

Wireless World

RADIO AND ELECTRONICS



DATE

12-19
12-20
1-22
1-23
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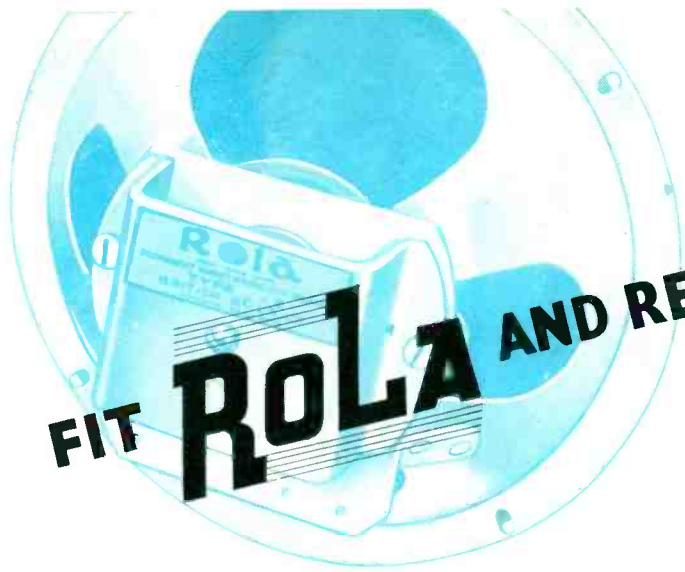
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PLEASE

DEC. 1947

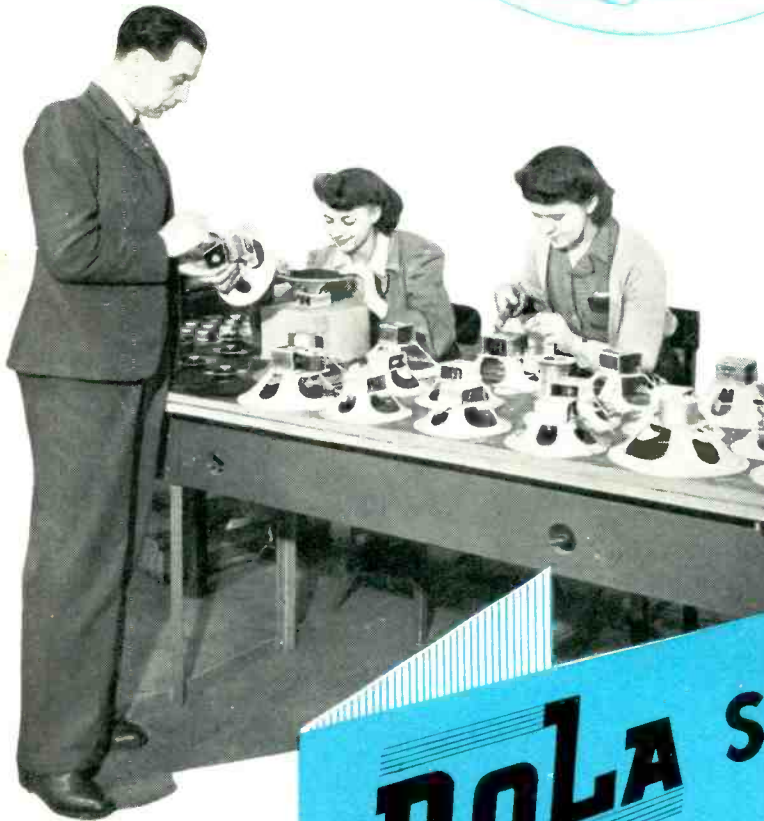
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Vol. LIII, No. 12

IN THIS ISSUE: DESIGN FOR A "QUALITY" RECEIVER



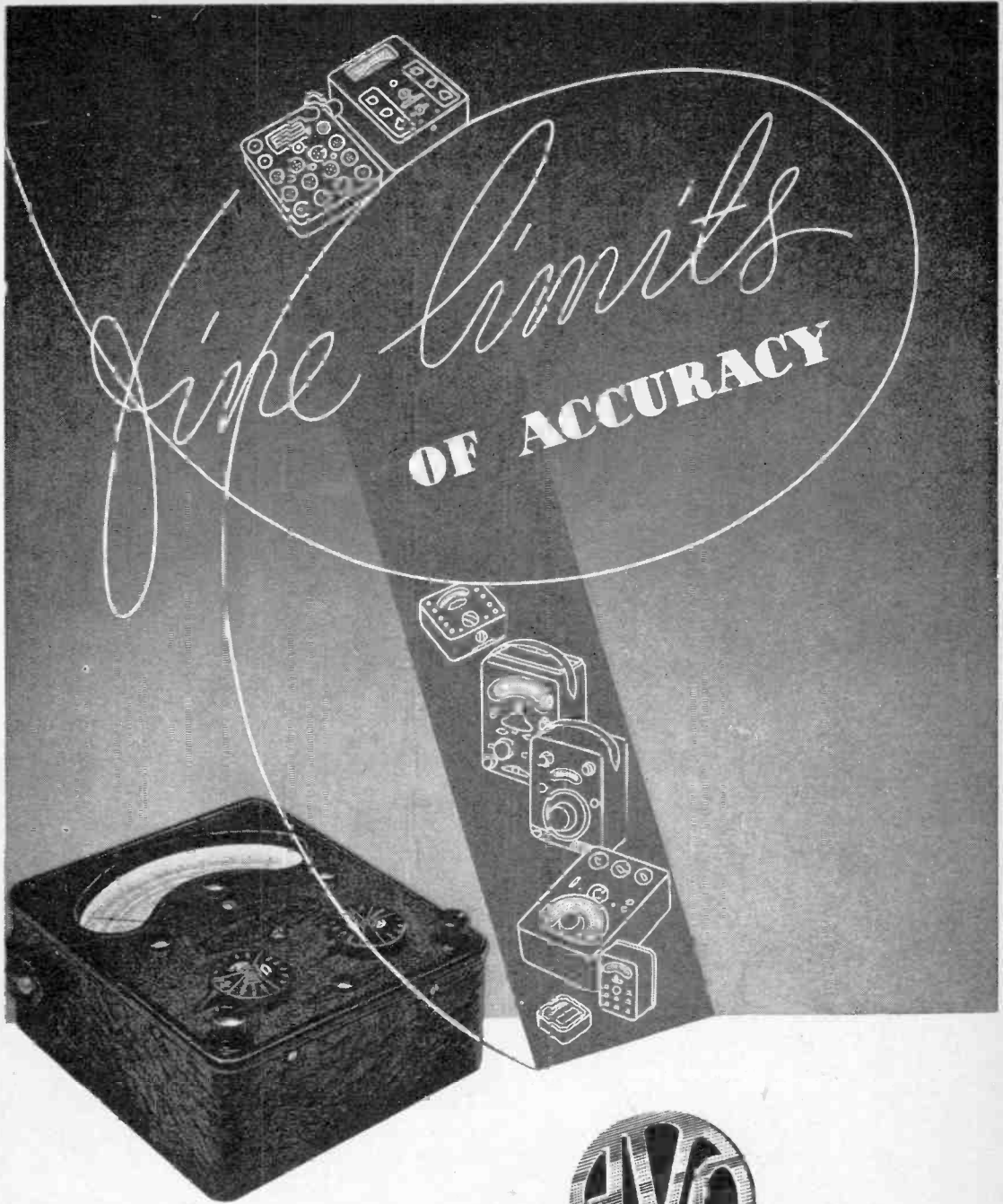
FIT ROLA AND RELAX



The Research Engineer knows that the best speaker for any set is one that offers complete reliability plus true tonal fidelity. After exhaustive tests his advice is always the same —fit Rola and relax!

ROLA SPEAKERS
THEIR QUALITY SPEAKS FOR ITSELF

BRITISH ROLA LTD • 8 UPPER GROSVENOR STREET • LONDON W.1



The 50-range Model 7 Universal AvoMeter, the pioneer of the comprehensive range of "Avo" Precision Instruments, is the world's most widely used combination electrical testing instrument. Fully descriptive pamphlet available from the Sole Proprietors and Manufacturers:—



Electrical Measuring Instruments

THE AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO., LTD.
 WINDER HOUSE · DOUGLAS STREET · LONDON · S.W. · TELEPHONE VICTORIA 3404/9

MARCONI Mastery of Measurement

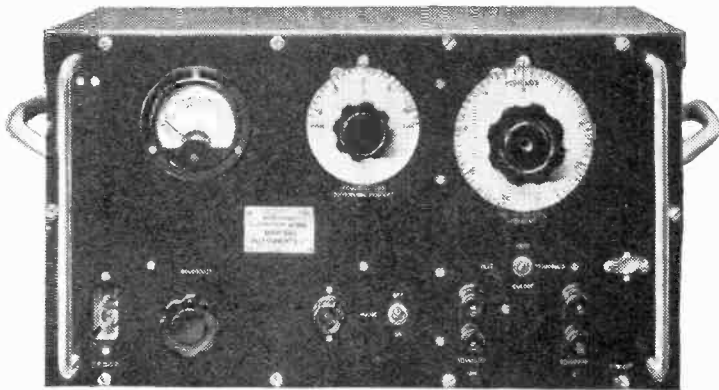
is displayed in its unique range of
Communications Test Gear

FOR IMMEDIATE DELIVERY

IMPEDANCE COMPARISON BRIDGE

TYPE TF 202E

The instrument is a self-contained A.C. mains operated bridge for the rapid comparison of similar capacitors, inductors or resistors and comprises a 10 kc/s oscillator, a bridge network and a visual balance-indicating system. It is precision-made to give lasting, reliable service.



Brief Specification:

Operating Frequency - 10 kc/s;
 Range - - - L 250 μ H—1H;
 C 20 μ F—1 μ F;
 R 20 ohms—1M ohm;
 Accuracy - - - \pm 0.2%



MARCONI INSTRUMENTS LTD

ST. ALBANS, HERTFORDSHIRE

Phone: St. Albans 6161/5

Northern Office: 30 ALBION STREET, HULL. Hull 16144

Western Office: 10 PORTVIEW ROAD, AVONMOUTH, BRISTOL. Avonmouth 438

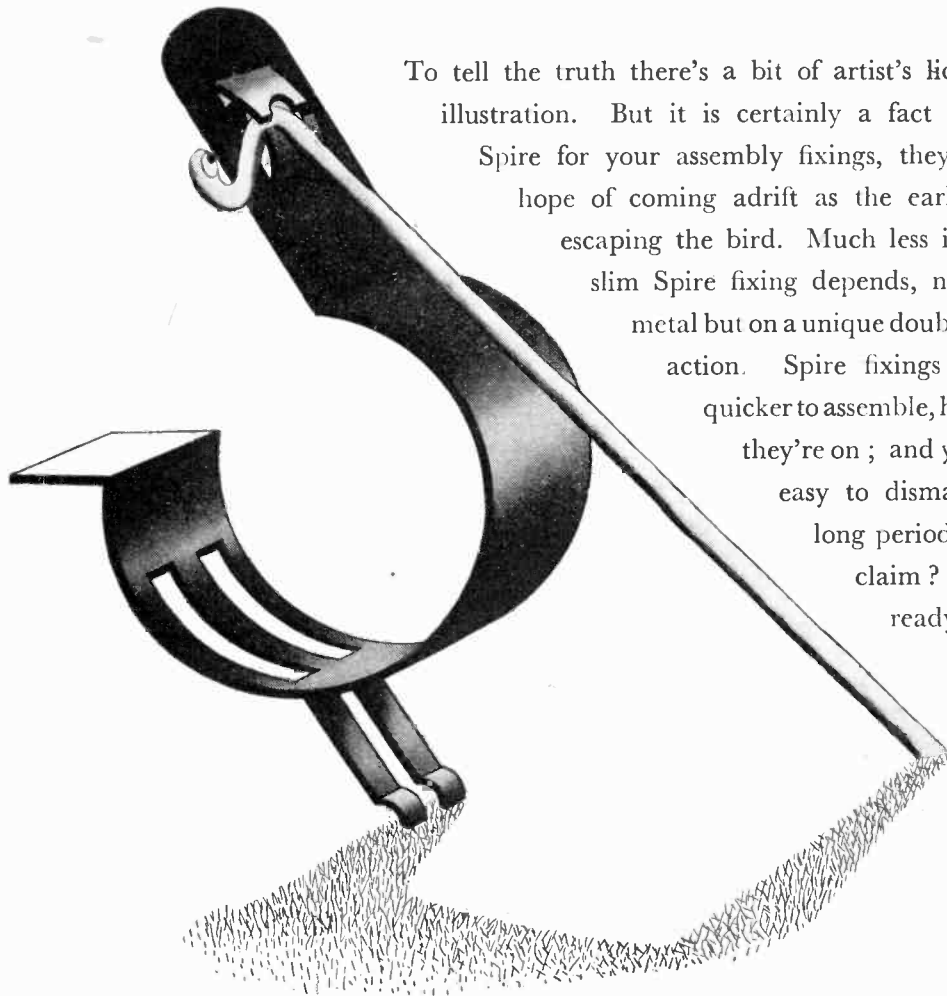
Southern Office: 109 EATON SQUARE, LONDON, S.W.1 Sloane 8615

THE *Quality* PRODUCTS OF

PAYNTON

VITREOUS RESISTORS FOR EVERY PURPOSE BY
 PAYNTON & CO LTD KINGSTHORPE NORTHAMPTON

A Spire fitting never leaves go!



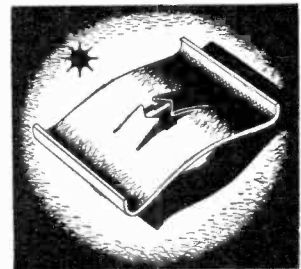
To tell the truth there's a bit of artist's licence about our illustration. But it is certainly a fact that if you use Spire for your assembly fixings, they have as much hope of coming adrift as the early worm has of escaping the bird. Much less in fact. For the slim Spire fixing depends, not on weight of metal but on a unique double-spring locking action. Spire fixings are easier and quicker to assemble, hold tighter when they're on; and yet they are quite easy to dismantle even after long periods. Sounds a big claim? We're quite ready to prove it.

Spire

(Regd.)

★ A BETTER way of fixing

A Spire Fix — the simplest, quickest, firmest and most tolerant form of light assembly. The illustration shows our Spire Fix No. FR337 suitable for use with $\frac{3}{16}$ " diameter studs.

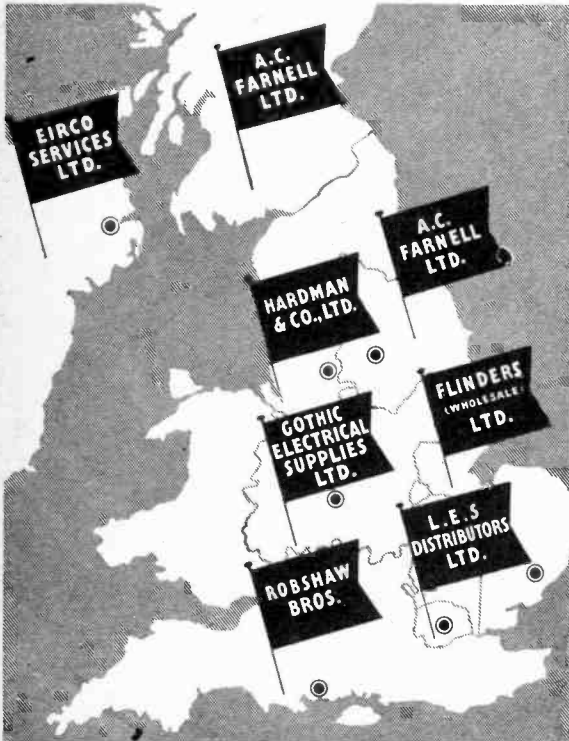


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Nation-Wide Distribution



The following area Distributors for U.I.C. Silvered Mica and Ceramic Capacitors, have now been appointed to serve the requirements of Retailers, Wholesalers and Service Engineers.

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LANCASHIRE & N. CHESHIRE
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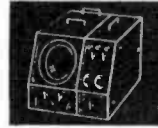
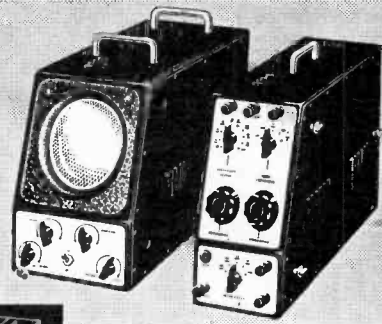
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Birmingham 19.

EAST ANGLIA
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UNITED INSULATOR CO. LTD
Oakcroft Road, Tolworth, Surbiton, Surrey
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A new departure
in

OSCILLOSCOPE DESIGN

The L.A.L. UNIT OSCILLOSCOPE presents an entirely original approach to problems confronting the research engineer and industrial user.

Constructed on the Unit principle, we can supply apparatus for every need from D.C. to radio frequencies.

Built-in multiple plugs and sockets with mechanical couplers instantaneously complete all electrical circuits and secure a number of Units into a rigid assembly without the use of tools.

We suggest the following representative Units for general investigation.

Type 15. C.R.T. unit 6" tube and self-contained shift supplies.

Type 84. Time Base; 5-200,000 cps. with sweep expansion; automatic synchronizing; push-pull deflection; single or triggered sweep.

Type 84Y. Amplifier; gain 25 (cathode follower input) or 600; response level ± 1 db 10-100,000 cps., useful at 0.5 Mc.; push-pull deflection.

Also available:—

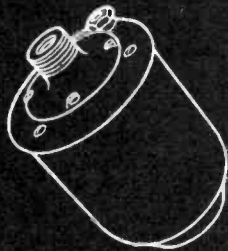
D.C. amplifiers, medium and high gain. Extra low frequency time base. Circular or spiral heptode time base. Voltage calibrator.

Fully described in our illustrated leaflets; your copies will be sent by return of post.

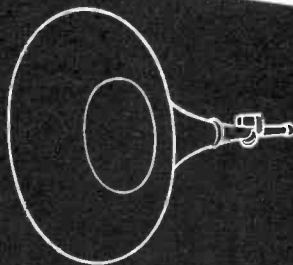


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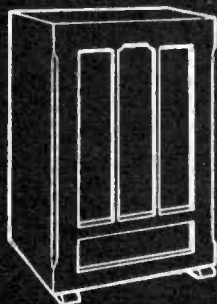
MODERN MASTERS OF REPRODUCTION



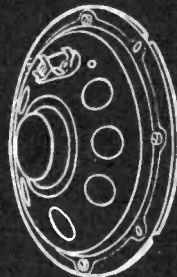
PRESSURE TYPE DRIVING UNITS



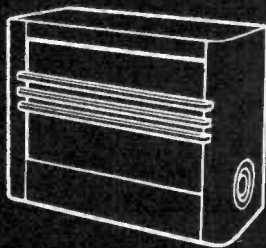
EXPONENTIAL HORNS



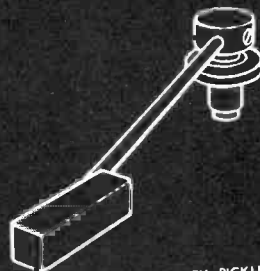
AUDITORIUM LOUD SPEAKERS



WAFER SPEAKERS



CABINET LOUD SPEAKERS



HIGH FIDELITY PICKUPS

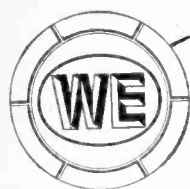
HERE are speakers that go higher and speakers that go lower: other speakers 50% shallower and 40% lighter; a pickup which can reproduce up to 20,000 c.p.s.; another pickup giving moving-coil quality with 1 volt output; public address speakers for all occasions — designed and made by men with eighteen years' practical experience.

TRUVOX

Write for full technical details
— a postcard will do

TRUVOX ENGINEERING CO. LTD., TRUVOX HOUSE, EXHIBITION GROUNDS, WEMBLEY, MIDDLESEX

VIBRATORS FOR RELIABLE REPLACEMENTS



TYPE N.S. 6 - 4-PIN U.X. BASE

Tested for radio-frequency
Proof against thermal mis-alignment of contacts.
HERMETICALLY SEALED.
FULLY TROPICALLY TESTED.

Entirely British in design and construction, and fully approved for Government Service equipment, W.E. Vibrators are ready for all your replacements. They are fitted as standard components by leading radio manufacturers.

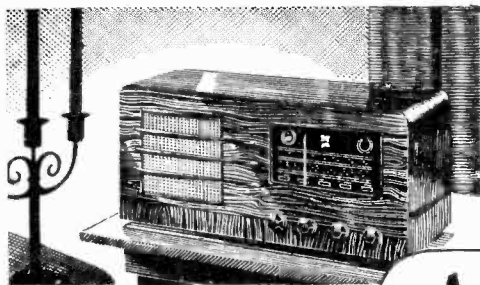
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GARTH ROAD · LOWER MORDEN · SURREY · TELEPHONE: DERWENT 4814, 5010.

C.R.C.2

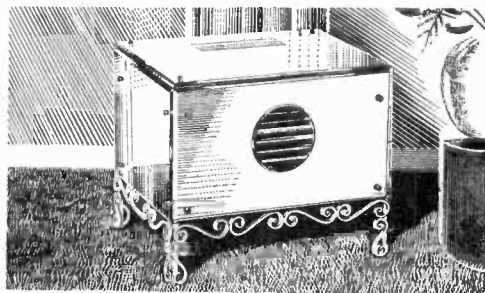
YOUR CHOICE for QUALITY

Manufacturers of high quality Broadcast Receivers and Radiograms designed for Home and the Export Market. The Export Models have fully tropicalised components, achieving unsurpassed short-wave performance.

Special dials supplied for any country
PRICES AND FULL PARTICULARS ON REQUEST



ALLANDER INDUSTRIES LTD.
48, Avenue St. Bridgeton, Glasgow, Scotland.



CHAIRSIDE MODEL A450

The housing of this Receiver is unique in that it is contained in a bevelled plate-glass mirror cabinet, fitted to a wrought iron framework finished in Cream enamel. It embodies all the latest technical developments for easy handling, range and clarity of reception, and provides not only a first-class radio but an attractive piece of furniture which can replace a Chairside Table and will harmonise with any surroundings.

SYMPHONY MODEL A420

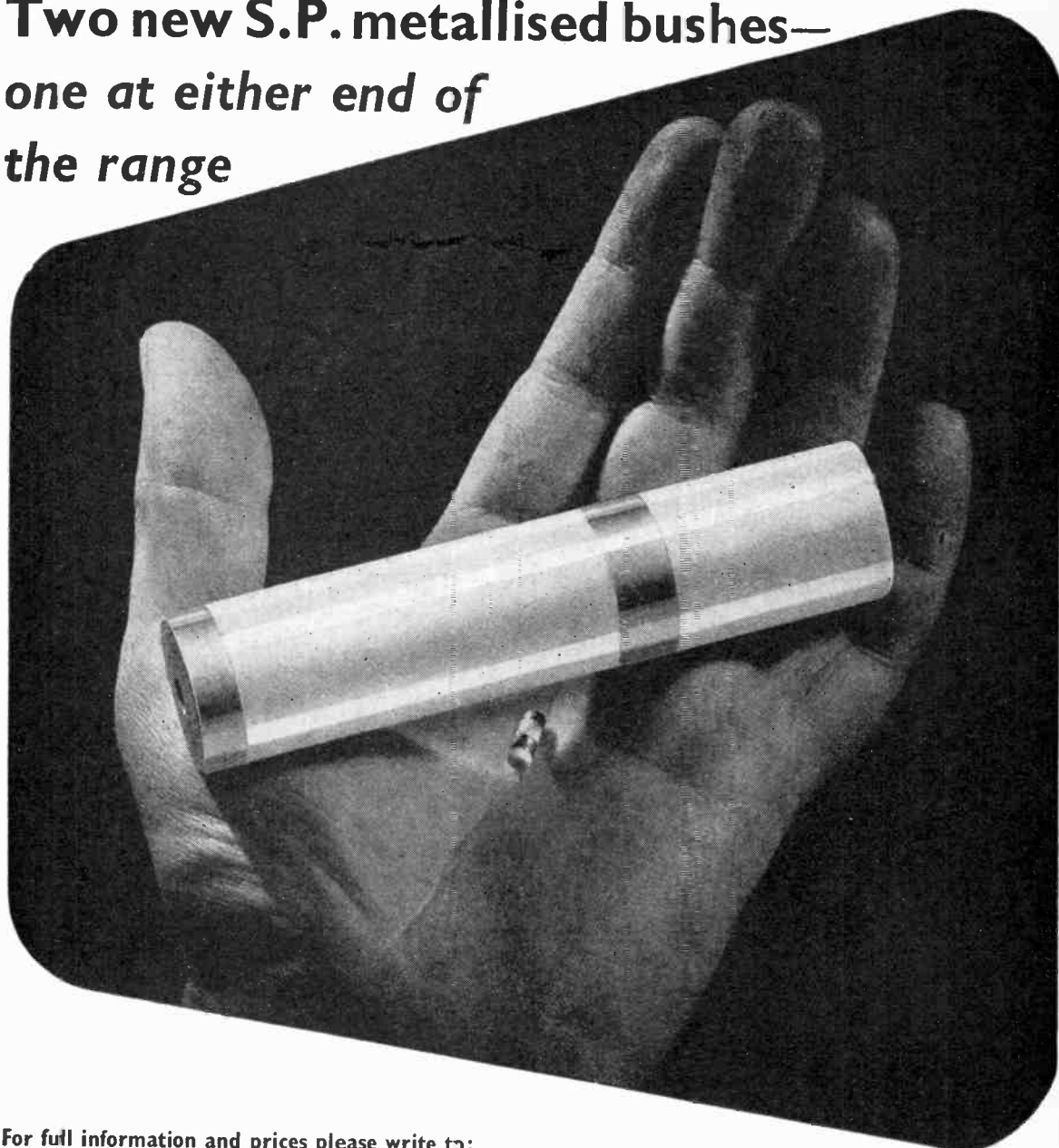
This new Receiver embodies the very latest technique in construction. The cabinet is richly veneered in Walnut with a cross banding of Macassar Ebony. Clearly readable edge-lit dial with an 8 in. traverse magic eye and 2-gear control. Instant, unerring selection of the required frequency range. Automatic volume control and an I.F. trap are incorporated in the circuit. Sockets are provided for gramophone pick-up and extension speaker.

ALLANDER



METALLISED CERAMICS

Two new S.P. metallised bushes—
*one at either end of
the range*



For full information and prices please write to:

STEATITE & PORCELAIN PRODUCTS LTD.

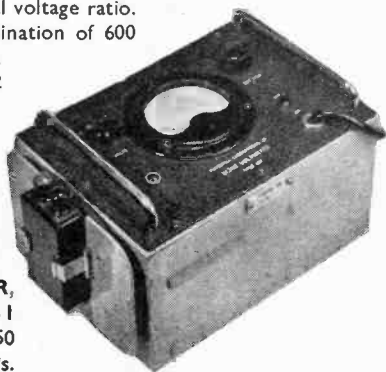
STOURPORT-ON-SEVERN, WORCS. Telephone: Stourport III. Telegrams: Steatite, Stourport.



SP.42



★ **A. F. ATTENUATOR, TYPE 1358**
 Frequency Range, zero to 20Kc/s. Input Impedance, 600 ohms. Attenuation, 0-110 dB in steps of 1 dB, $\pm 1\%$ nominal voltage ratio. Internal Termination of 600 ohms at option. Dissipation, 2 watts.



★ **DIODE VOLTMETER, TYPE 281**
 0.1-150 volts, 50 c/s. to 250 Mc/s. $\pm 2\%$ of F.S.D. Stable zero setting. Alternative model having additional d.c. voltage ranges available.



★ **HIGH DISSIPATION RESISTANCE BOX, TYPE 1752**
 0-1 meg. in 5 decades. 6 watts per resistor, 60 watts per decade, except last decade which is 20 watts. Accuracy $\pm 5\%$. Voltage limit 1,000 volts.

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Furzehill LABORATORIES LTD.
 BOREHAM WOOD, HERTS
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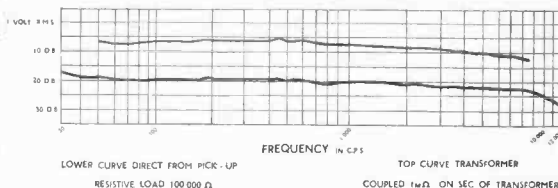


The "Connoisseur" is proved by trade tests

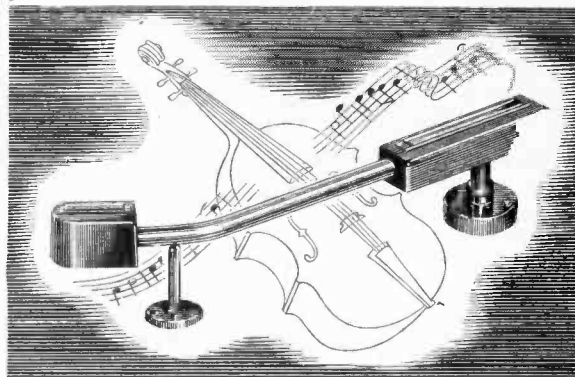
Exhaustive trade tests have substantiated our claims for the "CONNOISSEUR" pick-up. Below we give the response curve to which every "CONNOISSEUR" pick-up is individually tested.

Supplies are very limited but we invite trade enquiries to our distributors who will endeavour to meet your requirements.

RESPONSE CURVE *Connoisseur* PICK-UP



1. Every "Connoisseur" pick-up is hand tested and passed to $\pm 2\text{DB}$ of above response curve.
2. Our new type damping material working in gap direct on to armature does not affect bass resonance point.
3. The required downward pressure is 1.1/3 ozs. which has been achieved without counter-balancing or springs.
4. Being a constant velocity device Bass compensation is required in the amplifier and alternation of high frequencies to suit individual recordings.
5. Output direct from pickup .1 volt.
 With transformer coupled .5 volt.



Apply to :—
 Albion Electric Stores, 125, Albion Street,
 Leeds 1, or to
 Lawton Brothers (Sales) Ltd., Henry Square,
 Ashton-under-Lyne.
 Made by : A. R. SUGDEN AND CO.
 (ENGINEERS) LTD., BRIGHOUSE, YORKS.



TECHNICAL TOPICS

for Amplifier designers

● **Pentode (or beam Tetrode) or Triode output.**

With the demand for high sensitivity the popularity of an output Pentode (or beam Tetrode) has grown. OSRAM output tetrodes, in particular type KT61, are therefore widely used where the maximum sensitivity is required. Type KT66—a larger tetrode with aligned grids—is unsurpassed in combining high sensitivity with large power output and a long reliable life performance at maximum rating. For those who demand high quality, triode output is often preferred because of its lower impedance, and not only are directly heated triodes such as types PX4 and PX25 in wide demand, but the tetrode KT66 is also eminently suitable for wiring as a triode, giving similar characteristics to those of the PX25, but with a 6.3 volt indirectly heated cathode.

TYPE	FILAMENT OR HEATER		AS TETRODE					AS TRIODES PUSH PULL PAIR		
			V _a	V _{g2}	I _a	OUTPUT POWER*		V _a	I _a	OUTPUT* POWER
	VOLTS	AMPS	VOLTS	VOLTS	mA	WATTS	WATTS	VOLTS	mA	WATTS
KT61	6.3	0.95	250	250	40	4.3	—	not recommended		
			250	250	72	—	11.5			
KT66	6.3	1.27	400	300	85	7.25	—	400	125	14.5
			400	300	136	—	35			
KT33C	26	0.3	200	200	60	5.0	—	not recommended		
			200	200	113	—	15.5	300	100	13.5
PX4	4	1.0	—	—	—	—	—	500	100	20
PX25	4	2.0	—	—	—	—	—	—	—	—

* With auto-bias in every case.

Osram
PHOTO CELLS

S.E.C.
CATHODE RAY TUBES

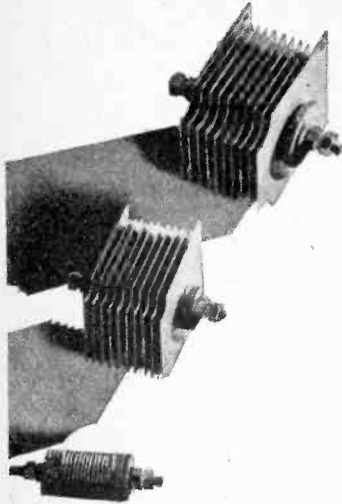
Osram
VALVES

The General Electric Co., Ltd, Magnet House, Kingsway, W.C.2.

H. T. RECTIFIERS

for broadcast receivers

A range of rectifiers is now available which will meet **manufacturers'** general requirements for broadcast radio receivers. These units are very much smaller in bulk and weight, have a high efficiency and good regulation.



Type	Output		Max. input Volts	Overall dimensions		
	Volts	mA		Length	Width	Height
14A118	600	120	275	4 1/16	2 1/4	2 1/2
14A79	400	120	210	3 1/8	2 1/4	2 1/4
14A79	400	75	210	3 1/8	2 1/4	2 1/4
14A59	300	75	170	2 13/16	2 1/4	2 1/4
4A79*	245	120	250	3 1/8	2 1/4	2 1/4
14A46*	270	60	250	2 3/8	2 1/4	2 1/4
15B46*	270	30	250	1 15/16	1 3/8	1 3/8
5D28†	120	20	108	1 9/16	1 3/8	25/32

* For AC/DC receivers.

† For battery eliminators.

Write for full details to Dept. W.W.,
WESTINGHOUSE BRAKE & SIGNAL CO. LTD., 82 York Way, King's Cross,
London, N.

WESTINGHOUSE
WESTALITE

METAL RECTIFIERS

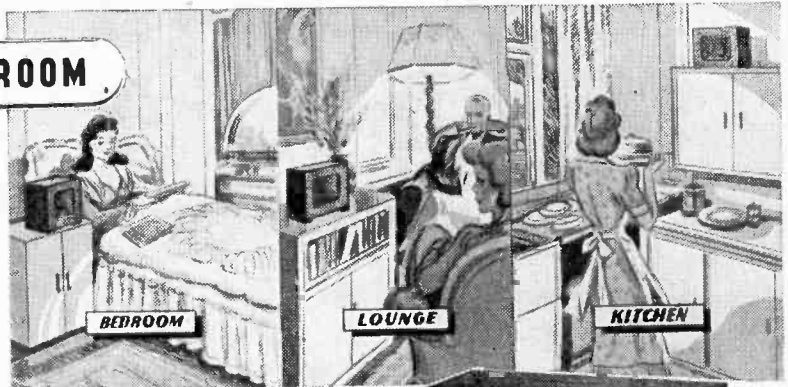
RADIO IN EVERY ROOM

with these

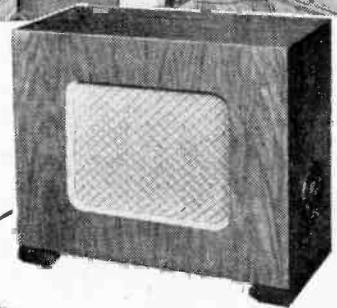
NEW & BETTER EXTENSION SPEAKERS

Are you enjoying the pleasure and convenience of having your radio instantly available in any room? These moderately priced Stentorian extension speakers, with their handsome acoustically designed wooden cabinets, give such superb quality of reproduction that you will be amazed at the difference a Stentorian makes to your receiver.

Ask your dealer for a demonstration.



- SENIOR MODEL**
Type SC with Universal Transformer £5.15.6
" SX minus " " £5.2.6
 - JUNIOR MODEL**
Type J with Universal Transformer £5.0.0
" JX minus " " £4.10.6
 - CADET MODEL**
Type C with Universal Transformer £4.10.0
" CX minus " " £4.0.0
- Other Cabinet models available from 39/6*



Stentorian

THE FINEST EXTRA SPEAKER FOR ANY SET

WHITELEY ELECTRICAL RADIO CO. LTD., MANSFIELD, NOTTS.

