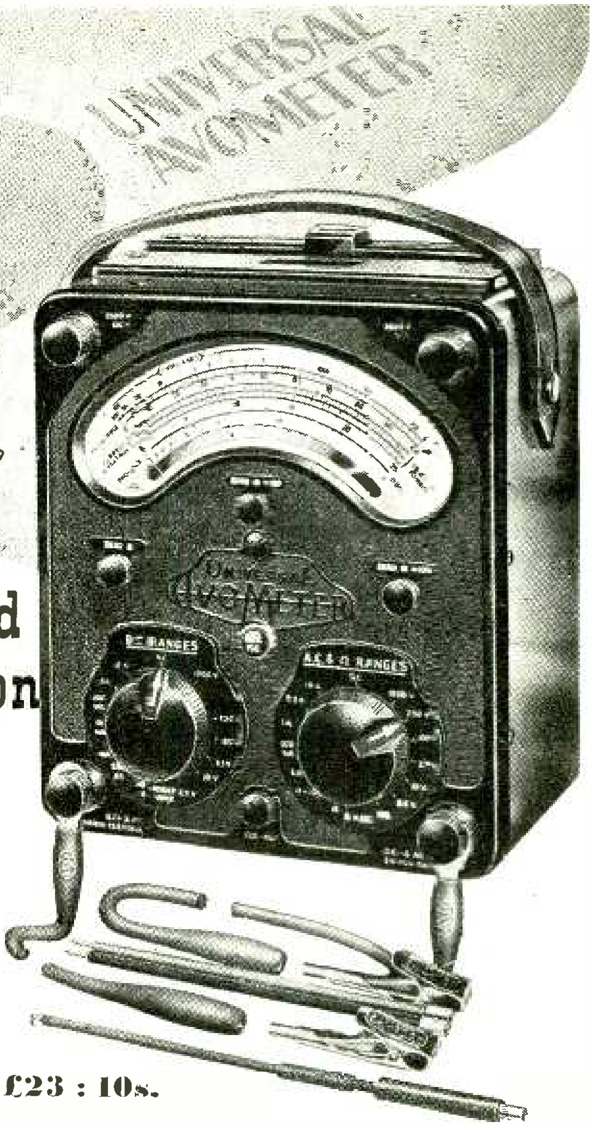

20,000 ohms per volt *plus* AUTOMATIC Overload Protection

Produced in response to a demand for a high sensitivity version of the world-famous Universal AvoMeter, this model incorporates the traditional design features of its predecessors, so highly valued for simplicity of operation and compact portability.

It has a sensitivity of 20,000 ohms per volt on all D.C. voltage ranges and 1,000 ohms per volt on A.C. ranges from 100V. upwards. A decibel scale is provided for audio frequency tests. In addition, a press button has been incorporated which reverses the direction of current through the moving coil, and thus obviates the inconvenience of changing over test leads when the current direction reverses. It also simplifies the testing of potentials, both positive and negative, about a common reference point. A wide range of resistance measurements can be made using internal batteries, separate zero adjustment being provided for each range.

It is of importance to note that this model incorporates the "AVO" automatic cut-out for protection against inadvertent overloads.

£23 : 10s.

Size $8\frac{1}{8}'' \times 7\frac{1}{4}'' \times 4\frac{1}{2}''$
Weight $6\frac{1}{2}$lbs. (including leads)

BRITISH INSTRUMENT INDUSTRIES EXHIBITION
OLYMPIA-LONDON JUN.30-JUL.11 '53
STAND Nº 115

For your Valve Characteristic Meter or Valve Tester

Owing to the very large number of valves which have been issued within the last two years, no further amendments will be issued for the original "Avo" Valve Testing Manual. A new, completely revised and fully up-to-date Valve Data Manual is now available from the Company at 15/- post free.

D.C. VOLTAGE	D.C. CURRENT	A.C. VOLTAGE	A.C. CURRENT	RESISTANCE
2.5V.	50µA	2.5V.	100mA.	First indication 0.5Ω.
10V.	250µA.	10V.	1A.	Maximum indication 20MΩ.
25V.	1mA.	25V	2.5A.	0—2,000Ω (using internal batteries)
100V.	10mA.	100V.	10A.	0—200,000Ω (using internal batteries)
250V.	100mA.	250V	—	0—20MΩ (using internal batteries)
1,000V.	1A.	1,000V.	—	
2,500V.	10A.	2,500V	—	0—200MΩ (using external batteries)

THE AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO. LTD.
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AVOCET TRADE MARK

A8/1

Specially designed for your new portable communications equipments.....

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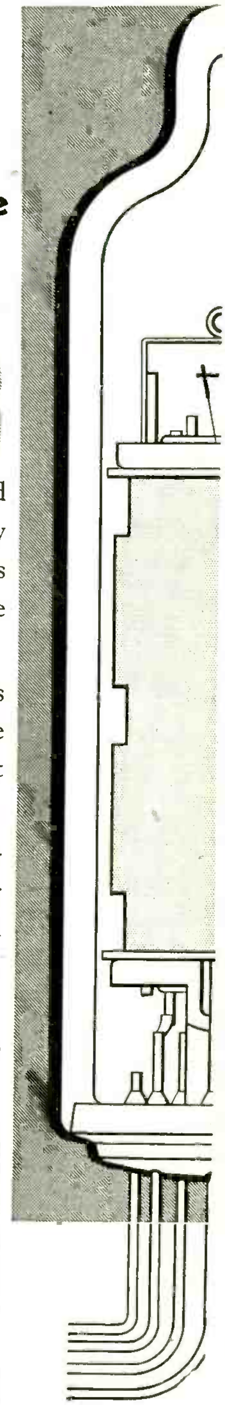
SUBMINIATURES



Combining outstanding electrical performance with small size and extremely low power consumption, this new Mullard range of battery subminiatures offers special advantages in compact telecommunications equipment of the "Hand talkie" and "Walkie talkie" nature, where space, weight, and available battery power are limiting factors.

With the exception of the DL70 R.F. output valve, these subminiatures have filament current ratings of only 25 milliamperes; the DL70, despite its power function, operates from the comparatively low filament current of 110 milliamperes.

Brief technical details of the current range of Mullard battery subminiatures for communications equipment are given below. Other subminiatures, including R.F. output types that will operate with high efficiencies at frequencies of up to 500 Mc/s, are now under development, and details of these will be made available shortly.

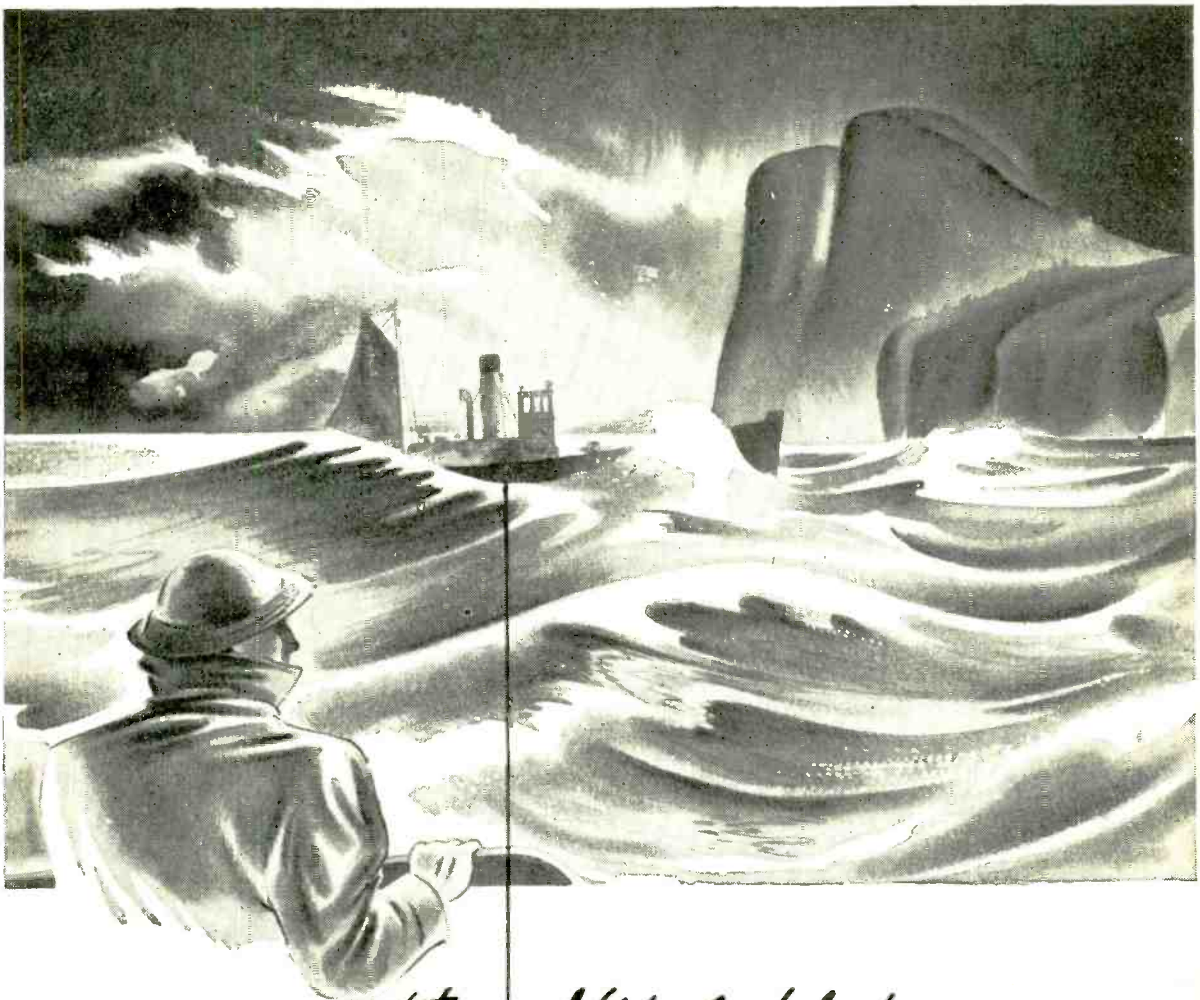
Complete technical details, including characteristic curves, of both battery and indirectly-heated subminiatures will be gladly supplied on request.

Type No.	Description	Filament (V) (mA)	Va=Vg2 (V)	Vg1 (V)	Ia (mA)	Ig2 (mA)	gm (mA/V)
DAF70	A.F. pentode combined with single diode	1.25 25	67.5	0	1.0	0.25	0.44
DF72	R.F. pentode with sharp cut-off ...	1.25 25	67.5	0	1.7	0.5	1.0
DF73	Variable-mu R.F. pentode	1.25 25	67.5	0	1.7	0.5	0.8
DL70	R.F. output pentode	1.25 110	150 (Vg2=90V)	−7.5	6.5	1.4	1.5
DL75	Output pentode ...	1.25 25	90	−2.5	1.75	0.4	0.85

Mullard

MULLARD LTD., COMMUNICATIONS & INDUSTRIAL VALVE DEPT., CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2

MVT134



The Vital Link . . .

. . . with safety in the hazardous enterprise of the deep sea trawler is its radio and radar equipment upon which safe navigation depends. Thousands of soldered joints contribute to the efficient functioning of this delicate apparatus. One dry or H.R. joint could mean the breakdown of a circuit, the destruction of the vital link, a perilous voyage.

FAULTLESS FLUXING PRESERVES THE VITAL LINK

Dry or H.R. joints are impossible with Superspeed for the flux is always released in exactly the correct proportion. This faultless fluxing action is achieved by the unique STELLATE core which gives six points of rapid solder collapse. At soldering temperature the activated rosin flux is released immediately for effective spreading and wetting. Superspeed is being used more and more in the production of radio and radar equipment where faultless joints are essential.

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"WHITE FLASH" ACTIVATED ROSIN-CORED SOLDER

for general electrical, electronic and telecommunication work and all standard uses. A.I.D. and G.P.O. approved. Complies with M.O.S. Specification DTD 599. In all standard tin/lead alloys, 10-22 s.w.g. Also available in a range of coloured cores, indispensable for simple intermediate and final inspection and circuit or operator identification. Samples of Superspeed and the comprehensive Superspeed booklet gladly sent on request. Technical advisers are available for free consultation.

Cored and solid solder rings and solid solder washers supplied to customers' specifications.

MANUFACTURED BY THE **ENTHOVEN** *GROUP*

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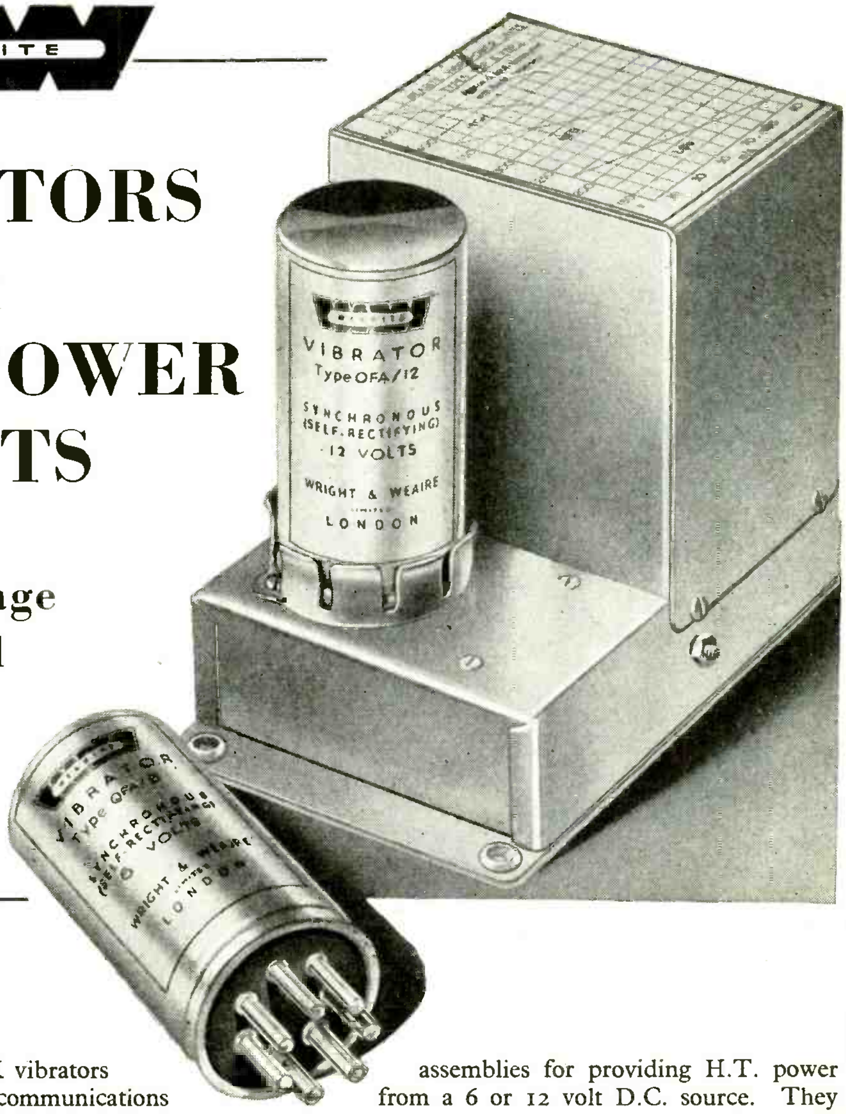
WEARITE

VIBRATORS & VIBRAPOWER UNITS

for Low voltage D.C. operated Electronic Equipment



THE range of Wearite/OAK vibrators for car radios and mobile telecommunications equipment has been especially designed for long and dependable service, whatever the extremes of climate.

The main structure is of steel and mica, so that expansion at varying temperatures is uniform, the base being sealed by the special Wearite process. The main contacts are ground to extreme limits of flatness and certain starting at the lightest of pressures and voltages is obtained by the use of non-tarnishable precious metal driving contacts. The vibrator is acoustically and electrically shielded by its sponge-rubber lined metal can.

A complete range—synchronous, non-synchronous and split-reed synchronous types—is available for all makes of car radio and other mobile equipment.

Vibrapower Units are completely self-contained assemblies for providing H.T. power from a 6 or 12 volt D.C. source. They include a tapped transformer for the selection of output voltage, buffer capacitors and basic R.F. filtering, and a Wearite/OAK vibrator of a type depending on input voltage. Provision is made for the earthed input pole to be connected to positive or negative as required.

H.T. smoothing is not included and must be externally connected, the value depending on the efficiency desired. An input filter must also be used.

The units are completely screened and are mounted on four rubber buffers to prevent possible transmission of vibration to other equipment. Full details of Wearite/OAK Vibrators and Vibrapower Units are available on request.

★ Wearite vibrators are manufactured under license of the Oak Manufacturing Co. of Chicago and are covered by various patents.

WRIGHT & WEAIRE LTD

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The new THE MASTER SOUND SYSTEM

MAGNETIC TAPE RECORDER

Type PMR/3

"from a pedigree line"

And its SPECIFICATION

The Tape Player itself is of unit construction which enables many special requirements and applications to be met without undue modification. The following features can be provided to special order:—

Tape speeds 7½" and 15" per second, or 3¾" and 1⅞" per second.

Synchronous drive motor.

Remote operation or foot control.

Automatic back spacing and reverse drive for dictation purposes.

Cassette tape loading.

Rack mounted assembly.

TAPE SPEEDS	7½" and 3¾" per second.
TRACKS	·1" wide. Number of tracks 2.
PLAYING TIME PER TRACK	30 minutes at 7½" per second. 60 minutes at 3¾" per second.
SPOOLS	Standard 7" and 5" plastic or metal.
SENSE OF SPOOLING	From left to right with tape coating inwards.
REWIND TIME	One minute for 1,200 ft. of tape (approx.).
HEADS	R.F. erase head. Record/playback head off-set for recording on upper track. Provision on player unit for additional monitoring head for special applications.
TAPE OPERATION	Single control provides:—Record, Playback, Fast Forward, Cueing, Rewind. To ensure additional safety against accidental erase, an additional record / playback switch is provided on the amplifier assembly. Power and brake operation is by means of a relay which will enable remote operation to be provided in special applications.

FREQUENCY RESPONSE	At 7½" per second 60-10,000 C.P.S. plus or minus 3 db. At 3¾" per second 70-7,000 C.P.S. plus or minus 3 db.
DISTORTION	Less than 2½% total harmonic distortion at normal operating level.
SIGNAL/NOISE RATIO	Approximately 50 db. using standard high output tape.
INPUTS	(1) Up to 50 ohms low level —110 db. microphone input. (2) High Z up to 100 K at 1v. unbalanced (radio input).
OUTPUTS	(1) 2½ ohms at 3 watts to internal loudspeaker. (2) 15 ohms at 3 watts for external speaker.
WOW AND FLUTTER	Total wow and flutter content less than ·2%.
MAINS SUPPLY	200/250 v. 50 cycles 230 V.A. Other voltages and frequencies supplied to special order.
DIMENSIONS	16" wide x 11" high x 18" deep approx.
WEIGHT	45 lbs.

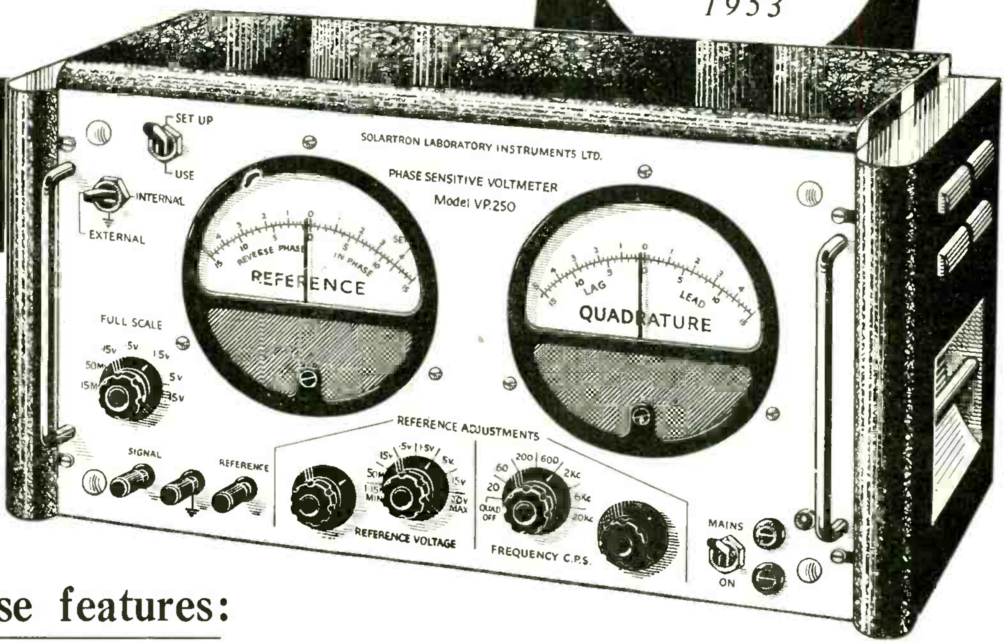
M·S·S· RECORDING COMPANY LTD

POYLE CLOSE · COLNBROOK · BUCKINGHAMSHIRE · TELEPHONE · COLNBROOK 284

SOLARTRON ANNOUNCE

The New
Phase Sensitive Voltmeter
Model VP.250

STAND No.10G
British Instrument Industries Exhibition
June 30th-July 11th 1953



Note these features:

★ Simultaneous display of reference and quadrature signal components on 6in. centre zero meters calibrated in volts.

★ Seven half decade sensitivity ranges covering 15 mV.–15 volts full scale.

★ Constant 50 megohms input impedance for both reference and signal channels.

★ High accuracy not affected by harmonics in signal under test.

Covering a frequency range of 20 c/s–20 Kc/s this instrument will measure the "in phase" and "quadrature" components of an applied test voltage, with respect to a given reference voltage. Provided the latter is of sine wave form, the readings will not be affected by harmonics or spurious frequencies.

An ideal instrument for the measurement of transmission characteristics of amplifiers, networks, transformers, high speed servo systems, etc.

Its resolved component presentation with harmonic free response makes it a suitable detector for A.C. strain gauge systems or for any pick-up with an A.C. output.

Other Solartron Instruments

Laboratory Amplifier	*Model AWS. 51A.*
Video Amplifier	*Model AWS. 52.*
Wide Band Power Amplifier	*Model AWS. 53*
Pulse Generator	*Model OPS 100A.*
Wide Range Oscillator	*Model OS.101.*
Regulated Power Supply	*Model SRS.151.*
Wide Band Attenuator	*Model AT.201.*
Twin Regulated Supply	*Model SRS.152.*
Varipack	*Model SRS.153.*

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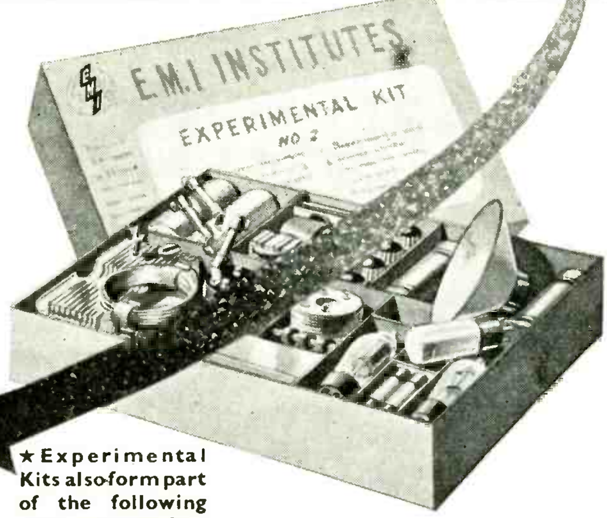

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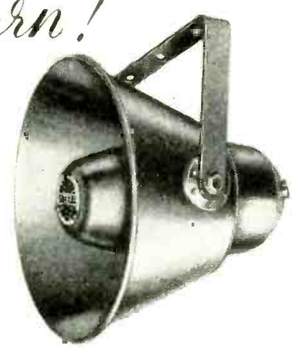

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Senior models give a substantially linear response from 250 to 8,000 c.p.s. with a peak handling capacity of 8 to 10 watts whilst Junior models range from 350 to 8,000 c.p.s. with 6 to 8 watts peak handling capacity. Either can be supplied with built-in transformer. Completely weatherproofed and designed to withstand prolonged exposure and vibration.

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'Phone: Emberbrook 3402-6.

Wholesale enquiries to—Truvox Ltd., Exhibition Grounds, Wembley, Middx. (WEM 1212)

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PUSH button controls and magic-eye tuning give you complete mastery over the Grundig's superb recording and reproducing qualities. The 1,200 feet of tape give you ONE HOUR of high-fidelity music recording and play back. High speed rewind mechanism enables you to reproduce from (or record on) any part of the tape in a few seconds. The same tape can be used repeatedly, each new recording automatically erasing the previous one, or recordings can be kept indefinitely. Sound frequency range: at 7½in. per second, 50-10,000 c/s., at 3¾in. per second, 50-6,000 c/s.

Price 80 gns.
including condenser mike. H.P. Terms available.

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- ★ Two-way telephone recorder—without alteration to handset.
- ★ As compact and *portable* as a suitcase.

THE GRUNDIG "*Reporter*"

700L TWO-SPEED TAPE RECORDER

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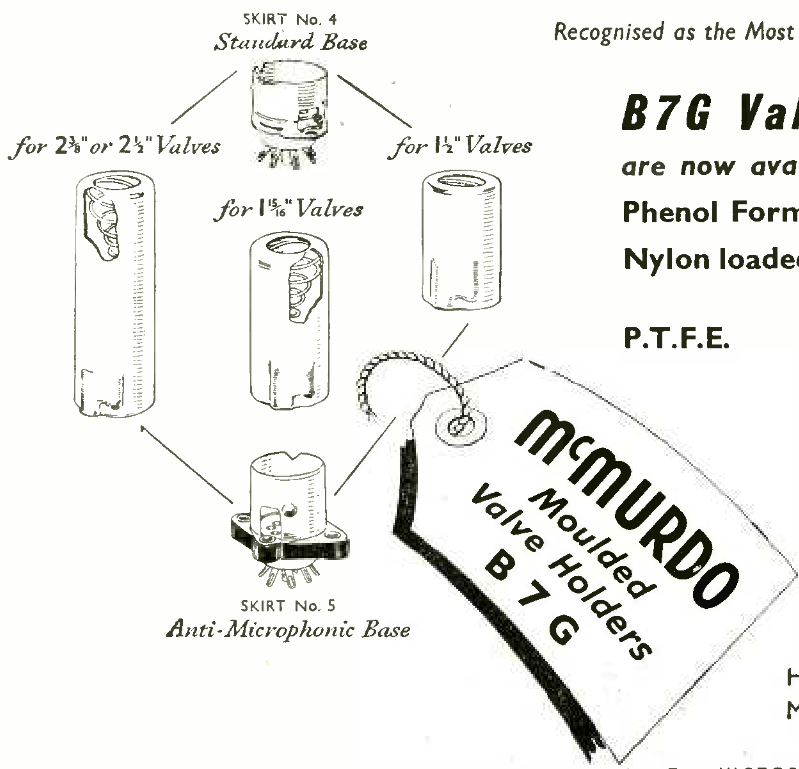

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Manufacturers' Enquiries: THE McMURDO INSTRUMENT CO. LTD., VICTORIA WORKS, ASHTEAD, SURREY
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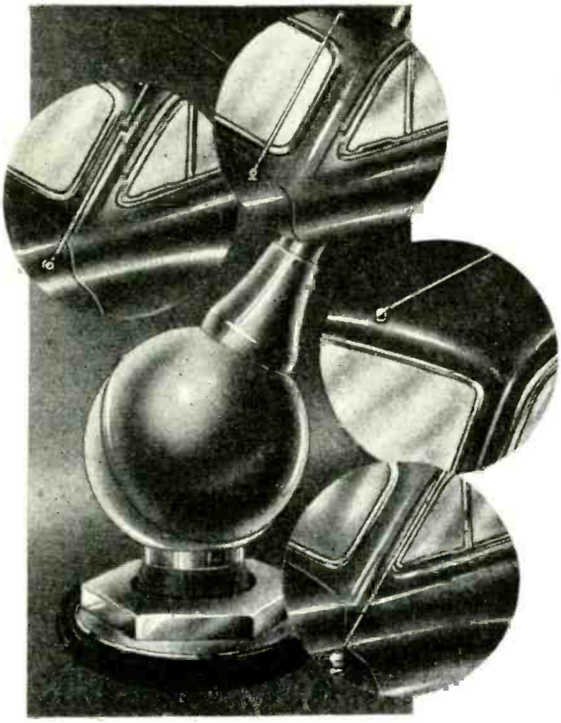

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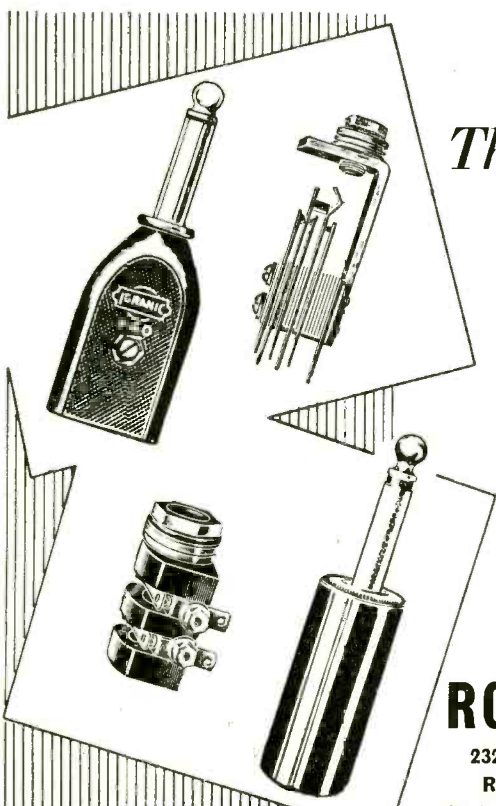
Here is revolution in car aerials—a ONE hole fixing model that can be installed FROM THE OUTSIDE. No longer need you manoeuvre under the scuttle or dashboard and work "by feel." Thanks to a special split washer device, and positioning sleeve, the aerial is self-locating, and firmly secured FROM THE OUTSIDE. Can be mounted vertically or horizontally (or at any angle in between) in any position on the car—on a flat or curved surface. It is entirely free from rattle—due to the special packing glands which also ensure the smooth action of the telescopic rod. *Full details in leaflet No. N1/W.*

MODEL TCA 6236. With sturdy die-cast metal mounting three section telescopic rod (extended 62in. closed 24in.) of high-grade brass. All exposed parts heavily chromium plated. Fully weatherproofed connections. Complete with 36in. low-loss co-axial polythene insulated P.V.C. covered cable, fitted standard co-axial plug. **PRICE 35/-**

MODEL TCA 6260 as above but with 60in. cable. **PRICE 37/6**

ANTIFERENCE LIMITED BICESTER ROAD, AYLESBURY, BUCKINGHAMSHIRE



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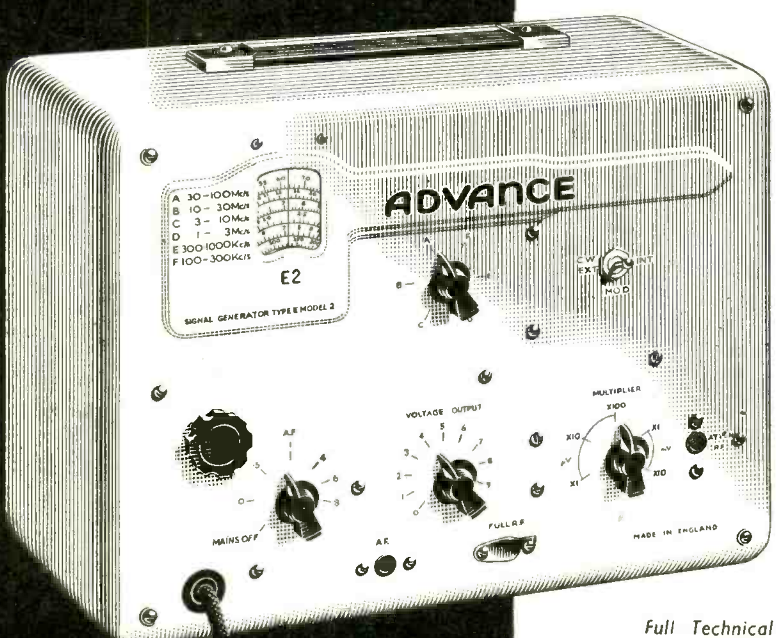
- *A.F. Output variable 0-50v. at 400c/s.*
- *Size 13″ × 10¼″ × 8″.*
- *Weight 17½ lbs.*

Advance signal generator

ADVANCE TYPE E2

100 Kc/s – 100 Mc/s ON FUNDAMENTALS



Full Technical Details available in Folder S/14/W

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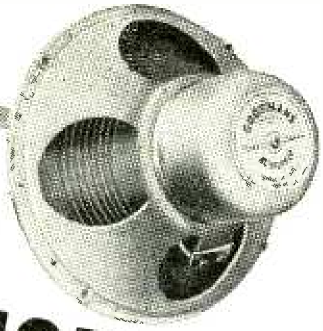

The AUDIOM '60' and VERSATILITY

This very popular versatile 12in. Single Cone Loudspeaker can be used for a variety of applications where good quality commercial reproduction is required with Audio Inputs of up to 15 watts. Emphasis is laid on the robust construction that takes into account the conditions met with in some P.A. applications.

The AUDIOM 60 is eminently suitable for general public address use, e.g. Small Theatres, Dance Halls, Ice Rinks and Amateur Cinema Installations. Other more specialised applications include Bass Units in multi-speaker combinations, Radiograms, Electronic Organs, Electric Guitars, or Amplified String Instruments.

Naturally we can only list a few of the many uses, although we are always pleased to give advice on specialised requirements.

Goodmans Heavy Duty Output Transformer type H.4 is specifically recommended for use with this Loudspeaker.

SPECIFICATION

Fundamental Resonance, 35 or 75 c/s. Voice Coil Diameter, 1¾in. Voice Coil Impedance, 15 ohms. Flux Density, 14,000 gauss. Total Flux, 158,000 Maxwells. Maximum Power Handling, 15 watts peak A.C. Overall Diameter, 12 5/16 in. Overall Depth, 7¼in. Baffle Hole Diameter, 11¼in. Mounting Holes, 4 holes 5/16in. dia. equispaced on a 11¾in. P.C.D. Nett weight, 12¾ lbs. Finish, Grey Rivelling Enamel.

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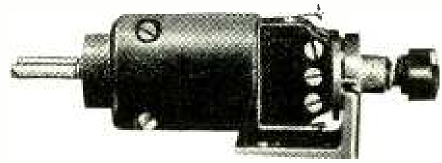

- A magnetic Turnover Cartridge with high output and cantilever styli.
- Entirely new principle. (Pat. applied for.)
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- The ideal replacement Cartridge for 3-speed record changers and units.

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- 1 Yaxley Switch Contact Adjuster
- 1 Low Capacity Trimmer
- 1 Screwdriver
- 1 Set of Feeler Guages
- 1 Set of Six Box Spanners from 1 to 8 B.A.
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in durable black crackle finish metal case.

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Marconi Television for Canada

The U.S.A., Italy, Venezuela, Thailand, Canada—these are some of the countries which have specified Marconi television equipment.

In Canada, Montreal and Toronto already possess Marconi television studios installed by the Canadian Marconi Company. The new Marconi Transmitter for Ottawa is an important link in the television chain planned by Canadian Broadcasting Corporation to span the entire country.

Marconi high or medium power transmitters, and high power aerials are installed in every one of the B.B.C.'s television transmitter stations.

Equipment supplied includes:

- Marconi Image Orthicon Cameras
- 5 kW vision transmitters
- 3 kW sound transmitters
- High-gain aerial systems
- Associated monitoring and control equipment

MARCONI

television transmitting equipment

MARCONI'S WIRELESS TELEGRAPH COMPANY LTD · CHELMSFORD · ESSEX

A*

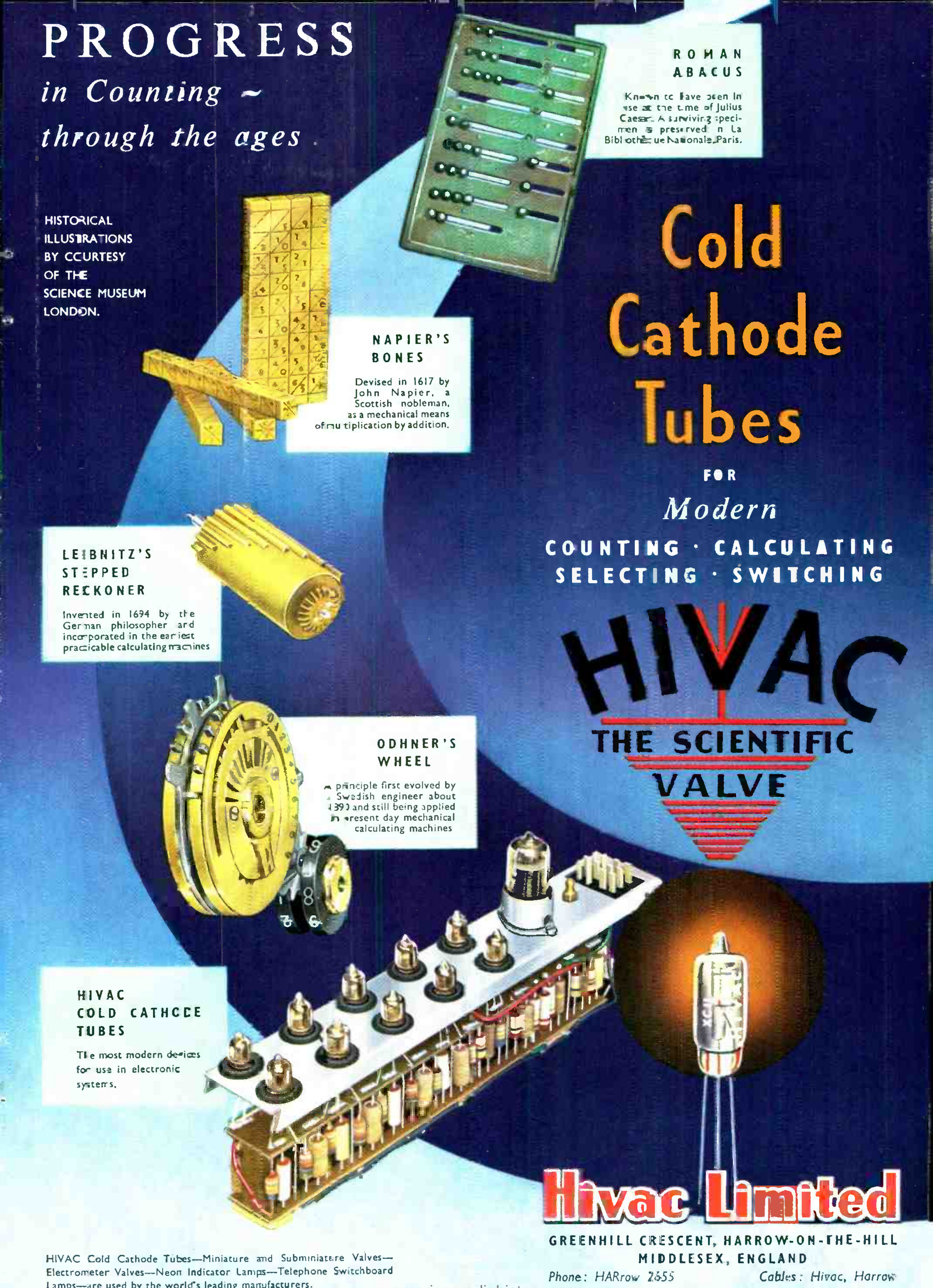
G.E.C. RADIO COMMUNICATION EQUIPMENT

for use in all parts of the **WORLD**

G.E.C. radio equipment for H.F. and V.H.F. communication has been developed with two important advantages from the purchaser's point of view constantly in mind. *Suitability for the exact operational need and reliability.* These advantages are entirely due to the long and valuable experience of the G.E.C. in all branches of radio engineering, backed by its unique research organisation.

Equipment is available for every kind of radio communication requirement — police, ambulance and fire services, aircraft, shipping, etc. The general purpose receiver shown here is the BRT400D, built to meet the most exacting needs of commercial service in all parts of the world, providing high grade telegraphy service and quality reception for re-broadcast.

THE GENERAL ELECTRIC CO. LTD. OF ENGLAND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Devised in 1617 by John Napier, a Scottish nobleman, as a mechanical means of multiplication by addition.
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A principle first evolved by a Swedish engineer about 1390 and still being applied in present day mechanical calculating machines
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The most modern devices for use in electronic systems.
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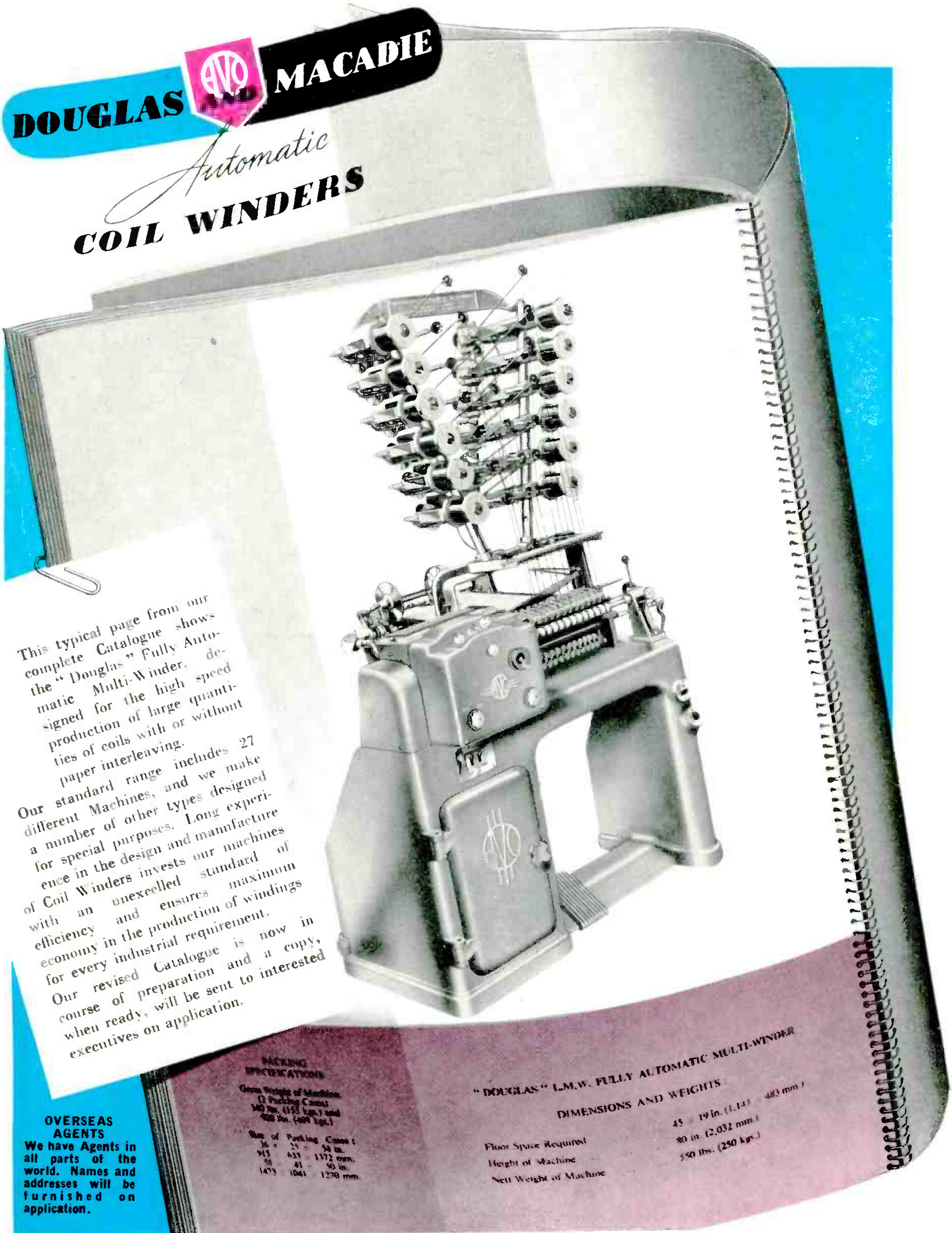

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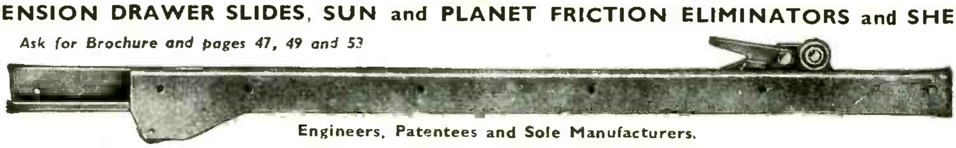

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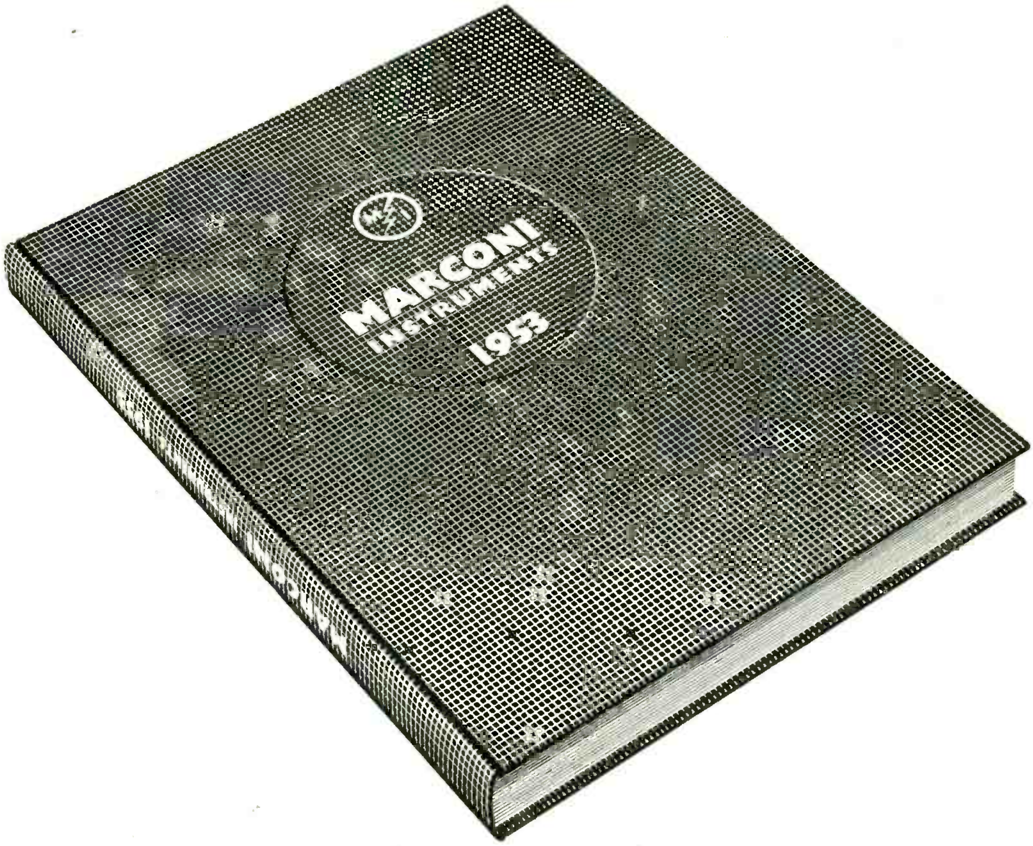

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We would like to draw the attention of all our friends to the new instrument catalogue. This handsomely bound publication records the latest developments in the communication and industrial fields — as have our loose-leaf catalogues up to now. But techniques advance as Marconi research progresses, and for clarity's sake all available data has been re-cast in the new format. We hope this will prove even more valuable to you than its predecessors.

If you are on our existing mailing list, you will have your new Marconi Instruments catalogue this month. But do jog our memory if, by chance, we overlook you — we want every executive who really needs one to have a copy.

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BRITISH INSTRUMENT INDUSTRIES EXHIBITION
OLYMPIA·LONDON JUN.30-JUL.11 '53
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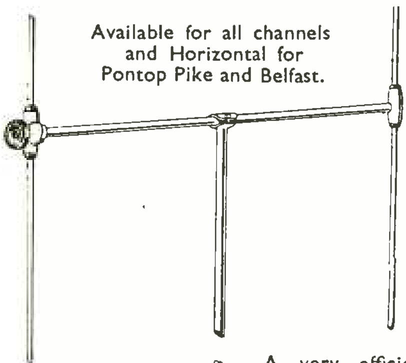

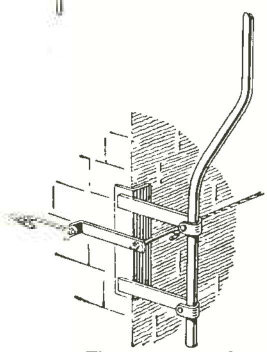

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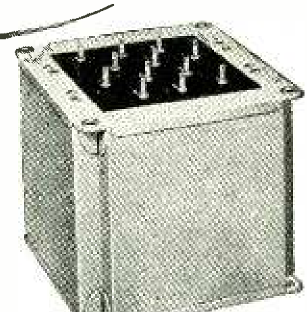

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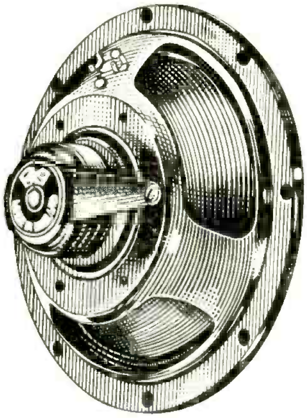

Coronation fever is over. Demand for television sets is more manageable. For a few weeks radio and television manufacturers will, we hope, have time to think about the autumn demand — and perhaps even to enjoy some recuperative sunshine! May we suggest that part of this respite could be profitably spent in studying the special features of the new range of R. & A. Reproducers? These features include:

- * **Co-axial construction for accurate and permanent alignment.**
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- **High sensitivity, with magnet assemblies in the '800' Series of 7,000 to 10,000 Gauss, and in the '900' Series of 10,000 and 12,000 Gauss.**
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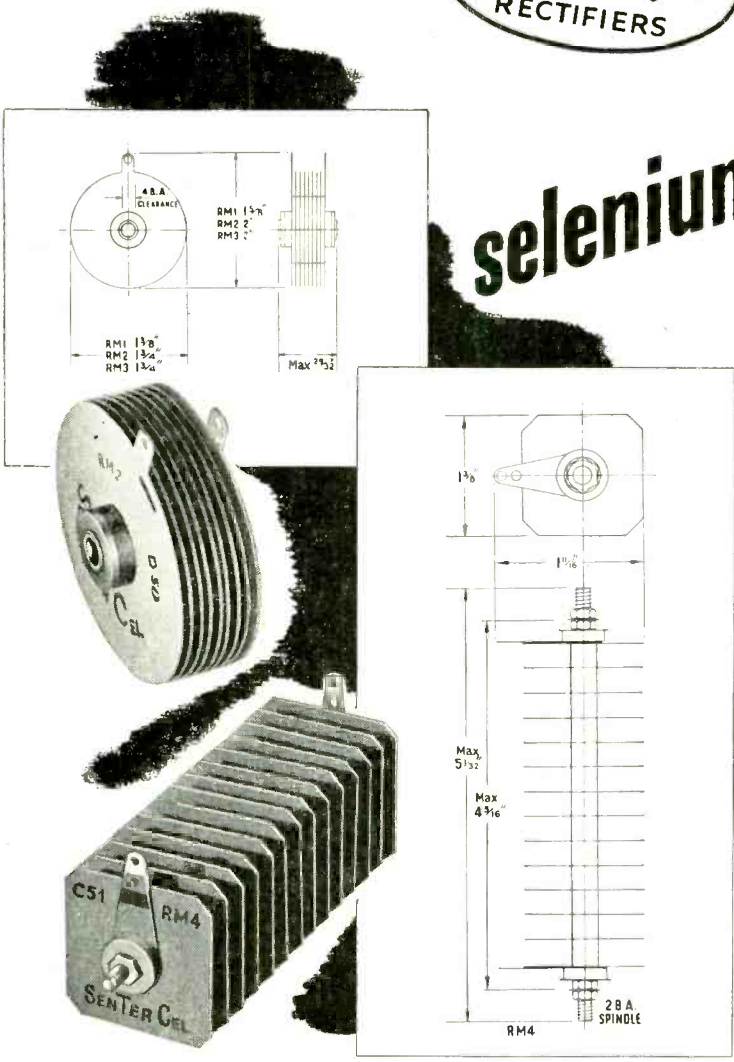

Compare these outstanding features with those of the rectifiers which at present you are using :—

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- No "warming-up" period.
- No valve-holder.
- Practically indestructible in normal service.
- No limit to size of electrolytic capacitor.
- Saves weight.
- Saves space.
- Low in cost.

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Maximum ambient temperature	35°C 55°C	35°C 55°C	35°C 55°C	35°C 55°C	35°C 40°C 55°C
Maximum output current (mean)	30mA 15mA	60mA 30mA	100mA 60mA	120mA 90mA	275mA 250mA 125mA
Maximum input voltage (r.m.s.)	125V	125V	125V	125V	250V
Maximum peak inverse voltage	350V	350V	350V	350V	700V
Max. instantaneous peak current	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited
Weight	0.82 oz.	1 oz.	1.4 oz.	2 oz.	4.5 oz.

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BRITISH INSTRUMENT INDUSTRIES EXHIBITION

OLYMPIA·LONDON JUN.30·JUL.11 '53

STAND No. 3 c.

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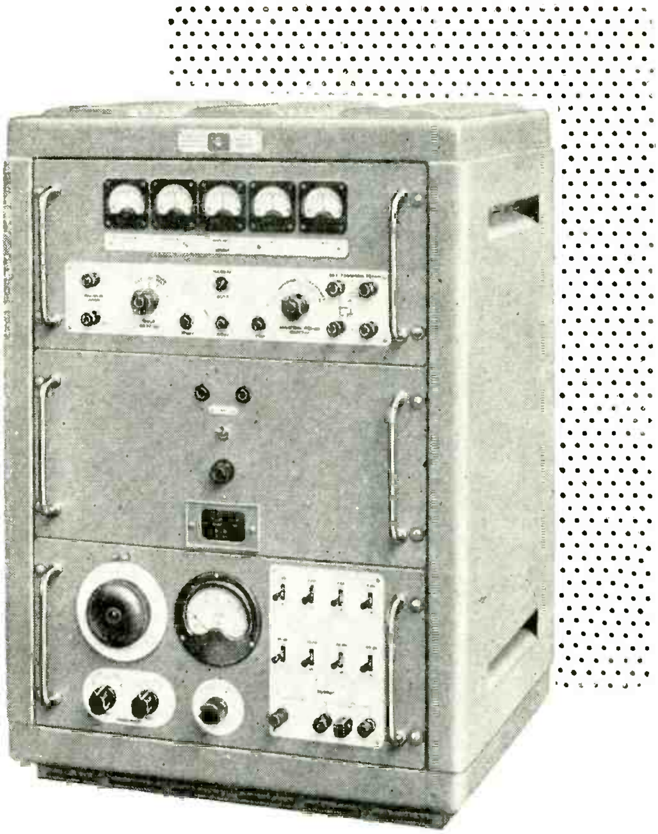

An instrument of exceptionally high accuracy and stability—the output frequency of which is automatically measured and presented in decimal notation.

Range	10c/s to 100kc/s
Accuracy	±0.005%
Output	0 to 30 volts r.m.s. metered
Attenuator	0 to 110db in 1db steps (constant 600Ω)

The equipment will measure any frequency in the range 10c/s to 100kc/s and any time in the range 10μsec to 10^4sec both to an accuracy within ±0.005%. It will also count up to a maximum rate of 10^5 pulses/second.

