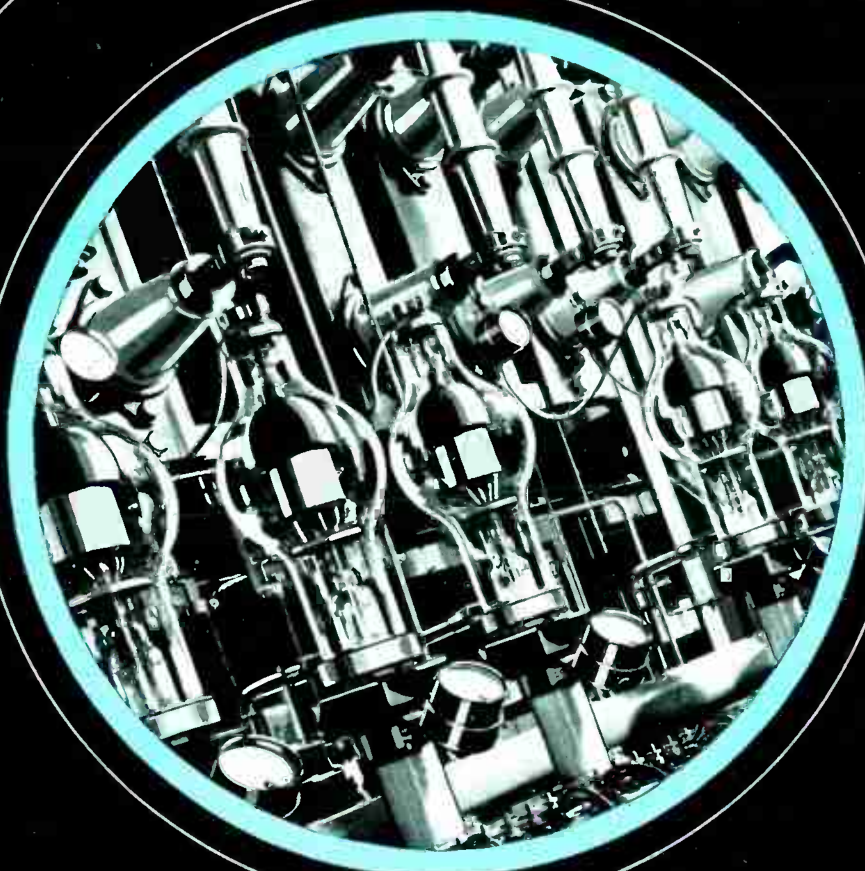
Wireless World

RADIO · ELECTRONICS · ELECTRO-ACOUSTICS



MAR. 1943

1/3

Vol. XLIX. No. 3

AUTOMATIC CIRCUIT CHECKING

The National Interest demands Standardisation

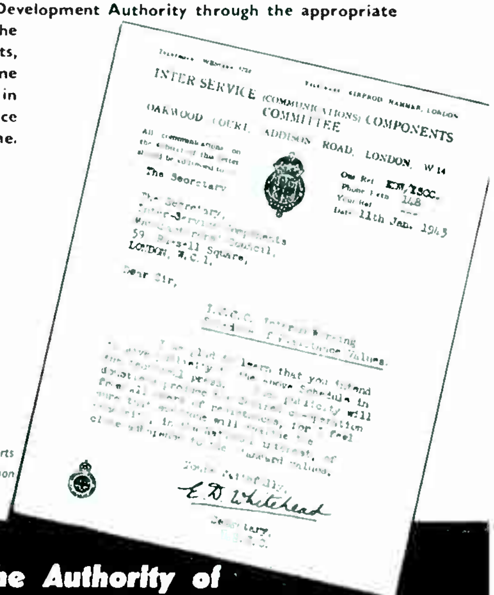
These "Standard Values" cover every Resistance Value from 10 ohms to 10 Meg.

20%	10%	★ 5%	20%	10%	★ 5%	20%	10%	★ 5%
10	10	10	1000	1000	1000	100000	100000	100000
		11			1100			110000
	12	12		1200	1200		120000	120000
		13			1300			130000
15	15	15	1500	1500	1500	150000	150000	150000
		16			1600			160000
	18	18		1800	1800		180000	180000
		20			2000			200000
22	22	22	2200	2200	2200	220000	220000	220000
		24			2400			240000
	27	27		2700	2700		270000	270000
		30			3000			300000
33	33	33	3300	3300	3300	330000	330000	330000
		36			3600			360000
	39	39		3900	3900		390000	390000
		43			4300			430000
47	47	47	4700	4700	4700	470000	470000	470000
		51			5100			510000
	56	56		5600	5600		560000	560000
		62			6200			620000
68	68	68	6800	6800	6800	680000	680000	680000
		75			7500			750000
	82	82		8200	8200		820000	820000
		91			9100			910000
100	100	100	10000	10000	10000	1.0 Meg.	1.0 Meg	1.0 Meg
		110			11000			1.1 Meg.
	120	120		12000	12000		1.2 Meg.	1.2 Meg.
		130			13000			1.3 Meg.
150	150	150	15000	15000	15000	1.5 Meg.	1.5 Meg.	1.5 Meg.
		160			16000			1.6 Meg.
	180	180		18000	18000		1.8 Meg	1.8 Meg
		200			20000			2.0 Meg.
220	220	220	22000	22000	22000	2.2 Meg.	2.2 Meg	2.2 Meg.
		240			24000			2.4 Meg.
	270	270		27000	27000		2.7 Meg.	2.7 Meg.
		300			30000			3.0 Meg.
330	330	330	33000	33000	33000	3.3 Meg.	3.3 Meg.	3.3 Meg
		360			36000			3.6 Meg
	390	390		39000	39000		3.9 Meg	3.9 Meg
		430			43000			4.3 Meg
470	470	470	47000	47000	47000	4.7 Meg	4.7 Meg.	4.7 Meg
		510			51000			5.1 Meg.
	560	560		56000	56000		5.6 Meg	5.6 Meg
		620			62000			6.2 Meg.
680	680	680	68000	68000	68000	6.8 Meg	6.8 Meg	6.8 Meg
		750			75000			7.5 Meg
	820	820		82000	82000		8.2 Meg	8.2 Meg
		910			91000			9.1 Meg.
						10.0 Meg.	10.0 Meg	10.0 Meg