WHY



CORE

SOLDER

Because only with a solder wire having more than one core of flux can you be sure that the flux is always present. The 3 cores of Ersin Multicore Solder are filled with Ersin—the extra active non-corrosive flux. Only Ersin Multicore Solder can guarantee you freedom from dry joints, elimination of waste, rapid melting and speedy soldering. Write for technical information and free samples to Multicore Solders Ltd., Mellier House, Albemarle Street, London, W.1 or phone REGent 1411 (P.B.X. 4 lines).

Technically

We believe that the only way to build a receiver is to begin at the beginning with a sound circuit design—a design that's been tested and re-tested—a design that will stand up to the most critical examination. From this design a prototype is constructed in which every component receives the some rigorous testing. We leave the experts to pass judgment on the resulting Sobell receivers. We are confident that for ease of control and absolute fidelity of reproduction these models will be found to have no equals—that, in fact, you will pronounce them to be 'technically outstanding'.

Outstanding



**SOBELL
MODEL 516
T.G. TABLE
RADIOGRAM**

Roll top gives easy access to gramophone turntable. The receiver is a 5-valve super-het. operating from 200/250 volts, 40/100 cycles per second A.C. supply. Wave range: 16-50 metres; 193-577 metres; 800-2, 140 metres.



**SOBELL
MODEL 717
7-VALVE
RECEIVER**

Built with a push-pull output stage giving 8 watts undistorted output. Incorporates a 10" loudspeaker. Covers long, medium and two short wave ranges. Voltages as for 516 T.G.

SOBELL RADIO

TWO YEARS' FREE ALL-IN SERVICE IN THE HOME
Advt. of Sobell Industries Ltd., Langley Park, near Slough, Bucks.



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for
**FLEXIBLE
SHAFT
ASSEMBLIES**
**CAR RADIO
SPEEDOMETERS
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Robert Sharp & Partners

WT 53

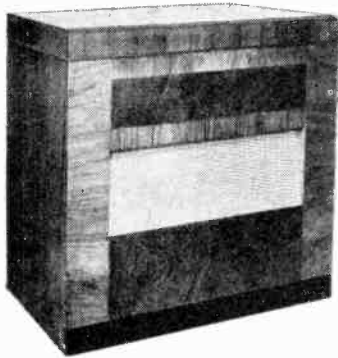
PREMIER RADIO COMPANY

MORRIS & CO. (RADIO) LTD.

ALL **POST ORDERS** to 167 LOWER CLAPTON RD., LONDON, E.5. 'Phone: Amherst 4723.
 ALL **CALLERS** to 169 FLEET STREET, LONDON, E.C.4. 'Phone: Central 2833.

Terms of Business: Cash with order or C.O.D. over £1. Send 2½d stamp for new Nov. 1947 list.

RADIOGRAM CABINETS



Dignified appearance and good workmanship. Size 11 1/2 in. high, 18 1/2 in. deep, 13 1/2 in. wide. French polished, veneered walnut. Price £26. Also available complete with electric motor, auto stop and magnetic pick-up. £34 5s. 0d.

Ditto with Rothermel Crystal Pick-up, £36 2s. 1d., or with 8 record-mixer changer, £46 7s. 6d.

SUPER OUTPUT TRANSFORMERS. By means of a series parallel arrangement wherein the maximum winding is used for each ratio extremely high efficiency is obtained. Any valve single or pushpull may be matched to any voice coil (2 to 30 ohms) type Mo. 15. 15 watts, 30".

GOVERNMENT SURPLUS OFFERS

TEST UNIT AP3874 consists of a Test Unit for a U.H.F. T.X., incorporates a 230 v. 50 a. Power Pack, with a smoothed output of 240 v. up to 50 m/a and 6.8 v. 2 a., 2 EF50, 1 EC59, 1 EA50, 1 5Z4G, 1 Y68 Magic Eye, and a large quantity of Condensers, Resistors and Tuning Gear. Contained in an attractive steel case. Size 10 1/2 x 9 x 8 1/2. Price 45s. Carriage and packing, 5/-.

TEST UNIT TYPE 72 consists of a special purpose Oscilloscope that requires only rewiring and the addition of a few condensers and resistors to convert into a standard Oscilloscope, input 230 v. 50 c. A 3 1/2 in. C.R. tube and 1 RU290A, 1 EH34, 1 5Z4, 2 SP41, 2 EA50, are included. Controls are "Brightness," "Velocity," "X Shift," "Y Shift," "Focus Amplifier," "in/out," "Calibrate," "on/off TX." Price £8 8s. 0d. Carriage and packing, 20/-.

RELAY UNIT Type 9 consists of a 24 v. operated relay unit incorporating 3 KT33C valves, a telephone line (unselector) switch with 6 poles 26 contacts, 5 P.O. type relays, 2 high-speed relays and a quantity of other material. Contained in an attractive relay rack type metal case 19 x 8 x 9 1/2 deep. Price £4 5s. 0d., or without valves 30s. Carriage and packing, 5/-.

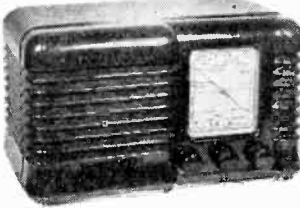
SIGNAL GENERATOR Type 33 consists of a battery-driven Generator, with two separate units for approx. 1 metre and 5 metre operation. Includes two OVG (VK135) "Horned" triodes and 1 diode. A large quantity of U.H.F. tuning gear. Contained in a teak case size 18 x 8 x 8. Price 30s.

OUTPUT TESTER Type 9 consists of a unit incorporating 3 separate diode detectors and a 3-valve amplifier, each diode with its separate U.H.F. tuning system. A retractable 18m. aerial is fitted and three VK130 (HL25) valves, 3 D1 diodes and a large quantity of U.H.F. tuning gear is included. Contained in a teak case size 18 x 8 x 8. Price 30s., or minus three HL25 valves, 15s.

METERS. A huge purchase of military surplus meters allows us to offer the following bargains. Best makes Bakelite cases, prices are approx. 1 original cost.

Range	Ext. Ham. Movement	Basic Fitting	Type	Price
300 v.	3 1/2"	8 M/A	Flush M/A/C	12 6
500 M/A	3"	—	Proj. M/C/D	12 6
40 v.	2"	5 M/A	Flush M/C/D	7 6
24 A	2 1/2"	—	Flush Thermo	7 6
24 A	2 1/2"	—	Port. H. Wire	7 6
40A	2 1/2"	25 M/A	Flush M/C/D	7 6
40A	2"	124 M/A	Flush M/C/D	7 6
25A	3 1/2"	5 M/A	Flush M/C/D	7 6
25A	3 1/2"	26 M/A	Proj. M/C/D	7 6
1 M/A	2 1/2"	4 M/A	Flush M/C/D	12 6
150 M/A	3 1/2"	160 M/A	Flush M/C/D	12 6
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MIDGET RADIO KIT. Build your own midget radio. A complete set of parts, including valves, loudspeaker and instructions. In fact, everything except cabinet necessary to build 4-valve Medium and long wave T.R.F. radio operating on 200-250 v. mains, A/C or D.C. Valve line-up, 6K7, 6J7, 25A6, 25V5. Wavelengths covered 200-557 and 700-2,000. Size 10 x 6 x 6 in. Completely drilled chassis. Price, including tax, £7 7s. 6d.

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Output Volts	Current	Type	Price
600	40 m/a.	H.W.	5/-
280	40 m/a.	H.W. or V.D.	5/-
325	65 m/a.	H.W. or V.D.	5/-
36	75 m/a.	Bridge	1 6
16	1 amp.	Bridge	12 6
48	14 amp.	Bridge	25/-
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16	1 amp.	H.W.	5/-

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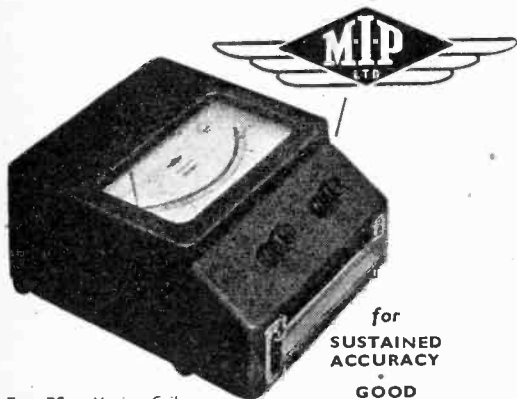
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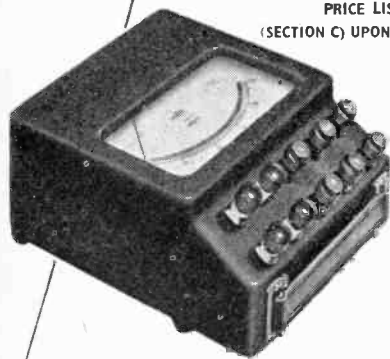


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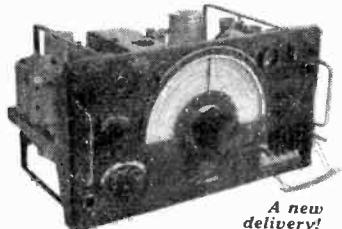
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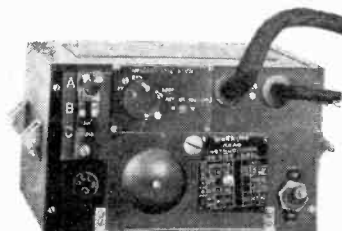
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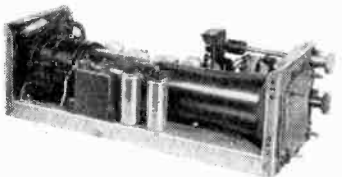


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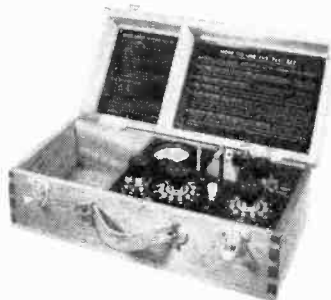
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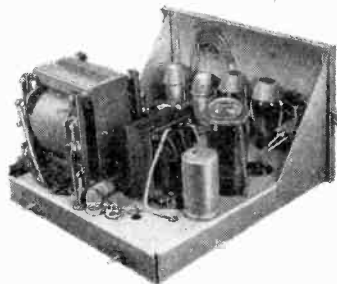


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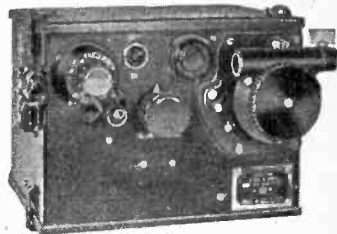
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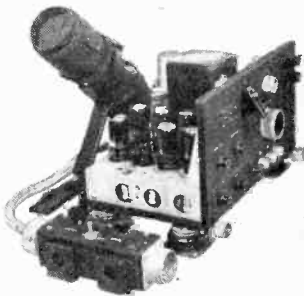
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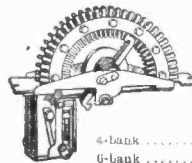


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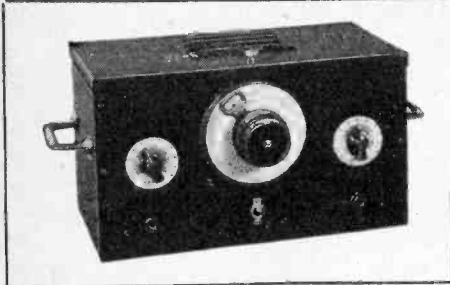
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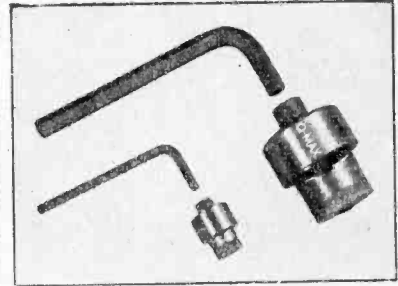
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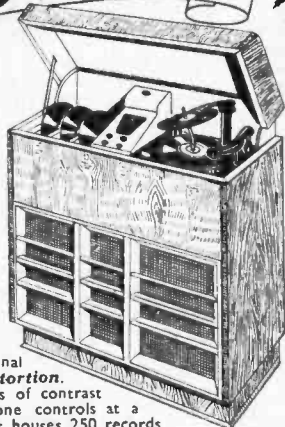
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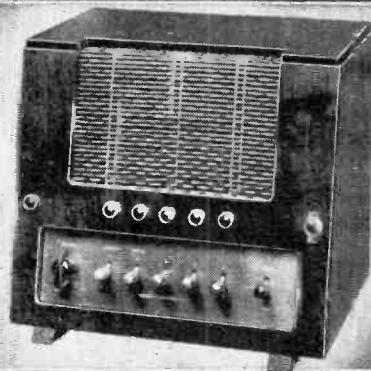


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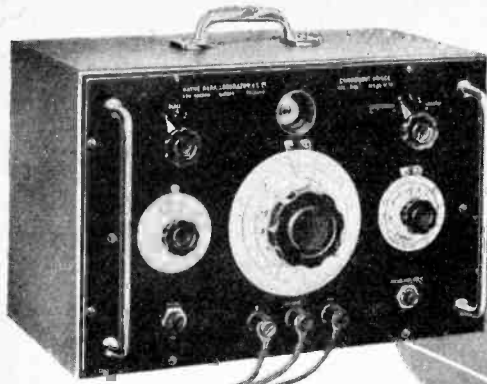
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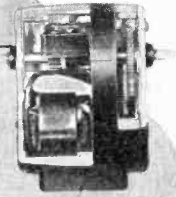
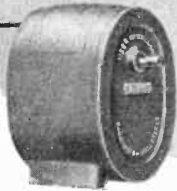
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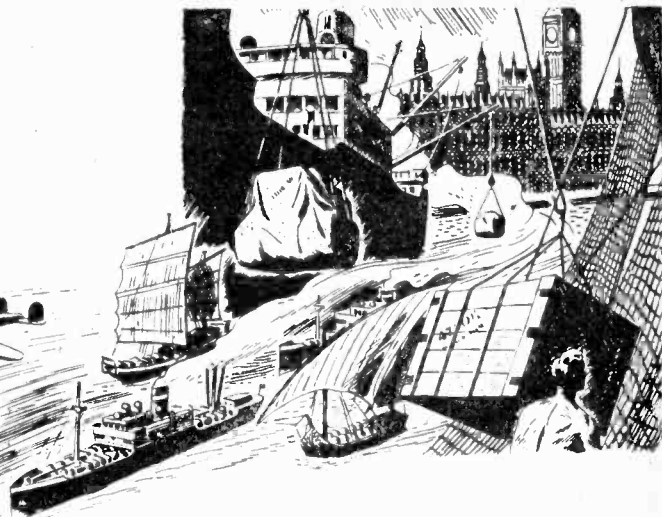
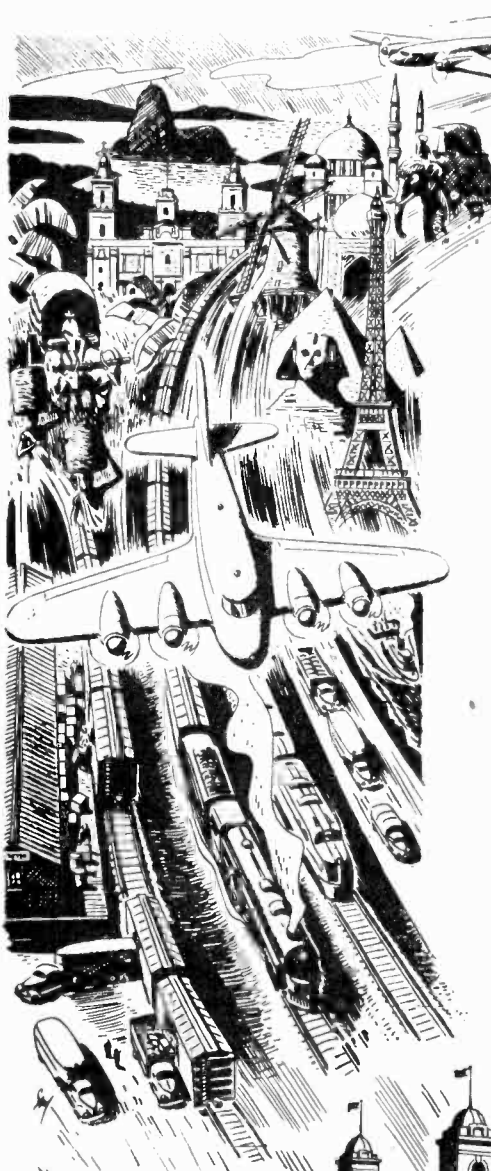
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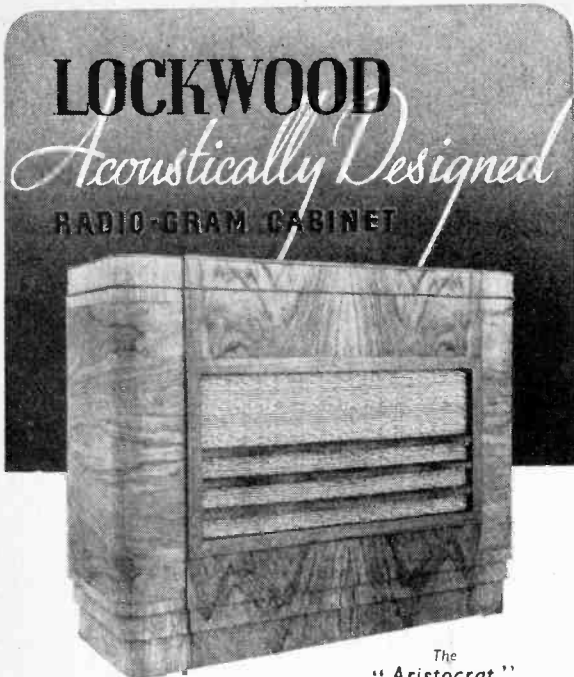
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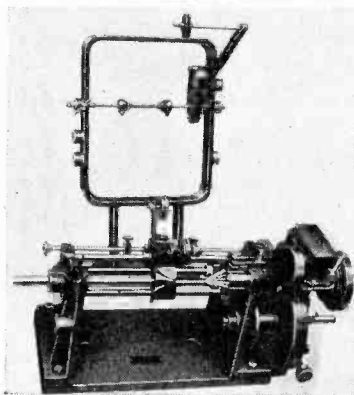
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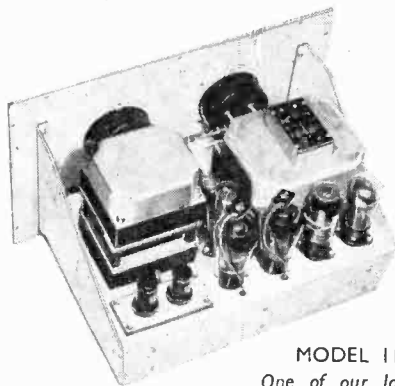
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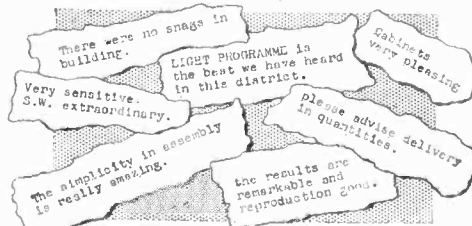
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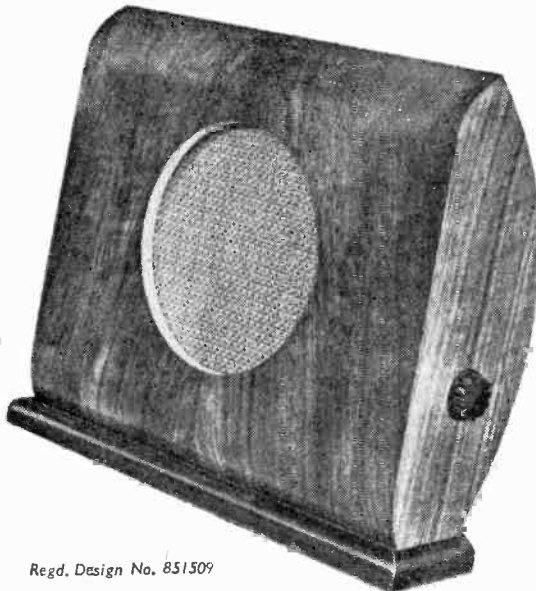
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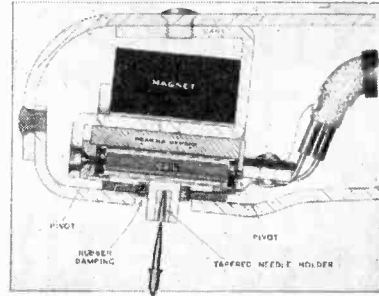
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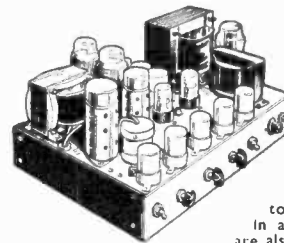


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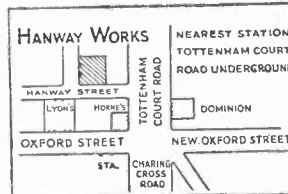
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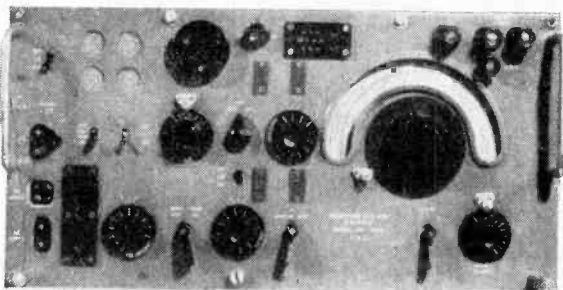
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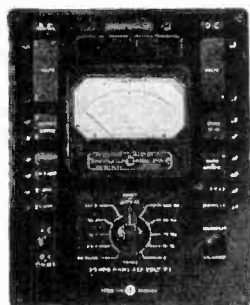
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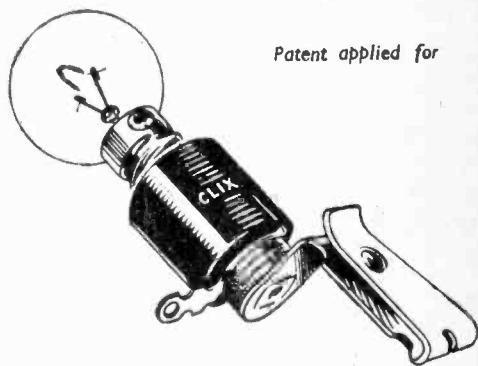
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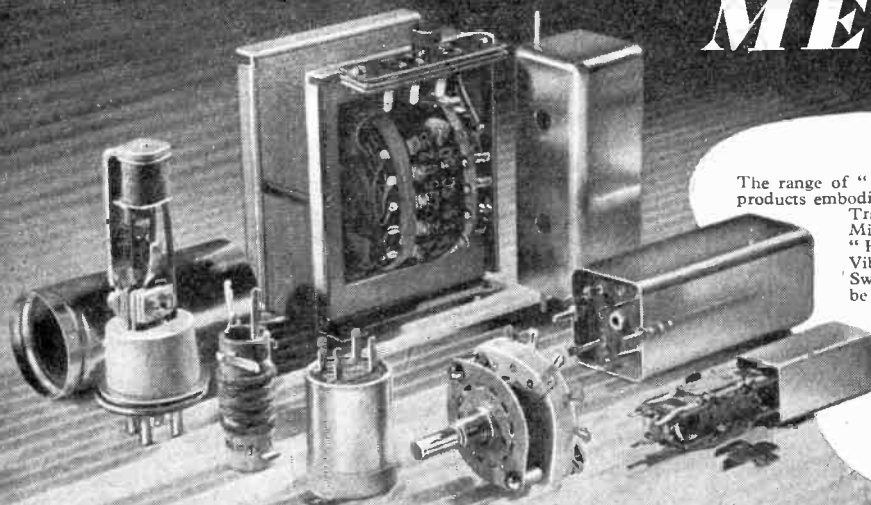


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VALVES AND THEIR APPLICATIONS

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

No. 12: Mullard V.H.F. Power-Amplifier Double-Tetrode QV07-40

THE great advantage of a tetrode for r.f. amplification is the internal screening, which renders neutralizing almost (if not quite) unnecessary. The effectiveness of the screening is largely lost, however, if the screen grid is not tied down to a constant potential. For example, if there is an impedance in series with the screen, and no by-pass capacitor, its potential is free to vary, and it can do little to prevent r.f. potentials at the anode from affecting the control grid.

At moderate radio frequencies a by-pass capacitor effectively ties the screen grid to earth or cathode. But at v.h.f. the internal connection to the screen has an appreciable inductance. Even with careful valve design it is of the order of $0.015\mu\text{H}$, which at 200 Mc/s is an impedance of about 20Ω . The only way to reduce it by doing anything outside the valve is by tuning it to resonance as an acceptor circuit. The disadvantage then is that the by-pass is effective only at the one spot frequency, and there is nothing to prevent instability at other frequencies.

One of the merits of push-pull is that any variation of the screen potentials is in opposite phase, so that if the screens are connected together they help to keep one another steady. This object, of course, is defeated if the connection between them has a substantial impedance; but if the two valves are in one envelope the inductance of these leads can be kept very small. That is what is done in the QV07-40.

Still, it is not wise to trust entirely to balanced anti-phase for the screening, and as we have seen there are difficulties about the external

by-pass. So in the QV07-40 there is an internal by-pass of 65 pF, arranged so that the inductance is negligible. At 200 Mc/s its impedance is about 12Ω , and even less at the valve's maximum rated frequency, 250 Mc/s.

If the valve is used at comparatively low frequencies this internal by-pass is likely to be insufficient, and the usual external capacitor should be used. A little attention may be needed at frequencies of the order of 100-150 Mc/s to ensure that the inductance of the screen connection, internal and external, does not tune the internal by-pass as a rejector circuit.

Some QV07-40 Data:

Heaters: 1.125 A at 12.6 V (series)
or 2.25 A at 6.3 V (parallel)
Max. Anode Voltage: 750
Max. Screen Voltage: 225
Max. Anode Dissipation: 40 W
Output at 200 Mc/s: 70-80 W



This is the twelfth of a series written by M. G. Scroggie, B.Sc., M.I.E.E., the well-known Consulting Radio Engineer. Reprints for schools and technical colleges may be obtained free of charge from the address below. Technical Data Sheets on the QV07-40 and other valves are also available.

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MONTHLY COMMENTARY

The "Elevated Electrode"

IN referring to the 50th anniversary of the foundation of the Marconi Company, we said (June issue) that Marconi's first great technical contribution was the addition of an elevated aerial to Hertz' oscillator. We had believed that Marconi's aerial priority was now beyond dispute.

In this belief we were wrong. Our statement has been questioned, and in particular it has been claimed that the Russian physicist Popov was the true originator, not only of wireless telegraphy but also of the aerial, with which we are here concerned. On this question we published (September issue) extracts from an article by the Marchese Solari, one of Marconi's earliest living associates, who also contributes a letter to the present issue. These communications, though lending support to our contentions, do not constitute documentary proof, and so we have delved into the half-forgotten literature of the dawn of wireless. Here are the results.

Exactly 50 years ago (November 26th, 1897) Popov wrote a letter to *The Electrician*, which was published in the issue of December 10th. He gave a translated *précis* of a paper of his that had appeared in the *Journal* of the Russian Physical and Chemical Society for January, 1896. In it was described the use of a coherer for recording atmospheric electric disturbances; a lightning conductor was connected to one side of the coherer and the other was earthed. The author expressed hopes that his apparatus would eventually be applied to signalling at great distances and went on to describe his use of a modified coherer for detecting electromagnetic waves at distances up to 5 km. Aerials for either transmitting or receiving were not mentioned here or in the specific claim that comes after the *précis*. This claim was that Marconi's receiver was a reproduction of Popov's "lightning recorder."

It seems highly significant that Popov made no claims to the aerial. His letter showed, by referring to a back number of November 12th, that he was a reader of *The Electrician*, and so he may be assumed to have known of the controversy on the origin of the aerial that had ended in the pages of that journal

only a fortnight before. This controversy seems to have been general in the English technical press of the time; and it was probably provoked by an editorial statement in the *Electrical Review* of October 8th, 1897, which read:—

"But we think there can be no doubt that Marconi is the true and first inventor of the elevated electrodes on the receiver and transmitter, and this detail appears to have contributed more to extend the possible distance of telegraphy by electric waves than anything that has been discovered."

That statement brought forward counter-claims by or on behalf of Minchin, Tesla and Edison—but not Popov. Those claims were apparently not regarded as entirely valid even at the time; now, with the accumulated knowledge of 50 years, we realize that the "elevated electrodes" devised by these early workers and used in the manner they described could not have contributed much to progress.

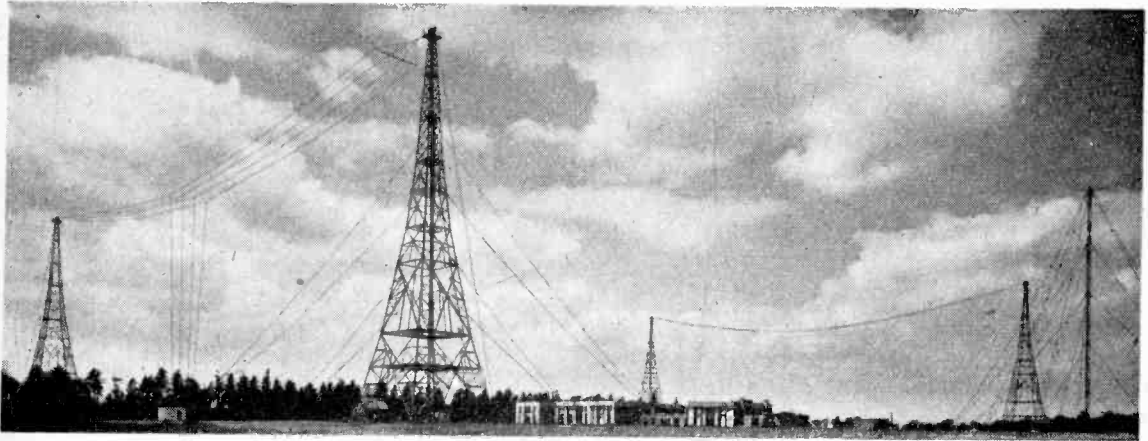
A True Pioneer

We do not belittle Popov's early work. On the contrary, some years ago we agreed that, subject to verification of the Russian documentation, he is to be regarded as the originator of the idea of using Hertzian waves for communication. Popov's published work pre-dated Marconi's first patent, but there is no record that he originated anything—including "elevated electrodes" on transmitter and receiver—which turned Hertz' oscillator and Branly's coherer into a practical means of communication.

Popov was essentially modest: such phrases as "my little work," and "repeating some of O. Lodge's experiments with the coherer . . ." which occur in his letter to *The Electrician* bear witness to that, and suggest that, were he alive to-day, he would hardly have been a party to the exaggerated claims made on his behalf.

He would probably have deplored as much as we do an intemperate article (containing, incidentally, a slighting reference to *Wireless World*) published recently in the U.S.S.R. journal *Culture and Life*.

Looking Backwards—and Forwards



LOOKING back from a technical vantage-point over the broadcasting scene makes the far-away look very close; the view is clear because not obscured by any remarkable event. Perhaps the 25-year-old emergence of broadcasting shows some mazy detail, not so clear as the rest; on the whole, however, the more it changes the more it is the same thing. The programmes have shown a tremendous improvement; the senior people must have read my book and adopted some of its suggestions! However, the mutttons here are technical and it is this technical aspect that is so singularly flat and undramatic.

I listen to broadcasting on an ordinary set belonging to a friend. This was bought just as the ordinary non-technical person buys any household appliance, a vacuum cleaner, sewing machine or electric fire. I can "get" a large number of stations; I get the Home, Light and Third programmes. The first two are reasonably free from background, the last is annoyingly accompanied by sounds made by the electric lift. I can also hear ghosts of other programmes behind the highbrow elegancies of the distinguished Third. As to

the reproduction, I should doubt if I hear any frequency higher than 3,500 c/s, and I know that orchestral reproductions are muzzy and confused. I am sure that I got at least as much pleasure, apart from the physical discomfort, from a crystal and telephones, *circa* 1923. I dare say

ings in the service we offered. I set down the points of a policy which seemed to me to be sound and which I had determined, were I to be allowed to remain in the Corporation, to put into practice. These were (1) that the listener wherever he lived in Great Britain should be given the opportunity to hear B.B.C. programmes without extraneous interference; (2) that the conditions of transmission should be such that the reproduction should be a faithful copy of the original sounds; (3) that the conditions of transmission should permit the cost of the receiver to be within the

means of the lower wage earner; (4) that there should be a sufficient number of channels of programme distribution to allow the diffusion of as many different programmes as there were different programmes to diffuse.

The Regional Scheme initiated the policy: high-power senders gave to a majority that strong field essential to overcome interference and there were two programmes to choose between. The field strength was enough to permit the use of simple, and therefore cheap, receivers.

The adoption of the policy of using high-power senders by Continental broadcasting authorities

Broadcasting Jubilee

By P. P. ECKERSLEY, M.I.E.E.

(Formerly Chief Engineer, B.B.C.)

behind the obscuring screen of annoyances which mar my pleasure I can detect a better acoustical environment in the studios. But I do ask, without trying to be funny, what remarkable difference is there between the reproductions of programmes given to the public now and those given twenty years ago?

As chief engineer of the B.B.C. in the middle 'twenties I was conscious of manifold shortcom-

OLD AND NEW.—The original Brookmans Park masts for London regional station, with, on the right, the recently erected 500-ft mast radiator are shown in the title illustration.

was (and is) one which has made it impossible to carry out the policy in full. The too-small frequency separation between carriers causes sidebands to overlap and receivers are perforce designed with a narrow bandwidth of reception. High-fidelity reproduction becomes impossible. The obsolescent method of distributing programmes by modulating medium waves, with the consequent lack of enough channels,

given by a miserly employer to his workmen: "If it were any worse we couldn't a-drunk it; if it were any better we shouldn't a-got it."

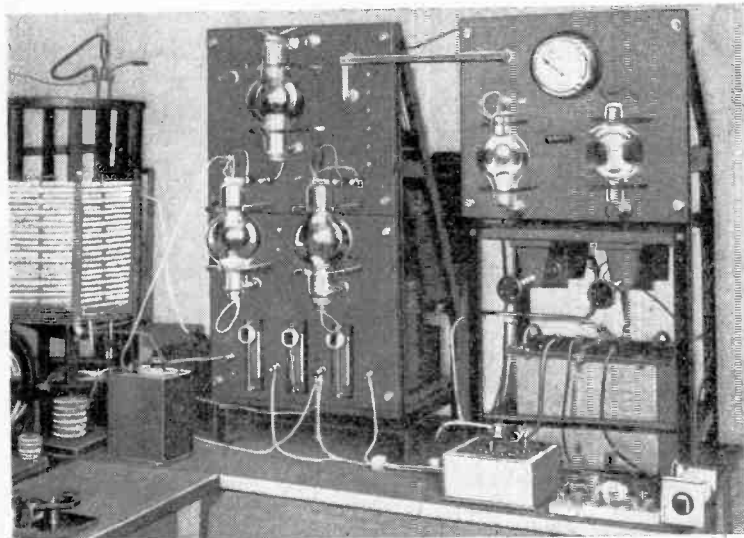
What does the future hold? What tools do we possess which could fashion a more exciting structure than we have to-day?

The primary requirement is more channels of distribution. This technical provision would give to the listener a wider choice

pursued we still want more channels for the sake of quality. Some argue that the ordinary listener does not like high-fidelity reproduction. What is in fact true is that he does not like the harsh and glittering top that is, at present, an almost universal concomitant of wide-band reproduction. Given a constant service, encouraging true high fidelity, the rather difficult problems of top reproduction would, in time, be solved, and their solution would be welcomed by all.

There are two main methods available to give us more channels: short-wave radio and carrier-on-wire networks. I am not concerned which of the two methods is adopted, but I do most devoutly hope that some day soon we shall get at least an experimental service, somehow, somewhere.

