detector A.V.C. and 1st L.F. Phase inverter, 2 output tetrodes in push-pull, 12 watts output.



UNIT No. 1

DELIVERY DATE ON APPLICATION.

UNIT No. 6: Power pack consisting of mains transformer (400-0-400 v., 150 mA.), high-voltage surge-proof electrolytic condenser, 20-henry choke, 12in. P.M. speaker with output transformer, mains fuses. (The above Unit can also be supplied for A.C./D.C. working.)

UNIT No. 7: High Fidelity Output and Power Stages—two L.F. valves feeding two PX4 valves in push-pull (triodes). Controls: Volume, Mains on/off, radio-gram, switch and Tone.

PRICES ON APPLICATION

This system gives a good theoretically correct application to practical radio, as each stage is completely screened from the others, making possible reproduction of the very highest quality.

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Wholesale and Retail enquiries are invited.

Orders can be executed for B.A.O.R., C.M.F., M.E.F. and S.E.A.C. customers.

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LEAK

"POINT ONE" RANGE OF ALMOST DISTORTIONLESS AMPLIFIERS

Here are performance figures, inclusive of output transformer, for the type 15:—

TOTAL DISTORTION, including hum and noise, for 15 watts output:—
1,000 c.p.s. – 0·1% (one-tenth of one per cent)
60 c.p.s. – 0·2% (one-fifth of one per cent)

FREQUENCY RESPONSE: level within 0·25db. 20 - 20,000 c.p.s.

LOAD DAMPING FACTOR: 20 (10 times better than for average Class A triode).

GAIN: The basic amplifier requires 0·5v RMS at grid impedance. An additional two stages can be supplied built into the chassis, thus reducing the input to 0·005v R.M.S.

Full information on leaflet S.15

SPECIAL NOTE: The above figures establish such radically new standards that they may occasion some surprise. We therefore wish to stress that no error appears in this announcement. The circuits are original, and result from war-time research in our laboratory.

H. J. LEAK & COMPANY LIMITED
470 UXBRIDGE ROAD · LONDON · W.12
TELEPHONE: SHEPHERDS BUSH 5626

Rate 6/- for 2 lines or less and 3/- for every additional line or part thereof, average lines 5-6 words. Box Numbers 2 words, plus 1/-. Press Day: May 1946 issue, first post Friday, April 5th. No responsibility accepted for errors.

NEW RECEIVERS AND AMPLIFIERS

AMPLIFIERS. — Complete equipment for P.A. industrial, dance and stage installations and portable apparatus from 15 to 150w; early deliveries; illustrations and spec. on request.—Broadcast and Acoustic Equipment Co., Ltd., Broadcast House, Tombland, Norwich 26970. [2903

ANELOY RADIO now offer improved set of components for med. and long wave semi-midget 4-valve a.c.-d.c. t.r.f. receiver, incl. striking cream cabinet, valves, drilled chassis, 6½in speaker, screws, etc.; nothing more to buy, £8/10.—Aneloy Radio, 36, Hindmans Rd., E. Dulwich, S.E.22. [5020

NOW ready, the Model P.A.3 7-valve amplifier; order now, immediate deliveries. MAINS transformers, output transformers, chokes, specially designed for the "Wireless World," 4, 8 and 12 watt Quality amplifiers. READY soon, the "Wireless World" 8 watt Quality amplifier with pre-amplifier and variable record compensation; write now for full details and lists.—Chadderton Radio & Television Co., Ltd., Peel St., Chadderton, Lancs. Special terms to factors and export agents.

RECEIVERS, AMPLIFIERS—SECOND-HAND

H.R.O., 9 coils, less power pack, once used. —Offers to Box 5939. [4935

NATIONAL H.R.O. receiver, in good condition.—Write Box 6249. [4994

BAKER'S 7v PX4 quality amplifier, good condition; offers.—Box 6513. [5076

20-WATT p.a. amplifier, well-known make, perfect; £20.—Box 5815. [4903

NATIONAL 1-10 receiver, complete, spare acorns, little use, £20.—Box 6519.