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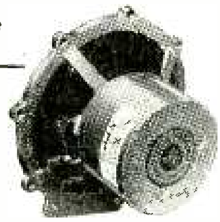
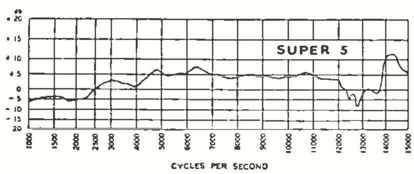
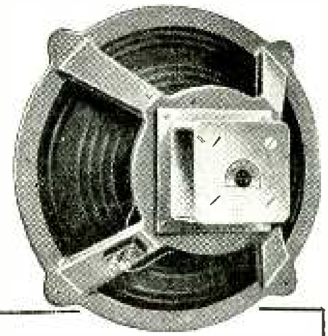
These two units, used in a 3-speaker system with a middle speaker of not less than 13,000 lines flux density, will give reproduction of very high quality.

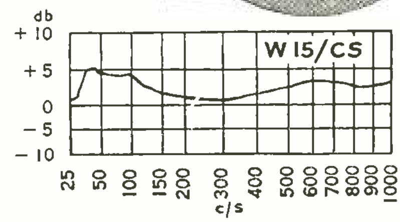


Response Curve Super 5





Response Curve W.15/CS



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The World's finest medium priced amplifier

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- ★ Close tolerance high stability resistors employed. Despite this vastly improved performance the price remains unchanged at **£14.**

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Price complete with Engraved Control Panel **£9.**

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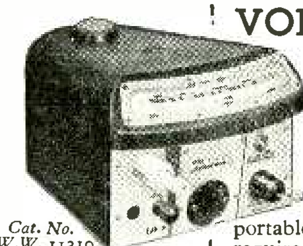

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BRITISH INSTRUMENT INDUSTRIES EXHIBITION OLYMPIA-LONDON JUN 30 - JUL 11 '53

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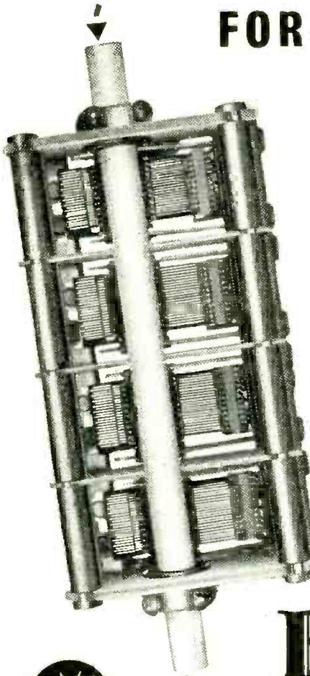

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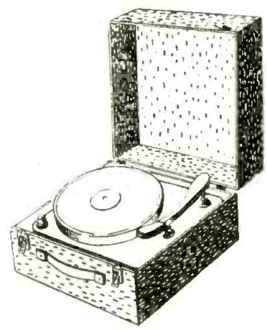

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An unsolicited
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on
AXIOM HIGH FIDELITY LOUDSPEAKERS

MODEL 150 MARK II 12″ TWIN CONE
101 8″ SINGLE CONE
102 8″ SINGLE CONE

BY THE COURTESY of Messrs. Goodmans Industries Ltd., we have recently had the opportunity of submitting these speakers to thorough tests.
The 150, Mark II, is a very definite improvement on the Mark I model, with a firmer, smoother middle register and lower fundamental resonance (nominally 35 c.p.s.). It was not possible to house the speaker in the cabinet designed for the purpose by Messrs. Goodmans, but mounted in a labyrinth which absorbed virtually all the sound from the back of the cone the outstanding characteristics of this reproducer were hard, clear bass, very even response in the middle and upper registers and low needle hiss of unobjectionable quality. Response extends to 15 k.c. This is an excellent single unit which should give every satisfaction to Societies. It will handle up to 15 watts.
The main difference between the Models 101 and 102 is the increased sensitivity and flux density of the latter. These qualities are, naturally, accompanied by improved damping and increased price.
These are undoubtedly the best 8″ units which we have so far tested, and the maker's claim for response within 3-4 db. from 40 to 15,000 c.p.s. was fully substantiated. They showed no signs of distress when fed with peak inputs up to 6 watts.
Excellent results were obtained running the Axiom 101 in parallel with the Axiom 150 to secure wider distribution of sound, and also by running two 8″ units in parallel. In the latter case there was rather less weight in the extreme bass.
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£13 . 11 . 5 *(incl. purchase tax)*

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AXIOM 102
£9 . 18 . 2 *(incl. purchase tax)*

★ *We acknowledge with thanks the permission to reproduce the above report which is an extract from the January issue of the Society's private journal*

All these models are stocked by the leading dealers, but in case of difficulty please order direct from us. We invite you to write for further details of any unit. Remember we can give you outlined dimensional drawings of reflex chambers for all Speakers mentioned.

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NOTE TO DEALERS—A special sales show stand which displays these units to your customers to the best advantage is available free of charge on application to the Swindon Factory. Stock models of all Garrard Products and the latest catalogue are also immediately available. Write for full particulars.

THE GARRARD ENGINEERING & MANUFACTURING CO. LTD.
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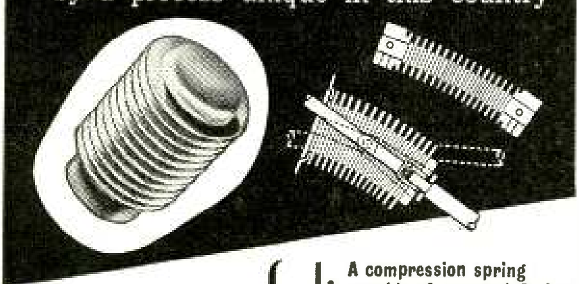

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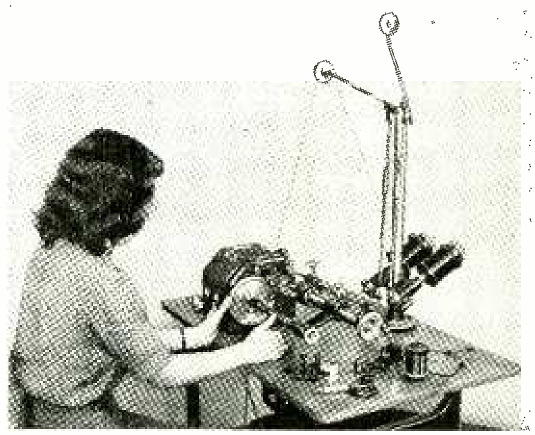

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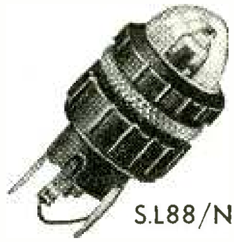

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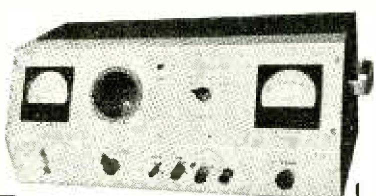

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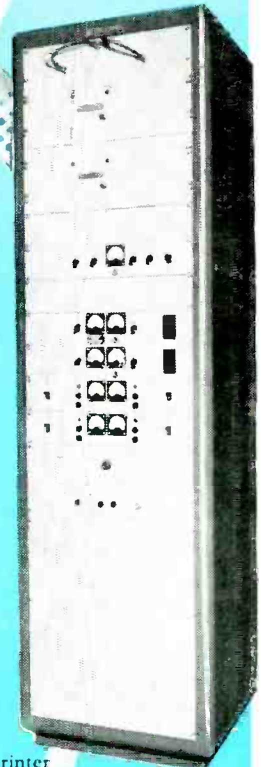

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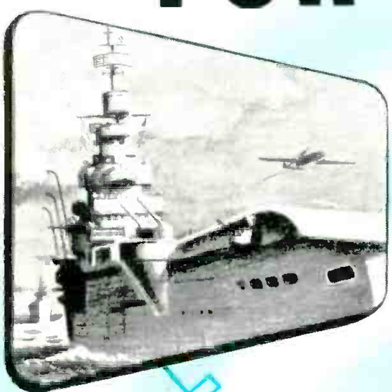

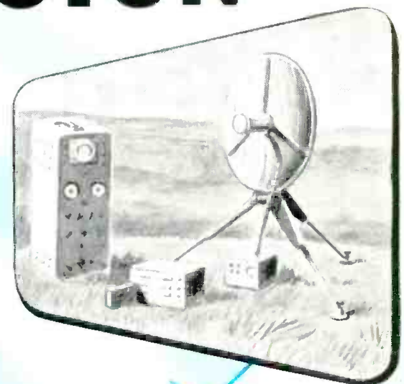

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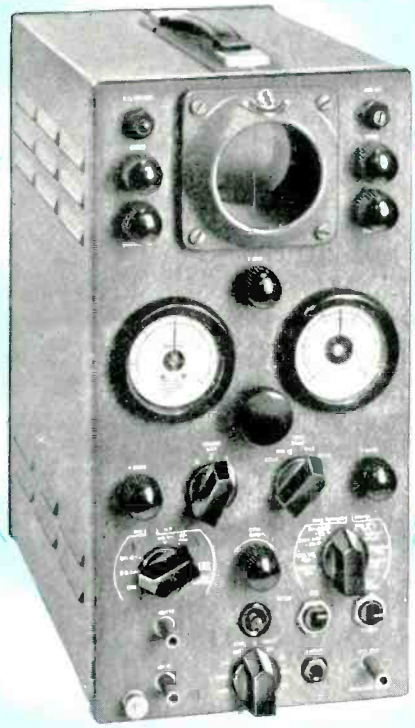

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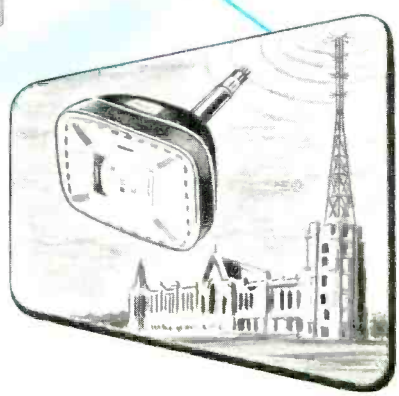

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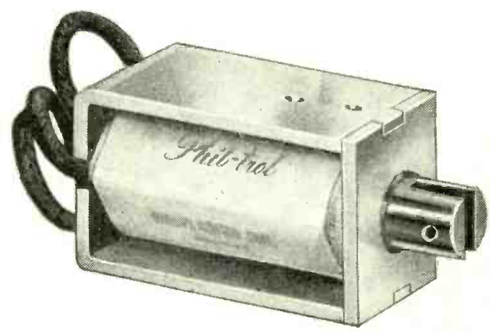

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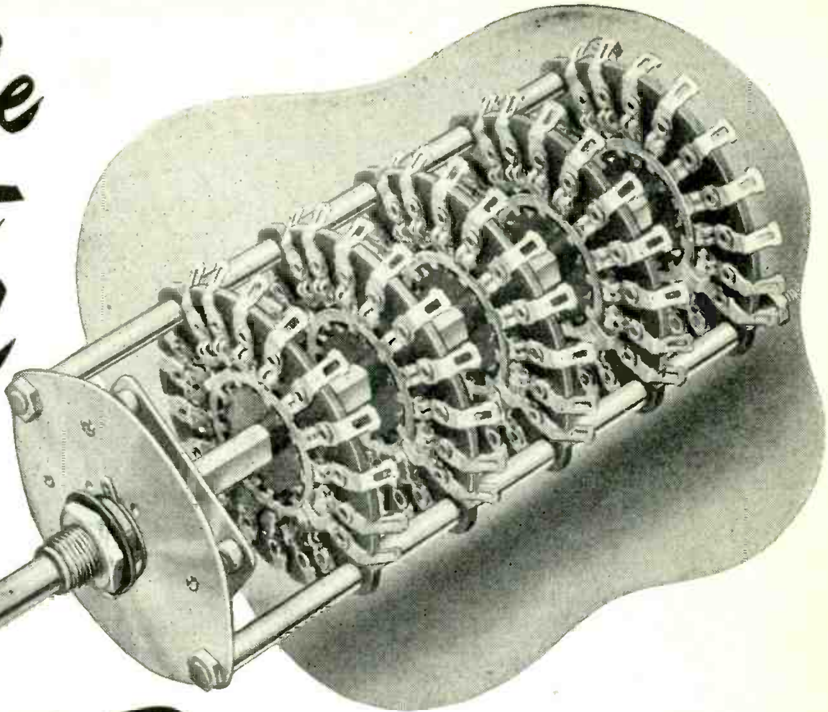

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HS3. 350-0-350 v. 80 m/a., **19/–**. **HS30.** 300-0-300 v. 80 m/a. 19/–
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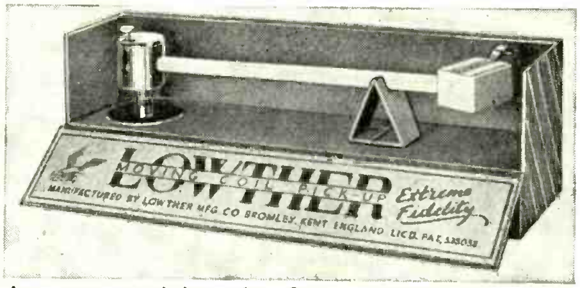

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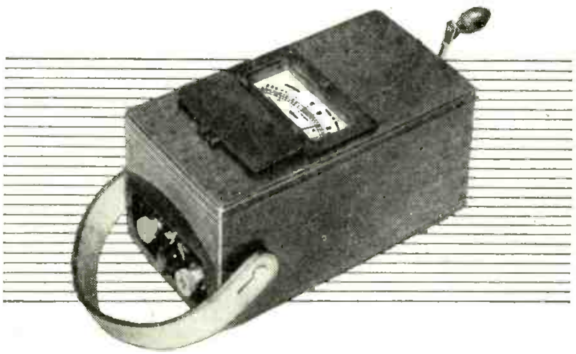

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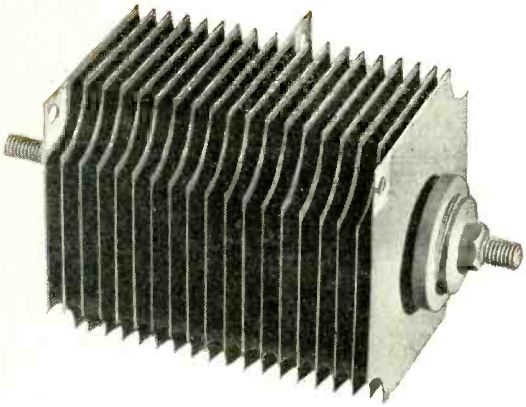

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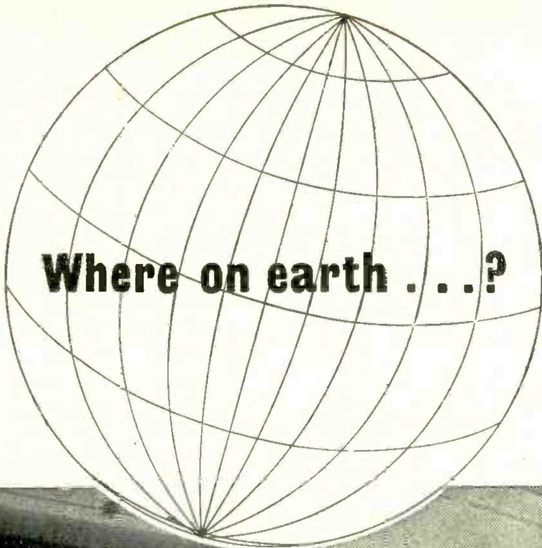

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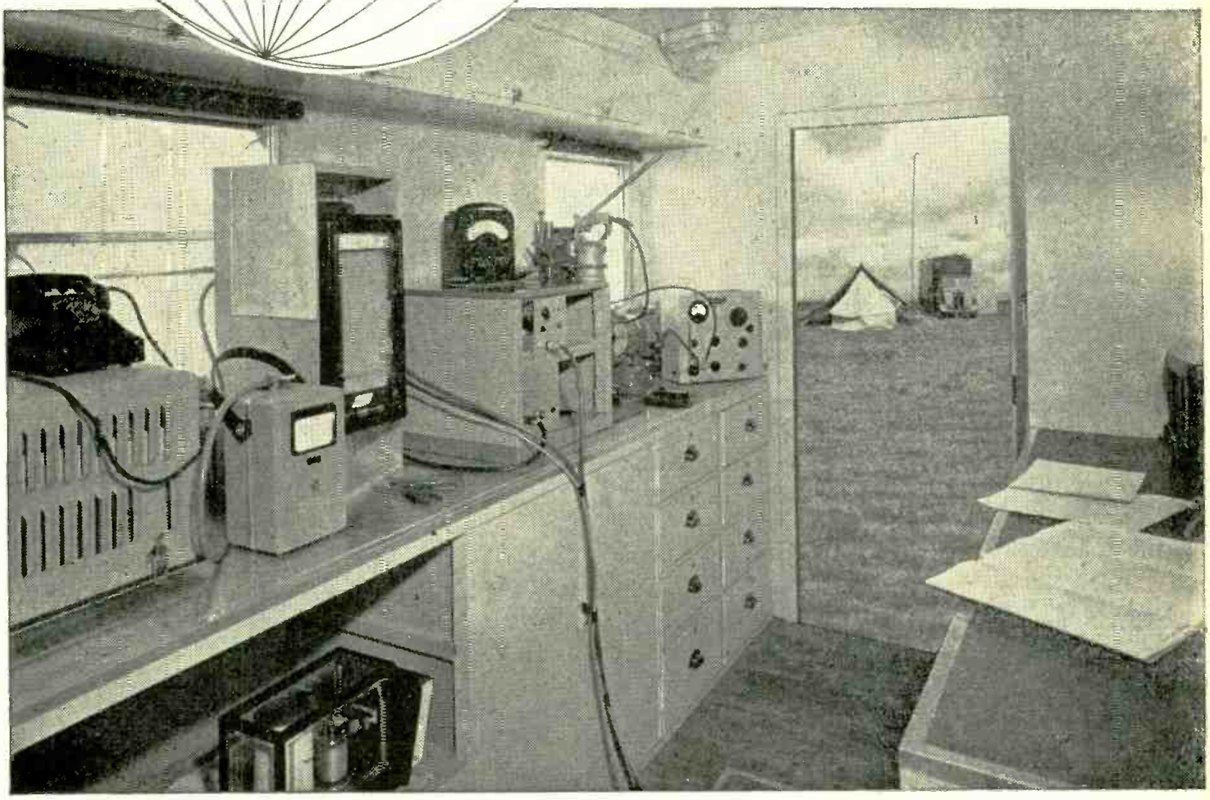

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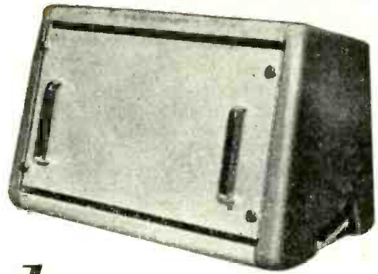

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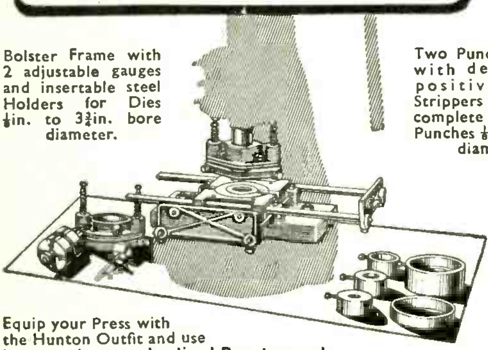

Two Punch Holders with detachable positive-action Strippers take the complete range of Punches $\frac{1}{8}$in. to $3\frac{3}{4}$in diameter.

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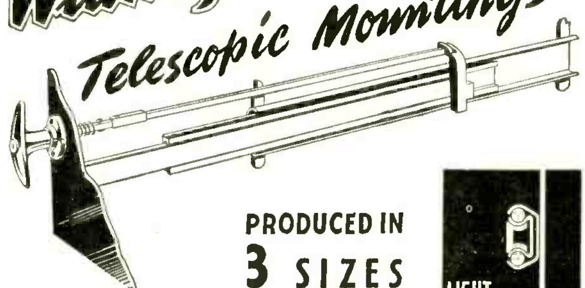

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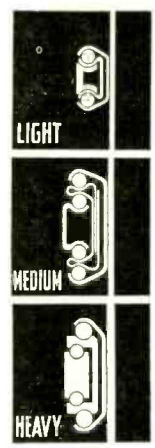

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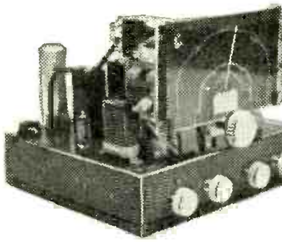

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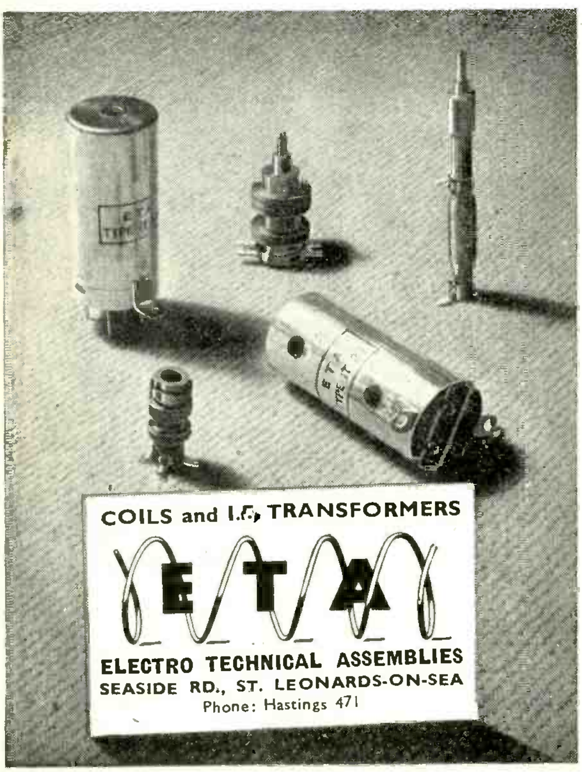

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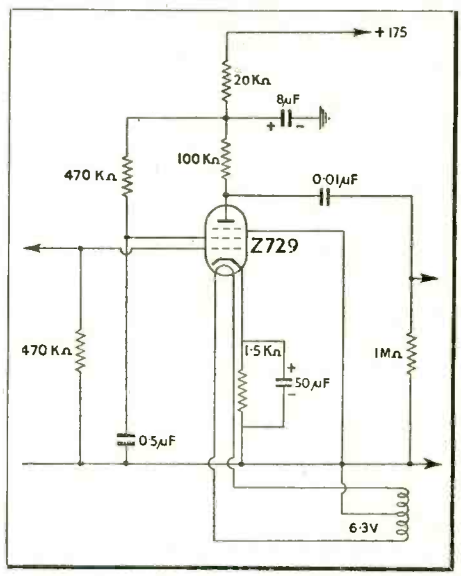
Using the circuit shown a gain of 110 can be obtained whilst the hum voltage referred to the control grid will not exceed 1.5 μV. This figure represents an improvement of at least 17 db over a valve of normal construction with good low hum characteristics used with a hum balancing circuit.

The Z729 is a preferred type for use in the early stages of all low level input audio equipment, while its very high input grid resistance renders it suitable for use in the instrument field, in applications where this characteristic is required but the use of an electrometer valve is not justified.

CHARACTERISTICS

V_a	250	V
V_{g2}	140	V
r_a	2	MΩ
I_a	3	mA
g_m	1.85	mA/V



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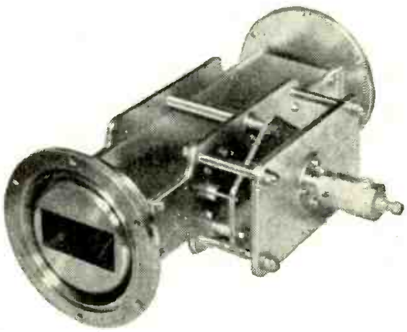

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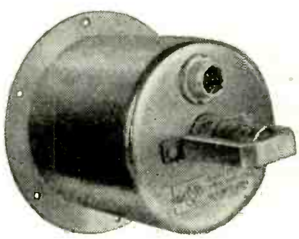

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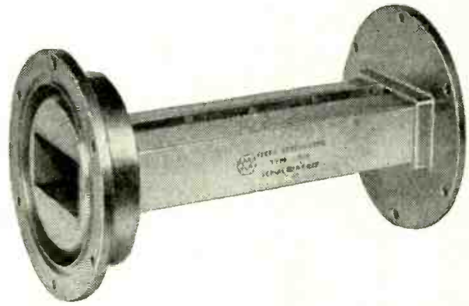

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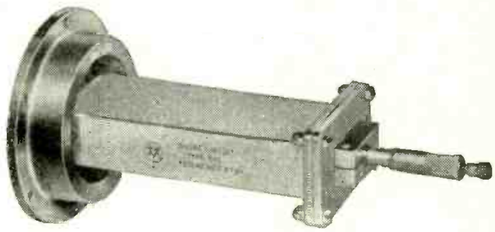

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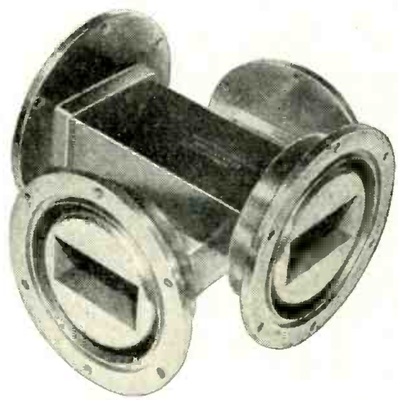

1 **PRECISION ATTENUATOR** Type 501

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4 **FIXED ATTENUATOR** Type 519

5 **SHORT CIRCUIT** Type 510

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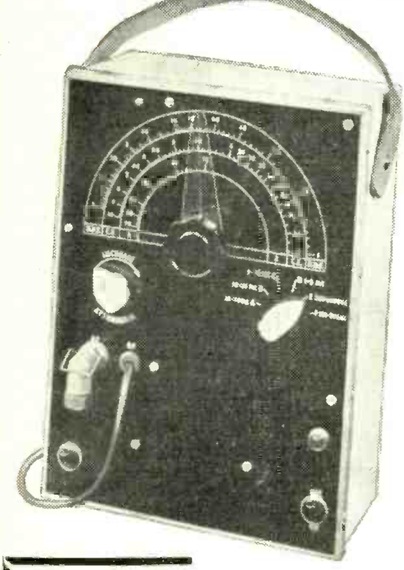

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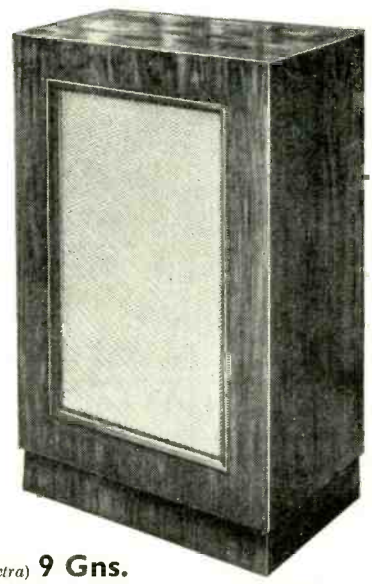

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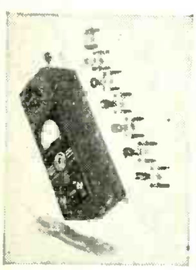

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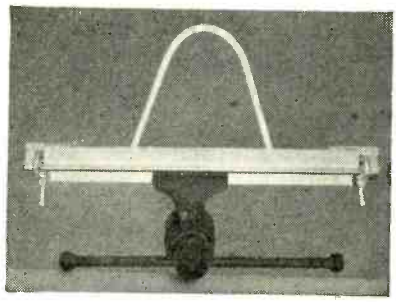

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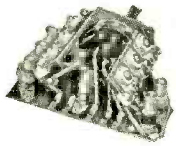

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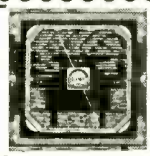

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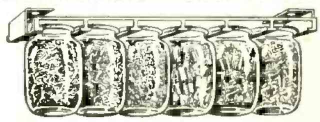

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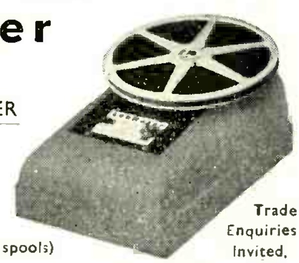

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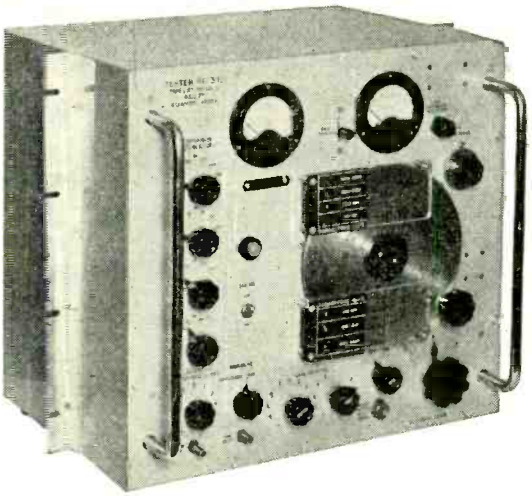

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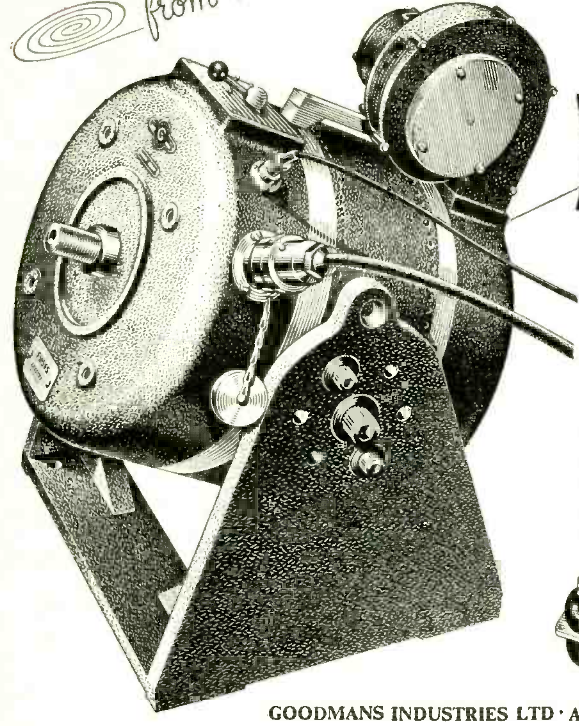

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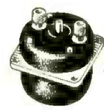

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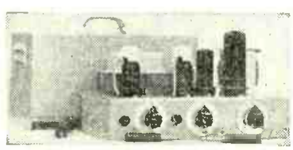

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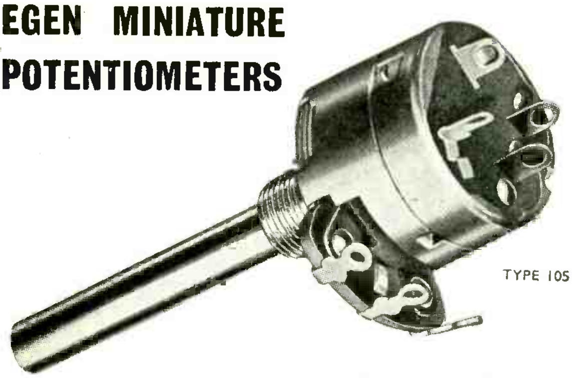

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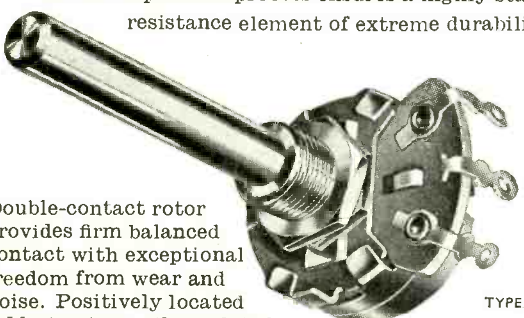

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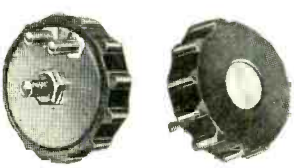

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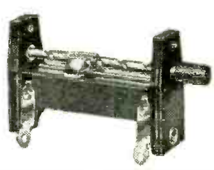

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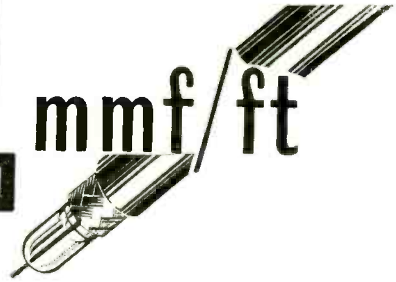

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C.44	4.1	252	1.03"
C.4	4.6	229	1.03"
C.33	4.8	220	0.64"
C.3	5.4	197	0.64"
C.22	5.5	184	0.44"
C.2	6.3	171	0.44"
C.11	6.3	173	0.36"
C.1	7.3	150	0.36"

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Wireless World

RADIO, TELEVISION AND ELECTRONICS

43rd YEAR OF PUBLICATION

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

JULY 1953

In This Issue

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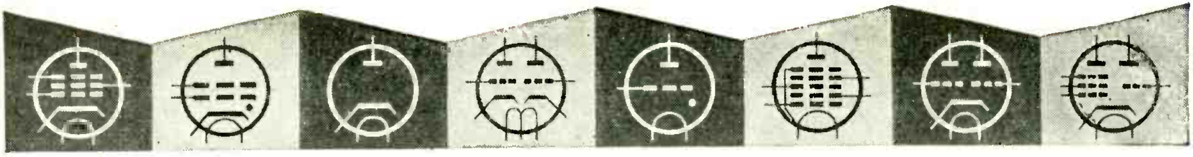


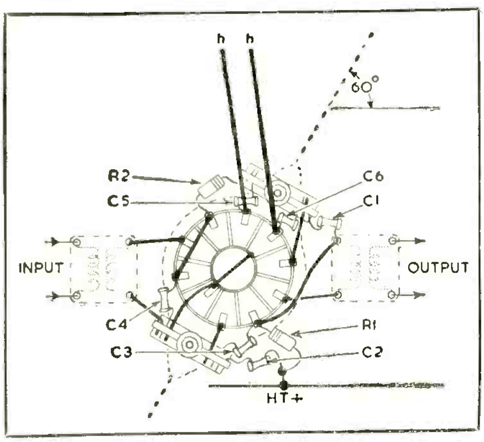
VALVES, TUBES & CIRCUITS

7. WIRING CONSIDERATIONS WHEN USING HIGH GAIN VALVES AT HIGH FREQUENCIES

The published figures for input damping usually refer to the valve alone; for instance, for the EF80 the input damping is 10kΩ at 50 Mc/s. The effective input damping of an EF80 in the lay-out illustrated is, however about 3·9kΩ at 50Mc/s, due to the inevitable small reactances introduced by leads and by the inductive reactances of the decoupling components. At frequencies above 20-30 Mc/s leads even $\frac{1}{4}''$ in length form appreciable reactive elements. Reduction of lead lengths cannot however be pursued indefinitely, so that a compromise is usually adopted between unnecessarily long leads and lead lengths which would involve difficulty during mass production and servicing of the equipment.

DESIGN HINTS. The cathode and screen electrodes should be well decoupled for optimum results. Furthermore, the cathode capacitor can be made to resonate with its own series inductance and the inductance of the cathode lead so as to offer a negligible impedance at the frequency under consideration. This method, however, is likely to depend critically upon the type of capacitor used; for instance, the performance with a 500 pF mica capacitor might be different from that experienced with a ceramic capacitor of the same value.

In some cases it is desired to vary the grid-to-cathode bias on the valve in order to achieve a measure of gain control. Unfortunately, as the gain is reduced there is a simultaneous increase in the effective parallel input damping resistance. The input capacitance is also reduced in value. The bandwidth and the resonant frequency of the grid tuned circuit may therefore change as the gain is altered. This effect can be minimised, however, by the introduction of a critical amount of negative feed-back in the cathode circuit of the valve. This is usually achieved by leaving a portion of the bias resistor undecoupled. For the EF80 it is suggested that an undecoupled 33Ω resistor should be connected to the cathode pin of the valve-holder, the remainder of the cathode resistive load, i.e. a 150Ω resistor being decoupled to chassis in the usual way. This circuit introduces a loss of approximately 2 dB per stage.



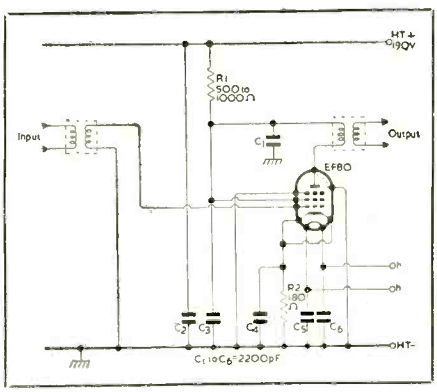


Fig. 1. Example of Wiring Layout.
Fig. 2. Circuit Diagram corresponding to Fig 1.

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

Mullard

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

MVM 232

Wireless World

JULY 1953 VOL. LIX No. 7

Electronic Confusion

AMERICAN researches into the origins of our art, reported recently in *Tele-Tech,* would suggest that the word *electronic* is of far greater antiquity than most of us think. It was undoubtedly used in *The Philosophical Magazine* (London) of June, 1832, by no less a person than Michael Faraday. But, rather disappointingly, there can be little doubt that it was a misprint for *electrotonic,* a word Faraday had used elsewhere at the same time. Can we regard this as an inspired printer's error, or an augury of future confusion? Everything was clear enough 60 years ago, when Johnstone Stoney coined the word *electron,* with *electronic* as its adjectival form. The confusion began much later when the noun *electronics* was formed, with a highly specialized meaning. What precisely, is *electronics?*

If a public opinion poll were conducted to ascertain the accepted definition of the noun *electronics*, laymen would probably describe it hazily as "the newest kind of electrical engineering, like that applied to wireless and radar." More technically informed opinion would probably be sharply divided into two groups. The definition of the majority would read something like "radio-like methods and devices, particularly valves, applied to non-communication uses." The more academic section would probably offer, as nearly as they could remember, the definition of the American Institution of Electrical Engineers, which runs "Electronics is that branch of science and technology which relates to the conduction of electricity through gases or *in vacuo*." There is all the difference in the world between these definitions, and in their diversity are all the seeds of confusion and misunderstanding. Some of us are even inclined, as a matter of expediency, to the dangerous practice of applying the two definitions interchangeably.

There has lately been a feeling that the American I.E.E.'s definition should be widened to embrace many modern devices and techniques (notably semiconductors) that have come into use since the word was coined. Expression was given to such ideas by Professor W. L. Everitt, who went so far as to propose, in the American *Proceedings of the I.R.E.,* that electronics should be redefined as "the science and technology which deals primarily with the supplementing of man's senses and his brain power by devices which collect and process information, transmit it to the point needed, and there either control machines or present the processed information to human beings for their direct use."

That definition is, to our mind, quite unsatisfactory and we do not seem to be alone in that opinion. B. E. Noltingk, writing in *Proc. I.R.E.* for May, says "The proposed new definition of *electronics* is altogether too wide. It is, in fact, almost synonymous with *instrumentation,* and if adopted, some new word would be needed when it was required to distinguish between pneumatic instrumentation and what is at present called electronic instrumentation." He goes on to propose that the only widening of the old definition that is necessary concerns the state of the electrons involved. "If, instead of limiting them to flow through a gas, we include in *electronics* any device in which electrons travel otherwise than along normal conductors, then I maintain that the definition has been brought up to date without stretching it beyond current usage."

It should be easy enough to write a precise definition along the lines suggested by Mr. Noltingk that would embrace those devices and techniques that are at present on the fringe of electronics.

Flawless Performance

CONGRATULATIONS have been showered on the B.B.C. for the manner in which the Coronation broadcasts were conducted, both on sound and vision. The general public has already shown its appreciation of the superlatively high standard maintained on the "programme side": readers of this journal will no doubt join with us in congratulating the engineering division of the B.B.C. on what was probably the greatest feat of operational skill in the whole history of broadcasting. Elsewhere in this issue are described some of the methods used so successfully on the Corporation's busiest day.

Stereoscopic Television

Is it Practicable for Broadcasting?

THE film industry's idea that three-dimensional films will prove an effective answer to the growing attractions of television has naturally made a lot of people ask "why not three-dimensional television?" It seems reasonable to suppose that the stereoscopic principles used in films could be applied to television, and, indeed, a number of experimental stereoscopic television systems have already been built and tried out on closed circuits. There is no difficulty, in fact, in getting stereoscopic television to work: the main problem is in making it practicable for broadcasting purposes—assuming, of course, that it is a desirable thing to have in the first place. At the moment there seems little chance that stereoscopic television can be made "compatible" with existing television systems, and for that reason the B.B.C. is not very interested in it. But there is some possibility that it can be made practicable for any new television broadcasting services that may be set up in the future.

Question of Bandwidth

As in colour television, one of the main technical problems is the bandwidth requirement. The basic principle of stereoscopy is to present the spectator with two separate views of the subject, a left-eye view and a right-eye view, and in television this would mean transmitting twice the normal amount of information and so doubling the bandwidth. In future television systems, of course, it may be possible to do this. But if not, there is the alternative of transmitting only half of the information in each view so that the bandwidth could remain unchanged. This would reduce the definition of each view, but any subjective loss to the spectator might be more than made up by the subjective gain given by the three-dimensional effect. From this point of view a stereoscopic system might actually be more efficient than an ordinary system in its utilization of bandwidth, for with ordinary television our ability to perceive three dimensions is entirely wasted on a picture which only has two dimensions. We might as well look at the screen with only one eye—and, in fact, some people actually get a better impression of depth by using only one eye, perhaps because this impression is based purely on the relative sizes and clarity of focus of objects and is not affected by the other eye telling the brain that "it's all on a flat screen anyway."

Probably the best-known method of achieving stereoscopy in the cinema is by the use of optical filters. The right-eye view and the left-eye view are projected on to the screen through different filters, either coloured or polarized, and the people in the audience have to wear spectacles with corresponding filters to separate them again. This principle has been used in a number of closed-circuit industrial television systems, but is not very suitable for broadcasting because of the inconvenience of having to wear spectacles all the time. The filters can be avoided by displaying the two views side-by-side or in time sequence, but again the spectator has to use some kind of viewing device to separate them and this is just as inconvenient as the spectacles.

Stereoscopy Without Spectacles

There are, however, three-dimensional film systems in which the viewer does not have to wear spectacles, and most of these are based on an ingenious principle devised by Frederick Ives in 1902 for making and viewing stereoscopic photographs. The left-eye view and the right-eye view are separated for the spectator by a mask containing a large number of thin vertical slots which is placed just in front of the screen. Fig. 1 illustrates the basic principle. When the observer looks through a slot at the screen his right eye sees one small section of screen and his left eye another section adjacent to it, and as long as the slot is narrow enough the two eyes cannot possibly see the same section. The complete system is shown in Fig. 2. The left-eye view and the right-eye view are presented together on the screen by being split into small vertical sections and interlaced—as shown by the alternating "L" and "R" sections across the screen. A short distance in front is the slotted mask, and this is arranged so that when the spectator looks through it his left eye only sees the "L" sections and his right eye the "R" sections, on the principle explained in Fig. 1. Each eye then integrates the thousands of small sections it sees into a complete picture. There are a number of positions round the screen where conditions are right for viewing, and, in fact, quite a large audience can be accommodated.

The process of getting the two views interlaced on the screen in the first place is simply the reverse of the viewing process—that is, to project them from different angles on to the back of the screen through a slotted mask. When the system is used for viewing still stereoscopic photographs the two views have to be interlaced on the same piece of film and this is again done by a slotted mask, inside the camera.

Application to Television

How, then, could this principle be applied to television? The most obvious arrangement is shown in Fig. 3. At the transmitting end the left-eye view and the right-eye view are interlaced on a translucent screen by means of a slotted mask. The composite picture is then viewed by a camera and transmitted to the screen of the receiver, where the two views are separated by another slotted mask. This could obviously be done with an existing television system and no changes would have to be made either at the transmitter or at the receiver. The system would not be "compatible," however, because the received picture seen without the mask would not be like an ordinary television picture but would have a rather blurred appearance.

Another possible method of interlacing the two views at the transmitting end would be to make use of the electronic interlacing already existing in the television system. In other words, in a complete picture period one view could be transmitted on the first frame (the odd lines) and the other view on the second frame (the even lines). This would necessitate two synchronized cameras with an electronic switch arranged to select their outputs alternately. An advantage of the scheme is that it would avoid the loss of light introduced by the slotted mask and translucent screen at the transmitting end of Fig. 3. It would, however, necessitate vertical scanning; and, with the existing television standards, the viewer would probably experience flicker, for each of his eyes would receive only 25 frames per second instead of the usual 50 per second.

Apart from the problems of applying the Fig. 2 principle to television it has two inherent disadvantages which go against it under any circumstances. The first is that a spectator looking obliquely at the screen from the side sees exactly the same three-dimensional image as he would do from a central position, when clearly he should from that position get more of a side view, as in the live theatre. So a change in viewing position does not produce the appropriate change of aspect. The second drawback is that between the viewing zones where the correct stereoscopic effect is obtained there are zones in which the spectator gets an "inverted" stereoscopic effect, the right eye receiving the left-eye view and the left eye the right-eye view. These "inverted" zones are the same width as the others, so that when the spectator moves about he sees the picture "jumping in and out" all the time.

"All-round" Viewing System

A system has been devised, however, which overcomes these disadvantages, and readers may have seen something like it used in shop windows for advertising purposes—a three-dimensional photograph which changes appropriately in aspect as one moves around it. The photograph is produced by moving a camera, with a slotted mask in front of the film, around the subject in an arc, and the result is a picture composed of a series of vertical strips in each of which the viewpoint changes gradually from left to right. Thus the composite picture does not contain just two views, as in the Fig. 2 system, but a multitude of views from various angles merging into one another.

Fig. 4 shows what happens when this composite picture is viewed through a slotted mask—and here it has been assumed that the camera has been moved not continuously, but in a series of six steps, each position giving a slightly different view from the next. As the spectator moves to the right the view on the film becomes increasingly right-sided and as

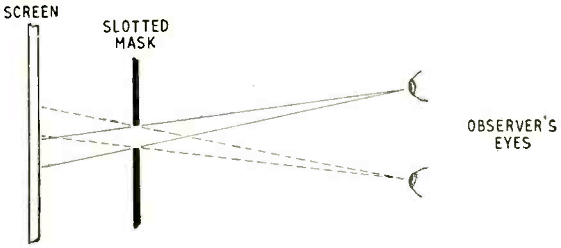
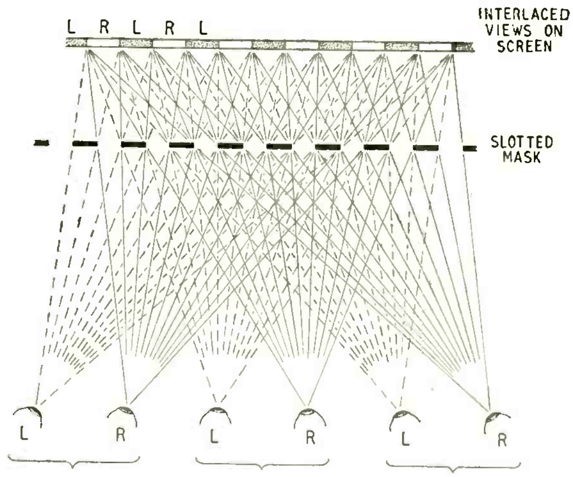
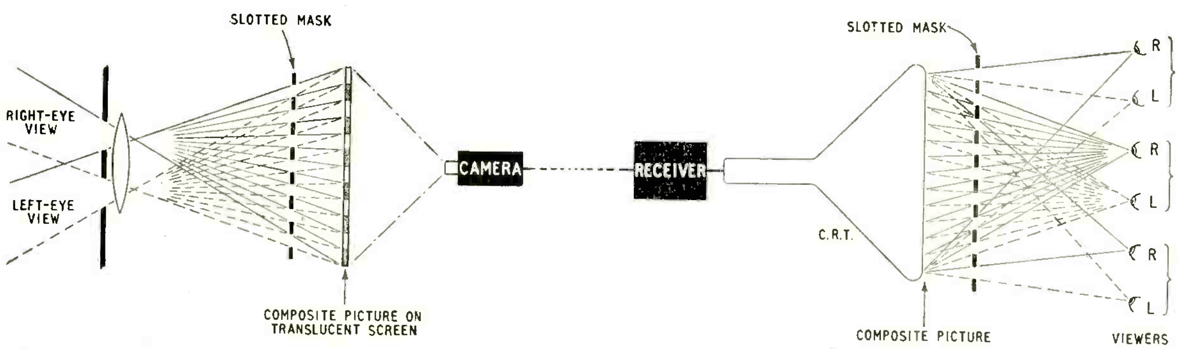


Fig. 1. Showing how each of the observer's eyes sees a different part of the screen when they look through a slot cut in a mask.



Right: Fig. 2. Stereoscopic viewing device. The viewers' left eyes can only see the sections of the left-eye view (marked L) on the screen, and their right eyes only the sections of the right-eye view (marked R). The size of the L and R sections and the slots has been greatly exaggerated to show the principle clearly, and in practice a large number of viewers can be accommodated behind and to the sides.

Fig. 3. Possible stereoscopic television system utilizing the principle illustrated in Fig. 2. A composite picture is transmitted.



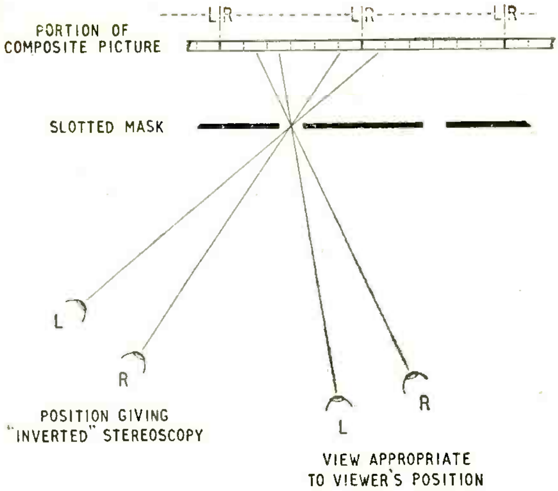


Fig. 4. Principle of stereoscopic system in which the view changes appropiately with the viewer's position. Across each vertical section of the composite picture the aspect progressively changes from a right-side view to a left-side view (indicated by R - - - - L). In practice, the viewer looks through a large number of slots at the same time, as in Fig. 2.

he moves to the left it becomes increasingly left-sided—and all the time a difference is maintained between the views seen by the two eyes, so that he gets the appropriate stereoscopic effect from all positions. Actually there are still viewing zones in which the spectator gets the "inverted" stereoscopic effect, but as can be seen from Fig. 4 these have a very small angular width compared with the correct viewing zones and are passed through so rapidly as to be hardly noticeable.

A method of applying this optical principle to television has already been proposed by one worker. Instead of the photographic camera moving around the subject, this has six lens-systems, arranged in an arc, which focus their respective views through slotted masks on to a translucent screen. The screen therefore displays a composite picture of six interlaced views. This is scanned from the other side by a television camera and transmitted to the c.r.t. screen of the receiver, where a slotted mask is used to give the stereoscopic effect as shown in Fig. 4.

Again the scheme could be operated with an existing television system, but would not be "compatible." Its worst drawback is that it reduces the definition of the picture: the transmitted information is shared between six interlaced views and consequently each view has only one-sixth of the information that would be present in an ordinary television picture. This is the price that has to be paid for the advantage of the "all round" stereoscopic effect. Another problem is that the total number of view-elements in the composite picture could not be greater than the horizontal definition of the television system, otherwise they would not be reproduced at the receiving end. On the British television system this means that there could not be more than about 500 of them and therefore (see Fig. 4) the slotted viewing mask would only have about 85 vertical slots in it and would appear as a very coarse grating.

Actually the slotted masks are not at all good things to use in practice because they introduce a considerable loss of light. The same job can be done without loss of light, however, by lenticular screens made of transparent plastic, and it is actually these that are used in most of the three-dimensional shop-window displays. The plastic sheet has one surface pressed into extremely fine corrugations, and each corrugation constitutes a tiny lens which performs the same function as a slot in the mask. Such screens can be made very cheaply and would only add a few shillings to the cost of television receivers.

Suppressing Gramophone Surface Noise

Points from a Lecture by D. T. N. Williamson

THE British Sound Recording Association's convention held at the Waldorf Hotel, London, W.C.2, from 15th to 17th May, was opened on the Friday evening with a lecture by D. T. N. Williamson on surface noise in gramophone reproduction, with particular reference to the impulsive type of noise associated with the dust particles adhering to plastic long-playing discs.

Analysis of the time and frequency functions of a typical pulse originating from this cause showed that it could be distinguished from transients in the recorded programme by the higher energy content of its spectrum above, say, 20 kc/s. By inserting a high-pass filter with this cut-off, pulses could be segregated and used to operate a gate circuit to remove the disturbance from the a.f. channel.

In practice the start of the pulse is indistinguishable from thermal noise and the peak of the energy burst in the high-frequency channel must be used to operate the gate. It is therefore necessary to delay the audio signal as a whole by half the width of the pulse, i.e., up to about 150 μsec. This could be achieved by a low-pass delay filter of comparatively simple design, with the result that the gate pulse straddled the noise pulse and removed it, together with an equivalent element of the wanted programme.

Mr. Williamson stated that experience had shown the ear to be tolerant of these abstractions, in individual pulses up to 250 μsec in length, and cumulatively up to one tenth of the total duration of the programme!

At the conclusion of the lecture the system was demonstrated in operation on a high-quality l.p. recording which had been specially marked to provide an easily recognizable background. "Clicks" were completely removed, but some further work is necessary, and is in progress, to eliminate a slight low-frequency disturbance arising in the gating circuit.

Inexpensive Pickups on Long-playing Records

By
G. H. RUSSELL,
Assoc. Brit. I.R.E.

Simple Compensating Circuit for the Principal H.F. Resonance

THE reproduction of string tone from long-playing records is often marred by what is perhaps best described as "buzz." This unnatural quality, somewhat reminiscent of a cloud of mosquitoes in flight, is often ascribed to the methods used by the recording company, but that this may not necessarily be true will be seen from the following investigation into a particular case, involving the use of a popular medium-priced pickup.

It is well known that due to the increased compliance of the long-playing record material the high-frequency resonances of the pickup are reduced in frequency.[1, 2] Until recently it has not been possible to test pickups reliably under long-playing conditions, as a test record was not available. This state of affairs has now been remedied, and the results produced by this record are shown in Fig. 1, after compensation has been made for the recording characteristic. It can be seen immediately that the resonance is particularly vicious, and that it occurs at a most unfortunate frequency. It is claimed, at any rate by one recording company, that long-playing discs are recorded up to 14 kc/s, and as the pickup cuts off very rapidly after the resonant frequency has been reached, it can be seen that a particularly wide frequency band is lost. What is probably worse is that the resonance gives an impression of good high-frequency response, which in fact is not present. It is suggested that here is the explanation of exaggerated string buzz, as well as such unfortunate noises as the "puffing" of the flautist, reproduced out of all proportion. Further, the resonance will amplify any distortion in the recording.

The broken curves in Fig. 1 show the effects of the usual top-cut control in a mid-way position and in the full-cut position. From these curves it can be seen that, with a pickup of this quality, the ordinary commercial radiogram will not show this fault to any marked extent, as the response would probably be similar to one or other of the broken lines in Fig. 1. Even so, the reproduction is bound to sound rather unnatural as the characteristic shows a "hole" in the response occurring between 6 and 8 kc/s.