On the short-wave side we have the new, exciting and revolutionary method of frequency modulation. There was once a doubt as to whether the extravagantly wide sidebands essential to F.M. would not be a relative disadvantage of the system. In other words, more A.M. senders than F.M. senders might give a more efficient national service. H. L.

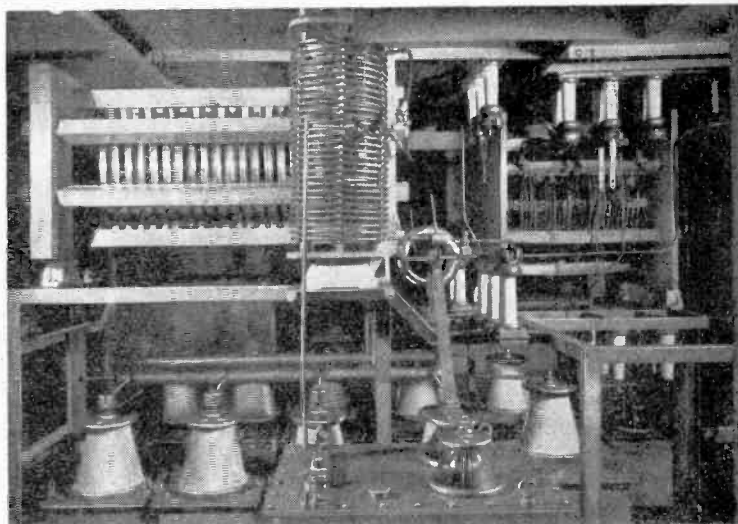


B.B.C. PROGRESS: 1922-1947.

In striking contrast are these photographs of the original Writtle, Chelmsford, transmitter, 2MT, which operated from February 1922 to January 1923, and the modulated amplifier tank of the B.B.C.'s most powerful station at Ottringham, near Hull.

completely nullifies any possibility of giving the listener a wide range of choice between different and clearly heard programmes.

The efforts I made, after leaving the B.B.C., to develop a scheme of wire broadcasting were attempts to pursue the policy of giving the public a high-fidelity multi-programme service. The attempts were in part frustrated, but the relay services have gained a wide measure of support, in spite of every obstacle, chiefly bureaucratic, put in their way. But broadcasting remains much as it has always been—a public service satisfying a public which is refused an opportunity to be better satisfied. One remembers the story of the beer



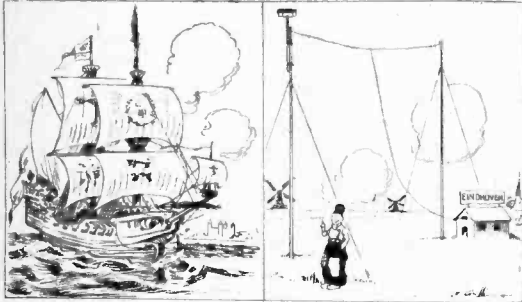
of programmes. I know the necessity for this is doubted by the pundits; it was doubted before the Third programme was born and given such a wide welcome. Even if the pusillanimous policy of denial of quantity is

Kirke has investigated and shows that, so far as distribution is concerned, F.M. is the better system. There is still, however, this doubt: the F.M. receiver is more complex than the A.M. type. Has this factor, throwing a

Broadcasting Jubilee—

greater burden on the public, been taken into account?

I happen to believe that wire broadcasting method is the better. Wire broadcasting receivers are cheap and efficient, the channels numerous, and no ether channels, so essential for mobile services, are used. The argument that wire broadcasting cuts off the listener from foreign-station listening is equally applicable to short-wave radio broadcasting. It was always a stupid argument; if "the people" watch "the Govern-



1927.—This cartoon appeared in *Wireless World* in June, 1927, when the Dutch station, PCJJ, having started short-wave overseas broadcasting some months prior to the introduction of Empire broadcasting by the B.B.C., emulated the Dutch commander Admiral Tromp.

ment" then no one need be cut off. If dictatorship comes, be sure that radio will be cut off whatever its technique. Quite likely the dictator would install a wire broadcasting system and confiscate all radio sets!

As to the network, probably in the long run the telephone wires are the most suitable. It is said, moreover, by competent authorities that it would be possible to distribute television programmes via subscribers' lines. I am as certain as I can be that the electric mains would be quite unsuitable for use in diffusing television programmes. Which leads to question about the future of television. I have little doubt that eventually the greater part of broadcasting will contain sound and vision images. The operative word here is "eventually." Today television is a technical marvel and a cultural horror. In its reportorial aspects it is useful to those who must know the latest at the earliest, to those who like to join in events, to sports enthusiasts maybe; but in its creative exhibitions it has hardly passed the standards of the embryonic cinema. This does not blame anyone; inevitably a new art has to find its new forms of expres-

sion. Early sound broadcasting was a mediocre business.

To my way of thinking, television should be developed as much by the cinema people as by the B.B.C. Some of the reasons are obvious—competition for service, widened experience and so forth—but one seems to be paramount. Apparently some of the imperfections of the images reproduced in the home to-day could be rubbed out by using a larger number of lines. On the other hand, the use of higher and higher frequency carrier waves,

essential to increased lines, would cause distortion because of reflections. This is a problem that could be solved, given a considerable expenditure, at any given reception location; i.e., at any particular cinema theatre. *Ergo*, the cinema reproductions could be better and the experience gained

OUR COVER illustration is this month devoted to an unusual view of the B.B.C.'s most powerful station at Ottringham, near Hull. It consists of four 200-kW transmitters, for operating in the long- or medium-wave bands, which can be coupled to give an output of 800 kW. The old 2LO transmitter had a power of 1 kW!

wider than by flogging the imperfect system essential at the moment as a public service.

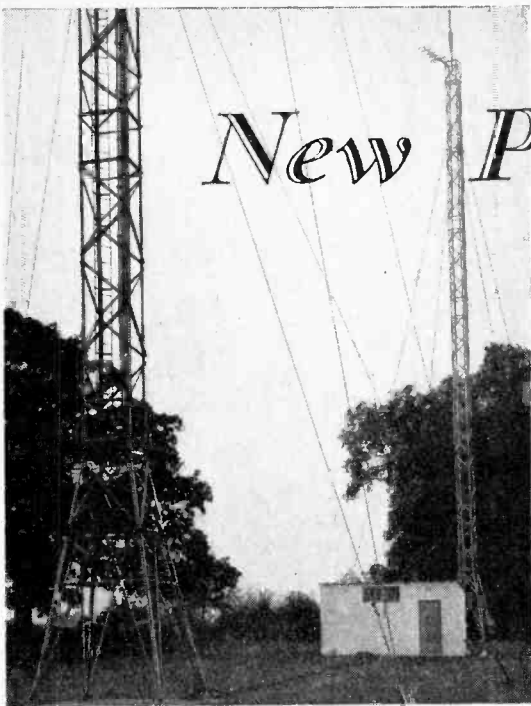
There is an easy and delightful pastime in exaggerating the virtues of the good old days; what I think makes anecdote negligible is the existence of some better new ones. One therefore ends this brief looking-backwards looking-forwards with the specific hope that something may soon be done to give listeners a wider choice between faithfully reproduced programmes than they get to-day. Monopoly can never be justified; at least it might be admired for its courage and enthusiasm.



PIONEERS.—In this group of pioneers of the Writtle days are (seated, second from left) Sir Noel Ashbridge, now B.B.C. Deputy Director General, (standing, second and third from left) H. L. Kirke, head of B.B.C. Research Dept., and R. T. B. Wynn, B.B.C. Assistant Chief Engineer. P. P. Eckersley the author of this article is seated in the centre. [Courtesy, "London Calling."]

New Police Radio

Two-station Diversity System with Radio-link Control



Two steel towers support the Leverstock Green aeri-als. On the distant one is a 6-element array beamed on Hatfield for reception on the link frequency and a vertical half-wave aerial for reception from the patrol cars. The near tower supports similar aeri-als for transmitting.

reliability, since there are fewer pieces of equipment to develop defects.

The block diagram of the installation shows the arrangement of the equipment at the three main centres: Hatfield, Leverstock Green and Barkway.

The 10-watt transmitter at Hatfield operates on a frequency of the order of 150 Mc/s and feeds a half-wave horizontal aerial at the top of a 100-ft steel tower. This is the link over which the switching signals are sent for starting up the two 100-W transmitters and for conveying the outgoing speech signals which modulate these transmitters.

Leverstock Green and Barkway operate on two carrier frequencies

SOME of the early experiments made by the Home Office radio branch which finally produced a workable system of V.H.F. diversity transmission for telephonic communication with police cars have already been described in *Wireless World*.¹ Descriptions of the equipment used in these tests² or developed especially for services of this kind^{3, 4} have already been published.

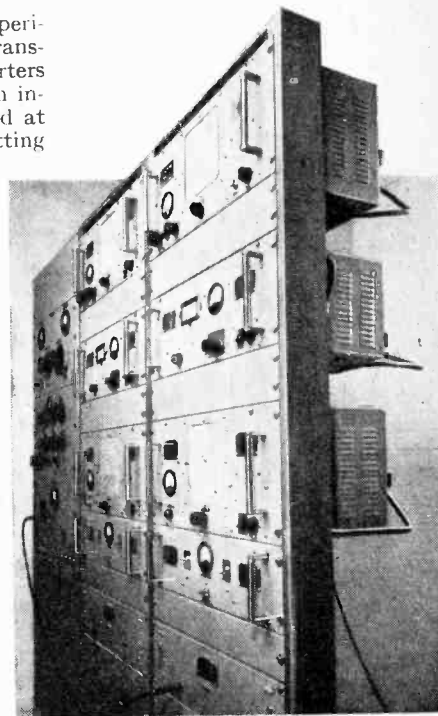
It is now possible to give details of the latest installation planned for the Hertfordshire county police. This is thought to be the first large-scale scheme of its kind employing diversity transmission with amplitude modulation.

The scheme employs two 100-watt V.H.F. transmitters one located at Barkway in the north-east corner of the county, and the

other at Leverstock Green, in the south-west corner. Both these unattended stations are controlled and operated by radio links from the county police headquarters at Hatfield.

In one of the earlier experimental installations the transmitter at the headquarters station was used to control an intermediate transmitter located at one of the main transmitting sites. This transmitter, of about 30 watts output, controlled and supplied modulation to the other two stations in the chain.

In the case of the Hertfordshire scheme the headquarters transmitter itself performs these functions. This not only reduces the amount of equipment needed; it also simplifies the installation and, incidentally, makes for greater



The equipment rack inside the Leverstock Green station building. The three racks contain the 100-watt and 10-watt transmitters, link and service receivers, modulation amplifiers and power supplies. Spare equipment for replacement in the event of a defect is also included.

¹ Multi-carrier Communication System, *Wireless World*, February, 1946, pp. 59-61.

² V.H.F. Communication Equipment, *Wireless World*, June, 1946, pp. 180-181.

³ Mobile V.H.F. Gear, *Wireless World*, November, 1946, p. 368.

⁴ Miniature V.H.F. Transmitter-Receiver, *Wireless World*, July, 1947, p. 269.

⁵ Mobile Radio-telephone, *Wireless World*, October, 1947, p. 357.

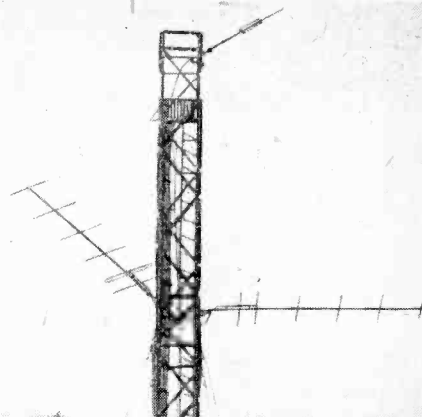
New Police Radio—

of the order of 80 Mc/s, the frequency separation being about 10 kc/s. This is considerably closer than the experimental systems already described for in those multi-carrier installations the carrier separation was 20 kc/s and since three stations were used the bandwidth of the operational signal receivers, mobile and fixed, was 100 kc/s. With the frequency spacing reduced to 10 kc/s and only two stations the receiver's bandwidth can be brought down to 40 kc/s. In order to prevent audible heterodyne of the two carriers the upper audio response is restricted to just below 5 kc/s. This provides good speech quality; indeed, this curtailment was certainly not suspected during the demonstration run at which time these details were not known.

It will be seen that a 50- μ sec delay network is inserted between the link receiver and the main transmitter at Leverstock Green, but not at Barkway. There is a difference of 10 miles in the dis-

miles to the radio path to Leverstock Green, thereby bringing the modulation at this station in phase with that of Barkway. Likewise a delay of the same amount is inserted in the incoming signal path at Leverstock Green.

The aerial system at Hatfield Police Headquarters consists of two 6-element horizontal receiving arrays beamed on Leverstock Green and Barkway respectively and a horizontal half-wave dipole for transmission.



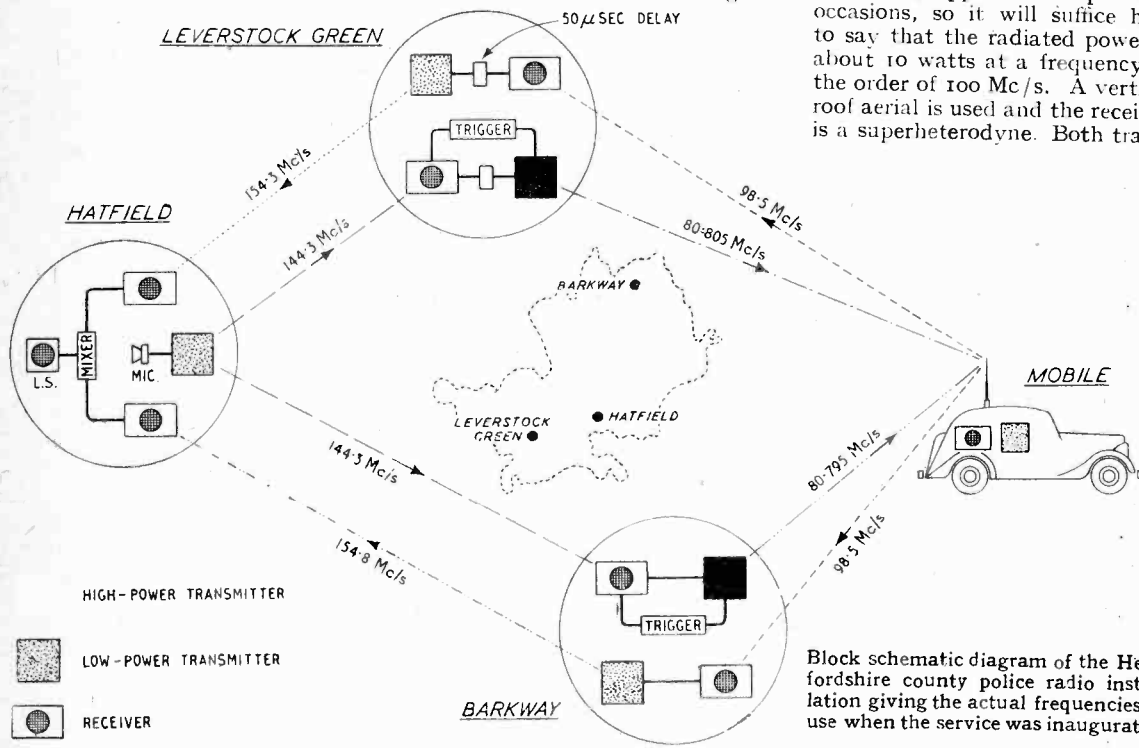
Despite these delay networks some phase difference is bound to exist as the patrol car will not always be the same distance from both stations. Extensive use has shown, however, that such phase difference that may occur under normal conditions does not introduce noticeable distortion.

Four aerials are used at each main transmitting site, those at Leverstock Green consisting of

zontally polarized. The other two are vertical half-wave dipoles and are used for transmitting to and receiving from the patrol cars.

At Leverstock Green the aerials are supported on two 120-ft steel towers, but at Barkway an existing tower 240ft high has been used.

Details of the receivers and transmitters fitted in the patrol cars have appeared on previous occasions, so it will suffice here to say that the radiated power is about 10 watts at a frequency of the order of 100 Mc/s. A vertical roof aerial is used and the receiver is a superheterodyne. Both trans-



Block schematic diagram of the Hertfordshire county police radio installation giving the actual frequencies in use when the service was inaugurated.

tances of these stations from Hatfield, Leverstock Green being the nearer of the two. The 50- μ sec delay is equivalent to adding 10

two six-element Yagi arrays, one for the incoming and one for the outgoing link signals. These are beamed on Hatfield and are hori-

mitter and receiver are crystal controlled.

A point of interest of the Hertfordshire scheme is that the six

divisional police headquarters in the county are also included in the radio chain. These stations use the same transmitting and receiving frequencies as the patrol cars, and can therefore receive all outgoing messages, but they cannot receive from or transmit to the cars. They have communication by two-way radio-telephone with the main headquarters in

Hatfield in the same way as the patrol cars, small 10-watt transmitters being employed.

The actual frequencies at present employed are marked on the block schematic diagram of the installation, but it is understood that these will be amended shortly as some are outside the bands agreed on recently at Atlantic City.

BOOKS RECEIVED

Television Explained.—By W. E. Miller. The various parts of a television set are simply explained and the book provides an introduction to television which is suited to those acquainted with ordinary wireless equipment. Covering the receiver stage-by-stage, it deals with aerials, R.F., I.F. and V.F. amplification, sync separation, time bases for electrostatic and electromagnetic tubes, cathode-ray tubes and power supplies. Pp. 50, with 56 illustrations. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 3s 6d.

School Broadcasting in Britain.—By Richard Palmer. Claimed to be the first considerable contribution on the subject of school broadcasting to be published in this country, this book describes the growth and scope of the system introduced by the B.B.C. in 1924. 144 pages. British Broadcasting Corporation, London, W.1. Price 3s 6d.

Reference Data for Radio Engineers.—Second editions of two manuals with this title have been received from the associated companies Standard Telephones & Cables (London) and Federal Telephone & Radio Corp. (New York). There is a marked similarity between them, but in the S.T.C. publication the material has been Anglicized. The books were originally compiled for the use of the staffs of the respective companies. The scope of the S.T.C. book, which was first made available

Rotating Dual Aerial System

Electric Drive and Remote Indicators

SHOWN here is a remotely controlled dual beam-aerial system which has been erected by C. G. Allen at his amateur station, G8IG, in Bromley, Kent. It is mounted on a wooden tower 30 feet high and consists of a three-element array for 20 metres and a similar one above for 30 metres.

Close spacing is used in both aerials and this has resulted in a very low impedance—about 6 ohms—at the centre of the radiator.

In order to bring this up to match a 50-ohm coaxial feeder a folded radiator is used. It consists of a $\frac{3}{8}$ -in diameter tube with a $1\frac{1}{8}$ -in tube in parallel. The feeder is joined into the centre of the thinner tube.

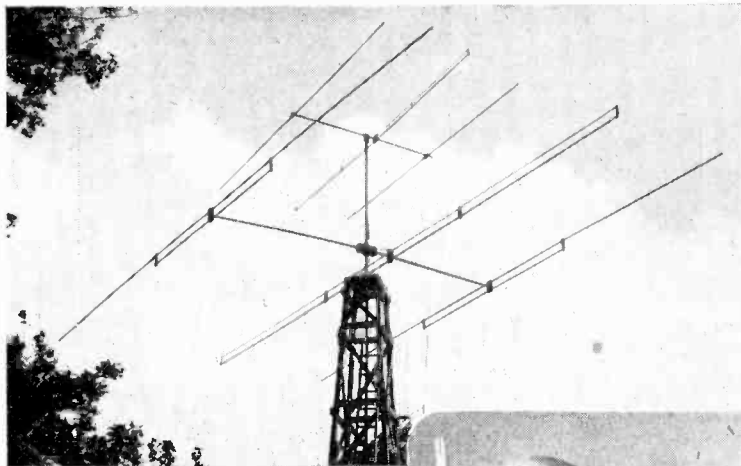
The dimensions of the 20-metre array are:—reflector 36ft, radiator 35ft and director 32ft. The reflector is 10ft behind the radiator and the director 7ft in front. The boom carrying the elements, which are insulated from it, is 17ft long and 2-in diameter. Reflector and director are $1\frac{1}{8}$ -in diameter and the whole is made of duralumin "B" thin-walled tubing and it weighs 28lb complete.

Supported 7ft above the 20-metre array is a replica of it scaled down to half-size for 30 metres and using smaller diameter tubes.

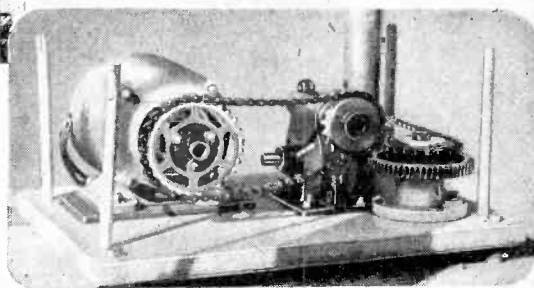
The whole head is carried in ball bearings and is driven through a vertical shaft from the base of the

tower by an electric motor and reduction gearing.

Clamped to the driving shaft is



The two-band aerial array for 10 and 20 metres erected on a 30 ft tower with its electric driving mechanism shown in the insert.



a rotary switch with 18 equally-spaced contact studs. In the transmitting room is a great-circle map of the world on a circular metal plate, with a 360-degree compass scale round the circumference and in which 18 radial slots are cut. Behind each slot, in a reflector, is a small lamp connected to the corresponding stud on the mast switch.

As the aerial rotates the lamps light up.

to the public in 1942, can be gathered from some of the chapter headings: General Engineering Tables; Engineering and Material Data; Audio and Radio Design in General; Rectifiers, Valves and Amplifiers; R.F. Transmission Lines; Radio Propagation and Aerials; Noise and Noise Measurement; Non-Sinusoidal Waveforms, Mathematical Formulae; Tables and General Information. British: 175 pages, Standard Telephones & Cables, Connaught House, Aldwych, London, W.C.2. Price 5s. The American edition costs \$2.

Deflector Coil

WHEN considering the problems associated with the electromagnetic deflection of a cathode-ray beam it is useful to have available information about the energy and power needed in the ideal case. It is useful because the ideal power requirement is one which can never be reached and it serves as a measure of the efficiency of a practical system and so indicates the possibility of improvement.

In a recent article¹*, Schlesinger has given equations for the energy in the magnetic field and for the power needed to provide that energy once every scanning cycle. Similar equations are developed below and extended to a form which expresses the efficiency of a practical coil in relation to an ideal one.

The ideal deflecting field will be considered as a field of uniform magnetic intensity H , extending for a distance l_0 along the neck of the tube, and occupying a volume v of cylindrical shape. The diameter of the cylinder is d_0 and is assumed to be the external diameter of the C.R. tube neck.

When the field is zero the undeflected electron beam passes along the axis of the cylinder as shown by the dotted line of Fig. 1 (a). The field is assumed to be perpendicular to this axis and of uniform intensity throughout the cylinder; outside the cylinder it is assumed to be zero.

Practically, this is an impossible condition, for the field always falls off more or less gradually outside its main boundaries. Only the ideal case is considered here, however.

The general arrangement of a deflecting system on the neck of the C.R. tube is shown in Fig. 1 (b) and for deflection in the plane of

the paper the magnetic field is perpendicular to this plane over the area bounded by l_0 and d_0 , the cross-section being circular of diameter d_0 . If the total angle of deflection from one extreme to the other is ϕ , the maximum angle from the undeflected position is $\phi/2$ and the beam is shown in this position.

The path of the beam through the field follows an arc ABC of radius r and the path of the beam outside the field is tangential to the arc at the boundary. By inspection $\angle CDE = \phi/2 = (\text{arc } ABC)/r$ and $l_0/r = \sin \phi/2$.

Reference to

any book on electron optics gives the relations

$$r = mu/He$$

$$e E_{HT} = \frac{1}{2} mu^2$$

$$\frac{e}{m} = 1.76 \times 10^7 \text{ e.m.u./gm.}$$

Combining these relations gives

$$H = \frac{10^{-3}}{2.96} \frac{\sqrt{E_{HT}}}{l_0} \sin \frac{\phi}{2} \text{ oersteds.}$$

$$\Delta H = 213.5 \frac{\sqrt{E_{HT}}}{l_0} \sin \frac{\phi}{2} \text{ oersteds} \dots \dots \dots (5)$$

$$\text{Energy} = 1.425 \times 10^{-4} E_{HT} \frac{d_0^2}{l_0} \sin^2 \frac{\phi}{2} \text{ joules} \dots \dots \dots (6)$$

$$P = 0.1425 E_{HT} f \frac{d_0^2}{l_0} \sin^2 \frac{\phi}{2} \text{ watts} \dots \dots \dots (7)$$

$$I = 0.00169 d_0 \sin \frac{\phi}{2} \sqrt{\frac{E_{HT}}{Ll_0}} \text{ amperes} \dots \dots \dots (8)$$

The field for full deflection in one direction is $H_1 = H$ and in the other is $H_2 = -H$. The total change of field for full deflection through the angle ϕ is thus in oersteds $\Delta H = H_1 - H_2 = 2H$

$$= \frac{2 \times 10^{-3}}{2.96} \frac{\sqrt{E_{HT}}}{l_0} \sin \frac{\phi}{2} \quad (1)$$

Text-books on magnetism show that the energy stored in an elementary volume dv of a magnetic field H , uniform over that volume, is $BHdv/8\pi$. In this case H is uniform over the whole volume v and as the medium is air $B = H$. The total energy

stored in the field is $H^2v/8\pi$ ergs. The volume $v = \pi d_0^2 l_0/4$ and so energy = $1.425 \times 10^{-8} \times$

$$E_{HT} \frac{d_0^2}{l_0} \sin^2 \frac{\phi}{2} \text{ ergs} \dots \dots (2)$$

If at the end of every scan this energy is dissipated during the fly-back in a resistance it must be supplied f times a second where f is the scanning frequency. Consequently, the power supplied is

$$P = 1.425 \times 10^{-15} \times E_{HT} f \frac{d_0^2}{l_0} \sin^2 \frac{\phi}{2} \text{ watts} \dots (3)$$

If the field H in the volume v were produced by a current I in a coil L , and if it were the only field produced by the coil, the energy in the field would be $\frac{1}{2} LI^2$. Equating this to the previous expression for energy gives

$$I = 1.69 \times 10^{-4} d_0 \sin \frac{\phi}{2} \sqrt{\frac{E_{HT}}{Ll_0}} \quad (4)$$

The foregoing expressions are all in fundamental electromagnetic units. Converting to the more convenient practical units of amperes, kilowatts, kilocycles per second, centimetres, oersteds, joules, watts, the expressions become:

A typical "9-in" C.R. tube has a maximum deflection angle of about 48° and gives a picture $7\frac{1}{2}$ in by 6in. The maximum angle is obtained only in the corners and corresponds to the diagonal of 9.6in. The half-angle is 24° and its sine is 0.406. Assuming that the deflection distance on the screen is proportional to the magnetic field, as it should be, $\sin \phi/2 = 0.406 \times 7.5/9.6 = 0.318$, or an angle of 18.55° , for the horizontal deflection.

Such a tube usually has a neck diameter of 3.55 cm and the deflection field can rarely exceed

Losses in Television Scanning

¹ "Magnetic Deflection of Kinescopes," by Kurt Schlesinger, *Proc. Inst. Radio Engrs.*, August 1947, Vol. 35, p. 813.

* See also "Line Scanning Systems for Television," by A. M. Spooner and E. E. Shelton, *Electronic Engineering*, October 1946, Vol. 18, p. 302, but note that the "figure of merit" used is proportional to the square root of the power efficiency.

Efficiency

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

5 cm in length. If $E_{HT} = 6$ kV the formulae give the following values:—

- $H = 33.2$ oersteds;
- $P = 2.175$ watts;
- Energy = 2.16×10^{-4} joules;
- $I = 0.222$ ampere;

assuming an inductance of 8.9 mH and $f = 10.125$ kc/s.

Now in any practical circuit the current I_L through the deflector coil needed to produce a given deflection d at a given final anode voltage E_{HT} is easily measured, as are also the inductance L_L and the resistance R_L of the coil. Following the same reasoning as before, if the energy in the magnetic field is dissipated in resistance during the fly-back, the power supplied to produce the field is:

$$P_L = \frac{I_L^2}{2} L_L f \times 10^3$$

and there is a loss in the resistance of

$$P_r = I_L^2 R_L / 12$$

Therefore the total power is

$$P_T = \frac{I^2}{2} L_L f \times 10^3$$

$$\{I + R_L / (6 \times 10^3 L_L f)\} \dots (9)$$

the units being watts, amperes, kc/s, Ω , henrys, kV.

It has been shown² that, in these units,

$$I_L = \frac{k_2 d \sqrt{E_{HT}}}{80.4} \dots (10)$$

where k_2 is a factor related to the deflection-coil efficiency which is easily determined in any practical case by measuring I_L and d , the deflection on the screen, for any convenient value of E_{HT} .

In terms of k_2 , then,

$$P_T = 7.78 k_2^2 d^2 L_L f E_{HT} \times$$

$$\{I + R_L / (6 \times 10^3 L_L f)\} \dots (11)$$

The efficiency of the practical deflector coil relative to the ideal is thus

$$\eta = \frac{P}{P_T} = 1.83 \frac{d_0^2 \sin^2 \frac{\phi}{2}}{k_2^2 l_0 d_0^2 L_L \{I + R_L / (6 \times 10^3 L_L f)\}} \dots (12)$$

In one practical case with $L_L = 8.9$ mH, and $R_L = 15 \Omega$, the factor k_2 was 1.08. Assuming the other

values to be unchanged the efficiency is 10.7 per cent. Instead of the input power being 2.175 W it must be 20.3 W.

It is instructive to examine the reasons for this low efficiency. In the first place, the effective diameter of the magnetic field is necessarily larger than the diameter of the tube neck. Allowing some clearance between the inside of the coils and the tube the mean diameter of the assembly can rarely be much less than 4.5 cm. Taking this as the real diameter of the field, the power is increased by $(4.5/3.55)^2 = 1.61$ times.

To obtain a uniform field the ends of the coils are usually bent

one-half of the total. The power needed is proportional to the square of the field; therefore the loss in the ends of the coils increases the power needed about 4 times.

These two factors make the input $4 \times 1.61 = 6.4$ times the ideal, or 14 W.

There is a loss in the resistance of the coils which amounts to some 2.7 per cent of the total, or 0.56 watt. All this brings the power up to 17.56 watts and leaves 2.74 watts so far unaccounted.

This represents the loss of field external to the coils. If no outer iron ring were used, one-half of the field produced by the sides would be wasted and a further increase of four times in the power would be needed! The usual outer iron ring provides a path of low reluctance for the external flux and by so doing it increases the internal flux.

These various sources of loss are shown in the Table as per-

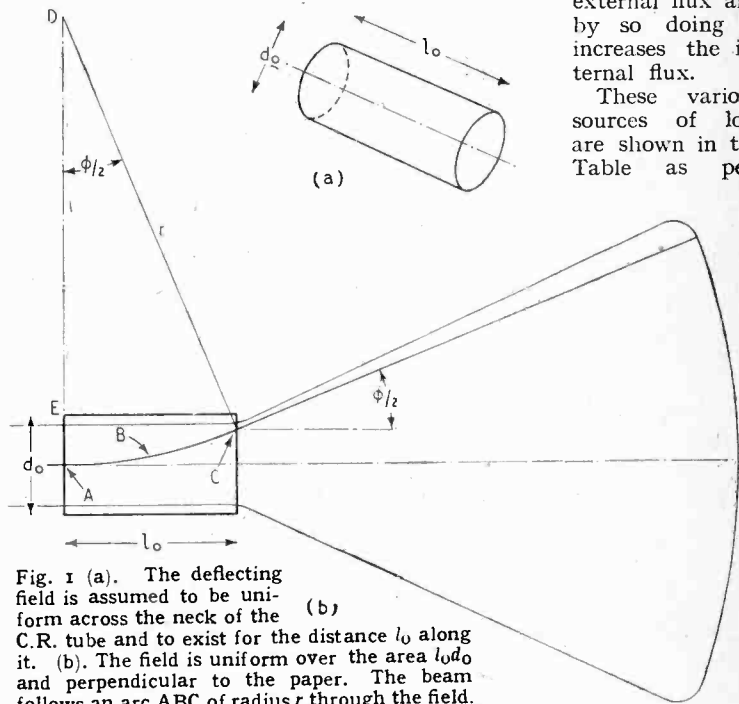


Fig. 1 (a). The deflecting field is assumed to be uniform across the neck of the C.R. tube and to exist for the distance l_0 along it. (b). The field is uniform over the area $l_0 d_0$ and perpendicular to the paper. The beam follows an arc ABC of radius r through the field.

centages of the total power so that it is easy to see their relative importance. It should, of course, be understood that this breakdown into components of loss is only approximate. The useful deflecting power is accurately calculable and the input power can be measured, so that the total loss is known accurately. The resistance loss can be com-

away from the neck of the tube and so the field from the ends contributes little or nothing to the useful field. The wire on the ends is about one-half the total wire in the coils and the field is also about

² "Television E.H.T. Supply," by W. T. Cocking, *Wireless World*, June 1947, Vol. 53, p. 207.

Deflector Coil Efficiency—

puted quite well from the known current and D.C. resistance of the windings. The loss remaining is apportioned among the three main causes largely by estimation and any individual one may be considerably in error.

What the breakdown does reveal is that there is one major source of loss—the end field of the coils—and a number of minor ones and that appreciable improvement in efficiency can be made only by attending to this major loss. Only when this loss can be reduced to a figure comparable with the others will it be profitable to spend much time in efforts to reduce them also.

The main problem in deflector coil design is clearly to obtain a uniform field in the neck of the tube without also producing a lot of waste field outside the tube.

It should be pointed out that

	watts	per cent
Useful deflecting power	2.175	10.7
Wasted power in excess of mean diameter of coils over tube neck diameter	1.325	6.53
Wasted power in ends of coils	13.5	66.5
Wasted power in coil resistance	0.56	2.77
Wasted power in field external to coils	2.74	13.5
	20.3	100

the expression for the efficiency of the deflecting coil holds whether or not resistance damping is used. Both expressions for the power, in the ideal and in the practical cases, are based on the assumption that the energy in the field is dissipated in a resistance during each fly-back. These expressions do not hold, therefore, in cases where some of the energy is utilized to provide part of the next scan, but their ratio, which is the efficiency of the coils, does hold in all cases. Equation (12) is, therefore the most useful one.

Before concluding, it may be as well to consider very briefly conditions for the frame scan. In the ideal case, the power input required is proportional to frequency so that for a field of the

same dimensions and for the same deflection angle the power needed is $50/10,125 = 0.00495$ of that for the line scan; that is, 0.0108 W instead of 2.175 W.

However, the losses in the series resistance of the coils are much more important. With the same values as before, but taking $f = 0.05$ kc/s (50 c/s), Equ. (12) gives $\eta = 0.0166$. The same deflector coil has an efficiency of 1.66 per cent at frame frequency compared with 10.7 per cent at line. The difference occurs solely because the series resistance losses are independent of frequency whereas the "reactive losses" are greatly reduced at frame frequency, and consequently form a smaller proportion of the total.

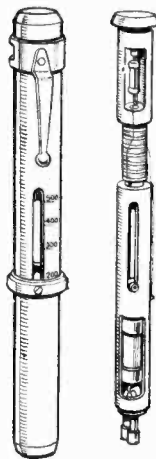
In practice, of course, the absolute magnitude of the power needed is more important than the efficiency, and in the frame scan the power is so small that even the low value of 1.66 per cent is not very important. It means a power of about 0.65 W as compared with 20 W for the line scan.

For mechanical reasons it is usually necessary to make the frame coils rather shorter than the line, and this reduction of l_0 makes it necessary to increase the input somewhat. However, the amplitude of scan needed is only 80 per cent of that of the line and these two effects roughly cancel each other.