★ **See note (1) in Text**

In the Fixed Composition Resistor Field "STANDARD VALUES" is the Solution

For a long time now the range of values demanded in Fixed Composition Resistors has been increasing until it has now reached an uneconomic and wasteful figure exceeding 800. This position has produced unavoidable delays in delivery because of the time expended in special sorting and colour-coding, and the consequential hold-ups in the manufacture and servicing of important equipment. In order to regularise the position the Services, the Manufacturers, their Engineers and Laboratories have co-operated in rationalising the range to the 255 STANDARD VALUES, listed in the accompanying table, without any loss of efficiency. Tolerance ±20% should be used wherever possible: ±10% should be used only where essential: whilst for (1) ±5% prior authorisation is required and should be sought by the Development Authority through the appropriate Supply Department Design Authority. The schedule applies only to new development projects, and not to existing contracts, spares for same or repeat orders for either. Your co-operation in using only STANDARD VALUES of resistance is vital if your demands are to be met on time.



"STANDARD VALUES"

GIVE
- Increased Production
- Quicker Delivery
- Speedy Servicing

SAVE
- Valuable Raw Materials
- Labour
- Dangerous Delays

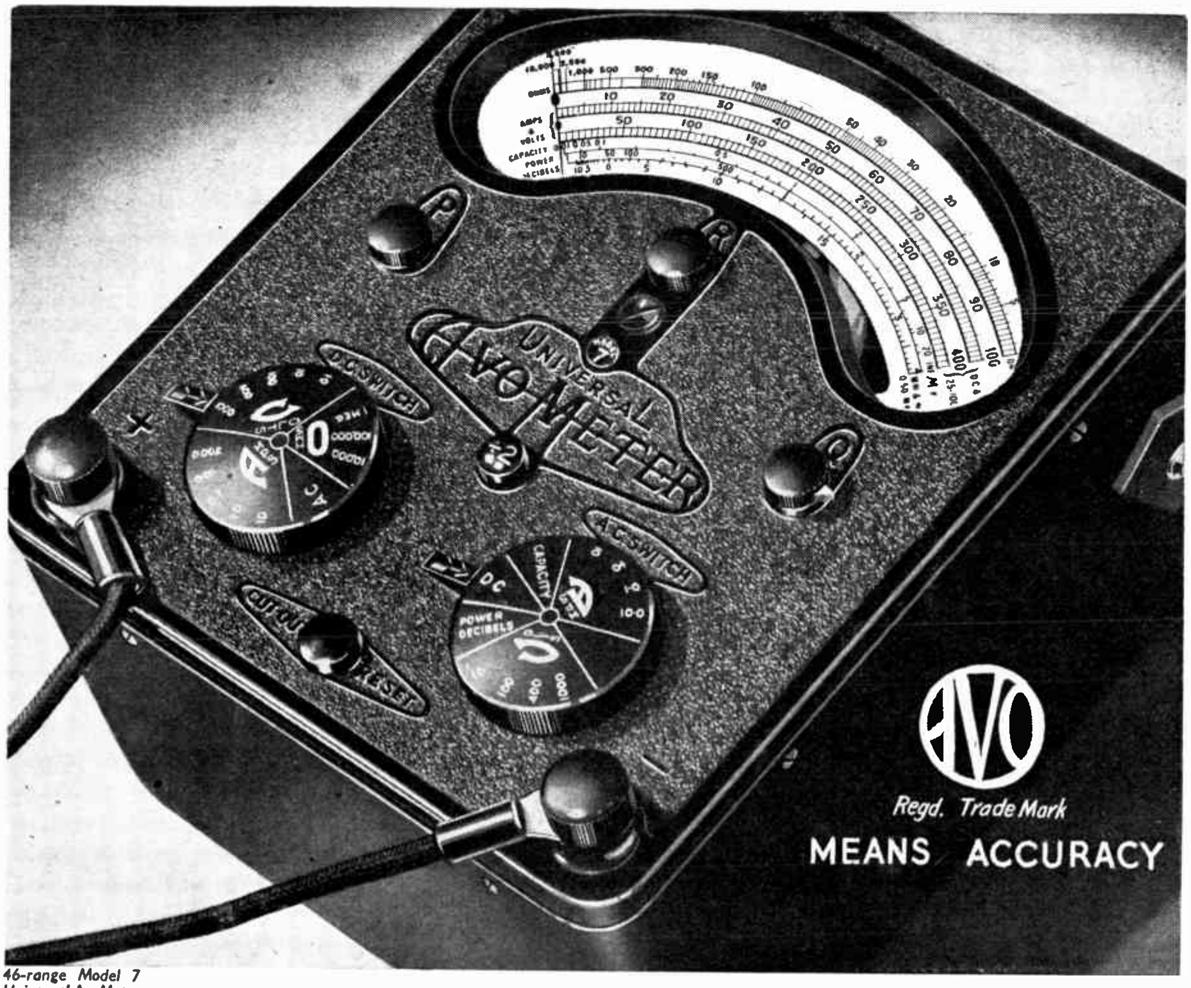
A limited number of "Quick Reference" STANDARD VALUES charts at 3d each is available from manufacturers of Fixed Composition Resistors to those engaged in work of National Importance.