One cannot entirely blame the pickup manufacturers, as this is a very difficult problem to solve economically. The response can be shifted to beyond 14 kc/s, at a price, and the price is not only that of the pickup, but also of the amplifier. Pickups with a resonance above 14 kc/s are not only expensive to make, but show a very great reluctance to deliver outputs beyond a few millivolts. This means more amplification, which can be equally expensive to provide, if it is to be free from hum and noise.

The resonance could be raised to a higher frequency by increasing the stylus pressure on the record, but this is inadmissible because of its effect on record wear.

The pickup discussed here was adjusted to 7.5 grams weight, and it became apparent that the only satisfactory method of eliminating the resonance was to introduce an equal and opposite resonance. It was also obvious that the easiest way to do this would be electrically rather than mechanically, and this meant using a series-tuned circuit.

This might have been somewhat difficult in the past, but was made easy by the availability of Ferrox-

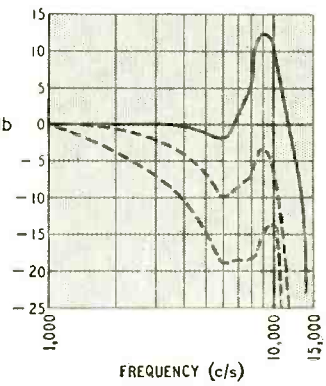


Fig. 1 Pickup response with 0.001-in stylus, 7.5 gm weight. Tested with Decca l.p. frequency test record No. LXT2695; compensation for recording characteristic included.

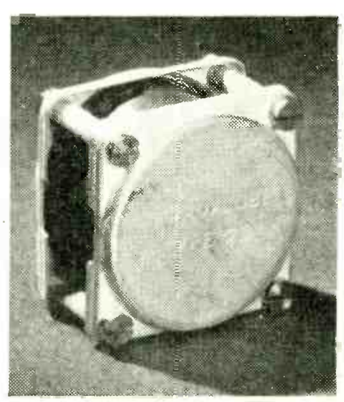
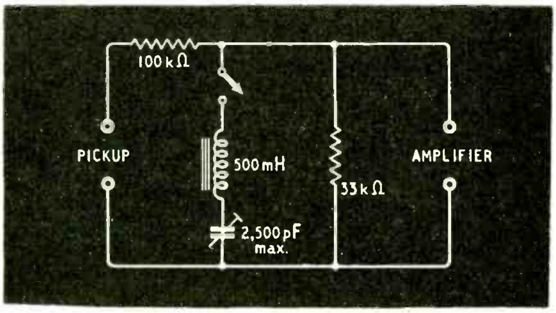


Fig. 2 Photograph (full-size) of Mullard Ferroxcube pot-core assembly, Type Y25.

[1] E. D. Parchment. "Microgroove Recording and Reproduction," *J. Brit. I.R.E.* Vol. 12, No. 5, May, 1952, p. 275.
[2] S. Kelly. "The Crystal Pickup with Special Reference to Long-playing Records," *Journal British Sound Recording Association*, Vol. 3, No. 8, April, 1951, p. 174.



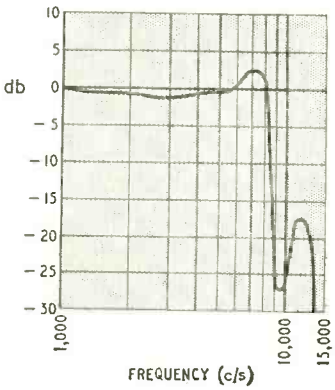


Fig. 3 Circuit diagram of anti-resonance filter, for pickups described in text.

Fig. 4 Conditions as for Fig. 1 but with filter networks inserted.

cube pot-core assemblies. These are manufactured by Mullard and are supplied as a complete assembly including coil former. Unfortunately, no method of fixing is provided and it must be left to the individual user to decide on the best method of achieving this. These assemblies are very neat and compact; a good idea of their size and appearance can be gained from Fig. 2. They possess a very high permeability and a negligible external field. These characteristics enable quite high inductances to be obtained with comparatively small amounts of wire, and the virtual absence of an external field means that they can be used in low-level circuit positions, where it would be hazardous to use any other type of winding.

The type used for this application is designated Y25 and has a winding area of 83 mm.[2] 52 turns are required for an inductance of 1 mH, and in order to make the circuit easily tunable, an inductance of 500 mH was used, requiring $52\sqrt{500} = 1,144$ turns of 40 s.w.g. enamelled copper wire. The tuning condenser is a Cyldon No. 26 mica compression trimmer, 2,500 pF maximum capacity.

Method of Connection

Handsome Q-factors can be obtained with these Ferroxcube assemblies (of the order of 200 at 10 kc/s), which are clearly not required here. It is inadvisable to shunt the pickup directly, as this could cause severe distortion in the region of resonance. Further, it is necessary to shape the resonance curve of the tuned circuit so that it is, as near as possible, a mirror image of the pickup resonance curve, and this has been achieved by using the tuned circuit as part of a frequency-dependent potential dividing network, as shown in Fig. 3. This network is placed between the pickup and the amplifier. It results in some loss of gain which is unavoidable. Also shown in Fig. 3 is a switch for disconnecting the filter when playing 78 r.p.m. records. This method of switching results in a similar loss of gain in the case of 78 r.p.m. records; this was thought to be desirable as no violent change in volume level occurs from the change-over.

Overall Response

The results obtained from the combination of pickup and filter are shown in Fig. 4 and it can be seen that apart from a slight rise of some 2.5 db at 7 kc/s, the response is substantially flat up to 8 kc/s, after which it drops very steeply. Nothing but a better pickup can improve the response beyond this point. After the filter had been inserted and tested, one or two "bad" records were played through. The worst of these, an early release, which before had exhibited "buzzing" to a most objectionable extent, sounded perfectly natural and somewhat more lifelike than a good many more recent issues.

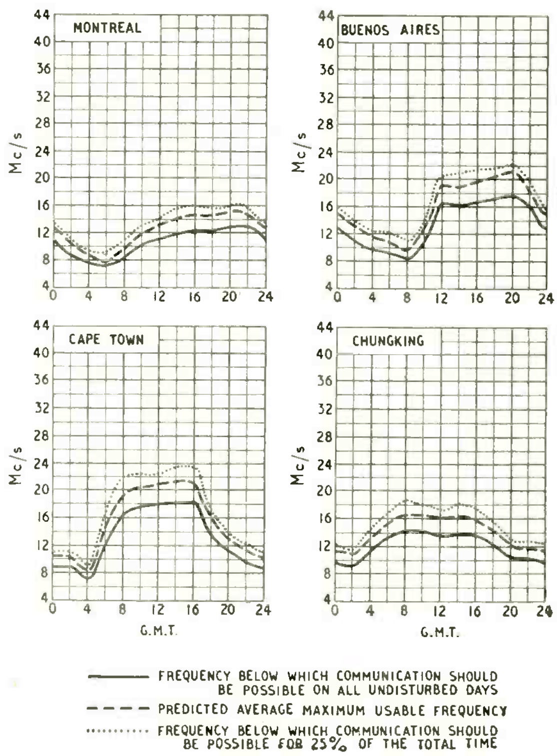
An interesting comment on the present state of the art is that, at the moment, it is easier to obtain a good high-frequency response with 78 r.p.m. records than with the long-playing variety, but, of course, with an accompaniment of needle scratch.

Short-wave Conditions

Predictions for July

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

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



Audio Developments

New Products Shown at the A.P.A.E. and B.S.R.A. Exhibitions

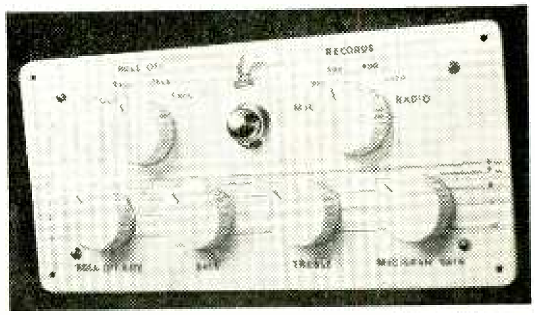
STEADY if not spectacular progress in the design of audio-frequency equipment is evident from a survey of the commercial products shown at the exhibitions organized recently in London by the Association of Public Address Engineers (May 5 and 6) and the British Sound Recording Association (May 16 and 17). Greatest activity in the immediate past would seem to have been in the design of magnetic tape recorders, though amplifiers and their control units have also shown that design in this well-established field is far from reaching stagnation. There is evidence of activity in loudspeaker design, particularly in line-source arrays for covering large areas out of doors; and microphone, pickups and other important accessories have all contributed food for thought.

Microphones.—A new noise-cancelling microphone (Model VC52) has been developed by Lustraphone and is designed as a close-talking microphone for use under high ambient noise conditions. It is stiffness-controlled over the working range and is of small dimensions compared with the wavelength of the upper limit of frequency. Two factors contribute to the high discrimination against noise, a polar diagram with a high front-to-back ratio and a sensitivity which falls off steeply with distance from the source. Its small size permits a variety of mountings, one of which is from an adjustable bracket attached to the operator's headphone set. Also new to the Lustraphone range is a ribbon microphone Model VR/53 with a frequency response up to 14,000 c/s.

Pickups.—An exhaustive investigation into the conditions under which pickups are required to perform when tracking long-playing records has been undertaken by Cosmocord in collaboration with the Decca Record Company and it has been established that pickups may be called upon to respond to accelerations as high at 2,000 times the acceleration due to gravity at a frequency of 10,000 c/s. Accordingly, Cosmocord have produced for manufacturers an entirely new range of "Hi-g" pickups and cartridges which can be relied upon to track not only all existing l.p. records, but any which may be produced in the future under the existing limitations of groove spacing and high-frequency cut-off. This performance has been achieved without exceeding a weight of 10 gm on the stylus. In the Type HGP33-1 turnover cartridge, which is typical of the series, an increase in compliance of the movement has permitted the use of a push-in sub-miniature stylus which can be replaced without special tools. With a simple two-element RC equalizing network a response flat from 50 to 13,000 c/s is obtained with only a 5 db drop at 20,000 c/s.

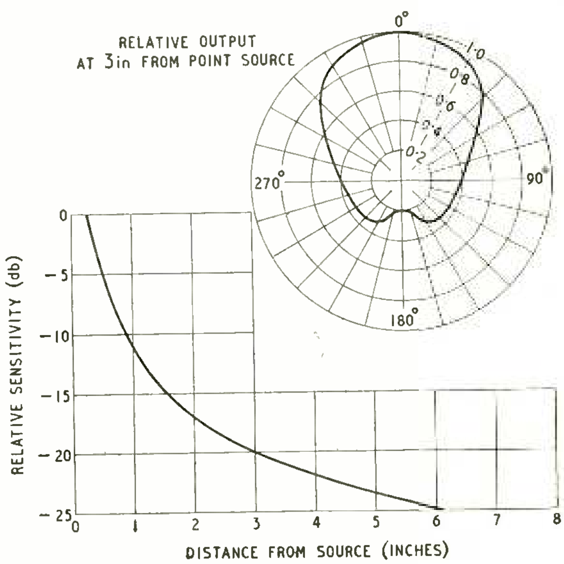
The prototype of a new moving-iron pickup was shown by A. R. Sugden with an armature mass of 10 milligrams and a high-frequency resonance of 15 to 20 kc/s when playing plastic long-playing or nitro-cellulose direct recording discs.

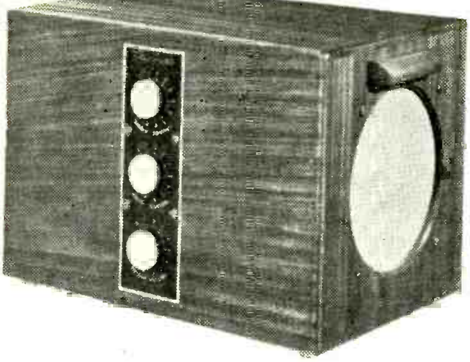
Pre-amplifiers, Control and Feeder Units.—A versatile "Master Control Unit" for microphone, recorded or radio inputs has been developed by the Lowther Manufacturing Company. It employs three ECC40 valves and in addition to standard equalization for the principal disc recording characteristics, has



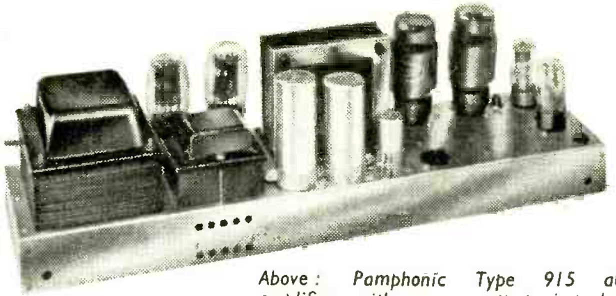
Above: Lowther "Master Control" pre-amplifier unit, providing compensation for four recording characteristics together with comprehensive tone controls.

Headphone mounting for Lustraphone noise-cancelling microphone and (below) sensitivity/distance and polar characteristics at 1000 c/s.

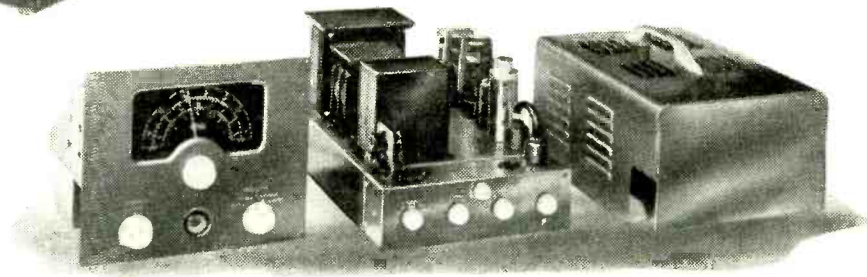




Above : "Truchord" Model 50T amplifier-loudspeaker unit.



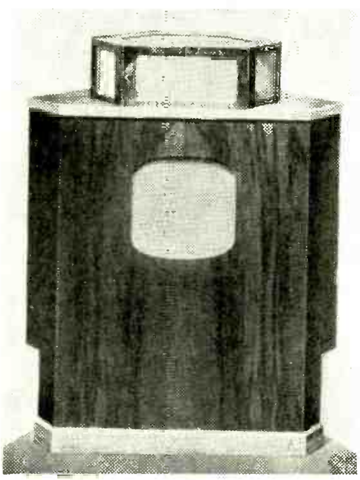
Above : Pamphonic Type 915 audio amplifier with zero output impedance.



Right : Leak radio feeder unit, Type VS, and portable combined TL/12 amplifier and control unit.

independent bass and treble controls giving continuously variable rise and fall up to 30 db, and separate variable-slope filters giving a "roll-off" at alternative fixed starting frequencies of 5, 7 and 9 kc/s. That the unit does perform according to specification was proved by a demonstration on the stand using an Industrial Electronics automatic cathode-ray curve tracer, which showed that operation of the controls was not accompanied by any secondary disturbances near the critical cut-off frequency. Not the least interesting feature of this unit is the ingenious parallel-line graduation of the front panel which serves all the controls. A neat AM-FM tuner unit covering 85-100 Mc/s has also been added to the Lowther range.

Designed for stable high-quality reproduction from long-distance short-wave stations as well as medium-wave stations, the new S6BS radio feeder unit made by C. T. Chapman (Reproducers) has two stages at i.f. with switched tertiary windings giving bandwidths of 5, 7 and 10 kc/s. Delayed, amplified a.g.c. is applied to the r.f. and frequency-changer stages as well as to the two i.f. valves, and the chassis is fully tropicalized.



Wharfedale reproducer with triple-unit loudspeaker system.

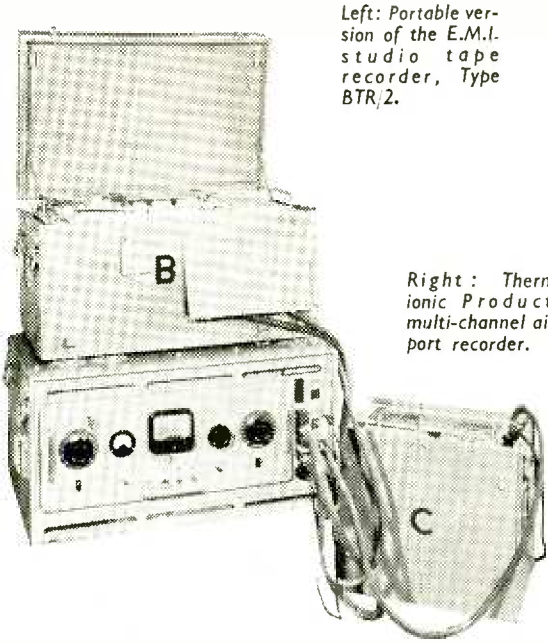
Amplifiers.—The Type 915 amplifier recently introduced by Pamphonic Reproducers has been designed for research and measurement work as well as for high-quality reproduction. It has a frequency response of 15 c/s to 150 kc/s, ±1 db and the distortion at the maximum output of 15 watts is claimed to be 0.05 per cent at 1,000 c/s. Feedback is designed to provide *zero* output impedance.

For high-quality p.a. applications G.E.C. have introduced a 30-watt amplifier of robust design (BCS2430) with tetrodes in Class AB1 push-pull and using a neon stabilizer for the screen feed resistance. Three fader-connected inputs are provided as well as the usual tone controls, and there is a test meter with switching for all valve cathode currents. A panel mounting version (BCS2430/2) of this amplifier is available.

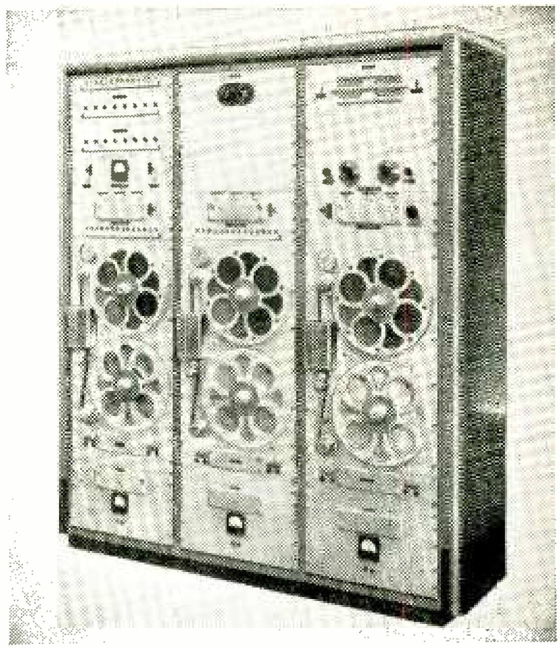
The Leak TL/12 amplifier and pre-amplifier control unit are now available as a combined portable unit, suitable for p.a. work. This unit is illustrated together with the VS radio tuner unit, which provides bandwidths of 6, 12 and 24 kc/s.

Rogers Developments have introduced a medium-priced "RD Baby de Luxe Mark II" amplifier to supersede their earlier "Baby" and "Junior" amplifiers. It has a larger output transformer and more conservatively rated h.t. supply. At 1,000 c/s harmonic distortion is 0.25 per cent at 8 watts output, and 0.6 per cent at 12 watts. Hum and noise have been reduced to −85 db referred to 8 watts.

An unusual amplifier-loudspeaker unit is now available from Reproducers (Electronic), Ltd., makers of the "Truchord" record reproducer. It consists of the main amplifier from this instrument together with a 10-inch loudspeaker and forms a nucleus to which the enthusiast can add auxiliary equipment of his own choice.



Left: Portable version of the E.M.I. studio tape recorder, Type BTR/2.

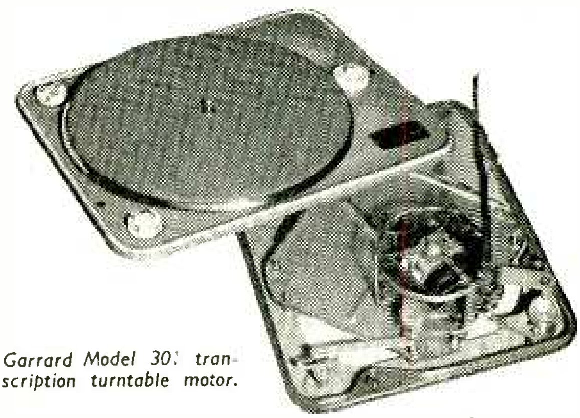


Right: Thermionic Products multi-channel airport recorder.

Loudspeakers.—Developments in loudspeakers, as exemplified by these two exhibitions were for the most part confined to minor improvements in existing and already well-known units. Wharfedale, however, were showing a new wide-range reproducer in which the frequency spectrum is divided between three units. A type W15/CS unit in a 9-cu ft vented enclosure covers frequencies up to 800 c/s. Above this frequency, a "Super 8/CS" is fed from the half-section crossover filter, and the extreme top is reinforced by a "Super 5" unit which is shunted across the mid-frequency unit with a series capacitor to restrict the input below 5 kc/s. A volume control is connected across the h.f. unit to provide a balance suited to programme conditions.

The new "Magneta-Decca Radiator" produced by the Magneta Time Company is a vertical line-source column loudspeaker and has a radiation characteristic designed to give reasonably uniform sound intensity (84 phons) over an elliptical area approximately 250 × 180 yds at the front and 85 × 60 yds at the back, with an input of 75 watts.

Gramophone Motors.—The new transcription-type 3-speed gramophone motor, Model 301, made by Garrard is of the induction type driving a heavy stainless steel turntable through a friction drive. The motor is fully floating on a spring suspension and its power consumption is 16 watts. Speed fluctuation ("wow") is less than 0.2 per cent. An unusual feature for a motor of this type is the provision of a speed control over narrow limits, so that pitch can be accurately adjusted when desired. A large-diameter disc under the turntable forms an eddy-current brake in conjunction with a small permanent magnet, the position of which can be adjusted to vary the retarding torque. Speed limits on $33\frac{1}{3}$, 45 and 78 r.p.m. (nominal) are 32.6-33.9, 44-46 and 76-80 r.p.m. respectively.



Garrard Model 301 transcription turntable motor.

Magnetic Tape Recorders.—The multi-channel airport recorder designed by Thermionic Products is an outstanding example of an important application of magnetic recording in air traffic communications. On a 0.7in wide tape running at 3.75in/sec, fourteen channels can be recorded simultaneously for four hours on each reel of tape. Automatic switching is provided to ensure continuity, and to transfer the recording to the standby unit in the event of any failure in the system. Coded time signals from an electrically wound spring clock are superimposed on each channel so that the time of any message can be established with accuracy.

In another sphere, the new E.M.I. Type BTR/2 portable equipment is equally imposing. In performance it is the same as the studio version, which is widely used by broadcasting and recording organizations, and gives a response at a tape speed of 15in/sec level within ±2 db from 50 to 15,000 c/s.

The production by M.S.S. of a new tape mechanism of their own design is an event of more than usual interest. Basically it follows established practice for high-quality machines designed for tape speeds of $7\frac{1}{2}$ and $3\frac{3}{4}$in/sec and the performance figures quoted for the higher speed are 60-10,000 c/s ± 3 db, $<2\frac{1}{2}$ per cent total harmonic distortion, "wow" <0.2 per cent, signal/noise ratio 50 db. Several types of complete machine are available, including models designed to work in conjunction with M.S.S. disc recorders for transcription work. Variations from standard specification which can be supplied to order include synchronous drive motor, tape speeds of $7\frac{1}{2}$ and 15, or $1\frac{7}{8}$ and $3\frac{3}{4}$in/sec, automatic back spacing and reverse drive for dictation purposes, and remote operation with foot control.

The range of tape recorders made by C.J.R. Electrical and Electronic Development, which incorporate a special version of the Bradmatic tape desk, covers every possible requirement for professional use. Three half-track heads are standard in all models, enabling the recording to be monitored while in progress. In addition to the portable models a console (Type D6) with a 10-watt push-pull amplifier and accommodation for $9\frac{3}{8}$-in diameter spools is available.

M. S. S. magnetic tape recorder, Type PMR/3.

British Ferrograph have produced a revised version (Model 2A) of their well-established portable recorder with synchronous capstan motor, endless loop cassette attachment and facilities for superimposing commentaries on previously recorded material. The new machine accommodates 1,750-ft reels and is fitted with a redesigned sustained-peak monitoring meter, giving easily interpreted readings.

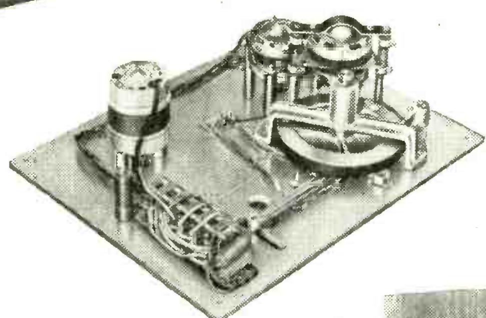
In addition to the portable "Reporter" tape recorder with which Grundig (Great Britain) entered the market, there is now a handsome console (700C). As in the "Reporter" control is by push buttons and there is provision for inductive pickup from a telephone instrument, as well as normal inputs from microphone or radio. All Grundig instruments are now sold with a 25-minute demonstration tape which includes a variety of celebrity recordings. Possibly of greater interest to the technically minded is the fact that a test tape (TB53) with a range of standard frequencies is also now available at 21s.

The redesigned Truvox Mark III tape mechanism is now in production and is notable for the clean and simple mechanical design. The capstan flywheel bearing is exceptionally long and the main drive motor is flexibly suspended.

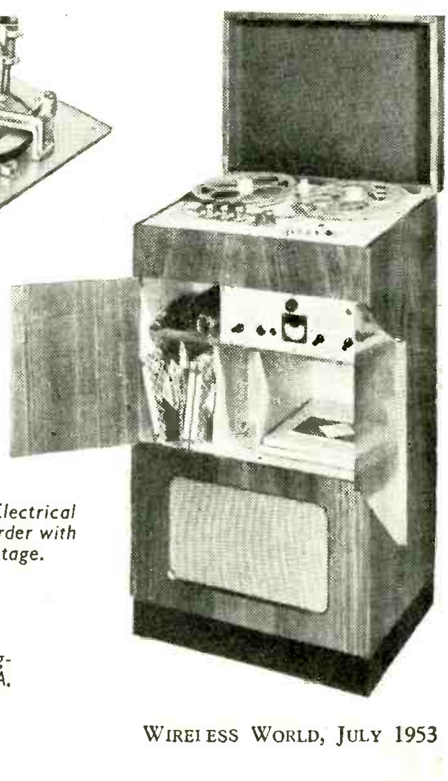
In the "Tape-Riter" office dictating machine (London Office Machines, Ltd.) the advantages of standard $\frac{1}{4}$-in tape, from the point of view of quality of reproduction, are exploited without incurring the normal difficulties of threading and loading, by the use of self-contained cartridges which, in addition to supply and take-up reels, contain a tape footage indicator.

A wide range of cinema-film edge coatings, as well as 35 mm and 16 mm film fully coated between perforations, are now available from the Minnesota Mining and Manufacturing Company, who have also produced an improved 0.25-inch tape (MC2-111)

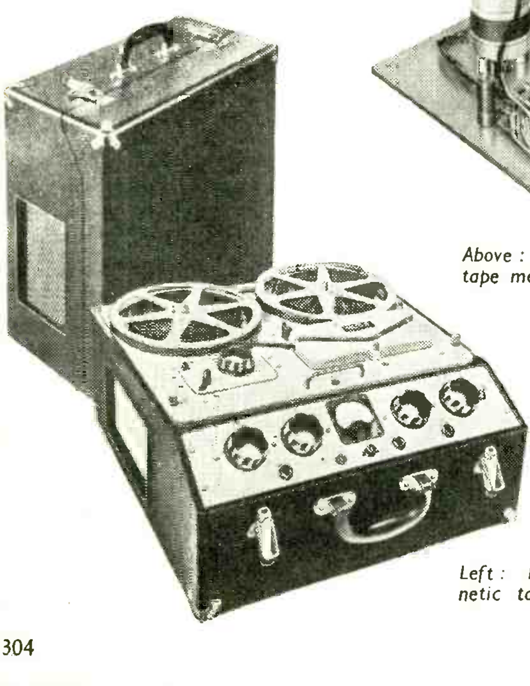
(*Continued on p.* 305)



Above : Truvox Mark III tape mechanism.

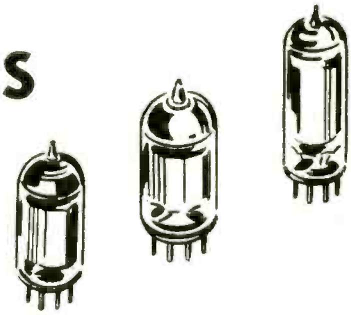


Right : C. J. R. Electrical console tape recorder with push-pull output stage.



Left : British Ferrograph magnetic tape recorder, Type 2A.

BRIMAR VALVES for VHF and UHF



For work in the higher frequency ranges Brimar types 5763 and 12AT7 are becoming increasingly popular. These performance details will give you some idea of their scope.

Type 12AT7

This high-slope double triode with separate cathodes is an excellent frequency-changer, oscillator, grounded grid or grounded cathode RF amplifier up to the 460 Mc/s band.

Frequency changer. With a conversion conductance of 2.5 mA/V., the 12AT7 at 430 Mc/s. gives a conversion gain of 5db. with a noise factor of 10, thus offering distinct advantages over a diode mixer at these frequencies.

Oscillator. Up to 500 Mc/s. With lines as the tuned circuit, the two halves in push-pull will deliver approx. 2 watts RF at 400 Mc/s.

Grounded grid R.F. amplifier. In push-pull grounded-grid operation the input impedance is approx. 300 ohms, thus matching to 300 ohm balanced feeder is simple. A single-ended amplifier using one half only gives at 200 Mc/s. a gain of about 10db. and 6db. at 400 Mc/s. Operation of both sections in Push-Pull gives an additional gain of 2-3db.

Grounded cathode R.F. amplifier. Feeding a grounded grid stage, a gain of 14db is obtainable at 200 Mc/s., with a noise factor of 7.

Type 5763

Due to its small size, this VHF beam power tetrode is very suitable for portable equipment. Designed as an R.F. amplifier and frequency multiplier, it is also a useful modulator or driver, since a pair in class AB2 will deliver 25 Watts with an anode voltage of only 300.

Typical Operation

	Oscillator or power amplifier	Doubler	Tripler
Anode Voltage	300	300	300 Volts
Anode Current	50	40	35 mA.
Screen Supply Voltage	250	300	300 Volts
Series Screen Resistor	—	12.5k	12.5k ohms
Screen Current	5.0	4.0	5.0 mA.
Control Grid Voltage	-60	-75	-100 Volts
Control Grid Resistor	22k	75k	100k ohms
Control Grid Current	3.0	1.0	1.0 mA
Peak RF Grid Voltage	80	95	120 Volts
Input Driving Power	0.35	0.6	0.6 Watts
Output Power	8	3.6	2.8 Watts

This data will apply up to 175 Mc/s, but above that frequency the maximum anode voltage and dissipation must be reduced.

BRITISH MADE

BRIMAR VALVES

SEND FOR FREE DATA SHEETS *to the* Publicity Department

Standard Telephones and Cables Limited **FOOTSCRAY, SIDCUP, KENT**

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Tracking 2000g at 10 grammes maximum stylus pressure

acos REG'D Hi-g SERIES

PICK-UPS & CARTRIDGES

The listening public is inclined to take technical achievements for granted—to assume, for instance, that the increasingly exacting requirements of microgroove records can automatically be met by pick-up manufacturers. This is not the case. There is nothing automatic about it. The technical progress made by record manufacturers is, in effect, a challenge to pick-up manufacturers—a challenge which Cosmocord, whose slogan "Always well ahead" really does mean something, are always ready to take up. Sometimes the record manufacturers set us a problem, to which the solution is "impossible" and therefore takes quite a time to provide.

Such a problem is involved with regard to pick-up tracing capabilities which now have to be of a substantially higher order than those for 78 r.p.m. records, and are likely to become even more critical.

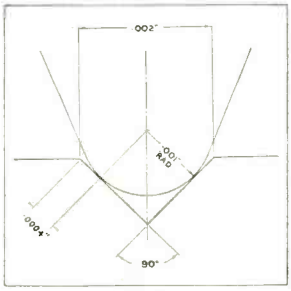


Fig. 1

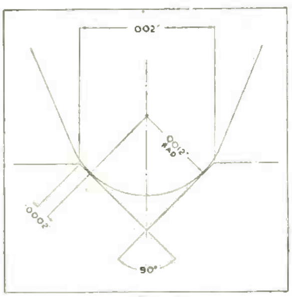


Fig. 2

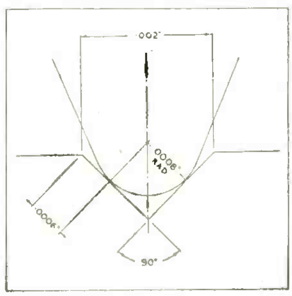


Fig. 3

Cosmocord, with the very helpful co-operation of the Decca Record Company, have recently made a detailed examination into the optimum tracking requirements that *could* arise in modern types of microgroove records. This was done in order to establish a basis for the design of pick-ups that would not only satisfy the requirements of all records at present available to the public, but if possible anticipate future developments within the limits as set out in the recently published British Standard Specification (B.S.1928 : 1953).

THREE FACTORS

The three important factors that had to be considered by Cosmocord in designing such a pick-up were minimum groove width, maximum lateral displacement and maximum stylus tip acceleration.

The minimum groove width as laid down by the British Standard Specification is .002in. The conditions existing in a record giving up to 30 minutes playing time per 12in. side are well demonstrated in the accompanying scale drawings. For simplicity's sake, the groove angle has been shown as 90° and the radius at the bottom of the groove has been left out, as at .0003in. maximum it has no effect. Three pick-up stylus radii are shown, the nominal .001in. radius (Fig. 1) and its upper and lower limits of .0012in. and .0008in. (Figs. 2 and 3 respectively) according to British Standard Specification. It can be seen that the .001in. radius has .0004in. wall above its point of contact, whilst the .0012in. radius has no more than .0002in. This does not take into account the pinch effect which can reduce the margin by .0002in. at 5,000 c/s.

PRACTICAL CONSIDERATIONS

In order to arrive at maximum possible displacement, some assumptions have to be made that are dictated by practical considerations. Working on the basis of 200 grooves per inch the maximum possible displacement (d) is .003in. At a frequency of 40 c/s. this displacement corresponds approximately to a maximum velocity of 2 cm/sec. ($v = 2\pi fd$).

Accepting the recording characteristics of the Decca Long Playing test record No. LXT 2695 as typical for commercially produced long playing records, the maximum velocity and corresponding acceleration at 10,000 c/s. can be calculated. According to the record specification the recording pre-emphasis at 10,000 c/s. relative to 40 c/s. is + 24.4 dbs. and this gives a velocity of 31.6 cm/sec. and a corresponding displacement of .0002in. $\left(e = \frac{v}{2\pi f}\right)$. It further follows that expressed in gravitational units the acceleration at 10,000 c/s. may be as high as 2000g $\left(g = \frac{ef^2}{10}\right.$, where e = displacement = .0002in. and f = 10,000 c/s.).

WHAT OF THE FUTURE?

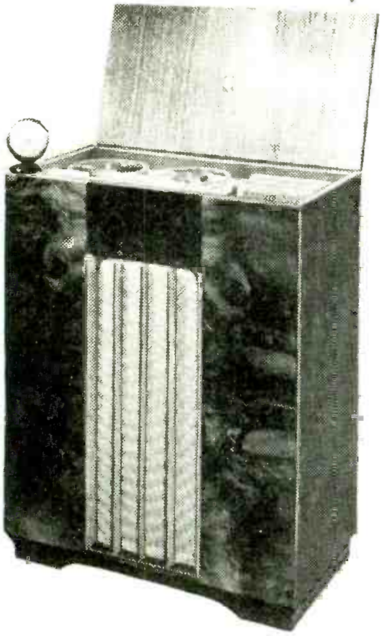
The examination, as can be seen even from this simplified statement, has brought to light conditions that appear to be incredible at first sight. They are, however, far from being purely hypothetical and it may be only a question of time before they appear on commercially produced records. Even now there are a few odd records on the market which come very close to these limiting conditions.

It can be seen that the problem set by the record manufacturers in this matter was a formidable one. Cosmocord have answered it so completely with their Acos "Hi-g" series of pick-up cartridges that they already meet, here and now, any likely future development of gramophone records within the B.S. 1928 : 1953 specification.

always well ahead

Acos Crystal Devices are Protected by Patents and Patent Applications in Gt. Britain and Other Countries

COSMOCORD LIMITED · ENFIELD · MIDDLESEX



Grundig 700C console tape recorder with 4½-watt output.

which shows an improvement of 2 to 5 db in sensitivity and 6 db in maximum output.

Erasure of complete spools of tape in a 50-c/s alternating field is often more effective and convenient than erasure by a separate head at bias frequency, and Leevers-Rich have for some time marketed an erasing machine for this purpose. They now offer a modified version with an extra field coil which will accommodate all spools from 3½in up to the large single-sided platter type as used by European broadcasters.

BOOKS RECEIVED

Monographs for Students. A series intended for general reading in the first two years of a degree course, or for students taking the Higher National Certificate in Applied Physics.

"Fundamentals of Thermometry" by J. A. Hall, B.Sc., A.R.C.S., D.I.C., F.Inst.P. Pp. 48; Figs. 13.

"Practical Thermometry" by J. A. Hall, B.Sc., A.R.C.S., D.I.C., F.Inst.P. Pp. 51; Figs. 8.

"The Magnetic Circuit" by A. E. de Barr, B.Sc., F.Inst.P.

"Soft Magnetic Materials Used in Industry" by A. E de Barr, B.Sc., F.Inst.P. Pp. 62; Figs. 35.

Price 5s each. Published by the Institute of Physics, 47. Belgrave Square, London, S.W.1.

Antennentechnik, by G. C. Oxley, A.M.I.E.E., and Alfred Nowak, Dipl. Ing. Theoretical and practical aspects of aerial design with special emphasis on dipoles for television and arrays for short wave communication. Pp. 234; Figs. 257. Fachbuchverlag Siegfried Schutz, Hanover, Germany.

Einfuhrung in die Theorie der Hochfrequenz-Bandfilter by Richard Feldtkeller. Mathematical treatise on the design of bandpass filters. Pp. 196; Figs. 95. Price DM 16. S. Hirzel Verlag, Stuttgart, Germany.

Differential and Integral Calculus by Philip Franklin Ph.D. Introductory treatise with numerous examples and exercises. Pp. 641; Figs. 367. Price in U.K. 48s. McGraw-Hill Publishing Company, 95, Farringdon Street, London, W.C.2.

TV Sweep Alignment Techniques by Art Liebscher. Adjustment and fault tracing with numerous c.r. oscillograms. Pp. 123; Figs. 66. Price $2.10. John F. Rider, Publisher, 480, Canal Street, New York, 13

PLASTICS

Radio Mouldings at the Olympia Plastics Exhibition

AMONG the wide range of plastic materials and mouldings shown at the recent Plastics Exhibition organized by *British Plastics* at Olympia were many used by the radio industry.

One of the most impressive exhibits was a giant parabolic aerial reflector measuring 14 ft in diameter and intended for use in the 9- to 11-cm waveband. It has been produced by F. G. Miles, Ltd., of Shoreham-by-Sea for the Cossor Mark VI airfield radar. Moulded in phenolic asbestos, it is said to be non-corrosive and has such a good strength-to-weight ratio that scanners of this kind can be constructed in approximately half the weight of an equivalent all-metal structure. The necessary conducting surface is provided by spraying the concave face with metal protected by a coating of paint.

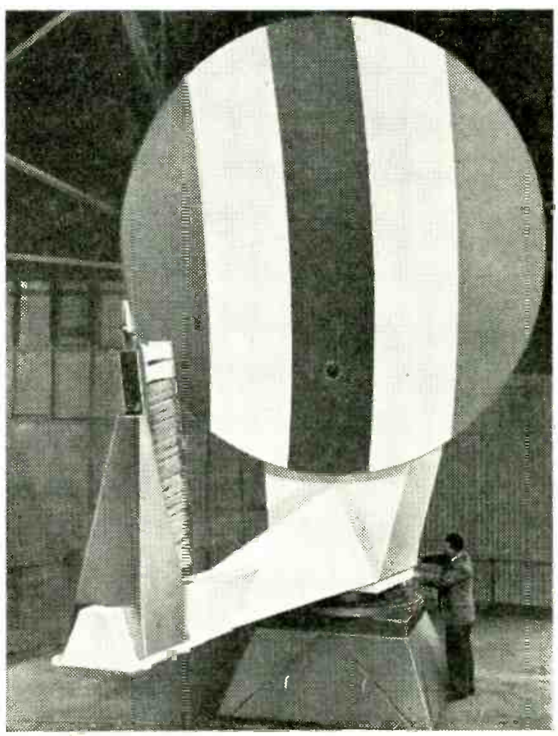
The plastics production of E. K. Cole, Ltd., now includes moulded instrument knobs, various kinds of r.f. and a.f. coil formers and some terminal and multi-plug inserts. A black phenolic moulding is used for the r.f. coil formers which take the form of small ¼-in and ½-in (approximately) diameter formers with fixing feet and having internal threads for a dust-iron core.

A lesser-known activity of the G.E.C. is the production of plastic mouldings of various kinds, many having radio applications. These include valve bases, c.r. tube bases, coil formers and complete radio cabinets.

Telcon plastics, mainly Telcothene, were well in evidence, while Redifon and Radio Heaters demonstrated sealing and welding of plastics by means of radio-frequency.

Printed circuitry as applied to the construction of an Ardente hearing aid was shown by Lacrinoid Products, the etched foil process on a plastic base being employed.

Giant parabolic reflector moulded in phenolic-asbestos for a Cossor airfield radar. The hole is for alignment purposes during installation and is normally covered by a metal disc.



MODERNIZING THE

(Concluded from p. 284 of the June Issue)

Wireless World Television Receiver

Part 3.—Construction

A FEW changes are needed in the apparatus associated with the time-bases, mainly in the power unit and the focus-coil unit.

The power unit originally had an output of 480 V but this is now too great. It is reduced to some 400 V by the simple expedient of omitting the 4-μF reservoir capacitor. The circuit then works with a choke input and provides a smoothed output of some 400 V which is dropped to 300 V in the focus-coil circuit. The arrangement is shown in Fig. 5. The focus circuit is arranged to minimize the variation of voltage drop across it with operation of the control and is only possible because the total current of 200 mA is over twice that needed by the focus coil. This coil is the one of the original design but requires a higher current because of the higher operating voltage of the tube.

The details of this focus coil are given in Fig. 4 which is repeated from the original description since this is now out of print. The type of focus coil employed is in no way critical, however, and there are suitable commercial types; as an alternative, permanent-magnet units are now available and would normally be preferred because they are not subject to a warming-up drift.

Some alteration to the values of R_1 and R_2 may be needed in some cases, depending on the tube used, the position of the focus coil and its design, for the range of control afforded by R_3 is not large. Because the resistance of the focus coil varies with temperature there is inevitably a small change of focus when the set has been in operation for some time.

The proper condition is to have the "cold" and "hot" settings of R_3 about equally on either side of its mid-point and in some cases an adjustment to R_1 and R_2 may be needed to achieve this and at the same time to secure the output h.t. line of 300 V. The value of R_2 governs the focus control setting. A reduction in its value shunts more current away from the coil and R_1 so that the slider of R_3 must be moved towards the coil end to maintain focus. The value of R_1 mainly governs the h.t. voltage and has little effect on focus.

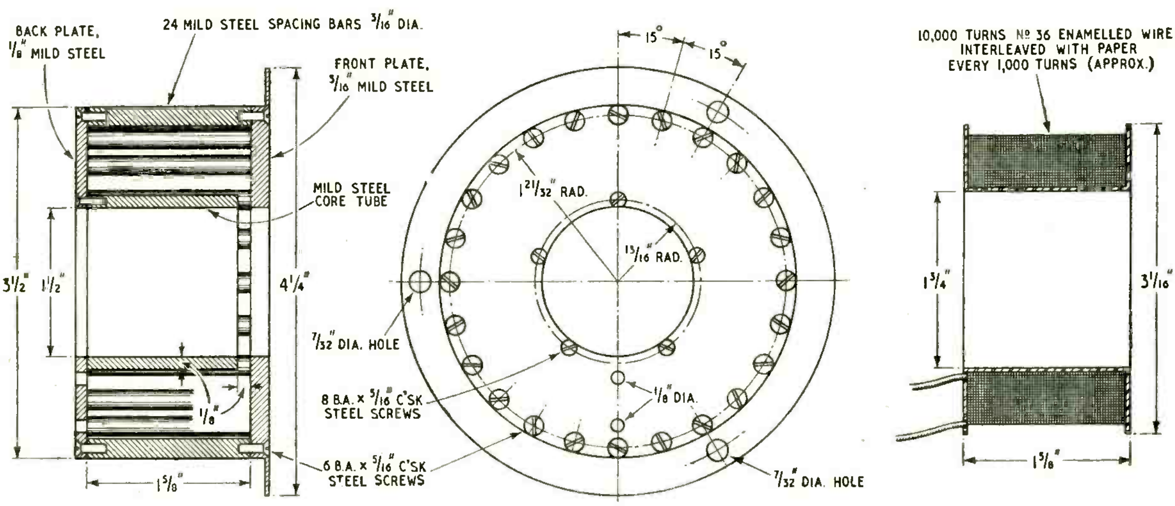
The values shown in Fig. 5, with R_1 zero, are suitable for the G.E.C. 6075A tube and probably for most other triode types. A tetrode gun, such as the Mullard MW 31-16, however, calls for a smaller focus-coil current. With such a tube its first anode should be joined to the $+HT_1$ point.

If a permanent magnet is used for focusing L_1, R_1, R_2, R_3, R_4 and C_2 are to be omitted and replaced by a simple dropping resistor of 500-Ω 25-W rating.

If a tube with an ion trap is used, an ion-trap magnet suited to the tube must be employed and the tube-maker's recommendations as to type of magnet and method of adjustment should be followed. Proper adjustment is important not only to secure the best results but because the tube may be damaged by incorrect adjustment.

The magnet is normally placed over the tube so

Fig. 4. Details of a suitable focus coil are given here. The core tube is $1\frac{1}{2}$-in long to give a $\frac{1}{8}$-in air gap at the front end. The spacing bars can be made from 5-in wire nails. The coil has a resistance of 1,000 ohms.



that the arrow on it agrees with the line marked on the tube base and sufficiently forward for it to be in front of the gun and over the trap. The position is adjusted by sliding it backwards and forwards, and rotating it slightly, to give the brightest raster. Initially, this must be done with a very dim raster, but the final adjustment can be done with one of normal brightness.

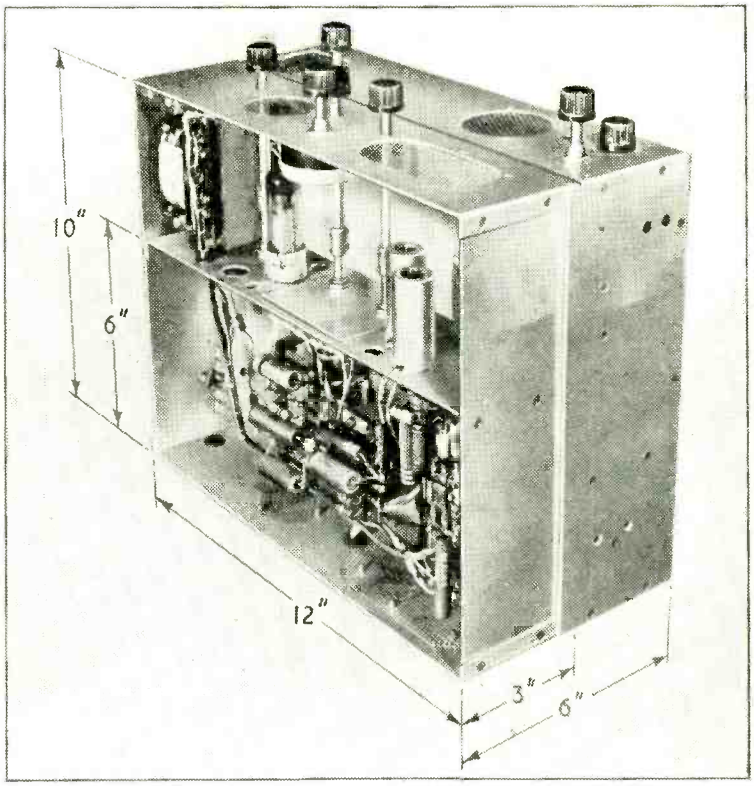
The brightness-control circuit has been altered slightly from the original in that the values of the resistors have been reduced to enable a wire-wound potentiometer to be used.

One change only is needed in the receiver unit and that only in the superheterodyne model. Because of the different supply voltage, R_{22} (the oscillator feed resistor) should be dropped from 100 kΩ to 82 kΩ.

The time-base circuit of Fig. 1 has been put into practical form in two different ways—one as a modification to the existing time-base chassis of the original receiver and the other as a new design. In the former, both chassis took the form of trays with open tops and bottoms and cross shelves for the valves. The open sides were mounted to face each other with a metal plate between them for screening. The outer chassis, for the line time base, was hinged at the bottom to open outwards, while the inner chassis was hinged at the back so that the whole unit could be tilted on one corner clear of everything else.

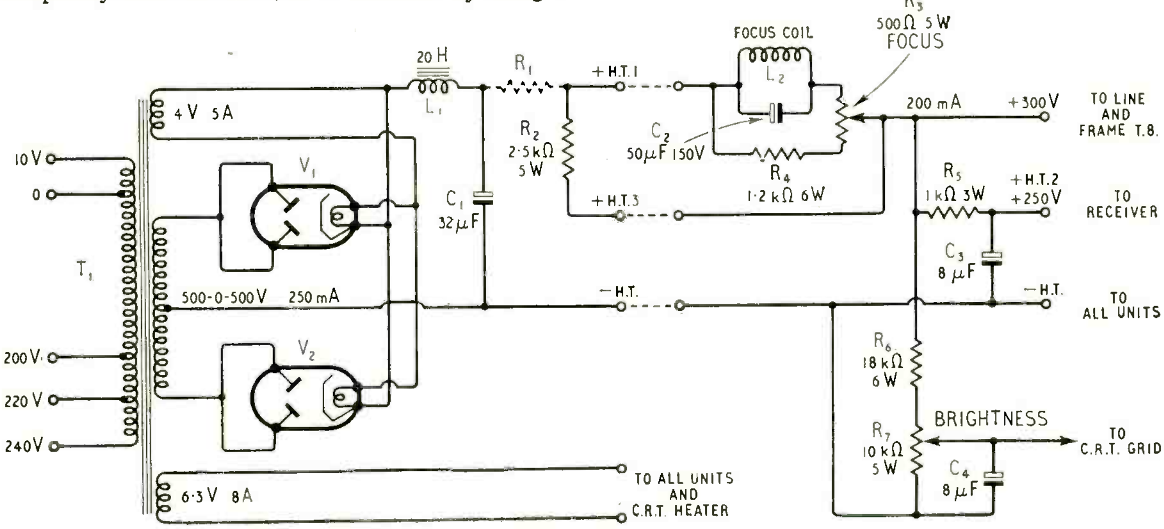
This form of construction proved very satisfactory, but it was found that the frame time-base unit, which remained always in a vertical position, was much less convenient to work on than the line time-base chassis, which opened out into a horizontal position. In the new design, therefore, both chassis will open out horizontally, one being hinged to the other as shown in the photographs.

To minimize radiation, the line time-base must be completely screened and this is achieved by using a



Here the frame time-base is shown together with the size of its chassis and the position of its shelf.

Fig. 5. Circuit diagram of the power unit with focus and brightness control connections. The output of the receiver unit is taken directly to the cathode of the c.r. tube and through a 10-kΩ resistor to the frame time-base unit.



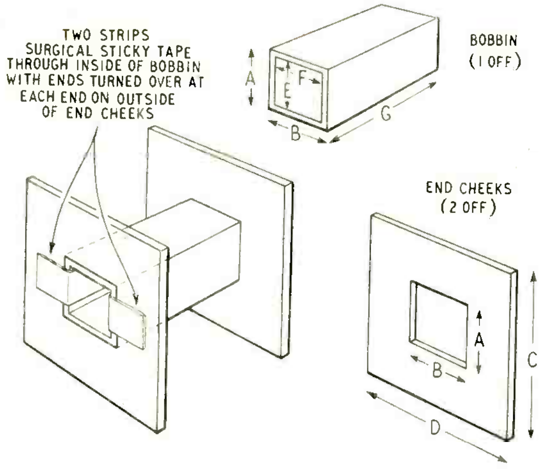


Fig. 6. Details of the bobbins for the transformers T_1, T_2 and T_3.

DIMENSIONS FOR FIG. 7

(inches)

	A	B	C	D	E	F	G	Stack
T_1	$\frac{13}{16}$	$\frac{7}{8}$	$1\frac{3}{8}$	$1\frac{7}{16}$	$\frac{11}{16}$	$\frac{3}{4}$	$1\frac{1}{32}$	$\frac{11}{16}$
T_2	$1\frac{1}{16}$	$1\frac{3}{16}$	$2\frac{11}{16}$	$2\frac{3}{4}$	$\frac{15}{16}$	$1\frac{1}{16}$	$1\frac{3}{16}$	1
T_3	$\frac{13}{16}$	$\frac{7}{16}$	$1\frac{3}{8}$	1	$\frac{11}{16}$	$\frac{5}{16}$	$1\frac{1}{32}$	$\frac{1}{4}$

chassis with four closed sides. Large holes are cut in top and bottom and covered with perforated zinc and one whole side is made of this material. This is essential to obtain adequate ventilation.

Ventilation holes are also provided in the top and bottom of the frame chassis but are less essential, since the whole of one side is normally open.

As in the previous design, the frame unit contains the sync separator as well as the frame time-base, while the line unit includes the e.h.t. supply. The performance is not critically dependent on the layout. Most details can be seen from the photographs.

Since R_{11} is at up to 2-kV peak with respect to the chassis, its internal insulation is not relied upon and it is mounted on the chassis by means of an insulating bush. For the same reason it should be provided with an insulating knob in case its spindle should become live. This is actually unlikely, for the internal insulation is quite good.

The metal rectifier D_1 is supported by an insulating bracket, for although it has an insulated spindle, this will withstand only 500 V or so and again the peak potential may be up to 2 kV.

The coil L_1, being wax-dipped, must be kept away from anything hot.

It is essential that both ends of D_3 and anything connected to it should have at least one-inch clearance from anything else, including the chassis, and that there should be no sharp points or edges on the metal work. All the soldered joints here should be nicely rounded blobs of solder. Great care is needed to avoid corona.

If it is found that the line synchronizing is poor in that vertical lines are ragged, the trouble is almost certainly due to corona, for the discharge results in the time-base being tripped erratically. If the corona persists when all sharp points have been buried in balls of solder an improvement can often be effected by painting the relevant parts thickly with shellac varnish. It is necessary to build up a very thick layer by applying many coats and allowing it to dry between them.

Corona occurs when the electric field in air is excessive and it can be avoided only by reducing the field strength below the critical value. For a given voltage on a conductor this requires that the radius of curvature be increased, hence the need for large smooth blobs of solder. However, the field strength in air can also be reduced by moving the air further from the conductor, which is what is done by painting the conductor with an insulating varnish.

If the time bases are built on the original chassis, it is not possible to include the frame-output transformer on the chassis, but it is quite satisfactory to mount it with R_{20} externally. The old line chassis is also not big enough for everything. What was done in a conversion, therefore, was to bolt on a new extension at the back to take the multivibrator.

The various special components are fully described in the drawings and, for the sake of completeness, details of some of the original parts which are retained are repeated here.