Because the line scan requires a much bigger power input than the frame the efficiency of the line coils is much more important than that of the frame. In spite of the fact that the latter is already by far the lower of the two, it would pay handsomely to improve the line efficiency even if it entailed a reduction of the frame efficiency. Thus, in the case considered, doubling the line efficiency would save 10 W input power to the coils. If this improvement could be made only by reducing the frame efficiency

to one-quarter, the increase of frame input would be no more than 2 W and the total saving would be as much as 8 W.

One cannot go too far in this way, of course, because the efficiencies of the valve and of the valve-to-coil coupling are often much lower at frame than at line frequency. Nevertheless, it may pay well to sacrifice frame coil efficiency if by so doing it is possible to improve the line coil efficiency.



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PUNCH HOLES HERE

TYPE	CHANGE SOCKET		CHANGE CONNECTIONS		PERFORMANCE CHANGE	REMARKS
	FROM	TO	FROM OLD SOCKET	TO NEW SOCKET		
6Q7GT	INT/OCTAL	NO CHANGE	PIN 3 " 4 " 5	REMOVE PIN 3 REMOVE	SLIGHTLY LESS GAIN	In certain sets pins 3 and 5 of the 6F5 may be used as soldering tags.
12Q7GT	INT/OCTAL	NO CHANGE	PIN 3 " 4 " 5	REMOVE PIN 3 REMOVE	SLIGHTLY LESS GAIN	Any connections to these tags must be removed before Brimarizing.

**6F5
12F5**

INSTRUCTIONS: Punch holes where indicated, cut away this portion and file sheets in order of appearance. This column will then form a quick reference index.

6F5
12F5

6Q7GT
12Q7GT

RATED CHARACTERISTICS		
	6F5	6Q7G/GT
Heater Voltage	6.3	6.3 volts
Heater Current	0.3	0.3 amp.
Anode Voltage	250	250 volts
Anode Current	0.9	1.1 mA
Amp. Factor	100	70
Bias Resistor	3,000	3,000 ohms

NOTE: The characteristics of types 12F5 and 12Q7GT are identical to those of types 6F5 and 6Q7G/GT respectively, except for the heater ratings, which are 12.6v., 0.15A.

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With R.F. Stage, 5-2,000 metres.

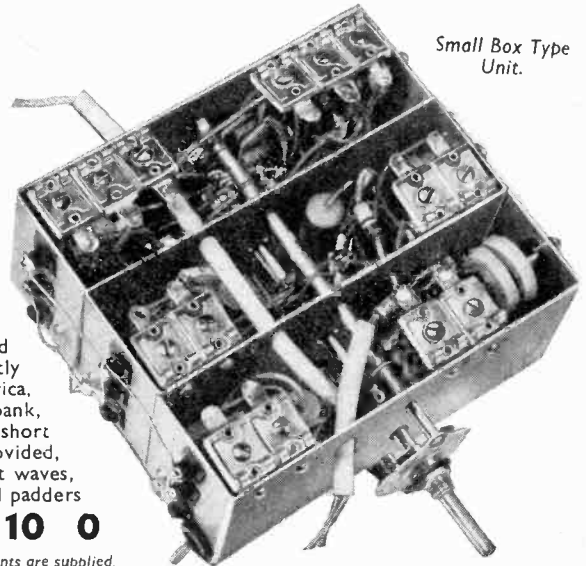
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All connecting leads are colour coded and full-size practical and theoretical blue prints are supplied.



Small Box Type Unit.

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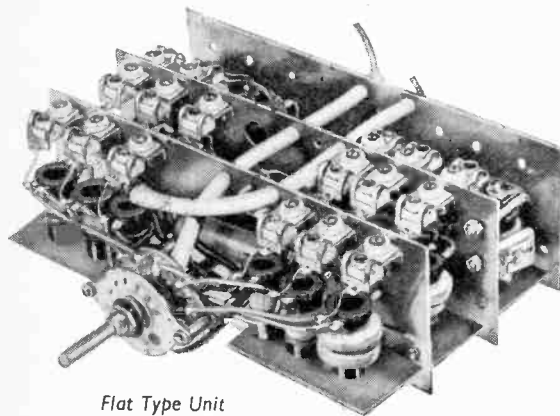
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Ignition Interference

ATENTION to the design and layout of the engine ignition system, on the lines suggested in the first part of this article, may often reduce the interference considerably, but such reduction will not in general give the degree of protection to radio services specified in the old or envisaged in the new British Standard Specification for automobile interference.

Additional suppression is, therefore, necessary. The methods in common use are complete screening, and resistors in the high-tension leads. High-frequency chokes in the leads will reduce the interference and proprietary types were marketed at one time. If they are used it is essential to incorporate a small capacitor between earth and the point of attachment of the lead to the choke. Tests made on proprietary types at frequencies up to 50 Mc/s showed them to give rather less suppression than does the average resistor. It is to be expected that they would have a frequency characteristic and probably the suppression efficiency falls off at the higher frequencies. They are not used today because they compare unfavourably with resistors in size, cost and ease of fitting.

Complete Screening.—In complete screening the coil or magneto is encased in a metal box to which is attached, by a suitable gland, the screened harness. This consists of a flexible screened cable leading to the distributor, similarly encased in a metal box, and screened leads from the distributor to the sparking plugs. The screened sparking plugs are joined to the high-tension leads by metallic glands completely enclosing the plug leads. The screened cable is bonded at frequent intervals to the engine. With coil ignition the low-tension lead to the battery is fed through a screened choke-capacitance filter.

Complete screening, if properly designed, reduces the ignition interference to a level which is too low to be measured, at least over the frequency range in which most

military equipment operates. The method has, however, serious disadvantages; the capacitive load on the system reduces the voltage output and necessitates the use of high-energy coils and magnetos; there is increased wear on the contact points and the sparking plug electrodes erode rapidly unless erosion resistors are fitted. These resistors, of the order of 1,000 ohms, serve to limit the peak discharge current—and prevent arc-

that optimum results are obtained with such resistors suitably disposed in the H.T. circuit.

It is impossible to generalize about the degree of suppression to be expected with a given combination of resistors, as this varies with the particular vehicle under test, the frequency of measurement and the way in which the resistors are fitted in the ignition circuit. However, for the frequency band up to 100 Mc/s and more particularly around the television frequencies, the following statements hold.

Concentrated resistors, for optimum efficiency, must be placed as close as possible to the source of the spark, i.e., at the actual plug and distributor terminals. For equal values of resistance the distributed type gives rather more suppression than does the concentrated one. The resistance of an individual concentrated resistor or a distributed resistance lead should not usually be less than 5,000 ohms nor need be greater than 15,000 ohms. With some engines in which the distance between coil and the distributor is very short, it may not be possible to employ a distributed resistance lead of more than 1,000-2,000 ohms.

The increase of suppression with increase of the total resistance between the H.T. terminal of the coil or magneto and the sparking plug falls off as the value approaches 25,000 ohms. E.R.A. tests have shown that between 25,000 and 100,000 ohms the increase of suppression is never more than 6 db and often is quite negligible.

The maximum suppression likely to be achieved by resistors is 40-50 db, and at any frequency in the band 200 kc/s-100 Mc/s it is possible to obtain not less than about 20 db.

The simplest arrangement for coil ignition and for magnetos with separate distributors is one resistor (or resistive lead) between the coil and distributor. With this it is possible in some cases to reduce the interference at television frequencies to below the $50\mu\text{V/m}$ level at 30ft. It is usually ineffec-

2.—Methods of Suppression

By W. NETHERCOT,
M.A., B.Sc., F.Inst.P.

(British Electrical and Allied
Industries Research Association)

ing; they do not contribute materially to the suppression of interference.

Insulation problems are more acute due to the increased stress on the H.T. cables and terminations and moisture penetration into the harness has to be prevented. The equipment is expensive and inevitably the accessibility is much reduced. These disadvantages have to be tolerated in aircraft and for military and other purposes where radio reception is of paramount importance, but they rule out the method for general adoption on ordinary vehicles.

Resistor Suppression.—This is the method which is employed in all cases where the highest degree of suppression is not required. It is simple and inexpensive, but gives good suppression over much of the frequency range. The resistors may be of the concentrated or the distributed type; in the latter the central conductor of the ignition cable has a resistance of 5,000-15,000 ohms per foot. The concentrated types are made in values of 5,000, 10,000 and 15,000 ohms, experience having shown

Ignition Interference—

tive above 80 Mc/s and may even increase the interference level.

Tests made on about 40 different vehicles showed that the addition of a 15,000-ohm concentrated resistor in the coil lead reduced the interference at 45 Mc/s by 3 to 23 db. This is a wide range, and it means that the single resistor would easily reduce the interference from some vehicles to below 50 μ V/m and on others it would have practically no effect. On most of the vehicles the reduction was between 10 and 15 db as evidenced by the mean value of 14 db.

Further suppression is obtained by inserting resistors at the sparking plugs (essential for magnetos with integral distributors) and at the distributor end of the sparking plug leads. Alternatively distributed resistance plug leads can be used. In the above series of tests the effect of adding resistance up to 15,000 ohms between the distributor and sparking plugs was to increase the suppression by anything up to 20 db.

British military vehicles which were not carrying radio equipment were suppressed so that they did not cause interference to those that were. Concentrated resistors were used, 5,000 ohms at the coil and sparking-plug terminals of the distributor and 15,000 ohms at the sparking plugs. This is the combination of concentrated resistors which is likely to give optimum results, although often the plug resistance can be reduced to 5,000 ohms and those at the sparking-plug terminals of the distributor omitted without noticeable loss in suppression efficiency.

Table I shows the suppression achieved by such a combination on two 1940 Vauxhall cars.

20 db is attainable for frequencies up to 100 Mc/s.

The efficiency of distributed resistors can be increased considerably by covering a short length of the lead at the plug end by a screen of metal foil to form a small capacitor of about 20 μ F, the foil being bonded to the cylinder block. This forms a network giving a high attenuation from the plug at high frequencies. Up to 10 db extra suppression may be obtained in this way, but as the method creates problems of cable insulation and earth termination it has so far been used only experimentally.

The use of iron wire as a resistance material for distributed resistors appears to offer some possibilities. Suppression of the order of 25 db has been obtained at television frequencies with

effective resistance at television frequencies was approximately 15,000 ohms. Such resistors might be of use in cases where engine performance is affected by the ordinary resistors as they present a low impedance to the low-frequency components of the ignition spark and so have little effect on the energy dissipated. It would be interesting to experiment with high permeability materials such as Mumetal.

The suppression efficiency of resistors at frequencies higher than 100 Mc/s was investigated in the series of tests described on page 355 of the October issue and quantitative estimates for both concentrated and distributed types were obtained over the frequency range 40-650 Mc/s. So far as the author is aware, these are the only measurements which

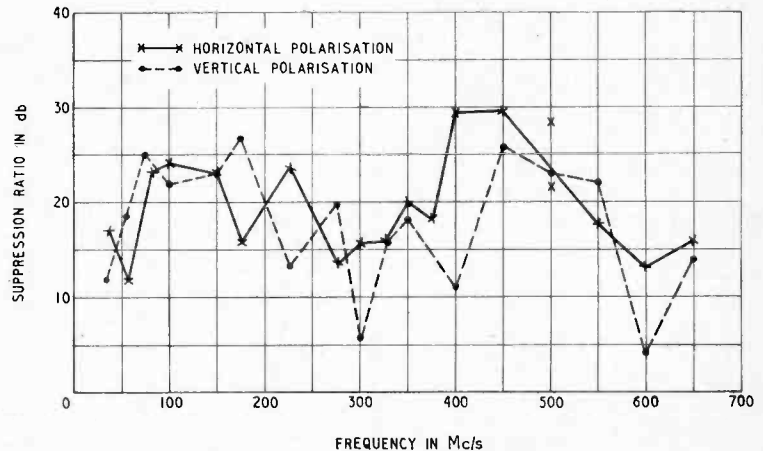


Fig. 1. Suppression efficiency of concentrated resistors on Vauxhall "14" car.

some cars fitted with distributed resistors comprising lengths of 30 S.W.G. iron wire wound in a single layer on a thin strip of in-

have been made over this frequency range.

Concentrated resistors, 5,000 ohms in the coil lead and 5,000 and 15,000 ohms at the distributor and sparking plugs respectively were tested together with a distributed resistor harness for the "14" car. This consisted of a coil lead of 1,800 ohms and sparking plug leads varying between 2,700 and 5,000 ohms.

Figs. 1 and 2 show the respective efficiencies of the concentrated and distributed resistors between 40 and 650 Mc/s for the "14" car. Fig. 3 shows the concentrated resistor results for the "12." These curves are exceed-

TABLE I

Vehicle	Suppression in db						
	30	35	40	45	50	80	100 Mc/s
Vauxhall 12	33	25	36	33	24	> 16	21
Vauxhall 14	21	27	25	27	35	23	22

This shows that the degree of suppression varies with the frequency but that a minimum of

insulating material. The D.C. resistance of these particular suppressors was 70 ohms but their

ingly peaky, part of which may be due to the difficulty of measurement. These cannot be

high frequencies are different and in some respects more serious than those at television frequencies.

trouble is experienced with the resistors themselves and electrical failures are fairly rare. The disadvantages are that it is not very easy to fit the plug type on some engines with jacketed plugs; furthermore the connections have a tendency to work loose and shorting may occur due to the exposed metal ends touching some part of the engine. With the coil lead type it is impossible to put them absolutely adjacent to the points of sparkover and so maximum efficiency may not be obtained.

In the event of general adoption of suppression for vehicles, either voluntarily by the motor manufacturers or as a result of legislation, the manufacturer will assume the responsibility of producing his vehicles suppressed to some specified level. If the suppression is obtained by resistors, then it will be maintained only for as long as the resistors are not removed, which might easily happen when servicing or replacing faulty components of the ignition system. The ideal solution is to incorporate the suppressors in the components themselves where they will be out of sight. There would be no difficulty in moulding the coil lead resistor in the distributor rotor, or resistors in the distributor terminals. The incorporation of the plug resistor in the body of the sparking plug does present difficulties due to the

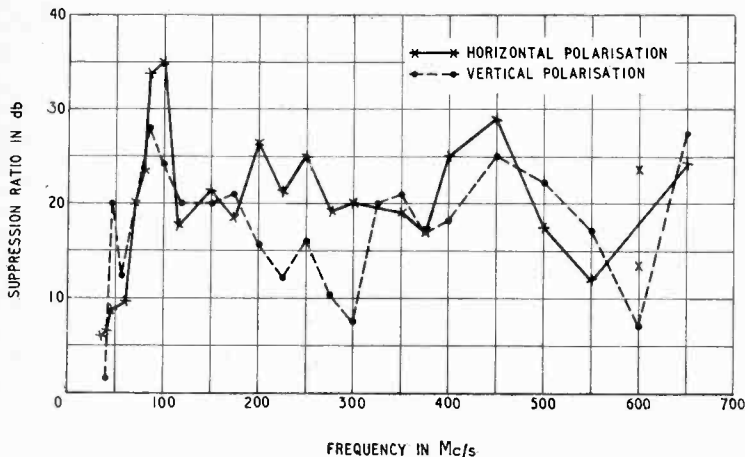


Fig. 2. Suppression ratios with distributed resistors on Vauxhall "14".

relied on to an accuracy better than 5 db and as the suppression curves were obtained by subtracting suppressed values from unsuppressed ones a maximum error of 10 db is possible. It is interesting to note, however, that there is no general falling off in suppression efficiency with increase of frequency, the average value being about 20 db.

The distributed resistors, of much lower resistance than the concentrated type, gave equally good suppression although the crests and troughs on the suppression frequency curves do not coincide. This could be due to the fact that the distributed suppressors are more efficient; on the other hand it might have been found that concentrated resistors, equal in resistance to the distributed, would have given equally good results.

It will be seen that the suppression efficiency is extremely low at frequencies around 300 Mc/s and 600 Mc/s, so low in fact that the measurements were repeated, but with the same results. In the region of 300 Mc/s the lengths of the H.T. leads or at least some of the longer ones, are approaching the half wavelength and so the possibility of standing waves on them has to be envisaged. If this be so it means that the problems of ignition interference suppression at very

Design of Resistor Suppressors.

In commercial types of concentrated suppressors the resistor element is enclosed within a sleeve of insulating material; the terminations for those intended for insertion in the coil lead or at the distributor ends of the plug leads consist of wood screw threads attached to each end of the resistor. Ignition cable is screwed into each end of the resistor, but with resistors intended for attachment to the sparking plugs one

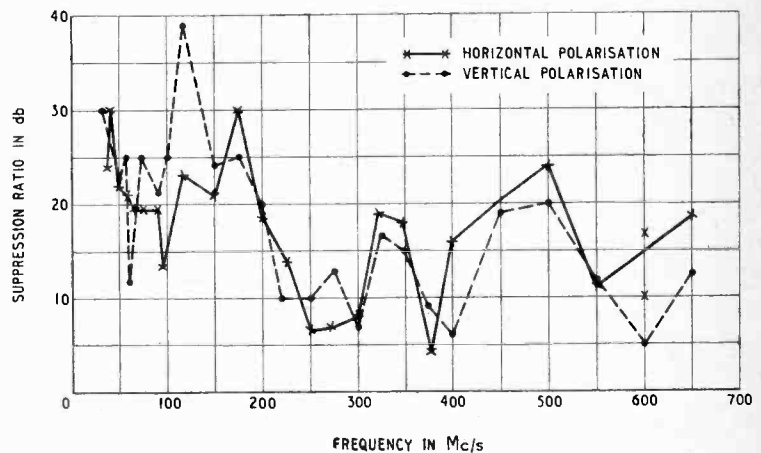


Fig. 3. Effect of concentrated resistors on interference from Vauxhall "12".

end at least has some form of spade or screw-type terminal for connection to the plug. Little

elevated working temperature (about 250°C). It is possible to incorporate erosion resistors of not

Ignition Interference—

more than 1,000 ohms satisfactorily, but it is not so easy to increase this to the 5,000-15,000-ohm value needed for suppression. It would seem that further research on this point is called for. Distributed resistance cable in its commercial form is a comparatively recent innovation. It consists of a central conducting core of graphited silk covered with a sheath of rubber.

Conducting rubber cable has been made but it is unsatisfactory on account of the variability of its resistance, which is very dependant on mechanical stress. It is also difficult to make the ohms-per-foot low enough and to make satisfactory terminations.

The earlier forms of the graphited silk cable were unsatisfactory for the same reasons, but under the stimulus of the Fighting Vehicles Design and Development Department of the Ministry of Supply, a satisfactory form of cable was evolved. The method of termination used consists of cutting back the rubber sheath by about an inch and crimping the silk core to a single or multistrand copper wire of appropriate size. The whole termination is then moulded in rubber, with the result that the cable end is completely sealed from the atmosphere and the mechanical stress is taken by the moulding and not by the silk core/copper wire joint.

This construction has proved eminently satisfactory for military purposes but it is hardly suitable for general civilian use. The leads are relatively expensive and the replacement problem is difficult as each lead is made, so to speak, to measure. Furthermore, the length of the moulding is such that on many vehicles, in which the coil-distributor distance is short, the actual length and, therefore, the resistance of the resistive part of the lead would be much too low unless cable with a higher ohms-per-foot were available. This means duplication of cable types which is undesirable.

What is wanted is a cheap and simple termination comparable in its ease of fitting with those used on normal ignition cable. If this difficulty can be overcome then the resistance cable becomes an

attractive alternative to the concentrated resistor.

Effect on Engine Performance.

—It was widely held at one time that the use of resistance suppressors on engines had detrimental effects on performance, e.g., that it may cause difficult starting from cold, poor slow running, bad acceleration and running at high speeds. Much of this was prejudice, and now the general opinion seems to be that on most popular types of engines there is no adverse effect, even with resistors considerably greater than those needed for suppression purposes.

In 1939 the Automobile Research Association carried out tests on behalf of the Society of Motor Manufacturers and Traders on a number of engines and vehicles of widely different types using resistors from 5,000 to 500,000 ohms.⁷ The conclusions were that there was no effect at moderate or high speed or under appreciable load and that side-valve engines in general were insensitive to the effect of suppressors. Some overhead-valve engines were affected by suppressors at the lower speeds, the maximum loss of power being 9 per cent. Generally the loss was much smaller than this. The effect was found to be due to insufficient turbulence and could be remedied by the fitting of shrouded inlet valves. Factors such as mixture strength, ignition advance, sparking plug gap, leaky plugs and spark energy were found only to have an effect if the predisposing condition of insufficient turbulence was present, and even then their effect was small. Additional evidence in confirmation of these conclusions is provided by long experience with army vehicles. Some of the manufacturers of popular low- and medium-power vehicles report similar results; on the other hand there is evidence that the performance of certain of the more expensive, high-powered vehicles is quite noticeably affected by resistors, even by those of low value. A detailed discussion on the reasons why resistance in the ignition circuit affects engine performance is outside the scope of this paper; furthermore, the quantitative evidence is not as extensive as one would wish. It would appear,

however, that little or no trouble is to be expected in fitting resistors to the popular type low- and medium-power vehicle, but that difficulties may arise with some expensive, high-powered types.

Acknowledgment. — The measurements at frequencies above 100 Mc/s were made possible by the collaboration of the Radio Division of the National Physical Laboratory to whom acknowledgment is due; and in particular to Messrs. B. G. Pressey and G. E. Ashwell.

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Radiolympressions

IT is far too late to say anything about Radiolympia but it is none too early to start thinking about the next show and what we should like to see there. As I cannot do that without some reference to the last show I have got to refer to it whether you like it or not.

Since one of the main objects of the show was to encourage the export trade, I entered it with the eye of the export buyer. My first impression was distinctly painful as I had the misfortune to sit down rather suddenly and heavily on that portion of my anatomy intended for that purpose. The cause of the trouble was apparently a banana-skin deposited by one of the many children one saw being reluctantly dragged around the show by interested parents.

In addition to this, however, I received a very painful mental impression in my self-appointed rôle of foreign visitor and buyer when I glanced aloft at the gaunt girders of Olympia unadorned by their usual array of bunting and gaily painted panels. I do not in the least blame the organizers of the exhibition as they doubtless had neither bunting nor labour with which to put it up. But all the same, if you are hoping to sell goods to a customer it does pay to dress well and put on a million-dollar look even if you have no shirt under your Palm Beach suit. Any commercial traveller of repute will bear me out in this.

If labour and materials are still short when the next show is held, then most of us, I feel sure, would be willing to lend the yards and yards of bunting, etc., which we hang out from time to time to celebrate the end of a war to end war and such like things. As for labour, well, I cannot help recollecting my early days before the mast in a whaler and feel sure that there are many more like me, as well as a good sprinkling of yachtsmen among us wireless men, who would be only too pleased to do the job gratis and waive all our rights under the Workman's Compensation Act.

Unbiased

With the exhibits I had no fault to find at all, but in the case of one or two of the exhibitors—and I would emphasize that it *was* only one or two—courtesy seemed to be in as short supply as their goods so far as the home market was concerned. In fact, in the case of one of them, it was only when I had gone round the corner and bashed my bowler into the semblance of a sombrero and adopted a lisping Castilian accent that I could get any attention. I concluded it was, even then, only because the young man on the stand was interested in bull-fights, of which I was fortunately able to give him a first-hand description. It is only fair to say, however, that at most of the stands I got all the information and help I wanted, no matter whether I spoke with a Castilian lisp or the idiom of sele Suffolk, so often debased by the ignorant into silly Suffolk.

Lastly, I definitely did not like the "Klystron-effect" manner in which we were bunched into Television Avenue from time to time and then ejected in gulps or waves after the principle of that famous tube. Moreover, the period between admission and emission was too short to give viewers the opportunity of making comparisons.

Lacteal Lessons

I WAS intensely interested to read in the *Radio Times* some time ago (Oct. 10th) a letter from a farmer in which he claimed (I presume that it was "he") that his cows gave their highest yield of milk when listening to chamber music broadcast by the B.B.C. whereas certain other types of programme, such as swing, made them



Kicking the bucket.

inclined to kick the bucket in a literal sense.

I am particularly interested in the matter since I have lately been

studying the effects of broadcast music on national output. These bovine statistics accord with my findings regarding humans, which is only to be expected as the cow is far more akin to us than Darwinian apes and monkeys. In infancy do we not fall back on the cow's output as our iron ration? There have, of course, been one or two notable exceptions to this rule, such as Romulus, Remus and Kipling's Mowgli.

As a result of my studies I am not in the least surprised to find that the cows' output is greater under the influence of chamber music. This is exactly what I should have predicted, for my colleague, a professor of industrial psychology, has

By FREE GRID

proved to me clearly that had this type of music been provided by the B.B.C. in their wartime music-while-you-work broadcasts, then it is not at all improbable that the war would have been over in half the time owing to the enormously increased tempo of munitions production. In fact, output might have risen to such proportions as to have enabled us to finish the war without outside help.

Music of the "step lively" kind which was actually broadcast tended to produce exactly the opposite effect to that desired. The workers, instead of getting on with the job, became interested in the music, whereas, had chamber music been provided they would have pressed on with their work with all speed, if only to finish the job and get away as quickly as possible.

The great thing, of course, is to get the Government to profit by the lessons to be learned from my researches and apply them to the present economic crisis. They should instruct the B.B.C. to make an immediate start in the urgent task of pumping out chamber music to the factories, thus enabling us to save both our bacon and our basic. I am, however, having tremendous difficulty in finding the correct Government department to approach. I have been referred from one to the other until I have completed the cycle and am well on in the second lap. But I have not yet lost hope of eventually getting a select committee to sit on this idea.

Sidebands Again

Why a Modulated Wave Must Have More Than One Frequency

By "CATHODE RAY"

IN "Channels of Communication" I referred to the old controversy about the physical reality of sidebands. If letters I have received are anything to go by, it seems that this controversy still rages, if not openly, then at least in the minds of some readers. The cause of the trouble, you remember, is the statement that it is impossible to modulate a carrier wave without producing waves of other frequencies. In particular, one cannot vary its amplitude without producing other frequencies.

It seems that many people are prepared to take the word of the wise that this is so, but just can't see it themselves. Others are frankly sceptical. They say "Fig. 1 depicts a portion of unmodulated carrier wave of a certain frequency; what is to prevent one from varying the amplitude as in Fig. 2, and so conveying information without affecting the frequency at all? This is *amplitude* modulation we are talking about; not frequency modulation!" Or they may show Fig. 3, in which the carrier wave is keyed to convey morse signals. Its cycles are obviously identical with those in the modulated carrier, and therefore of the same



Fig. 1. The familiar graphical representation of a pure unmodulated carrier wave.

frequency. Why drag in sidebands, which seem to be an entirely unnecessary and unreal complication?

They may also offer experimental evidence, saying that even when their receiver is tuned sharply to one frequency it can still receive morse.

* *Wireless World*, June and July, 1947.

To dispose of the last point first; it must be understood that hand-keyed or even machine-keyed morse represents quite a low frequency of modulation, so it is difficult to make a receiver selective enough to demonstrate loss of morse modulation due to loss of sidebands. But it can be done.

Although the sceptics can hardly deny that high modulation frequencies are lost when the receiver is made very selective, they reply that the sort of modulation used, say for broadcasting, no doubt does cause sidebands.

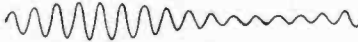


Fig. 2. Simplest amplitude modulation of Fig. 1, in which the modulating waveform itself is a pure sine of lower frequency.

which can be tuned out, but that just proves that it cannot really be pure amplitude modulation; see Figs. 1-3 again, etc.

What we have to find, then, is some convincing way of showing that you cannot do things like Fig. 2 or Fig. 3 on one frequency.

The usual book method is to add together waves of two or three different frequencies, which yield something like Fig. 2, and to say that therefore Fig. 2 must consist of waves of these different frequencies. If two parts of hydrogen combined with one part of oxygen are found to be water, then it is reasonable to suppose that water consists of two parts of hydrogen combined with one part of oxygen. Or isn't it? This back-to-front sort of proof doesn't seem to satisfy everybody.

Then there is the mathematical approach. This may have to be made very circumspectly, like a banker's approach to a communist. I shall try to render it a little less abstract than usual. But we are arguing about frequency, and so even the sceptics

must know what frequency means, although it is quite an abstract idea. One thing that surely must be granted is that in a pure



Fig. 3. Sample of carrier wave interrupted by morse keying. Here the carrier cycles that remain are identical with those in Fig. 1, so where do side frequencies come in?

wave train (that is, one having only a single frequency) every cycle occupies exactly the same time. The only other requirement is that every cycle must have a sine shape (that includes the cosine, of course, because it has exactly the same shape). Probably nearly everybody will grant that, too, but in case there is any hesitation it may be as well to offer some reason for preferring one particular shape to all others.

As Fourier pointed out, a repeating wave of any other shape can be analyzed into a combination of sine waves whose frequencies are exact multiples. But a sine wave itself cannot be broken up into any simpler form. This is not just a mathematical fancy. If an oscillation is of sine waveform it can be tuned in at only one frequency, whereas if the oscilloscope shows it to have any other shape, then the component frequencies calculated by Fourier analysis can be detected. They actually exist.

Another significant fact is that the natural way for things to oscillate, either electrically or mechanically, when complicating effects are absent, is according to a sine law. That is proved mathematically and confirmed by experiment.

There is one important condition in the second requirement

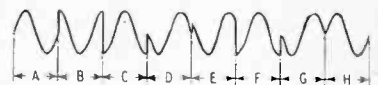


Fig. 4. Each of the equal time intervals is occupied by a single pure sine wave. But the wave train as a whole is not exactly sinusoidal!

for singleness of frequency; the sine shape must hold for every cycle, no matter what part of the cycle one takes as the starting point. In Fig. 4 each of the equal time intervals A, B, C, D, etc., contains one cycle, and each has a sine shape, but I hope you will agree that the wave train as a whole cannot be called sinusoidal! It is certainly not a natural mode of oscillation, and in practice would not be found to be entirely free from harmonics.

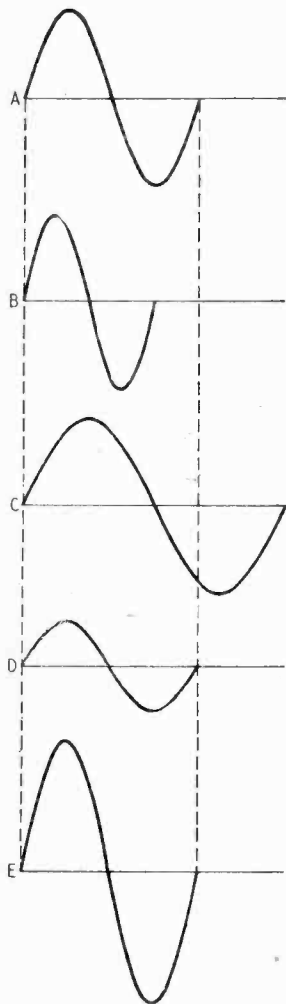


Fig. 5. A-E are all pure sine waves, and are assumed to repeat exactly and continuously. That being so, A, D, and E are equal in frequency though different in amplitude. B and C, though equal to A in amplitude, differ in frequency.

To deal with this simply, look at Fig. 5. A is a single sine-wave cycle; a sample from a continuous succession. If it is compressed or expanded along the time axis, as at B or C, then obviously the frequency is altered. If it is expanded or contracted along the amplitude axis only, strictly to

scale, as at D or E, then it is still a sine wave of the same frequency.

"Ha!" say the sceptics, "That is just our point! All you do in true amplitude modulation is to expand and contract the amplitude without altering the shape or the duration of any cycle, and the result, as you have just admitted, is a pure single-frequency wave train."

But is it? Look at Fig. 6, where two adjacent cycles of different amplitude are shown. Reckoning one whole cycle from either *a* or *c*, each has an immaculate sine shape. But what about reckoning from *b*? The unequal half-cycles and the nasty join between disqualify that cycle completely. So any wave train of which Fig. 6 forms any part fails to meet the requirements for a single frequency. It is no good saying that the two cycles in Fig. 6 are too different in amplitude, and that you can draw an amplitude-modulated train that doesn't show any faulty joints. The fact that the faults are too small to be seen by the eye does not mean that they are not there, or even that they are negligible in radio communication. Nor is it any good rounding off the sharp angles with a pencil, because that destroys the purity of waveform.

What we have shown, then, is that it is *not* possible to vary or modulate the amplitude of a carrier wave without spoiling the pure waveform of the whole; and by every test—mathematical, graphical, and experimental—departure from sine waveform is found to introduce new frequencies.

Bringing the mathematical approach to bear more directly: if the graph of a voltage *v* varies with time *t* according to the equation

$$v = V_0 \sin 2\pi ft,$$

then it is a pure unmodulated wave of peak value V_0 and frequency *f*. If you assume any constant values of V_0 and *f*, you can make a table, writing down as many different values of *t* as pos-

sible and calculating from a table of sines² the corresponding values of *v*; when these pairs of *v* and *t* are plotted as a graph the result is a continuous pure unmodulated

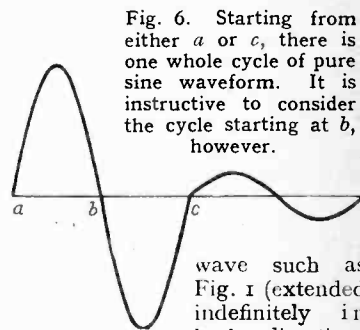


Fig. 6. Starting from either *a* or *c*, there is one whole cycle of pure sine waveform. It is instructive to consider the cycle starting at *b*, however.

wave such as Fig. 1 (extended indefinitely in both directions of time). If you plot cosines instead of sines, the result is the same except that it is a quarter of a cycle nearer along the time axis. You can complicate matters by adding together as many sine and cosine waves as you like, with as many different amplitudes and phases as you like, but so long as only one *f* is used for them all the result is invariably a pure unmodulated wave train. You cannot possibly obtain a graph like Fig. 2—still less Fig. 3—from an equation in which there is only one *f*.

But if you draw the graph of an equation in which *v* equals $V_0 \sin 2\pi ft$ plus equal-amplitude sines of two other frequencies equally above and below *f*, the result is Fig. 2—the simplest case of amplitude modulation. Perhaps it is because this is such a tedious job to do, and the drawing has to be done so accurately, that probably not many students have actually taken the trouble. If everybody who is still not happy about side frequencies would draw this graph, it might put an end to much of the uncertainty. It can be done either by drawing three pure sine wave graphs one above the other, the frequencies of the second and third being higher and lower than that of the first by an equal amount, and then adding them all together vertically to make a fourth, which comes out like Fig. 2. Or they can be added together numerically to give the data from which the final graph is drawn.

² If the table is made out in degrees (instead of radians), substitute 360 for 2π in the equation.

Sidebands Again—

by using a table of sines to evaluate the equation—

$$v = V_1 \sin 2\pi ft + V_2 \sin 2\pi(f + f_m)t + V_2 \sin 2\pi(f - f_m)t$$

You can use any numbers you like for V_1 , V_2 , f and f_m , so long

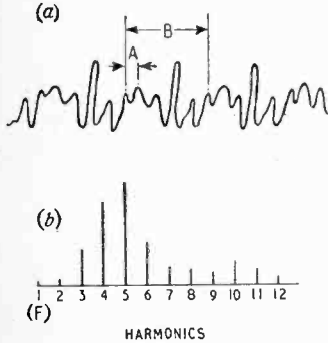


Fig. 7. In the waveform generated by an oboe (a) the fundamental cycle is not A, as might be supposed, but B. This appearance is because the fundamental amplitude (b) is nearly zero. Similarly in modulated waves the carrier frequency is not the fundamental, but a high harmonic, and the side frequencies are other harmonics.

as V_2 is not more than half V_1 . You will see why later; f_m , the modulating frequency, is, of course, normally much less than f , the carrier-wave frequency.

I hope that Fig. 6 has disposed of the fallacy that it is possible to modulate the amplitude of a sine-wave train without spoiling the purity of waveform and thereby introducing other frequencies. But while you may now see that there must be a slight (even if visually imperceptible) distortion of the cycles in order to make their amplitude vary as in Fig. 2, you may quote Fourier against me by pointing out that, according to him a distorted waveform can be analyzed into a fundamental and harmonics. Now the frequencies of harmonics are, of course, exact multiples of the fundamental frequency. Supposing Fig. 2 is the result of adding together pure sine waves whose frequencies are, say, 100, 94, and 106, it consists of these and no others. The harmonics of the carrier frequency, however, are 200, 300, 400, etc.; certainly not 94 or 106. So what price Fourier?