Issued under the Authority of

INTER-SERVICE COMPONENT MANUFACTURERS' COUNCIL

59, Russell Square, W.C.1. Tel: MUSeum 4031-2

FP



46-range Model 7
Universal AvoMeter

The Model 7 Universal AvoMeter (illustrated) is a compact combination electrical measuring instrument of B.S. 1st Grade accuracy. Its 46 ranges cover A.C. and D.C. amperes and volts, resistance, capacity, audio-frequency power output and decibels. No external shunts or series resistances. Protected by automatic cut-out against damage through overload.

Some delay in delivery of Trade Orders is inevitable, but we shall continue to do our best to fulfil your requirements as promptly as possible.

In every sphere of electrical test work . . . in the laboratory, the workshop, the service engineer's bench or "out on a job" . . . the word "AVO" is synonymous with instruments of precision.

The "AVO" range embraces instruments for every essential electrical test. By reason of their reliability and maintained accuracy, even under the most searching of workshop conditions, they are frequently used as a standard by which other Instruments are judged.

Sole Proprietors and Manufacturers:

AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT Co., Ltd., Winder House, Douglas St., London, S.W.1

Telephone: VICtoria 3404/7

WHY ERSIN MULTICORE

the Solder wire with 3 cores of non-corrosive ERSIN FLUX is preferred by the majority of firms manufacturing the best radio and electrical equipment under Government Contracts.

WHY THEY USE CORED SOLDER

Cored solder is in the form of a wire or tube containing one or more cores of flux. Its principal advantages over stick solder and a separate flux are:

(a) it obviates need for separate fluxing (b) if the correct proportion of flux is contained in cored solder wire the correct amount is automatically applied to the joint when the solder wire is melted. This is important in wartime when unskilled labour is employed.

WHY THEY PREFER MULTICORE SOLDER. 3 Cores—Easier Melting

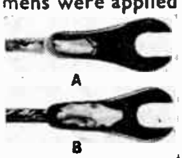
Multicore Solder wire contains 3 cores of flux to ensure flux continuity. In Multicore there is always sufficient proportion of flux to solder. If only two cores were filled with flux, satisfactory joints are obtained. In practice, the care with which Multicore Solder is made means that there are always 3 cores of flux evenly distributed over the cross section of the solder, so making thinner solder walls than single cored solder, thus giving more rapid melting and speeding up soldering.

ERSIN FLUX

For soldering radio and electrical equipment non-corrosive flux should be employed. For this reason either pure resin is specified by Government Departments as the flux to be used, or the flux residue must be pure resin. Resin is a comparatively non-active flux and gives poor results on oxidised, dirty or "difficult" surfaces such as nickel. The flux in the cores of Multicore is "Ersin"—a pure, high-grade resin subjected to chemical process to increase its fluxing action without impairing its non-corrosive and protective properties. The activating agent added by this process is dissipated during the soldering operation and the flux residue is pure resin. Ersin Multicore Solder is approved by A.I.D., G.P.O., and other Ministries where resin cored solder is specified.

PRACTICAL SOLDERING TEST OF FLUXES

The illustration shows the result of a practical test made using nickel-plated spade tags and bare copper braid. The parts were heated in air to 250° C, and to identical specimens were applied ½" lengths of 14 S.W.G. 40/60 solder. To sample A, single cored solder with resin flux was applied. The solder fused only at point of contact without spreading. A dry joint resulted, having poor mechanical strength and high electrical resistance. To sample B, Ersin Multicore Solder was applied, and the solder spread evenly over both nickel and copper surfaces, giving a sound mechanical and electrical joint.



ECONOMY OF USING ERSIN MULTICORE SOLDER

The initial cost of Ersin Multicore Solder per lb. or per cwt. when compared with stick solder is greater. Ordinary solder involves only melting and casting, whereas high chemical skill is required for the manufacture of the Ersin flux and engineering skill for the Multicore Solder incorporating the 3 cores of Ersin Flux. However, for the majority of soldering processes in electrical and radio equipment Multicore Solder will show a considerable saving in cost, both in material and labour time, as compared either with stick solder or single cored solder. Cored solder ensures that the solder and flux are put just where they are required, and by choice of suitable gauge, economy in use of material is obtained. The quick wetting of the Ersin flux as compared with resin flux in single core resin solder ensures that with the correct temperature and reasonably clean surface, immediate alloying will be obtained, and no portions of solder will drop off the job and be wasted. Even an unskilled worker, provided with irons of correct temperature, is able to use every inch of Multicore Solder without waste.

ALLOYS

Soft solders are made in various alloys of tin and lead, the tin content usually being specified first, i.e. 40/60 alloy means an alloy containining 40% tin and 60% lead. The need for conserving tin has led the Government to restrict the proportion of tin in solders of all kinds. Thus, the highest tin content permitted for Government contracts without a special licence is 45/55 alloy. The radio and electrical industry previously used large quantities of 60/40 alloy, and lowering of tin content has meant that the melting point of the solder has risen. The chart below gives approximate melting points and recommended bit temperatures.

ALLOY Tin Lead	Equivalent B.S. Grade	Solidus C.°	Liquidus C.°	Recommended bit Temperature C.°
45/55	M	183°	227°	267°
40/60	C	183°	238°	278°
30/70	D	183°	257°	297°
18.5/81.5	N	187°	277°	317°

VIRGIN METALS—ANTIMONY FREE

The wider use of zinc plated components in radio and electrical equipment has made it advantageous to use solder which is antimony free, and thus Multicore Solder is now made from virgin metals to B.S. Specification 219/1942 but without the antimony content.