The three transformers, T_1, T_2, and T_3 are wound on formers of the same general form but different sizes as shown in Fig. 6. The blocking-oscillator transformer T_1 has a primary and secondary each of 3,000 turns of No. 40 enamelled wire with three layers of thin paper between windings for insulation. The coils are scramble wound. The core comprises a $\frac{11}{16}$-inch stack of M. & E. No. 74 laminations, 0.014-inch thick of Silcor 3 (or 1). The E and I parts are butted together without a gap and the core is held by the usual bent channel metal. A tag board is conveniently screwed to this frame.

The frame output transformer T_2 has the secondary for its inside winding and this comprises 350 turns of No. 22 enamelled wire evenly layer wound with a turn of waxed paper between layers. The winding must be tight. There should be six layers of waxed paper outside the secondary. The primary has 5,250 turns of No. 38 enamelled wire scramble-wound. It is advisable to put on a turn of waxed paper about every 1,000 turns.

Before winding, the end cheeks of the former should be liberally provided with $\frac{3}{16}$-inch holes to permit the entry of wax in the subsequent impregnation.

The core comprises a 1-inch stack of M. & E. No. 93A Silcor 3, 0.014-inch laminations. The T and U pieces are assembled for a butt joint with a 0.003-inch air gap. The core is clamped by four stout strips of steel and 4-BA bolts which are long enough to provide the mounting. They should be provided with rubber grommets where they pass through the chassis so that the mounting is somewhat resilient. Because of the high magnetizing current, this transformer is especially liable to produce an audible buzz. The resilient mounting is desirable to prevent the chassis from being set into vibration and acting as a sounding board. The wax dip is necessary to prevent movement of the windings.

The whole component, when finished, should be immersed in melted paraffin wax at a temperature of about 100–120°C and left there until all bubbling ceases. This may require up to two hours. If a thermometer is not available the wax can be melted in a double saucepan. This will ensure that the temperature does not exceed 100° C and if the water in the outer saucepan is kept boiling the wax temperature will not be very far below it.

When all bubbling has ceased, lift the transformer out of the wax and allow it to drain. When the wax on the outside starts to set, give it another quick dip. Build up a thick exterior coating by a succession of quick dips, each time allowing the wax to set before re-immersing.

The line-linearity transformer T_3 has a winding of 1,000 turns of No. 36 enamelled wire tapped at 333 turns from the start. On the circuit, the start is labelled 3, the tap 2 and the end 1 so that 666 turns come between 1 and 2. It is scramble-wound. The core is a ¼-inch stack of M. & E. No. 74, Silcor 3, 0.014-inch laminations, butt-jointed, without a gap. The core is held by the usual bent channel metal. The whole transformer must be insulated to withstand 2 kV from the chassis. It must also be acoustically insulated to prevent an audible magnetostriction whistle. The two forms of insulation are obtained together with sponge rubber.

The case is made of tinplate to the dimensions of Fig. 7 with the joints soldered together. A flat bottom plate is rivetted to the true bottom for mounting. A rubber sponge measuring 2 in × 5 in × 3½ in is cut into two pieces 2 in × 2½ in × 3½ in. Each of these has a small piece dug out of the middle to take the bobbin of the transformer but not the core. The transformer is placed between the two pieces of rubber with the leads coming out together. The whole is then forced into the case, the leads are passed through a grommet in the lid and the lid is placed on and secured with a touch of solder.

The e.h.t. coil L_1 is wound on a cylinder of hard wood of 1-inch diameter and 1⅞-inch long, Fig. 8(a). One solder tag for the start of the winding is held to the former by a wood screw close to one end. The other end is drilled for two wood screws for mounting.

Drill two series of circumferential holes around the former to take steel pins (such as lengths of knitting needle) with a tight fit. The inside faces of the pins are to be ⅜-inch apart and one of them 7/16 inch from the end of the former. The rows of holes should be ⅜ inch plus the thickness of the pin apart. There must be 12 pins in each row.

The winding comprises 1,220 turns of No. 30 enamelled wire in 50 layers of approximately 26 turns per layer. After one layer, give it a thin coat of shellac. Then put in a cotton spacer by winding No. 36 sewing cotton round pins as in Fig. 8(b) so that a thread of cotton lies across the winding by each pair of pins. Continue winding with cotton interleaved between all layers and shellac each winding lightly as it is done.

It is important to fill each layer with wire irrespective of the actual number of turns. If one layer is short, the next layer will tend to push the cotton down. Towards the end, the turns per layer will tend to become fewer because of the pins pulling inwards by the tension of the cotton.

When wound, attach a connecting lead to the end

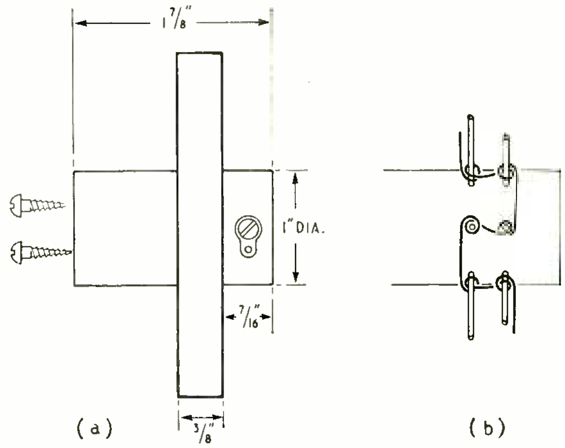


Fig. 8. The former dimensions and coil position for the e.h.t. coil are shown at (a) and the way in which the inter-layer cotton is wound at (b).

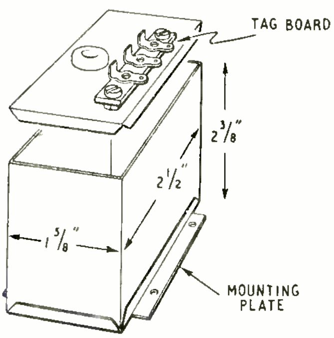
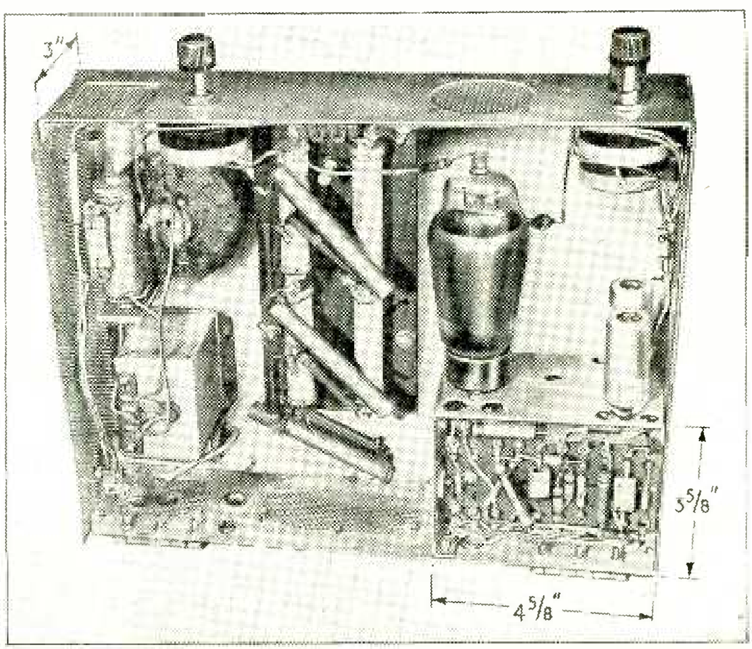


Fig. 7. Details of the case for the line-scan linearity-correcting transformer are given here.



The line time-base chassis is the same size as the frame time-base chassis. The valves are mounted on a bracket, as shown in this photograph.

and tie off firmly on the outside of the winding. Leave to dry.

Then quick dip in paraffin wax. Drain thoroughly after each immersion at first so that the wax does not penetrate between the layers to any extent. When the sides are covered, build up the wax thinly. Then immerse only the outside of the coil while rotating the coil by its former to build up a tyre of wax about ⅛-in thick over the outer periphery.

An error occurred in Part 2 which must be corrected. The value of C_{21} was given as 200 pF; it should be 50 pF.

LIST OF PARTS

C_1	32μF, 500 V, electrolytic.	Dubilier Type CT.
C_2	50μF, 150 V.	Dubilier Type BR.
C_3, C_4	8μF, 500 V.	Dubilier Drilitic BR850.
R_1	See text.	
R_2	2.5 kΩ, 5W (see text).	Welwyn.
R_3	500Ω, 5 W, Linear, wire-wound.	Reliance Type T.W/1.
R_4	1.2 kΩ, 6 W (see text).	Welwyn.
R_5	1 kΩ, 3 W.	Welwyn.
R_6	18 kΩ, 6 W.	Welwyn.
R_7	10 kΩ, 5 W, linear, wire-wound.	Reliance Type T.W./1.
	(Resistor ratings are minimum ones).	
V_1, V_2	IW4/500 (or GZ 32, but transformer must then have 5-V winding).	Mullard.
T_1	Primary 200/250 V, Secondaries 500-0-500 V, 250 mA; 4 V, 5 A; 6.3 V 8 A.	Partridge 4204 A.
L_1	20 H, 250 mA, 185Ω.	Partridge 4204 B.

R.F. SOLDERING

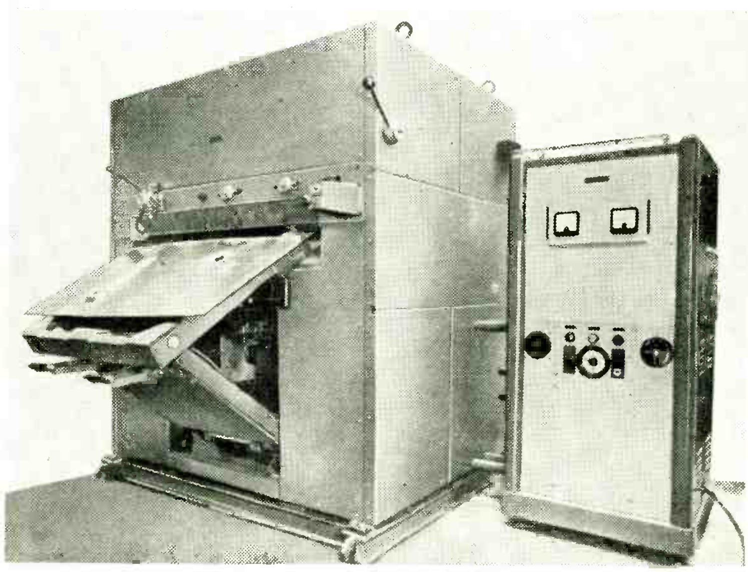
Petrol Tank Production by Radio Heating

A NEW radio-frequency plant designed and built by Redifon for Vauxhall Motors enables all the fittings for a petrol tank to be soldered on by one operator in under one minute. Soldering by hand of such items as the tank filler, drain plug, draw-off pipes, etc., may take up to 10 minutes by three or four operators, according to the complexity of the work. Thus a very considerable saving in time and labour is effected by this machine.

The sequence in production of the petrol tank has been modified and the parts mentioned are soldered in position before the tank is shaped on the bending machine and the Redifon machine is thus designed to handle flat sheets.

It is semi-automatic and the operator merely loads a sheet on to the work carriage, places the items to be soldered in position, applies solder and flux and initiates the movement of the carriage, and hence the soldering cycle, into the machine.

Lifting the sheet off the work carriage, timing of the soldering and cooling cycles and ejection of the finished plate is automatic, but the operator can immediately arrest all motion should it be necessary.



Redifon semi-automatic r.f. soldering plant for motor vehicle petrol tank fittings.

TELEVISION BANDWIDTH COMPRESSION

IN one chapter of his new book on information theory,* D. A. Bell puts forward an interesting suggestion for reducing the bandwidth required by television transmissions. Instead of allowing the sidebands of the transmission to straggle out across the frequency spectrum, it should be possible, he says, to interlace them all into a tight bunch, occupying a very narrow band, by using heterodyne oscillators to shift the various sideband frequencies. This would be possible because the sideband frequencies of a television transmission occur at harmonics of the picture repetition frequency, so there are regular gaps between them which could be occupied by the shifted sidebands.

The interlacing process could only be carried so far because movement in the television picture causes the individual sideband frequencies to broaden out into bands, and sufficient space would have to be allowed for this "breathing in and out." In this respect, the scheme amounts to a system of information coding which would make the bandwidth requirement dependent more on the rate of transmission of real information (changes in the picture) than on just the maximum possible detail in a static picture (represented by the 3-Mc/s chequer-board pattern).

The chapter in which these ideas are discussed is concerned with practical applications of information theory in telecommunications, and as such will be the one of most direct interest to radio people. The remaining six chapters are mainly theoretical and deal with such topics as the binary digit measure of information, the idea of entropy, bandwidth and signalling speed, signal-to-noise ratio, coding and filtering. As a whole the book amounts to a comprehensive summary of all the papers that have been written on information theory, and is, in fact, probably the first real *book* on the subject. The compilation of information has been done very well and the author has a clear and easy style, but the book is not intended as an introduction for beginners, and is only recommended to those who already have some familiarity with the subject.

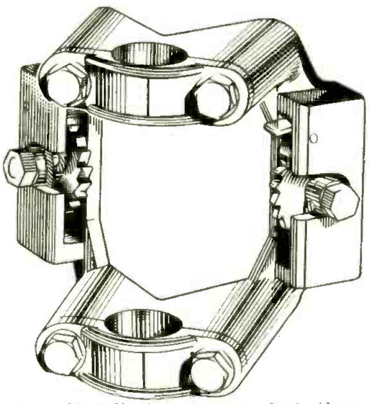
* **Information Theory and its Engineering Applications.** By D. A. Bell. M.A., B.Sc. (Oxon), M.I.E.E. Pp. 138+viii; Figs. 29. Sir Isaac Pitman & Sons, Pitman House, Parker Street, Kingsway, London, W.C.2. Price 20s.

THE "BELLING-LEE" PAGE

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

Real Progress in Bracket Design

For some years now we have been trying to evolve an aerial bracket that incorporated a ratchet movement to facilitate the tightening of strainer wires. Something that would save time in erection without increasing cost, and not just something done for cleverness sake. The thought is not new, something of the kind has been used before. We ourselves made one and had it tried out by our



own installation teams, but they found we had gone wrong in trying to pull the wire round three corners at once, so we dropped that idea and started again. The present bracket pulls up on both sides separately, thereby enabling correct tensioning on each side regardless of the dimensions of the chimney. This new bracket will make its first appearance as part of the Junior "H" cranked mast aerials sometime during July.

High Gain v High Front-to-Back Ratio

Which is the most important feature in a fringe aerial, high gain or high front-to-back ratio? It all depends on local conditions. If the situation is one where the aerial is between the transmitter and a big town or a busy road with a lot of local interference, then the best aerial would be the one that gave a minimum interference from behind, i.e., one with a high front-to-back ratio such as a "Junior Multirod." An aerial with greater gain such as a "Multirod," but with a lot of interference coming in from behind would probably be a waste of good money.

It is very easy to sit back and say "why not have both"? In practice it just isn't possible to incorporate in one aerial, all the best features. The best aerial for a given location is a compromise, e.g., to start off with we have two frequencies to consider, sound and vision. An aerial which was peaked on sound would be a bad aerial.

A New Choke and Capacitor Suppressor Effective at both Television and Broadcast Frequencies.

This is a choke and capacitor suppressor somewhat similar in appearance to our L.1174, but its use is limited to 2 amps, as this is the safe carrying capacity of the small chokes incorporated.

It has been designed for connection in the lead of domestic electrical equipment such as hair dryers, vacuum cleaners, sewing machine motors, electric fans, etc., and to be truly effective, must be fitted really close to the appliance, certainly within nine inches from the electrical connections to the brushes of the appliance. List No. L.799.

Communal Amplification at Sea

Just as "Music while you work" is now commonplace in factories and workrooms, working conditions of ships' crews are very rightly improving, and ever increasing numbers of ships are being equipped for broadcast reception, with communal amplifiers supplying outlet points to the cabins and quarters of officers and crew.

One of the latest installations in which our equipment was used was that on m.s. "London Splendour" launched from Newcastle. The installation was carried out by Messrs. Arthur Jones & Co. Ltd., of Middlesbrough.

Ships installations differ from those on land, because although the installation may appear to be satisfactory when at the dock side, at sea, the signal-to-noise ratio falls, and the inherent losses in the "Eliminoise" anti-interference transformers attenuates the signal, so that the resulting energy may only be sufficient to operate one receiver, leaving insufficient energy for distribution to other points. With the introduction of the new "Belling-Lee" distribution amplifier, sufficient energy is made available so that each receiver is able to accept as much signal as if only one was connected to the aerial.

Truleigh Hill The Brighton Booster

At the time of writing this particular item, i.e., 7th May, and just a few days after the opening of the Brighton Booster transmitter, we had a letter from the Isle of Wight telling us of wonderful results. We have had a similar report from Portsmouth. Now the Isle of Wight is 45/50 miles from Brighton, and the power is in the region of 400 watts. We grant you it is all across water, which is always advantageous, but pleased as we are, we can only hope that the results will prove to be general or lasting. They may be due to some freak of propagation conditions which are so often followed by acute depression and disappointment. We sincerely hope to be proved wrong.

We are sending our Mobile Research Unit into the Brighton district to see what can be expected. It will work out from Newhaven, Worthing, Littlehampton, etc., and we hope to be able to publish results in the next issue.

Fire Protection by "Minitrip"

Every now and again we read in the newspapers that a T.V. receiver "caught fire." There are a number of ways in which this can happen, even if fuses are incorporated. Let us say right now that practically any electrical appliance, even a table lamp, can be the cause of fire without blowing the house fuses. Whereas it might be difficult to give absolute protection in the case of the table lamp, we can now get very near to it in the case of a T.V. or broadcast receiver by the fitting of "Minitrip" thermal delay switches. These small bi-metal switches each cost about as little as a fuseholder and spare fuses, and operate on excessive current or heat or both. It is well worth while fitting them when a receiver is being serviced. Their presence provides a very quick and sure indication as to which part of the circuit is at fault. Their cost is less than the labour cost in finding out by any other means.

A number of prominent set manufacturers already build one or more "Minitrips" into their receivers. We are sure the number will grow.

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

Written 27th. May, 1953.

MARCONI communication systems

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TRANSISTORS

6.—*Stabilizing the Working Point*

By THOMAS RODDAM

THE most important characteristic of modern electronic circuits is designability. It was fun, in the old days, to make a circuit work, by brute force and classical scholarship. Fun, I must add, for the designer who would set out to build a receiver, and find he had produced the first all-electric mousetrap. It was not such fun for the production and test departments, or for the unfortunate customer. Many organizations, indeed, inserted a buffer between the experimental laboratory and the production drawing office, just to be sure. This intermediate department still remains, like the human appendix, although its function has now passed away. The professional circuit designer regards the experimental work as a mere checking of his calculations and will usually demand a lab re-check if there is any disagreement.

This change in attitude is seen very clearly when we look at some of the information which is being published on transistors. It is easier to find out the way in which the current amplification varies from sample to sample than to find the distribution of mutual conductance values for a common valve, like the 6AK5. This is no doubt due partly to the hatred all valve manufacturers have for engineers: transistors at present are being produced by engineers.

Since we must accept the variability of our transistors, and since some of the variation depends on the ambient temperature, we must be prepared to design our circuits to take account of the tolerance range. We have at our disposal two obvious techniques, the use of negative feedback to stabilize the gain, and the incorporation of pre-set controls to allow for basic differences between units. Quite clearly, however, we cannot use the controls to deal with the changes which occur during the warming up period: less clearly, perhaps, there are changes in the working conditions of amplifiers which cannot be dealt with by negative feedback.

Measurements have been made which indicate very clearly what happens when a transistor is warmed up and then allowed to cool. For the *n-p-n* transistor, which is the most interesting in this connection, the data does not seem to have been published, but some indication of the effects is given by Fig. 1, which shows the variations of I_{c0}, the collector current at 40 volts on the collector and zero current into the emitter, and V_{c1}, the collector voltage in the saturation condition, with 1 mA emitter current and 2 mA collector current, for a point type transistor of Type 1698 (switching type). These measurements were taken as the ambient temperature was raised to 85 deg. C and then cooled again. It will be seen that I_{c0} is very sensitive to changes in temperature. The same effect, on a different scale, is obtained with the junction transistor.

Let us now look at the circuit of Fig. 2. The resistors R_1, R_2, R_3, are used to control the base, emitter and collector currents. The circuit is drawn for a *p-n-p* junction transistor. It is reasonable to assume that the collector current is independent of collector voltage: a glance at the junction transistor characteristics given in Part 4 will confirm this for a normal working point. The current amplification α is assumed to be constant over the working range: if it is not constant, we shall have distortion in the output. The emitter-base voltage is taken as zero: usually it will not exceed 0.1 volt.

If we now write down the equations for this circuit and solve them to get the electrode currents, we obtain:

$$I_c = \left\{ I_{c0}\left[1 + \frac{R_1}{R_2} + \frac{R_1}{R_3}\right] + \frac{\alpha E}{R_3} \right\} \Big/ \left\{ 1 - \alpha + \frac{R_1}{R_2} + \frac{R_1}{R_3} \right\}$$

$$I_e = (I_c - I_{c0})\,\alpha$$

$$I_b = \{I_{c0} - I_c(1 - \alpha)\}/\alpha$$

We may follow R.F. Shea (*Proc. I.R.E.*, November 1952, p. 1435) and obtain a "stability factor" S, which is the $\alpha I_c/\alpha I_{c0}$ and is thus

$$S = \left(1 + \frac{R_1}{R_2} + \frac{R_1}{R_3}\right) \Big/ \left[\left(1 + \frac{R_1}{R_2} + \frac{R_1}{R_3}\right) - \alpha\right]$$

In a special case, which we discussed in Part 4,

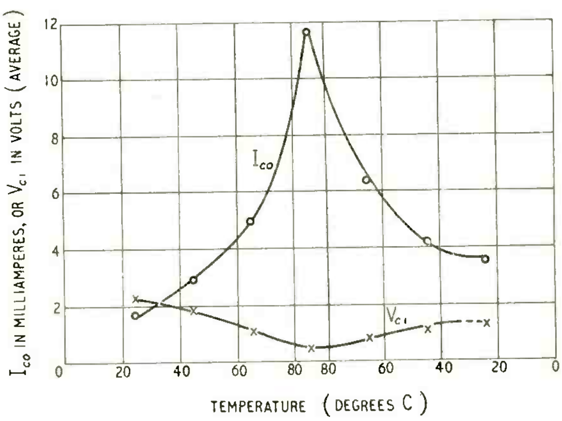
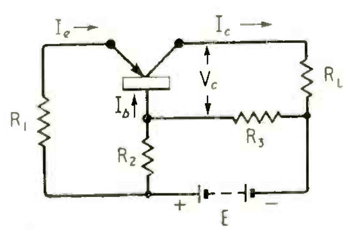


Fig. 1. Variation of two critical parameters of a Type 1698 point transistor as it is heated to 85 deg C and allowed to cool again.

Fig. 2. Basic circuit for operation of a transistor from a single battery.



the values of R_2 and R_3 are infinite, so that $S = 1/(1 - \alpha)$. With α in the neighbourhood of 0.95, this makes $S = 20$.

Shea goes on to express I_c in terms of S :—

$$I_c = SI_{c0} + \frac{E}{R_3}(S - 1)$$

and then points out that we usually want to specify the working point in terms of I_c and V_c. Given E, the available battery voltage and choosing a value for S, the following equations are obtained for the resistances.

$$R_1 = \frac{\alpha(E - V_c - R_L I_c)}{I_c - I_{c0}}$$

$$R_2 = (S-1)\Big/\left\{\frac{(1 - S + \alpha S)(I_c - I_{c0})}{\alpha(E - V_c - R_L I_c)} - \frac{I_c - SI_{c0}}{E}\right\}$$

$$R_3 = E(S - 1)/(I_c - S I_{c0})$$

It must be noticed here that R_2 is the d.c. resistance of the load, not the impedance. For a transformer-coupled output the difference is very large, of course.

The power taken from the battery is

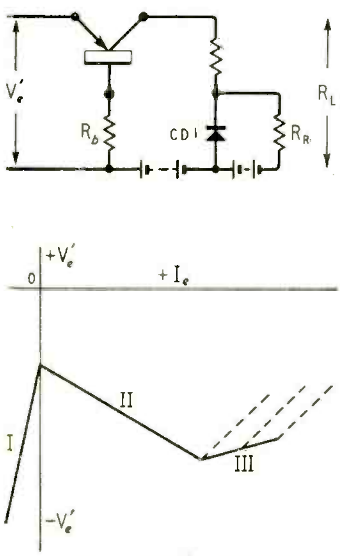
$$P = E I_c + \frac{(V_c + R_L I_c)(I_c - S I_{c0})}{S - 1}$$

Quite obviously, the smaller we make S, the more power we need from the battery. A particular example taken by Shea shows that to make the working point 2½ times as stable, the power consumption rises from 6 mW to 14.6 mW. These equations do enable the designer to estimate what it costs him to stabilize his working point, and what will happen if he does not do so. For a *n-p-n* transistor the value of I_{c0} can be assumed to vary over a range of 10-100 μA, so that an S-value of about 5 is the maximum for large signal working.

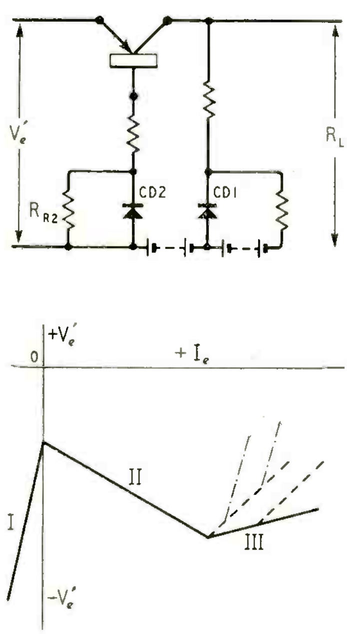
Although the initial assumptions are more in error for point transistors, the discussion above will usually provide quite good guidance in estimating the effects of temperature variations and the price to be paid for reducing these effects. It will also be clear to the reader that the input signal can be applied to either base or emitter, appropriate decoupling capacitors being inserted to prevent alternating-current feedback.

A very interesting extension of the reasoning given above has been used by D. E. Thomas in the design of an oscillator. (*Proc. I.R.E.*, November 1952, p. 1385). His oscillator consists essentially of the circuit shown in Fig. 1 but with R_L replaced by a tuned transformer, the secondary winding of which is connected in series with R_1. Suppose that we do not have resistances R_2 and R_3 in the circuit. The collector current at zero emitter current is small, and the emitter bias produced by the drop in the internal base resistance is also, by the careful design of the transistor, made small. At very low currents, the current gain, α, of the transistor may not be high enough for oscillations to start. The addition of the resistances R_2 and R_3 will, of course, bring the transistor to a suitable working point, but if the oscillator is to be a very low power device—Thomas has been limited to 35 mW from a 6-volt battery—the designer is placed in a quandary. If he uses a very small resistance for R_2 to avoid getting too large a loss of collector supply voltage when the circuit is oscillating, in which case R_3 must also be small to give the necessary bias, the bleeder network consumes an excessive amount of power. If he limits the current in the bleeder network to keep up the overall efficiency he must use large resistance values, and then the stability factor we have discussed above is large.

The solution was found in the use of a non-linear resistance in the base as R_2. When first switched on the emitter resistance is high, but since the base current is small the value of R_2 is also high and the collector current divides almost equally between emitter and base. As the collector current builds up, the base current increases and the resistance in the base falls from its initial value of the order of 700 ohms to something around 100 ohms. The differential resistance in the base is lower still, so that the positive feedback shifting of working point is almost negligible. These two stability problems have been questions of operation in the linear or quasi-linear range. The non-linear circuits considered in the last article can also benefit from stabilizing modifications. If you refer to Fig. 7 of Part 5, you will see that when the circuit is triggered, it runs up to a very high value of emitter current, and from the low slope of region III you can understand that the exact value of current is rather uncertain. A diode added at CDI, with a suitable bias voltage applied through R_R, will make the slope of region III much steeper once the collector current reaches a certain value. Three possible settings are shown in Fig. 3. The region III lines are more clearly defined, but the slope is still rather gradual. The circuit of Fig. 4 shows a biased diode also added in the base circuit. The feeding resistors R_R and R_{R2} are chosen to bring the diodes to a suitable



Above : Fig. 3. The diode CDI produces a steeper slope in region III.



Right : Fig. 4. A further steepening is produced in region III by a second diode CD2.

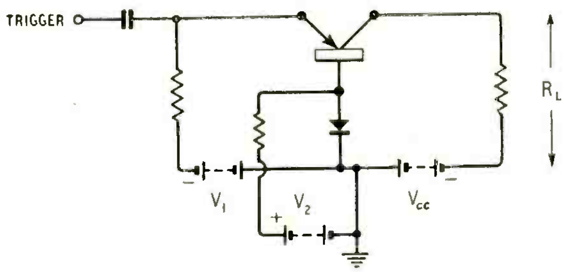


Fig. 5. The base diode in this circuit makes the trigger voltage almost independent of the transistor variations.

low-impedance working current when they are "on." The diode in the collector limits the collector current sharply, but the emitter current tends to rise. As a result the voltage across the diode CD2 in the base is reversed and the emitter characteristic is made still steeper.

These two techniques for defining the peak current have their equivalents for the collector and base connections. Another problem with trigger circuits is to maintain the peak turning point at a constant voltage. The turning point at $I_e = 0$ is at a voltage

$$V'_{e0} = \frac{R_b V_{cc}}{R_b + R_L - V_{c0}/I_{c0}}$$

where V_{cc} is the collector supply voltage and V_{c0} is the base-collector voltage at 2 mA collector current, and the emitter open-circuited. The minimum value of V_{c0} is probably 40 volts. This gives

$$V'_{e0} = R_b V_{cc}/(R_b + R_L - 500 V_{c0})$$

For the values considered previously, $R_b = 6.8$ kΩ $R_L = 2.2$ kΩ and $V_{cc} - 45$ volts,

$$V'_{e0} = \frac{6800 \times 45}{9000 - 500 V_{c0}}$$

If $V_{c0} = 36$ $V'_{e0} = -34$
$V_{c0} = 45$ $V'_{e0} = -22$
$V_{c0} = 54$ $V'_{e0} = -17$

There is quite a large movement here. Can anything be done to stabilize this point? The answer is again to use a diode, connected in the base circuit as shown in Fig. 5. This circuit is due to A. J. Rack, of Bell Telephone Laboratories, and operates in the following way. With zero emitter current the diode is normally conducting. Consequently the resistance in the base circuit is low and is actually about 200-300 ohms. This reduces V'_{e0} to a value of

$$V'_{e0} = (200 \times 45)/(2400 - 500 V_{c0})$$

If $V_{c0} = 36$ $V'_{e0} = -0.58$
$V_{c0} = 54$ $V'_{e0} = -0.37$

The change in transistor characteristic which moved the peak point 17 volts without the diode moves it only 0.2V with the diode.

In operation the circuit will trigger as soon as the algebraic sum of emitter and collector currents, which flows into the base, exceeds the bias current through the diode. The diode then becomes a high resistance. The total voltage between collector and base then becomes $V_{cc} + V_2$ and the emitter is biased to $V_1 + V_2$. The load line shifts parallel to itself. This arrangement also reduces the dissipation in the "off" condition.

These examples of the design problems involved in the use of transistors have been selected to indicate the methods of analysis and the methods of solution which have proved valuable. Each application will require individual examination, to determine which solution is the best. For example, the stabilization of the linear amplifier working point is of vital importance in the design of a stage giving maximum output. There is no choice here at all. A low-level stage, however, may be designed to operate at an appropriately low current and collector voltage. Low collector voltage and low emitter current appear to be desirable if the best noise figure is to be obtained. The price paid is in the stabilization, since the low-level working point must be maintained accurately. The alternative is to work out a higher-level working point, and allow it to drift if changes in transistor characteristics take place. It will usually be desirable to make several test calculations to find where the best working point will be.

The various stabilizing techniques described for the trigger circuits will influence the time constants of the monostable and astable actions. In particular, the steeper slope of region III will tend to lengthen the output pulses and make the astable circuit more nearly a square-wave generator.

Just as we omit the cathode resistor, its decoupling, the anode decoupling circuits and quite a lot of other oddments when carrying out general valve circuit investigations, so these stabilization processes will often be omitted in general transistor circuit studies. In any future circuit discussions these basic elements will be assumed.

Acknowledgment. Fig 1 is based on Fig. 6 of "Variations of Transistor Parameters with Temperature" by A. Coblenz and H. L. Owens, *Proc.I.R.E.* Nov. 1952, p. 1473, and Fig. 2 is based on Fig. 1 of "Transistor Operation: Stabilization of Operating Points," by R. F. Shea, *Proc.I.R.E.* Nov. 1952, p. 1435.

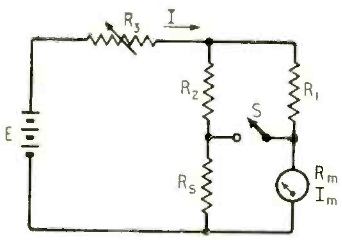
METER SHUNTS

Their Accurate Adjustment

THE VALUE OF SHUNT required to extend the range of a milliammeter is easily calculated if the resistance of the meter is known. Unfortunately, it is not always known with sufficient accuracy; any uncertainty about the meter resistance produces a roughly equal uncertainty about the current range of the shunted meter.

It is often difficult to measure the resistance of a meter with sufficient accuracy. An a.c. method may be inaccurate because of the inductance of the coil, while a d.c. method may not be sufficiently sensitive if the current in the meter is kept to a safe value.

When resistances other than that of the meter can be measured accurately, or rather compared accurately (for their actual values need not be known) it is possible to adjust the resistance of a shunt very accurately indeed by using the circuit shown in the figure on the following page. This is a form of bridge with the meter in one of the arms and a resistance R_3 to limit the current to a safe value. A switch S is connected in place of the usual galvanometer



Circuit used for adjusting a meter shunt.

and the shunt R_3 is adjusted so that the meter deflection is unchanged by opening or closing the switch.

Let the meter resistance be R_m and the current needed in it for full-scale deflection be I_m. It is required to shunt the meter by R_s so that when so shunted the meter reads full scale for a total current I. The current in R_s is then $I - I_m$, and the proper value of shunt is given by the well-known expression

$$\frac{R_m}{R_s} = \frac{I}{I_m} - 1$$

In Fig. 1, the two resistances R_1 and R_2 are chosen so that

$$\frac{R_1}{R_2} = \frac{I}{I_m} - 1$$

There is no other restriction on their value, which need not even be known, but it is of some advantage if they are considerably larger than R_m and R_s, for the sensitivity of the meter indication is thereby increased.

When the shunt has been adjusted to the proper value

$$\frac{R_m}{R_s} = \frac{R_1}{R_2} = \frac{R_m + R_1}{R_s + R_2}$$

The currents I_m and I have been set up in the proper ratio. When S is open, only I_m flows through the meter. When S is closed, I flows through the shunted meter. If the deflection is the same this is the required condition.

As an example of the procedure, suppose it is desired to shunt a 1-mA, 100-Ω meter for 10 mA full-scale deflection, the figure of 100 Ω for the meter resistance being a nominal one only. Then

$$\frac{R_1}{R_2} = \frac{R_m}{R_s} = 10 - 1 = 9$$

The required shunt R_s will be about 11 Ω and a length of resistance wire giving about 15 Ω should be chosen to start with.

The resistors R_1 and R_2 must be chosen to be in the ratio 9 : 1 as accurately as possible. It is convenient to make $R_2 = 100$ Ω and $R_1 = 900$ Ω but the exact values are unimportant as long as the ratio is right. It is convenient to operate with the meter at about one-half scale, for which it takes 0.5 mA. The voltage drop across R_1 and R_m is $0.5\ (0.9 + 0.1) = 0.5$ V so R_3 must drop about 1 V if a single dry cell is used for E. The current in R_3 will be 5 mA, so it must be 200 Ω and so this component must be a variable resistor of, say, 400–500 Ω maximum value.

When S is closed, the meter reading will drop if R_s is too low but increase if R_s is too high. It is desirable to start with too low a value of R_s, therefore, and to increase it until closing S does not alter the meter reading. The method is quite sensitive, for it is usually possible to detect a flicker of the meter needle which amounts to a deflection of only 0.1% of full-scale and so it is possible to adjust the shunt to the same order of accuracy.

While adjusting the shunt, care should be taken to prevent it from becoming open-circuited. If it does open, the meter current may exceed the full-scale value. It will be greatly excessive if S is closed and for safety, S should be a push-button type and only operated when R_s is in place. It may also be excessive with S open if R_3 is large and, for safety's sake, it is a good plan to make R_1 and R_2 high enough for R_3 to be dispensed with. This does not permit such great freedom in the choice of values for R_1 and R_2, for R_1 must be about $2\ E/I_m$ or some 3 kΩ for the example considered. One could use, for instance, $R_2 = 300$ Ω and $R_1 = 2{,}700$ Ω. The meter current with S open would be $1.5/2.8 = 0.536$ mA, which is quite suitable.

Having in this way found the right value of shunt for a given current ratio, one can measure the shunt on any bridge and so obtain indirectly the value of the meter resistance.

Extension Hearing Aid

DESIGNED to enable a deaf person to hear broadcast (including television) sound in comfort without raising the normal loudspeaker volume, the "Adaphone" Type M3 unit recently developed by the Multitone Electric Company, 223-227, St. John Street, Clerkenwell, London, E.C.1, is provided with an independent volume control and a "hot-wire" volume compression circuit. The latter is considered to be essential now that miniature insert earpieces are available which reach the threshold of pain (130db) for inputs of only 5mW, and also because a large proportion of potential listeners with "recruitment" deafness, benefit from this type of response.

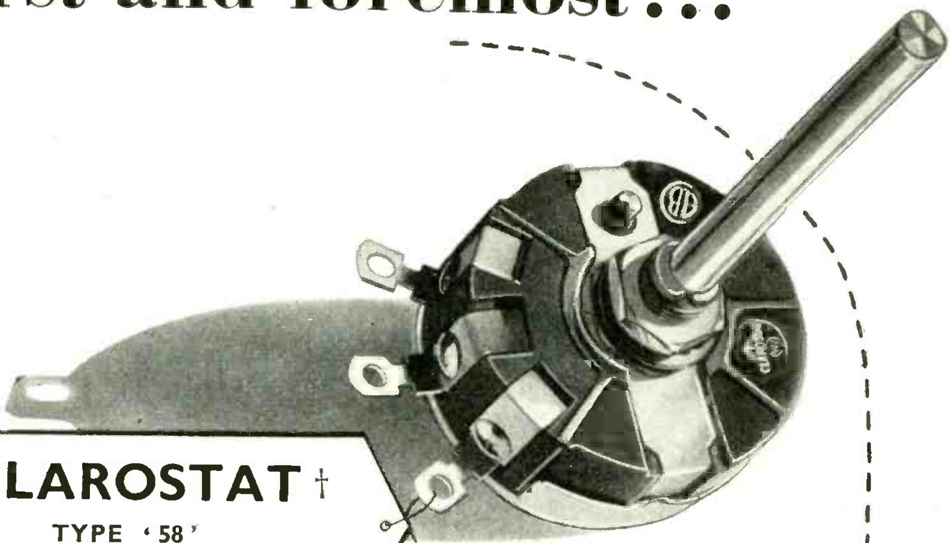
Complete isolation of the mains is ensured by a double-wound transformer, and in cases where the output transformer secondary on the set is not earthed, a 1:1 transformer can be supplied for installation inside the set to make the extension leads themselves safe.

The price of the Type M3 unit is £5 15s complete with earpiece and earmould. An alternative model without a.v.c. is available at £4 19s. The 1:1 transformer, when necessary, costs 10s 6d.

It has been suggested that as the response curve of the earpiece is smooth, and the quality of reproduction is acceptable also to persons with normal hearing, the "Adaphone" when used in conjunction with the normal free sound field at some distance from the loudspeaker, gives an interesting quasistereophonic effect.

"Adaphone" Type M3 extension hearing aid.

First and foremost . . .



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LETTERS TO THE EDITOR

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

Two-band Television Reception

THE letter from W. T. Cocking in your June issue was most timely. It has been the secret hope of those who are closely concerned with the coming problems of alternative television programmes that someone would give voice to the misgivings felt by many of us in the light of often uninformed comments in the lay press about converters for existing television sets.

The problems of double conversion in a superhet television receiver, due to the various combinations of oscillator frequencies and harmonics with consequent whistles, may in fact prove so difficult that it might, in the event, prove cheaper to make the converter slightly more complex than that required for double conversion. An added reason might well be that by so doing, one type of converter could find a more widespread application. It is therefore suggested that, rather than add to the converter the requirement for conversion in both bands 1 and 3 or band 1 channel switching in the set, direct conversion from band 3 to the sound and vision i.f.s might be feasible. In this way it would only be necessary to stop the receiver oscillator when using the converter, thus considerably reducing the problem of oscillator harmonics and radiation. This method might involve less modification to the receiver itself.

Clearly, converters can and will be mass-produced but the designers must be in possession of all the facts and requirements before they can hope fully to assess the problem and complete their designs.

Needless to say, as soon as such information becomes available there will be heavy public demand in anticipation of the new service but it behoves designers and makers alike not to be stampeded into premature release of converters if they are not to pass on to the retail trade and public many of the problems which should rightly be solved by themselves.

What surely is needed at this time is an authoritative statement in the popular press setting out in language understandable to the layman just what is involved by giving an indication of the cost of a converter and stressing that an external aerial will be required and so forth.

Failing this, the present confused situation may well become chaotic, doing disservice to public and industry alike.

Richmond, Surrey. R. W. ADDIE.

A Matter of History

THOMAS RODDAM'S comparisons between the development of the valve and the transistor were well suited to the April issue. To the radio historian, there is a remarkable similarity between their paths so far.

Most of the early audion valves went for use in long-distance telephone circuits, leaving few for other applications. These valves, with a G_m of less than unity, gave a gain of 6-12 db. using 50 V h.t. and the output power was of the order of milliwatts. De Forest boasted a gain of 120 times with three transformer coupled stages. Every effort was to obtain increased gain. More than one grid was tried and every sort of connection. While the use was confined to known (voice) frequencies, a functional analysis similar to that now given for transistors was adequate. I can well imagine de Forest remarking about his ultra-audion circuit, that "the base-emitter capacitance plays an important part in the functioning of the circuit."

The use of the valve at r.f. (1913) produced instability and damping resistors and "reversed" feedback were used for control. Expansion of the theory came with increased development during the war (Hartley, Valauri, etc.). Only after the war were valves available for general use. Incidentally the early method of connecting a transformer was in the h.t. negative end of the anode circuit. This was not negative feedback but a cathode follower circuit was given in 1924 (see *Wireless World*, Vol. XIV, p. 336). The "diminisher" circuit was also used at about this time in a Marconi receiver having five tuned stages.

Huddersfield, Yorks. W. M. DALTON.

Broadcast Transmitter Distortion

ALTHOUGH I readily agree with and support the arguments for the introduction of v.h.f. broadcasts, I do not accept the contention that this is the only solution to the problem of distorted transmissions. I am convinced from many years of listening that the hideous non-linearity distortion on peaks that is often, but by no means always, radiated is not simply the result of inevitable volume compression. If so, why is it that superb quality is sometimes radiated from the Midland transmitter at Droitwich during programmes that clearly require much compression, e.g., the broadcast of "Die Fledermaus" in March?

Secondly, although in the past the quality of recorded transmissions has called for severe criticism, this does certainly not apply invariably to-day. The quality of the Jack Jackson records on Saturday nights is often splendid, and better than many direct broadcasts.

Although it is impossible for a mere listener to ascertain at which link in the chain of transmission distortion creeps in, I am convinced that the worst emanates from the audio network before the signal arrives at the final modulator. If this were not the case quality would not vary but would always be bad.

My view is that the B.B.C. could do far more than it does to improve the standard of medium- and long-wave transmissions, without adopting the defeatist policy of assuming that nothing but v.h.f. will improve the situation. In fact, until the audio chain is beyond reproach v.h.f. will only emphasize non-linearity distortion by extending the high-frequency response. Television sound is not always perfect!

With the advent of the high-fidelity reception now attainable, more stringent and consistent control of broadcast quality is required. With some diffidence, and assuming that no such post exists, may I suggest the appointment of an enthusiastic engineer devoted to and responsible for quality control alone. Future improvements in quality are in the hands of the B.B.C. and such an appointment might go some way towards effecting an improvement.

Wednesbury, Staffs. A. A. COTTERELL.

THE correspondence regarding B.B.C. transmitter distortion is interesting and, let us hope, profitable. One thing seems to have been overlooked, however, namely, distortion in the detector circuit.

As is well known, conventional diode and "infinite impedance" circuits will neatly clip the peaks of any modulation exceeding a certain percentage. Such clipping gives rise to a very objectionable form of distortion, particularly on wide-range reproducing equipment. Clipping can take place at modulation levels as low as 80 per cent with quite usual circuit values.

The writer has used for some time a circuit similar to the "No-compromise R.F. Tuner" described in the Oct., 1952, issue of *Wireless World*. It is because B.B.C. transmissions do not show the distortion complained of by your correspondents, on his own equipment, the acoustic output of which extends well beyond 15 kc/s, that he ventures to draw attention to the possibility of detector distortion being the cause of complaint.

London, S.W.12. T. S. MARSHALL.

Lamp Interference

IT is likely that K. Robinson (your May issue) can cure or alleviate his interference by placing a magnet near the lamp. This indicates the electron origin of the oscillation.

It is in fact fairly easy to get a standard 230-V lamp to oscillate above 40 Mc/s by connecting a suitable choke in each lead. The ends of the filament are then comparable to the grid and anode of a Barkhausen Kurz oscillator. Used on d.c. the interference pattern is a series of stationary bars, but a.c. gives a single bar and a diathermy herringbone. The likely cause is f.m.

A 60-watt 230-V lamp can be used as a transmitter; modulation can be applied by holding a magnetic earpiece near enough or, in the cheaper type of bulb, by shouting at it. The result is received on an f.m. receiver between 40 and 100 Mc/s.

An article by P. S. Rand in "*CQ*" for July, 1952, gives more information on this subject.

It is unwise to place a lamp on a TV set—interference is then quite likely.

Fraserburgh. A. Q. MORTON.

YOUR correspondents on this subject will be interested in the April issue of *Popular Science*, which, on page 133, gives an illustration of this type of interference under the heading "Old Style Lamp: Obsolete Tungsten Filament Can Do This."

In the same article it was stated "Worcester, Mass., had an epidemic of TV interference until the power company offered to replace old-style tungsten-filament lamps with the modern variety free of charge. Some 150 of the old lamps were turned in and complaints dropped to nil."

Ratmalana, Ceylon. F. E. SIGGERS.

Amateur Allocations

UNDER the heading "Amateur 2-Mc/s Band" in your June issue it is stated that amateurs have been granted the use of the band 1800 kc/s-2000 kc/s instead of the band 1715 kc/s-1800 kc/s withdrawn from May 1.

Obviously the implication is that the authorities, in generous mood, have given more than twice as much as they have taken away. The unfortunate wording of this report, which is undoubtedly published in all good faith, could not present the position of the amateur on this band more inaccurately, nor could it be more prejudicial to the interests of the fraternity at the present time.

In fact, amateurs have had the use of the band 1715-2000 kc/s on a non-interference basis for a number of years, and it has now been reduced in width, therefore, quite appreciably. Some, at least, of the maritime stations listed in your May issue, have been operating within the same band hitherto, and as far as is known, cases of interference, if any, being caused by amateurs have been so rare that their continued use of the band on these grounds has never been in doubt.

The real significance of changes in the maritime list is not apparent at first sight, but on analysis it will be found that amateurs now have the use of about half-a-dozen spot frequencies (subject to total sidebands of 1 kc/s), and some 27 kc/s distributed (after allowing for 3 kc/s sidebands). The frequencies at present covered by the Loran transmissions have not been included, but if this service is reallocated a further 16 kc/s could become available. Few will care to disagree that the foregoing presents an entirely different picture from that conveyed in the bald statement that we have now a new band of 200 kc/s in width. Furthermore, it has been hinted that we shall lose the band altogether eventually, and there can be little doubt that this will be the first of the m.f. bands to be axed completely so far as amateur activity is concerned.

The m.f. bands are the ones of primary interest to the fraternity, and to summarize briefly the overall position it may be stated that 3.5 Mc/s-3.8 Mc/s, which has always been shared with other services, now carries so much traffic that it is useless to the majority of us. In the notorious 7-Mc/s region, 200 kc/s has already been taken for broadcasting, and the remaining 100 kc/s, nominally exclusive to amateurs, is being encroached upon by all and sundry as circumstances, apparently, justify. The major long-range band at 14 Mc/s now supports at least one high-power commercial transmission, and may very well come in for closer attention by such interests in the near future.

On the other hand a generous allocation was made recently at 21 Mc/s, generous no doubt because nobody else wanted it, and because it is as useless for most purposes as the 28-Mc/s band which has long since been abandoned. The conclusion is, that whereas on paper we have a few megacycles, in practice it is difficult to find a few hundred kilocycles which we can use.

In encroaching upon your space, it is in the hope that your journal may recollect the role of the amateur in the field of radio communication, and enter this as a plea for a new deal for those, and their heirs, who if by no other right, have staked their claim to recognition in the form of permanent and unmolested frequency allocations.

Buckhurst Hill, Essex. H. E. JAMES, G5JM.

Are Symbols Overdone?

THE correct use of standard letter symbols and abbreviations is a great convenience where space-saving is worth while, such as in writing and in printed tables, abstracts, diagrams, etc. It is, of course, essential to use only standard symbols as given in B.S.I. publications: incorrect or obsolete symbols are never justified. Some symbols are unfortunately still in use which are long obsolete; for example, ω has been replaced by Ω for ohms for about 30 years. But the use of symbols by non-technical people such as shorthand-typists, clerks, etc., can lead to confusion which may be avoided by reading and speaking symbols as words and not as letters. Why should a typist be expected to learn all electrical terms and symbols? She won't, anyway, unless very exceptional. The copy typist has no difficulty: on typing from a written MS she types as she reads, and in such cases as "μF" she can type "uF" and add the tail of the "μ" by hand. Should she type "microfarad" as MFD, MF, mf, mFd, or introduce any other incorrect symbol then she initiates possible confusion which should be strongly discouraged. Storemen and others, although not technically trained, have to handle electrical equipment; some components being so small that there is no room for the term in full, but only the symbol or colour-coding. They therefore need to know correct symbols, and colour-coding. A verbal request to the storeman for a "50 M.A. choke" may be taken as microamps or milliamps, since he will know that "MA" is often wrongly used in print for microamps or milliamps, whereas it should mean megamp. But if he is correctly told in words, such as "50 milliamps," then no error can arise. Many shop windows and advertisements will be seen with components and instruments marked 100 M/V, 50 MA, 200 mmf, etc.; often inconclusive without inspection of the component itself. Should we not therefore do better to retain the use of symbols to ourselves, and quote the terms in full to non-technical users who should not be expected to know the symbols without the possibility of error?

E. H. W. B.

B.B.C.'s Big Day

[Screen photograph by John Cura]

UNDOUBTEDLY the Coronation day broadcasts were a real triumph for the B.B.C. Everyone who looked-in or listened-in on June 2 was full of praise for the excellent way in which this great operation was handled. In particular it was a triumph for the special technique of outside broadcasting—the best demonstration we have ever had of radio's power to convey all the excitement and actuality of a great event at the very moment of its happening. Naturally, the immediate reaction of most people was to the artistic presentation of the programmes, but those in any way connected with radio would be thinking at the same time of the great complexity of the technical arrangements which made it all possible.

Although television was undoubtedly the star performer on this occasion, sound broadcasting had really the bigger job to do. The programme we heard at home was only one of many that were put out to all parts of the world. Altogether facilities had to be provided for some ninety commentators along the route of the procession and in Westminster Abbey—and this does not include all the additional microphones used for sound effects, of which some forty were installed in the Abbey alone. Not only were there all the B.B.C.'s home and overseas transmitters to be served, but a number of foreign broadcasting organizations as well, and at the same time arrangements had to be made for supplying several newsreel film companies, the television sound control room, the sound reinforcement system in the Abbey and public address loudspeakers along the route of the procession. It was, of course, the Post Office who provided and maintained all the lines necessary for this complicated link-up, and a share of the credit must go to them for the vital part they played in the whole operation.

Without going into details, the general plan of the sound broadcasting arrangements was this. Microphones were grouped at a number of important points along the processional route (one group being in the Abbey itself), and at each of these sites a temporary control room was set up to house the associated control gear and programme engineers. From these temporary control rooms the microphone outputs intended for transmission abroad were routed to a main control room on the new Colonial Office site, while those for the B.B.C. home transmitters were connected to another main control room in Westminster Abbey. The assembled programmes coming out of these two main centres were then sent to Broadcasting House for distribution to their various destinations, most of them going by way of B.B.C. and Post Office transmitters and others by line to the Continent. It goes without saying that there was a good deal of duplication of equipment and circuits to guard against possible breakdowns, although in fact none of it actually proved to be necessary.

The commentators were using lip ribbon microphones, so they could work quite close to each other without their speech interfering (about 4ft 6in apart) and there was no necessity for sound-proof commentary boxes. They wore headphones which could be switched either to the home programme or to the programmes they themselves were handling. Each commentator was associated with a particular control engineer in the control room, and the engineer could speak to him by telephone or give cues by means of red and green signal lights.

The B.B.C. recording department was also very much involved in the day's proceedings. They made recordings of the entire home programme, of the ceremony from the Abbey, and of nearly forty overseas commentators, and at the same time handled items coming in from all over the world for the evening programme preceding the Queen's speech. Altogether, they used some 3,600 disks and about 85 miles of magnetic tape on 192 reels.

And now for the television arrangements, which will be described by the Superintendent Engineer of the B.B.C.'s television outside broadcasts department.

Television Arrangements

By T. H. BRIDGEWATER

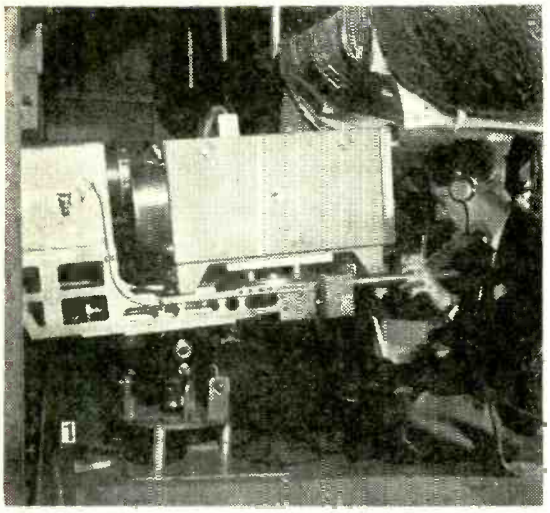
APART from the sheer size of the operation—the deployment of twenty-one cameras, five mobile control rooms, three subsidiary control points, and so on—the television broadcast of the Coronation ceremonies presented a number of problems not usually met on the simpler type of O.B. It was also made the occasion to introduce several new technical refinements.

In the ordinary course of events, O.Bs originating in the London area are routed into the distribution network via the central control room at Alexandra Palace. On this occasion, with five main sources to be handled simultaneously, it was necessary to instal a temporary O.B. central control room in Broadcasting House. The last-mentioned was chosen as being the most convenient point into which to bring the Post Office lines carrying vision and sound signals from the five mobile control rooms disposed along the processional route (including, of course, the one at the Abbey). This central point was able to preview the pictures from all these sources and to switch them at will into a single outgoing channel to Alexandra Palace, whence they were distributed to the whole television network in this country and on the Continent.