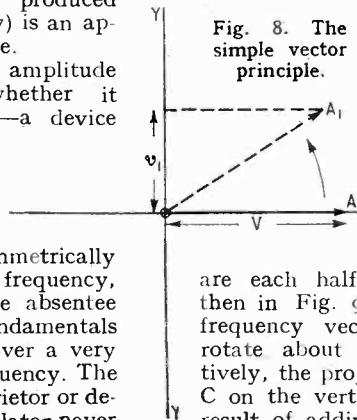
The answer to that one is the definition of frequency, namely, the rate at which a periodic wave repeats. If a 100-kc/s carrier wave is modulated at 6 kc/s, each successive cycle is slightly different, and one has to wait for 300 cycles of the 100 kc/s to be shown in order to see the programme round to where we came in. (300 is the lowest common multiple of 6 and 100.) By that time the carrier and modulating waves are in the same relative phase as at the beginning, and the whole thing repeats. Therefore, the fundamental frequency is $\frac{1}{3}$ kc/s, and the three component frequencies in the modulated wave, 94, 100 and 106 kc/s, are respectively the 282nd, 300th and 318th harmonics. So everything is fully according to Fourier after all. A waveform consisting of harmonics without the fundamental is, in fact, of the Fig. 2 type. The sound waveform produced by an oboe (Fig. 7) is an approximate example.

So a typical amplitude modulator is—whether it knows it or not—a device for producing a combination of very high harmonics, all of which are grouped symmetrically around one fixed frequency, even although the absentee fundamental or fundamentals may be varying over a very wide range of frequency. The fact that the proprietor or designer of the modulator never really intended to achieve this curious result, and may even deny that it happens that way, doesn't make any difference to it. Actions that appear to be quite simple (such as varying the amplitude of a constant-frequency oscillation) often have unforeseen but inevitable results. The motives of an eater are generally much less complicated than the processes which subsequently go on inside him.

In common parlance one would say that in Fig. 2 there were 16 cycles, but, strictly speaking, every cycle of a periodic waveform must be exactly the same as every other, or frequency has no meaning. Remembering this, the fallacy of the "single-frequency modulated wave" cannot arise.

One can usually grasp difficult ideas more effectively by visualizing them in a number of different ways. There is a much neater way of demonstrating the multiple-frequency composition of a modulated carrier than by plotting the graphs, yet it seems to be much less used. It comes direct from the basic idea of vectors, shown in Fig. 8, where OA is a line representing by its length, V , the peak voltage (or whatnot) of the continuous oscillation, and its number of revs per second around O represents the frequency. The instantaneous voltage is then represented by the projection of OA on the vertical axis, YY'. At the moment shown by the full line it is zero, of course; but, as OA rotates, its projection oscillates up and down about O sinusoidally. In the dotted position OA_1 , the voltage is v_1 .

Fig. 8. The simple vector principle.



Assuming now that a pair of side frequencies is added, the vectors representing them must rotate respectively a little slower and a little faster than the carrier-wave vector OA. Supposing they are each half as long as OA, then in Fig. 9, where the side-frequency vectors AB and BC rotate about A and B respectively, the projection of the point C on the vertical axis gives the result of adding the three wave trains.

Well, of course, the task of trying to visualize the movements of the point C—to say nothing of its projection on YY'—with a mechanism consisting of three pivoted links all rotating at different speeds, is not one that I would wilfully inflict on readers. The difficulty can be removed by imagining oneself to be on vector OA, so that relatively it is stationary. Then, relative to OA and to oneself, AB is rotating in one direction at modulation frequency, and BC in the opposite direction at the same frequency. And now it is quite easy to see that C oscillates between its present position and O, as shown in Fig. 10, where it is performing one complete cycle at modulation

frequency. So the combination of a carrier-wave vector of fixed length and these two side-frequency vectors is equivalent to an amplitude-modulated carrier-wave vector. Bearing that in mind, we can now get off OA, so as to see that it is rotating at carrier-wave frequency, and we realize that the whole outfit represents a 100-per cent amplitude-modulated oscillation. Smaller depths of modulation are represented by shortening AB and BC.

Second Sideband Function

So the purpose of the second sideband is now quite clear, it is to balance out what would otherwise be a certain amount of phase modulation. Note, in Fig. 10, how the phase of OB varies relative to OA. And whereas the length of OC, representing the modulated carrier amplitude, can easily be shown to vary sinusoidally about A, the variation in length of OB is non-sinusoidal. The difference is not very serious if AB is small, but becomes more and more marked as single-sideband modulation approaches 100 per cent. So if one sideband is removed, as happens during certain types of fading, there is distortion.

It might look as if such distortion would be a drawback in the single-sideband system of communication, which economizes in transmitter power by omitting the carrier wave and one sideband. But as a carrier wave has in any case to be supplied locally at the receiving end in order to render the signals intelligible, it is quite easy to supply so much of it that the depth of modulation is always very small. Suppressed-carrier communication

does not prove that the ingredient is unnecessary. It can be left out temporarily because water and unmodulated carrier waves are the same on both sides of the

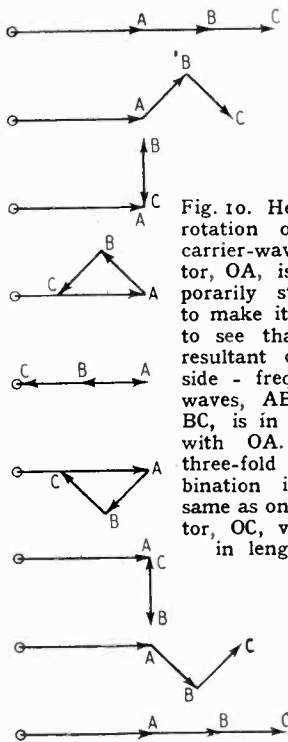


Fig. 10. Here the rotation of the carrier-wave vector, OA, is temporarily stopped to make it easier to see that the resultant of the side-frequency waves, AB and BC, is in phase with OA. The three-fold combination is the same as one vector, OC, varying in length.

Atlantic, and readily obtainable almost anywhere, so the original product can easily be reconstituted at the receiving end. Water alone contains no nourishment, and an unmodulated carrier wave no information. But they are needed to make the nourishment or information fit for reception.

What about Fig. 3? So far we have been considering the simplest case of a amplitude modulation, with only one modulating frequency. Each "cycle" in Fig. 3 is admittedly a sine wave, so it may not be easy to see why merely stopping and starting a succession of them introduces other frequencies. But it is possible to discover a combination of continuous waves of different frequencies which, added together, give a keyed carrier wave like Fig. 3, whereas it is quite impos-

sible to arrive at Fig. 3 or anything remotely like it by adding together any number of continuous waves of the same frequency. In practice there is bound to be some rounding-off of the starts and stops, or an infinite number of side frequencies would be necessary. The neighbours of amateur transmitters sometimes observe that excessively abrupt keying causes a very wide range of frequencies to be radiated.

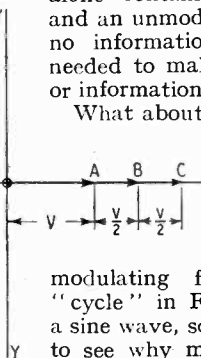
This is another example of the inexorable laws of nature. They always win against anyone who calls a process "amplitude modulation" and tries to ignore the fact that it is also sideband production. To insist that there is only one frequency in a Fig. 3 type of wave, and that therefore there is no limit to the selectivity of the receiver that could be used, is defeated by practical test. For although the connection with the mathematical theory of sidebands may not be obvious, tuning circuits that are made more and more selective do in fact show an increasing sluggishness and inability to respond to stops and starts in the signal wave, and the extent of this agrees exactly with the sideband calculations. Sluggishness in response, and tuning-out of sidebands, may seem to be two quite different things; but they are just two different ways of looking at exactly the same thing. Nothing can be done about the sluggishness except widen the tuning to the extent that mathematics indicates to be necessary to include the sidebands of the desired signal. In television, where stops and starts have to be very sudden, that means a considerable wideness.

"QUALITY" AMPLIFIERS

A BOOKLET "Amplifiers for High Quality Sound Reproduction" is obtainable from the General Electric Co., Magnet House, Kingsway, London, W.C.2. The information it contains is based on the articles by D. T. N. Williamson in our April and May issues. It also includes a design for an amplifier with PX4 output valves and a two-stage pre-amplifier with tone correction, suitable for gramophone pickups. A simplified alternative bias circuit is given for the 15-watt amplifier using KT66 valves as triodes.

Fig. 9. A simple amplitude-modulated wave is represented by the addition of three vectors, all rotating at different rates to represent the component frequencies. This is difficult to visualize all at once, but see Fig. 10.

cation is very much like the dried egg trade; for economy in transmission one ingredient is removed at the sending end. This



Quality Design for a Nine-valve Receiver Superheterodyne

THE receiver described in this article is the result of a series of experiments spread over a period of several weeks. Their object was the development of a moderately priced quality receiver which, while possessing all the features of a modern design, did not contain "gadgets" and was simple to construct. The circuit which finally appeared to satisfy all the conditions proved quite conventional and the components used are types in plentiful supply (with the possible exception of

in a phase-splitting circuit, its outputs being passed directly to a pair of power triodes operating in Class A push-pull. The "magic eye" tuning indicator is fed from the A.G.C. diode in the ordinary manner through R_{28} .

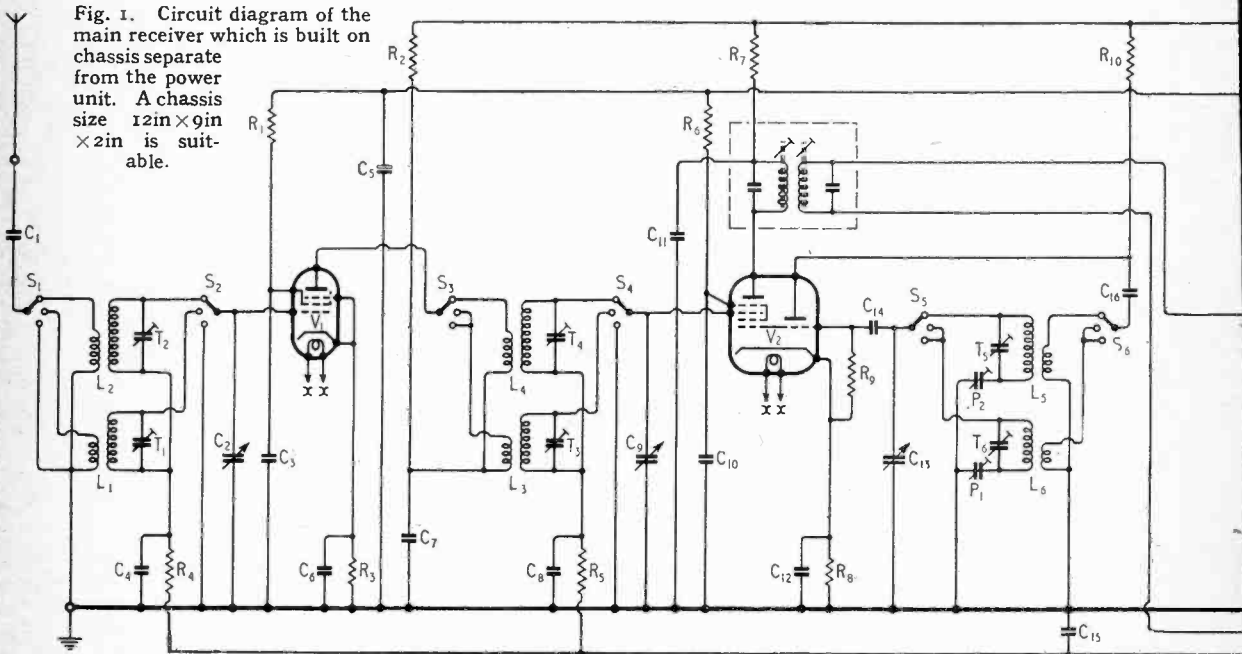
By S. A. KNIGHT

The use of the superheterodyne principle in a "quality" receiver may cause some misgiving, in view of the high degree of selectivity normally associated with

interfere too seriously in one another's business.

The receiver is designed only for the medium and long wavebands, since in the writer's opinion the programmes of the B.B.C. and a few of the near Continental stations provide sufficient entertainment. For the enthusiastic S.W. listener there is, of course, the communications receiver, but that is certainly not our concern at the moment.

As already pointed out, the



the output triodes, of which more will be said later).

On examination of the circuit of Fig. 1, it will be seen that the receiver consists of a conventional superheterodyne as far as the detector V_4 —that is, radio-frequency amplifier, triode-hexode (frequency changer, I.F. amplifier and double-diode-triode for detection, A.G.C. and A.F. amplification. After this a medium impedance triode ($6C_5$) is used

this type of receiver. In the present case, however, the selectivity is not sufficiently high to interfere seriously with the quality of the output, but it should not be thought that this results in interference. In actual fact a happy medium has been struck in the design of the apparatus, and selectivity and quality—the cats and dogs of the wireless world—seem to have settled down to an amicable agreement not to inter-

circuit is a fairly conventional one. The aerial input is applied through C_1 and S_1 to the primary windings of the aerial coils, where it is applied to the main grid windings, tuned by the first capacitor gang C_2 , by inductive coupling. A.G.C. is applied through the tuned windings to the grid of the R.F. amplifier, the lower ends of the coils being returned to chassis, from the point of view of R.F. through C_4 .

R_3 provides a standing bias on approximately 4 volts on the valve grid, and the screen is supplied through R_1 from the main screen-voltage line. The output of the stage is applied to the grid of the mixer through a further tuned circuit (second gang C_9), and A.G.C. voltage is again applied to the stage through the coil secondary windings. A standing bias of about 2.5 volts is developed across R_8 for the hexode section of the frequency changer, the screen being supplied through R_6 .

The oscillator section of this stage consists of the long- and medium-wave oscillator coils L_5 and L_6 respectively, switch banks S_5 and S_6 , and the third tuning gang C_{13} . The oscillator is of the tuned-grid variety, back-coupled from the anode through C_{16} and

tude is sufficiently well maintained over the wave ranges to avoid the need for including series or parallel damping resistances on the coils.

It will have been noted, no doubt, in considering these two stages that the wavechange switch is of the three-position variety. This is incorporated to enable the receiver to operate as a radio-gramophone, the third switch position being used for this purpose. The actual switch consists of a three-bank unit of the Yaxley or Oak type, each bank being three-pole, three position. S_1 and S_2 are located on the first bank, S_3 and S_4 on the second, and S_5 , S_6 and S_7 on the third. In the case of the former two banks the additional pole is not used. The circuit diagram is drawn so that the set is switched to LONG

first two stages on gramophone and there are no voltage changes on the receiver H.T. line. This may seem uneconomical at first sight, but the current drawn by the R.F. and I.F. stages is very small in comparison with the A.F. end of the set and there is little object in switching out the former when the apparatus is being used on gramophone. S_7 , located before the detector, automatically switches the pick-up into circuit when the switch is set to the third position.

The intermediate - frequency signal appears at the anode of the frequency-changer and is applied to the first I.F. transformer, this being of the permeability-tuned variety with fixed-tuning capacitors contained within the can. This type of transformer was chosen on account of the high

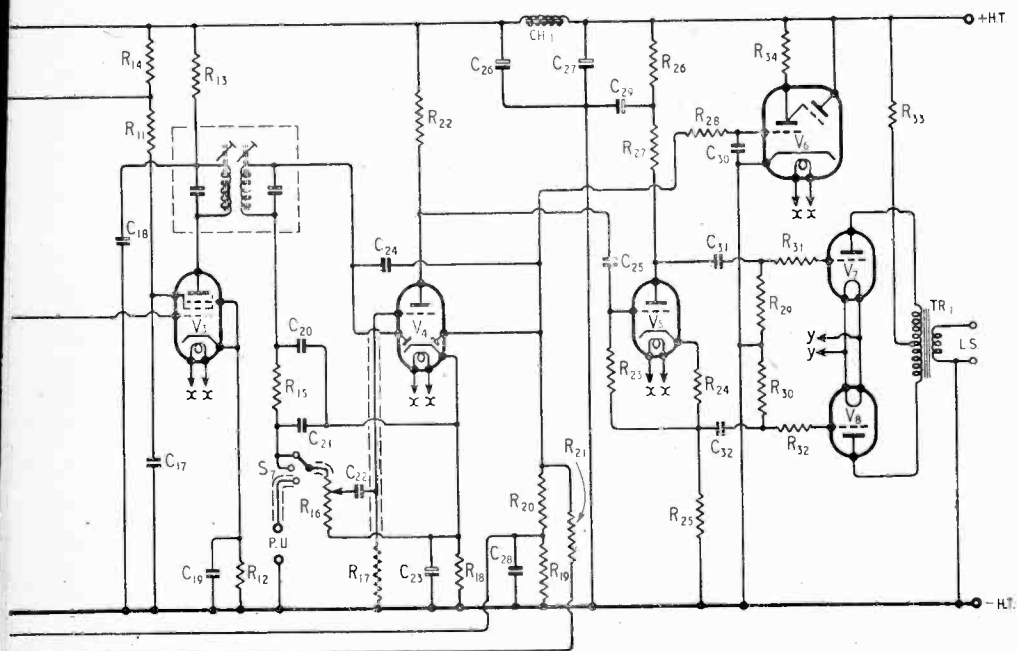
degree of tuning stability normally found with dust-iron cores for the adjusting elements. This is important in fixed tuned circuits, such as I.F. transformers, where the bulk of the receiver amplification is being carried out. The anode circuit is decoupled in the normal manner by R_7 and C_{11} , R_7 also serving to drop the H.T. to the required value of 250 volts. The I.F. amplifier valve is a variable- μ pentode, cathode-bias being obtained across R_{12} (4 volts), and the

screen voltage via R_{11} . A.G.C. voltage is obtained through the secondary winding of the I.F. transformer.

The second I.F. transformer is similar to the first, and the anode circuit of V_3 is decoupled in this case by R_{13} and C_{18} . The output of the secondary tuned winding is applied directly to the signal diode of V_4 , and also through C_{24} to the A.G.C. diode of the same valve. R_{15} , C_{20} and

the coil primaries, and the grid capacitor and leak are respectively C_{14} and R_9 . The medium-wave padding capacitor P_1 and the long-wave padding capacitor P_2 are connected at the dead ends of the coil secondaries to avoid an increase in circuit minimum capacitance and also to ensure that their moving plates are at chassis potential. R_{10} is the anode load of the oscillator, and maintains the anode at about 105 volts. The oscillation ampli-

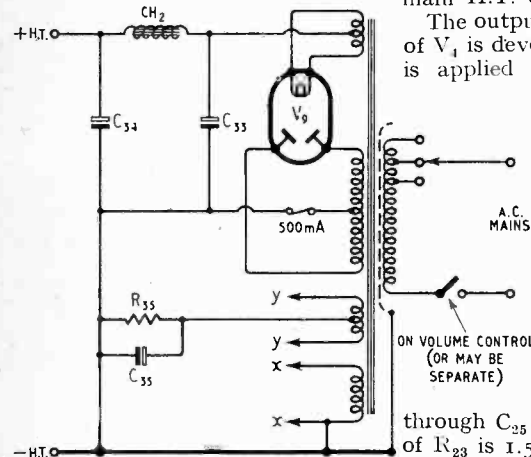
waves, the central position being MEDIUM waves, with the third position as GRAM. In this third position it should be noted that the aerial and signal grids of the R.F. and mixer valves are earthed, but that the anode of the former valve and the oscillator circuit connections are still virtually switched as for the medium waveband. This is arranged so that no changes occur in the normal operating conditions of the



Quality Superheterodyne—

C_{21} form an I.F. filter circuit, and the diode load proper, consisting of the receiver volume control R_{16} , completes the signal-diode circuit back to the valve cathode. A part of the A.F. voltage available across R_{18} is tapped off by the slider of the control and applied through C_{22} and R_{17} to the grid of the triode section of the valve, where normal A.F. amplification takes place. R_{17} has a value of 2 M Ω so that the shunting effect on R_{16} is small.

The value of C_{24} , the A.G.C. coupling capacitor is quite small (30 pF) since a larger value makes it difficult to peak the secondary of the I.F. transformer due to the damping of the tuned circuit. The A.G.C. diode load consists of R_{19} and R_{20} in series, a total value of 1.47 M Ω , and full A.G.C. is applied via R_{21} , R_4 and R_5 to the R.F. and F.C. control grids, C_{15} providing decoupling. About two-thirds of the total A.G.C. voltage available (that developed across R_{19}) is applied to the I.F. amplifier through the I.F. transformer and reduces the possibility of harmonic distortion arising in this stage. Since the diode load is returned to chassis, a small delay voltage equal to that developed across R_{18} is present upon the A.G.C. diode and A.G.C. is, therefore, inoperative on very



weak signals. The voltage across R_{18} , which is about 1.3 volts, is also bias for the valve triode section since the leak R_{17} is returned to chassis. It is by-passed

COMPONENT VALUES	
$C_1 = 500$ pF.	$R_{15} = 91$ k Ω
$C_2, C_9, C_{13} = 3$ ganged 500 pF tuning.	$R_{16} = 0.5$ M Ω ; Vol. control (with switch)
$C_3, C_4, C_6, C_7, C_8, C_{10}, C_{11}, C_{12}, C_{17}, C_{18}, C_{19}, C_{31}, C_{32} = 0.1$ μ F.	$R_{17} = 2$ M Ω
$C_5 = 4$ μ F.	$R_{18} = 4$ k Ω
$C_{14} = 50$ pF.	$R_{19}, R_{34} = 1$ M Ω
$C_{15}, C_{28}, C_{30} = 0.05$ μ F.	$R_{20}, R_{21} = 470$ k Ω
$C_{16} = 200$ pF.	$R_{22} = 220$ k Ω
$C_{20}, C_{21} = 100$ pF.	$R_{23} = 1.5$ M Ω
$C_{22} = 0.006$ μ F.	$R_{24} = 1500$ Ω
$C_{23} = 25$ μ F, 25 V wkg.	$R_{25}, R_{27} = 27$ k Ω
$C_{24} = 30$ pF.	$R_{26} = 22$ k Ω
$C_{25} = 0.01$ μ F.	$R_{28} = 330$ k Ω
$C_{26}, C_{27}, C_{29}, C_{33} = 8$ μ F, 450 V wkg.	$R_{33} = 350$ Ω (5 watt)
$C_{34} = 16$ μ F, 450 V wkg.	$R_{35} = 500$ Ω (5 watt)
$C_{35} = 50$ μ F, 50 V wkg.	L_1, L_2 , Wearite PA2, PA1
P_1 , M.W. Padder, max. 600 pF.	L_3, L_4 , Wearite PHF2, PHF1
P_2 , L.W. Padder, max. 250 pF.	L_5, L_6 , Wearite PO2, PO1
$T_1, T_2, T_3, T_4 = 70$ pF; Aer. and R.F. Trimmers.	Ch_1, Ch_2 ; Suitable A.F. Chokes.
$T_5, T_6 = 100$ pF; Osc. trimmers.	TR1, Premier Radio, Type M.O.7
$R_1 = 2$ k Ω	TR2, Premier Radio, Type SP.351 (see text).
$R_2, R_7, R_{11}, R_{13}, R_{31}, R_{32} = 10$ k Ω	I.F. Transformers, 465 kc/s, permeability tuned.
$R_3 = 470$ Ω	$V_1, V_3 = 6K7G$
$R_4, R_5, R_{29}, R_{30} = 270$ k Ω	$V_2 = 6K8G$
$R_6 = 5$ k Ω	$V_4 = 6B6G$
$R_8 = 250$ Ω	$V_5 = 6C5G$
$R_9, R_{10} = 47$ k Ω	$V_6 = Y63$
$R_{12} = 390$ Ω	$V_7, V_8 = PX4$
$R_{14} = 22$ k Ω (2 watt)	$V_9 = FW120/350$

by C_{23} , an electrolytic of 25- μ F capacitance. Little need be said about the tuning indicator; the triode control grid is supplied from the A.G.C. diode through R_{28} , and is decoupled by C_{30} . The triode anode load is R_{31} , a resistance of 1 M Ω , and the target is returned directly to the main H.T. supply line.

The output of the triode section of V_4 is developed across R_{22} , and is applied to the phase-splitter

Fig. 2. Circuit diagram of the power unit. A chassis size of 9in x 4in x 2in is suitable for this unit which connects to the main chassis through a cable form.

through C_{25} and R_{23} . The value of R_{23} is 1.5 M Ω , but the impedance of the grid circuit is much more than this from the point of view of a voltage appearing between grid and earth. Such a stage is therefore liable to hum pickup and short grid-lead wiring must be maintained at this point.

Outputs are taken from the anode and cathode circuits, and are consequently in antiphase, being approximately equal, since $R_{25} = R_{27}$. R_{26} is the anode decoupling resistance, and therefore does not enter into the matter of the anode load, and the small bias voltage developed across R_{21} (about 3.5 volts) does nothing to upset the normal working of the stage. Some doubts were expressed during the design of this stage as to whether the proposed valve (6C5G) would stand the heater-cathode voltage developed across R_{25} , since one side of the heater has to be earthed to avoid hum. However, after several weeks faultless operation, the valve seems to stand up to the voltage quite successfully, and the performance and reliability have been entirely satisfactory.

The push-pull output circuit is necessary from a quality reproduction point of view, for it cleans out the unpleasant components of distortion present in the single-ended receiver and avoids the necessity for excessive decoupling. Directly heated triodes are used, despite the attractions of tetrodes from the point of view of power efficiency. The use of negative feed-back is

nearly always necessary with the latter (which offsets the advantage of a smaller drive), and the effect of a slight speaker mismatch is considerably worse with tetrodes than it is with triodes. In fact, a transformer ratio that is slightly high is preferable with triodes since, while reducing the power output, it actually improves the quality. The output transformer used is a multi-ratio type of generous dimensions and will match to almost any speaker impedance. The anode-to-anode load of PX4 or equivalent valves is 4,000-6,000 Ω , and the undistorted output obtainable is about 8 watts.

Components Employed

The power unit, which is built on a separate chassis, is shown in Fig. 2 and requires little comment. It is quite conventional, the mains transformer delivering 350-0-350 volts at 150 mA, as H.T. plus 6.3 volts at 3 to 4 A for the valve heaters, and 4 volts at 2 to 3 A for the output triodes, with a 4-volt winding for the H.T. rectifier. The heater winding for the output valves is centre-tapped for the inclusion of the bias resistance R_{35} . H.T. smoothing is carried out by C_{33} and C_{34} (8 + 16 μF) and Ch_2 .

The characteristics of most of the components are given in the list of parts, and few additional notes are necessary. All resistors may be rated half-watt except where the table indicates otherwise, and for the A.G.C. circuits quarter-watt types are quite sufficient. Capacitors, with the exception again of the A.G.C. and cathode by-pass circuits where the voltages developed are negligible, should preferably be rated at 350 to 450 volts D.C. working. The coils are of the Wearite un-screened "P" types, each consisting of a primary and a secondary winding, and are available with tags to accommodate postage-stamp type trimmers directly across the tuned windings. They are Aerial, H.F. Transformer and Oscillator types for an I.F. of 465 kc s, covering the ranges 200-600 and 800-2,000 metres. In Fig. 3 (b) is shown a skeleton layout of the underside of the main chassis, where it will be seen that the coils are divided

off from each other (in pairs) by aluminium screens, the switch banks being similarly spaced and placed as closely as possible to their respective coil sections.

The output triodes depend upon the valves available. If the 4-volt types (PX4 or equivalents) cannot be obtained, then the 2-volt types may be used. The only alteration in the receiver is then that of the bias resistance R_{35} and the fact that the heater must be rated at 2 V, 4 A. The mains transformer used by the

The first winding is stripped off in practice (it is a simple matter to strip these transformers of iron, and the heater windings are wound on the outside of the bobbin) and a 6.3-volt winding substituted from 18 S.W.G. enamelled wire. The number of turns-per-volt is easily determined when the 4-V winding is removed (it was 3 t.p.v. in the writer's case), and so no difficulty should be experienced in replacing it with a 6.3-V winding. This winding, which need not be centre-tapped,

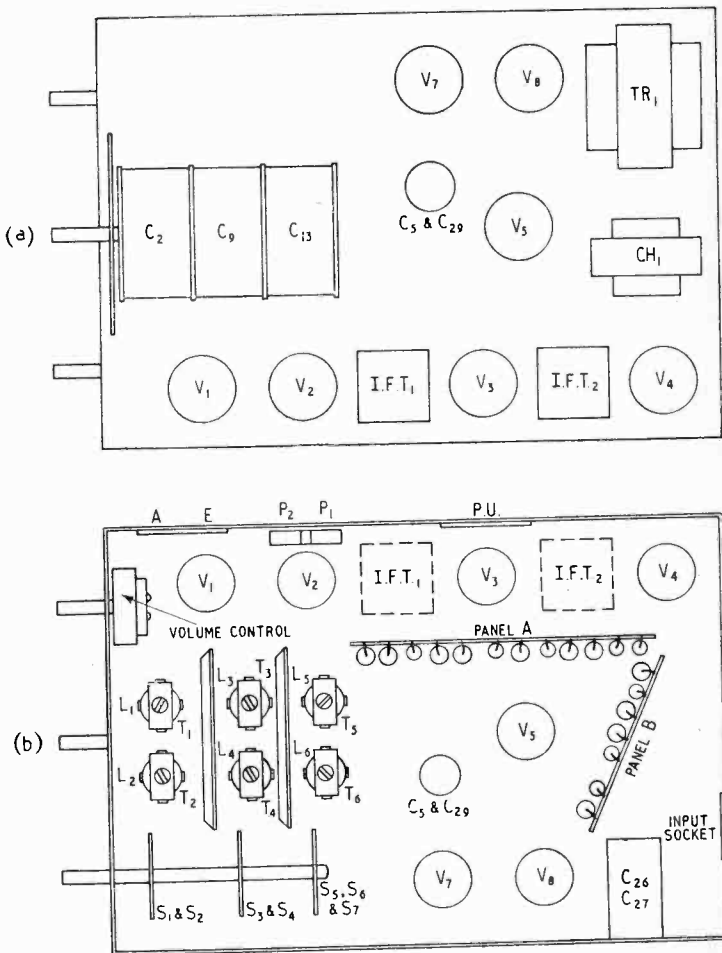


Fig. 3. (a) shows a convenient upper-chassis layout for the main receiver. (b) shows the under-chassis layout. The panels A and B are ordinary resistance and capacitor tag boards of suitable size and hold all the appropriate resistances and capacitors. Cathode resistors, capacitors, etc. may be wired directly to the valveholders

writer is a Premier type SP 351 which delivers as L.T. 4 V at 1-2 A, 4 V at 2-3 A and 4 V at 3-6 A

then feeds the receiver valves as far as V₆, the remaining 4 V at 2-3 A serving the rectifier

Quality Superheterodyne—

heater and the 4 V at 3-6 A supplying the output valves. These windings are ready centre-tapped. If 2-V output triodes are used, the latter winding must, of course, be halved and re-centre-tapped during the winding of the 6.3-V heater. It is therefore essential to get the output valves *before* modifying the mains transformer or specially buying one suitable for the purpose.

The output from the power unit is taken through a short cable form to an octal plug which connects to a valveholder socket mounted on the rear of the main chassis. The mains supply is also taken through this point to the switch on the receiver volume control.

Alignment

The trimming of the receiver is fairly critical, but calls for no special skill or apparatus. A good signal generator is recommended for I.F. alignment, but actual signals may be utilized for the aerial, R.F. and oscillator trimming and padding. In accordance with usual practice, the trimming order is: (a), I.F. circuits; (b), medium-wave oscillator, aerial and R.F. trimmers in that order at the high-frequency end of the band; (c), medium-wave paddler capacitor at the low-frequency end of the band; (d), long-wave oscillator, aerial and R.F. trimmers in that order at the high-frequency end of the band; (e), long-wave

paddler capacitor at the low-frequency end of the band. With a signal generator suitable frequencies for the medium waveband are 1,500 kc/s (200 m) and 600 kc/s (500 m), and for the long waveband, 300 kc/s (1,000 m) and 150 kc/s (2,000 m). With station alignment, the B.B.C. Light on 1,149 kc/s (261 m) and the B.B.C. Third on 583 kc/s (514 m) are suitable for the medium waveband, while the weather-forecast station on 250 kc/s (1,200 m) and the B.B.C. Light on 200 kc/s (1,500 m) are suitable for the long waveband. Each trimming operation should be rechecked as the opposite end of the wave range is adjusted. The tuning indicator makes a useful alignment "tool" for these purposes.

A table of voltages follows taken from the writer's receiver which will assist anyone who duplicates this receiver.

Valve	Anode	Screen	Cathode
V ₁	220	110	4.1
V ₂	Hex. 250 } Osc. 10 }	95	2.6
V ₃			
V ₄	220	100	3.8
V ₅	140	—	1.3
V ₆	40	—	—
V ₇	230	—	3.5
V ₈			
V ₉	325	—	48.0*
V ₉	350 R.M.S.	—	—

* Across R₃₃ in power unit.

Readings taken with no signal, 1,000 Ω per volt meter, highest ranges in each case.

Barker Model 148 Speaker

Single-diaphragm Wide-range Reproducer

DESIGNED primarily for high-quality sound reproduction in the home, this permanent-magnet loudspeaker is constructed on the original dual drive principle evolved by A. C. Barker. The main voice coil is coupled mechanically and electrically to a thin metal former which is cemented to the apex of the diaphragm. At low frequencies the system vibrates as a whole, but at high frequencies the metal former acts as a single turn of low inertia and vibrates independently of the comparatively heavy speech coil. A small concave area near the apex, which acts as the high-frequency

radiator, blends into the main diaphragm, which is a 10-inch cone of impregnated woven fabric with concentric corrugations.

The speakers are individually constructed and assembled, and each is subjected to critical aural tests, so that the number available is limited. The price is £15 15s, and enquiries should be addressed to BCM/A.L.D.U. London, W.C.1.

We have had an opportunity of listening to this loudspeaker and there is little doubt that it ranks in performance with the best reproducers available today. In two respects it is outstandingly good.

namely, the excellent balance at comparatively low levels (below 1 watt), and the homogeneity of its high-frequency response. There is no marked focusing of high frequencies and none of the detached "leatheriness" often associated with frequency responses up to 15,000 c/s. In a properly designed baffle the low frequency response is sensibly uniform down to 40 c/s with no major bass resonance.

We can fully endorse the maker's claim to have achieved natural quality of reproduction at a volume level suited to the average living room.

Manufacturers' Literature

ILLUSTRATED catalogue of silvered mica condensers from Londex Electrical Manufacturing Co., 459, Fulham Road, London, S.W.10 (available to manufacturers only).

Revised leaflet (MV121) of Mullard Transmitting Valves for Amateur Communications from Mullard Wireless Service Co. (Transmitting and Industrial Valve Dept.), Century House, Shaftesbury Avenue, London, W.C.2.

Descriptive leaflets dealing with receivers Type 186A and Type 371A, from Philips Electrical, Century House, Shaftesbury Avenue, London, W.C.2.

Leaflet No. 32 (Insulating Beads) from Steatite and Porcelain Products, Stourport-on-Severn, Worcs.

Instruction sheets MR14 for use of rectifiers for H.T. supply to radio receivers (Supplement 1) and Westectors (Supplement 3); also data sheet No. 42 on "Westalite" rectifiers Types 16K and 16HT, from Westinghouse Brake and Signal Co., 82, York Way, King's Cross, London, N.1.

Leaflet describing the "Derwil" servicing cradle for receiver chassis from the Wilder Instrument Co., 75-81, Tooley Street, London, S.E.1.

Leaflet giving details of the "Reveille" combined clock and radio receiver from Thames Valley Products, 28, Camden Avenue, Feltham, Middlesex.