IMPORTANCE OF CORRECT GAUGE

Ersin Multicore Solder Wire is made in gauges from 10 S.W.G. (.128"—3.251 m/ms) to 22 S.W.G. (.028"—.711 m/ms). The choice of a suitable gauge for the majority of the soldering undertaken by a manufacturer results in considerable saving. Many firms previously using 14 S.W.G. have found they can save approximately 33 1/3%, or even more by using 16 S.W.G. The table gives the approximate lengths per lb. in feet of Ersin Multicore Solder in a representative alloy, 40/60.

S.W.G.	10	13	14	16	18	22
Feet per lb.	23	44.5	58.9	92.1	163.5	481

CORRECT SOLDERING TECHNIQUE

Ersin Multicore Solder Wire should be applied simultaneously with the iron, to the component. By this means maximum efficiency will be obtained from the Ersin flux contained in the 3 cores of the Ersin Multicore Solder Wire. It should only be applied direct to the iron to tin it. The iron should not be used as a means of carrying the solder to the joints. When possible, the solder wire should be applied to the component and the bit placed on top, the solder should not be "pushed in" to the side of the bit.

ERSIN MULTICORE SOLDER WIRE is now restricted to firms on Government Contracts and other essential Home Civil requirements. Firms not yet using Multicore Solder are invited to write for fuller technical information and samples.

MULTICORE SOLDERS LTD., BUSH HOUSE, W.C.2. 'Phone Temple Bar 5583/4

From the fiery FURNACES . . .

. . . of Britain's factories, from her shipyards and laboratories and mines has come many an invention, many a discovery that has changed the course of history. We search for and hold fast to whatever good we can. We know full well that by perseverance only shall we blot out hatred and destruction, misery and hardship and emerge with a fierce determination to make the world a better, safer place. It is our wish always to be associated with that spirit of true comradeship which shall be continued on through happier days.

DUBILIER
CONDENSER CO. (1925) LTD.

C.R.C.162

◆ LINAGLOW LIMITED ◆

SPECIAL PURCHASE

of the entire stock of a well-known accumulator hire service, due to premises being taken over by Government Department. We offer, in used condition, as new

C.A.V. 60 volt H.T. ACCUMULATORS

in strong carrying case, with handle. Pre-war price over 70/- each. Unrepeatable bargain,

25/-

Secure one of these and overcome your battery difficulties.

EVER-READY CAR STARTER BATTERIES, 6 volt, new, in metal container, with carrying handle, **12/6** each, plus tax.

TELSEN Illuminated Disc Drive, will fit any variable condenser, modern silver oxidised escutcheon, **1/9** each.

RADIO CABINETS, walnut veneered, attractive design, dim. 19in. × 12in. × 10in. Dial aperture 5in. × 7in., drilled for tuning, tone and volume controls, **39/6** each.

RADIO CABINETS, walnut veneered, suitable for extension loudspeaker, dim. 9in. × 7in. × 7in. Bargain, **10/6** each.

.0003 VARIABLE CONDENSERS. 3-gang, ceramic insulation, with trimmers, copper braided connecting strips, ball and gear drive, **12/6** each.

.0003 VARIABLE CONDENSERS, 2- and 3-gang, ceramic insulation, with trimmers, ball drive, **7/6** and **9/6** each.

CLEAR BULBS. 2.5, **15/9** per 100, inc. tax.

OSRAM PILOT BULBS, 6.2 volt, 3 amp. MES Tubular, **1/-** each, including tax.

LISSEN R.C. Intervalve Coupling Units, **1/6**.

COLVERN COIL BASES. 5- and 6-pin, **6d.** each.

GLASS RADIO FUSES. Spring clip, bakelite base, 1-5 amp., **1/-** each.

L.F. INTERVALVE TRANSFORMERS. Heavy laminations. Exceptionally well made. Ratios 4 : 1, **3/6** each.

PHILIPS WIRE WOUND POTENTIOMETERS, with switch, **1/6** each.

PHILIPS EXTENSION LOUDSPEAKER SWITCH, mounted on metal bracket, **1/6** each.

TUBULAR PAPER CONDENSERS, 350-500 v., D.C. working. .00005, .0001, .0003, .0006 mfd., **4/-** doz.; .001, .0015, .002, .003, .004, **6/-** doz.; .01, .025, .03, .05 mfd., **7/-** doz.; .08, .1 mfd., **12/-** doz.; .15, .2, .25, .3 mfd., **15/6** doz.; .5 mfd., **18/-** doz.; or Assorted Parcel of 50 for **27/6**. Minimum orders, 1 doz. any type.

BAKELITE TUNING KNOBS. Brown and Black, 0-180°, 3" dia., 2 BA. fixing, finest quality, **9d.** each.

The Directors of Linaglow Ltd.

offer their apologies for the delay in handling orders. This is due entirely to shortage of staff. Orders are being dealt with in strict rotation and will be delivered as speedily as possible.

● NOTE.—POST ORDERS ONLY ●

All orders C.O.D. or Cash with Order, carriage paid. We cannot hold ourselves responsible for goods damaged or lost in transit.

—ONLY A FEW LEFT !—

5-V. ALL-WAVE SUPERHET CHASSIS.

Complete with

VALVES & SPEAKER

DE LUXE LATEST MODEL

Brief Specification :

Wave Band coverage 18m. to 2,000 metres, 5 watts output. Large 6in. Glass Dial. Separate tone and volume controls. Extremely good selectivity and sensitivity. Really "Hot" on Short Waves. Heavy gauge Steel Chassis. Moving Coil Speaker. Provision for extension Loudspeaker and Pick-up.