All this imposed a heavy strain on the resources of the Post Office Engineering Department who ably exploited all the available systems and techniques—video on "balanced pair," telephone pair and coaxial, and so on—in order to meet this exceptional demand. This they did to such effect that not only were there five circuits in simultaneous use but also adequate reserves for immediate use in the event of breakdown. The Post Office also provided three other vision circuits to carry the outputs from isolated cameras—on Buckingham Palace roof, on the roof of Abbey House, Tothill Street, and in the Annexe of Westminster Abbey—to their nearest mobile control rooms.

Camera Positions

The positioning of cameras had to be carefully worked out several months beforehand in conjunction with the Ministry of Works and the Abbey architects, and in relation to the claims of sound broadcasting, newsreels, press and other interests at the several main sites, particularly at the Victoria Memorial, the Colonial Office and Westminster Abbey. The Abbey presented exceptional problems, the selection of viewpoints having to be reconciled with the needs of many other parties and with the over-riding requirement that the equipment be not only unobtrusive but, in nearly all cases, out of sight. This led to compromises and to some remarkably cramped and unhandy positions that imposed the severest discomfort and strain on the operators at a time when they would have wished for ease and freedom. For example, in three of the positions the height of the operating box was



(1) Camera with zoom lens installed over the West Door in Westminster Abbey. Because of the low roof the viewfinder had to be taken off the camera and placed on the floor.

(2) Temporary television control room installed at Broadcasting House, where the pictures from five mobile control rooms were previewed and selected.

(3) Temporary control room for sound broadcasting in Trafalgar Square. Each control position manned by an operator was associated with one commentator, and had a mixer for introducing sound effects.

only about three feet, so that, as will be seen from the picture, the cameraman had not even the space to *sit* upright, let alone stand.

The event saw the introduction of many more zoom lenses and a total of five were in service. Two of these were of the new Watson type with interchangeable back elements, giving a choice of two 5 : 1 magnification ranges—with angles of view of 3 deg to 15 deg and 6 deg to 30 deg—while another, also a new design, came from Taylor, Taylor and Hobson with a range between 5 deg and 25 deg. The B.B.C. has encouraged the development of zoom lenses over a number of years and camera technique is now reaping the benefit of research and design in this important field. Viewers of the Coronation O.B. may have noticed the smooth manner in which interesting features in the subject were brought closer, or when the television camera appeared to "catch up" again on some part of the procession that had already receded into the distance.

Telephoto Lens

Another special lens, relatively new to television, was the Dallmeyer 40in "double-folded" telephoto. This was in use at the Victoria Memorial position on a camera facing Buckingham Palace, and since its horizontal angle (in conjunction with an image orthicon pick-up tube) is as little as $1\frac{3}{4}$ deg a very close view of members of the Royal Family during their appearances on the balcony could be obtained. An angle of this order calls for extreme care in use as any slight shake or vibration—even the effect of a puff of wind—will result in a greatly exaggerated movement of the image on the screen.

Every effort was made to transmit the clearest possible pictures and a noticeable enhancement of definition came from the use of the new "derivative equalizers," developed by the B.B.C.'s Research Department* and produced in sufficient quantity to equip nearly all the cameras in use on June 2. These equalizers work on the principle of adding to the picture signal derivatives of itself obtained by differentiating circuits, and provide a simple means of adjusting and compensating optical and electrical losses.

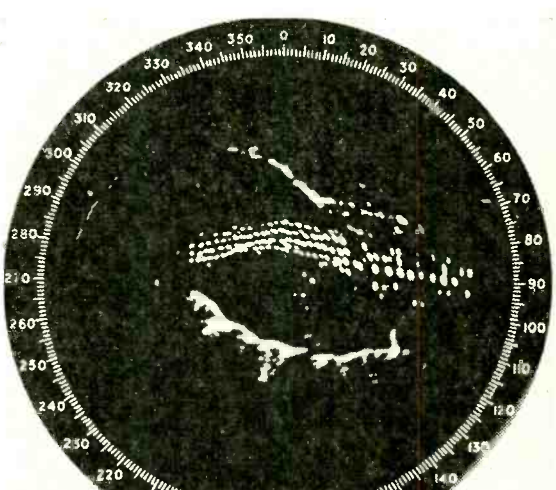
It was thought desirable to avoid the momentary frame-slips which usually occur when switching between vision sources or cameras whose wave-forms are not triggered from the same pulse generators; the number of such interruptions in the course of a long broadcast would have been sufficient to be considerably distracting. Accordingly the B.B.C.'s Designs Department evolved a system of remotely locking each of the eight pulse generators in use by means of a master frequency sent by lines from the Broadcasting House central control point. A phasing control in series with the signal fed to each line permitted precise frame phasing to an accuracy of a very small fraction of one line; hence it was quite feasible to "cut" from one picture source to another without any loss of synchronism.

The relaying of the Coronation broadcast to France, Holland and Western Germany was looked upon by the B.B.C. as a project of the greatest importance and the most careful preparations and tests were made during the preceding six months. It was arranged that the pictures would be the same as those provided for our home audience, but commentaries in the different languages would be superimposed on the effects and ceremony. French commentators were installed alongside the British at several of the main camera positions and spoke through independent microphones and circuits to a separate control point in a studio at Broadcasting House, thence to Paris.

The vision signals reached their various Continental destinations almost entirely by centimetre-wave links, five of which were installed and operated between London and Cassel (France) by Standard Telephones and Cables, on behalf of the B.B.C. and Radiodiffusion-Télévision Française. A particularly important—indeed essential—feature was the use of diversity reception on the cross-Channel link, in order to overcome the fading which is such a well-known and troublesome phenomenon on over-sea paths with frequencies of 4,000 Mc/s or higher. From previous experiments, S.T.C. had established the value of using two receivers with their parabolic aerial dishes mounted some fifteen feet apart in the vertical plane. It has been found that when the signal at one receiver is subject to fading, that of the other is steady; thus, with both signals available, a fading-free signal can always be obtained. This method amply justified itself both during the tests preceding the Coronation transmission and on Coronation day itself. There is no doubt that this method will find applications in the future, not only for any further links with the Continent but also for certain O.Bs within the British Isles.

* "Spectrum Equalization" by G. G. Gouriet; *Wireless Engineer*, May, 1953.

CORONATION NAVAL REVIEW



Another notable outside broadcasting event was the televising of the Coronation naval review at Spithead by cameras on board H.M.S. Eagle *and* H.M.S. Reclaim. *The vision signal was relayed by radio to a shore receiving station near Portsmouth and then on to London. The cameras on board the ships were synchronized with the apparatus on shore by means of a mains locking signal sent out to them on a Navy radio channel (140 Mc/s). This picture shows how the assembled ships appeared on the radar screen of the Marconi Marine research and demonstration yacht* Elettra II.

WORLD OF WIRELESS

Brighton "Booster" Troubles ✦ Radio Technicians' Association ✦ Electronics Show

Television Interference

BRIGHTON VIEWERS whose receivers are tuned to Alexandra Palace are experiencing severe interference from sets receiving the local "booster" station on Truleigh Hill working on 56.75 Mc/s vision and 53.25 Mc/s sound.

The interference either completely wipes out the picture or produces the familiar "herring-bone" pattern, and in some cases gives rise to a heterodyne on the accompanying sound transmission.

It is caused by superhet receivers having a vision i.f. lying between 9 and 15 Mc/s and a sound i.f. between 5.5 and 11.5 Mc/s, with the local oscillator on the lower frequency beat. When receiving the Brighton booster the local oscillator in these receivers must be tuned between 41.75 and 47.75 Mc/s, which is within the pass band of any television set tuned to Alexandra Palace on 41.5 and 45 Mc/s.

Owing to the good signal from the booster many viewers who have had their sets converted have not bothered to replace the aerial. This means that with the aerial flatly tuned over 41 to 48 Mc/s it is bound to radiate any locally generated oscillations. Reports given at a specially convened meeting of the Brighton and District Radio Club show that a receiver radiating in this way on about 45 Mc/s can cause serious interference to A.P.-tuned sets within a radius of about ¼ mile.

Another aspect of the trouble is that amateurs within the service area of Truleigh Hill are suffering quite bad interference when working on the 2-metre waveband.

Catering for Technicians

BECAUSE technicians outnumber "professionally qualified electrical engineers" by at least five to one the I.E.E. has been considering for some time the possibility of forming an organization to cater for the needs of this important and growing section of the industry. It has, however, been recognized that to set up a single association purporting to cater for the needs of all electrical technicians would be ineffectual. The sub-division represented by the four specialized sections of the I.E.E.—radio, supply, utilization and measurement—has, therefore, been adopted in the Institution's approach to the problem.

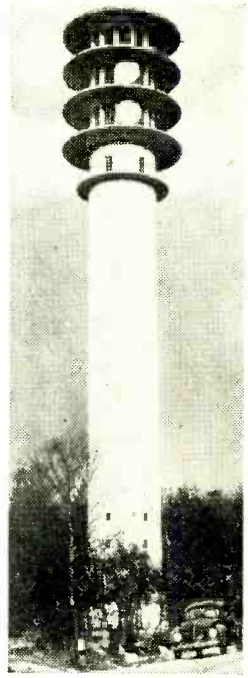
The work of the Study Committee on Associations for Technicians set up by the I.E.E. in 1950 has advanced furthest in the "utilization" field, where the existing Association of Supervising Electrical Engineers is considered to meet the need. In other fields work is continuing, and in the May issue of the *Journal of the I.E.E.* it is reported that the policy is to act where possible in collaboration with an existing body "having a substantial technician membership" and only where this is impracticable to consider stimulating the setting-up of an entirely new body. It remains to be seen what will happen so far as the radio technician is concerned.

Radio Production

THE CENSUS OF PRODUCTION for 1950*, covering *inter alia* radio and telecommunications, details separately the information regarding private firms and Government establishments. The number of radio firms in the U.K. employing more than ten persons is given in the report as 424, compared with 156 in 1935. Their gross output was £136,523,000 in 1950, compared with £27,910,000 in 1935. The number of operatives ("manual wage earners") employed was 106,999, while the number of administrative, technical and clerical employees was 35,944.

There are 28 Government establishments listed as employing 59,166 operatives with an administrative-technical staff of 13,282.

* "Report on she Census of Production for 1950: Vo. 4 Engineering, Shipbuilding and Elec.rical Goods." H.M.S.O. 2s.



TELEVISION RELAY—One of the eleven Telefunken relay stations used by Nordwestdeutscher Rundfunk to link its chain of five television transmitters.

Wired Broadcasting

THE USE of the telephone network to convey r.f. to listeners is not new. Experiments were carried out in this country and others before the last war, but it is interesting to read, in the March issue of the *Bulletin* of the European Broadcasting Union, of its development in Sweden. Ten years ago the Swedish broadcasting authority (Radiotjänst) recommended that the distribution of its programmes over wires should be a normal auxiliary to their radiation.

The system has provision for distributing three separate programmes on different channels in the long-wave broadcasting band, although at present only one is being transmitted on 164 kc/s. A signal of only a few microvolts is required at the subscriber's connection, and it is claimed that there is little risk of interference of any sort. The low power of the transmitters (6mW), the low impedance of the telephone circuits, and the fact that they are balanced to earth make it impossible to detect any radiated signal at distances of much more than 20 metres. Filters are provided to prevent mutual interference between radio and telephone.

The r.f. signals are fed into the networks serving homes within a radius of not more than 150 kilometres from the transmitter. Amplifiers are installed at intervals varying from 10 to 30 kilometres according to the attenuation of the circuits and subscribers' distribution amplifiers are provided at all telephone exchanges in the network.

At present there are 15 networks in use serving some 50,000 subscribers, who pay an installation fee of 5 crowns and the annual wireless licence fee of 15 crowns (approximately £1).

Electronics Exhibition

RESEARCH DISPLAYS and demonstrations by universities, hospitals and the industry as well as exhibits by more than 50 manufacturers are included in the plans for the eighth annual Electronics Exhibition, organized by the N.W. Branch of the Institution of Electronics, which opens in Manchester for six days on July 15th.

During the exhibition, which will be held at the College of Technology, Sackville Street, Manchester, 1, there will be a programme of some 40 lectures dealing with a variety of subjects from printed and potted circuits to electromedical equipment.

Among the demonstrations in the Research Section will be one showing the principles of colour television by Ferranti, and another of electro-acoustics provided by the B.S.R.A.

The exhibition catalogue (price 1s 6d) will be available early in July from W. Birtwistle, 17, Blackwater Street, Rochdale, Lancs, to whom applications (enclosing a stamped addressed envelope) should be made for free exhibition and lecture tickets. The exhibition opens on the first day at noon and on subsequent days at 10 a.m., and closes at 10 p.m. each day except the 18th (7 p.m.) and 21st (9 p.m.).

CORONATION HONOURS

Dr. E. C. Bullard, M.A., F.R.S., who has been director of the National Physical Laboratory since 1949 and was previously professor of physics at Toronto University, is among the new Knights Bachelor created by H.M. the Queen to mark her Coronation.

F. S. Barton, M.A., B.Sc., M.I.E.E., who is among the new C.B.E.s, has been Principal Director of Electronic Research and Development (Ministry of Supply) since 1951. He joined the Radio Department of the Royal Aircraft Establishment at Farnborough in 1922 and became deputy head of the department in 1936. For five years (1941/46) he was chief radio engineer for the British Air Commission (Washington).

F. C. McLean, B.Sc., M.I.E.E., deputy chief engineer of the B.B.C., is appointed C.B.E. in the Honours List. He was already a Member of the Order. He has been with the B.B.C. since 1936.

Among the new Officers of the Order of the British Empire (O.B.E.) are:—

W. H. Grinsted, M.B.E., F.C.G.I., M.I.E.E., chief telecommunications engineer of Siemens Bros. & Co.

E. L. E. Pawley, M.Sc.(Eng.), M.I.E.E., who has been head of the Engineering Services Group of the B.B.C. for the past 18 months. He joined the Corporation in 1931.

W. R. Piggott, principal scientific officer at the D.S.I.R. Radio Research Station, Slough.

W. West, B.A., M.I.E.E., staff engineer at the Post Office Research Station.

H. J. H. Wassell, chief radar development engineer of Marconi's Wireless Telegraph Co., Ltd.

F. S. BARTON (C.B.E.)

F. C. McLEAN (C.B.E.)

Among the new Members of the Order of the British Empire (M.B.E.) are:—

N. H. Aldersley, radio officer on the m.v. *Australia Star* employed by Siemens Bros. & Co., Ltd.

W. G. Allen, senior experimental officer, Directorate of Electronics Research and Development (Air), Ministry of Supply.

R. S. Bastin, who was until recently chief wireless officer in the Gilbert and Ellice Islands.

R. T. Lakin, chief engineer of the Whiteley Electrical Radio Co., Ltd., of Mansfield.

R. H. Linnell, superintendent of the B.T-H. Radar Factory at Leicester.

E. E. Spillan, telecommunications technical officer in the Ministry of Civil Aviation.

The British Empire Medal was awarded to **W. T. J. Cox,** radar chain installation engineer, Marconi's W.T. Co., and **L. W. Kyle,** radio mechanic in the telecommunications section of the Ministry of Civil Aviation.

PERSONALITIES

H. Andrewes, O.B.E., M.I.E.E., B.Sc., A.C.G.I., who received his technical training at the City and Guilds College and joined the Dubilier Condenser Co. in 1945, has been appointed technical sales executive of the company. During the last war he served in the R.A.F. as signals officer and later as chief radar officer, Base Air Force South East Asia, with the rank of Wing Commander. While with Dubilier's, he has been responsible for the design, manufacture and installation of test equipment for the quality control of the company's products.

A. E. Bennett, the new chief engineer in charge of the Dubilier Condenser Company's laboratory, joined the company in 1926 as laboratory assistant. He received his college-works training at Ferranti, Ltd., Hollinwood, Lancs. In his new position he will be responsible for the design and development of the company's products.

George J. McDonald, B.Sc.(Hons.), A.M.I.E.E., deputy technical manager of the Marconi International Marine Communication Co. since 1949, has been appointed technical manager. He graduated from Glasgow University and in 1935 joined Marconi's W.T. Company, where he was engaged in research work on d.f. techniques. During the war he was engaged on Naval communications work, and in 1949 transferred to the Marconi Marine Company.

L. H. Bainbridge-Bell, long known as a stalwart campaigner in the interests of clear presentation of technical information particularly in circuit diagrams, is retiring in August from the Admiralty Signal and Radar Establishment which he joined in 1939. He hopes to continue his mission in other fields. It will be recalled that he was granted an award by the Royal Commission on Awards to Inventors for his contribution to the development of radar.

K. Higginson, the well-known technical representative of the Dubilier Condenser Co., Ltd., which he joined in 1934, has retired. Before joining Dubilier he was chief engineer of Oliver Pell Control, Ltd. He hopes to be able to make use of his wide knowledge of the radio industry as a consultant for technical publicity. His address is 322, Richmond Road, Kingston-on-Thames, Surrey (Tel.: Kingston 8072).

W. A. Scarr, M.A., who was president of the Radio Society of Great Britain during 1950 and 1951, has been elected an honorary member of the Society. (There are only eight other honorary members.) Mr. Scarr, who graduated from Cambridge shortly after the 1914-18 war, is an educationist and seven years ago joined the British Council as director of the Students' Department.

E. Morgan, who, as announced last month, has joined the Plessey Co., was an assistant to and not, as stated, *the* superintendent engineer (transmitters) in the B.B.C. E. F. Wheeler holds this position.

OBITUARY

Brigadier John B. Hickman, C.B.E., M.C., M.A., who was managing director of British Telecommunications Research, Ltd., and was on the boards of A.T. & E. (Bridgnorth), Ltd., Automatic Telephone & Electric Co., Ltd., and Hivac, Ltd., died suddenly on June 3rd at the age of 54. Throughout his army career he was in radio and held many technical administrative positions, including deputy chief inspector of electrical and mechanical equipment (1941-44), deputy director of signals (equipment) at the War Office (1944-45) and Director of Telecommunications Research and Development, Ministry of Supply, from 1945 until his retirement from the army in 1949, when he joined B.T.R.

Alfred Weedon Hall, who has one of the team of engineers who assisted C. S. Franklin in the development of the Marconi short-wave beam system in the 1920s, died on May 22nd at the age of 60. He joined Marconi's W.T. Co. as a test-room assistant in 1913, and after service in the Navy during the first world war returned to the company in 1919. He was largely concerned with the design and installation of short-wave transmitters until 1943, when he was lent to the Admiralty for research work. Mr. Hall returned to Marconi's in 1946 and was latterly in charge of a technical liaison section.

IN BRIEF

Broadcast Licences.—During April the number of television licences in the U.K. increased by 60,891, making a total of 2,203,343. There were 10,523,105 "sound" licences and 186,338 for car radio sets current at the end of the month, making a total of 12,912,786.

Transistor Standards.—Electrical specifications for transistors, supplementing those covering physical standards which have been in use for some months, have been drawn up for the U.S. Services and the Joint Electron Tube Engineering Council (America's B.V.A.). According to a report in *Electronics*, transistors will be supplied with 2-in leads, which if not required for soldering direct into circuits may be cut and spaced to fit standard 5-pin in-line sub-miniature valve holders. The emitter and collector leads will occupy sockets one and five and the base lead the socket next to the emitter.

Automatic Computing.—A summer school in programme design for automatic digital computing machines will be held in the University Mathematical Laboratory at Cambridge from September 22nd to October 2nd. A detailed syllabus and form of application for admission may be obtained from G. F. Hickson, M.A., secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge, to whom the completed application form should be returned by July 18th.

R.I. Club.—At the 22nd annual general meeting of the Radio Industries Club, Edward E. Rosen, chairman and managing director of Ultra Electric, Ltd., was elected president in succession to Lord Brabazon of Tara. The vice-presidents are A. J. Dew, H. de A. Donisthorpe (G.E.C.), A. J. P. Hytch (B.B.C.), and J. H. Williams (R.G.D.). The new chairman of the committee is H. A. Curtis (R.T.R.A.) with R. F. Payne-Gallwey (Erie) as vice-chairman. It was reported at the meeting that the membership of the parent club (London) is now 794 and that there are six affiliated clubs in other parts of the country.

Radio Section of the I.E.E. continues to have the largest membership of any of the four specialized sections of the Institution and again held more meetings than any other section during the last session (25). Of the Institution's total membership of 37,782 at the end of March, 4,811 were members of the Radio Section.

Television Society Council.—The four vacancies on the Council of the Television Society have been filled by the election of the following Fellows: L. S. Allard (G.E.C. Research Laboratories), T. Kilvington (Post Office Radio Research Branch), T. M. C. Lance (Cinema-Television) and Dr. W. J. Thomas (Norwood Technical College).

South Coast Reception.—The permanent low-power (2 kW) transmitter to provide improved reception of the B.B.C. Home Service along the South Coast east of Beachy Head is to be erected near Bexhill. This transmitter will operate on 1,457 kc/s and will replace the low-powered temporary station at Hastings towards the end of this year.

Egypt's new air-cooled 100-kW s.w. transmitter at Abu Zaabal, near Cairo, which was supplied by Marconi's, has now been brought into service and operates on six frequencies. A new Marconi 100 kW medium-wave transmitter (620 kc/s) is in course of construction.

S.O.S.—Commenting on a recent criticism of the use of the 500-kc/s frequency for both marine traffic and distress calls, two writers in the *Journal des Télécommunications* state that the composition of the distress signal is such that it is received through the most intense interference. The writers add, "We, in our many years' ship and coast station experience in a part of the world with very dense ship traffic, never heard of a single case of an S.O.S.-signal 'drowned' in congested traffic on 500 kc/s."

Canadian Television Plans announced by the C.B.C. include the expenditure of over $6M on new stations in Vancouver, Winnipeg and Halifax (all of which are expected to be in operation in the late autumn) and a second transmitter for Montreal. It is also planned to extend the inter-city television relay network which at present links Montreal, Ottawa and Toronto.

U.S. Television Density.—A chart published in the May issue of *Electronics* shows that, in 30 U.S. television areas in which there are 22.3 million homes, there are 19.8 million television sets. The figures, provided by the National Broadcasting Company, show that in these 30 areas television density is about 89%. In the other 46 areas listed, television density is only 18%. Of the 1.9 million homes in New York there were on January 1st slightly more than 1.8 million television receivers.

Ship-shore R/T Services, operated by Cable and Wireless, Ltd., are now available to ships in the vicinity of Lagos and Sierra Leone, West Africa, and the company is also planning to open a similar service at Bathurst.

Short-Wave Listeners are invited by the International Short Wave Club to send on a postcard the names of their three favourite short-wave broadcasting stations and to state briefly the reasons for their first choice. Entries for the competition must be sent by July 31st to I.S.W.C., 100, Adams Gardens Estate, London, S.E.16.

Amateur Show.—It is proposed by the Radio Society of Great Britain to hold the seventh annual amateur radio exhibition at the Royal Hotel, London, W.C.1, during the week November 23rd to 28th.

Home Construction.—The interests of the radio and television home constructor are catered for in the plans for the second National Handicrafts and Hobbies Exhibition which will be held at the Central Hall, Westminster, London, S.W.1, from September 17th to 30th.

PUBLICATIONS

Limits and Tolerances.—A new Standard (B.S. 1916, Pt. I:1953) giving limits and tolerances for engineering, which are stated to be "sufficiently comprehensive to cover every need from the watchmaker at one end to the heavy industries at the other," has been issued by the British Standards Institution. The telecommunications industry was among the many represented on the investigating committees. Part II of the Standard will give guidance in the use of Part I, which is available from the B.S.I., 24, Victoria Street, London, S.W.1, price 10s.

Second-hand Prices.—Maximum allowances on second-hand broadcast and television receivers purchased by the trade are given in "Used Radio and Television Set Values" prepared by the Radio and Television Retailers' Association and published by the Trader Publishing Co., Dorset House, Stamford Street, London, S.E.1. Manufacturers are listed alphabetically and the oldest broadcast receivers quoted are of 1941-1942 vintage. Older sets than those listed are stated to have no commercial value. The allowances indicated for television sets are based on the need for a new cathode-ray tube to be fitted. The 80-page book costs 2s 9d, including postage.

"QRP" is the title of the monthly journal of the QRP Research Society, which was formed in 1950 to foster interest in low-power transmission. The Society is organizing a monthly contest for transmitters and listeners. The operating hours are from 1900-2100 each Sunday, and the frequency band for July is 21 Mc/s. Details of the contest and membership of the Society are obtainable from the Honorary Secretary, J. Whitehead, The Retreat, Rydens Avenue, Walton-on-Thames, Surrey. A. O. Milne (G2MI), vice-president of the R.S.G.B., has been re-elected president of the QRP Society for a second year.

BUSINESS NOTES

Pye V.H.F. amplitude-modulated R/T equipment is being supplied by Rees Mace Marine, Ltd., to the Norwegian shipping authorities. Shore stations have already been installed at Tröndheim, Oslo and Drammen, and a number of craft including 40 whaling vessels have been equipped.

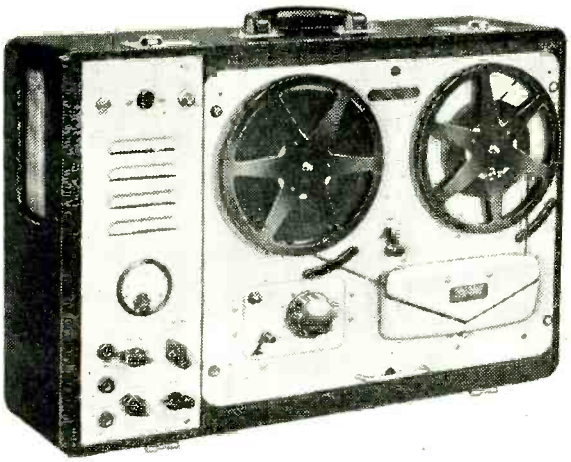
Ground-to-Air V.H.F. transmitters, receivers and spares worth $1.4M are to be supplied by the British General Electric Co. to N.A.T.O. countries under a contract placed by the United States Air Force in Europe.

Marconi International Marine Communication Co. has opened a Service Depot at the Ferry Docks Pumping Station, Dover. Inspector E. Trethewey, whose telephone number is Dover 800 (ext. 79), is in charge of the Depot.

Oryx Electrical Laboratories announce that they have appointed ANTEX (Anglo-Netherland Technical Exchange, Ltd.), of 3, Tower Hill, London, E.C.3 (Tel.: Royal 4439), as sole distributors of the Oryx sub-miniature soldering irons.

VORTEXION TAPE RECORDER

FEATURES WORTH NOTING . . . . . .



The amplifier, speaker and case, with detachable lid, measures 8$\frac{1}{4}$in. x 22$\frac{1}{2}$in. x 15$\frac{3}{4}$in. and weighs 30 lb

PRICE, complete with WEARITE TAPE DECK £84 0 0

★ The noise level is extremely low and audibly the hum level and Johnson noise of the amplifier and deck are approximately equal. Only 25% of this small amount of hum is given by the amplifier alone.

★ Extremely low distortion and background noise, with a frequency response of 50 c/s.—10 Kc/s., plus or minus 1.5 db. A meter is fitted for the measurement of signal level and bias level.

★ Sufficient power is available for recording on disc, either direct or from the tape, without additional amplifiers.

★ A heavy mu-metal shielded microphone transformer is built in for 15-30 ohms balanced and screened line, and requires only 7 micro-volts approximately to fully load.

★ The .5 megohm input is fully loaded by 18 millivolts and is suitable for crystal P.U.'s, microphone or radio inputs.

★ A power plug is provided for a radio feeder unit, etc. Variable bass and treble controls are fitted for control of the play back signal.

★ The power output is 3.5 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

★ Facilities are provided for using the amplifier alone and using power output or headphones while recording or to drive additional amplifiers.

★ The unit may be left running on record or play back even with 1,750 ft. reels with the lid closed.

POWER SUPPLY UNIT to work from 12 Volt Battery with an output of 230v., 120 Watts, 50 cycles within 1%. Suppressed for use with Tape Recorder. **PRICE £18 0 0.**

TYPE C.P.20A AMPLIFIER

For A.C. Mains and 12 volt working giving 15 watts output, has switch change-over from A.C. to D.C. and "Stand-by" positions. Consumes only 5$\frac{1}{2}$ amperes from 12 volt battery. Fitted with mu-metal shielded microphone transformer for 15 ohm microphone, provision for crystal or moving iron pick-up with tone control for bass and top. Outputs for 7.5 and 15 ohms. Complete in steel case with valves.

PRICE
£30.16.0

Manufactured by

VORTEXION LIMITED, 257-263, The Broadway, Wimbledon, London, S.W.19

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The Ohmmeter

By W. TUSTING

Its Basic Characteristics

FOR the measurement of resistance, the ohmmeter is probably the most widely used instrument, although it is rarely a highly accurate one. There are several reasons for its popularity. In the first place, the ohmmeter usually exists, not as a separate instrument, but combined with a multi-range voltmeter and milliammeter with the result that it is usually the cheapest form of resistance-measuring apparatus. Secondly, a continuity tester is an essential piece of test equipment and the ohmmeter performs this function without any detriment to its measuring ability. Thirdly, high accuracy of measurement is not often necessary in ordinary radio work so that its relative inaccuracy is but little drawback.

In spite of the fact that the ohmmeter is so widely used and its main characteristics are generally known, there does not seem to be such common appreciation of its finer points. Nor is it always realized that there are two basic forms of ohmmeter—the series and the shunt types. The shunt ohmmeter is not a common one, and all the ordinary ones are series ohmmeters.

The basic circuit of the series ohmmeter is shown in Fig. 1. A battery E, a meter M and a resistor R_T are connected in series with the resistance R_x to be measured. The current which flows is

$$i_m = \frac{E}{R_T + R_x} = \frac{E}{R_T} \cdot \frac{1}{1 + R_x/R_T} \quad \ldots \quad (1)$$

If the current required for full-scale deflection (f.s.d.) of the meter is I_m, this equation can be written as

$$\frac{i_m}{I_m} = \frac{E}{I_m R_T} \cdot \frac{1}{1 + R_x/R_T} \quad \ldots \quad (2)$$

and if the values are so chosen that $E = I_m R_T$ it reduces further to

$$\frac{i_m}{I_m} = \frac{1}{1 + R_x/R_T} \quad \ldots \quad (3)$$

This simple equation describes the law of the scale of any series-type ohmmeter as long as it includes only linear circuit elements. No matter how complex the internal resistance network may be, and some are quite complicated, it can be reduced to this form.

The left-hand side of equation (3) represents the fraction of full scale by which the pointer is deflected for any value of R_x, while the right-hand side shows that the important factor which governs the deflection is not the absolute value R_x but its relation to the internal resistance R_T. When we say that i_m/I_m represents the fractional deflection, we are implicitly assuming that the deflection of the meter needle is proportional to current. In practice, it may not be precisely so, in which case the equation really indicates resistance in terms of the current scale of the meter. Using this equation, any current-indicating meter can have a resistance scale marked off directly from the current scale.

It can be seen that when R_x is infinite, the current is zero and the meter needle is not deflected at all, whereas when R_x is zero the current is I_m and the meter reads full scale. In a series ohmmeter, zero resistance always corresponds to full-scale deflection and infinite resistance to zero deflection. The resistance scale reads from right to left and always covers all possible resistance values.

When R_x and R_T are equal, $i_m/I_T = 1/2$; the current is one-half of the full-scale value. It is here that the scale-reading accuracy is at its highest and it is only in the neighbourhood of this point that any reasonable accuracy is obtainable In practice, therefore, it is the value of R_T which sets the useful range of the instrument and to change the range it is necessary to change R_T. This is not the only requirement, however, for equation (3) holds only if $E = I_m R_T$ so that if R_T is altered it is necessary also to change E/I_m by the same amount. This can be done by altering the battery voltage or the full-scale current of the meter (as by shunting it) or by a combination of both.

The requirement that $E = I_m R_T$ sets a very definite limit to the resistance range obtainable in practice. Cost and durability set a limit to the sensitivity of the meter that can be used and this limit is probably reached with a 100-μA meter movement. Many ohmmeters have nothing better than a 1-mA movement. Cost, size and weight limit the battery voltage that can be used, but also it is generally necessary to keep the voltage below the value at which any noticeable shock is obtained when the R_x terminals are touched. These factors will usually limit the battery to about 50 V.

With a 50-V battery and a 100-μA meter, the maximum value of R_T is $50/0.1 = 500\,\text{k}\Omega$. With a 1-mA meter it is $50\,\text{k}\Omega$. These correspond to mid-scale values of R_x. Good accuracy is maintained, as will be seen later, for resistance values up to three times R_T, moderate accuracy up to 10 times R_T and rough indications of value are obtainable up to some 50 times R_T.

The lower limit of resistance with the series ohmmeter is set by the maximum current which can conveniently be supplied by the battery. Unless exceptionally big cells are used this is usually around 150 mA. The smallest value of E is that of a single cell, nominally 1.5 V, so that the minimum value of R_T normally practicable is $1.5/0.15 = 10\ \Omega$. Below the mid-scale value R_T, good accuracy can be obtained down to $R_T/3$, moderate accuracy to $R_T/10$ and rough indications to $R_T/50$.

In general, therefore, the useful limits of a series

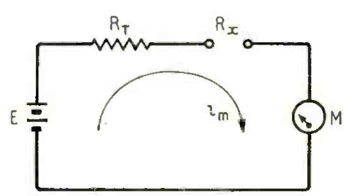


Fig. 1. Basic circuit of series ohmmeter.

ohmmeter extend from about 3 Ω (the limit being set by the battery current) to about 4 MΩ (the limit being set mainly by the meter sensitivity, but partly by battery voltage).

By differentiating equation (3) with respect to R_x it is possible to find the relation between very small changes of resistance ΔR_x and the consequent change of current Δi_m. This relation is

$$\frac{\Delta i_m}{I_m} = -\frac{\Delta R_x}{R_x} \cdot \frac{1}{2 + \frac{R_x}{R_T} + \frac{R_T}{R_x}} \quad \ldots \quad \ldots \quad (4)$$

This has its maximum value when $R_x = R_T$ and then

$$\frac{\Delta i_m}{I} = -\frac{1}{4} \cdot \frac{\Delta R_x}{R_x}$$

To see what this means, suppose that it is possible to read a small change of current Δi_m with a certain degree of accuracy on a meter of I_m full-scale deflection. Then $\Delta i_m/I_m$ is the fractional change of current and, for the same accuracy of reading, it is only possible to read a fractional change of resistance four times as great. For example, if the smallest change of current that can be read on the meter is 1% of full-scale, then the smallest change of resistance that can be read is 4%. It is necessary to distinguish between a readable change and a detectable change; the latter may be only a tenth as great.

The relative reading accuracy at different parts of the scale can be expressed as

$$\frac{4}{2 + R_x/R_T + R_T/R_x}$$

and this shows how the reading accuracy of the scale varies relatively to the best position. If $R_x/R_T = 10$ or 0.1, the relative accuracy is $4/12.1 \approx \frac{1}{3}$ times, which is why, in the foregoing, a range of 0.1 to 10 times mid-scale has been classed as of only moderate accuracy. If $R_x/R_T = \sqrt{10}$ or $1/\sqrt{10}$, the relative accuracy is 1/1.37 times and this is quite a small decrease and is considered here to represent the limit of range for good accuracy.

The reason for choosing the, at first sight, peculiar value of $\sqrt{10}$ for the limits of each range is that it is the natural limit when the ranges are in steps of 10, which they must be if the same resistance scale is to be used for all ranges with a simple multiplier. $R_x/R_T = \sqrt{10}$ on one range then corresponds with $R_x/R_T = 1/\sqrt{10}$ on the next higher range and it is necessary to read outside the $\sqrt{10}$ limits only on the highest and lowest ranges.

Effect of Battery Changes

Most practical difficulties with the ohmmeter arise through the range-changing arrangements and through the circuits which are needed to compensate for the effect of changes in the battery. It is an unfortunate fact that neither the internal e.m.f. of a battery nor its internal resistance is a constant, but is liable to change, not only during the life of the battery but from one battery to another. It is necessary, therefore, either to design the ohmmeter circuit so that these variations cause negligible error or to provide compensating adjustments so that their effect can be corrected. It is here that various ohmmeters differ most from each other.

The effect of a change of battery resistance is to alter the value of R_T, for R_T is the total internal resistance of the ohmmeter viewed from the R_x terminals.

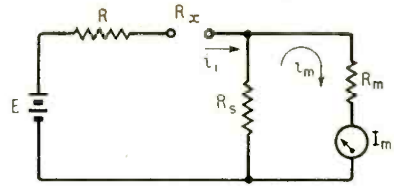


Fig. 2. Series ohmmeter with compensation for battery e.m.f. variations by a shunt R_s.

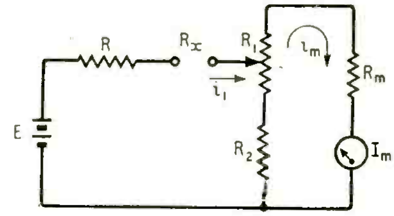


Fig. 3. Ohmmeter with "constant-resistance" e.m.f. compensator.

The effect thus depends on the magnitude of the change of resistance relative to the proper value of R_T. On a high-resistance range, R_T might be 500 kΩ and a 50-V battery of small cells might develop an internal resistance of 2 kΩ at the end of its life. The resulting error is only 0.4% and by making the resistance external to the battery 499 kΩ and, taking the battery as having a resistance of 1±1 kΩ, the error can be made ±0.2%.

On a lower range of 50 kΩ mid-scale there are two alternative ways of obtaining the proper conditions. One is to retain the 50-V battery and to shunt the meter to take ten times the current. The battery resistance is then ten times as important and, in the example, the error due to it reaches ±2%. The alternative is to leave the meter unshunted but to reduce the battery voltage to one-tenth, which also reduces the battery resistance to one-tenth, and leaves the resistance error at ±0.2%. This is clearly the better course. In practice, matters are likely to be even better, because one would usually employ larger cells for a low-voltage battery than for a high-voltage one and the battery resistance is likely to be relatively much less.

In order to make battery resistance a negligible factor, it is necessary to use as sensitive a meter as possible so that the current is a minimum and to use a battery of as large-capacity cells as is practicable. On the higher-resistance ranges, it is then usually possible to ignore the battery resistance. On the lower-resistance ranges, however, compensation is nearly always needed. Such compensation is simple. It is only necessary to choose the total resistance lower than the required value of R_T by the amount of the maximum battery resistance and then to insert in series a variable resistance of this same maximum value. As the battery resistance increases, the variable resistor is reduced by the same amount and the total stays constant.

Compensation for changes of e.m.f. is necessary on all ranges and is more troublesome to arrange. It is hardly practicable to arrange an adjustable source of e.m.f. and what is done in practice is to alter the sensitivity of the meter to suit the e.m.f. On any range, the requirement is to have $E/I_m = R_T$ and compensation for changes of E is obtained if I_m is arranged to be proportional to E. The simplest way of doing this is to have a variable shunt to the meter.

The circuit then takes the form shown in Fig. 2, and the relevant equation analogous to equation (2) is

$$\frac{i_m}{I_m} = \frac{E}{I_m R_T} \cdot \frac{1}{1 + R_m/R_s} \cdot \frac{1}{1 + R_T/R_x} \quad .. \quad (5)$$

which reduces to equation (3) if $E = I_m R_T(1 + R_m/R_s)$. Here I_m is the meter current itself and is a fixed unalterable quality, so that it is R_s which is varied to correct for changes of E ; R_m is, of course, the internal resistance of the meter.

It is not practicable to vary R_s continuously over any range extending to infinity, so there is always some finite value in shunt with the meter. This reduces the sensitivity and makes i_1 greater than i_m. Accordingly, the resistance range obtainable is reduced.

A penalty which must be paid for having e.m.f. compensation is a reduction of the maximum resistance range and, with the simple shunt of Fig. 2, the best that can be done is to have a range of about 80% of that with the unshunted meter. This is actually about the best that can be done by any method.

Adjustment of R_s unfortunately affects the value of R_T, for R_m and R_s together form an effective meter of resistance $R_m/(1 + R_m/R_s)$ and of full-scale current $I_1 = I_m(1 + R_m/R_s)$. The effective meter resistance is thus $R_m I_m/I_1$. Now I_1 must vary in proportion to the battery voltage if R_T is constant and so the effective meter resistance must vary in inverse proportion to the voltage. The percentage variation of effective meter resistance is thus the same as the percentage variation of battery e.m.f. In practice, the magnitude of the change of resistance will rarely exceed about 100 Ω. It is quite negligible on high-resistance ranges, but is a major factor on low-resistance ranges.

Range Changing

The variations of resistance can be very greatly reduced by using the form of compensation shown in Fig. 3. Here, a potentiometer R_1 is used and arranged so that one side of it acts in series with R_2 as a variable shunt, while the other side puts resistance in series with R_m. There is an optimum position for the slider on R_1 at which the resistance is a maximum and this corresponds to an equal division of the current i_1 between the two paths. Consequently, the two paths are then of equal resistance and the total resistance viewed from the slider is $(R_1 + R_2 + R_m)/4$. The current i_1 is twice i_m. At other settings of the slider the resistance falls, but only slightly for small changes of i_1/i_m.

The change of resistance is of the order of a quarter or a fifth of that with the simple shunt of Fig. 2, which is a considerable improvement. Unfortunately, however, the ratio of i_1 to i_m is much larger, being about 2 : 1 instead of some 1.2 : 1. This means that it restricts the maximum resistance range more.

For range changing, it is necessary at some stage to shunt the meter or to do some equivalent thing. With neither Fig. 2 nor Fig. 3 is a simple meter shunt satisfactory. In Fig. 2, a meter shunt calls for a change of value of R_s and separate zero-adjusting variable resistors are needed for each range. As well as taking up a lot of space, they become expensive.

The same thing applies to Fig. 3 if the meter itself is shunted unless, at the same time, resistance is inserted in series to keep the total resistance of the effective meter constant. This is satisfactory, except that the low-resistance ranges are limited by a high effective meter resistance. An alternative is to shunt not the meter itself but the whole meter plus compensator. This would be ideal if the resistance were truly constant but as it is not it makes the e.m.f. adjustor vary somewhat from one range to another.

The most convenient arrangement depends on circumstances and some commercial instruments use one method of compensation for some ranges and another for other ranges. Where the aim is to obtain the widest possible resistance range, with especial emphasis on high values, however, the arrangement shown in Fig. 4 is one of the best, if not the best. This is basically the circuit of Fig. 2 with the resistances R_1 and R_2 added. The resistance R_1 is made so large compared with R_s and R_m together that their variations are swamped. Then R_2 is the shunt for increasing the current on low ranges. R_A is the compensator for battery resistance and R_s the compensator for e.m.f. variations. If the resistor values are precise and the same battery is used for all ranges, the adjustments of R_A and R_s hold for all ranges.

The equation for this circuit is quite a simple one and is

$$\frac{i_m}{I_m} = \frac{E}{I_m R_T} \cdot \frac{1}{1 + R_m/R_s} \cdot \frac{1}{1 + R_1'/R_2} \cdot \frac{1}{1 + R_x/R_T} \quad (6)$$

where $R_T = R + R_2' + R_A + R_B$

$$R_2' = \frac{R_1' R_2}{R_1' + R_2}; \quad R_1' = R_1 + \frac{R_m R_s}{R_m + R_s}$$

and R_B is the battery resistance.

This circuit is so important that it is of interest to consider the detailed design of an ohmmeter embodying it. In spite of its basic simplicity, the design is a little intricate and it is probably both clearest and shortest to set out the steps rather in the form of a drill. In the following the references are to Fig. 4 ; values of current for any value of R_x are indicated there by i, i_1 and i_m. Corresponding currents for $R_x = 0$ are I, I_1 and I_m.

Step 1. Knowing I_m and R_m, which are characteristics of the meter, compute the range of values required for R_s to compensate for variations in the e.m.f. of the battery, bearing in mind that the current I_1 is proportional to the e.m.f. The necessary relation is

$$\frac{R_s}{R_m} = \frac{1}{I_1/I_m - 1}$$

Example 1. Let $I_m = 100\ \mu A$, $R_m = 531.5\ \Omega$ and the e.m.f. per cell be 1.3 V to 1.67 V.

Assume a minimum value for I_1, which will occur

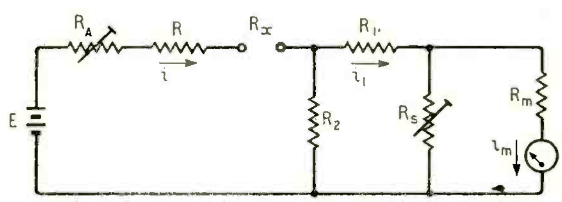


Fig. 4. Basic circuit of a practical ohmmeter with both resistance and e.m.f. compensation ; R and R_2 are altered to change the range.

when the e.m.f. is 1.3 V per cell, of $1.1I_m$. When the e.m.f. is 1.67 V per cell I_1 will be $1.1I_m \times 1.67/1.3 = 1.41I_m$ (approx.).

At the lower current

$$R_s = \frac{531.5}{1.1 - 1} = 5315\ \Omega$$

At the higher current

$$R_s = \frac{531.5}{(1.1 \times 1.67/1.3) - 1} = 1290\ \Omega$$

To employ standard components and ensure plenty of coverage one could make R_s a fixed resistor of 820 Ω in series with a variable of 5 kΩ.

Step 2. At a nominal battery voltage of 1.5 V per cell and for a current I_1 roughly mid-way between the limits of Step 1 decide on the highest resistance range and maximum battery voltage. Also, choose I_1 at a round figure to simplify calculation. (If $R_2 = \infty$, $I = I_1$.)

Example 2. From example (1) $I_1 = 1.25I_m = 125\ \mu A$. For a range in the neighbourhood of 400 kΩ mid-scale we might choose a 45-V battery, which would give 360 kΩ. However, lower ranges will demand a lower-voltage battery to avoid excessive current and this can be connected in series with the 45-V battery to give a higher voltage. With a little trial and error it is found that a 45-V and a 6-V battery, giving 51 V together, will allow a 400-kΩ mid-scale range if the current is changed to 127.5 μA.

Step 3. Recalculate Step 1 on the basis of the new figures from Step 2.

Example 3. Since I_1 is 127.5 μA at 1.5 V, it is $127.5 \times 1.67/1.5$ at 1.67 V and $127.5 \times 1.3/1.5$ at 1.3 V. The limits of R_s are thus

$$R_s = \frac{531.5}{1.275 \times 1.67/1.5 - 1} = \frac{531.5}{0.4195} = 1267\ \Omega$$

$$R_s = \frac{531.5}{1.275 \times 1.3/1.5 - 1} = \frac{531.5}{0.105} = 5061\ \Omega$$

The previous values of 820 Ω fixed and 5 kΩ variable are still suitable.

Step 4. Compute the limits of R_m and R_s in parallel using the results of Step 3.

Example 4.

$$\frac{R_m R_s}{R_m + R_s} = \frac{531.5 \times 1267}{1798.5} = 374.42\ \Omega$$

$$\frac{R_m R_s}{R_m + R_s} = \frac{531.5 \times 5061}{5592.5} = 480.98\ \Omega$$

The total change of resistance is $480.98 - 374.42 = 106.56\ \Omega$. Therefore,

$$\frac{R_m R_s}{R_m + R_s} = 427.7 \pm 53.28\ \Omega$$

Step 5. For decade range steps, each range will be one-tenth of the preceding one and the current will be ten times as great but modified by any change of battery voltage. Compute the ranges obtainable in view of the increasing battery drain.

Example 5. The top range is 400 kΩ mid-scale with E = 51 V and I = 127.5 μA. The next range will be 40 kΩ with E = 6 V, so the current will be $127.5 \times 10 \times 6/51 = 150\ \mu A$. Successive further ranges will be 4 kΩ, 400 Ω and 40 Ω and will take 1.5 mA, 15 mA and 150 mA respectively. A lower range still would have to be 4 Ω and would take 1.5 A which is out of the question.

Step 6. R_2' should be as large as possible in order that R_1 may be large compared with $R_m R_s/(R_m + R_s)$. Choose R_2' for the lowest range so that R is zero (i.e., so that $R_2' = R_T - R_A - R_B$). Values of R_2' for the other ranges, except the highest, follow at once since each is ten times the preceding one. Tabulate the results.

Example 6. On the lowest range $R_T = 40\ \Omega$. The battery resistance is unlikely to exceed 20 Ω, so that if R = 0, $R_2' = 20\ \Omega$. Then for the other ranges the figures are as in Table 1 but the value for range 1 cannot be inserted yet.

Step 7. The value of R is $R_T - R_A - R_B - R_2'$ and, except for range 1 can be computed at once.

Step 8. On range 2 the battery current is $I = E/R_T$ and I_1 is known from Step 2. Then $I/I_1 = R_1'/R_2'$. Compute R_1', then R_1 by deducting $R_m R_s/(R_m + R_s)$.

Example 8. $I = 6/40 = 0.15$ mA ; $I_1 = 0.1275$ mA, so

$$\frac{I}{I_1} = \frac{150}{127.5} = \frac{60}{51}$$

$$R_1' = 20 \times \frac{60}{51} = \frac{1200}{51} = 23.53\ k\Omega$$

$$R_1 = 23.53 - 0.429 = 23.102\ k\Omega.$$

Step 9. On range 1, R_2 is infinite and $R_2' = R_1'$, so R for this range can now be found using the formula of Step 7 and a mean value of battery resistance.

Example 9. Assume $R_B = 1 \pm 1$ kΩ then

$$R = 400 - 1 - 23.53 = 375.47\ k\Omega$$

Step 10. The current I is known for ranges 1 and 2 It increases ten times for each further range. Compute the values for all ranges, then I/I_1 and $I/I_1 - 1$. List the values.

Step 11. Compute R_2 from $R_2 = R_1'/(I/I_1 - 1)$. List the values

Example 11. For range 2 we have $R_1' = 23.53$ kΩ, $I/I_1 - 1 = 9/51$ so

$$R_2 = \frac{23.53 \times 51}{9} = 133.3\ k\Omega$$

From the results of Table 1 the complete circuit diagram of Fig. 5 can be drawn with all values. In

TABLE 1.

Range	R_T (kΩ)	E (V)	$R_a + R_B$ (kΩ)	R_2' (kΩ)	R (kΩ)	I (mA)	$\frac{I}{I_1}$	$\frac{I}{I_1} - 1$	R_2 (kΩ)
1	400	51	1±1	23.53	375.47	0.1275	1	0	∞
2	40	6	0.02	20	19.98	0.15	60/51	9/51	133.3
3	4	6	0.02	2	1.98	1.5	600/51	549/51	2.1857
4	0.4	6	0.02	0.2	0.18	15	6,000/51	5,949/51	0.2017
5	0.04	6	0.02	0.02	0	150	60,000/51	59,949/51	0.020017

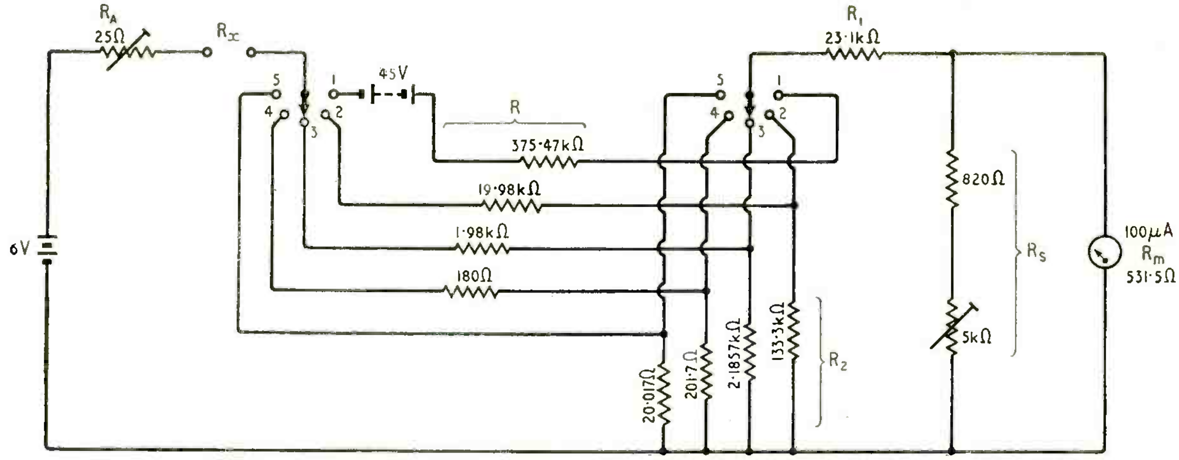


Fig. 5. Complete circuit diagram of a 5-range series ohmmeter covering about 4Ω to 4MΩ.

its five ranges the ohmmeter covers 12.6 Ω to 1.26 MΩ with good accuracy, or 4 Ω to 4 MΩ with moderate accuracy. Outside this range it will give rough indications of resistance up to some 20 MΩ.

If range 1 with the 45-V battery is omitted, the top figures are all one-tenth. This would apply also to a redesigned instrument using a 45-V battery but with a 1-mA meter movement.

If the resistor values are precise the zero adjustments hold for all ranges except the top one, where, as the battery is changed, a readjustment becomes necessary. If they are not precise and a readjustment of R_s is made on each range this cancels the e.m.f. error, but leaves an error due to the change of R_T. This can be quite small even for quite a large change of zero adjustment between one range and the next, depending on just where the error occurs.

It is necessary that the values of R_2 should be especially accurate on ranges 4 and 5, for it is necessary that the e.m.f. compensation should hold accurately between these two ranges. Then R_s can be adjusted on range 4 and R_A on range 5 until the meter reads zero resistance on both ranges.

The procedure for zero adjustment on any range except range 5 is to short-circuit the R_x terminals and to adjust R_s to zero ohms on the scale; that is, to full-scale current deflection. Except on ranges 4 and 5, the setting of the resistance compensator R_A has a negligible effect. Having adjusted R_s on range 4, adjust R_A on range 5; readjust R_s on range 4 and then R_A on range 5. Continue alternately until the meter reads zero ohms when switched to either range. Once R_A has been so set it needs no further adjustment until the battery resistance changes. However, R_s may need slight readjustment on other ranges and will nearly always need it on range 1. However, after a readjustment of R_s only, R_A does not need further alteration until the battery resistance changes. R_A need be adjusted only when it is found that there is a change of zero between ranges 4 and 5.

It is now pertinent to enquire what sort of errors are likely to exist and we shall assume that in every case the instrument is properly zeroed for the range concerned. Now $\frac{R_m R_s}{R_m + R_s}$ varies by $\pm$ 53.28 Ω, so R_1' varies by the same amount or 5328/23.530 = 0.225%. In addition, there is the tolerance on R_1 itself. If this is $\pm$ 1%, the variation of R_1 is $\pm$ 0.231 kΩ. The total variation of R_1' is thus 0.284 kΩ, giving an error of $\pm$ 284/23.53 = $\pm$ 1.2%.

On range 1, with $\pm$ 1% resistors, the possible variations are $\pm$ 1 kΩ for the battery, $\pm$ 3.7547 kΩ for R, and $\pm$ 0.284 kΩ for R_1', a total of 5.04 kΩ in 400 kΩ. The error is thus $\pm$ 1.26%.

Accuracy

On other ranges, R_1' and R_2 come in parallel and errors have two different effects. If the errors are of the same magnitude and sign the current division ratio is unaffected, but R_2' is in error by the same percentage. If the errors are of the same magnitude but of opposite sign the current division ratio is affected but R_2' is altered very little when R_2 and R_1' are of similar magnitude. A change in the current division ratio does not affect the accuracy appreciably but merely calls for a different adjustment of R_s to correct for it.