HALLICRAFTERS SX24, preselector and spare set of valves; £35.—Cundy, Park 9685 after 5.30. [4908

SCOTT Phantom 16-valve with Garrard auto-change, condition perfect; offers over £125.—Box 6195. [4989

R.C.A.-VICTOR Communications rec., model 88D, 6 wavebands 535-32,000 kc, as new; offers.—Box 6459. [5052

MODERN, powerful, Philco, 5v ac, all wave radiogram, just overhauled, repolished, £45; carr. paid, securely packed.—Box 6514.

SUPERB His Master's Voice, 6v ac, all wave 5 waveband, autoradiogram, as new, £90; carriage paid.—Box 6515. [5078

HALLICRAFTERS S20R, unused since 1940, recently overhauled by Webb's, excellent condition; what offers?—Box 5813.

A.C.S. RADIO, 44, Widmore Rd., Bromley, Kent, offer small selection com. sets, radio receivers, amp. and televisors; list free.

AMPLIFIERS, 30watt, 12in speaker, mike, stand, Garrard a.c. turntable and p.o., £45; 15watt two 10in speakers, £14; Mallory vibrator unit (6volt), 35/-.—10, Newport Rd., Shifnal. [4928

PUSHPULL PX4 amplifier, a.c. mains, separate inputs 2 gram, 1 mike, m.w. pre-power built in, also 3ft Trivox horn speaker, 15Ω £18; or offers to P. A. Shears, 49, Shooters Hill Rd., S.E.3. [4992

VORTEXION super 50watt amplifier, brand new, with 12in Goodmans T1205/15 p.m. and all-wave quality tuner unit, 2 RF (6SH7) and infinite impedance detector (6J5), laboratory built; £40 or offer.—Box 5818. [4906

£75.—Complete radio station, Hallicrafters Sky Champion receiver and 10watt transmitter with power pack crystals and coils for 10, 20, 40 metres, wavemeter, etc., all 230 a.c. —G3LC, 66, Baker St., Burton-on-Trent. [5005

SUPER American Pilot radio, 2 s.w. bands and mw, hf stage, 7 valves, cabinet french polished by ex-Maples man, looks as new; first offer of £25 secures.—Muir, 36, Stoneyfields Lane, Edgware, Middx. Mill Hill 1901.

BRIERLEY Quality amplifiers, 5 watt, 8½ gns.; 12 watt, £14; comprehensive tone control types, radio units, P.A. and S.O.F. amplifiers available; send s.a.e. for copy of "Design for Quality," and lists stating requirements.

PICKUPS. No magnetic type pickup designed to give the highest quality with small downward pressure can satisfactorily be used with a steel turntable. [5085

ARMSTRONG 9v 6w PP receiver, £10; Universal gramo motor and turntable, £5; Rothermel P.U. and arm, £3; double spring motor and turntable, £2/10; r'gram cabinet, £5; Marconi heavy duty P.M. (15lb), £3; £27/10 the lot.—Box 5943 [4939

FOR sale, Eddystone 1-valve S.W.H.F. amplifier or short-wave converter a.c. model, £5/10; Ferranti output transformer, type O.P.1, 25/-; Weston galvanometer, model 375, 20/-: all new cond.—Box "M," c/o Corbett, Stationer, Brook St., Broughty Ferry, Angus.

R.M.E. 69 communications receiver, with DB.20 preselector and speaker, all as new; £60 or nearest offer.—Croll, 264 Salisbury Rd., Totton, Southampton. [4990

W.W. Super Seven and Q.A. 3-unit radio-gram, complete with £50 worth fibre used only records, mainly classic; £85.—Neville, 51, Culverley Rd., S.E.6. Hither Green 3096.

LOUDSPEAKERS, SECOND-HAND

VOIGT twin unit, perfect condition; £18.—44, Tapton Hill Rd., Sheffield. [4927

VOIGT spkr, 16gns; Rothermel deluxe pick-up, £2/15.—88, Beaconsfield Rd., Enfield.