£14 . 15 . 0

ALSO SIMILAR TO ABOVE BUT WITH

PARAPHASE PUSH/PULL OUTPUT 7-VALVE CIRCUIT

£19 . 10 . 0

Above prices include Purchase Tax

10-WATT P.A. AMPLIFIER

pre-war manufacture, exceptionally well built, finest quality components. 100/250 volt A.C. Amplifier in portable carrying case with space for gramophone motor, 10" Rola Energised Loudspeaker, with long circular rubber connecting cable and plug in separate carrying case. Worth 30 guineas. Bargain,

£19 . 10 . 0

SILVER MICA CONDENSERS. Flat Wire End—Assorted and Useful Values, **17/6** per 100 (not more than 5 alike).

I.F. AND AERIAL TRIMMERS. 12 Assorted and Useful Values for **2/6**.

L.F. CHOKES. 20 hys. 100 m.a., brand new, **16/9**; 40 hys. 100 m.a., brand new, **21/-**.

LOUDSPEAKER FRETS, coppered brass, 8½" × 7", **3/6**; 10" × 16", **10/6** each.

VOLUME CONTROLS, 100,000 ohm, ¼, ½, 1 and 2 meg. without switch, long spindle, **4/9**. As above, with switch, **6/9** each.

VOLUME AND TONE CONTROLS, with and without switch—suitable for all well-known makes of radio. 6 assorted and useful values for **£1 7s. 6d.**

FIXED WIRE WOUND RESISTORS. Wire Ends. 4-watt (500, 1,000, 3,000, 4,000 and 5,000 ohm only), **110/-**; 10-watt (800 ohm only), **150/-** per 100. Minimum orders 12 of any value.

FIXED CARBON RESISTORS. Wire Ends. Assorted and Useful Values. ¼-watt, **24/-**; ½-watt, **30/-**; 1-watt, **36/-**; 2-watt, **55/-** per 100. Minimum orders 50 assorted. Assorted parcel for **£3.** Contains 25 ¼-watt, 50 ½-watt, 50 1-watt, 25 2-watt, 10 3-watt.

HEAVY DUTY WIRE WOUND RESISTORS. Copper Ends. 15-watt, 17,500/47,500 ohm, **3/6** each; 25-watt, 250/70,000 ohm, **5/6** each; 50-watt, 17,500/35,000 ohm, **7/-** each.

TAPPED WIRE WOUND RESISTANCES. Special Offer. 25-watt, 375 ohm, tapped 125 and 250, **6/6** each.

LINAGLOW LIMITED, *'Phone : Mountview 9432* **3, HAMPSTEAD LANE, LONDON, N.6**

SIGNALLING EQUIPMENT LTD

Specialists in Morse Equipment

also makers of Small Transformers, Coil Windings, Small Bakelite Mouldings, Turned Parts, Light Pressings, and other components and accessories for the Wireless and Electrical Trades

Merit House, Southgate Road, Potters Bar

'Phone : Potters Bar 3133
Telegrams & Cables : SEL, POTTERS BAR

BASICALLY BETTER...

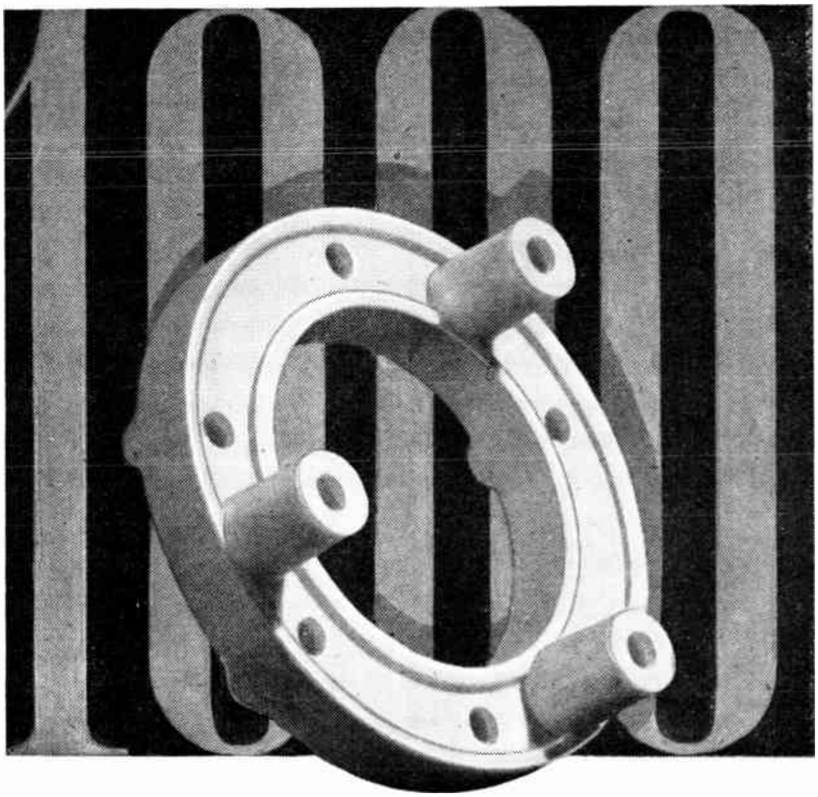
Air Insulation is the basic principle of

CO-AX

LOW LOSS CABLES

Unequalled H.F. PROPERTIES

TRANSRADIO LTD. Inc. TELEQUIPMENT CO. 16 HIGHWAY. BEACONSFIELD.



ONE IN A THOUSAND

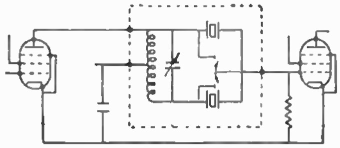
Ten years ago we introduced the first British-made low-loss ceramic. Today the range of FREQUENTITE components covers more than a thousand pieces of every shape and size.