Let x be the fractional tolerance on R_1', y that on R_2 and z that on R_2', then

$$R_2'(1 + z) = \frac{R_1'(1 \pm x) R_2 (1 \pm y)}{R_1'(1 \pm x) + R_2(1 \pm y)}$$

whence

$$z = \frac{\pm y R_1'(1 \pm x) \pm x R_2 (1 \pm y)}{R_1'(1 \pm x) + R_2(1 \pm y)}$$

$$\approx \frac{\pm y R_1' \pm x R_2}{R_1' + R_2}$$

The error z is always greatest when x and y are of the same sign, so we need only consider this. In our case, we have $x = 0.012$, $y = 0.01$. On range 2

$$z = \pm \frac{0.01 \times 23.53 + 0.012 \times 133.3}{25.53 + 133.3} = 0.01165$$

and as R_2' is 20 kΩ this is an error of 0.233 kΩ. The error in R is $\pm$ 0.1998 kΩ and so the error in R_T is 0.433 kΩ or 1.08%. On range 3, the error in R_2' is about $\pm$ 1.02%, so the total error in R_T is just a shade over 1%.

As R_2 falls in value, the effect of R_1' becomes less and less and the error in R_2' becomes negligibly different from the error in R_2 alone. Range 4 will thus give 1% error, considered by itself.

On range 5 conditions are different, for ranges 4 and 5 are adjusted together to compensate for battery resistance. The e.m.f. adjustment is made on range 4 only, consequently a change in the current-division ratio between the ranges leads to an incorrect value of R_A and so to a change of R_T. The worst case occurs when the errors in R_1' and R_2 are of opposite sign on one range and the same sign on the other. The current division ratio can then change by 2% (very nearly) between ranges.

Assume now that on range 4 battery resistance is still negligible. R_T may be 1% out and this leads to a certain setting of the total current-division ratio which is 1% different from the ideal value. This is the overall ratio set by R_2, R_1, R_s and R_m. If R_T is high the current-division ratio is low and vice versa. There are two possibilities. If R_T is high and the division ratio of R_2 and R_1' is low the ratio of R_s and R_m becomes the correct one, but if the division ratio of R_2 and R_1' is 1% high also, the ratio of R_s and R_m becomes 2% low.

Now on range 5 any error in the ratio of R_s and R_m is carried over and if on this range the current-division ratio of R_2 and R_1' is in error in the opposite sense to that on range 4, it is an extra error. Thus, if it is 1% low, the total current division ratio becomes 3%. Now on this range the value of R_T is adjusted with reference to the current-division ratio. It is assumed to have been set correctly on range 4 to suit the battery voltage, any error therefore leads to an equal error in R_T and may be as much as 3%.

Using $\pm 1\%$ tolerance resistors throughout the electrical errors on ranges 1-4 should be less than $\pm 1.5\%$ and not more than $\pm 3\%$ on range 5. The error on range 5 can be greatly reduced if it can be arranged that the errors in R_2 for ranges 4 and 5 are of the same sign.

To these figures must be added the reading errors of the meter used which depend mainly on the meter itself—its length of scale, the fineness of graduation of the scale, the pointer thickness, parallax and so on. In addition, there are the calibration errors. These can be small if the scale is calibrated directly using close tolerance resistors, but if it is done by calculation from the current scale of the meter, the accuracy of this current scale must be taken into account. This is only $\pm 1\%$ over the upper regions of the scale for the usual B.S.1. grade meter.

Even when considerable care is taken, it is doubtful whether an overall accuracy of much better than $\pm 5\%$ is obtainable.

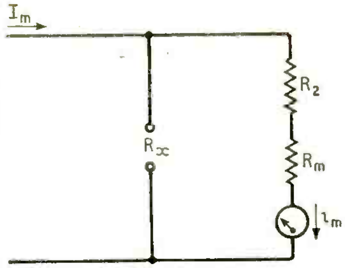


Fig. 8. Idealized form of shunt ohmmeter fed from a constant-current source.

While the form of ohmmeter shown in Fig. 5 is probably the one best suited to radio work, some mention should be made of the shunt ohmmeter. This has the basic circuit of Fig. 6; ignoring battery and meter resistance for the time being, conditions are arranged so that the meter reads full scale when R_x is infinite. This requires $E = I_m(R_1 + R_2)$. The connection of R_x then shunts some of the current from the meter and reduces its reading. When R_x is zero, all the current is diverted and the meter reads zero.

Like the series ohmmeter, the scale covers all possible resistance values but it is reversed left to right. Zero ohms correspond to zero current in the meter and infinite ohms to full-scale current. The basic equation is

$$\frac{i_m}{I_m} = \frac{E}{I_m(R_1 + R_2)} \cdot \frac{1}{1 + R_T/R_x}$$

where $R_T = R_1R_2/(R_1 + R_2)$.

The law of the scale is precisely the same as that of the series ohmmeter but reversed left to right, so all the earlier remarks about the reading accuracy apply with equal force. The range is still set by the value of R_T and the same definition of R_T applies—namely, it is the internal resistance of the instrument viewed from the R_x terminals.

However, R_T is always lower with a shunt ohmmeter than with a series type. In Fig. 6 it is the value of R_1 and R_2 in parallel and is a maximum when R_1 and R_2 are equal. As a series ohmmeter, R_T would be $R_1 + R_2 = E/I_m$. As a shunt ohmmeter, the maximum value of R_T is $(R_1 + R_2)/4 = E/4I_m$. For the same battery and meter, the maximum resistance range of a shunt ohmmeter is one-quarter of that of a series ohmmeter.

Since the value of R_T depends on R_1 and R_2 in parallel but the full-scale current I_m upon R_1 and R_2 in series, it is possible to change R_T and the mid-scale range without affecting the zero adjustment in any way. By using a tapped resistance for R_1 and R_2 the range can be changed merely by varying the position along it at which R_x is connected, as shown in Fig. 7. Unfortunately, the number of ranges obtainable in this way is not very large unless the battery voltage is high, for the minimum range is that of the meter resistance. With a 50-V battery and a 100-μA meter, $R_1 + R_2$ is 500 kΩ. The top range is thus 125 kΩ and lower ranges of 12.5 kΩ and 1.25 kΩ are obtainable, but a range of 125 Ω is not, because it is less than the meter resistance of some 500 Ω.

By shunting the meter, or using a less sensitive one, the lower ranges can be extended indefinitely but at

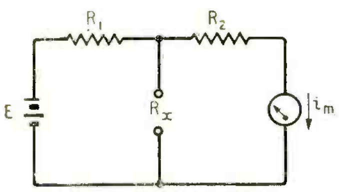


Fig. 6. Basic circuit of shunt ohmmeter.

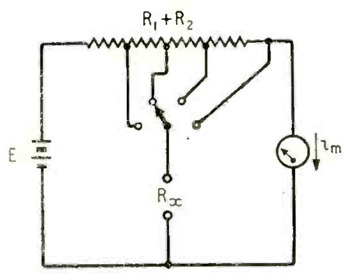


Fig. 7. Multi-range shunt ohmmeter.

the expense of the beautifully simple switching of Fig. 7. If the meter is shunted, R_1 and R_2 must be changed also.

For low-resistance ranges, the resistance of the meter R_2 becomes small compared with R_1 and the ohmmeter tends to the limiting form of Fig. 8 where a constant-current source supplies the current $I_m (\approx E/R_1)$ and $R_T \approx R_2 + R_m$. To reduce the range to one-tenth, $R_2 + R_m$ is shunted by $(R_2 + R_m)/9$ and I_m is increased to 10 I_m.

With a basic 100-μA meter movement, $R_2 + R_m$ might be 600 Ω and this would be one mid-scale range. By increasing the current to 1 mA and shunting $R_2 + R_m$, a 60-Ω range could be obtained. By repeating the process, ranges of 6 Ω for 10 mA, 0.6 Ω for 100 mA and so on, could be obtained.

For a given low-resistance range the current is much lower than with the series ohmmeter. As against this must be set the fact that the current drain is continuous whereas in the series ohmmeter it flows only when R_x is actually connected. If it is used in the same manner as a series ohmmeter, therefore, the current may well flow for hundreds, or even thousands, of times as long as with the series type. The initial advantage of a lower current may thus be quite nullified; in fact, the battery life may be much shorter.

For reasonable battery life with the shunt ohmmeter one must acquire different habits and it is a good plan to include a "Press to Read" switch in series with the battery. But it is inconvenient.

It is largely because of this that the shunt ohmmeter is so rarely used. It is not, therefore, proposed to go into battery compensation in any great detail. It is sufficient to say that resistance compensation is usually unnecessary, for R_1 can usually be kept large compared with changes in the battery resistance. Compensation for variations of e.m.f. is necessary and is probably best carried out by a potentiometer across the battery.

COLOUR TELEVISION

As an experiment in colour television, Pye Ltd. installed cameras on the roof of a building overlooking Parliament Square in order to televise a part of the Coronation procession. Receivers were installed at the Children's Hospital, Great Ormond Street, connected by a radio link operating at 575 Mc/s.

A demonstration was given on the previous day in which two directly-viewed receivers were used to give pictures of 16 in by 12 in and a projection set to give a picture of 4 ft by 3 ft. Some trouble occurred at times during the tests and was stated to be due to rain in one of the transmitter units. Apart from this, excellent pictures were seen, the definition and the colour rendering both being good. Compared with the directly-viewed pictures, the projected picture appeared rather "washy," however, probably because of its lower brightness.

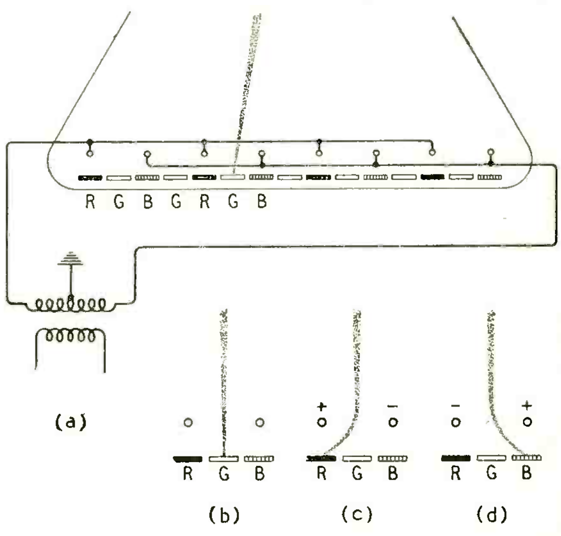
A frame-sequential system was used with 50 complete pictures per second and 150 colour frames. At the camera, a colour disc was used but at the receiver colour tubes were employed for direct viewing. No details of the projection system were given.

The colour tubes were of the Lawrence type and were made by Chromatic Television Inc. of America. The operating principle of these tubes has been previously described[1]. The screen is built up in strips of three differently-coloured fluorescent materials, red, green and blue. The strips are 0.015 in wide and alternate in a regular sequence across the face of the tube. Behind each red strip is a wire of 0.004 in diameter and behind each blue strip is another similar wire. All red wires are joined together and all blue wires are similarly connected. A deflecting voltage is applied in push-pull between the two sets of wires.

The tube has a single gun and focusing and scanning are accomplished in the normal way. When the colour-deflecting voltage is zero, the wires screen the blue and red strips from the electron beam which passes between them to fall on a green strip only. When the colour-deflecting voltage has the proper value and one polarity, it deflects the electrons passing between the wires so that they fall on a blue strip. Similarly, when the voltage has the opposite polarity the deflection is in the opposite direction and the electrons land on a red strip.

In this type of tube a typical sequence of the colour strips is Green, Blue, Green, Red, Green, Blue, Green, Red, Green, Blue, etc., as shown in Fig. 1(a). When both sets of rods are at the same potential the colour deflection, which is subsidiary and is superimposed on the ordinary scanning deflection as a "wobble," is zero (b). When the red rods are positive and the blue negative, the colour deflection is to the red (c)

Fig. 1. At (a) is shown a section through the colour screen and colour-deflecting rods while in (b), (c) and (d) the path of the beam between a pair of rods is sketched for the three possible colour conditions.



[1] *Tele-Tech*, November 1951; *Electronics*, November and December 1951.

and when the red rods are negative and the blue positive it is to the blue (d).

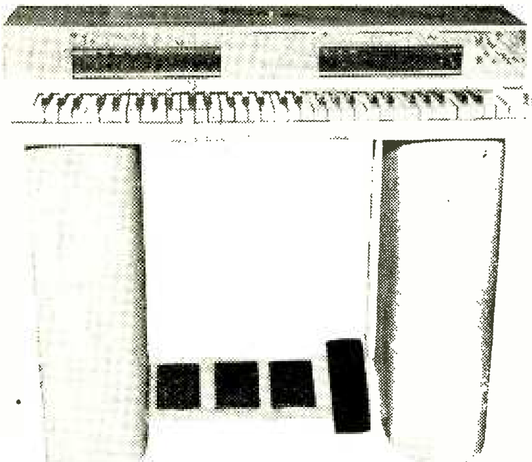
Post-deflection acceleration is used so that operation at around 16 kV can be secured without excessive deflecting power. The colour deflection requires a supply of about 300—400 V and the total capacitance of the grid wires is considerable. In its original form, this resulted in the tube's being only suitable for a frame-sequential system where, because of the low colour-repetition frequency, the necessary voltage could be developed across the high capacitance with the expenditure of quite small energy. It is stated, however, that recent developments have made it possible to reduce the deflecting power sufficiently to render the use of the tube practicable for other systems.

Reproduction with this tube appears to be free from the irritating momentary loss of colour frames on moving the eyes which has been observed in reproducers using a rotating disc. This is probably because an effective overlap of the colour frames can be obtained by arranging for the decay time of the phosphors to be such that one colour frame is not extinguished before its successor. This is impossible with a disc.

The experiment demonstrated a considerable advance in colour television in so far as the reproduction of the picture is concerned.

AMATEUR CONSTRUCTORS' EXHIBITION

Prizewinners in this Year's B.S.R.A. Competition

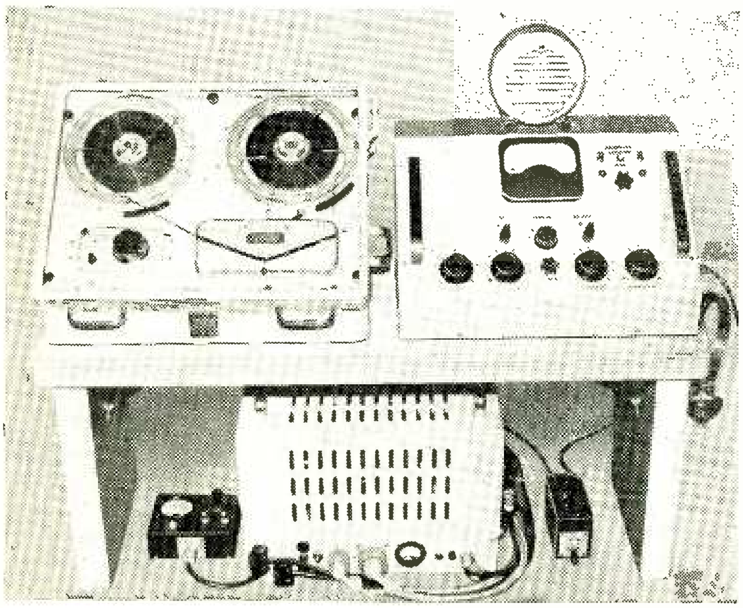


Electronic organ designed by R. E. Winn and awarded the President's Trophy and the Wireless World *Prize in the amateur constructors' competition.*

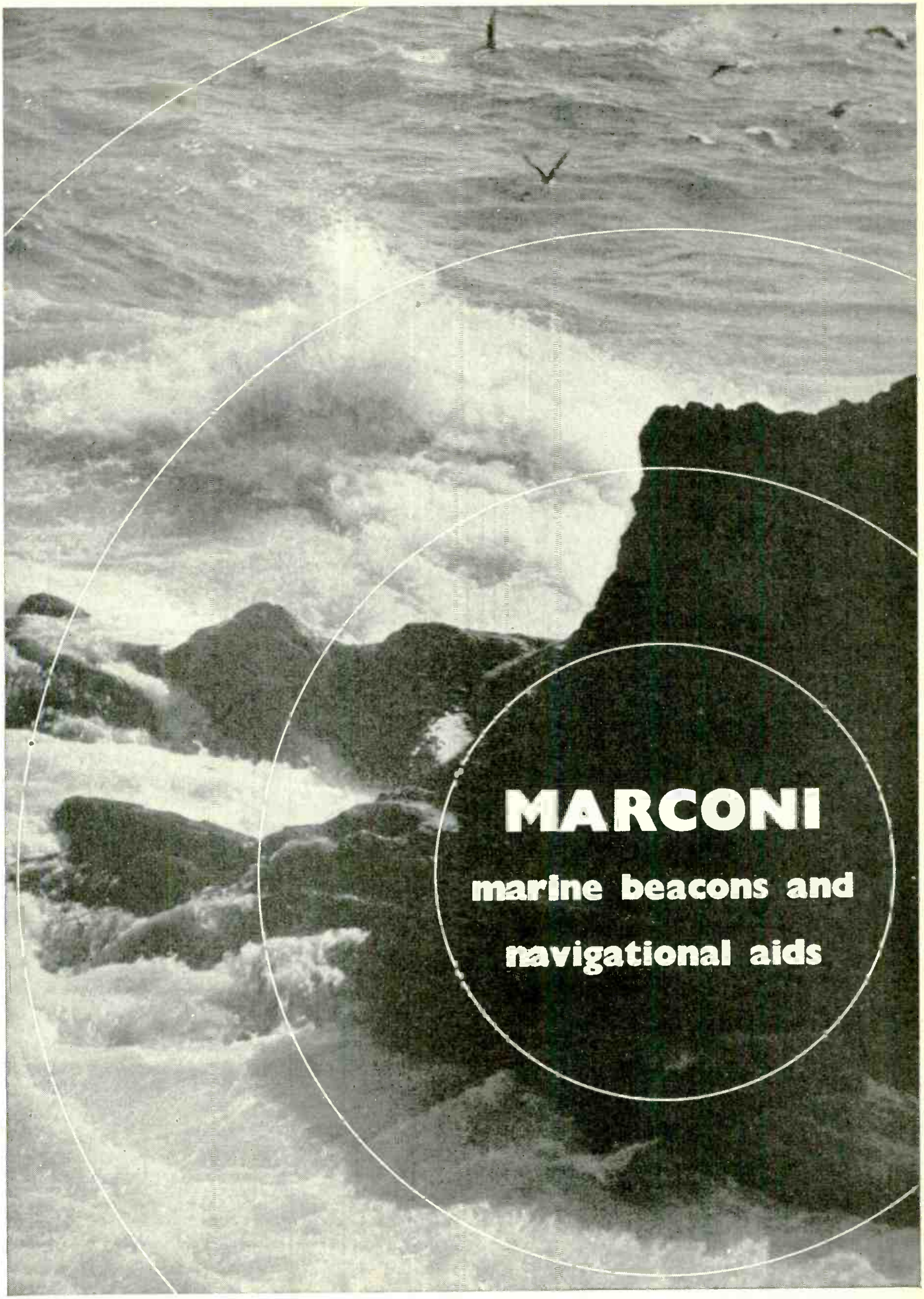
THE competition organized by the British Sound Recording Association for the best amateur-constructed sound reproducing equipment paid tribute, both in the variety and quality of the exhibits, to the enthusiasm and skill of the Association's "Constructors Circle," which was formed recently to encourage and instruct members who have an interest in designing and building their own equipment.

The premier award went to R. E. Winn for a 5-octave "electronic" organ incorporating rotary electromagnetic generators, a wide range of harmonic filters and an electro-acoustic synthetic reverberation device in which a spiral steel wire was used as a delay line. The judges also decided to award the *Wireless World* prize for this exhibit, on the score of ingenuity in the integration of several basic principles and for general planning and design.

The Committee Prize went to H. Silver for a studio-type magnetic tape recorder of comprehensive specification and excellent finish. The equipment is divided into three units. The first consists of a Type B Ferrograph tape mechanism with three leads, and the second is a combined pre-amplifier and control unit for mixing two microphones and a radio input. It provides six alternative response characteristics, and a change-over switch permits aural comparison between the incoming and the recorded programmes. The third unit comprises the main amplifiers and power supplies.



Magnetic tape recording equipment made by H. Silver and awarded the Committee Prize.



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WAVES and AERIALS

The Ether as a Transmission Line

By

"CATHODE RAY"

SOME people object to analogies. They will probably object to that statement of mine too, unless I put it more precisely and say that what they object to is the use of analogies as a help in explaining or understanding things. Their objection is that an analogy doesn't prove anything, and may actually mislead. They would think it very wrong of me to try to explain to a beginner what an electric current is by talking about water flowing through pipes, because the fact that one can say some things about water in pipes that are true about electric currents in wires might lead him to suppose that if he cut the wire the electricity would gush out. They no doubt have such enlightened intellects that they can apprehend new things fully without any such crude aids. If so they are lucky, but have no right to criticize poor morons like ourselves who need some picture in our minds to help us. In any case I don't think we need bother any more about them. I can think of at least one very precise and critical and learned authority on electrical principles who does not hesitate to use analogies.

One of the pleasures of life is finding something that is a perfect fit. That is the basis of jigsaw puzzles, of course. But a good analogy is better than a jigsaw puzzle, because instead of being just an arbitrarily cut outline it is part of a beautiful natural design. Add to the pleasure of tracing such a design the satisfaction of discovering that you have two or more sets of relationships for very little more than the price (in mental effort) of one, and it is not difficult to understand why analogies are in demand. Provided one is on guard against the risk of being misled by pursuing them too far, they can be recommended.

Circuits in Space

Some time ago* I dealt with the analogy between current, voltage, resistance, series, parallel, etc., on the one hand, and voltage, current, conductance, parallel, series, etc., on the other. Having found a relationship between one lot, you can straightaway use it for the other, instead of having to learn it all up as a separate subject. Not only does it save time and effort; it is what the high-class writers call more elegant, by which they mean that the method is so neat that it gives pleasure even to think about.

If you read last month's instalment, on radio waves, I wonder if you noticed another and even more interesting analogy. You remember I assumed that most people know where they are with circuits but are somewhat hazy about the mechanism of waves in space. So I began with an electromagnet consisting of a loop of wire and a battery, which everyone can understand more or less, and showed what would follow from the basic laws of electricity if it were dragged across the sky at high speed. The movement of the magnetic field would cause an electric field, which would drive a current causing the magnetic field which would cause the electric field which . . . and so on *ad inf.* At a sufficiently high speed—299,792,000 metres per second, to be tolerably precise—the two fields are mutually supporting, without any circuital apparatus at all. Although one can continue to think of waves of e.m.f. and (displacement) current, it is better to grow out of this circuit-bound point of view and think in terms of fields alone. A butterfly emerging from its static chrysalis probably shares the same initial difficulty in feeling at home in unrestricted three-dimensional space, but it is worth while. When that freedom has been won, current and voltage in a circuit can be regarded as just a rather special case of a general field system.

Emerging from the chrysalis can be made less painful by making full use of analogy. In finding the strength of the magnetic field we started from the fact that it is proportional to the current flowing around the path of the field. But it also depends on the path length of the field; a long path necessitates more current to maintain a given field strength. (Here, of course, is an analogy with Ohm's law that is worth stopping a moment to consider. A long circuit path necessitates more e.m.f. to maintain a given current.) The magnetic field strength, denoted by H, is proportional to the ampere-turns per unit length of field. In the now superseded c.g.s. system of units the unit of H—the oersted—is equal to 0.4π times the ampere-turns per centimetre length of magnetic field path. The m.k.s. system abolished the 0.4π because it doesn't make sense, and (in order to bring volts, amps, etc., into itself) substituted metre for centimetre. On the assumption that "amperes" means the total current around the magnetic field, equal to amps per turn multiplied by number of turns, the unit of H is now the amp per metre, which makes much clearer the close relationship between current in a circuit and magnetic field in space.

"Ohm's Law" of the Ether

The same sort of relationship exists between electric field and voltage; the electric field (ϵ) is measured in volts per metre. So the beginnings of an analogy between circuit and space ought by now to be seen looming through the mist. For current in amps, substitute magnetic field in amps per metre; for p.d. in volts, substitute electric field in volts per metre.

* "Duals." April 1952. p. 152.

Since space is measured by distance, the appearance of the "per metre" is quite natural. Now this is where one begins to try the "fit" of the analogy, to see where it leads. The simplest relationship between voltage and current is Ohm's law; the ratio V/I in volts and amps gives the resistance of the circuit in ohms—or the impedance, if a.c. If we divide ϵ in volts per metre by H in amps per metre the metres cancel out, so the result also has the dimensions of an impedance in ohms. This idea is not particularly helpful if the fields are caused wholly or partly by circuits. Just as Ohm's law wouldn't work if field ratios were brought into it, so the corresponding law for fields makes no sense if currents and voltages, which belong to circuits, are brought in. The only situation in which fields depend exclusively on one another is when they are travelling as waves, and then the ratio ϵ/H depends on what the waves are travelling through. Last month we found that in electromagnetic waves $\epsilon = v\mu I$, which in a one-metre cube is the same as $\epsilon = v\mu H$. We also found that $v = 1/\sqrt{(\mu\kappa)}$. (v is the velocity of the waves, μ the permeability of space, and κ the permittivity of space.) Substituting this in the first we get

$$\frac{\epsilon}{H} = v\mu = \frac{\mu}{\sqrt{\mu\kappa}} = \sqrt{\frac{\mu}{\kappa}}$$

In empty space, $\mu = 4\pi/10^7$ and κ is practically $1/(36\pi \times 10^9)$; putting in these values, we then get:

$$\frac{\epsilon}{H} = \sqrt{\frac{4\pi \times 36\pi \times 10^9}{10^7}} = 120\pi = 377$$

This is the ratio that the electric and magnetic field strengths in waves through space must bear to one another; $\epsilon = 377H$. It should not be taken to mean that the electric field is 377 times as strong as the magnetic field, for the actual figure depends on the units employed. The only proper way to compare the two field strengths is to use a standard of reckoning that is common to both, namely energy. When that is done it is found that they are equal. The meaning of the 377, if our analogy is a safe guide, is the impedance of space to electromagnetic waves, in ohms. We know already that ϵ and H are in phase, so we conclude that this impedance, ϵ/H, is a resistance.

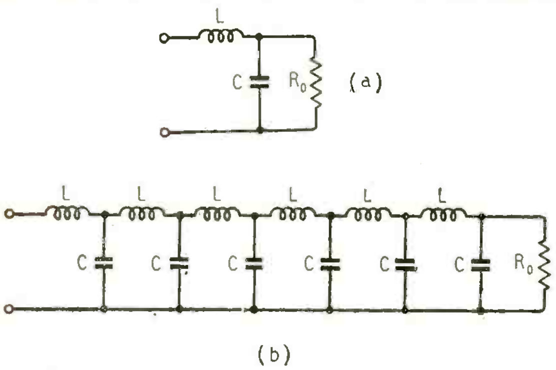
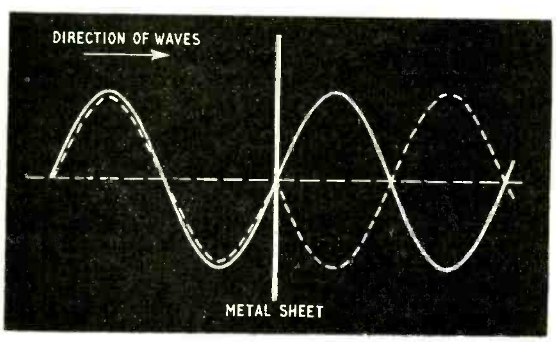


Fig. 1. The effect of shunting a small capacitance across a resistance can be neutralized by a small series inductance, so that the combination (a) is still equivalent to the resistance R_0, except for a small phase delay between the terminals and R_0. This can be repeated any number of times (b), giving an approximation to a transmission line with a "characteristic resistance" equal to R_0.

Fig. 2. How a conducting sheet causes reflection of waves by generating additional waves (shown dotted) that cancel out in the original direction and add in the reverse direction.



Waves Along a Line

The fact that the impedance of space is a resistance may seem to be a flaw in the analogy, for a resistance in a circuit is an absorber of energy, and we know that empty space absorbs none of the energy of waves going through it. The analogy certainly does break down at this point if waves through space are compared with currents through ordinary circuits, but it can be restored by making the comparison with waves along a transmission line. This was my subject in July and August 1950; I will just recall that the action of a line also can be approached from the circuit point of view, as in Fig. 1(a), where a resistance R_0 is shunted by a small capacitance C. The reactance of C can be neutralized by a small series inductance L, and if the right value has been chosen the impedance between the terminals is a resistance equal to R_0. The process of adding C and L can be repeated indefinitely, as in Fig. 1(b), with the same result, that the terminal impedance is equal to R_0. An a.c. generator connected to the terminals cannot tell whether it is supplying R_0 directly or through a long chain of reactances. The practical difference is that this chain introduces a time lag. A transmission line or cable is electrically equivalent to such a chain in which the links are so small and so numerous as to be indistinguishable. When the generator is connected to the line terminals its power flows into the line, but it is only after a time lag that it is absorbed in the actual resistance R_0. So although the line looks to the generator like a resistance because it takes away its energy and gives none back, it does not itself actually absorb any—being made up of reactance only, it cannot—but simply passes it on to a real resistance. It is exactly in this sense that space is and is not a resistance.

R_0, the so-called characteristic resistance of a line, is well known to be equal to $\sqrt{L/C}$, where L and C are the inductance and capacitance per unit length. We found that resistance to free waves is $\sqrt{(\mu/\kappa)}$, and it should give us no surprise to see that μ is analogous to L, and κ to C, for of course the L and C of lines and circuit parts are proportional to the μ and κ of the space around. The analogy fits even closer: if you were to calculate the capacitance between plates with an area of one square metre spaced one metre apart (assuming uniform field in the space) you would find it to be κ farads, and as the κ of space (in m.k.s. units) is $1/(36\pi \times 10^9)$ the answer is 8.854pF. So a way of expressing the value of κ_0 (the κ of space) that brings out its significance is as 8.854pF per metre.

Arguing along the same lines for μ we would say that for space it is $0.4\pi \times 10^{-6}$ or 1.257μH per metre. (Don't be misled by the fact that μ stands for both permeability and "micro"—among other things!)

Air has almost exactly the same μ and κ as empty space, so its resistance to waves is almost the same. But suppose we transmit waves through a block of glass, whose μ is the same as space but its κ might be six times as much. If so its ϵ/H, being $\sqrt{(\mu/\kappa)}$, works out at 154 ohms. One would expect it to be lower than for air because a capacitor with glass substituted for air between the plates has a higher capacitance, which means that its impedance is less.

On the other hand magnetic materials, with a high μ/κ ratio, have a higher impedance, analogous to the higher impedance of a coil when an iron core is fitted.

Another thing that depends on μ and κ is v, the velocity of the waves. It is, in fact, equal to $1/\sqrt{(\mu\kappa)}$ as we have found already. So when the waves come to a block of the kind of glass just considered they slow down to $1/\sqrt{6}$ of the speed, which is 122 million metres or only about 76,600 miles per second. Increasing μ also slows them, so presumably they proceed through Ferroxcube at a mere crawl.

Since in this country at least the general public still identify broadcasting stations by wavelength, it may not be realized by everyone that the wavelength of a given transmission is not fixed, like its frequency,* but depends on what the waves are travelling through. If a station broadcasts on 1 Mc/s it is bound to push out one cycle every microsecond, but the distance travelled by a wave during that time, which is the wavelength, obviously depends on how fast it is travelling. In space it is 300 metres, and that would be the figure given in the *Radio Times*, but within the block of glass the wavelength of the same transmission would be only 123 metres. So that is another argument for frequencies rather than wavelengths.

Of course the same thing applies to waves along lines; that is why the peaks of successive waves are closer together along a cable with solid dielectric than they would be along an air-spaced feeder.

And so one could pursue the analogy further and learn a lot in the process. I recommend anyone who wants to do so to study a paper by Dr. H. G. Booker, "The Elements of Wave Propagation Using the Impedance Concept," published in the Journal of the I.E.E., Part III, May 1947. In particular, it is very enlightening to compare what happens when radio waves come up against something or other with what happens when waves travelling along a line reach the impedance at the end. If the load impedance is a resistance R_0, all the energy is absorbed, but if it is anything else some at least is reflected. A pure reactance, being unable to absorb any energy permanently, reflects everything.

How does a sheet of highly conducting metal appear to a radio wave that comes up against it? Not as a resistance presumably. The difference of potential in the wave will cause currents in the sheet, and these currents will cause corresponding magnetic fields additional to those of the impinging wave. So the sheet turns out to be analogous to an inductive reactance. Actually the alternating currents in it launch waves that cancel out the original waves in the original direction and double them in the opposite direction, as in Fig. 2, so the net effect can reasonably be called reflection. This is analogous to a transmission line terminated by a short-circuit.

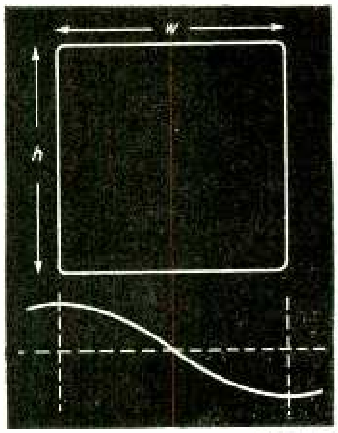


Fig. 3. Simple representation of a single-turn frame aerial of height h and width w, showing how the net e.m.f. generated around it depends on a phase difference in the arriving waves.

It may also remind us of the behaviour of the reflector in a television aerial, considered two months ago. At least it reminds me of my intention to finish where many radio waves finish—at the receiving aerial. The question that started off the last two instalments, you may remember, was whether the signal in the aerial was caused by the electric field or the magnetic field in a radio wave, and the conclusion was that the electrons in the aerial, whose movements are the signal current, are directly affected by the electric field, but since the electric field in radiation (in contrast to induced electric fields, close to the source) is caused directly by the travelling magnetic field there is no reason why—if it suits us—we should not leave out the electric field stage and regard the signal as being caused by the magnetic field. The calculation can be done either way, and both are bound to give the same answer. But don't add them together!

Frame Aerials

Reception by a frame aerial is easier to understand than by an open aerial. We shall assume that the arriving waves are vertically polarized (i.e., electric field vertical and magnetic field horizontal), and that the aerial is h metres high and w metres wide and has only one turn (Fig. 3). The results are applicable to an N-turn aerial by multiplying by N.

Whichever field one happens to have in mind, the horizontal parts of the aerial clearly make no direct contribution. Each vertical part receives an e.m.f. of ϵh volts, and if these are in phase they tend to drive current round the aerial in opposite directions so the net result is nil. The purpose of the horizontals is to enable the two verticals to be placed where the e.m.fs will not be in phase, so that there will be a net e.m.f. available for causing current. No amount of w is of any avail if the aerial is oriented so that the verticals are equally distant from the sender; i.e., if the aerial receives the waves broadside on. The maximum difference in distance, equal of course to w, is when the aerial is edge on, with the sender in its plane. The difference in phase depends on the ratio of w to λ, the wavelength. The greatest difference is when w is half λ, as suggested by the waveform underneath in Fig. 3, because then the e.m.fs received by the verticals are 180° out of phase, so are exactly in phase round the aerial, giving a total e.m.f. of

* The critical reader will point out that to an observer accelerating towards or away from the sender the frequency is not fixed either, but even when taking off in one's spaceship the selectivity would have to be rather excessive for serious mistuning to be experienced!

$2\epsilon h$ volts. But in practice w is almost invariably less than $\lambda/2$—usually much less—so the effective e.m.f. is less. Anybody who wants a little exercise in trigonometry will probably be able to prove that it is $2\epsilon h \sin (\pi w/\lambda)$. The angle $\pi w/\lambda$ is in radians, and as the sine of an angle in radians is almost equal to the angle when it is small, " sin " can be omitted when w is not more than about $\lambda/10$; when this is done the formula is $2\epsilon hw\pi/\lambda$, and we notice that hw is simply the area of the aerial. For a given area, the shape of the aerial makes no difference to the amount of signal received; a circular one has the lowest resistance, other things being equal, and a square one has the lowest resistance of any rectangle. Notice too that the signal received from a given strength of field is proportional to $1/\lambda$, that is to say the frequency.

Exactly the same results would be obtained by calculating the e.m.f. generated around the aerial by the periodic variations in magnetic flux passing through it, but most people would probably find the calculation a little harder. Obviously when the aerial is broadside-on no flux passes through it. When it is edge-on the maximum flux passes through it, but if it were of uniform strength there would be no variations and hence no signal; the flux entering at the left would be balanced by what was leaving at the right. This agrees with our previous view of the matter, for a uniform field means zero frequency. The field in radio waves, however, is not uniform—if it were they wouldn't be waves! Along the path of the wave the field alternates, so if the rate at which flux is entering the aerial from the left happens to be at peak field strength, the rate of leaving from the right must be less (assuming w is less than $\lambda/2$), and there is a net increase in linkage, generating an e.m.f. round the aerial.

Current in the Aerial

What makes the frame aerial relatively easy to reckon is that one can usually assume that the current is the same all round it. There is some difference owing to self-capacitance, but when the aerial dimensions are small compared with the wavelength this should not amount to much. But with an open aerial it is quite different, for the return path is via capacitance distributed all along its length, and one needs fairly advanced mathematics to cope with this.

There is no difficulty at all in calculating the e.m.f.; it is equal to ϵh, where h is the height measured parallel to ϵ. To simplify matters we shall assume that the aerial is parallel to ϵ, so h is its actual height. But the e.m.f. is of no practical interest if it does not enable one to calculate the current it can yield at the point where the aerial is connected to the receiver. One can measure the impedance of the aerial (including its connection to the receiver) at that point, but dividing ϵh (the received e.m.f.) by it gives a larger value of current than one in fact obtains. When testing a receiver the procedure is to connect the input through an impedance equal to that of a typical aerial to a signal generator capable of giving a known signal e.m.f. This e.m.f. is less than the e.m.f. ϵh generated in an aerial of the same impedance yielding the same input to the receiver. One method of allowing for this is to specify an effective height, h', less than the actual height h, which when multiplied by the electric field strength ϵ gives the same value of e.m.f. as is required from the signal generator. For some types of aerial h' can be calculated. In a resonant half-wave dipole $h'=0.63h=0.63\lambda/2$; in most other types it is less.

When I first began to think about reception by an open aerial I ran into a difficulty. I was applying the basic principle that if a piece of wire is in a varying magnetic field it has generated in it an e.m.f. proportional to the rate of variation. It happens if the wire is near a coil carrying an alternating current. If the peak value of current is kept constant while the frequency is raised, the rate of field variation increases in proportion to frequency and so the induced e.m.f. increases with frequency. Now I knew that this does not apply to an open aerial worked well below its resonant frequency. Yet for a given peak value of field, the rate of variation is proportional to frequency.

I first explained this apparent contradiction to myself by saying that it was due to confusing the generation of e.m.f. by a stationary but varying field close to a circuit carrying a.c. with that by radiated waves, where the variation is due to their moving past the aerial. So even if a " d.c." radio wave were possible, in which the strength of the magnetic field did not vary at all, a steady e.m.f. would be generated by its movement. And no doubt this view could be substantiated by authorities, especially those who go in for the flux-cutting idea, for is not this what is happening? But I cut myself off from that line of retreat last month by pointing out that with flux-cutting one could never be sure unless one knew what was happening to the rest of the circuit. And this is none too clear with an open aerial, where the return path is through its capacitance spreading out vaguely into the surrounding space. But by following last month's argument, using the idea of flying electromagnets, it should be easier, for we saw that the higher the frequency the shorter the wavelength and the narrower the space each side of an aerial or other fixed line to contain the flux linked therewith. If this is still not clear the best thing is to think in terms of the electric field, whose peak value we know does not depend on frequency.

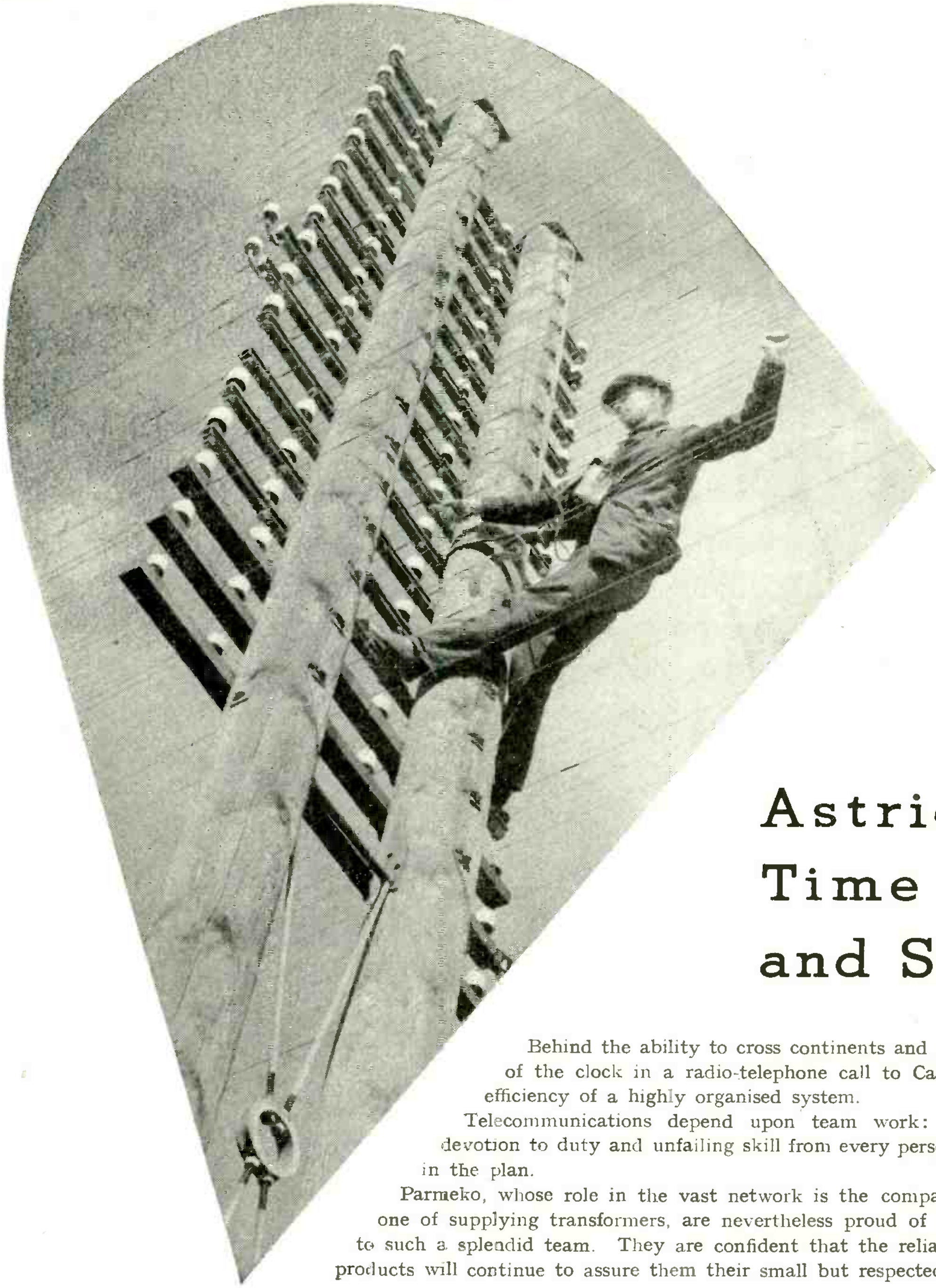
Of course, the current generated in an aerial by waves of a given strength usually does vary with frequency, but that is due to variations of impedance with frequency, which is quite another matter.

RADIO IN WORLD WAR II

EVERYONE knows that wireless has profoundly affected military strategy and tactics, though few have more than vague ideas on precisely how it is used. Now, for the first time, much detailed information has been published on the application and organization of military radio communication in the second World War. The book* in which this appears deals with the whole field of signals —including carrier pigeons—but naturally radio claims most of the limelight. The author does not discuss the technical design of Army sets, but does give the salient features of most of the well-known types, and also touches upon their relative performance.

The story of the Royal Corps of Signals in every theatre of war is told, and there are general chapters on such things as training, signal systems, Anglo-American co-operation and co-operation with the other fighting services. Apart from its historical value, the book is a valuable source of information for all concerned with the organization of communications on a big scale.

* "The History of British Army Signals in the Second World War." By Major-General R. F. H. Nalder, C.B., O.B.E. Pp. 377. Published by Royal Signals Institution. Obtainable from Gale and Polden, Wellington Press, Aldershot. Price 17s 6d post free.



Astride Time and Space

Behind the ability to cross continents and gain a quarter of the clock in a radio-telephone call to Calcutta lies the efficiency of a highly organised system.

Telecommunications depend upon team work: this demands devotion to duty and unfailing skill from every person, every *part*, in the plan.

Parmeko, whose role in the vast network is the comparatively small one of supplying transformers, are nevertheless proud of their selection to such a splendid team. They are confident that the reliability of their products will continue to assure them their small but respected place.

PARMEKO *of* LEICESTER

Makers of Transformers for the Electronic and Electrical Industries

*Photograph by courtesy H.M. Postmaster-General

Rational Planning of Radio Channels

A Book on the Conservation of Our Natural Resources

RADIO to-day is so diverse in its uses, and so supremely important in its general utility to mankind, that it must constantly affect the life of nearly every inhabitant of the earth. But for years past it has been impossible to utilize it with maximum efficiency. This is not so surprising when one considers that frequency allocations among services have not generally been made upon the basis of technical knowledge of propagation, but largely upon methods of expediency, and upon concepts which have long since been outmoded or shown to be false.

It is very desirable that such a valuable thing as the radio spectrum be properly used, and its resources taken care of in the same way as are those of other natural assets. The authors of a recently published book* compare its conservation with that of farm lands, forest reserves, water power and mineral wealth. It would appear to the present reviewer, however, that there is some difference between the two cases, for whereas all these assets are generally under the direct control of the national governments who set up the conserving authorities, the radio spectrum is not. A closer comparison would seem to be that of the conservation of the food fishes of the sea, which, like the radio spectrum, are outside the exclusive control of any one nation. Have we any occasion to hope that when men have had so little success in conserving the resources of the abounding, but not inexhaustible, sea, they will be any more successful in their use of a more intangible thing like the radio spectrum?

The authors of the book are fully aware of the difficulties surrounding the project, but this does not deter them in their work of formulating a conservation plan. Nor should it deter others from evincing an interest in this vitally important work.

History of Frequency Allocation.—The use of the radio spectrum has developed very gradually from about the turn of the present century, its first employment being almost exclusively for ship-to-ship and ship-to-shore communication. The frequency of operation was determined largely by the dimensions of the aerial systems, which, on board ship, were limited. The Second International Conference in 1906 allocated frequencies suitable for ships on this basis, among which were 600 metres (500 kc/s) as an international calling and distress wave, for which purpose it is still retained.

Larger aerial systems developed for point-to-point communication led to the use of lower frequencies, whilst improvements in apparatus, including the introduction of the arc and the valve, made it possible to extend the usable spectrum at the high frequency end, so that in 1917, frequencies between 20 and 1500 kc/s were in use. The development of the valve was followed by the introduction of radio-telephony and by broadcasting. By 1922 long-distance communication on frequencies between 2 and 25 Mc/s was opening up. The frequencies most suitable for broadcasting were, however, already in use by the ship services, so broadcasting had to operate in the band 550-1500 kc/s, as the ships could not be moved to other frequencies. In 1927 the useful part of the spectrum was considered to extend to 25 Mc/s, but the Fourth International Conference in that year found certain services already established on the higher frequencies and so could not adopt an idealized allocation plan.

New services—navigational aids, aeronautical services, land mobile services, television and v.h.f. broadcasting—rapidly came into being, and the older ones expanded, and in 1938 the Sixth International Conference attempted to deal with all their demands. From 1939 to 1947 many advances took place, including the development of radar and the use of frequencies up to 10,000 Mc/s. H.F. broadcasting expanded so much that when the Seventh Conference was held in 1947 conditions in the h.f. bands were in a chaotic state. The Provisional Frequency Board was set up to prepare a master list of allocations, but this has never been accepted owing to the disagreements between the nations, and subsequent Conferences have all failed to achieve their objects.

Summing up this situation it may be said that the spectrum has become occupied with the radio services as time went on almost always before there was adequate knowledge of the behaviour of the frequencies. In the early days it was the dimensions of the aerials which determined the bands occupied, then the limitations of equipment set the limits, and latterly frequencies have had to be allocated largely on the basis of avoiding those that were already in use. The result is very far from ideal. But now that the technical knowledge of propagation of the various frequencies is available it should be possible to correct the past errors and to re-create the frequency distribution structure on a properly engineered basis.

Propagation Characteristics.—A summary of the propagation characteristics for the various radio frequencies is then given. It occupies 107 pages and forms by far the longest chapter in the book. Considering that the frequencies dealt with range from 10 kc/s to 300,000 Mc/s (the extent of the spectrum now considered usable for radio purposes) it is not surprising that even a summary of these facts occupies

* "Radio Spectrum Conservation"; a Report of the Joint Technical Advisory Committee of the Institution of Radio Engineers and the Radio-Television Manufacturers' Association of the U.S.A. McGraw-Hill Book Company; price in U.K., 42s 6d.

so much space. The behaviour of radio waves, and the way they are affected by certain phenomena, varies so greatly throughout this huge range of frequencies that it is as if one were dealing with a totally different thing when one compares radio communication at one end with that at the other.

Notwithstanding that this is only a summary of radio propagation facts it is pretty comprehensive. Every known effect, variation and related phenomenon seems to have been touched upon. Further compression of all this mass of information is impossible—Nature does not permit it. Suffice it to say that in the allocation of the frequencies of the radio spectrum in an ideal way all this information needs to be taken into account, for only if this is done can the maximum utility of those frequencies be expected. Even so it must be borne in mind that the propagation knowledge cannot even yet be regarded as being by any means complete, for in certain parts of the spectrum, and notably at the extremely high-frequency end, a great deal still remains to be learnt.

Ideal Allocations.—With all this propagation knowledge at their disposal the authors then approach the problem of allocating the available frequencies on an ideal basis, taking into account the present and prospective needs, and current trends. It is assumed that no radio services already exist, and that the money which has been spent and the knowledge gained are now available to start a new radio industry. Also that the world is peaceful and that all nations are ready to co-operate in the work of making the most efficient use of the spectrum, so that it is not necessary to consider any military or political factors.

The allocations of frequency bands are made according to the *services* which would require to use them, as follows.

Fixed Services.—This includes all services between specified fixed points, except certain special services. To-day there is often a multiplicity of circuits between certain points, and it is proposed to combine numbers of existing services into single ones, carrying all communication between large centres. Modern information theory indicates that there are methods of conveying more intelligence in a given band in a given time than those at present in use. Super-high-frequency relay stations are proposed, which could supply the necessary bandwidth. Such a relay system, it is stated, involving stations located within the radio horizon of each other, could be built from New York to the southern tip of South America, and from New York through Alaska, across the Behring Strait into Asia, Europe and Africa, and *via* a chain of islands into Australia, the greatest distance between stations being about 90 miles. This system would be capable of giving wide-band service to all major population centres of the world. Taking all possibilities into consideration, the ideal frequency allocations for fixed services are 4.25-7 Mc/s, 9.5-12 Mc/s, 15-17 Mc/s, 21-25 Mc/s, 2,500-8,000 Mc/s and 10,000-13,000 Mc/s.

Mobile Services.—These are the services between fixed and mobile stations, and between mobile stations themselves, and are divided into maritime, land and aeronautical services. Radio is especially important for mobile stations, because it is often the only type of communication possible, and because communication is needed in the operation of mobile units for the protection of life and property.

Integration of a number of the present mobile services would lead to frequency economy, and a general mobile network interconnected with a fixed network would provide much improved service. The mobile service must have frequencies for medium and long-distance communication, and frequencies between 2 and 25 Mc/s would be suitable for these purposes. There must also be provision for short-distance communication on land, on frequencies beginning at about 60 Mc/s, and for short-distance communication to aircraft—near 1,000 Mc/s. A band near 60 Mc/s and one near 800 Mc/s would take care of the different propagation conditions for land-mobile stations over average terrain and in built-up areas. The distress wave, which has always been at 500 kc/s, would be at 2 Mc/s. The ideal allocations for the mobile service are 2-4 Mc/s, 7.5-9.5 Mc/s, 12-14 Mc/s, 17-21 Mc/s, 54-100 Mc/s and 770-900 Mc/s.

Broadcast Services.—These are all the services intended for reception by the general public, and do not include services auxiliary to broadcasting (like radio links) which receive allocations under the fixed or mobile services. The frequency band for sound broadcasting should be such as will ensure a stable signal over large areas, and this is best achieved by ground-wave transmission on frequencies from 200-1,000 kc/s. V.H.F. transmissions on frequencies above 50 Mc/s are suitable for multiple-programme provision in large centres of population, with the l.f. transmitters serving less populated districts. As to h.f. "international" broadcasting, the authors do not seem to think much of it, describing it as an "inferior" broadcast service, due to the mode of propagation involved. However, to many people, such as to those at sea or residing in undeveloped or remote countries, it is often the only form of broadcasting available, a fact which the authors recognize, but which they do not appear to take account of. For, in fact, they propose to abolish h.f. broadcasting altogether, for the following reasons:— the audience is limited and specialized and it is thus uneconomic to attemtp to improve their reception; under the peaceful conditions assumed there would be no need for propaganda broadcasts; the interchange of cultural programmes could be better effected over high-quality fixed circuits or by transcriptions and tape recordings; the number of persons at sea is insufficient to justify a large amount of h.f. space. Even tropical h.f. broadcasting can often be bettered by that on l.f.

Television services require wide bands and a stable transmission medium, and provision is made for these on frequencies above those subject to ionospheric phenomena, with a band about 600 Mc/s wide to accommodate multiple programmes. The ideal allocations for the broadcast services are 0.18-1.2 Mc/s (sound), 100-700 Mc/s (television and sound) and 700-720 Mc/s (sound).

Amateur Service.—It may seem a trifle inconsistent of the authors, after treating large numbers of present-day broadcast listeners in so cavalier a fashion as to deprive them of service altogether, to be prepared to allocate any frequencies to the 100,000 or so people throughout the world who use radio as a hobby. However, the authors deem it wise to encourage amateur radio, and to make provision for wide-band as well as narrow-band types of service, so as to allow for experimentation and investigation. In the ideal plan there should be allocations for amateurs of a number of frequency bands in harmonic relation where possible, the width of which would be determined by the requirements of other services having priority. Amateurs should also be allowed to use the industrial, scientific and medical bands, for the rather strange reason that they can often accomplish some communication even in the presence of severe interference. The ideal allocations for amateurs are bands at 3.5, 7.0, 14, 28, 50, 720, 2,500, 5,000, 10,000, 20,000 and 30,000 Mc/s, which, considering the width of some of these bands, seems, in a conservation scheme, to be treating the amateurs more than liberally.

Radiolocation and Navigational Services.—The aeronautical services of the world are expanding rapidly and are placing increasing reliance on radio for navigation and traffic control. Instead, however, of there being a number of different radio aids, as at present, there should be developed a complete system, and the aeronautical aids required for overland flying could all be provided in a single band centred on 1,000 Mc/s. In general, this takes account of the needs of flying over land routes where control is from the ground. For long-distance navigation over seas a system using low frequencies should be used. Airborne radar should be operated in a band at 9,000 Mc/s. Because the aeronautical service depends so much on radio for safety purposes and for navigation, and because the aircraft themselves are fast changing in their requirements, about twice as much spectrum space as is immediately needed should be allocated, in order to permit development.

The maritime services are considered to require a long-distance navigational aid and a short-distance aid for use in restricted waters where traffic is heavy. The long-distance aid should be the same one which is provided for long-distance aircraft over seas. Shipboard radar should provide the short-distance requirement, in conjunction with suitably placed responders, and, in some instances, with land-based radar. A medium-range radiolocation or navigation system might also be required in some areas.

Mobile units operating on land do not, at present, require a navigational service, but small bands near 2,000 kc/s and 900 Mc/s should be provided in case such a need develops. The ideal allocations for the radiolocation and navigational services are 0.12-0.18, 1.9-2.0, 900-1,900 and 8,300-9,600 Mc/s.