VITOVOX K12/10 12in speaker, new, boxed; 5gns., carriage extra.—34, George Rd., Birmingham, 23. [5045

HARTLEY Turner P.M. twin cone, in perfect condition; £5.—Jackson, 24, Downs Way, Southwick, Sussex. [5068

MAGNAVOX "Duode," 2,500Ω field, 15Ω speech coil less transformer; £5.—90, Fairbank Rd., Bradford. Tel. 2812. [4947

VOIGT twin cone speaker, energising unit 400v H.C. corner horn and base chamber, professionally built, finished natural wood; £30.—Box 6410. [5030

6 LOUDSPEAKERS, 10in Rola, 10in Auditorium model, etc., clockwork turntables with pick-ups, 1 Broadcast receiver made G.E.C. Telephone Works in steel cabinet, Emerson car radio with aerial, rotary converter, 220 ac, .47 amps, 1 microphone and amplifier, 6watts; various other wireless articles.—Giles, 112, Belsize Rd., Hampstead. 10 minutes Swiss Cottage Station. [5011

GRAMOPHONE AND SOUND EQUIPMENT

PORTABLE disc recorder, p.a. spks., microphones. Graham Newbery, Radio, Axminster

SIMPLAT style tracking gear, 12in, suit serious recordist; best offer; perfect, as new.—Box 6463. [5056

AUTORADIOGRAM, all-wave Lissen-Garrard, 1940, ac model, perfect, as new; £60.—Maythorne, Epsom Rd., Guildford.

R.C.A. recording machine, 3ohm cutter, fitted Saja motor & transit case; £44 or nearest.—3, Emscote Rd., Stoke, Coventry.

GARRARD U.5 in rexine case, Voigt P.U., also Hartley Turner duode 33, field 2,500ohms; £22 or separate offers.—Box 6250.

COILS for filters, tone controls, all types of transformers for "Wireless World" circuits.—R. Clark, 30, Langland Crescent, Stanmore. Wor 5321 [4584

H.M.V. hyper-sensitive pick-up, pre-amplifier and rejector unit, as Hartley's circuit, "W.W." July and August, 1944; £15.—Tel. Winkfield Row 284. [5024

PROFESSIONAL recording equipment.—Condenser microphone, 12watt amplifier with tone stage, studio recording machine, full guarantee, superb results; £125; playing desk with lt-wt pick-up extra.—Box 6354.

COLLARO mixed automatic record changer with crystal pick-up, ac; Cosmocord player desk, walnut, crystal pick-up; B.T.H. motor 90-250v ac/dc; Baker's Selhurst 15w quality amplifier (6v6's) and 12in p.m. speaker: all in new condition, offers.—Box 6447. [5041

M.S.S. recording machine, 20watt amplifier, special matching transformer m/c mike on floor stand, complete professional block, £100; immediate delivery; blank discs, cutters, etc., P.A. amplifiers, playing desks, lightweight pick-ups, external transformers giving 1,000-3,000ohms from 5 or 15ohms, 63/-. LIVERPOOL Sound Studios, 83a, Bold St., Liverpool. [4943

TEST EQUIPMENT

TAYLOR 65B signal generator, Mullard GM 4140 bridge, universal Avominor, all new.—Offers to Box 6461. [5054

AVOMETER, No. 7, 56 range, complete in case, with complete list clips and prods, new, never used; makers' price.—Box 6110.

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AVO oscillator, small battery type, new cond., £6; Avominor universal, £7; B.T.H. transverse current microphone and transf., £5.—19, Campion Rd., Isleworth, Midx.

FURZEHILL Laboratories Beat Frequency Oscillator, type A.F.2, 0-11,000 cycles, output 10 to 600ohms; 0-5v and 0-50v a.c. meter; offers wanted.—5, Upper Brook St., Rugeley, Staffs. [4975

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CENTRALAB v/controls L/S, 2/6; w/s, 3/6

CONDENSERS, .1, .01, .05, .002; 6/- doz.

STANELCO & Solon soldering irons; 13/6 ea

TWO- and three-gang condensers, .0005, 2-gang, 11/6; 2-gang s/motion, 13/6; 3-g. 14/6.