With such a store of manufacturing experience we are able to offer advice backed by practical knowledge on your insulation problem. Please consult us before you finalize your design.

STEATITE & PORCELAIN PRODUCTS LIMITED

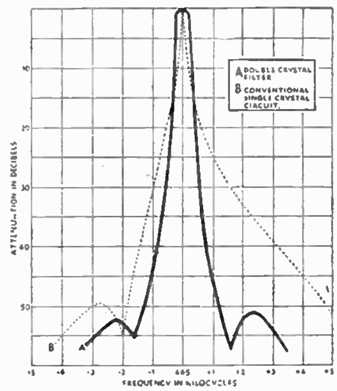
Head Office: Stourport-on-Severn, Worcs. Telephone: Stourport 111. Telegrams: Steatain, Stourport

SP.17



BAND-PASS FILTER CIRCUIT

Above is shown the fundamental circuit similar to that employed in the Eddystone 358X receiver. When in circuit the band-width is 300 c/s, front panel control allowing optional use of normal I.F. selectivity, band-width 5 Kc/s.



SELECTIVITY CURVE "A"

shows the steep sides and flattened top response curve of the Band-pass Filter. Compare the normal crystal gate (Curve B) with its typical sharp peak necessitating constant tuning adjustment with the slightest signal frequency variation. Note the symmetrical rejection given by Curve "A" as opposed to the uneven tail effect of Curve "B."

In the 358X version of this famous receiver a Band-pass Crystal circuit is employed giving high selectivity and complete rejection of unwanted adjacent signals. Furthermore the double crystal circuit avoids the extreme "peaked" effect of the conventional crystal gate, allowing easier tuning and accommodating some frequency drift of the wanted signal. These advantages are readily appreciated by operators familiar with the hair-breadth tuning of the normal filter.

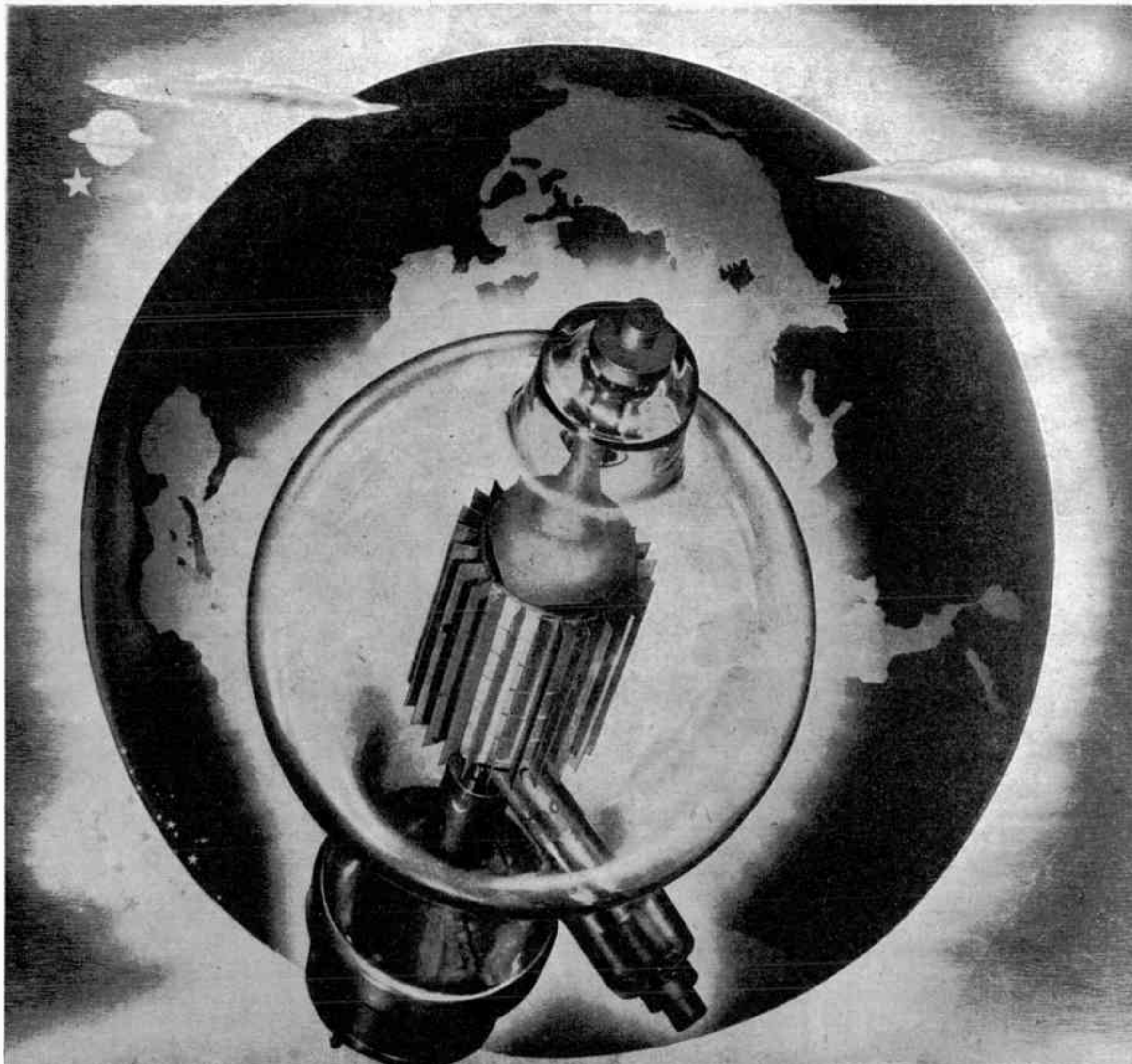
The "358X" may be inspected at 14, Soho Street, preferably by appointment.