Special Services.—Examples of these are standard-frequency services, meteorological services and fixed and mobile services for forestry and other conservation operations, all requiring special treatment because of differences in their requirements from those of other similar services. Then there are the numerous applications for low-power "walkie-talkie" transmitters, etc. The standard-frequency service requires frequencies throughout the h.f. band, and some similar frequencies are necessary for conservation services. The bands 1-2.5 and 20-50 Mc/s are in the frequency range where propagation changes from one type to another, and, though subject to sky-wave interference at times, are not particularly useful for sky-wave communication. They could well be utilized for various types of low-power special services. The band 10-120 kc/s is considered useful for certain special services intended for reception over wide areas, and a further band is necessary at 1,900-2,400 Mc/s. But there remain many special uses for radio which it is impossible to consider in detail, and it is proposed that these requirements be met in the special service bands either on a shared basis or by sub-allocation. The ideal allocations for the special services are 0.01-0.12, 1.2-1.9, 25-50 and 1,900-2,400 Mc/s, with standard frequency bands at 2.5, 5, 10, 15, 20 and 25 Mc/s.

Industrial, Scientific and Medical Uses.—These are the services in which radiation is merely incidental, or, if intended, does not convey intelligence. Examples are the use of radio for heating and for producing other reactions in certain substances. A great deal of the radiation from such devices could be prevented by suitable screening, and, since the devices do not interfere with each other, many can work in very narrow bands. Nevertheless, different frequency bands are required for different types of operation. There should therefore be a large number of bands in harmonic relation below 100 Mc/s and several bands above 100 Mc/s.

Time to Change.—The authors point out that changes in the present allocations will need to be nicely timed; if they are made too soon mistakes may be made, if too late it will be more difficult and costly to have them made at all. Examples are given of the well-established reluctance on the part of some users—notably in the maritime field—to adopt technological improvements even when the advantages of doing so have been clearly demonstrated. Many services, it can be shown, occupy parts of the spectrum not really suitable to them, and the fact that they remain where they are is largely due to economic forces which resist any change, and not to any technological limitations. If, however, the use of radio is to be conducted on a more realistic basis, so as to eliminate the present disadvantages and permit of rational development, allocation changes will have to be made, tending towards the substitution of the ideal for the present haphazard allocation plan.

Dynamic Conservation.—The last chapter gives some idea of steps which might be taken to accomplish this change, and to bring the actual allocation in line with the ideal.

For various reasons no fixed plan will meet the case: there must be a programme of dynamic conservation, in which, upon sound technical and economic principles, allocations are continually changed in favour of newer and more valuable services, as the older ones lessen in value. To this end it is necessary to consider all the uses of radio as they affect commerce, industry and the public welfare. A table of these "end uses of radio" is then given, comprising no fewer than 83 different uses to which radio is put, and by considering things in these terms a clearer view of exactly what is involved in the problem of spectrum allocation may be obtained.

"The limit of spectrum occupancy occurs when all portions of the spectrum are fully, continuously and uniformly utilized and each frequency assignment is employed by many stations so arranged that their service areas are adjacent but do not overlap." That is the definition of ideal occupancy given by the authors, but complete occupancy can never be fully realized for a variety of technical and economic limitations.

Whilst some of these can be overcome, there will always remain certain limitations set by Nature, or by the facts of social organization which it cannot be hoped to change. Technical and administrative measures which may be adopted to implement conservation should, above all, avoid hampering future development.

The following measures should be taken:—

(1) New services should be granted experimental assignments in all parts of the spectrum, but where it is shown that the functions of a new service can be performed by a non-radio service, non-radio services should be used, unless the radio service possesses overwhelming superiority.

(2) Frequency tolerances should be as small as the state of the art permits.

(3) Off-frequency operation and pirating should be rigidly suppressed.

(4) The use of guard bands should be curtailed.

(5) The most efficient modulation systems should be encouraged.

(6) Every method known for restricting the interference area of stations should be employed, such as restriction of power, suppression of harmonics, use of directional aerials, etc.

(7) Services established in unsuitable parts of the spectrum should be transferred to other regions, and outmoded services deleted.

(8) Time and geographical frequency sharing should be made use of to a much greater extent than at present, such as, for example, between military and civilian services.

So much for technical considerations. The economic factors affecting dynamic conservation are equally numerous and important, but we shall not deal with them here.

Several examples of prospective changes in allocations which illustrate the technical and economic trends are then given. But the main changes, it is said, are likely to encounter resistance from those who are required to make alterations in equipment or operating procedures. But if they are shown to be technically sound and to be of ultimate benefit, it is in the public interest that they should be made. The authors think that when this is recognized, and when the changes are made so that undue financial hardship is avoided, this resistance will disappear, and will, in fact, be transformed into co-operation in the work of radio spectrum conservation. T. W. B.

Manufacturers' Literature

Telecommunications Equipment; an illustrated booklet reviewing in general terms the radio and line telegraphic and telephonic equipment developed by British Telecommunications Research, and describing briefly the company's establishment at Taplow Court, Bucks.

Timers for opening or closing circuits at intervals up to 60 seconds; short descriptions in a leaflet from the Electrical Remote Control Company, Elremco Works, East Industrial Estate, Harlow New Town, Essex.

Television Receiver, type TUG34A; a console model with a 14-in rectangular flat-faced tube described briefly in a leaflet from Bush Radio, Power Road, London, W.4.

Galvanometers, pointer and reflecting types; brief descriptions and specifications in an illustrated catalogue of various scientific instruments from W. G. Pye & Co., Granta Works, Cambridge.

A.C. Generator, driven by a petrol engine with a governor and producing an output of 250-300W at 220-250V, 50-60 c/s, and another of 12-15V d.c. for charging purposes. The engine is self-starting and has interference suppression. Specification on a leaflet from the Teddington Engineering Company, 29-31, High Street, Teddington, Middlesex.

Transmitter Capacitors, ceramic, for low- and medium-power working, in disc, tubular, plate and pot form. A technical bulletin (No. 29) from The Telegraph Condenser Company (Radio Division), North Acton, London, W.3. Also a technical bulletin (No. 30) on **Twin Mica Capacitors** designed as end plates of i.f. transformer assemblies.

Miniature H.T. Rectifiers, Types RM1, RM2 and RM3. Ratings, dimensions and weights in a leaflet from Standard Telephones and Cables, Rectifier Division, Warwick Road, Boreham Wood, Herts.

A.C. Voltage Stabilizer, using a servo-mechanism and giving an output voltage continuously variable between 200 and 240V with a regulation of within 1 per cent and an output current of 0-10A. Described in a leaflet from Servomex Controls, Crowborough Hill, Jarvis Brook, Sussex.

Height of the Ionosphere

New Evidence from Audio-frequency Atmospherics

AT the annual conversazione of the Royal Society on May 21st, more than a third of the exhibits were concerned with radio and electronic subjects, and one of these, arranged by L. R. O. Storey of the Cavendish Laboratory, is likely to prove of far-reaching importance in adding to our knowledge of the upper atmosphere.

Unlike most explorations into the ionosphere in which radio transmitters and receivers are involved, this latest research has been effected with no more complicated apparatus than a 30-ft aerial connected to an *audio* amplifier. Between aerial and amplifier a cathode follower and coaxial cable is interposed, presumably to enable the aerial to be erected in a site free from mains and other interference, while a magnetic tape recorder at the output from the amplifier preserves significant atmospherics for subsequent analysis.

The bandwidth of the input to the amplifier is restricted to 400-10,000 c/s and the disturbances investigated take the form of audio-frequency electromagnetic whistles, descending smoothly in frequency over periods up to 3 or 4 seconds in duration. The whistles originate in lightning discharges, and under favourable, i.e., stormy, conditions the output is reminiscent of a Ludwig Koch recording of a flight of widgeon. In some cases the whistles can be correlated with "click" type atmospherics generated by local discharges, and from the time intervals involved it is deduced that part of the initial electromagnetic pulse travels upwards through the ionosphere at vertical incidence, is deflected to follow a path coincident with the lines of force of the earth's magnetic field, crosses the equator at a height of about 7,000 miles, descends through the ionosphere at a complementary latitude in the southern hemisphere, is reflected from the earth's surface and retraces its original path, to be heard at the point of origin as a long-drawn-out whistle. The whistle starts at high pitch and descends in frequency because the speed of propagation in the ionized medium is greater for high than for low frequencies. Thus the original pulse is analysed into its component frequencies which are presented in sequence to the observer. Lightning flashes originating in the southern hemisphere are heard in the northern hemisphere as whistles which can be identified by their different frequency dispersion in time, and by the absence of the initiating "click."

The path length, and the consequent delay and frequency dispersion, will depend on the latitude of origin and at the equator no whistling atmospherics should be heard. We understand that observations are now being made to verify this prediction. An upper limit of observation is set by the increasing rarity of thunderstorms as the poles are approached.

This unexpected incursion of audio-frequency techniques into the exploration of the ionosphere has produced startling results and has already called for a drastic revision of earlier estimates of the height of the atmosphere. Full results have not yet been published and until they are it is not profitable to guess whether this high-altitude propagation is due to an extension of atmospheric ionization processes as we know them or to extra-terrestrial matter coming under the influence of the earth's field.

Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

Lightweight Microphones

A RANGE of new lightweight hand microphones, housed in a polythene plastic case with thumb switch, has been introduced by Lustraphone, Ltd., St. Georges Works, Regents Park Road, London, N.W.1. Type HD/54 is fitted with the CI.51 moving-coil movement, and Types HC/54 and HC2/54 have single- and double-button carbon microphone inserts.

The spring-loaded switch can be connected in the microphone circuit or used for relay operation as a shorting, opening or changeover switch.

Lifeboat Transmitter

FOR installation in ships' lifeboats not normally fitted with radio, Venner Electronics, of Kingston By-Pass, New Malden, Surrey, have produced a small transmitter which automatically radiates SOS messages as long as the handle of its hand-driven generator is kept turning. It transmits on a fixed frequency of 2.182 Mc/s (the maritime R/T distress frequency) and has a range of 20 miles. The circuit consists of an EF40 crystal-controlled electron-coupled oscillator and an EL42 power amplifier, giving an output of 1 W into the 8-ft aerial.

The hand-driven generator is a d.c. dynamo with a 6-V l.t. winding and a 370-V h.t. winding feeding out through separate commutators. It has a slipping clutch which prevents the voltage from rising too high and damaging the valves. This generator also drives a tone-wheel, for imposing a 1-kc/s modulation note on the transmission, and a code disc carrying the SOS messages.

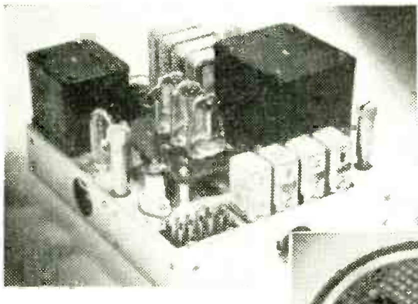
The transmitter is housed in a water-tight metal case with lugs for fixing to the underside of a thwart. The generator handle folds in and the aerial is stowed away in two sections when not in use, so the whole equipment takes up very little room. It actually measures 12in × 6in × 5in and weighs 17lb. We understand the price is in the region of £30.

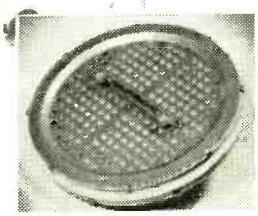
Electronic Humidity Control

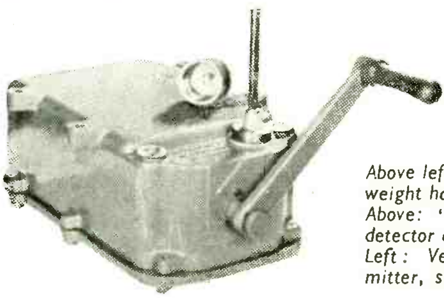
THE affinity of very fine glass fibre for moisture is exploited in the "Humicon" moisture measuring and control instrument made by W. H. Sanders (Electronics), Ltd., 48, Dover Street, London, W.1. A cell formed by two 6-inch diameter perforated and rhodium-plated discs, separated by a ceramic ring, contains the fibre, and its resistance varies from 40 kΩ to 100 MΩ over the range of humidity from 100 to 42 per cent. The instrument is suitable for use in temperatures ranging from 0 to 90 degrees C.

In the control unit, an a.c. energized bridge samples the cell resistance and the out-of-balance voltage can be used to operate up to three thyratron-controlled relays for auxiliary control apparatus.

The control unit works from 200-250 V a.c. mains.







Above left: Lustraphone H/54 series lightweight hand microphone.
Above: "Humicon" glass-fibre humidity detector and control relay unit.
Left: Venner Electronics lifeboat transmitter, showing part of aerial.

RANDOM RADIATIONS

By "DIALLIST"

Cut and Rolled

THERE ARE, as many readers will know, two ways of manufacturing metal screws. The threads may be cut by dies; or, they may be rolled. Rolled-thread screws are far cheaper to make and they serve admirably for many purposes. One of their virtues is that they vary little in diameter from the standard for any particular size. Cut-thread screws, on the other hand, tend to become larger in diameter as the dies wear with long use and unscrupulous (or should one write unscrewpulous?) producers may be responsible for the utterance of many naughty words by their victims as these try to coax undersize nuts, made with worn taps, on to oversize screws, made with worn dies. You've been one of the victims? So have I! The moral is that it pays to buy screws of reputable make.

They Bite Wires

Speaking generally, cut-thread screws are to be preferred for precision work, particularly in the smaller gauges. Rolled-thread screws of sizes 6BA and above do all that is needed for most ordinary jobs. But there is one purpose for which they should never be used—though far too often they are. This is to clamp wires inserted into screw-down terminals. Take a close look at the end of an average rolled-thread screw, and you'll see why. At the tip there is a pronounced hollow, surrounded by a narrow rim. That rim is actually quite sharp and you do not need to do much thinking to realize the highly undesirable results of turning it hard down on to a softish copper wire. One does occasionally come across cut-thread screws with their ends tapered off to fine points and these are just as unsuitable for terminals. The good-quality cut-thread screw has a smooth, rounded tip; with it you can tighten down hard enough to make a good mechanical and electrical contact, with no risk of cutting the wire.

Stations' Ups and Downs

MANY READERS have been kind enough to write to me about that curious phenomenon which I mentioned in the May number of *Wireless World*; the reduction in range from which many broadcasting transmitters appear to suffer after being on the air for a few years. Of the many explanations suggested I can refer to only a few in the space allotted to these notes: (1) "It was the stations near the top of the broadcast band which came in so strongly at great distances; many of these are now working on shorter wavelengths." I'm afraid that this won't hold water, for some of the most strongly received medium-wave stations used channels well below 300 metres: the original 2-kW Nuremberg was an outstanding example. (2) "People are using smaller, lower and less efficient receiving aerials nowadays." Not all of them by a long chalk; and in any event most of us now command far higher pre-detector amplification than we did 20 years ago. (3) "Many m.w. stations now use anti-fading aerials, which cut down sky-wave radiation." True; but by no means all of those whose signals have disappeared are so equipped. (4) "Some l.w. stations now have directional aerials." Agreed; but how many are directed away from this country? Certainly that of Luxembourg isn't, or it wouldn't attract British sponsors. And speaking of that particular station, do you recall the Luxembourg Effect, once so much in evidence? We don't seem to hear anything about it to-day. All things considered, I'm afraid we haven't yet got a completely satisfying answer to the question: Why are so many broadcasting stations at distances of 150 miles and more now so much less strongly received than once they were?

Persuasion No Use

THE POSTMASTER-GENERAL had occasion to deplore recently the poor response to the campaign to persuade people to have the ignition systems of their cars fitted with suppressors. Readers will not need to be told that the response has indeed been lamentable, though they may not, perhaps, realize how great the proportion of unsuppressed vehicles remains. I am specially well placed for making a check, for I live on a road which carries comparatively little traffic; on the average not more than 20 cars, motor cycles or lorries pass the house in an hour. Thus, I can see individual vehicles approaching and can find out by means of the Wrotham receiver, tuned to the a.m. transmission, whether any of them is a sheep or a goat. Very few lorries or tradesmen's delivery vans fail to create a machine-gun rattle from the loudspeaker. Private vehicles have a rather better record, though most of the older ones are either unsuppressed or ineffectively suppressed. A curious point is that some car manufacturers, at any rate, seem to have decided that the letter of the law is all that they need bother about; they will fit suppressors at the appointed time but not before. A friend who took delivery of a new car a few weeks before this was written drove it home and left the engine ticking over while going in to collect his wife. He found her cursing the snowstorm on the TV screen!

Make 'Em Sit Up

You'll never stop car ignition interference by begging or persuading people to have suppressors fitted. The only way is to make it a punishable offence to own an unsuppressed vehicle. The P.M.G. said he didn't want to make such a regulation, because there was no way of enforcing it. But, saving his presence, there is. All police cars nowadays are fitted with metre-wave radio, which means that those using a.m. could act as detectors of unsuppressed motor vehicles if the noise limiter was switched out of circuit. I'm not going to suggest for a moment that large numbers of police cars should be diverted from their proper business and set to track down vehicles that radiate interference. No such thing would be necessary. All that is required is a regulation outlawing interfering vehicles after a certain date and laying down fines, of say, £2 for the first offence and £5 for the second. Follow this up by giving wide publicity to the fact that police cars can detect unsuppressed vehicles and there would be a stampede to have suppressors fitted: you will recall how wireless and television pirates hasten to haul down the Jolly Roger when the arrival of G.P.O. detector vans is so much as rumoured.

Tailpiece

As I was writing these notes, the telephone bell rang. The call was from a friend who lives on one of the main roads from London to the South Coast, and a sad tale he had to tell of television reception during the Whitsun holidays. He and his family had stayed at home since they prefer to make outings at less crowded times. They'd get plenty of entertainment, they thought, from the television set. Alas for human hopes! There was only one single hour in the whole three days when interference from car ignition systems did not blot out the screen images. Isn't it really time, my Lord De La Warr, to protect your 2,250,000 television licence holders by compelling motorists to abate the nuisance by spending ten minutes and a couple of shillings at any garage?

UNBIASED

By FREE GRID

"*Only Just*"

THOSE OF YOU who are readers of *Punch* may recall a humorous drawing which appeared many years ago showing a canny Scot complete with kilt and tammy slowly and carefully counting the change which the booking clerk at the railway station had just handed to him with his ticket.

Correct, but "only just"

The irate clerk, observing him, asks sarcastically and with some asperity whether the change is not correct. The canny Scot, looking up at him with a reproving look, replies "only just."

I was reminded of this old story when reading in *Wireless World* (May, 1953) the obituary notice of the late Andrew Gray who for a third of a century, commencing in 1899, held responsible positions on the engineering staff of our pioneer wireless company. The tribute to his memory paid by *W.W.* starts off with the seemingly innocuous statement that "There were not many wireless engineers in Queen Victoria's days, and still fewer who dated back to the 19th-century part of the reign."

Like the Scotsman's change, this statement may be perfectly correct but most certainly "only just" correct. In fact, without having looked up any statistics, I venture to say that the statement may be incorrect. I doubt if there were any more wireless engineers in the 20th-century part of Queen Victoria's reign than in that part of her reign in the 19th century.

The reason is simple. Queen Victoria died at 6.30 p.m. on Tuesday, January 22nd, 1901. Therefore, the length of the 20th-century part of her reign was obviously 21 days and 18½ hours, or, in other words, just over three weeks. Therefore, to make *W.W.'s* statement true some men must have become wireless engineers during those three weeks.

Of course, it is quite true that if only one electrical engineer had started to specialize in wireless during that period it would make the statement strictly accurate. If, therefore, any reader knows of a man who, not being a wireless engineer at midnight on December 31st, 1900, became one before 6.30 p.m. on January 22nd, 1901, I am sure the Editor will be glad to publish the information if only to confound me. But I hope no attempt will be made by him or readers to try and convince me that the twentieth century began on January 1st, 1900, or any similar nonsense.

A.P. and C.P.

EVERYBODY KNOWS that the B.B.C. has been negotiating for a piece of land in the Crystal Palace area on which to build the new high-power London television station when the Corporation's lease of the Alexandra Palace expires in three years time. Even *W.W.* admits rather cautiously in its news columns (May, 1953) that it understands this to be the case. I can, however, scarcely believe that the B.B.C. can be so foolish as to relinquish the Alexandra Palace site, for if they do, nothing is more certain than that one of the sponsored television interests will quickly mop up so valuable a site.

I do not mean, of course, that the B.B.C. should not build its new station on the Crystal Palace site: in fact, I am all in favour of it. But by 1956 we, in the London area at any rate, will all be equipped with tunable TV sets in order to get the sponsored programmes as well as the B.B.C. one. We shall then undoubtedly be demanding a second television programme from the B.B.C. and the A.P. site, chosen with such care in 1936, could hardly be bettered for the second programme transmitter. But even if the B.B.C. is so shortsighted as not to heed my words, I'm sure that sponsored television will give us a programme from there.

V.H.F. Further Vindicated

I HAVE from time to time protested against the B.B.C. forcing us to jump to our volume controls when, after a quiet talk has ended, they suddenly switch over to the crashing crescendos of a brass band. I have suggested many remedies, but the Editor's remarks in the May issue about the Government's apparently cooling ardour for v.h.f. broadcasting prompts me to advance yet another strong reason for its immediate adoption.

V.H.F. is obviously the ideal solution for this decibel disparity about which I have complained. With the much greater etheric elbow room in the v.h.f. band it will be possible for the B.B.C. to send quiet items like talks and such-like from one transmitter, and music and other noxious noises from another.

Of course, the B.B.C. will require twice the number of transmitters and we shall all need to use two receivers for every programme, but we shall be able to adjust each set to the volume level which best suits our depraved tastes. Thus the musical highbrows who object to such things as scale distortion will be able to have their way and we uncouth Philistines who couldn't care less about scale distortion and the like will be able to have ours.

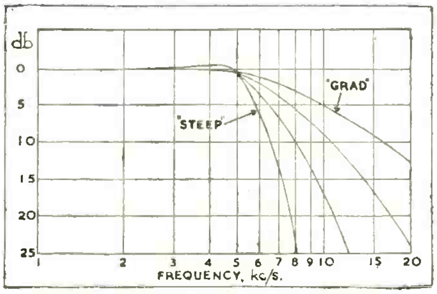
Of course you always get a bit of distortion off centre

The HIGHEST ATTAINABLE ★ QUALITY of ★ SOUND REPRODUCTION

Representing a unique feedback circuit development, the "Vari-Slope" pre-amplifier gives audibly better reproduction. This advance consists of variable-slope "electronic" low-pass filters operating on negative voltage feedback principles.

No Inductors ("Chokes") are used, and their disadvantages are completely eliminated. The turnover frequencies are 5 kc/s, 7 kc/s and 9 kc/s and the slopes of attenuation are continuously variable over the range 5db to 50db per octave.

The VARI-SLOPE



Frequency amplitude curves for the "TREBLE-3" position (5kc/s turnover). Curves of the same slopes are obtained on the other two positions turning over at 7kc/s and 9kc/s ("—2" and "—1" positions).

The filters consist essentially of twin-T resistor-capacity networks inserted in the return circuit of a single-loop feedback amplifier. The more obvious advantages of this electronic feedback method over conventional choke filters include:

(a) Improved transient response characteristics (due to absence of chokes having self-capacitance) and the consequent reduction of "ringing."

(b) Extremely low harmonic and inter-modulation distortion due to negative voltage feedback action.

(c) No discontinuities in the rates of slope when the slope control is operated, and no change in signal level at frequencies below turnover. (Both these faults occur in variable-slope choke filters due to the slope control, altering the terminating impedance and the insertion loss.)

(d) No chokes to cause magnetic hum pick-up.

(e) Smaller size, lighter weight, greater uniformity in production.

LIST PRICE IN BRITAIN **12 Gns.**

POINT ONE TL/12

Triple Loop Feedback Amplifier

For laboratory use as a stabilised-gain audio frequency power amplifier. For the highest possible standard of disc recording. For the highest possible quality of reproduction from Pick-up, Radio, Microphone, Film and Magnetic Tape. For use as a driver amplifier in the speech modulator chain of broadcast transmitters. Used with the "Vari-Slope" pre-amplifier and the best available complementary equipment, the TL/12 power amplifier gives to the music-lover a quality of reproduction unsurpassed by any equipment at any price.

27 Gns.

The "Point-One" TL/12 Amplifier is built to a tropical specification and used throughout the world, including:
The British Broadcasting Corporation.
The South African Broadcasting Corporation.
The Swedish Broadcasting Corporation.
The Swiss Broadcasting Corporation.
The Italian Broadcasting Corporation.

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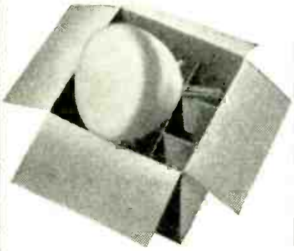
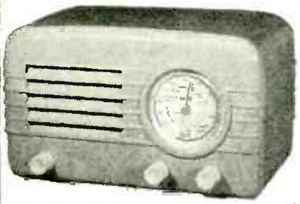
ELECTRONIC PRECISION EQUIPMENT LTD.

STILL AVAILABLE 15in. MAGNETIC TELEVISION TUBE



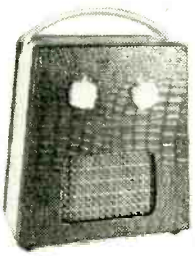
By famous maker. Specification Blue/White screen 9 Kv. ion trap triode, heater 6.3 v. at .55 amp., 50° deflection. New, with written guarantee, offered at approximately half price, £12/10/- each, plus 10/- carriage and insurance. H.P. terms £4/4/- deposit and 12 monthly payments of 18/3. Limited quantity, so order immediately.

CONSTRUCTORS' PARCEL, SPECIAL OFFER



Modern design, bakelite cabinet in ivory, blue or brown, complete with metal chassis punched out for speaker and 5 valves, etc. Parcel also includes moulded Perspex window, matched set of knobs, scale and hardboard back. Price 22/6. Carr. and pkg. 2/6.

PORTABLE RADIO CABINETS



Correct dimensions to take "P.W." "Mini Four" and similar midget superhet or TRF. Internal dimensions 6½in. high ×5¾in. wide×3in. deep.

Special plastic grained finish, 15/9 plus 1/6 postage and packing. De Luxe model covered with brown crocodile leathercloth and banded with grey lizard leathercloth, 22/6 plus 1/6 postage and packing.

1154 TRANSMITTER

We can offer this, unused and in original transit cases, complete with valves at £6 each—plus 12/6 carriage.

Model 314

Model 312 has a drawer on runners and cupboard space beneath. It is also slightly wider and slightly deeper than the others. Price 54/-.

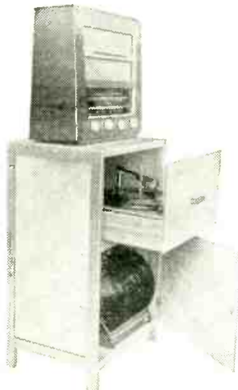
Model 313A. Shelf and cupboard. Fitted half shelf inside cupboard. Price 37/6.

Model 313C. Drawer and cupboard, half shelf inside cupboard. Price 39/6.

Model 314. Five Drawer Chest, suitable for personal papers, etc. Price 54/-.

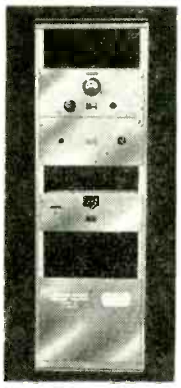
WHITEWOOD CABINETS

Hundreds of uses in the home, office or workshop; for instance two of these and 2/- worth of hardboard (obtained locally) make an excellent desk or work bench. Sturdily constructed of well seasoned softwood frames and fronts, birch ply top, sides and doors, hardboard backs and bottoms. External dimensions 29in. × 14½in. × 13½in.



The illustration shows Model 312 fitted up for record playing.

NON-CALLERS PLEASE ADD 5/- PER CABINET TO COVER CARRIAGE CHARGE.



AMPLIFIER RACK—SPECIAL LOW PRICE

This stands approximately 6ft. high, and was made originally for the G.P.O. The top panel contains the amplifier proper, which consists of an A.C. mains-driven power pack, capable of delivery 200 mA. at 400 v. and, of course, the normal L.T. supplies, and the amplifier itself uses an MHL4 feeder and two PX25s in the output stage, giving approximately 25 watts. This top deck also contains the heavy duty output transformer. The lower panel contains the feeder unit which can be used as a pre-amplifier for microphone and gramophone work. You will observe that on the rack there is ample space for fitting a monitor speaker and an R.F. unit if same are required. Note that the anode current of the PX25 valve is monitored by a 2½in. flush meter. Further note that these amplifiers were made by the famous MARCONI company. Complete as illustrated but less valves, unused and only very slightly storage soiled. Price £5/10/-, plus 12/6.

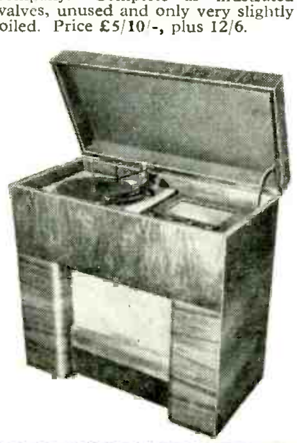
RADIOGRAM CABINET

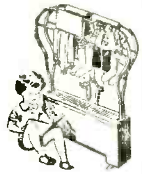
Console Type Cabinet. With full grained walnut finish, will take standard type auto change gram unit. Price, £11/10/-. H.P. terms, £3/17/- deposit, and 12 monthly payments of 16/9, plus 15/- carriage.

Radio Chassis to suit. £8/19/6. H.P. terms, £3 deposit and 10 monthly payments of 13/-, plus 7/6 carr.

Auto Change Units. For long-playing and standard records with suitable pick-up head, £11/11/-.

SPECIAL OFFER. Cabinet Radio Chassis and Auto Changer, 29 gns. H.P. terms, £10/14/- deposit and 12 monthly payments of £2/3/-.



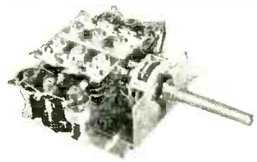


LAST FEW £3/19/6. LAST FEW

The Lectross warms room as it dries clothes, bathing costumes, towels, etc. Size 3ft. wide, 3ft. high, and 5in. deep. It has four stove enamelled rails and works off AC or DC mains, consuming 650 watts. Fully guaranteed. Price £3/19/6 plus 7/6 carriage.

THIS MONTH'S SNIP

Due to a recent huge purchase of ungraded germanium and silicon crystal diodes we are able to offer these at less than cost. Also being ungraded you stand a good chance of finding one or more of the really expensive special purpose types. This month we are offering 12 assorted, all made by B.T.H. and G.E.C. for £1 post free. Every crystal is guaranteed to be in perfect working order.



LAST TIME AT THIS PRICE

We are almost sold out of 3 waveband coil packs, but if you apply quickly you may still be lucky. Manufactured by a famous company—long, medium, short wavebands and gram position. Complete with circuit, 19/6 post free.

GREATLY REDUCED CATHODE RAY TUBES

VCR97, Brand new and unused, ideal for 'scope, etc. Price 12/6. Carriage and insurance 5/- extra.

VCR517. 6½in. guaranteed full picture. 29/6 plus 5/- carriage and insurance.

VCR139A. 2½in., 32/6 plus 2/6 carriage, etc.

VCR138. 3½in. electrostatic short persistence, suitable for T.V. and ideal for 'scope work, 37/6 plus 3/6 carriage, etc.

VCR112. 5in. electrostatic, persistence not known, 15/- each plus 5/-carriage, etc.

CV996. 6in. electrostatic, persistence not known, 15/- each plus 5/- carriage, etc.

CV1140, CV1590, CV1546. All 12in. magnetic long persistence £4/10/- plus 10/- carriage.

This Blueprint FREE

To advertise our latest purchase of germanium diodes suitable for crystal sets which we can offer at the very low price of 1/9. With each we give a free blueprint of a crystal set to be made from parts found in any junk box. You have a youngster friend who will be thrilled to make this little receiver.

THE VIEWMASTER

ALL COMPONENTS IN STOCK

ANY SINGLE ITEM AVAILABLE SEPARATELY

LASKY'S RADIO
World Renowned for Service & Reliability

COILS
All models available including filter chokes. Price (except Alexandra Palace), 28/- per set. Alexandra Palace, 20/- per set. L9 RF choke, 2/-.

CHASSIS
Sound-Vision, 18/6. Power-Pack/Time base, 18/6.
Support for S.V. chassis, 6/-.

G.B. T.V. COMPONENTS

Line Trans.	29/6
Frame Trans.	22/6
Main choke	12/6
Width Coil	6/11
Boost Choke	3/9

All suitable for Home Construction T/V.

LASKY'S LINE TRANSFORMER
RF. EHT for line fly back. 6-8Kv, with EY51 heater winding. Suitable for home construction T/V 25/-.

TELEVISION SELENIUM
The very latest "Sentercell" S.T.C. range

K3/40, 3.2 kV	7/6
K3/45, 3.6 kV	8/2
K3/50, 4.0 kV	8/8
K3/100, 8.0 kV	14/8
K3/160, 12.8 kV	21/6

DARK SCREEN FILTERS

18in. × 14½in.	25/-
14½in. × 12½in.	19/6
13¾in. × 11in.	14/11

PERSPEX. 13½ × 10½ × ⅛in. Neutral shade, slightly marked 5/11 per piece.

W/B & PLESSEY

Line EHT trans.	32/6
Frame trans.	25/6
3 Mc/s boost choke	5/9
Width control	10/-
Scanning coil	33/3
Main choke	15/6
Focus ring	22/6
Heater trans.: WB/103	42/-
WB103A	52/6
Front and rear C.R.T. supports	21/6

C.R.T. MASKS.
Brand New.
LATEST ASPECT RATIO

9in.	7/-
10in.	7/6
12in.	15/-
12in. Flat Face	15/-
12in. Old ratio	9/6
12in. Plastic, with dk. sc. filter and gold finish escutcheon	17/6
15in. do. do.	21/-
14in. Rect'glr.	21/-
15in. Cream rubber	17/6
16in. Eng. Elect.	42/-
16in. Double D	31/6
17in. Rect'glr.	25/-

SOILED. NEW ASPECT RATIO

9in. sorbo	5/-
12in.	7/6
12in. with fitted armour plate glass, cream	11/6
12in. do. Black	8/6

TEST PRODS. Fully fused, with retractable points 4/11 per pair (1 red, 1 black).

METAL RECTIFIERS

WX3 and 6. Ea.	3/9
14D36	12/4
14A86	20/4
14A100	21/6
36EHT45	23/8
36EHT50	26/1
36EHT100	29/6

PLESSEY
Scan coils per pair 25/-
Width Control 6/6

NOW AVAILABLE. LARGE SCREEN, WIDE ANGLE CONVERSION DETAILS FOR THE VIEWMASTER. Send 3d. stamp for full data. Fully itemised price list of all Viewmaster components now available.

ALL T.C.C. CONDENSERS exactly as specified for use in The Viewmaster can now be supplied from stock.

The television set you can build at home from standard parts.

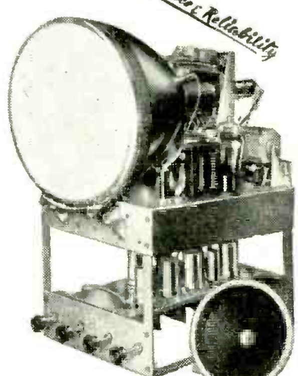
A MODEL FOR EACH FREQUENCY. State station required.

Brilliant high definition black and white picture. Superb reproduction.
Uses 9in. or 12in. Cathode Ray Tube. Table or Console Model.
Incorporates all the latest developments.

Television for the home constructor at its finest

Send to-day for the CONSTRUCTION ENVELOPE. 32-page booklet crammed with top-rate information and all the necessary data, also 8 full-size working drawings and stage by stage wiring instructions.

Alexandra Palace, Sutton Coldfield, Holme Moss, Kirk o'Shotts, Wenvoe, Pontop Pike, Belfast. State model required.



PRICE Post free **7/6** per copy.

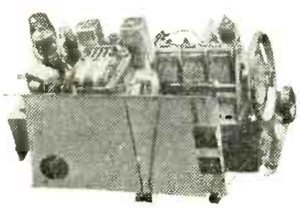
ARMOUR PLATE GLASS

15in. Actual size 18¼in. × 19¼in. × ⅛in.	7/11
12in. Actual size 13in. × 10½in. × ⅛in.	4/-
9in. Actual size 9in. × 8in. × ⅛in.	3/-

Co-Axial Cable. 70-80 ohms impedance.
Single core, 9/- doz. yards.
Twin core, 12/- doz. yards.
Twin feeder, 6/- doz. yards.
Co-Axial Connectors. For standard ¼in. cable, 1/11.

12 VOLT VIBRATOR UNITS
Output 230 volts 80 mA. BRAND NEW AND UNUSED. Size: 9 × 5 × 5⅞in. Supplied less vibrator. Vibrator required is 6 pin synchronous.
LASKY'S PRICE 19/6 Carr. 3/6 extra.
Other types in stock from 15/-.

MAINS TRANSFORMERS
All 200-250 volts c.p.s. primary. Finest quality, fully guaranteed.
MBA/3. 350-0-350 v. 80 mA., 6.3 v. 4 a., 5 v 2 a. Both filaments tapped at 4 volts. An ideal replacement trans. Price 18/-.
MBA/6. 350-0-350 v. 100 mA 6.3 v. 3 a. 5 v. 2 a. With mains tapping board. Price 22/6.
MBA/7. 250-0-250 v. 80 mA., 6.3 v. 3 a., 5 v. 2 a. Both filaments tapped at 4 volts. Price 18/-.
AT/3. Auto transformer. 0-10-120, 200-230-240 volts 100 watt. Price 17/6.



LIMITED QUANTITY (Frustrated Export). 5 WAVEBAND CHASSIS.
Circuit has RF stage, Magic Eye Tuning Indiator, and many other features. For use on A.C. mains 100-250 volts. Waveband coverage: 11.5 metres to 550 metres. In 5 bands.
LASKY'S PRICE £10-19-6
Complete with valves, less dial. Carriage and packing 15/- extra.
WILL MAKE A SUPER RADIO-GRAM.

T.C.C. VISCONOL HIGH VOLTAGE CONDENSERS
(Cathodray).

.001 mfd. 15 kV.	10/-
.001 mfd. 25 kV.	18/-
.0005 mfd. 25 kV.	18/-
.0005 mfd. 12.5 kV.	10/-

Plastic case, single bolt fixing.
Other high voltage condensers

.1 mfd. 7 kV.	15/-
0.04 mfd. 12.5 kV	7/6
.001 mfd. 12.5 kV	7/6

FILAMENT TRANSFORMERS
6.3 v. 1.5 a., 7/11.
6.3 v. 3 a., 12/6.
Special Transformer. 2 amps. with the following tappings: 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24 and 30 volts. Price 17/6.

INTERCOM UNITS
4-station operation. For use on A.C./D.C. mains 200-250 volts. Supplied complete, with 3 new valves, ready for immediate installation. Fitted in attractive plastic cabinet.
Suitable for use as baby alarm.
MASTER UNIT £7/15/-. Carr. 5/- extra.
Extension Units. Price 21/-. each complete. Carriage 2/- each extra.

DINGHY AERIALS WITH REFLECTORS
Umbrella type, with wire mesh reflector complete with setting up instructions. Mast not supplied.
LASKY'S PRICE 7/6 Post 1/6.

TANNOY PRESSURE UNITS
10 watts. 7.5-ohms impedance. Last Few only
Price Reduced to 59/6
Carriage 4/6 extra.

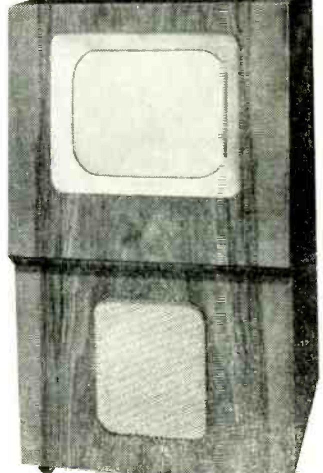
DE LUXE TELEVISION CABINETS

For 12in. cathode ray tubes Beautiful figured medium walnut finish, with high polish Fitted with shelf for receiver glass speaker baffle and fret and castors for easy movement. Undrilled. Suitable for use with the Viewmaster. "Practical Television," "Practical Wireless." and "Wireless World" televisors

LASKY'S PRICE £8.10.0
Carriage 12/6 extra.

Outside dimensions of cabinet 17¼in. × 16¾in. × 32in. **Why not convert your table receiver to a console?** Adaptor frames for fitting 9in. or 10in. C.R. tubes available if required.

This cabinet can also be supplied cut out for a 16in. C.R. tube.



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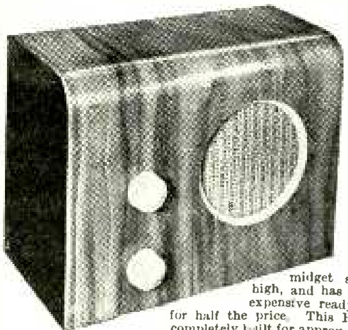
ESTABLISHED 25 YEARS

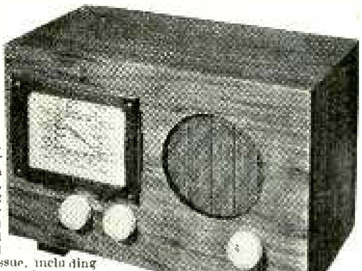
BUILD A PROFESSIONAL RADIO OR AMPLIFIER AT LESS THAN HALF TODAY'S PRICE



A MIDGET 4-STATION "PRE-SET" RECEIVER

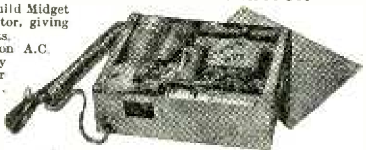
A complete Kit to build a 4-station "Pre-set" Superhet Receiver for A.C. mains operation.
The set is designed to receive any three stations on medium waveband and one on long wave, each station being received by the turn of a rotary switch—no tuning being necessary. It is of midget size, being 8¾in. × 4½in. × 7in. high, and has the performance of a far more expensive ready-made set, but can be built for half the price. This Receiver, as illustrated, can be completely built for approx. **£9/9/-**. The complete assembly instructions, including component layout and component price list, are available for **1/9**

THE "Wireless World" 3-Valve Set



A Midget 3-valve T.R.F. Receiver for operation on A.C. mains, covering long and medium wavebands. We are able to supply all of the components to build this set, as designed and specified in the Feb. 1950 issue, including the drilled chassis. Valves and moving coil speaker, etc., at the following prices — To construct complete chassis, less dial and drive assembly, **£5/5/-**. Ditto including dial and drive assembly, **£6**. To construct the complete set, including dial and drive assembly and cabinet, **£7/3/6**. Overall size of cabinet is 7¾in. × 3½in. × 11¼in. A reprint of the designer's article, giving circuit and assembly instructions (this is available separately for **9d.**) together with a practical component layout is included with each of above assemblies.

"PERSONAL SET" BATTERY ELIMINATOR



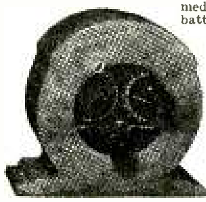
A complete Kit of parts to build Midget "Alldry" Battery Eliminator, giving approx. 69 volts and 1.4 volts.
This eliminator is for use on A.C. mains and is suitable for any 4-valve Superhet Receiver requiring H.T. and L.T. voltage as above, or approx. to 69 volts.
The Kit is quite easily and quickly assembled and is housed in a light aluminium case size 4¾in. × 1¾in. × 3¾in. Price of complete Kit with easy-to-follow assembly instructions, **42/6**.
In addition we can offer a similar COMPLETE KIT to provide approx. 90 volts and 1.4 volts. Size of assembled unit 7in. × 2¾in. × 1¼in. Price **47/6**.

A MAINS OR BATTERY PORTABLE KIT

A Midget 4-valve Superhet Portable Set covering medium and long wavebands.
Designed to operate on A.C. mains 200/240 volts, or by an "Alldry" battery. The set is so designed that the mains section is supplied as a separate unit which may be added at any time. The Kit therefore can be supplied (a) as an "Alldry" Battery Superhet Personal Set which can then be accommodated in the attache case as illustrated (size 9½in. × 4½in. × 7in.), this is attractively finished in lizard, maroon, dark green or blue rexine, or (b) as a combined Mains/Battery Superhet Portable Receiver, for which a polished wood cabinet is available to accommodate both Mains Unit and Batteries together.
Circuit incorporates delayed A.V.C. and pre-selective Audio Feedback. Kit is complete in every detail and includes ready-wound frame aerials, fully aligned I.F. transfs. and drilled chassis, etc. Overall size of assembled chassis 8in. × 4in. × 2½in. This receiver, as illustrated, can be completely built for approx. **£10** (plus Mains Unit if required). Send **1/9** for the fully descriptive Assembly Book which includes Practical Layouts and complete price list of Components. Attache case available separately, **37/6**.

THE "MINI-TWIN" 1-VALVE BATTERY SET

A design of a simple 1-valve 2-stage Battery Receiver, giving excellent results on medium and long wavebands and having exceptionally low battery consumption.
Drilled chassis and practical diagrams make it the ideal set for the beginner to build.

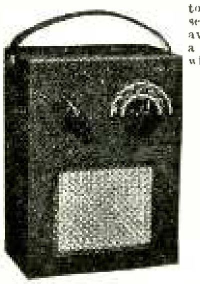


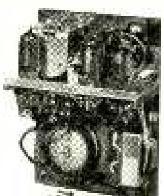
The complete chassis, including valve, can be built for **37/6**, the attractive plastic case is **9/6**, and suitable headphones **14/9**.
The complete assembly instructions, layouts and a component price list, are available for **1/6**.
This Receiver also performs excellently, without modification, as a tuning unit, and in addition, with simple modifications for which a complete diagram is provided makes a first-class pre-amplifier for pick-up or microphone.

TWO BATTERY PORTABLES

(a) THE "MINI TWO-THREE"

An "Alldry" Battery Portable of midget size, 6¾in. × 4½in. × 3½in., designed to cover medium waveband 190-559 metres, with use of short trailer aerial.
The simple design of this Receiver is so arranged that either a 3-valve set or a 2-valve (afterwards easily converted to the 3-valve) can be made.
Consists of a T.R.F. circuit using a regenerative detector with H.F. stage and a high gain output pentode. Valve line up IT4—IT4—DL94.
The 2-valve set can be completely built for **£4/3/6** (less case), and the 3-valve for **£5/3/-** (less case). Each price includes valves, speaker and drilled chassis.
Send **1/9** for the assembly instructions: they include simple and complete practical component layouts and diagrams, which enable the most inexperienced constructor to successfully build either set. All components are available for separate sale, a price list being supplied with assembly instructions.





(b) THE "MINI-FOUR"

A 4-valve Battery Superhet Receiver designed to receive 4 pre-set stations, three on medium waveband and one on long wave to suit local conditions. Each station is obtained on the set by the turn of a rotary switch. No tuning is necessary.
It is of midget size, being only 4½in. × 6½in. × 4½in. when completely built and is very easily assembled from diagrams supplied.
Cost of all components to build this set, in accordance with the design, including a drilled and cut chassis and panel and new valves, is **£9/10/-** (or less valves for **£6/7/6**). Attractive carrying case finished in blue leatherette, **16/9**. Complete constructional data with a blue print, which shows the practical component layout and wiring diagram, together with an individual component price list, is available separately, **1/6**. Our battery eliminators (illustrated above) available in kit form are suitable for use with this set.

THE VIEWMASTER TELEVISOR

We have had very considerable experience in assisting customers to build this T/V and can supply a SPECIFIED COMPONENTS EX-STOCK. The assembly instructions showing practical layouts and price list are available for **7/6** for London, Sutton Coldfield, Holme Moss, Kirk-o'-Shotts and Wenvoe. Complete television price list is contained in our general STOCK LIST at **9d.**, including Haynes, etc., components.

THE DENCO ULTRA MIDGET SUPERHET COIL TURRETS WITH A ROTARY TURRET ACTION

Type CT9 consists of a four station "pre-set" unit from which any three stations on medium waveband and one on long wave can be received by a turn of the turret switch. Price **39/6**.
Type CT10, is a 3 waveband coil pack incorporating a fourth switch position for 'Gram. Complete coverage is, long waveband 700-2,000 metres, medium waveband 190-570 and short wave 15-50 metres. Price **£2/8/-**.
A complete receiver circuit and all necessary data is included with each turret. These can be supplied separately for **6d.**

PICK-UPS

Cosmocord "G.P.20," for standard records, **£3/5/9** interchangeable (G.P.19) head for L.P. records, **£2**.
Decca lightweight "turnover head" type, for L.P. and standard records, **£3/12/6**.
Goldring, Standard, lightweight Magnetic, **33/-**.
Cosmocord "Acos" G.P.30, turnover crystal type. For Standard or L.P. Records, **£3/5/9**.

BATTERY CHARGER KITS

All kits incorporate metal rectifiers and are for use on A.C. mains 220-250 volts. All kits include an easily followed wiring diagram. All prices include a TAPPED RESISTOR and a five-position SELECTOR SWITCH to enable the charging rate to be varied.
For 6 or 12 volt batteries at max. 1 amp., **£1/18/9** (excluding Resistor and Switch, **£1/3/6**).
For 6 or 12 volt batteries at max. 1½ amps., **£2/4/-** (excluding Resistor and Switch, **£1/8/9**).
For 6 or 12 volt batteries at max. 2½ amps., **£2/14/6** (excluding Resistor and Switch, **£1/19/6**).
For 6 or 12 volt batteries at max. 4 amps., **£3/2/6** (excluding Resistor and Switch, **£2/7/3**).

HOME CONSTRUCTORS

A CAR RADIO RECEIVER FOR £12 . 0 . 0

A design of a 5 Valve Superhet Receiver, employing an R.F. Stage for 6 or 12 Volt supply.
Send **2/8** for the complete set of Assembly Instructions, CIRCUITS, LAYOUTS, and POINT-TO-POINT WIRING DIAGRAMS, together with a complete component Price List.
THIS IS NOT AN EX GOVT. RECEIVER. IT IS A NEW DESIGN EMPLOYING NEW COMPONENTS.

TELEVISION !! A GENUINE SPECIAL OFFER FOR CALLERS ONLY

A FAMOUS MANUFACTURER'S 19-VALVE T/V CHASSIS FULLY ASSEMBLED AND READY FOR USE

For London transmission only employing a superhet circuit and incorporating the following valve line up ;—

6 Type E.F.42	1 Type E.C.H.42
2 Type E.L.33	1 Type E.L.38
2 Type E.B. 41	1 Type E.Z.35
1 Type E.F.41	1 Type G.Z.32
1 Type E.C.C.91	2 Type E.Y.51
1 Type 6SN7	

WE HAVE A FEW ONLY AT THE VERY SPECIAL PRICE OF **£19/19/-**, including all Valves, or **£33**, including a NEW MULLARD TYPE M.W.31/14c 12in. Tube. (Loudspeaker extra.)

COME AND SEE IT WORKING!

D. COHEN

RADIO & TELEVISION COMPONENTS

Terms of Business: Cash with order. Despatch of goods within 3 days from receipt of order. Where post and packing charge is not stated please add 1/- up to 10/-, 1/6 up to £1, and 2/- up to £2. All enquiries and lists, S.A.E.

SPECIAL NOTE: NO GOODS SENT WHERE CUSTOMS DECLARATION IS APPLICABLE.

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ACTON, W.3 Telephone: ACOrn 5901

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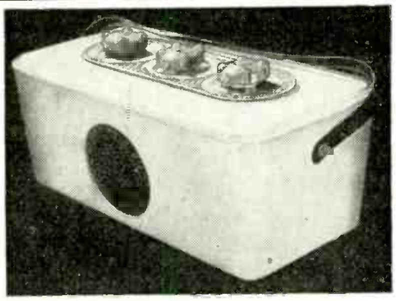
MAINS TRANSFORMERS
Primary, 200-250 v. P. & P. 2/-.
300-0-300 250 mA., 6 v. 5 a., 5 v. 3 a. Unclamped, **27/6**.
400-0-400 250 mA., 4 v. C.T., 3 a., 4 times. Unclamped, **32/6**.
300-0-300, 100 mA., 6 volt 3 amp., 5 volt 2 amp., **22/6**.
Drop thro' 350-0-350 v. 70 mA., 6 v. 2.5 amp., 5 v. 2 amp., **14/6**.
Drop thro' 250-0-250 v. 80 mA., 6 v. 3 amp., 5 v. 2 amp., **14/6**.
Drop thro' 110-110 60 mA., 6 v. 0.5 amp., **8/6**.
280-0-280, drop-through, 80 mA., 6 v. 3 amp., 5 v. 2 amp., **14/6**.
Auto-wound, H.T. 280-volts at 360 mA., 4 v. 3 amp., 2 v. 3 amp., or 6 v. 3 amp. Separate 4 v. 3 amp., **10/6**.
Auto-transformer, 110 v. 70 watts, **10/6**.
250-0-250, 80 mA. 6 v. 4 amp., **14/-**.
Pri. 230 v. Sec. 200-0-200 35 mA., 6 v. 1 amp., **8/6**.
Pri. 200/250 v., secondary 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24 and 30 volt at 2 amps., **13/-**.
Semi-shrouded drop-thro' 200/250 v. primary; sec. 280-0-280, 200 mA., 6 v. 5 amps., 5 v. 3 amps., **27/6**.
Semi-shrouded drop thro', 270-0-270, 80 mA., 6 v. 3 amp., 4 v. 1.5 amp., **13/6**.
Semi-shrouded drop thro', 270-0-270, 60 mA., 6 v. 3 amp., **11/6**.
Heater Transformer. Pri. 230-250 v. 6 v. 1½ amp., **6/-**; 2 v. 2½ amps., **5/-**. 2, 4 or 6 v. at 2 amps., **7/6**; 2 v. 2½ amp. and 6 v. 0.6 amp. E.H.T. insulated. **8/6**. P. & P. each 1/-.
800-0-800 250 mA., 4 v. 2 amp., **27/6**. P. & P. 5/-.