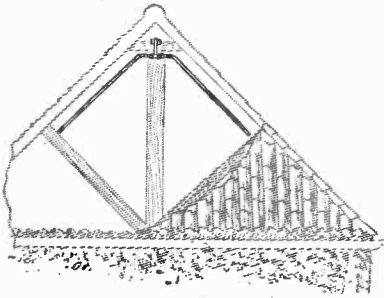
Illustrated catalogue of mica and ceramic capacitors, hermetic seals, metallized bushes and insulators for radio and electronic equipment, from United Insulator Company, Oakcroft Road, Tolworth, Surbiton, Surrey.

Electrothermal Valve Retainers

IT was stated in our Radiolympia I show report that the valve retainers made by Electrothermal consist of moulded rubber and fibre-glass. This is incorrect as the former material is not used, fibre-glass being the main constituent employed.

BELLING-LEE QUIZ (No. 18)

Answers to questions we are often asked by letter and telephone



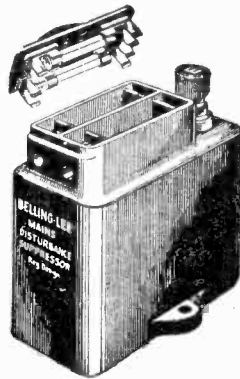
*1 Shows the Belling-Lee inverted "V" television aerial mounted in the attic. L.605 Attic Model sells at £2 7s. 6d.

Question 50. What sort of questions did you have to answer from Visitors to your stand at Radiolympia?

Answer 50. Radio dealers ask this one, and wholesalers want to know what questions the retailers ask. We had a conference—all hands on deck—on the stand on the last Friday of the show before opening time. The greatest number of enquiries related to television aerials, and the forms of interference most commonly associated with the reception of television programmes. This was followed by general questions on interference, and the third group was questions by amateurs. We will deal with them in this order.

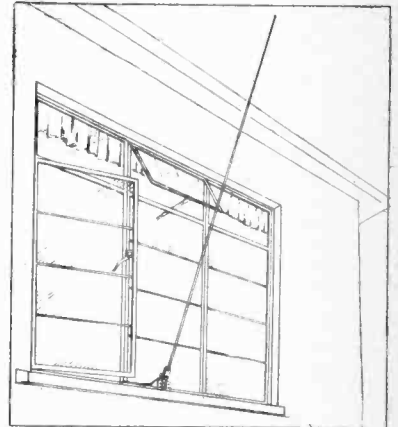
Television. The interest in the inverted "V" loft or attic aerial L.605 surprised us all. In this series of questions, most came from people who already had television receivers, but who were situated at the outside edge, or beyond the useful service area of Alexandra Palace. In other words, people who had a weak or unstable picture and who were therefore liable to annoyance from most forms of interference. It really must be appreciated that whereas many liberties may be taken with a strong signal, a weak one requires not only the best possible aerial, but it must be erected with skill and not a little craftsmanship and cunning. Everybody, not only the viewer, must realise that the aerial must be paid for, its erection must be paid for, and generally speaking you don't get much for nothing these days.

Interference. These questions came from people whose enjoyment was spoilt by various kinds of interference. There are still people in the trade who are inclined to shut their eyes to this matter. We wish we could have had time to take names and addresses of enquirers but those who tried to get near our stand will appreciate that this was impossible. Our engineers found themselves "in conference" with four or five at a time, surrounded with interested listeners eager not to miss a word. It must be admitted that many complaints came from those who were using either an indoor aerial or none at all. In most cases, probably the cheapest way out would be the installation of a *2 "Winrod" window mounting aerial L.581. This is not an anti-interference aerial, but any outdoor aerial is better than none, and would be bound to improve the signal to noise ratio. In really bad cases, a "Skyrod" anti-interference aerial might be necessary.



A typical capacitor suppressor L.1118/CT for fitting at the source of interference, e.g., electrical motors, rectifiers, etc., or at the meter board. Price £1 7s. 6d.

When the interference is known to be coming from some appliance or machine under the control of the person complaining, or of a friendly neighbour, the obvious thing to do is to have a suppressor fitted to the appliance. If this is not practicable write to us or report the matter to the nearest post office who will give you form T.466G to fill up, and in due course a specially trained suppression engineer will get in touch with you to investigate the matter.



*2 The "Winrod" L.581 is in 3 sections and has a universal bracket providing several fixing arrangements. Price 19s. 6d.

The post office engineers take a very keen interest and are really efficient.

Growing Amateur Interest. The questions from the growing band of amateurs and their interest were most refreshing. Many had already seen our amateurs catalogue P.339 and came to us with queries. Many were complaints of long deliveries of our aerial array. We would like to emphasise that we are all out to help the radio amateur. He requires components of high quality such as were developed for war time radar and communications equipment and today are only applicable to the highest grade electronic equipment—and to the amateur. We are very interested in both.

We had very few enquiries from professional users of components, but most of them already know and use our products. An exhibition like Radiolympia is useful because it brings us in touch with those with whom we have no other contact except by letter—and after all, letters cannot take the place of a visit.

To be continued.

*1 "VIEWROD" (Regd. Trade Mark) television aerials see illustration top left.

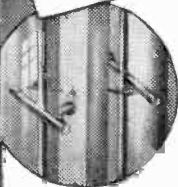
*2 "WINROD" (Regd. Trade Mark) see illustration top right.

BELLING & LEE LTD
CAMBRIDGE ARTERIAL ROAD, ENFIELD, MIDD



**FOR
FREQUENCY
SUB-STANDARDS**

TYPE JCF/200, 100 KC/S
Available from stock adjusted to $\pm 0.01\%$
Higher accuracies supplied to special order
PRICES ON APPLICATION



V WIREMOUNTING
BRITISH PATENT NO 570290

The type JCF/200 unit illustrated above is representative of the wide range of vacuum type units available for low and medium frequencies.

G.E.C.

QUARTZ CRYSTAL UNITS

FOR STABLE FREQUENCY GENERATION

FEATURES:

Low temperature coefficient—less than 2 in 10^6 per $^{\circ}\text{C}$. Patented nodal suspension. Mounted in vacuum; performance independent of climatic conditions. Exceptionally high Q value. High stability. Small size, 3in. \times $\frac{5}{8}$ in. overall excluding pins. Fits standard miniature deaf aid valve socket.

SALFORD ELECTRICAL INSTRUMENTS LTD.
PEEL WORKS SALFORD 3
Phone: BLA. 6688 (6 lines) Grams & Cables "Sparkless, Manchester"

Proprietors, THE GENERAL ELECTRIC CO. LTD. England.

1817

The Problem

The directional response characteristic of single unit loudspeakers is very pronounced at the higher audio frequencies which are audible only in a comparatively narrow channel directly in front of the reproducer with a corresponding lack of intelligibility and brilliance elsewhere.

This feature is particularly troublesome when high quality sound reproduction is required in public halls, theatres and small cinemas where the size and expense of a large dual channel loudspeaker system is often not justified.

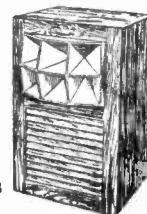
The Solution

It is for such installations that the Vitavox Bitone Reproducer has been designed. High frequency reproduction in this instrument is handled by a small multicellular horn and moving coil pressure unit, this assembly providing adequate coverage and at the same time because of its high efficiency, a rising high note characteristic which is an advantage in auditorium reproduction. A 12" moving coil cone type loudspeaker operating in a vented enclosure reproduces low frequencies and a cross-over filter network is fitted to divide the frequency spectrum correctly between the two units. The whole assembly is mounted in a polished Walnut finished cabinet 'as standard, Oak and Mahogany veneered models being available to special order, and can be relied upon for applications where quality of performance rather than first cost is the main consideration.

SPECIFICATION AND PRICES

Power Handling Capacity: Model 610—10 watts; Model 620—20 watts. Size: 32" \times 21" \times 20". Terminating Impedance: 7.5 ohms. Filter Attenuation: 12 d.b. per octave. H. F. Distribution (appx): 60° \times 40°.

MODEL 610 — £42 0 0
MODEL 620 — £50 0 0



VITAVOX LTD., WESTMORELAND ROAD, LONDON, N.W. 9. TEL: COLINDALE 8671-3

WORLD OF WIRELESS

Radar & D.F. Nomenclature ♦ Amateur Activities ♦ Reception of French Television

TERMINOLOGY

THE need for overhauling our terminology in the field of position-finding by radio was stressed by C. E. Strong, O.B.E., the new chairman of the I.E.E. Radio Section, in his inaugural address.

He suggested that there were two main branches of the tree of which radio is the root and trunk. The first, generally known as radio-communication, and the second, embracing the whole field of direction and range determination by radio, he suggested should be called "radiolocation." Whilst realizing that the term had been used before in a different sense and, too, that it had such "important historical associations," he felt it would be hard to find a more comprehensive one. We would then speak of "communication systems" and "location systems".

Developing still further the idea, Mr. Strong proceeded to sub-divide radiolocation itself so that from the main branch came on the one side all time-sum methods giving range, which he called "range determination," and on the other time-difference methods giving direction, which he called "direction determination." The latter is further divided into "direction giving" and "direction finding." The first would include Gee, Decca, omnirange beacons, overlapping beam course beacons and all systems transmitting azimuth information, while the second would embrace all the counterparts of the above. The branches were then further split into broad-based and narrow-based systems.

TELEVISION—S.B.A. INTERFERENCE

INTERFERENCE from the B.B.C. television sound transmissions with Standard Beam Approach reception in aircraft flying in the London area was reported recently.

The Ministry of Civil Aviation has now issued a notice to airmen (No. 267, 1947) outlining modifications to the marker beacon receiver R1125D which is particularly prone to the interference when using a horizontal aerial. No interference has been experienced with receivers R1125A, R1125B and R1125C when using a dipole aerial.

It is stated that even with the

suggested modifications the television transmissions may still break through in the immediate vicinity of Alexandra Palace.

COMPONENTS EXHIBITION

THE fifth annual private exhibition of components and test gear to be organized by the Radio Component Manufacturers' Federation will be held from March 2nd to 4th in the Great Room, Grosvenor House, Park Lane, London, W.1.

As in former years the exhibition, which is promoted to acquaint equipment manufacturers with the latest developments in the component and instrument section of the industry, will be open to visitors by invitation only.

EUROPEAN DX CONTEST

AN All-European DX contest has been arranged by the Netherlands amateur radio society (V.E.R.O.N.). During the contest, European stations will attempt to work as many different countries outside Europe, whilst amateurs in the other continents will endeavour to work European stations.

The telegraphy contest will be held from 1801 G.M.T. on November 28th to 2359 G.M.T. on November 30th, and the telegraphy contest during the same hours from December 12th to 14th. Full details and the rules for the contests are given in the October R.S.G.B. *Bulletin*.

Logs must be sent to the QSL Bureau, V.E.R.O.N., Post Office Box 400, Rotterdam, Holland, on or before December 31st.

AMATEURS AND THE INDUSTRY

THE principal guest and speaker at the October luncheon of the above Radio Industries Club was John Clarricoats, general secretary of the R.S.G.B. After a brief outline of amateur history and achievements he spoke of the pressing need for valves, components, sets and accessories for use on the wide range of frequencies allocated to amateurs at Atlantic City.

He estimated the present strength of the amateur movement in the British Isles at about 10,000 and that this represented a potential home market of at least £250,000 per annum. In addition, he pointed out that there is a considerable export market awaiting the right type of equipment.

FRENCH TELEVISION

THE suggestion that an attempt might shortly be made to link the British and French television services for an interchange of programmes lends added interest to an account of an R.A.F. wartime intelligence activity which has just come to light.

As a result of information received through Intelligence sources a television receiving centre was set up to intercept transmissions from Paris during the German occupation. Wing Cdr. G. T. Kelsey, O.B.E., who is now with E.M.I., secured two of the company's television sets and, with a certain array consisting of 32 dipoles slung between two 150ft masts, successfully received the transmissions which were monitored

for two years. The special aerial was found to be necessary to eliminate the powerful signals from the nearby radar stations.

The transmissions, usually news reels of bomb damage in France, provided useful

PARIS interval signal received at Beachy Head—a distance of 180 miles—during the German occupation of France.



World of Wireless—

information on the success of R.A.F. raids.

RADIO AIDS TO NAVIGATION

A BROCHURE containing short technical descriptions of all the radio aids to civil aviation demonstrated by the Research and Development Establishments of the Ministry of Supply during last year's international conference has been issued by H.M. Stationery Office. Entitled "P.I.C.A.O. Demonstration of Radio Aids to Civil Aviation, September 1946," it is priced 5s.

A complete set of the technical papers read before the London conference is available in three volumes entitled "P.I.C.A.O. Demonstrations—Technical Papers on Equipment and Systems." Price £4 4s the set. Individual papers, obtainable at 6d each, or the bound volumes are available from the C.E.R.C.A. Central Office, Room 211, Ministry of Civil Aviation, Ariel House, Strand, W.C.2.

E.I.B.A.

THE annual report of the Electrical Industries Benevolent Association, which helps radio as well as electrical non-manual workers in times of misfortune, records that the number of cases dealt with last year (253) showed an increase of 25 per cent on the previous year.

The amount paid out to members of the radio industry last year was over £2,000. The income from the radio industry was, however, less than 25 per cent of that amount.

One regular source of income is from the collections taken at the Radio Industries Club luncheons, which last year amounted to £189. The proceeds (£218) from the Radio Industries Ball, held at the Royal Albert Hall during the Olympia show, were devoted to the E.I.B.A.

PERSONALITIES

Sir Ernest Fisk, managing director of E.M.I., Ltd., was elected president of the International Federation of the Phonographic Industry at the recent annual general meeting in Brussels attended by the representatives of twelve countries, including the U.S. and Germany.

C. R. Denny has resigned from the chairmanship of the U.S. Federal Communications Commission which he has held for the past three years. He served as chairman of the International Telecommunications Conferences, Atlantic City, during the four and a half months' duration of the three conferences which ended on October 2nd. He

is to become vice-president of the National Broadcasting Company.

F. T. Cotton, chief valve engineer of the Cossor valve and cathode-ray tube subsidiary, Electronic Tubes, Ltd., High Wycombe, has resigned to take up the position of head of the physics laboratory of Ekco-Ensign Electric, Ltd., the electric lamp subsidiary of E. K. Cole. He joined the Cossor organization in 1932.

Dr. Hilary Moss is assuming responsibility for the research and development engineering division of Electronic Tubes, Ltd.

B. N. MacLarty, O.B.E., M.I.E.E., head of the B.B.C. Design and Installation Dept., who has been with the corporation since 1926, has resigned to become a deputy engineer-in-chief of Marconi's W.T. Co. He was one of the band of Marconi engineers who started the broadcast transmissions from station 2MT at Writtle in 1922. He appears (standing left) in the photograph on page 456.

WHAT THEY SAY

Unanimous.—"I am pleased to be able to advise you that we feel that all three conferences [at Atlantic City] were successful and that the new International Telecommunications Treaty and the new International Radio Regulations, both of which were signed by all of the 78 countries participating in the conferences, are satisfactory in



working without exhausting the tube and without any damage there by using the arrangement in my registering apparatus."

From the foregoing remarks may be inferred that the arrangement of Marconi's receiver is a reproduction of my lightning recorder.—Yours, &c., A. POPOV.

Torpedo School, Cronstadt, Russia, Nov. 26, 1897.

Alexander Stepanovich Popov (born 1859, died 1906) with a facsimile of his claim made in a letter to *The Electrician* exactly 50 years ago. The significance of his early work is discussed in our leading article. The portrait is from an engraving issued by l'Union Internationale des Télécommunications.

every respect."—Charles K. Denny, chairman of the International Telecommunications Conferences, reporting to President Truman.

OBITUARY

We regret to record the deaths of:—
W. Densham, one of the small group of technicians which assisted Marconi during his early experiments in this country. He joined the Marconi Co. in 1899 and took part in the pioneer work in the Isle of Wight, at Poldhu, Clifden and in the U.S.A. He held technical and administrative posts in the company and retired in 1939, but returned for three years during the war. He was 70.

F. S. Hayburn, at the age of 69, He joined the Marconi International Marine Communication Co. in 1904 and became managing director in 1933. Two years later he relinquished that position in order to become foreign envoy for the Marconi group of companies. He retired in 1944.

Air Comdre. H. Leedham, C.B., O.B.E., managing director of Ericsson Telephones, Ltd. From 1929 until 1935 he was head of the Radio Division, Royal Aircraft Establishment. During the war he was successively director of radio production and director of radio research and development at the Ministry of Aircraft Production. He joined Ericsson's in September, 1945.

IN BRIEF

Nearly 11,000,000 broadcast receiving licences were in force in Gt. Britain and Northern Ireland at the end of September. 25,050 of the 10,950,650 licences were for television receivers.

Servicing Certificate.—Of the 65 entrants for the Radio Servicing Certificate Examination held in May, 41 passed in both written and practical sections. This examination was the first to be held jointly under the auspices of the Radio Trade's Examination Board and the City and Guilds of London Institute.

International Broadcasting.—According to a survey by the American State Department Great Britain leads the list of 55 nations as the biggest user of international short-wave broadcasting. The survey shows that at the end of last year the percentages of the world's international broadcasts used by the U.K., U.S., Russia and France were 16.56, 9.21, 6.09 and 3.83, respectively.

I.S.M.—A typographical error appeared in our summary of the Atlantic City frequency allocations in last month's issue. The last of the frequencies allocated to industrial, scientific and medical equipment should have been 5,850 Mc/s. This frequency, which comes at the top end of a new amateur band, will be used with a tolerance of ± 0.6 per cent.

School Broadcasting.—The Central Council for School Broadcasting has

been dissolved and a new body, the School Broadcasting Council for the United Kingdom, formed. Similar councils have also been formed in Scotland and Wales to guide the B.B.C. in undertaking broadcasts to schools. In an endeavour to raise the standard of reception in schools the Council is giving advice to local education authorities. It is of interest to recall that the recent McNair Committee's report on education stressed the need for teachers to be trained in the use of broadcast equipment in schools.

Poland.—A change of wavelength has been notified by the Polish broadcasting authorities. Warsaw II, which, since reopening last December, has been temporarily operating in the medium waveband, has returned to its pre-war wavelength of 1339.3 metres. Its power is 10 kW. Warsaw I is operating on 395.8 metres with a power of 50 kW.

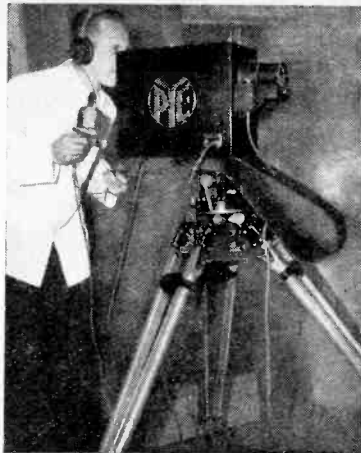
Telecommunications Courses.—A syllabus of courses and examinations in telecommunications and electrical subjects has been issued by the City and Guilds of London Institute for the 1947-48 session. The courses include telecommunications engineering, electrical installation work, electrical engineering practice and radio service work. Details are also given of the final examination in radio service work, conducted jointly by City and Guilds and the Radio Trade's Examination Board, for the Radio Servicing Certificate.

Jamaican Broadcasting.—It has been decided by the Jamaican Government to discontinue broadcasting from its own transmitter in Kingston and to invite applications for private broadcasting under licence. Cable and Wireless has intimated that the company would be willing to provide the technical facilities but is not prepared to undertake the programme side.

International Television.—A meeting of television technicians of various countries was held at Cannes in September as part of the Comité International pour la Diffusion Artistique, Littéraire et Scientifique par la Cinéma. The British representative was A. G. D. West, past president of the British Kinematograph Society. The opportunity was taken to form a Comité International de Television (C.I.T.), with R. Barthelemy (France), Dr. A. Castellani (Italy), Professor F. Fischer (Switzerland), and A. G. D. West (Great Britain) as founder members.

Wire-to-Disc Transcriptions.—Equipment for the production of personal disc recordings installed by Modern Messages, Ltd., at their recently opened studio at 9, Piccadilly Arcade, London, S.W.1, includes wire recording apparatus for preliminary rehearsal. High-quality transcriptions from wire to disc afford the opportunity of selecting the optimum performance and effect considerable economies in recording materials.

Technical Literature Wanted.—Language classes in technical and scientific English are being started in Sweden; F. P. Thomson, A.M.Brit.I.R.E., has been appointed by the Stockholm educational



BELGIAN TELEVISION.—A Pyc mobile television station recently toured Belgium. The only failures throughout the 500-mile tour, during which the station operated for 150 hours, were two miniature valves

authorities to arrange lectures and classes in polytechnics, clubs, etc. Mr. Thomson, whose address is Box 846, Stockholm 1, Sweden, is in urgent need of manufacturers' literature containing illustrations of modern electronic equipment as a help in explaining worn-out expressions or idioms which are quite unfamiliar to Swedish students.

Amateur Prefixes are given in alphabetical order on a card measuring 8½ x 10½ in published at sixpence by R. Martin and Co., Bridge Street, Worksop, Notts.

B.W.I. Transmissions.—The Trinidad Broadcasting Company has arranged two special amateur transmissions from its short-wave station VP4RD. "Radio Trinidad," working on 9.625 Mc/s with a power of 500 watts, will radiate these programmes on November 30th from 1000 to 1100 G.M.T. and on December 1st from 0830 to 0930 G.M.T. Reception reports will be welcome by the Trinidad Broadcasting Co., Ltd., Broadcasting House, Port-of-Spain, Trinidad, B.W.I.

I.S.W.C. Broadcasts.—Details of the special short-wave transmissions from overseas broadcasting stations for amateurs, arranged by the International Short-Wave Club, are given in the club's duplicated four-page monthly news-sheet, "International Short-Wave Radio," issued from its headquarters, 100, Adams Gardens Estate, London, S.E.16.

Amateur F.M.—Australian amateurs have been granted permission to employ frequency modulation for transmissions between 27.185 and 27.455 Mc/s, on 50 Mc/s and above. Pulse transmission is permitted on, and above, 166 Mc/s.

R.S.G.B. Officers.—The following members have been nominated for election at the annual general meeting of the Radio Society of Great Britain to be held on December 19th: V. M.

Desmond (G5VM), president, and W. A. Scarr, M.A. (G2WS), executive vice-president.

B.I.O.S. now T.I.D.U.—Enquiries about reports in the B.I.O.S. series have in the past been made to the British Intelligence Objectives Sub-Committee, 32-37, Bryanston Square, London, W.1, and applications to examine the original documents made to Documents Unit, Board of Trade, Lansdowne House, Berkeley Square, London, W.1. These two units have been merged and are now known as the Technical Information and Documents Unit, German Division, Board of Trade, 40, Cadogan Square, London, S.W.1.

American Production.—According to figures given at the New York meeting of the U.S. Radio Manufacturers' Association the estimated production of broadcast and television receivers during 1948 will be between 13,000,000 and 15,000,000.

U.S. Radio Week.—America's third annual National Radio Week, which ended on November 1st, brought to a close the year's campaign organized by the U.S. Radio Manufacturers' Association to increase receiver sales, for which the slogan was "Radio in Every Room".

I.P.R.E.—At the first annual dinner of the Institute of Practical Radio Engineers, it was stated that there were now 800 members and 900 students. The raising of the standard and status of service technicians was given as one of the primary aims of the institute.

INDUSTRIAL NEWS

"Cossor Courier," the dealer journal of A. C. Cossor, Ltd., has reappeared after a break of over nine years. The first issue, dated Autumn, includes, in addition to details of the 1947-48 range of receivers, some interesting figures on Cossor's wartime production.

Decca.—A new publication, *Music*, has been produced by the Decca Record Co., and will be issued quarterly, price 2s. Its scope will not be confined to recorded music, but is intended to "bridge the gap between the essentially academic type of review and the 'popular' music paper".

"Marconi Mariner" is the title of a new journal to be published bi-monthly by the Marconi International Marine Communication Co. The first issue, July-August, of this purely staff journal includes details of Seamew and Seagraph equipment.

Multicore distributors in New York have ordered five tons of Ersin Multicore solder—sufficient for 100,000,000 joints.

CLUBS

Battersea.—The London Short-Wave Club now meets on Fridays at 8.0 at "The Crown," Battersea Park Road, London, S.W.11. It is affiliated to the International Short-Wave Club, the secretary of which is A. E. Bear, 100, Adams Gardens Estate, London, S.E.16.

World of Wireless—

Birkenhead.—The December meetings of the Wirral Amateur Radio Society will be held on the 3rd and 17th at 7.30 at the Y.M.C.A., Whetstone Lane, Birkenhead. Sec.: B. O'Brien, G2AMV, 26, Coombe Road, Irby, Heswall, Cheshire.

Birmingham.—The annual general meeting of Slade Radio will be held on November 28th at the Parochial Hall, Broomfield Road, Erdington. On December 12th the club will hold a D.F. contest. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23, Warwick.

Birmingham.—Having obtained premises at 220, Moseley Road, Birmingham, 12, the Birmingham and District Short-Wave Society now meets on alternate Thursdays for practical work, in addition to the monthly meeting at the Hope and Anchor Hotel, Edmund Street, Birmingham. Sec.: N. Shirley, 14, Manor Road, Stechford, Birmingham, 9, Warwick.

Bradford.—A discussion on "who should be the members of the R.S.G.B." will be held by the Bradford Amateur Radio Society on December 9th at 7.30 at Cambridge House, Horton Lane, Bradford. A social evening is proposed for December 23rd. Sec.: W. S. Sykes, G2DJS, 287, Poplar Grove, Great Horton, Bradford, Yorks.

Brighton.—The December meetings of the Brighton and Hove Group of the R.S.G.B. will be held on the 1st and 15th at 7.30 at the Golden Cross Hotel, Western Road, Brighton, Sussex. Town Representative: J. R. D. Sainsbury, G8HV, 80, Lansdowne Place, Hove, Sussex.

Eastbourne.—The recently formed Eastbourne and District Group of the R.S.G.B. meets on the first Friday in the month at the Friends' Meeting House, Wish Road, Eastbourne. Sec.: R. F. Nugent, G3FTS, 12, St. Anthony's Avenue, Eastbourne, Sussex.

Grimsby.—The Grimsby Amateur Radio Society has been granted a 150-watt licence (G3CNX) for its transmitter—a 11131. Meetings are held each Thursday at 7.45 at 115, Garden Street, Grimsby, Lincs. Sec.: R. F. Borrill, G3TZ, address as above.

Harrogate.—Premises have been obtained at the rear of 31, Park Parade, and the Harrogate and District Short-wave Radio Society now meets there every Wednesday at 7.30. Sec.: K. B. Moore, 2a, Wayside Crescent, Harrogate, Yorks.

Kentish Town.—The St. Pancras Radio Society now meets on Mondays and Thursdays at 7.0 at the L.C.C. Evening Institute, Holmes Road, Kentish Town, London, N.W.5. A third evening is being arranged for beginners. Sec.: H. Brown, 84, Blenheim Gardens, Willesden Green, London, N.W.2

Leicester.—The subjects of the lectures at the December meetings of the Leicester Radio Society are: "Army Radar" (2nd) and "Dielectric Characteristics and their Importance" (16th)

Meetings are normally held at 7.30 at the Charles Street United Baptist Church, but that on December 2nd will be at the Drill Hall, Ulverscroft Road, in order that the radar equipment may be inspected. Sec.: O. D. Knight, 16, Berners Street, Leicester.

Romford.—Meetings of the Romford and District Amateur Radio Society are now held on Tuesdays at 8.0 at the Y.M.C.A., Western Road, Romford. Sec.: R. C. E. Beardow, G3FT, 3, Geneva Gardens, Chadwell Heath, Essex.

Sutton and Cheam.—Meetings of the Sutton and Cheam Radio Society are held on the first and third Tuesdays of the month at Ye Olde Red Lion, Cheam Village. Sec.: R. G. Finch, 26, Sunnymede Avenue, Carshalton Beeches, Surrey.

Walworth.—A radio club has been formed by the Walworth Men's Institute and meets at the Avenue School, John Ruskin Street, London, S.E.5, on Wednesdays and Fridays at 7.0. Sec.: P. Senechal, 92, Grove Park Road, Camberwell, London, S.E.5.

West Bromwich.—A series of talks covering many aspects of amateur radio has been arranged for the coming meetings of the West Bromwich and District Radio Society which are held on alternate Mondays at 7.30 at the Gough Arms Hotel, Jowett's Lane, West Bromwich. Sec.: R. G. Cousens, G3BCS, 38, Collins Road, Wednesbury, Staffs.

Wolverhampton.—Details of the winter's programme arranged by the Wolverhampton Amateur Radio Society, which meets on alternate Mondays, are obtainable from the secretary, H. Porter, G2YM, 221, Park Lane, Wolverhampton.



MURPHY RADIO is continuing the development of Service equipment. The latest Army set to be made is this WS31, a F.M. transmitter-receiver operating in the extra high-frequency band.

MEETINGS

Institution of Electrical Engineers

Ordinary Meeting.—"Speech Communication under Conditions of Deafness or Loud Noise," by W. G. Radley, C.B.E., Ph.D. (Eng.), on December 4th. (Joint meeting with the Physical Society.)

Radio Section.—"The Design and Operation of High-power Broadcast Transmitter Units with Their Outputs Combined in Parallel," by T. C. Macnamara, A. B. Howe, M.Sc., and P. A. T. Bevan, B.Sc., on December 3rd.

Informal lecture on "Commercial Disc Recording and Processing," by B. E. G. Mittell, on December 9th.

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

Cambridge Radio Group.—"Industrial Applications of Electronic Techniques," by H. A. Thomas, D.Sc., on December 2nd, at 6.0, at the Cambridge-shire Technical College.

"New Possibilities in Speech Transmission," by D. Gabor, Dr. Ing., on December 16th at 8.15 at the Cavendish Laboratory

North-Western Measurements Group.—"The Design and Construction of a New Electron Microscope," by M. E. Haine, B.Sc., on December 16th, at 6.0, at the Engineers' Club, Albert Square, Manchester.

Rugby Sub-Centre.—"New Possibilities in Speech Transmission," by D. Gabor, Dr. Ing., on December 8th, at 6.45, at the Rugby Corporation Electricity Showrooms.

Radio Society of Great Britain

Annual general meeting on December 19th at 6.30 at the I.E.E., Savoy Place, London, W.C.2.

Institute of Physics

"The Travelling-Wave Tube," by R. Kompfner, on December 17th at 5.30 in the Rooms of the Royal Society, Burlington House, Piccadilly, London, W.1.

Institution of Electronics

North-West Branch.—"The Electron and other Constituents of Matter," by Prof. R. E. Peierls, F.R.S., on December 12th, at 6.30, at the Reynolds Hall, College of Technology, Manchester. Non-members may obtain tickets from L. F. Berry, 105, Birch Avenue, Chaderton, Lancs.

British Sound Recording Association

"Factors in the Reproduction of Gramophone Records," by W. J. Lloyd, B.Sc., on December 19th at 7.0 at the Royal Society of Arts, John Adam Street, London, W.C.2.

British Kinematograph Society

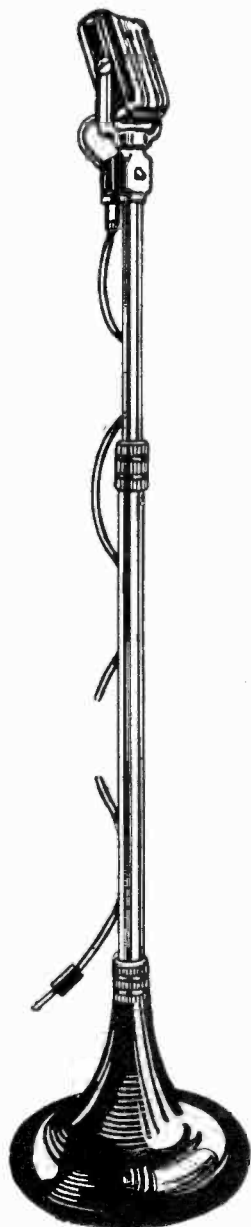
Manchester Section.—"Electronics in Industry," by J. Baggis on December 2nd, at 10.30, at the Manchester Geographical Society, 16, St. Mary's Parsonage, Manchester.

Television Society

"Impressions of American Television," by T. M. C. Lance, on November 28th at 6.0 at the I.E.E., Savoy Place, London, W.C.2.

Virtually Distortionless

A.D/47 AMPLIFIER



This is a 10-valve amplifier for recording and play-back purposes for which we claim an overall distortion of only 0.01 per cent., as measured on a distortion factor meter at middle frequencies for a 10-watt output

The internal noise and amplitude distortion are thus negligible and the response is flat plus or minus nothing from 50 to 20,000 c/s and a maximum of .5 db down at 20 c/s.

A triple-screened input transformer for $7\frac{1}{2}$ to 15 ohms is provided and the amplifier is push-pull throughout, terminating in cathode-follower triodes with additional feedback. The input needed for 15 watts output is only 0.7 millivolt on microphone and 7 millivolts on gramophone. The output transformer can be switched from 15 ohms to 2,000 ohms, for recording purposes, the measured damping factor being 40 times in each case.

Built-in switched record compensation networks are provided for each listening level on the front panel, together with overload indicator switch, scratch compensation control and fuse. All inputs and outputs are at the rear of the chassis.

Send for full details of Amplifier type AD/47

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Telegrams : "VORTEXION, WIMBLE, LONDON."

The Polyphonic Electrogram



For record connoisseurs, the world over, we have the pleasure to announce the Polyphonic Electrogram, incorporating the Phase Inverter Speaker and a specially designed six valve paraphrase push-pull Amplifier with triode output and negative feedback, together with individually controlled tone compensating channels via electronic mixing giving up to 26db Bass Lift., 15db Treble Lift from linear response, as required. Control without raising the lid via finger tip instrument panel; this instrument compares favourably with anything on the market, regardless of cost, and is provided with ample space for a high fidelity Radio Feeder Unit.

PRICE: Non-Automatic model .. £65 plus P.T.
Automatic model £80 plus P.T.

AGENTS. Barnes & Avis, Reading; Bowers & Wilkins, Worthing; Binns Ltd., Newcastle; Dalton & Sons Ltd., Derby; Clark & Sons, Isle of Wight; C. C. Gerry, Newquay; Hickie & Hickie Ltd., Reading (and branches); Thomas Lynn & Sons, Andover; Merriotts Ltd., Bristol; Needham Engineering Ltd., Sheffield; Pank's Radio, Norwich; Sound Ltd., Cardiff; Bernhard Smith, Barnstaple; Sound Services, Jersey, C.I.; Precision Services, Edinburgh; Seals Ltd., Southsea; G. E. Samways, Hazel Grove; Weybridge Radio Electric, Weybridge; West End Radio, Farnham; Vallance & Davidson Ltd., Leeds (and Branches).

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Television Receiver Construction

DETAILS of all units comprising the television receiver have now been given, including those of the framework which carries them and links them with the C.R. tube, deflector and focus coils into a complete receiver. To conclude the description it remains only to describe the operation of the set as a whole and to deal with a few points which have arisen out of enquiries made by readers.

Of these last probably the commonest relates to the use of cathode-ray tubes other than the Mullard MW22-7. Some notes on this were given in Part 6, but there is a demand for some amplification of them. The MW22-7 has a tetrode gun and the heater is rated for 6.3 V and is run from the same heater winding as the other valves. The heater is thus earthed and as the V.F. signal is fed to the cathode of the tube the cathode is considerably positive with respect to the heater. Most other tubes have a triode gun. This occasions no difficulty, for it leads merely to the omission of a connection between +H.T.₂ and a tube electrode. Most other tubes have a heater rated for a voltage other than 6.3 V, usually 2 V. This again causes no difficulty for

10.—Operating Notes and Conclusion

nections to a low-voltage tube, since much less voltage drop in the leads is permissible. The MW22-7, for instance, takes 0.6 A at 6.3 V, and if a drop of 5 per cent in heater voltage is permissible, a resistance of 0.525 Ω can be allowed in the wiring. A 2-V tube may take 2 A heater current and the resistance for the same percentage drop must be no more than 0.05 Ω. The conductors used in the heater connections all the way back to the transformer must be of ten times the cross-sectional area in the case of these low-voltage tubes.