EDDYSTONE COMMUNICATION RECEIVERS ARE AVAILABLE ON PRIORITY ORDER ONLY.

WEBB'S RADIO

Hours of Business 9 a.m.—5 p.m. Saturdays 9 a.m.—12 noon.

14, SOHO ST. OXFORD ST. LONDON, W.1. Telephone. GERRARD 2089



MEMO

From: MASTERADIO LTD., WATFORD, HERTS

To: **DEPARTMENTAL HEADS, RESEARCH ENGINEERS, LIAISON OFFICERS**

Subject: DEVELOPMENTS CONCERNING VIBRATOR-OPERATED EQUIPMENT

Analysis of past design methods reveals two essential requirements. These are:

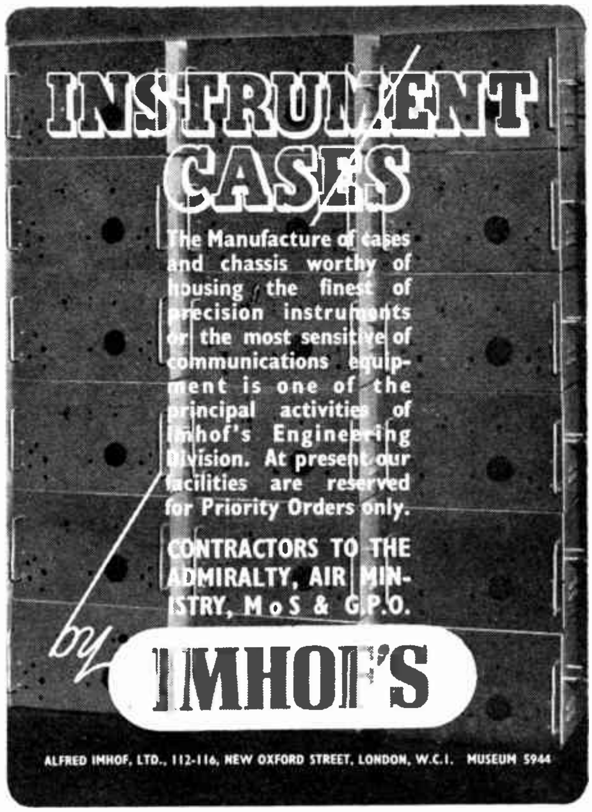
Elimination of the "D.C. minded" planning, with which many have struggled.

Careful consideration of sensitivity characteristics outside the normal range of the basic design.

Synthesis from a nucleus thus prepared is always successful.

We invite you to accept our co-operation

Masteradio



DAGENITE

AND

PERTRIX

—the dependable

BATTERIES

FOR RADIO, CARS MOTOR CYCLES COMMERCIAL VEHICLES ETC.

Sales Concessionaires:

HOLSUN BATTERIES LIMITED

137 Victoria Street, London, S.W.1

Electronic Engineering Services, Ltd.

24 STANLEY ROAD HEATON MOOR
STOCKPORT
TELEPHONE HEATONMOOR 3107

FOR

AMERICAN EQUIPMENT

WE WELCOME ENQUIRIES FOR ANY OF THE FOLLOWING. REASONABLY QUICK DELIVERY AGAINST GOOD PRIORITY.

STATIONARY TRANSMITTERS: A WIDE RANGE IS AVAILABLE, BOTH A.M. & F.M., ALSO CAR & AIRBORNE TRANSMITTER-RECEIVERS.

INSTRUMENTS: TRANSIENT ANALYSERS, DIRECT-INKING OSCILLOGRAPHS.

COMPONENTS: GANGED R.F. SWITCHES, SPECIFICATION TRANSFORMERS, SENSITIVE TYPE RELAYS, MIDGET VALVES & PARTS.

GENERAL: THROUGH OUR AMERICAN ORGANISATION WE CAN HELP IN LOCATING SOURCES OF SUPPLY FOR SPECIAL REQUIREMENTS UNOBTAINABLE IN THIS COUNTRY.

STABILITY

UNITED INSULATOR Cº Lᵀᴰ

12-20 LAYSTALL ST., LONDON, E.C.1

Telephone : TERminus 7383 *Telegrams : Calanel, Smith, London*

The Pioneers of low-loss Ceramics

B.I.

RADIO MATERIALS

We have had a long experience in the manufacture of all kinds of Cables and Wires, Static Condensers, Insulators and Ironwork, Telephone Cords and Copper Earthing Rods, for Radio use.

U.K. Regd. Trade Mark.

BRITISH INSULATED CABLES LTD.,

Cable Makers and Electrical Engineers

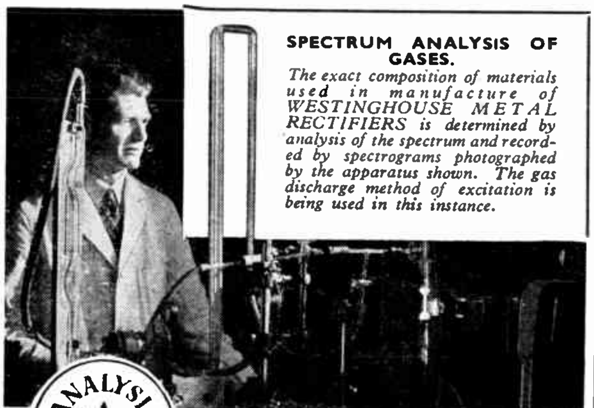
Head Office : PRESCOT, LANCS. *Tel. No.*: PRESCOT 6571

TUNGSRAM VALVES

Our production of Radio Valves is both large and continuous. So, too, is the demand for them for urgent purposes. Some are available for domestic use, but the range is necessarily limited. You may be assured of our willing help whenever possible.