P.M. SPEAKERS (closed field)

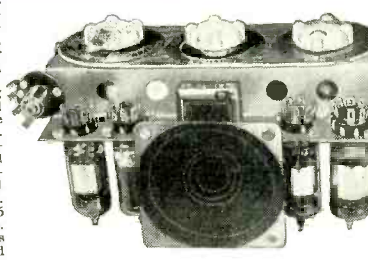
	with trans.	less trans.
3in.	—	10/-
2½in.	—	15/6
3½in.	—	13/6
5in.	16/6	12/6
6½in.	16/6	12/6
8in.	18/6	15/-

P. & P. on the above 1/- each.
10in. less trans., **21/-**. P. & P. 1/6.
R. & A. 8in. M.E. Speaker field coil, 1,600 ohms O.P. trans. 5,000 ohms, imp. **18/6**. P. & P. 2/-.
5in. M.E. field coil 750 ohm with O.P. trans., **17/6**. P. & P. 1/-.
Extension speaker cabinet, in contrasting walnut veneers, size 15 × 10½in. Will take 6½ or 8in. speaker. **17/6**. P. & P. 2/-.
Volume Controls, Long spindle less switch. 50K, 500K, 1 meg., **2/6** each. P. & P. 3d. each.
Expanded aluminium speaker fret, 13½ × 9in. **2/-**.
Volume Controls. Long spindle and switch. ¼, ½, 1 and 2 meg., **4/-** each; 50 K., **3/6** each. ½ and 1 meg., long spindle double pole switch, miniature, **5/-**. P. & P. 3d. each.
Trimmers, 5-40 pf., **5d.**; 10-110, 10-250, 10-450 pf., **10d**.
Twin-Gang .0005 Tuning Condenser, **5/-**. With trimmers, **7/6**. P. & P. 1/-.
Line Cord. 3-way 0.3 amp. 180 ohms, per yard. **1/3 per yard**.
Twin-gang, .0005 with feet, size 3½ × 3 × 1⅞in.. **6/6**.
3-gang .0005, with feet, size 4⅞ × 3 × 1⅞in. **7/6**.
Television Coils wound in alican, size 2⅞ × ⅞in., with former and iron core, **1/-** each.
Hoover Variable Speed 600-1,200 revs. Tape Recording Motor. Silent running, 200/250 v. A.C. Shaded pole with fixing. Weight 5 lb.. **27/6**. Plus P. & P. 2/6.
PERSONAL SHOPPERS ONLY. 9in. Enlarger **17/6**. 12in. **27/6**.
Germanium Crystal Diode, 2/3 post paid.
Television Masks. White Rubber 9in. with glass. **7/6**. Cream Rubber, 12in. with armour-plate glass, **15/-**, 15in. Cream, **17/6** plus 1/6 P. & P.
T.V. Width Control, 3/6.
AMPLIFIER CHASSIS. 18 gauge cadmium plated steel with transformer and 5 v/holder cut-outs. 12½ × 8 × 3in. **3/-**. P. & P. 1/6.
USED C.R.T. TUBES. Heater cathode shorts, 12in. **75/-**; 9in. **45/-**. Ion burn, 12in. **55/-**; 9in. **35/-**. Post and Packing 7/6 each.
CRYSTAL PICK-UP by famous manufacturer, complete with sapphire trailer needle and volume control, **23/-**. Post and packing on each 1/-.
EX-GOVT. RECEIVER TYPE B28. Complete coil unit, 6 bands, 60 kc/s.-420 kc/s., 500 kc/s.-30 Mc/s., **21/-**. Plus 2/- P. & P. Circuit for above, **4/-**.
Variable selectivity IF Switch to suit above, **7/6**.
MODERNISE YOUR OLD CABINET BY FITTING A WALNUT BAKELITE ESCUTCHEON. Size 15 × 8⅞in. Complete with 3 wave-band scale size 5½ × 4⅞in., **5/-**. P. & P. 1/6.

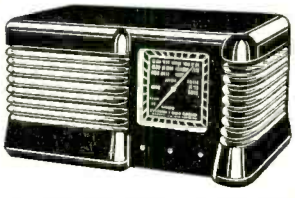


PERSONAL PORTABLE CABINET. In cream-coloured plastic; size 7 × 4½ × 3in. Complete 4-valve chassis. Scale and 3 knobs. Takes miniature 90 v. and 7½ v. batteries, **9/-**, post and pkg. 1/6.

2½in. **P.M. Speaker** to fit above, **15/6**. Miniature output transformer, **5/-**. Miniature wavechange switch, **1/6**. Miniature 1-pole 4-way used as Volume and Off, **1/6**. 4 B7G valve holders **2/4**. Midget twin gang ⅞in. dia., ⅞in. long and pair medium and longwave TRF coils ⅞in. long × ⅜in. wide; complete with 4-valve all-dry mains and battery circuit, **8/6**. Condenser Kit, comprising 11 miniature condensers, **3/6**. Resistor Kit, comprising 15 miniature resistors, **4/-**. The above receiver (less valves and batteries) could be built for approximately **51/-**. All valves to suit above available. Point to Point Wiring Diagram, **1/-**.



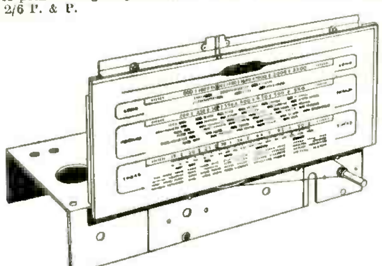
View of chassis as it would look when assembled with valves inserted.



CABINET as illustrated, 11½ × 6½ × 5½, in walnut or cream, complete with T.R.F. chassis, 2 waveband scale, station names, new waveband, back-plate, drum, pointer, spring drive spindle, 3 knobs and back, **22/6**. P. & P. 3/6.
AS ABOVE but complete with 5in. speaker and O.P. trans. (these speakers have been used but tested O.K.), **30/-**. P. & P. 3/6. Metal rectifier **7/6**. Gang with trimmers, **7/6**. Medium and long T.R.F. coils **5/6**. 3 obsolete ex-Govt. valves, 3 v/holders, and circuit of an A.C. mains 3-valve plus rec. T.R.F. which can be built for approx. £4, **8/6**. Heater trans. **6/-**. Volume control with switch **3/6**. Wave-change switch **2/-**. 32 + 32 mfd. **4/6**. Bias condenser **1/-**. Resistor kit **2/-**. Condenser kit **4/-**.

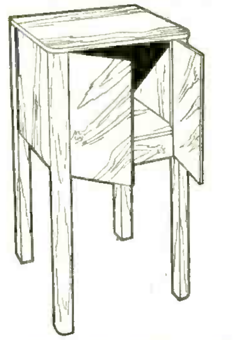
KIT OF PARTS FOR SIGNAL GENERATOR. Coverage 110 Kc/s.-320 Kc/s., 320 Kc/s.-900 Kc/s., 900 Kc/s.-2.75 Mc/s., 2.75 Mc/s.-8.5 Mc/s., 8.5 Mc/s.-20 Mc/s., metal case 10in. × 6⅞in. × 4½in., size of scale 6½in. × 3½in., 2 valves and 1 rectifier valve, A.C. mains 230/250. Internal modulation 400 c.p.s. to a depth 30 per cent. Frequency calibration accuracy plus or minus 1 per cent. Modulated or unmodulated R.F. output continuously variable 100 millivolts. **£3/10/-**. P. & P. 4/-. This includes the return to us for checking and calibration. We will build same for **15/-** extra. Circuit and point-to-point wiring diagram, **3/6**. **Kit of parts for above**, less checking and calibration, **£3**, plus 2/6 P. & P.

CONSTRUCTOR'S PARCEL, comprising chassis 12½ × 8 × 2in., cad. plated 18 gauge, v/h., IF and trans. cut-outs, back-plate, 2 supporting brackets, 3 waveband scale, new wavelength station names. Size of scale 11½ × 4⅞in., drive spindle, drum, 2 pulleys, pointer, 2 bulb holders, 5 paxolin international octal valve holders, 4 knobs, and pair of 465 IF's, **16/6**. P. & P. 1/9.
AS ABOVE, but complete with 16 + 16 mfd. 350 wkg. and semi-shrouded drop thro' 250-0-250 60 m/a., 6 v. 3 amp. Pri. 200-250, and twin-gang **31/6**. P. & P. 3/-.



MAINS OR BATTERY SUPERHET PORTABLE COILS. Medium-waved frame aerial and long-wave loading coil, used as aerial coils. Midget iron-core screened L/M osc. coils, with circuit I.F. 465 Kc., **9/6**.
465 KC. MIDGET I.F.s. Q 120, size 1⅜in. long, 1in. wide, ⅝in. deep by very famous manufacturer. Pre-aligned adjustable iron-dust cores, per pair, **12/6**. Both these items **£1**, post paid.
CONSTRUCTOR'S PARCEL comprising chassis 8in. × 4in. × 1½in., with speaker and valve holder cut-outs, 5in. P.M. speaker with transformer, twin gang with trimmers, pair T.R.F. coils long and medium, iron-cored, four valveholders, 20 K. volume control and wave-change switch, **23/-**. P. & P. 1/6.
CONSTRUCTORS 3-VALVE T.R.F. PARCEL. Comprising chassis, L. and M. coils, gang, pot., switch, resistor and condensers, heater trans., v/holders, smoothing and bias condenser, 4 ex-Govt. obsolete valves, speaker and O.P. trans., choke, with circuit. **37/6**. P. & P. 3/-.

CONSOLE CABINET



In polished walnut originally made for gram. motor. Would make ideal bedside cabinet or T.V. stand. Size 28½in. high by 17½ wide by 13½in. deep. **39/6** plus 7/6 P. & P.,

Valve Holders, moulded octal Mazda, and loctal, **7d.** each. Paxolin, octal, Mazda and loctal, **4d.** each. Moulded B7G, B8A and B9A, **7d.** each. B7G moulded with screening can, **1/6** each.

32 mfd., 350 wkg.	2/-
16 × 24 350 wkg.	4/-
4 mfd., 200 wkg.	1/3
40 mfd., 450 wkg.	3/9
16 × 8 mfd., 500 wkg.	4/6
16 × 16 mfd., 500 wkg.	5/9
8 × 16 mfd., 450 wkg.	3/9
32 × 32 mfd., 350 wkg.	4/-
32 × 32 mfd., 350 wkg. and 25 mfd., 25 wkg.	6/6
25 mfd., 25 wkg.	11d.
250 mfd., 12 v. wkg.	1/-
16 mfd., 500 wkg., wire ends	3/3
8 mfd., 500 v. wkg., wire ends	2/6
8 mfd., 350 v. wkg., tag ends	1/6
50 mfd., 25 v. wkg., wire ends	1/9
100 mfd. 350 wkg.	4/-
16 + 16 mfd. 350 wkg.	3/3
Ex-Govt. 8 mfd., 500 v. wkg., size 3½ × 1⅞, 2 for	2/6
60 + 100 mfd., 280v. wkg.	7/-
16 × 32 mfd., 350 wkg.	6/-
50 mfd., 180 wkg.	1/9
65 mfd., 220 wkg.	1/6
8 mfd., 150 wkg.	1/6
60 + 100 mfd., 280 wkg.	8/6
50 mfd., 12 wkg.	11d.
32 + 32 mfd., min., 275 wkg.	4/-
50 mfd., 50 wkg.	1/9
Miniature wire ends moulded 100 pf., 500 pf., and .001 ea.	7d.

Combined 12in. mask and escutcheon in lightly tinted perspex. New aspect, edged in brown. Fits on front of cabinet, **17/6**. P. & P. 2/-.
Frame Oscillator Blocking Transformer, **4/6**.
Frame O.P. Transformer, Inductance 10 hy. ratio 10 : 1, **9/6**.
Tube Mounting Bracket, size 9½ × 4⅞in., 12in. tube clamps, **2/-**.
Smoothing Choke, 2 henry 150 mA., **3/6**. 250 mA. 4 henry. **5/-**; 250 mA. 5 henry, **6/-**; 250 mA. 10 henry. **10/6**; 250 mA. 8 henry, **8/6**.
P.M. Focus Unit for any 9 or 12in. tube except Mazda 12in., with Vernier adjustment, **15/-**. P. & P. 1/6.
P.M. Focus Unit for Mazda 12in. with Vernier adjustment **17/6**. P. & P. 1/6.
Wide Angle P.M. Focus Units, state tube **25/-**. P. & P. 2/-.
Energised focus coil, high resistance with mounting bracket **17/6** plus 2/-. P. & P.
Scan Coils, low line low impedance frame, complete with O.P. transformer, **17/6**. P. & P. 2/-.
Ion Traps for Mullard or English Electric tubes, **5/-**, post paid.
465 Kc. I.F.s, size 2½ × 1⅞in. Q.110 removed from American equipment, **5/-** per pair. Standard 465 Kc. iron-cored IF's. 4 × 1½ × 1⅞in., per pr. **7/6**. Wearite standard iron-cored 465 Kc. IF's, 3½ × 1⅞ × 1⅞in., per pr., **9/6**.
Iron-Cored 465 Kc. Whistle Filter, **2/6**.
OUTPUT TRANSFORMERS. Standard type 5,000 ohms imp., 2 ohms speech coil, **4/9**. 42-1 speech coil 2-ohm with extra feed-back windings, **4/3**. Miniature 42-1 2-ohm speech coil, **3/3**. Multi-ratio 3,500, 7,000 and 14,000 2-ohm speech coil, **5/6**. 10-watt push-pull, 6V6 matching, 2 ohm speech coil, **7/-**.
PUSH-BACK CONNECTING WIRE. Doz. yds. **1/6**, post paid.
STANDARD WAVE-CHANGE SWITCHES. 6-pole 3-way, **2/-**. 4-pole 3-way, **1/9**; 5-pole 3-way, **1/9**; 3-pole 3-way, **1/9**; 9-pole 3-way, **3/6**; Miniature type, long spindle, 3-pole 4-way, 2-pole 5-way, 4-pole 3-way and 4-pole 2-way, **2/6** each. P. & P. 3d.

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HALLICRAFTERS SKY CHAMPION S20R. Price £21, plus 10/- carr. **HALLICRAFTERS SKY RIDER DEFIANT.** Price £27 10/-, plus 10/- carriage. Send S.A.E. for further details re these sets.
COMMUNICATION RECEIVER R1155 for world wide reception. Can be heard at any time during shop hours. Air tested prior to despatch. Brand new at £11 19/6. A few soiled at £7/19/6. Also have a number of R1155N's at £17/19/6. Carriage in original transit case 10/6 extra on all models. Send 1/3 for circuit details, etc.
A.C. MAINS POWER PACK/OUTPUT STAGE enables the R1155 to be used to operate speaker from 200/250 volts A.C. without any modification whatever. Guaranteed 6 months. Price £4 10/- plus 3/6 postage.
SAVE MONEY BY PURCHASING THE NEW R1155 AND POWER PACK TOGETHER. ONLY £15 19/6, PLUS 12/6 CARRIAGE.
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R1355 RECEIVER. The justly famous receiver unit specified for the "Inexpensive T.V." Valve line-up 8-SP61, 1-VR92, 1-VU120 and a 5U4. Slightly used, but in very good condition. BARGAIN PRICE 29/6 plus 5/- carriage and packing.
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STANDARD TRANSFORMERS of current manufacture. Two types, both standard tapped primaries. Universal mounting. (1) 350-0-350 volts 80 mA., 0-4-5 volt 2 Amp., 0-4-6.3 v. 4 Amp. (2) 250-0-250 v. 80 mA., 0-4-5 2 A., 0-4-6.3 v. 4 A. Both these transformers are new and boxed, fully guaranteed. Price 18/- post paid.
HEAVY DUTY CHOKE. 5 Hy. 300 mA., size 3 x 4 x 4½in. high. Totally enclosed, chassis mounting. A beautiful job, brand new and boxed for only 12/6 plus 2/- postage.
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METAL RECTIFIER. 12 volt 2 Amp., full wave bridge type. Suitable for use with above trans. Price 12/6.
METAL RECTIFIERS. Selenium 230 volts 60 mA. at 5/-. 250 volts 100 mA. at 7/6. RM2 at 4/3 or two for 8/-. RM3 at 5/-. RM4 at 17/-.
TEST SET 205A. This is a 3 centimetre precision test set. Latest version, brand new condition at £20.
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UNIVERSAL AVOMETERS MODEL 40—very little used, thoroughly checked and tested. First class multi-range test meter for ONLY £9/19/6.
SPEAKER CABINET rexine covered 5 ply, takes heavy duty 12in. speaker. Size 19in. x 19in. x 14in. Brand new at 59/6 plus 4/6 carriage. Can be supplied with Vitavox K12/20 12in. extra heavy duty P.M. speaker for only £10 plus 4/6 carr. LIMITED NUMBER AT THIS PRICE.
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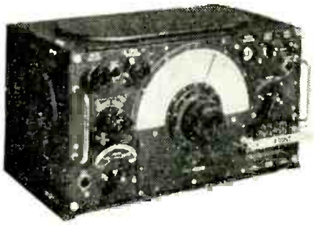

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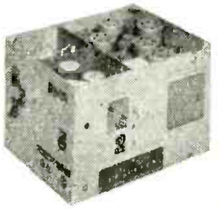

G.E.C. VHF RECEIVERS complete with 10 valves. Ex-Govt. As used by police. Used but guaranteed in excellent condition. Valves comprise ZA2's, 954's, or EF50's in HF and 1st Det. stages. Det 19 in local oscillator, KTW63's in three IF stages, D63 Det and AVC, LF H63, Output KT63, Noise suppressor D63, Power requirements 6v. 3a, 270 v. 80 ma. Frequency range 78.5-82 Mc/s. Intermediate frequency adjustable 8.3-9.8 Mc/s. Oscillator Crystal controlled (No Crystal included). Grey enamel steel case with lid 10 x 8 x 7in. Weight 22lbs. Note the amazingly low price, 39/6 plus 5/- carr.

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SLYDLOK FUSES. 5 amp, 2/6 each; 15 amp, 3/- each; 30 amp. 3/6 each. Post 6d. per half dozen.

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JONES PLUGS or SOCKETS. 8 way chassis mounting 6/- dozen; 8 way with covers 7/6 per dozen; 4 way plugs only chassis mounting 4/6 per dozen. Post 1/- per dozen.

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24 VOLT AND 12 VOLT 60 AMP CUT OUTS, Type "D" 5C/1616 and 5C/1615 10/- each, post 1/-.

Finally, after you have finished work clean your hands with **"SWARFEGA"** gritless hand cleanser, obtainable from us at 1/6 per tin, post 6d. Trade supplied at 13/6 per dozen. 4 dozen post free.

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SPECIAL OFFERS. Germanium Crystal Diodes **2/9.** Midget Mains Transformers (size approx. 2½ × 3 × 2½in.). Screened Primary 220/240 v. 50 c/s. Output, 250-0-250 v. 60 mA., 6.3 v. 2.5 a. Only **11/9.** Small Filament Transformers, 220/240 v. input, 6.3 v. 1.5 a. output, **5/9.** Auto Transformers (with separate l.t. 6.3 v. 1.5 a.), 0-110-200-210, 230-250 v. 50 watts, **4/9** each.

BATTERY SET CONVERTER KITS. All parts for converting any type of Battery receiver to All Mains. A.C. 200-250 v. 50 c/s. Kit will supply fully smoothed h.t. of 120 v. 90 v. or 60 v. at up to 40 mA., and fully smoothed l.t. of 2 v. at up to 1.a. Price complete with circuit, only **48/9.** Supplied ready for use to **7/9** extra.

PERSONAL SET BATTERY SUPERSEDER KIT. Complete with case. Supplies 90 v. 10 mA. and 1.4 v. 250 mA. fully smoothed, from normal 200-250 v. 50 c/s. Mains. For 4 valve Superhet Receivers. Price with circuit **31/6.** Or ready for use, **38/9.** Size of Unit 5½ × 3½ × 1⅝in. approx.

H.T. ELIMINATOR AND TRICKLE CHARGER KIT. Consists of h.t. and l.t. transformer, h.t. and l.t. rectifiers, smoothing electrolytic, choke, and steel case with black crackle finish. For Mains input of 200-250 v. Output 120 v. 40 mA. and 2 v. 1 a. Price with circuit, **29/6.** Or in working order, **37/6.**

BATTERY CHARGER KITS
For 200-250 v. 50 c/s. Mains input.
To charge 6 v. acc. at 2 amp., **25/9.**
To charge 6 v. or 12 v. acc. at 2 a., **32/9.**
To charge 6 or 12 v. acc. at 4 a., **49/9.**
Above consists of transformer, full wave rectifier, fuse, fuseholder, strong steel case with black crackle finish, and circuit.
Supplied in working order, **6/9** extra.

SELENIUM RECTIFIERS
6/12 v. 1 a. H.W., **4/6**; 6/12 v. 1 a. F.W. (Bridge), **7/6**; 6/12 v. 2 a. F.W. (Bridge), **10/9**; 6/12 v. 4 a. F.W. (Bridge), **18/9**; 6/12 v. 6 a. F.W. (Bridge), **22/9**; 120 v. 40 mA., **3/11**; 250 v. 50 mA. (ex equip.), **5/9**; 230 v. 80 mA. (ex equip.), **7/9.**

ELECTROLYTICS (Current production. **Not** ex-Govt.).

Tubular Types		Can Types	
8μF 450 v.	**1/11**	16μF 450 v.	**2/9**
8μF 500 v.	**2/9**	24μF 350 v.	**2/11**
16μF 350 v.	**2/3**	32μF 350 v.	**2/11**
16μF 450 v.	**2/9**	32 mfd. 450 v.	**4/9**
16μF 500 v.	**3/9**	40μF 450 v.	**4/9**
24μF 350 v.	**3/3**	50μF 350 v.	**4/9**
32μF 350 v.	**3/9**	8-8μF 350 v.	**3/9**
32 mfd. 500 v.	**5/9**	8-8μF 450 v.	**3/11**
8-16μF 500 v.	**4/11**	8-16μF 450 v.	**4/6**
25μF 25 v.	**1/3**	16-16μF 450 v.	**4/11**
50μF 12 v.	**1/2**	16-16 mfd. 500 v.	**5/9**
50μF 50 v.	**2/3**	16-32 μF 350 v.	**4/9**
Can Types		32-32μF 350 v.	**4/9**
8 mfd. 450 v.	**2/3**	32-32μF 450 v.	**5/11**
8 mfd. 500 v.	**2/11**	60-100 mfd. 350 v.	**7/6**
16 mfd. 350 v.	**1/11**	3,000 mfd. 6 v.	**6/9**

CHASSIS. (16 s.w.g. Undrilled Aluminium) Receiver type. 6 × 3⅝ × 1½in., **1/11**; 7¼ × 4¾ × 2in., **2/9**; 16 s.w.g. 10 × 5¼ × 2in., **3/9**; 11 × 6 × 2½in., **4/3**; 12 × 8 × 2½in., **5/3**; 16 × 8 × 2½in., **7/6** 20 × 8 × 2½in., **8/11**; Amplifier Type, 12 × 8 × 2½in., **7/11**; 16 × 8 × 2½in., **10/11**; 14 × 10 × 3in., **13/6**; 20 × 8 × 2½in., **13/6.**

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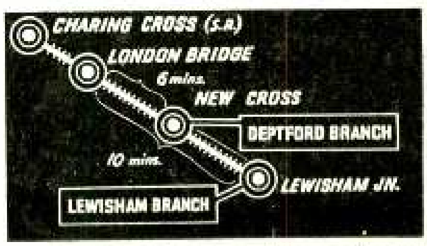

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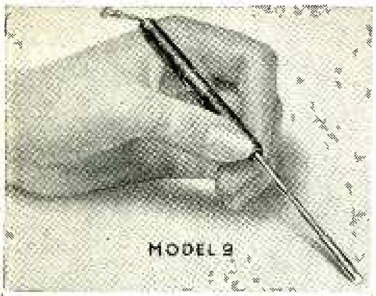

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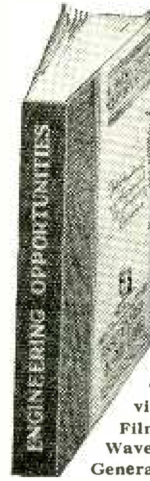

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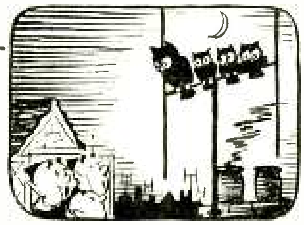

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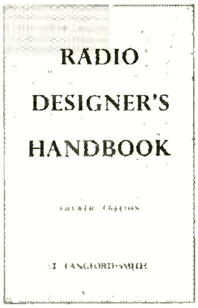

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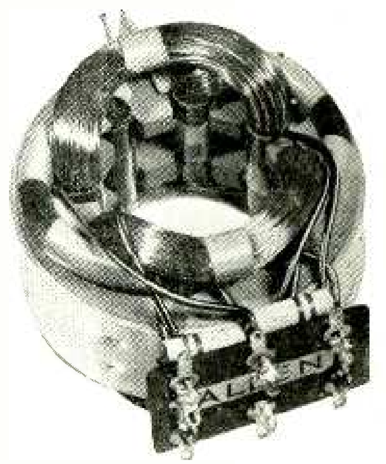

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BC610 Hallicrafters, also spares; RCA ET 4336 series with spares; BC348 receivers, also TCS6, TCS12 and components.
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45/- each offered for 813 type valves.—Write Box 7050. [1073

LEAK high-fidelity radio and amplifier or similar required.—Box 7692. [1434

HIGH-QUALITY 3ohm 10-watt loudspeaker required in cabinet.—Box 7694. [1436

WANTED, receivers A.P.R.4, also T.N. 16, 17, 18, 19, etc., and any radio test gear.
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WANTED, RCA 4331 transmitters.—P.C.A. Radio, Cambridge Grove, Hammersmith, W.6. Tel. Riverside 3279. [0093

BULK quantities urgently wanted for export ex-W/D radio, telephone, signalling equipment of every description.—Box 6880. [1038

WANTED, HRO coils, Rxs, etc., A.R.88s, BC348s, S27s, etc.—Details to R.T. & I. Service, 254, Grove Green Rd., London, E.11 Ley. 4986. [0163

WANTED, laboratory test equipment, including standard signal generator, watt meter, oscilloscope, bridges, recorders; send price and details to:
HATFIELD INSTRUMENTS, 175, Uxbridge Rd., Hanwell, W.7. Tel. Ealing 0779. [0037

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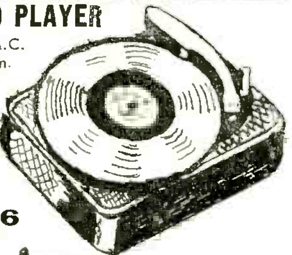

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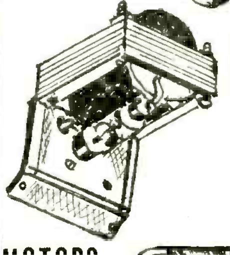

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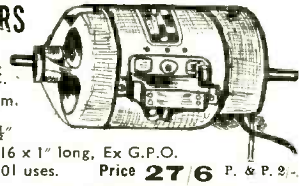

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SALARIES: Consolidated Provincial Rates.
LEADING Draughtsmen: £592×£20 to £702.
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APPLY in writing: Personnel Department, G.C.H.Q., 53, Clarence Street, Cheltenham. [1362

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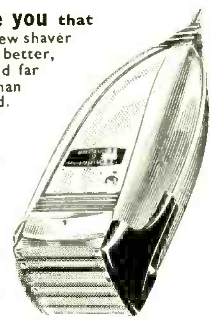

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SITUATIONS VACANT

A. V. ROE & Co., Ltd., have a vacancy in their ENGINEERING Research Department on interesting work for an ELECTRONIC Engineer preferably with knowledge of electronic equipment used in vibration testing, and strain gauge work; some knowledge of vibration and fatigue an asset.

APPLICANTS for the above post should possess at least Higher National Certificate or equivalent.

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(d) PULSE circuitry; 4 engineers.
(e) MICROWAVE circuits; 1 senior engineer, 2 engineers.
(f) TEST equipment; 1 senior engineer, 3 engineers.
(g) GENERAL radar circuit development; 1 senior engineer, 3 engineers.

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ALL applicants must have served a recognised relevant apprenticeship.

INSTRUMENT mechanics (Electronic) must have sound theoretical knowledge of electronics (Ordinary National Certificate standard desirable) with practical knowledge of pulse amplifiers, D.C. amplifiers, electronic scalers, discriminations, and general trigger circuits, and in wiring and assembly of electronic apparatus. Experience of test gear and general instrument calibration an advantage.

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TELEVISION radio electrical salesman; good salary and comm.—Apply in confidence 13, High St., Harlesden, N.W.10. Elgar 5914. [1355

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One Hand Generator for H.T. and L.T. One Miniature Relay 1,000 ohms 28 volts. Two 6.3 volt warning bulbs. Holders. One small Neon lamp. One 2-pin Socket—12 fixed Condensers, assorted sizes. 6 fixed Resistors. One valve 12SC7. One valve 12A6. One variable air-spaced Tuning Condenser, .0005 mfd. One 6-way single pole 60 degree Yaxley Switch. One Transformer BX/17/20. One 6-way Miniature Jones Plug and Socket. 4 Tuning Coils. One Push Button. One Coil covered Aerial wire, flexible. One Coil Earth wire. ONLY **55/-** each. *Carriage and Packing 5/- England, Wales and Scotland.*

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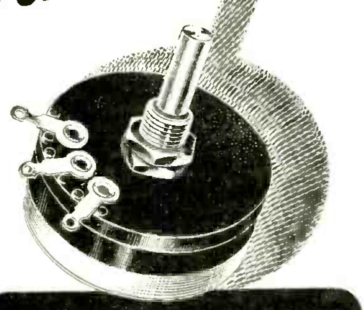

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MESSRS. PYE. Ltd., Cambridge, have vacancies for senior and junior test engineers, also electronic wiremen on very interesting work in their television transmission equipment department.—Apply in writing to Personnel Department. St. Andrew's Rd., Cambridge. [1395

TECHNICIAN, with experience in electronic work, required for development laboratory in large telecommunication engineering works; give particulars of experience, education and technical training, qualifications and commencing salary required; London S.E. area.—Box 6765. [1019

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WIREMEN, skilled, required for high-grade electronic equipment, ability to undertake prototype work from schematic drawings an advantage, first-rate workshop conditions, West London area and pension scheme.—Write, stating age, details experience and present rate.—Box 7138. [1097

DRAUGHTSMAN wanted for a small drawing office engaged in the design and drafting of electronic instruments for the industrial and telecommunications field.—Write, stating age, experience and salary required, to Dawe Instruments, Ltd., Harlequin Ave., Great West Rd., Brentford. [1346

RADIO and radar testers; first-class men required for work on V.H.F. communication gear and Government contracts for radio and radar equipment by Midland manufacturers. —Men with wide experience of fault finding in any of the fields mentioned should write, giving full details to Box 7631. [1413

CARDIFF.—Leading television dealers handling all worthwhile agencies, require television engineers thoroughly trained in fault finding on all leading makes of receivers; salary at £500 p.a.; full particulars on application and copy references if possible; good accommodation provided if required.—Box 7608. [1408

DEVELOPMENT engineer required by well-established firm to develop components and electronic apparatus; ability to exploit ideas and work on own initiative essential.—Send full details of previous positions held and type of work undertaken, together with approximate salary required, to Box 7204. [1339

LONDON BRICK Co., Ltd., has a vacancy for an instrument mechanic, preferably with some electronic experience, to work in the Research Department at Stewartby; salary £400-£550 according to qualifications and experience. —Apply in writing to the Personnel Manager, London Brick Co., Ltd., Stewartby, Bedford. [1380

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THE position offers good prospects for advancement.
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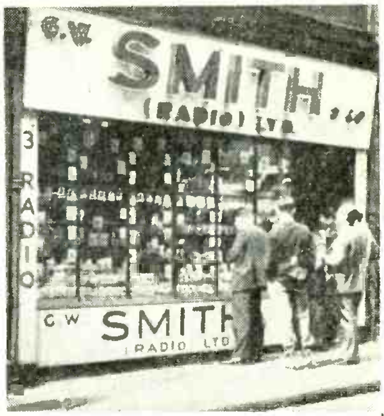

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E. K. COLE, Ltd., Electronics Division, Malmesbury, Wiltshire, require Draughtsmen (mechanical or electrical of National Certificate Standard), aged 21 to 25 years, for interesting and varied work on radar and communication equipments, also for test gear, excellent conditions and prospects.—Apply, in writing, to Personnel Manager. [1099

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ELECTRONIC engineer required by large food factory in London in the development section on the construction of specialized factory electronic equipment; age 20-28; applicants should possess initiative and be capable of working with the minimum of supervision; good canteen; salary according to age and experience. —Write Box W.344, c/o 191, Gresham House, E.C.2. [1361

LABORATORY assistants required on development of special materials for use in telecommunications; applicants must have National Certificate or higher qualifications and a special interest in chemistry or electrical measurements. —Apply in writing to Personnel Manager, Standard Telephones & Cables, Ltd., N. Woolwich, E.16, stating age, qualifications and salary required. [1352

ELECTRONIC engineer for work in connection with the development and production of electronic measuring instruments; sound theoretical knowledge and several years' experience in this field essential; excellent opportunity for capable person to progress with young and rapidly expanding organisation.—Rivlin Instruments, Ltd., 7a, Maitland Park Villas, N.W.3. [1350

THE De Havilland Engine Co., Ltd.—Electronic engineer required, interested in physical measurement rather than construction of apparatus, required for vibration measurement and analysis on gas turbine and piston engines. —Please write in confidence, stating age and full details of previous experience to the Personnel Officer, The de Havilland Engine Co., Ltd., Stag Lane, Edgware, Middlesex. [9951

SCIENTIFIC instrument makers in North London have a few vacancies for skilled laboratory assistants and wire-men for the development and production of high quality electrical and electronic apparatus.—Please apply, in writing only, stating qualifications, experience and salary required, to Personnel Officer, Hilger and Watts, Ltd., Hilger Division, 98, St. Pancras Way, London, N.W.1. [9990

THE ENGLISH ELECTRIC Co., Ltd., Luton, have vacancies for electronic engineers for development work on V.H.F. radio sub-miniature equipment and/or recording techniques; some field trials engineers and assistants also required.—Applications, stating age, experience and qualifications, and quoting ref. 456L, should be sent to Central Personnel Services, English Electric Co., Ltd., 336/7, Strand, London, W.C.2. [9930

PHYSICIST required in the north-west for the development of capacitors for use in telecommunication equipments, including silvered mica and paper and plastic dielectric types; the posts available are permanent, on full staff status with contributory pension fund, etc.—Please write, giving full details of qualifications and experience and the approximate salary required, to Box 194, Dorland Advertising, Ltd., 18-20, Regent St., London, S.W.1. [1356

ELECTRONIC, radar and radio engineers, senior and junior, are urgently required for new division of the General Electric Company at their Stanmore Laboratories; applicants for the senior posts should be capable of directing the work of a small team engaged on the electrical development of electronic equipment for guided missiles or radar; knowledge of M.O.S. specifications and procedure would be an advantage.—Applications should be made in writing, stating age, qualifications and experience to the Personnel Manager, G.E.C., Stanmore Laboratories Brown's Lane Division, The Grove, Stanmore Common, Stanmore, Middlesex, quoting ref. RG/BLS. [9881

DECCA RADAR, Ltd., requires a senior engineer to form a new division of the company undertaking the planning and erection of large radar stations both in the United Kingdom and abroad; the appointment calls for a man between 30 and 45 years of age, with exceptional experience in the engineering design, planning and progressing of electrical projects of a major nature; while a knowledge of radio and radar engineering at high powers is a distinct advantage, very favourable consideration will be given to heavy power engineers; sound engineering knowledge, experience and ability to plan and direct are the major requirements; a salary commensurate with the qualifications and responsibility will be paid; the post is permanent and pensionable. —Apply, in strict confidence, to Managing Director, Decca Radar, Ltd., 1-3, Brixton Rd., S.W.9. Ref. H.I.D. [1341

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ALL applicants must have served a recognised apprenticeship.
INSTRUMENT MAKERS. Must be able to read and interpret working drawings English and 3rd Angle and to work to rough sketches and verbal instructions; ability to produce individual scientific test gear on a one off basis working to fine tolerances, and to operate the necessary machining tools. Knowledge of simple electronic circuits and ability to wire up an instrument from a diagram an advantage.
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APPLY giving details of apprenticeship, training (including Forces' training), qualifications, and experience, to Chief Superintendent, Radar Research and Development Establishment, Gt. Malvern, Worcs. [1370

WALTHAM Cross.—T.V. service engineer required.—Write in first instance to Teleradio, 18, Turnpike Lane, N.8, detailing experience. [1411

PETO SCOTT ELECTRICAL INSTRUMENTS, Ltd., have vacancies for TV development engineers of Graduate and Higher National standards.
ALSO Radar mechanics for work on ultra high frequency equipment.—Applications should be made to The Chief Engineer, Weybridge Factory. [1401

TELEVISION development engineer of degree standard required for firm in Harrow district.—Write, stating experience, age and salary required, to Box 7203. [1336

EXPERIENCED TV engineers required for retail service; permanent positions at good salary.—Full details to Shenstones (op. Town Hall), Leyton, E.10. Ley. 1362. [9266

ELECTRONIC engineer required by new division of prominent engineering concern in Northern Ireland for development work on guided weapons and other projects.
DEGREE or equivalent in electrical engineering or physics, with good practical experience, preferably of D.C. amplifiers, electronic computation, pulse techniques, or miniature equipment.
GOOD salary and prospects for man with originality.
DETAILS of housing accommodation available and facilities for removal supplied at interview.
SEND full details of age, qualifications and experience, quoting reference E.E.1, to Box 7295. [1351

SECOND radio and television engineer required by old-established west end business; good knowledge of all makes essential; state experience and salary required.—Box 7568. [1404

VICKERS-ARMSTRONGS, Ltd. (Aircraft Section), have vacancies for Technical Authors with electrical and radio experience, for compilation of aircraft manuals—both military and civil.
APPLY to Employment Manager, Vickers-Armstrongs, Ltd. (Aircraft Section), Weybridge, Surrey.
APPLICATIONS, with certain exceptions, are subject to the approval of the Ministry of Labour and National Service. [1358

EXPERIENCED TV engineer required to take charge of service dept., good salary and prospects.—Write, giving experience and character references, Marshall, 76, High St., Witham, Essex. [1337

SERVICE engineer and directorship.—Required, radio/television service engineer, must be first-class man with good references; a directorship is offered with this post if desired (North-West).—Box 7411. [1372

GLASGOW.—Radio mechanic, preferably experienced tape and wire recorders; permanent position with prospects; commencing salary £7/10.—Land, Speight & Co., Ltd., 73, Robertson St., Glasgow. [1373

EXPERIENCED fault-finders wanted by Midland manufacturers of radio equipment; permanent posts located in the Midlands are offered to men with experience of radar, radio control, V.H.F. equipment.—Write, stating fully, experience and salary required, to Personnel Manager, Box 7632. [1414

SITUATIONS VACANT

JUNIOR electronics engineer required to assist in the development of an analogue computer; previous development experience is essential and a knowledge of d.c. amplifiers would be advantageous.
APPLICANTS, who should be 21-24 years of age and hold the Higher National Certificate, should write, quoting full particulars, to The Personnel Officer, E. Cowes, Isle of Wight, ref.: W.W./C.1. [1396

TELEVISION engineers, experienced field and fast bench work; salary commensurate with ability; good conditions; permanency.—Apply in confidence The Genuine Co., Ltd., 364, Edgware Rd., W.2. Pad. 6179. [1354

RADIO engineer required, for responsible position by Cambrian Air Services, Cardiff Airport, must hold "A" licence; salary in scale £600-£700 p.a., according to qualifications.
APPLY: Chief Engineer. [1385

SENIOR engineer with several years' experience of television receiver design is required by a manufacturer in South-West London.—Write, giving full details of experience and salary required, to Box 7405. [1364

RADIO mechanics required for development work on test apparatus.—Write, giving full particulars of experience, age, etc., to Personnel Manager, S. Smith & Sons (England), Ltd., Bishops Cleeve, Nr. Cheltenham. [1127

PRODUCTION electrical testers required for television, radio and electronic equipment; very interesting work; good facilities and pay; keen technicians only required.—Dynatron Radio, Ray Lea Rd., Maidenhead. [1344

RADIO service mechanics required by Smiths (Radiomobile), Ltd., for all parts of the country.—Write details of experience and qualifications to Personnel Officer, Goodwood Works, North Circular Rd., London, N.W.2. [0342

ELECTRONICS engineer required for development work on magnetic amplifiers for use in control systems, experience of design and construction essential.—Write fully stating experience, qualifications and age, to Box 7522. [1392

TEST engineer, electronics required, some experience with oscilloscopes, pulse generators, counters and radar generally, preferred; give details of experience and wage required.—Erskine Laboratories, Ltd., Scalby, Scarborough. [1377

TECHNICAL representative required by old-established firm to handle electronic acoustic correction equipment from a London H.Q.; excellent scope for ambitious man to develop and expand completely new field.—Full particulars to Box 7064. [1074

ELECTRONIC engineer with Higher National Certificate or equivalent is required for the development of V.H.F. equipment and components; applicants must have good laboratory experience and sound practical knowledge in this sphere.
WRITE, stating qualifications, experience and salary required, to Wingrove & Rogers, Ltd., Domville Rd., Liverpool, 13. [1349

ASSEMBLY wiremen required, must be first-class, used to small, intricate chassis work.—Apply by letter, stating age, nationality and experience to E.M.I. Engineering Development, Ltd. (Wells Division), Penleigh Works, Wells, Somerset. [1108

FIRST-CLASS radio and television engineers required by old-established, expanding business; good salary and prospects; permanent; all leading agencies, including Murphy, Bush, Pye, Ekco, etc.—E. P. Fox, Ltd., East Molesey, Surrey. Molesey 2721. [0442

AIRCRAFT radio mechanics skilled in workshop practice or aircraft installations to work at Stansted Airport, Essex; hostel accommodation available; minimum hourly rates 3/9.—Write to the Personnel Manager, Skyways of London, 7, Berkeley St., W.1. [0019

B.B.C. requires tracer for planning and installation department, central London; wage £6/5 with increments to £7/5; some training engineering drawing and tracing; knowledge electrical symbols and theory desirable.—Apply E. E. O., B.B.C., London, W.1. [1338

SKYWAYS OF LONDON, have vacancies for a radio engineer i/c and a radio section inspector with A and/or B licences, at Stansted Airport, Essex; hostel accommodation available, salary £715 to £815 p.a.—Apply to the Personnel Manager, 7, Berkeley St., W.1. [1383

SENIOR tester required by scientific instrument company located North-East outskirts of London; wide experience of electrical and electronic instruments; housing accommodation can be provided.—Write giving full details of age, salary, etc., to Box 7404. [1366

EXPERIENCED radio testers and inspectors required for production of communication and radio apparatus, also instrument makers, wirers and assemblers, for factory test apparatus.—Apply Personnel Manager, E. K. Cole, Ltd., Ekco Works, Malmesbury, Wilts. [0238

DECCA RADAR, Ltd., invites applications from young scientists and engineers due to graduate this year, and who expect to get good Honours degrees. The posts offer interesting and well-paid careers in radar engineering for young men who are prepared to work hard. British nationality essential.—Write, quoting ref. CPH, to Decca Radar, Ltd., Research Laboratory, 2, Tolworth Rise, Surbiton, Surrey. [0243

SITUATIONS VACANT

ASSISTANTS (Scientific). The Civil Service Commissioners invite applications for pensionable posts. Applications may accepted up to 31st December, 1953 but an earlier closing date may be announced either for the competition as a whole or in one or more subjects. AGE at least $17\frac{1}{2}$ and under 26 years of age on 1st January, 1953, with extension for regular service in H.M. Forces, but candidates over 26 with specialised experience may be admitted. CANDIDATES must produce evidence of having reached a prescribed standard of education, particularly in a science subject and of thorough experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces, covering a minimum of two years in one of the following groups of scientific subjects:—
(i) Engineering and physical sciences.
(ii) Chemistry, bio-chemistry and metallurgy.
(iii) Biological sciences.
(iv) General (including geology, meteorology, general work ranging over two or more groups (i) to (iii) and highly skilled work in laboratory crafts such as glass-blowing).
SALARY according to age up to 25; £236 at 18 to £363 (men) or £330 (women) at 25 to £500 (men) or £417 (women); somewhat less in provinces Opportunities for promotion. FURTHER particulars and application forms from Civil Service Commission, Scientific Branch Trinidad House, Old Burlington St., London, W.1, quoting No. S 59/53. Application forms should be returned as soon as possible. [1376

TEST and junior development engineers are required to assist in the development and production of precision electronic laboratory instruments; applicants should have a sound theoretical knowledge and have had substantial practical experience of measuring instrument circuits; salary in the region of £450-£650 p.a., according to qualifications and experience.—Apply, stating full details, to the Chief Engineer, Furzehill Laboratories, Ltd., Boreham Wood Herts. [0244

McMICHAEL RADIO, Ltd., require senior and junior engineers in their equipment division laboratory at Slough; training and experience in the field of applied electronics (including communications) and experience of working with Government Departments are the chief qualifications required.—Write, stating age and full details of training, qualifications and experience, to the Chief Engineer, Equipment Division, McMichael Radio, Ltd., Slough. Bucks. [0198

BELLING & LEE, Ltd., Cambridge Arterial Rd., Enfield, Middlesex, require research assistants in connection with work on electronic components, fuses, interference suppressors and television aerials; applicants must be graduates of the I.E.E. or possess equivalent qualifications, together with similar laboratory experience; salary will be commensurate with previous experience; 5-day week; contributory pension scheme.—Applications must be detailed and concise, and will be treated as confidential. [0230

SENIOR mechanical designer; two or three vacancies exist in our electronics division for senior design draughtsman on electronic equipment; candidates should be of at least Higher National Certificate standard and should be capable of leading a design team in this class of work; salary £650 per annum upwards according to qualifications and experience; applications should include full details of experience to date and may be forwarded in confidence to the Personnel Manager, Murphy Radio, Ltd., Welwyn Garden City. [9883

DECCA RADAR, Ltd., requires a senior engineer to take charge of the testing of high-power centimetric radar equipment; previous experience of high-power radar, including receivers and A.F.C. systems, is required; a good salary, commensurate with experience, will be offered to the right man, for whom there are excellent prospects in this progressive and expanding company.—Please apply, giving full details of experience and stating salary required, to Ref. F.L. Decca Radar, Ltd., 1-3, Brixton Rd., London, S.W.9. [1340

B.B.C. requires engineer in Radio Section, Research Department, Kingswood, Surrey, normal starting salary £795 (may be higher or lower according to qualifications) rising by 5 annual increments to £1,065 max.; degree electrical engineering or physics with sound mathematics essential; duties: theoretical and practical investigations on radio frequencies, reference transmitting aerials and R/F measurements, experience of which essential; experience transmitters and receivers desirable.—Apply E.E.O., B.B.C., London, W.1, quoting E.787. [1388

VACANCIES are available in the transmission department for: (1) development engineers, experienced in the design of multi-channel carrier telephone systems, or in allied techniques, including amplifiers, filters and radio; (2) equipment engineers, with such knowledge of modern line communication practice as will enable them, after training in the company's methods, to prepare detailed specifications of equipment requirements and to develop arrangements for rack-mounting of the apparatus; (3) draughtsmen to work with the engineers, preferably having experience in the telecommunications industry; the positions available are permanent, on full established staff status, with contributory pension fund and usual staff conditions.—Please write to Personnel Manager, Automatic Telephone & Electric Co., Ltd., Liverpool, 7, giving full details of experience, qualifications, age and approximate salary sought. [1359

SITUATIONS VACANT

PROJECT engineers (aged 28/38) required for development of small electronic, electrical and radio components by well-known manufacturer; experience of this work and up-to-date manufacturing methods essential, academic or professional qualifications advantageous; the positions are permanent and pensionable and salary commensurate with qualifications.—Applications (which will be treated in confidence) giving full details and an indication of the salary range expected to Box 7521. Advertiser's staff are aware of the vacancies. [1391

DRAUGHTSMEN; The English Electric Co., Ltd., have vacancies at their Liverpool works for electrical draughtsmen with good experience in the layout of power installations, wiring diagrams and switchgear; pensionable and progressive positions with excellent opportunities for promotion are offered to men with initiative; housing assistance for successful applicants and travelling expenses for interview will be paid.—Write, giving full details of age, qualifications and experience, quoting ref. 140B, to Central Personnel Services, Marconi House, 336-7, Strand, London, W.C.2. [9984

THE GENERAL ELECTRIC CO., LTD., Brown's Lane, Coventry, requires Senior and Junior Electronic Development Engineers for work on Guided Weapons and like projects, particularly in the field of Microwave and Pulse Applications; Mechanical Development Engineers, Designer Draughtsmen and Draughtsmen, preferably with experience of radar type equipments, also required for the above projects; salary according to age, qualifications and experience; houses available to selected senior staff.—Apply by letter stating age and experience to the Personnel Manager (Ref. R.G.). [0259

MURPHY RADIO, Ltd. have vacancies for two or three senior engineers to lead development teams in their electronics division; applications are invited from men with engineering or physics degrees or equivalent, and with first-class experience in the fields of Radar navigational aids, V.H.F. communications receivers and low-power transmitters; salary upwards of £650 per annum according to qualifications and experience; candidates prepared to bring energy and drive to their work may address their applications in confidence to the Personnel Manager, Murphy Radio Ltd., Welwyn Garden City. [9884

MINISTRY OF CIVIL AVIATION.—Radio mechanics required at aerodromes and radio stations; special training courses for keen mechanics with basic qualifications; interesting work in progress providing electronic aids to navigation; prospect of permanent pensionable posts; rates of pay (London) from £290 per annum at age 19, to £385 at 25, rising, subject to qualifying test to £475, plus pay addition of 10%, slightly lower for provinces; candidates aged 19 or over with practical experience in maintenance of radio or radar equipment should apply to Ministry of Labour and National Service, Barnsbury Rd., London, N.1, quoting Order No. 576. [1368

DECCA RADAR Ltd., invites applications from experienced microwave engineers to join the company in its extensive work in a wide field of microwave link and radar development; the company offers excellent starting salaries and first rate opportunities for men to exploit their initiative and to rise rapidly to responsible posts; Graduates without industrial experience who are prepared to undertake intensive training are also invited to apply for junior posts; applicants must be of British nationality.—Apply in writing, quoting ref. MW to Research Director, Radar Laboratory, 2, Tolworth Rise, Surbiton, Surrey. [0245

OLD-ESTABLISHED British firm in Bangkok require sales and service engineer for their radio department; principals handle the distribution throughout Thailand of a well-known American range of domestic radio receivers, commercial and broadcast transmitters and allied equipment; applicants will be required to take charge of the department and must be fully conversant with the entire range of broadcasting equipment; a knowledge of television, both transmitting and receiving, will be to the applicant's advantage; applicants up to 35 years of age will be considered.—Write with full particulars to Box "JN/9," c/o 95, Bishopsgate, London, E.C.2. [1424

ADMIRALTY Royal Naval Scientific Service. Vacancies for Experimental Officers and Assistant Experimental Officers in London area and Gloucestershire. Candidates should be engineers or physicists with a strong interest or research experience in electronics or telecommunications, line and radio. Candidates, British subjects, must possess one of following qualifications: University degree in engineering, physics or mathematics, graduate membership of an appropriate professional institution, Higher National Certificate, Final certificate of a 5-year grouped course in a relevant subject at City & Guilds or comparable institutions. Higher School Certificate with Maths. or Science as principal subject or equivalent qualification. Experimental officers at least 26 years of age. London salary scale (men) £681-£838. Assistant Experimental Officers at least 17½ years £274-£607. Rates for women and post in Gloucestershire somewhat lower. Starting salaries above minima may be granted according to age and experience. All appointments unestablished, but opportunities to compete for permanent posts will occur from time to time.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King St., London, S.W.1. Quoting A130/53/A. Closing date July 14, 1953. [1394

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BRIDGE CONNECTED HEAVY DUTY 7¼in. SQUARE COOLING FINS. 17 v. 6 a., **49/6** ; 10 a., **56/-** ; post 1/6.

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SITUATIONS VACANT

AIR MINISTRY requires civilian instructors, Class I, radio fitter, for temporary posts, with prospect of permanency, at R.A.F. Radio Schools, Yatesbury (Wilts) and Locking (Somerset); qualifications at least 5 years' practical experience and ability to instruct; trade test before entry; pay is £480 at 26 rising to £597.—Apply to (K.1) Air Ministry, S.5(g), Cornwall House, Stamford St., London, S.E.1. [1375

DEVELOPMENT engineer required; experience in electronic communication field an advantage; excellent opportunity for man with technical and industrial experience to broaden experience with well-established and well-known company; near town centre and all amenities and within easy reach London.—Apply Marconi Instruments, Ltd., Longacres, Hatfield Rd., St. Albans. [1028

ELECTRONIC Engineer required by Ministry of Supply, London Headquarters, to supervise the development by industry of electronic navigation aids for Service use; experience of the development of radio and radar equipments and a knowledge of current navigation equipment is desirable; quals. minimum or Higher School Cert. (Science) or equivalent, but degree or H.N.C. in engineering may be an advantage; salary within range experimental officer (min. age 26). £681—£838; women somewhat less; post unestablished.—Applications forms from M.L.N.S., Technical and Scientific Register (K), 26, King St., London, S.W.1, quoting D223/53A. Closing date July 14, 1953. [1428

SENIOR Experimental Officer required by Ministry of Supply trials Wing Outstation, Aberporth, South Wales, for control of operation and maintenance of electronic instruments and supervision of technical work; experience with radio or radar equipment, preferably used for measurement of physical quantities, desirable; liking for field work essential; quals.: Minimum of Higher School Cert. (science) or equiv., but H.N.C. or degree in elec. eng. may be an advantage; min. age 35; salary within range £927—£1,091 (male); post unestablished.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King St., London, S.W.1, quoting D 222/53A. Closing date July 14, 1953. [1429

RADIO research department; junior technical assistant able to assist in as many as possible of the following: electrical and radio measurements, construction of prototype apparatus, preparation of reports, technical records, etc., generally to be useful in small laboratory; ability to use metal and wood-working tools with some degree of accuracy is desirable and a knowledge of typing could be advantageous; good education to matriculation standard and some knowledge of electrical theory is essential; female applicants would be considered if possessing typing experience and good training in radio theory (e.g., ex-W.R.N.S., etc.).—Full details of age, education, experience and salary required to Box No. 544, c/o Era Publicity, Ltd., 7, Fitzroy Sq., London, W.1. [1365

A VACANCY exists with a subsidiary of British Relay Wireless and Television, Ltd., operating in Gloucester, for a television engineer, mainly for servicing television receivers, but also for work in connection with the maintenance and installation of television relay distribution equipment; applicants should be under 25 years of age and should have had experience in handling and servicing television receivers or associated equipment; applications should be made in writing to Link Sound and Vision Services (Gloucester), Ltd., 28, Southgate Street, Gloucester. Applicants wishing to be interviewed in London should apply to British Relay Wireless and Television, Ltd., 6, Giltspur St., E.C.1, marking their letters "Gloucester" in top left-hand corner. [1376

THE PLESSEY COMPANY have vacancies at their Ilford works for engineers and draughtsmen of senior and intermediate grades for development work on components and mechanisms for radio, television and communications equipment; these vacancies occur as a result of the enlargement of the laboratories to permit a substantially increased interest in the design of circuits and components for specific applications; all positions are permanent and pensionable and the expansion now in progress offers good prospects of advancement; attractive initial and progressive salaries are offered to men who are qualified by reason of educational attainment or practical experience.—All applications will be dealt with in confidence and should be addressed, in the first instance, quoting reference WW/ED. for the attention of the Personnel Manager, The Plessey Company, Limited, Vicarage Lane, Ilford, Essex. [1347

MINISTRY OF SUPPLY requires technical authors at Chessington, Malvern, Farnborough, to prepare instructional publications for services on all aspects of ground/airborne centimetric radar or radio communications equipment. Qualifications: British of British parents; recognised eng. apprenticeship and Eng. or Physics degree, A.M.I.C.E., Mech.E. or Elec.E. or exempting qualns.; alternatively wide experience in responsible tech. position preferably holding H.N.C. or equivalent would be considered; appropriate experience, either research and development in industry or operation and servicing in Services essential; experience in writing, editing tech. publications advantageous; salary within £592-£949 according to age, qualns., location; not established but opportunities to compete for establishment may arise.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King St., London, S.W.1, quoting D198/53A. Closing date July, 13, 1953. [1369

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MOVING COIL METERS-2½in. FLUSH MOUNTING. 0-10 m/a., 0-30 m/a., 0-200 m/a., 0-500 m/a., any type, **12/6** each. P.P. 1/-.

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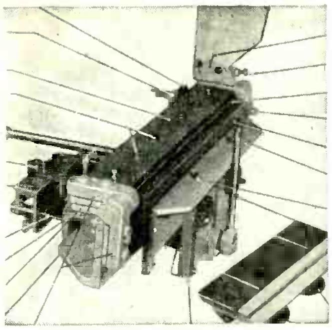

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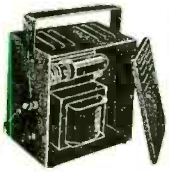

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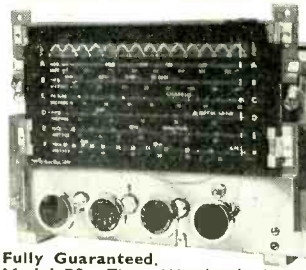

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