The next point arises out of the permissible heater-cathode voltage rating of the tube. With the connections given in the earlier description the heater-cathode voltage has a maximum of about 130 V. Some tubes are not rated for as much as this. When this is so, cathode feed can

rated for a voltage other than 6.3 V the separate winding is needed in any case. The floating-heater circuit is a simple way out of the difficulty and in no case in which the writer has tried it has it led to any undesirable effects.

There are a few tubes, notably pre-war ones, in which heater and cathode are joined internally. With these it is necessary to feed the signal to the grid. This entails the use of a phase-reversing stage and, of course, there must be a separate heater winding for the tube.

The phase-reverser, shown in Fig. 1, is an anode follower giving phase reversal and a gain of about unity. The direct connection to the grid of the tube is reasonably safe because of the use of the potential-divider output which limits the amount by which the grid can be carried positive in the event of a valve failure.

With this arrangement R₂₃, R₂₄ and C₂₃ of Fig. 1, Part 7, are no longer necessary, but their retention does no harm. If they are omitted L₅ must be joined directly to the anode of V₆.

The "V.F. Output" socket is, of course, connected as usual through C₁ of Fig. 1, Part 6, to the frame time-base "Sync" socket.

Some alteration is needed to the wiring of the Brightness control. The leads to the two ends of R₁₁ of Fig. 1, Part 6, must be reversed, and its slider and C₂ must be taken to the cathode of the tube instead of to the grid. Resistor R₁ should be joined from grid to -H.T., instead of from cathode to +H.T.₂.

These modified connections for a tube having heater and cathode joined internally can be used, of course, with any tube, but when heater and cathode are not joined it is much simpler to adopt cathode feed.

When all units are completed

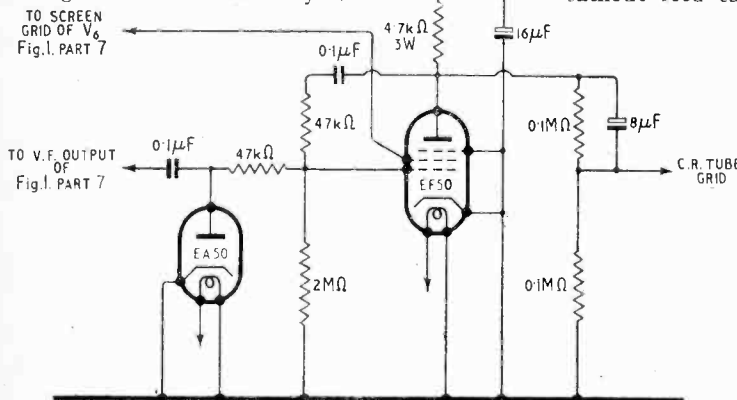


Fig. 1. Circuit diagram of anode-follower phase reverser for use with a C.R. tube having heater and cathode joined internally.

it can be met by providing an appropriately rated winding on the mains transformer.

It should be pointed out, however, that it is necessary to use heavy leads for the heater con-

be retained by the simple expedient of providing a separate heater winding on the mains transformer and connecting it to the tube heater only and to nothing else. As such tubes are usually

Television Receiver Construction— and connected together the time comes to receive a picture. If it is at all possible the individual units should be tested independently to make sure that there is nothing seriously wrong with any one. If the whole equipment is put into operation at once in an untried form the location of any fault may prove quite troublesome.

Start off with Brightness, Contrast and Picture Width turned right down (fully anti-clockwise); switch on and give the valves time to warm up. Turn up Picture Width gently until the time base is heard to sing quietly. Turn up the Brightness until the raster just appears. Now adjust Height and Width so that it is roughly of the right size and Focus for maximum line sharpness.

Adjustments

It is assumed that the receiver has previously been aligned with a signal generator, so the signal should appear when Contrast is turned up. It will probably be a confused jumble of black and white marks. Adjust Line Hold so that the line time base locks in. A recognizable picture should now be found but probably moving more or less rapidly vertically. Also the "singing" of the line-scan transformer will change from

a rough and ragged note to a clean one of lower intensity and probably higher pitch.

Incidentally, this note sounds very like an inter-station heterodyne whistle and it is extremely difficult to make it completely inaudible. It comes from the mechanical vibration of the line-scan transformer and can be reduced by putting the transformer into a heavy box packed with sound-absorbent material. Care must be taken to preserve insulation, however. The whistle is, of course, greatly reduced when the equipment is housed in a cabinet and these remarks about its audibility apply to the use of the set without a cabinet.

The next step is to adjust Frame Hold and the picture should then lock in and be seen as a complete steady picture. Now adjust Height, Width and Line Linearity for the proper picture size and for an even horizontal scan. Focus will probably need readjustment from time to time during this process.

When approximately right, turn down Contrast and adjust Brightness so that the raster is just not visible. Turn up Contrast so that the picture appears. It will now be found that the frame fly-back lines show in dark parts of the picture; therefore, turn down Brightness until they just disappear. Contrast must then be increased somewhat and Brightness turned down a little more. This is continued until the best picture is secured. Some Focus adjustment may be needed during this process.

If Contrast is not advanced far enough a clean picture will be obtained but it will be "thin" and either it will be very dim or the frame fly-back lines will show. If it is advanced too far the picture will become what is often termed "soot and whitewash." The scanning spot will defocus on whites and there will be no detail in the blacks.

Once the correct setting of Contrast is found, this control will rarely need readjustment, for the day-to-day variations are best controlled by Brightness. Having found it, final adjustments to Height, Width, Linearity and Focus can be made.

Normally, Focus and Bright-

ness are the only panel controls. The former because occasional readjustment during a programme may be necessary to compensate for the change of resistance of the focus coil as it warms up and the latter since it is advisable to black out the picture before switching off.

The focus drift is normally small and it is less with a C.R. tube having a tetrode gun than with one having a triode gun, since the latter usually needs a heavier focus current.

In normal operation the proper procedure is to see that the Brightness is right down, switch on and allow a couple of minutes for the valves to warm up. Then turn up Brightness to the required level. At the end of a programme, turn Brightness right down and switch off.

Before concluding, it may be as well to make some mention of the effect of mains voltage variations, since these can be sufficient nowadays appreciably to affect the performance. It is quite common for a nominally 240V supply to be anything from 220V to 260V and at periods of heavy load it may well fall below 220V. The most noticeable effect of a change of mains voltage will be on picture width and with any serious drop in voltage it may not be possible to obtain the full width.

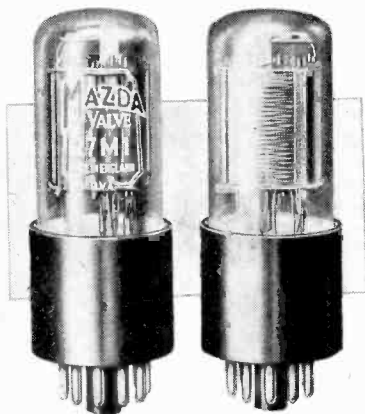
It is inadvisable to alter the tapping on the mains transformer to correct for the drop, unless a voltmeter is used to keep a check on the voltage, since it can result in the valves being over-run when the voltage rises. Unless a voltage-regulating transformer is fitted, the best thing is to adjust the transformer tap for the average voltage.

WIRELESS WORLD DIARY

COPIES of the *Wireless World* Diary for 1948 will be distributed through stationers and booksellers shortly. Readers are advised to place their orders at once as supplies are limited.

The 80-page Reference Section of the Diary has been completely revised and now contains a considerable amount of additional information. Base connections for some 400 valves, including the new B.V.A. Standard B8A, are included.

The Diary, which shows one week at an opening, costs 3s 8d, including purchase tax.



THE MAZDA TYPE 27M1 photoelectric electron multiplier has nine stages rated at 100 V per stage. At 50 V, the current amplification is one million times and the luminous sensitivity is 10 μ A/lumen. The base is a small shell 11-pin sub-magnal.

New "All-stage" Valve

Details of the
Sargrove-Tungsrø
Type UA-55

DESIGNED primarily to reduce the cost of valves used in receivers manufactured by the E.C.M.E. system (see *W.W.*, April, 1947) the Type UA-55 is capable of performing all the stage functions in a straight or superhet receiver and is yet of comparatively small dimensions and robust construction. Effective limitation of size has been achieved by accepting a reasonably small output (of the order of 1 watt) when the valve is used as a power amplifier.

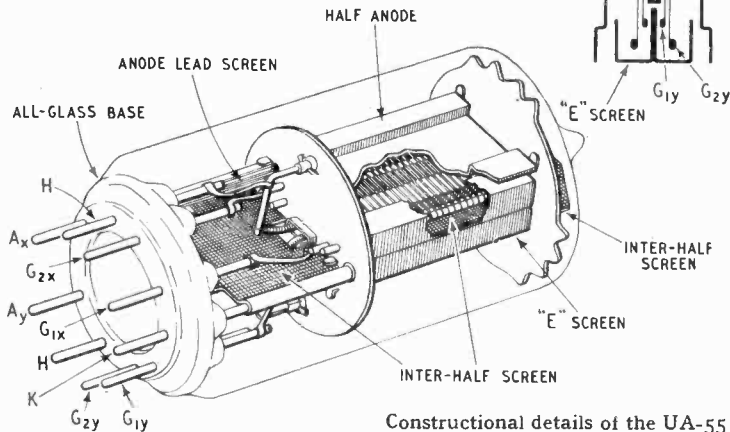
The valve is a combination of two beam tetrodes disposed symmetrically on either side of a common cathode. The heater is rated at 55 V, 100 mA and is therefore convenient for series connection



grid wires are aligned behind the grid wires, and a method has been found of doing this without optical aids. It is claimed that a ratio of anode to screen current of the order of 10:1 is maintained throughout the life of the valve.

With a screen potential of +15 V a high-impedance voltage amplifier with a slope of 4.5 mA is obtained. The anode-grid inter-electrode capacity is of the order of 0.07 pF per

section, and it is therefore necessary to use somewhat unconventional circuits for R.F. and I.F. amplification. A neutralized circuit using a capacity centre tap on the secondary of the input transformer may be employed with one half of the valve, the other half being used as second detec-



in 110- and 220-volt mains supply circuits. A central screening plate with extensions between the leads to each section of the valve is connected to the cathode and is shaped to act also as the beam-forming plates. In cross-section it is "E" shaped and shields the first and second grid supports from the anode. The accelerator

Constructional details of the UA-55 valve and (top right) section showing arrangement of electrodes

tor. Alternatively, the two halves may be arranged as an amplifier of the Colebrook R-C coupled type, when stable gains of the order of 300 can be obtained at 465 kc/s.

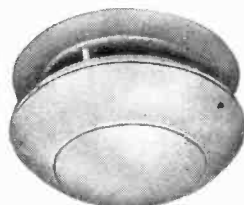
In circuits where the input can be applied to both control grids



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Cathode-ray Tube Data

Characteristics of some Ex-Service Surplus Types

Compiled by D. W. Thomasson

New "All-stage" Valve—

simultaneously, variable - mu characteristics can be obtained by applying dissimilar voltages to the screens. Otherwise, remote cut-off characteristics can be obtained by supplying the accelerator grid potential through a comparatively high series resistance.

With anode and screen strapped, a high-slope low-impedance triode is obtained. One half of the valve can be used as an oscillator under these conditions, the other half being employed as a tetrode mixer. With this arrangement and a line voltage of only 90, a conversion conductance of 0.7 mA/V is claimed, with a cathode current of 9 mA.

When the two sections are connected in parallel and both screen and anode are supplied from a 90-volt H.T. line, the valve functions as a power amplifier with a slope of 7 mA/V at -5 volts bias and gives over one watt into a load of 2,500 ohms with an anode dissipation of 3½ watts.

It may seem rather wasteful to use a valve of this type as a power rectifier, but the makers consider that this is economically justified if specimens which do not meet the required standards for general circuit use, and which would normally be rejected, are earmarked for use as rectifiers. Resistors must be used in series with the first and second grids to limit current, and the D.C. output voltage is substantially the same as the R.M.S. input voltage for currents up to 20-25 mA, the value drawn by the simple two-valve receiver illustrated on page 438 of the November issue.

A special nine-pin valveholder is necessary. The possibility of using existing nine-pin holders was considered, but it was decided that it would be less expensive to go for optimum design in the valve and to call for a special holder. The pitch circle is 11/16 in diameter and the pins, 1mm in diameter and ¼ in long, are spaced 36 degrees apart except the anode pins, which are spaced at 72 degrees.

Full characteristics of the UA-55 are given in a paper which will be read at the Brit. I.R.E. discussion meeting on Dec. 11th. Advance copies are obtainable from Sargrove Electronics, Sir Richard's Bridge, Walton-on-Thames.

THE following list gives some of the more important data on some of the C.R. tubes now available in the surplus market. All the types given have

4-V heaters, taking about 1 A, and are of the electrostatic focus and deflection type. The figures given are average values, but considerable variation may be

Type	Screen	Base	Size		Operating Conditions					Sensitivity	
			L	D	V ₁	V ₂	V ₃	V _{max}	I _b	X-axis	Y-axis
NC1	G. M.	9.1	160	25	0.8	0.135	0.8	—	3	100	90
NC6	G. —	12.1	350	75	1.45	0.6	3	4	10	320	480
NC7	G. S.	12.2	630	230	1.7	1	6	6	40	1490	1270
NC12	G. S.	12.3	420	160	1.8	0.8	5	6	3	550	1000
NC14	B. —	12.3	420	160	2	0.35	2	2.5	20	600	1140
NC16	G. M.	12.4	200	70	0.8	0.12	0.8	1.5	3	150	150
NC19	G. M.	9.1	160	25	0.8	0.135	0.8	—	3	100	90
VCR97	— —	12.3	420	160	2	0.35	2	2.5	20	600	1140
VCR138	G. S.	12.3	310	85	2	0.35	2	2.5	—	750	350
VCR139A	G. M.	12.4	200	70	1.5	0.25	1.5	1.5	3	170	170
VCR522	G. M.	9.1	160	25	0.8	0.135	0.8	—	3	100	90

NOTES.—Screen type; G = Green, B = Blue, M = Medium persistence, S = Short persistence.

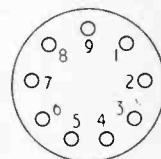
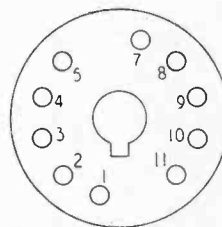
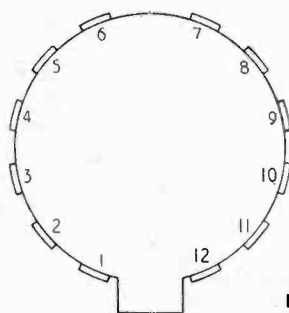
The connections given in the lists of bases are liable to alteration. The effective connections will usually be as shown, however, as the changes usually involve taking two leads to a common connection to avoid the necessity of strapping them externally. The addition of a suffix letter is sometimes used to indicate more extensive changes.

The dimensions given are the overall length and the effective screen diameter (mm). Symbols: V₁ = first anode, V₂ = focus anode, V₃ = final anode, V_{max}, maximum final anode potential in kilovolts; I_b, beam current (µA). The sensitivities are given in mm/V.

12-WAY S.C.

12-PIN SPIGOT

BRITISH 9-PIN



BASE CONNECTIONS

British Standard 9-pin Base

	1	2	3	4	5	6	7	8	9
9.1	X ₁	Y ₁	A ₂	H C	H	M	A ₁ A ₃	X ₂	Y ₂

Standard 12-way side contact (G.E.C. type)

	1	2	3	4	5	6	7	8	9	10	11	12	Caps	
12.1	M	—	H C	H	A ₁	A ₂	Coa.	X ₂	—	A ₃	—	X ₁	Y ₁	Y ₂
12.2	M	—	H C	H	A ₁	A ₂	Coa.	Y ₂	X ₂	A ₃	X ₁	Y ₁	—	—
12.3	M	C	H	H	A ₁	A ₂	Coa.	Y ₂	X ₂	A ₃	X ₁	Y ₁	—	—

12-pin spigot-type base

	1	2	3	4	5	6	7	8	9	10	11	12
12.4	C	M	H	H	A ₂	—	Y ₂	X ₂	A ₃	X ₁	Y ₁	—

SYMBOLS: M = Modulator (grid); H = Heater; C = Cathode; Coa. = Coating; X₁, X₂ = X-axis deflector plates; Y₁, Y₂ = Y-axis deflector plates; A₁, A₂, A₃ = Anodes numbered from the cathode. (Anodes one and three may be strapped internally, the A₁ connection being omitted. X₁ and Y₁ may be similarly treated. These variations are unpredictable.)

experienced between different tubes of the same type.

It may be noted that, while some of the types given are closely similar as far as the quoted characteristics are concerned, they

are not equivalents. This may be due to different minimum spot sizes or similar factors relatively unimportant for many applications, but is often a matter of construction.

Short-wave Conditions

Expectations for December

By T. W. BENNINGTON (Engineering Division, B.B.C.)

DURING October daytime maximum usable frequencies for this latitude increased very considerably, and during the last week of the month reached very high values, for example, a measured value of 47 Mc/s at 1200 G.M.T. on 31st. Contrary to expectation night-time M.U.F.s were, on the average, no lower than during September.

Had it not been for a large amount of ionosphere storminess daytime working frequencies would have been much higher than they were. Even so, frequencies like the 28-Mc/s amateur band were more or less regularly usable, while it is reported that a Dutch amateur established contact on 50 Mc/s with two amateur stations in Capetown. Night-time working frequencies were relatively high for the time of year. Sporadic E decreased very considerably in the frequency of its occurrence during the month.

Conditions were very disturbed during the first three weeks of the month, the worst periods of ionosphere storminess being 1st/3rd, 9th/16th, 18th/20th and 24th.

Forecast.—Daytime M.U.F.s are expected to be somewhat lower in December than in November, due to the peculiar "mid-winter" effect in the Northern Hemisphere. Daytime working frequencies will, however, still be relatively high, though the period when high frequencies are usable will be somewhat shorter than during November. The 28-Mc/s amateur band should still be regularly usable over daylight paths, but conditions will not be so favourable for long-distance contacts on 50 Mc/s, which is not to say, of course, that none will occur. Night-time M.U.F.s will fall to their lowest values for the winter, and night-time working frequencies, which will be as low as 7 Mc/s over some long-distance circuits, will remain in use for longer periods than at present.

Below are given, in terms of the broadcast bands, the working frequencies which should be regularly

usable during December for four long-distance circuits running in different directions from this country. *All times in this article are in G.M.T.* In addition, a figure in brackets is given for the use of those whose primary interest is the exploitation of certain frequency bands, and this indicates the highest frequency likely to be usable for about 25 per cent of the time during the month for communication by way of the regular layers:—

Montreal :	0000	9 Mc/s	(14 Mc/s)
	0300	7 "	(12 ")
	0900	9 " or 11 Mc/s	(16 ")
	1100	17 " or 21 Mc/s	(26 ")
	1300	26 "	(38 ")
	1800	21 "	(29 ")
	2000	17 " or 15 Mc/s	(22 ")
	2300	11 "	(18 ")
Buenos Aires :	0000	11 Mc/s	(16 Mc/s)
	0500	9 "	(14 ")
	0700	11 "	(18 ")
	0800	21 "	(28 ")
	0900	26 "	(40 ")
	1900	21 "	(32 ")
	2000	17 " or 15 Mc/s	(22 ")
	2200	11 "	(18 ")
Cape Town :	0000	11 Mc/s	(16 Mc/s)
	0300	9 "	(15 ")
	0500	11 "	(20 ")
	0600	17 "	(29 ")
	0700	26 "	(40 ")
	1700	21 " or 17 Mc/s	(29 ")
	2000	15 "	(21 ")
	2200	11 "	(18 ")
Chungking :	0000	7 Mc/s	(12 Mc/s)
	0400	9 "	(14 ")
	0500	11 "	(16 ")
	0600	17 " or 21 Mc/s	(23 ")
	0800	26 "	(36 ")
	1200	17 " or 15 Mc/s	(24 ")
	1700	11 " or 9 Mc/s	(15 ")
	2300	7 "	(13 ")

Ionosphere storms are not particularly frequent or of exceptionally long duration in December, though those which do occur are often particularly troublesome after darkness, because of the already low ionisation prevailing during the winter night. At the time of writing it would appear that disturbances are more likely to occur within the periods 2nd/5th, 8th/9th, 13th/14th, 22nd/23rd and 30th/31st than on the other days of the month.

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Additive and Multiplicative Mixing

THE recent article¹ by C. J. Mitchell is a very useful contribution to a difficult subject. There can be very little doubt that the multiplicative and additive processes are the same thing. In each case the mixing is performed by a valve — by an "anode bend" or other device of non-linear current/voltage characteristic in the case of "additive" mixing, and by a "linear" modulator such as a tetrode, pentode, hexode or heptode, in the case of "multiplicative" mixing.

To take the first case first, it is worth while to examine closely the significance of the term "additive." It is true that the two oscillations are added together in the input circuit of the non-linear device, but that is not all. The fact that the current/voltage characteristic is not linear indicates at once that multiplication must occur *within* the device.

For example, suppose we have a valve possessing a current/voltage characteristic of the form

$$i_a = a + bv + cv^2$$

where a and b are constants and v is the total signal input, and suppose this to be

$$v = A \sin pt + B \sin qt \quad (p > q)$$

Then $i_a = a + b(A \sin pt + B \sin qt) + c(A \sin pt + B \sin qt)^2$

Expanding this expression we obtain terms in $\sin pt$, $\sin qt$, $\sin^2 pt$, $\sin^2 qt$, and the product $\sin pt \cdot \sin qt$. The last-mentioned can be resolved, as Mr. Mitchell points out, into terms involving $(p - q)$ and $(p + q)$. In other words, *through the multiplying action of the valve*, the output current contains, amongst other things, components of angular frequencies $(p - q)$ and $(p + q)$, and also p . These represent a carrier wave of frequency $p/2\pi$ flanked by sidebands of respective frequencies $(p - q)/2\pi$ and $(p + q)/2\pi$. Or, if you like, the valve has modulated p with q .

If p is of radio frequency and q is of audio frequency, the output current contains what we generally regard as a normal modulated wave; but if p and q are both of radio frequency and are separated by a few hundred cycles per second, then the output current contains an audio frequency term $(p - q)/2\pi$ which is not present in the input circuit, and we have a case which is identical with the heterodyne reception of C.W. telegraphy. Similarly, if $p/2\pi$ represents an incoming signal

By J. W. WHITEHEAD,

B.Sc., M.I.E.E., A.Inst.P.

frequency, and $q/2\pi$ is a local oscillator frequency, then $(p - q)/2\pi$ can be the intermediate frequency of a superheterodyne receiver.

Let us now proceed to the "multiplicative" mixer. Consider a tetrode valve with two concentric grids. Each grid has its own effect on the anode current, but they will also produce, together, effects which neither of them can produce singly.

Let the mutual conductance of the portion comprising cathode,

Further Thoughts on Heterodyning and Modulation

inner grid and anode be g_1 , and let that of the cathode, outer grid and anode be g_2 , both slopes being measured at the same electrode potentials. Now suppose the bias to the inner grid to be made more negative by an extent V_{g1} . The anode current will fall and the outer part of the valve will behave as though the emissivity of the cathode is reduced, and accordingly its slope will be less, depending on the value of V_{g1} . By suitable design, it can be made directly proportional to V_{g1} , and we may write the new slope as $KV_{g1}g_2$. Now apply a steady voltage change V_{g2} to the outer grid. The anode current will change by $KV_{g1}g_2V_{g2}$, i.e. the anode current is proportional to the product of the voltages applied at the two grid circuits. But the voltages need not be steady ones. They are usually in the form of a fixed bias plus an alternating voltage, and so V_{g1} and V_{g2} could be written as $(C + A \sin pt)$ and $(D + B \sin qt)$. The resulting anode current will then be:

$$I_a = g_2 K (C + A \sin pt) (D + B \sin qt)$$

$$= g_2 K \left[CD + CB \sin qt + DA \sin pt + \frac{AB}{2} \cos(p - q)t - \frac{AB}{2} \cos(p + q)t \right]$$

Again we have our carrier p and its sidebands $(p - q)$ and $(p + q)$.

A point here is worthy of note. If the angular frequencies p and q are zero, then

$$I_a = g_2 KCD.$$

On applying signals of frequencies $p/2\pi$ and $q/2\pi$, the only additions to the anode current are alternating ones. *No rectification occurs.*

From the foregoing, therefore, it

is apparent that both types of mixing are multiplicative, the term "additive" being really a misnomer; and furthermore, it is clear that modulation, frequency changing, and the heterodyne reception of C.W. are all different versions of the same thing, the difference lying only in the relative values of p and q .

It could perhaps be appropriate to make constructive comments on a few points in Mr. Mitchell's article.

On p. 360 at the top of column 2 it is stated that the resultant frequency of two beating oscillations is the average of the two components. I feel that Mr. Mitchell should have

stated more clearly that this applies *only* to the case in which the component oscillations have equal amplitudes. It can be shown that the resultant oscillation is to some extent frequency modulated at the beat frequency between the limits (using my notation)

$$p \left[1 - \frac{B}{A} \left(\frac{p - q}{p} \right) \right] \text{ and } p \left[1 + \frac{B}{A} \left(\frac{p - q}{p} \right) \right]$$

i.e. the mean angular frequency tends to p rather than to $(p + q)/2$, and in fact is only equal to $(p + q)/2$ when $A = B$.

Mr. Mitchell further states (p. 361, col. 1) that a wave-form diagram of the resultant of two beating oscillations does not reveal a phase-shift. If such a diagram is drawn, a closing-up of successive half-cycles is revealed as we move from positions of maximum to minimum resultant amplitude, and the reverse as we move from resultant minima to maxima. Presumably, this could be regarded as both a progressive shift of phase and as an indication of frequency modulation.

We can derive an expression for the instantaneous phase ϕ by splitting $(A \sin pt + B \sin qt)$ into terms

$$+ \frac{AB}{2} \cos(p - q)t - \frac{AB}{2} \cos(p + q)t$$

involving sums and differences of half-angles. It is that

$$\tan \phi = \frac{A - B}{A + B} \tan \frac{p - q}{2} t$$

Lastly, it is stated on p. 360, col. 2, that "the simple addition of two sinusoidal quantities results in multiplication." This is not true, and I do not think that the author

¹ Wireless World, October, 1947.

Additive and Multiplicative Mixing—really means this. What I feel he means to say is that the resultant of two beating oscillations is another oscillation of varying amplitude and phase *which can therefore be regarded as a modulated wave*. Modulated waves, as we usually understand them, are composed of at least three oscillations, whereas heterodyne action need involve only two. Nevertheless, it is possible to derive mathematically an expression for a modulated waveform which approaches closely to that resulting from the superposition of two oscillations of roughly equal frequency.

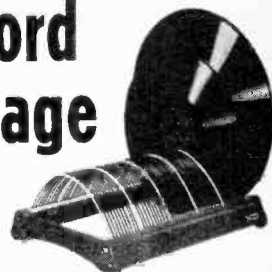
Two tuning forks of almost equal frequency can be used in the follow-

ing manner readily to demonstrate the effect of the multiplying together of two oscillations.

Take two tuning forks of the same frequency and load one with a small piece of sealing wax or chewing gum. On sounding them simultaneously, the ear at first detects a beat tone of one or two cycles per second, but as the amplitudes decay and become very small, the beat tone vanishes. This is accounted for by the fact that the input/output characteristic of the ear is non-linear for large inputs, and so "multiplication" occurs and the difference frequency is apparent. For small inputs, the characteristic is sensibly linear and so no beats are heard.

1937

Record Storage



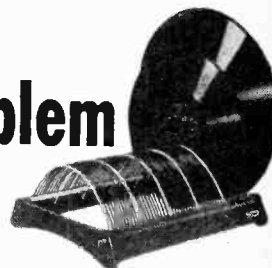
Here, to end your record storage problem once and for all, is the new lightweight portable 'IM RAK'. Holds up to 50 records, 10" and 12", yet requires little more space than a medium-sized table lamp.

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For details of your nearest supplies write to Alfred Imhof, Ltd., Dept. W3, 112, New Oxford Street, London, W.C.1. Museum 5944.

LETTERS TO THE EDITOR

The First Aerial ♦ Damping Speaker Coils ♦ Modulation and Frequency-Changing

Who Invented the Aerial?

WITH reference to the article published in your September issue on the invention of the aerial, I beg to inform you that a group of Russian scientists has written an open letter of protest to the committee which is organizing in Italy the celebration of the 50th anniversary of Marconi's invention of wireless telegraphy. According to the Russian professors the real inventor of wireless telegraphy should be the Russian physicist Popov. I have replied to the above open letter, repeating the statements made by Popov himself on board the Italian cruiser *Carlo Alberto* in July, 1902 (statements already reproduced by *Wireless World*). But now I beg to add the following facts:—

At the first Berlin international wireless conference in 1903 a Russian delegation, which included Popov, was present. As one of the Italian Government delegates, I made during the conference an official statement about the invention of wireless telegraphy and about the long examination made by the patents offices of Russia, of Germany, of England and America upon Marconi's patent application for wireless telegraphy by electric waves. This examination lasted about one year and the fundamental patent for wireless was granted to Marconi on June 2nd, 1897. Nobody was able to contradict my statement, which made a clear reference to the aerial.

Rome. LUIGI SOLARI.

Loudspeaker Damping

I AM very pleased to note the increasing recognition of the advantages of a high intensity magnetic field for damping loudspeaker speech coils.

I, too, share the belief that when the effective resistance of the speech supply circuit is low relative to the D.C. speech coil resistance, then little is to be gained from the point of view of damping by further reducing the input resistance.

In the case of triodes operating at a higher load line than the usual makers' rating, for example, with a PX25 (at 400V; R_a approximately 1,100Ω) operating at a 5,000-Ω load line, we have a drive-to-load ratio of about 1:4½. Even if the speaker is so efficient that its D.C. resistance is half the dynamic impedance, the ratio of drive-to-load D.C. resistance is still 1:2½, and this without circuit complications. If, by feedback, the input impedance is reduced to zero, the D.C. resistance of the speech coil still exists and currents due to back-E.M.F. cannot exceed $\frac{3}{2} = 1.45$ of their previous value.

A reduction of input resistance to one-third or one-quarter of its natural value will allow very nearly this maximum effect.

From the point of view of diminishing harmonic distortion, hum, etc., which in some circuits is reduced in the same ratio as the apparent amplifier output impedance, it will be obvious that it may well be desirable to use much more

Letters to the Editor—

feedback than that needed for damping purposes alone.

It is possible to overcome the damping limitation resulting from the D.C. speech coil resistance if this resistance is neutralized (in part) by something corresponding to radio-frequency reaction, only operating at A.F. and without tuning.

Such circuits naturally involve an element of possible instability in which frequency responses can "go crazy" and which may also lead to a region of overdamping.

Imagine a speech coil so solidly

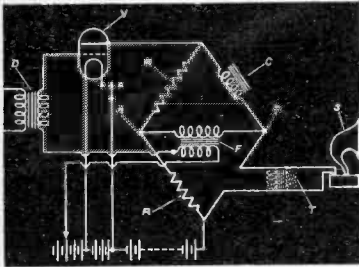


Diagram reproduced, by permission of the Patent Office, from Specification No. 231,972. (P. G. A. H. Voigt.)

damped that it becomes virtually a rigidly fixed object, the diaphragm vibration characteristics will then be quite different from those obtained when the coil is able to move. This may, or may not, be an improvement on the original design.

Circuits of the general type shown by D. T. N. Williamson in his letter (*Wireless World*, October, page 402) and evolved according to suggestions by P. d'E. Stowell and M. K. Taylor can produce such A.F. reaction effects if thrown slightly out of balance. It will be remembered that the circuit involved placing the loudspeaker in one arm of a bridge in which any unbalance voltage was fed back into the amplifier, so that if the back-E.M.F. due to coil vibration was excessive or deficient, this feedback remedied matters.

I have no doubt that the three gentlemen named would be interested to know that some years ago I patented a circuit in which the loudspeaker formed one arm of a bridge and in which unbalance voltage was fed back into the amplifier so that at resonance the appropriate frequency was automatically diminished, etc., etc. The circuit did actually work, the effect on multiple voices being to make them seem to go down the horn, and to sort themselves out better. The circuit, however, never went into

commercial production, as it was judged to be a little ahead of its time. This opinion you will understand when you look at the enclosed Specification [No. 231,972] and see that the application date is 29/1/1924.

P. G. A. H. VOIGT
London, S.E.19.

Heterodyning and Modulation

I WAS interested in the article by C. J. Mitchell on heterodyning and modulation, and the view he puts forward that modulation and frequency changing are the same process accords with my own.

The only difference between the two is that with modulation the output circuit is tuned to accept the carrier and both sidebands, whereas with frequency changing the output circuit is made selective to a band of frequencies centred about the lower sideband frequency.

I do not like his suggestion that addition can be shown to be multiplication as I think this view is apt to confuse the student. It is merely a mathematical wangle to change $\sin A + \sin B$ into

$$2 \sin \frac{(A+B)}{2} \cos \frac{(A-B)}{2}$$

and to say that addition is therefore multiplication. Multiplication, as I would understand it, is the multiplication of the original input frequencies; i.e. it would be represented by $\sin A \times \sin B$ and the result is the sum and difference and frequencies represented by $(A+B)$ and $(A-B)$. Pure addition cannot produce these sum and different frequencies; if these are required addition must be followed by multiplication, and this is performed by the rectification process. Taking the simplest rectifier, the square law type, the expression for anode current is:

$$I_a = a_0 + a_1 E_0 + a_2 E_0^2 \dots \quad (1)$$

If $E_0 = E_1 \sin \omega_1 t + E_2 \sin \omega_2 t$ (we can neglect any bias voltage there may be) the second term in (1) gives $a_2 (E_1 \sin \omega_1 t + E_2 \sin \omega_2 t)^2$ which contains the term

$$2a_2 E_1 \sin \omega_1 t \times E_2 \sin \omega_2 t$$

thus providing the sum and difference angular frequencies $(\omega_1 \pm \omega_2)$. With the multiplicative frequency changer such as the pentode with suppressor grid injection, or the heptode, etc.

$$I_a = (a_0 + a_1 E_{01}) (b_0 + b_1 E_{02}) \dots \quad (2)$$

where neglecting bias

$$E_{01} = E_1 \sin \omega_1 t$$

and

$$E_{02} = E_2 \sin \omega_2 t$$

The term $b_1 b_2 E_1 \sin \omega_1 t \times E_2 \sin \omega_2 t$ will be obvious from the above. Incidentally, detection is by the same process as modulation and frequency

changing, and the output circuit is now tuned to the lower sideband frequency, (the audio difference frequency) produced by multiplying the carrier by the lower and upper sidebands. Rectification is also similar, the output circuit being tuned to the lower sideband frequency produced by multiplying the mains input voltage by itself. The difference frequency from this product will, of course, be zero frequency; i.e. it will be D.C.

Evesham. K. R. STURLEY

[This subject is also referred to on p. 486.—ED.]

Effective Use of Amateur Frequencies

AT the present time we hear quite a lot about vicious spirals in connection with economic affairs. May I, as an old amateur, venture to suggest that amateur radio is at present in the throes of a vicious spiral of a rather different type, and it looks to me rather like this:

Every month between 100 and 150 new licences are issued in this country, which means that by 1950 there will probably be about 10,000 amateur transmitters in the small area of the British Isles—and there will be fewer channels for them.

More amateurs, fewer frequencies; this is by no means the whole story. British amateurs are now allowed inputs up to 150 watts (except for the first prentice year of operation). Increasing congestion in the amateur bands sorely tempts every amateur to go to the limit of the power and employ his full 150 watts (and some!), in order to make himself heard.

Even this is still not the whole story; much of this high-power operation in congested bands is by means of telephony, so that one powerful phone station spreads over enough kilocycles to accommodate twenty telegraphy stations.