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THE finest drawings and instructions ever produced for the enthusiastic set builder; theoretical circuit, under chassis layout, above chassis layout, drilling template, heater wiring, group board assembly and point to point wiring instructions, also parts list, price 5/-, available April; this set can be made without previous radio experience, and can be built in stages out of income; 3-wave coil pack specially designed for the job; group board assembly obtainable ready made; also available "Wizard" 4-valve TRF ac/dc circuit, 5/-; "Dorset" battery 3 circuit, 3/6; "Dorset" amplifier circuit, ac/dc, 6-7 watts, 5/-. —Write Weldona Radio Accessories, Ltd., 12, Gilbert Rd., Swanage, Dorset. [4988

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SPECIAL offers: Band pass aerial coils with diag, 2/6 ea; I.F. trans 110kc, 3/6 pr; oscillator coils 110kc, 3/6 ea; wave-change switches for the above coils, 2/6 ea; all the above items are stripped from Ekco chassis; also 0-2 mains droppers, 2/6; 6b.a. nuts and bolts, 4/- gross; moving coil mikes, undamaged, 5/6 ea; damaged, 1/6 ea; 1mfd Mansbridge condensers 4/6 doz; 2mfd 25v wkg cans, 6/- doz; parcel of mixed resistors, block smoothing and tubular condensers containing about 24 items, 6/ ea; send for list "W." Terms cash or c.o.d over £1.—Charles Britain Radio, Radio House, 2, Wilson St., London, E.C.2. Tel. Bis. 5985 ext. 7. [5086

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ALIGNED INSTRUMENTS SERVICES, 25, Park Grove Rd., Leytonstone, E.11. Tel. Leytonstone 5601.
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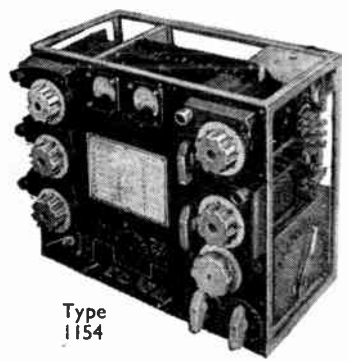

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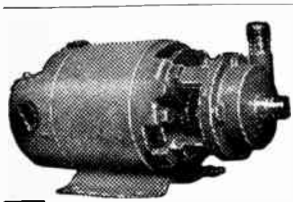

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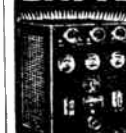

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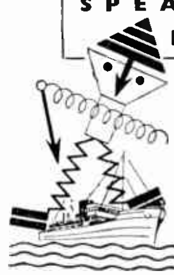

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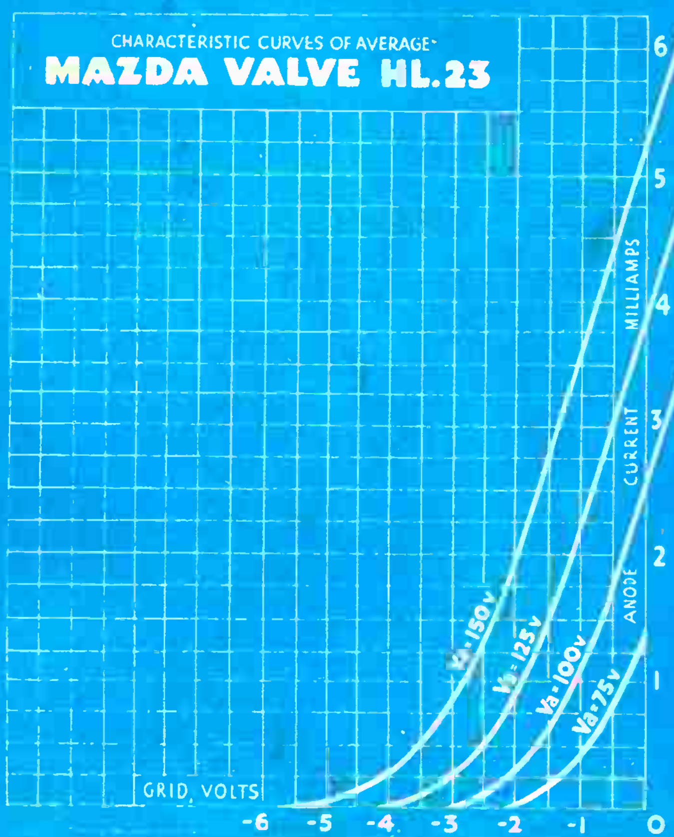

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