The temptation to "pile on the watts" is aggravated by the present crazy Gadarene rush to work DX—a procedure which seems quite purposeless, since any individual with a good aerial, a good receiver and a few hundred watts can work any part of the world to order; there is little cleverness and no merit in doing so. I must also make mention of another abuse of the amateur bands: this is the selfish employment of high-power telephony for local or semi-local communication.

Two years ago you published an article from my pen forecasting, more or less, the state of affairs in the amateur bands as we see (or rather, hear) them to-day. I suggested there that if action were not taken among amateurs themselves

to rationalize their operation, then amateur radio would choke itself to death by sheer weight of numbers. To-day that is more true than ever. What it will be like by 1950, I shudder to think.

Can British amateurs discipline themselves in time? Or is amateur radio, as a pleasant scientific hobby, doomed to extinction?

That, flatly, is the choice before us. "ETHERIS."

Television Afloat

IT may be of interest to some of your readers to learn that a Pye Di6T console television receiver has been successfully installed in a 35-foot four-berth cabin cruiser, "Golden Spray," on the River Cam.

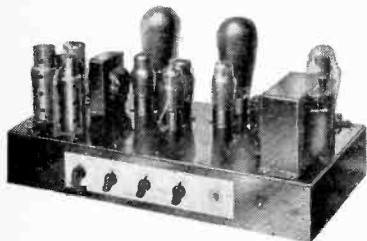
Consistently excellent results have been obtained on the waterways in and around Cambridge and about 30 miles north at Redmere. Furthermore, a picture of reasonable entertainment value has been obtained whilst sailing in The Wash between King's Lynn and Hunstanton. Considering the aerial is mounted on a 20-foot telescopic steel mast, 6 feet of which is inside the boat, this could be regarded as a tribute to the sensitivity of the receiver used.

The Antiference aerial used lends itself admirably for this job due to the ease of dismantling when the mast is telescoped after use.

"CONCERTO" AMPLIFIER

DESIGNED for the reproduction of records, this amplifier has eight triode valves and a rectifier. The first stage is a pre-amplifier for moving-coil pickups, and can be switched out when the input is from moving-iron or crystal pickups. The output stage consists of two PX25s in push pull, and negative feedback is applied over three stages, including the phase-splitter.

Separate tone controls for "Treble" and "Bass" are provided. The



Separate "Treble" and "Bass" tone controls are provided in the "Concerto" model made by Charles Amplifiers.

"Treble" control provides both cut and boost, while the "Bass" has six steps, from linear to full boost at 8db per octave.

It is claimed that the overall distortion for an output of 7 watts is 1.3

Apart from being telescopic, the mast is also rotatable, allowing the aerial to be swung for "maximum" irrespective of the orientation of the boat.

The power supply is obtained from a carbon pile regulated rotary converter which is driven by the boat's 24V D.C. battery supply.

If any of your readers have had experience of installations of a similar nature it will be most interesting to hear of the results obtained.

C. E. TATHAM.

Langham Radio Services,
Cambridge.

Aerial Aesthetics

JUDGING from the photograph of the model of the television relaying site appearing in your last issue, there is little wonder that the proposal, put forward earlier in the year, to erect a television relay station near White Horse Hill on the Berkshire Downs aroused so much antagonism.

The designers of these and other aerial masts and towers might do well to examine some of the long-span bridges. If the civil engineer can design bridges that are pleasing to the eye, why cannot the electrical engineer, justly proud of his circuit design, take interest in the appearance of the work as a whole?

Cambridge. P. G. BRIGGS.

per cent, and 2 per cent at 13 watts. The price is £27 10s and the makers are Charles Amplifiers, 1e, Palace Gate, London, W.8.

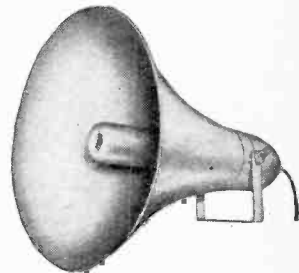
RADIO'S ENEMY No. 1

A COMPREHENSIVE survey of existing knowledge on all kinds of radio noise is made in a special report (No. 15) just issued by the Department of Industrial and Scientific Research. The types of interference dealt with are summarized in the main chapter headings: receiver, thermal, cosmic, atmospheric and man-made. Two later chapters are on the influence of noise on reception and on measurements. Suppression is not treated at any length.

In the concluding "Recommendations" it is stated, "The survey shows that in no section is the knowledge complete; in fact, it indicates a wide field for further investigation."

"Survey of Existing Information and Data on Radio Noise over the Frequency Range 1-30 Mc/s," contains 126 pages and 57 figures; it is issued by H. M. Stationery Office, Kingsway, London, W.C.2, at 3s (by post 3s 4d).

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The 42REH is not of the "loud-hailer" type of speaker, but is designed to cover a range of frequencies considerably greater than those needed for purely "announcing" purposes; i.e., it is suitable for all normal requirements of high power reproduction of music as well as speech.

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Bell diameter	... 22in.
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Effective Air Column	... 42in.
Weight Horn only	... 8 lbs.
Shipping space	... One—23in. x 23in. x 18in. 12—33in. x 33in. x 27in.

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RANDOM RADIATIONS

By "DIALLIST"

The More the Merrier!

IT is a rather amazing thought that one person in every hundred of the whole population of Great Britain visited the Radio Exhibition during its ten days' run. Nevertheless it was so, for there are forty-four million-odd of us and the attendance at Radiolympia was 440,320. Had the show been held in school holiday time the figure might have been a good deal higher, for schoolboys (and schoolgirls too) are great wireless enthusiasts, as all of us know who either have children of our own or number other people's amongst our friends. That the attendance was so large—nearly double that of any pre-war exhibition—seems to me to be due to four main causes. The first, and possibly the most important, is that so many veteran receivers are now crying out to be placed on the retired list. The second, that many visitors rather expected to find breath-taking advances due to wartime progress. The third, that television was a prominent feature and that interest in this department of wireless is more lively than ever. The fourth, that it was a genuine radio exhibition and not just a show of broadcast receiving equipment. Whether or not that's a correct diagnosis, all the world and his wife were certainly there. On some of the most crowded days the hall became so packed that one could have believed almost any attendance figure!

Sound, but Not Spectacular

Of course there were those who crabbled the show. There always are. One cynic told me that the only important advance he'd been able to discover in broadcast receivers was in their prices—the kind of thing that has to be said by a fellow with a reputation for mordant wit, no matter how far it may be from expressing his real opinion. I agree that there weren't any spectacular developments—things to knock the non-technical visitor all of a heap, as did, for example, the all-mains receiver, the screen-grid valve, the pentode, the moving-coil loudspeaker, the ganged tuning condenser and the pickup in their respective years. But there were plenty of good things there, if you looked for them. What, perhaps, interested me most was the way in which so many makers had managed to turn out good jobs of work whilst making little or no use of

materials that are now scarce, though once they were plentiful enough. The spirit seemed to be: If we can't get *this*, we'll make do with *that* and jolly well see that the job's as good as ever it was. Another important point is that one of the things we had perforce to learn during the war was how to make sets of all kinds that were easy to handle and could be relied upon to stand up to hard wear. The knowledge gained in wartime has been put into the peacetime receiver, which at its best is a sound, well-designed piece of work mechanically as well as electrically.

What Next?

Come to think of it, how and where are spectacular improvements possible in broadcast receivers today? Increased sensitivity? Today's receiver brings in pretty well all the stations that the ordinary listener is likely to want. Selectivity? Most respectable sets will separate stations with channels 9 kc/s apart. Unless we discover some new method of transmitting we can hardly ask the broadcast receiver to do more than that. Higher fidelity in reproduction? Here, perhaps, something might be

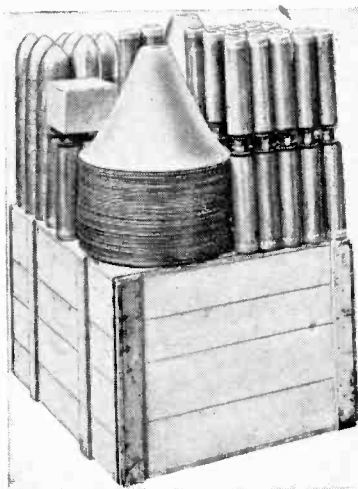
done, though with the present limited A.F. band imposed on short-, medium- and long-wave transmitters, I doubt whether the public would regard the results as spectacular. Something, again, might be achieved in the moderately priced sets in the way of lessening the content of 2nd or 3rd harmonic in the output: but would the man in the street be in raptures over that? Again I permit myself to be doubtful. More efficient valves? We already have quite a few three-valve-plus-rectifier superhets. Valves making a smaller drain on sources of H.T. and L.T. supply? Already the mains set costs no more to run than a single small electric light bulb. Battery users would be pleased; but such an improvement would hardly be as sensational nowadays as it might have been some years ago, for battery sets are fast becoming fewer and fewer. No, it's not easy to think of any likely improvement on existing methods of long- and medium-wave broadcast reception which could cause a furore. The most probable "sensational" of a future Radiolympia is F.M., of which the ordinary listener in this country has heard little as yet.

The Popular Televisor

In television receivers, though, I feel that the improvement since the previous radio exhibition has been phenomenal. I'm thinking particularly of the moderately priced instruments, made up in compact form and with all but the most straightforward controls preset, which give an image of round about seven and a half inches by six. I have an idea that that size of image is going to make a very wide appeal, so long as our transmissions are limited to 405-line definition. People have begun to realize that it is about the largest you can do with comfortably in the average living room of to-day, if you're not to spoil results by viewing at too close quarters. Compare the best of the $7\frac{1}{2} \times 6$ or $8\frac{1}{2} \times 6\frac{1}{2}$ vision receivers of to-day with medium-priced sets of 1939, and I think you must agree that there has been a very remarkable advance. Their clear, contrasting, steady pictures; their effective limiting of the snow-storm effects due to ignition interference; their simplicity of operation—all these make them completely different things from most of the television of pre-war days.

A Moot Point

One thing the manufacturers do not yet seem to be at all certain about is the form that the great public is going to want its television receivers to take. Will the



COMPRESSED SPEAKER HORNS. Film Industries have re-designed their re-entrant loudspeaker horns to save space in export packing; 80 of them now go in a case of 24 cubic feet

most popular set eventually prove to be the SV, the VML, the VAW, or the VAWRg? I'm beginning to change my mind about that. I used to think that Mr. and Mrs. Everyman's ideal was to have a single piece of furniture which would be the complete provider of entertainment in the home and that they would not really be satisfied with anything less than the television *cum* all-wave radio receiver *cum* gramophone unit. I still believe that there will be a big demand for such instruments by those who have the money to pay for them and living rooms large enough not to be overweighted by their necessarily rather large cabinets. But something tells me that the small vision *plus* accompanying sound only model is going to have bigger sales than any other in the immediate future. And it's not just its modest price and its small size that may be the deciding factors. Many people do not want to put all their eggs into one box, so to speak. They prefer to be able to have the broadcast receiver in one room and the television in another when they want to do so. Others, again, already have broadcast receivers or radiograms with which they are quite satisfied.

□ □ □

Another One On Magnets

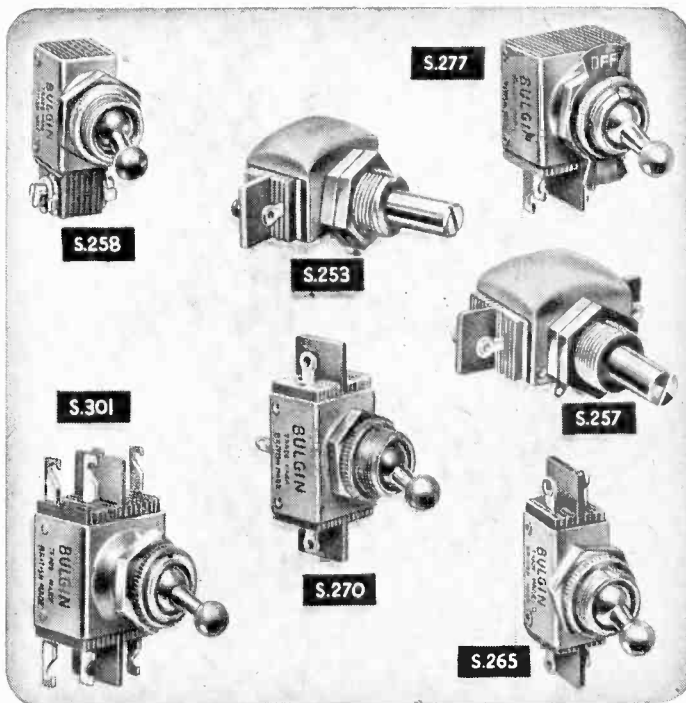
YOU may recall that some months ago I suggested a simple little problem about two steel bars of exactly the same size and appearance, one of which was magnetized whilst the other was not. How could you quickly tell t'other from which, supposing that you had no instruments of any sort or kind, no other bits of iron or steel, not even a piece of string? The answer given was: arrange them like a T. Then if there is no attraction, the cross piece is the magnet. If there is, the magnet is the upright. I was surprised that no one wrote in to say that he could produce a pair of steel bars answering the description given on which this test would fail. Any offers?

MULLARD VALVE DATA

A REVISED edition of the Mullard Wall Catalogue has been issued for use by retailers by Mullard Wireless Service, Century House, Shaftesbury Avenue, London, W.C.2.

A very useful new section is that dealing with substitution types. Full details of alterations to base connections and associated circuits are given in cases where these are necessary.

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S.265	" " " " change-over, for 6-250V. 2A. wkg.
S.270	" " double-pole, change-over, for 6-250V. 1A. wkg.
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BOOK REVIEWS

Radar System Engineering. Edited by L. N. Ridenour. Pp. 748 + xviii, with 446 illustrations. McGraw-Hill Publishing Co., Ltd., Aldwych House, London, W.C.2. Price 37s 6d.

THIS volume is the first in a monumental publication—a series of twenty-eight, recording the work of the Radiation Laboratory of the Massachusetts Institute of Technology, which was the great American wartime centre for radar research and development. Circumstances in this country having restricted systematic publication of our work in this field to Part III A of the I.E.E. Journal, appreciation will be felt for the acknowledgment in the Foreword that the Radiation Laboratory Series records the collective result of work done not only in the U.S.A. but also in Britain and in the Dominions, and that it is dedicated to all who contributed in any way, anywhere, to what was perhaps the most remarkable cooperative development enterprise ever carried out.

Most of the other volumes in the series are devoted to specialized principles and techniques, and since many of them have applications far beyond radar the aim has been to point out the general applicability of the work reported, avoiding any special emphasis on radar. The present volume is intended to apply this work specifically to radar.

The first eight chapters are devoted to the broad principles of radar, and include such matters as the radar range equation, the properties of radar targets, limitations of pulse radar, the alternative of c.w. radar, and the gathering, presentation and use of radar data. The last two deal with two special techniques which hitherto have not had much notice—moving target indication and radar relaying. The seven intervening chapters are on radar design, first in its components and then as complete systems.

This work has been divided among the team of experts responsible for the whole series, and has been ably carried out. In spite of an apologetic note about continued shortages, the volume is to British eyes a handsome one, doing credit to the ambitious scheme of which it forms a part.

While acknowledging the value of most of the material thus presented, the reviewer cannot help feeling that it does not quite fulfil expectations aroused by the title. The considerable sections on the tactical use of radar during the war seem completely out of place in an engineering work that claims to pro-

vide a basis for design. There is sufficient matter to make up what ought to have been a separate volume, of military and historical interest. Space would then have been released for filling in some passages which are somewhat superficial and descriptive, and for practical design data. Present-day radar engineers are more interested in present and future equipment than in what was done during the war, and may be disappointed at having to reorientate this for themselves instead of having it done for them. This criticism, applied to a work that announces itself as a record of war work, may on that account be a little unfair; but seeing that the general principles of radar have already been written—in some respects better—it is a pity that the Radiation Laboratory staff could not have been retained long enough for them to have reached a more forward-looking viewpoint, at which they would have turned their backs on details of merely historical interest and been able to concentrate on quantitative data of more use to the practical radar engineer.

M. G. S.

The Principles & Practice of Wave Guides. By L. G. H. Huxley. Pp. 328 + xi; 148 figures. Cambridge University Press, 200, Euston Rd., London, N.W.1. Price 21s.

THIS is the first of a new series of monographs to be published by the Cambridge University Press under the heading "Modern Radio Technique," the aim of which is to describe the advances in radio technique made during the war. It is based on courses given by the author at the Radar School of the Telecommunications Research Establishment.

The fact that a single hollow conductor could act as an efficient transmission line for waves of suitably high frequency has been known for many years, but prior to the war this waveguide had hardly emerged from being a laboratory curiosity. The development of centimetre-wave radiolocation, however, required also intensive practical and theoretical work on waveguides, and it is with these developments that the book is mainly concerned.

The first three chapters describe the various modes possible in rectangular and circular guides and the simpler properties of wave propagation in them. Those who have previously been alarmed by the seemingly difficult mathematics required in the study of this subject

will be gratified to find that the author uses only simple mathematics, and deduces the wave properties mainly from physical reasoning. The student thus gets a good appreciation of general principles, in which he is aided by excellent diagrams. But this process is limited, and the reader has for the moment to take many results on trust.

The fourth chapter introduces one to the many practical devices which have been developed—terminations, couplings, bends, transformers, etc.—and to some associated microwave apparatus. Examples are drawn from equipment designed for use at 9-cm and 3-cm wavelengths, but it is a pity that so much reference is made to $3\text{in} \times \text{rin}$ and $2\frac{1}{2}\text{in} \times \text{rin}$ guides as standards for the 9-cm waveband; these have little to recommend them and are now obsolescent.

In the next chapter waveguide techniques of a more advanced character are described. Impedance in waveguides and its relation to corresponding ideas in coaxial lines is treated well, but the reader will not gain much idea of when he may use the formula for intrinsic impedance and when that for total impedance. He will be more troubled later (p. 196) when he finds the formula for total impedance used under the name of intrinsic impedance. Detailed treatment is given of series and shunt junctions, and of such elegant devices as ring switches and T.R. cells.

Chapter 5 treats the modes of oscillation and some of the applications of cavity resonators. The diagrams are good, but it is not made clear which characteristic numbers are allowable for the different modes, and the E_{111} and E_{011} are wrongly stated as being the fundamental E-modes for rectangular and circular resonators respectively.

Thus far the mathematical treatment has been deliberately kept simple in order not to obscure the physical arguments; in the final chapter a purely analytical treatment is given, supplying the basic mathematical theory of the subject. The change is abrupt, and may come as a shock to the reader who thinks that he has learned everything without much mathematics, but it certainly has to be tackled if he is to have a sound understanding of the subject.

It is a good book, thoroughly up to date, and comprehensive, but it is spoiled by quite a number of errors, both of a major and a minor nature; none appear to be printer's errors. The layout and production of the book are attractive, and the price is not at all excessive.

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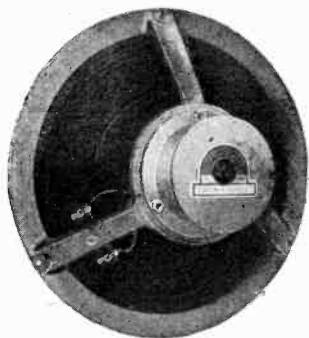
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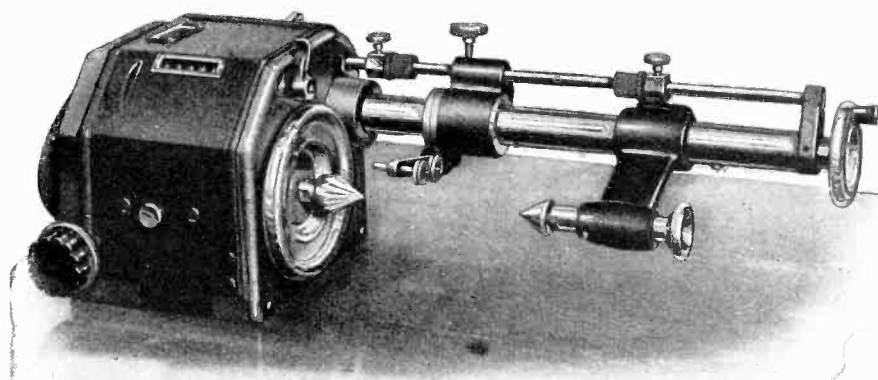
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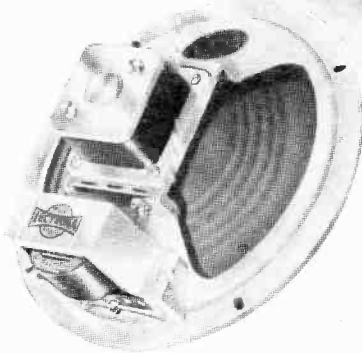
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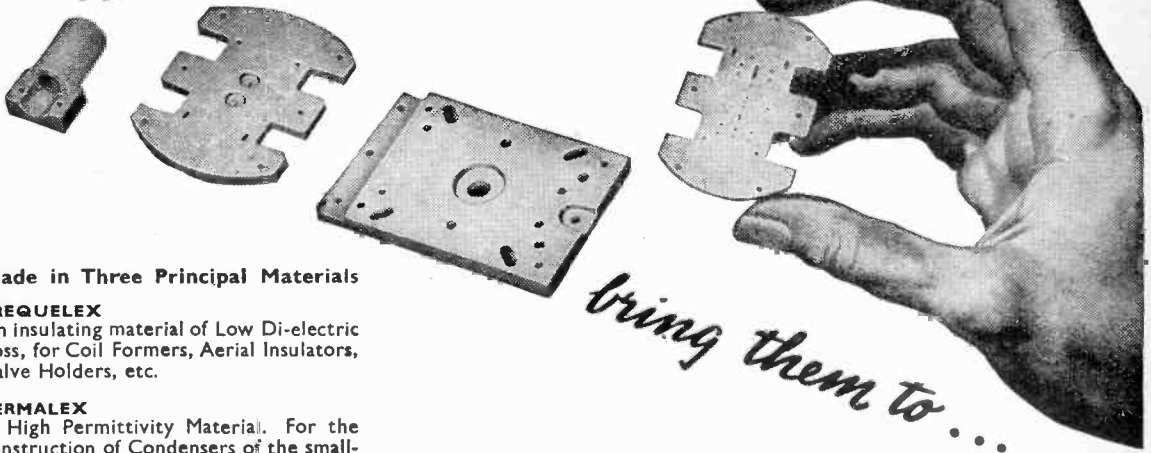
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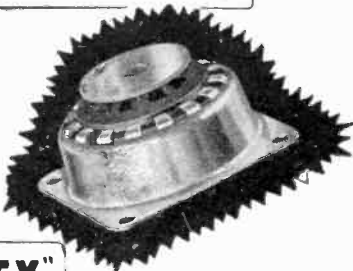


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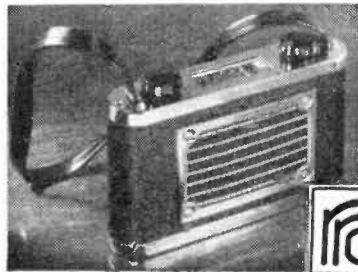
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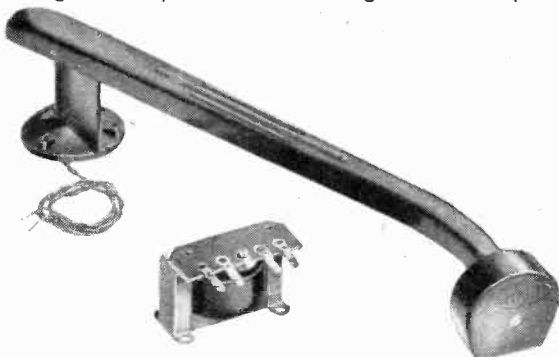
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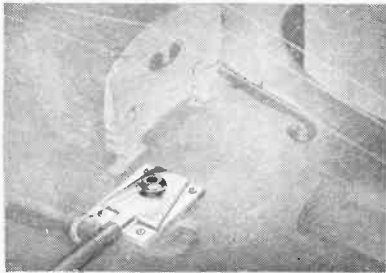
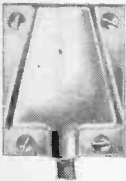
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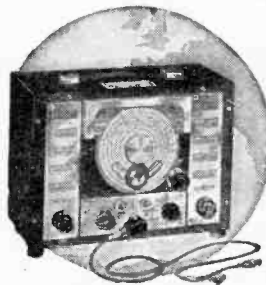
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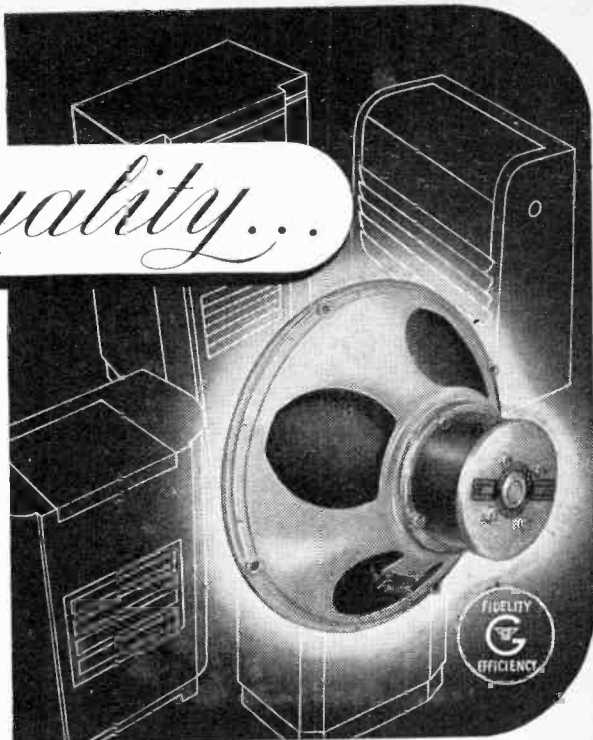
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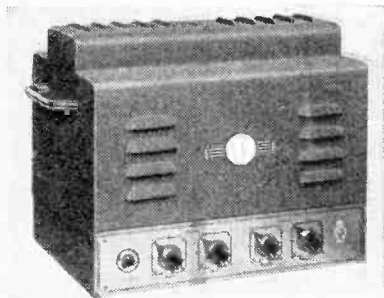
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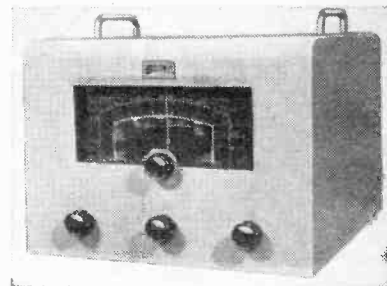
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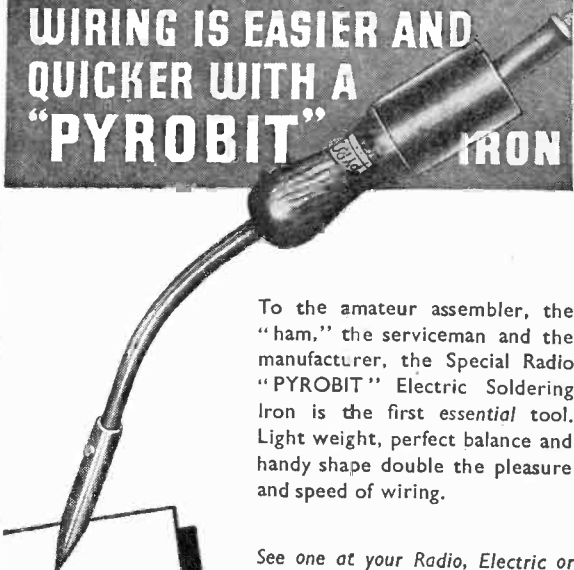
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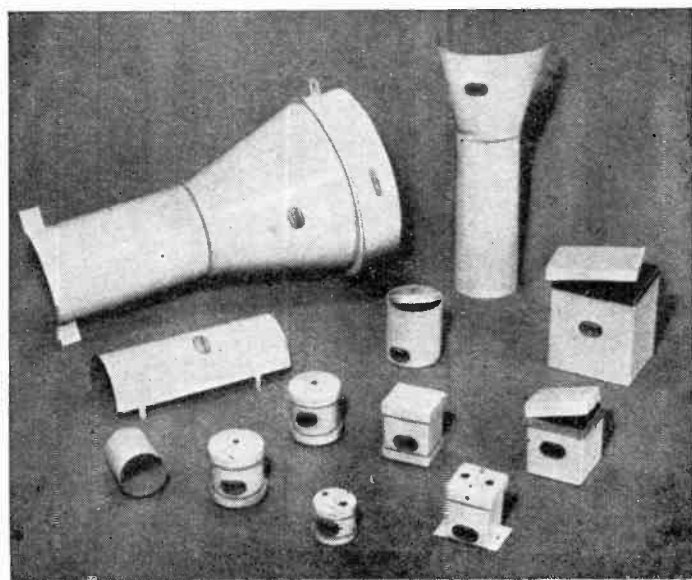
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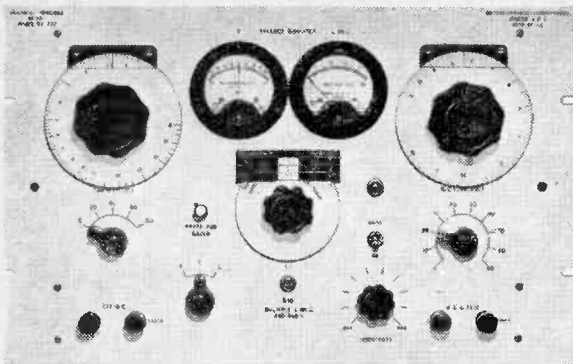
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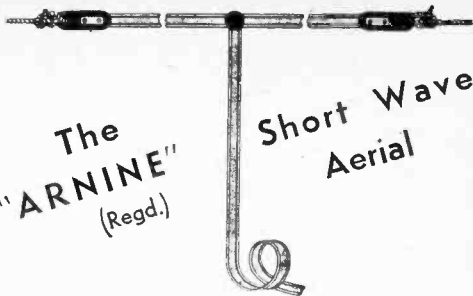
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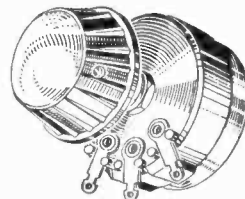
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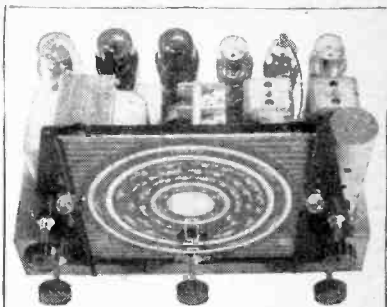
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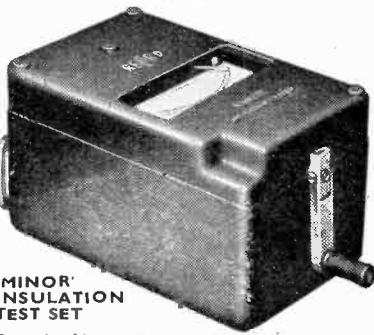
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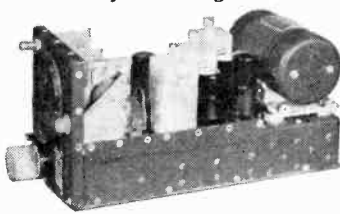
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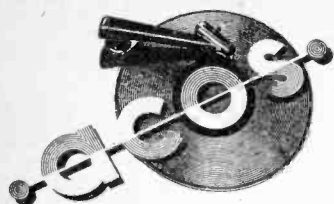
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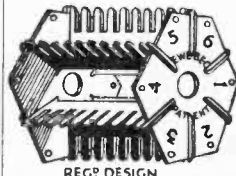
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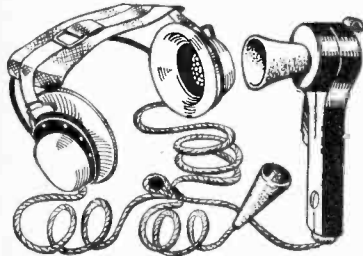
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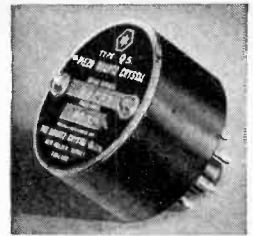
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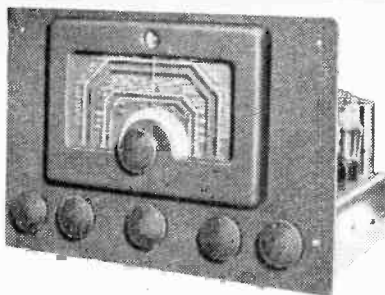
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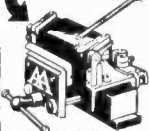
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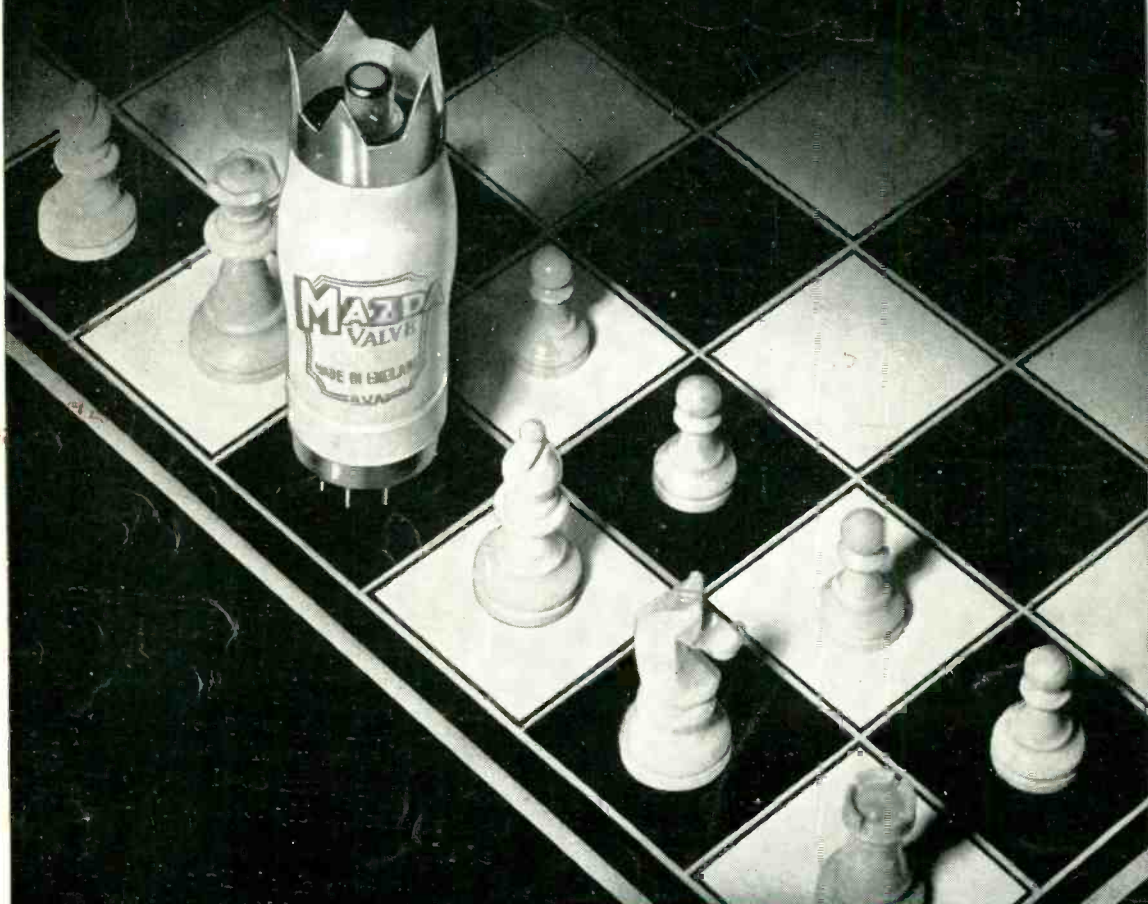
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