Announcement of

BRITISH TUNGSRAM RADIO WORKS LTD., WEST RD., TOTTENHAM, N.17



SPECTRUM ANALYSIS OF GASES.

The exact composition of materials used in manufacture of WESTINGHOUSE METAL RECTIFIERS is determined by analysis of the spectrum and recorded by spectrograms photographed by the apparatus shown. The gas discharge method of excitation is being used in this instance.

ANALYSIS

In spite of greatly increased production we are unable to supply Westinghouse Rectifiers as freely as we would wish. We hope customers will understand and accept our assurance that the constant research now going on in our laboratories and designing departments is resulting in Rectifiers of remarkably advanced design which will be available after the war.

Westinghouse Rectifiers

WESTINGHOUSE BRAKE & SIGNAL CO., LTD.
PEW HILL HOUSE, CHIPPENHAM, WILTS.

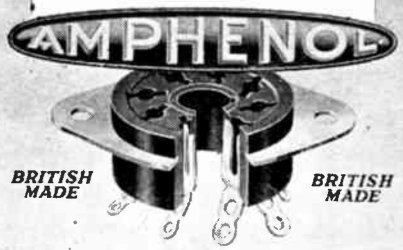
CELESTION

VALVEHOLDERS

Manufactured under "Amphenol" Licence

Preferred by radio engineers because of their Strength, Efficiency and Uniform Contact

Send for List of English and American types.



CELESTION LTD.
(Engineers),
KINGSTON-UPON-THAMES, SURREY.
Telephone: KINgston 5656-7-8.

Wartime installations show more conclusively than ever that

you can *trust* TRIX

30-watt Amplifier with Radio.

Quality SOUND Equipment

To priority order only

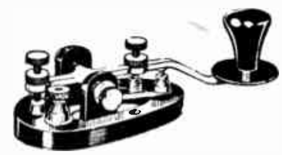
There are TRIX amplifiers from 5-500 watts.
Send for details.

TRIX ELECTRICAL CO. LTD., 65, Bolsover St., London, W.1.
'Phone: EUS 5471/2. 'Grams: Trixadio, Wesdo, London.

Improve your Keying!

Correct spacing and high sending speeds are more quickly obtained by those operators who exercise sound judgment when purchasing their KEYS.

Scientific weight distribution, rigidity of construction, extreme lightness in action, heavy silver contacts and a high grade spring for accurate gap adjustment; these are the most important features, and, they are all to be found in the ***Raymart "Speed" Key.*** It combines all that is best in British and American key design.



This British-made Key is definitely the finest value ever offered to the public. Choose the ***Raymart "Speed" Key.*** It will give you full satisfaction and years of useful service.

Price **8/6** Post Paid.

SPECIAL NOTE:
WIRE-WOUND POTS. Refer to our advertisement on page 18 of the January issue, and then note that we only have *a small number* of 20,000 ohm (4/- each) and 5,000 ohm (3/- each) types still available. These are 5-watt American C.T.S. wire-wound Volume Controls.

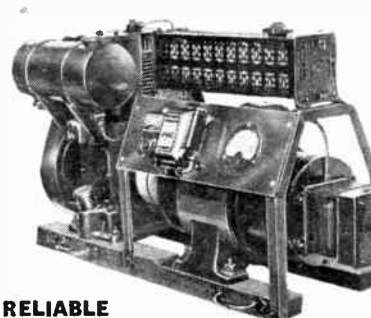
RAYMART
CRAFT A CREED

Please add postage on all orders valued 5/- or less.

Send stamped, addressed envelope with all enquiries.

Telephone: MIDLAND 3254
48 HOLLOWAY HEAD, BIRMINGHAM, I

BRIMAIN
POWER UNITS (Regd.)



Priority orders only.

AS RELIABLE AS THE MAINS

V.S.3
230 A.C.
1.25 K.V.A.

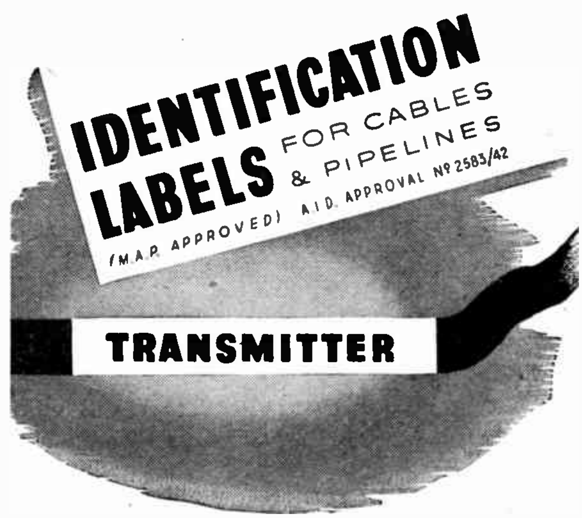
The V.S.3 is a compact, sturdily built Petrol Electric Generator, produced specially for 16mm. film projection where constant voltage must be maintained and light load surge eliminated. The output of 1.25 K.V.A. is amply sufficient for standard 16mm. projectors. Fitted with handles and spring bolts, the V.S.3 is instantly detachable and can be removed in a matter of seconds from the light van in which it would travel for mobile work.

UNITS BUILT TO SPECIAL REQUIREMENTS

Designers and constructors of
MOBILE CINEMAS for indoor and outdoor displays

BRITISH FILMS LIMITED

Head Office: 199 PICCADILLY, LONDON. *Regent 2828*
Works: 260 HIGH ROAD, BALHAM, LONDON. *Battersea 8506*



Indelibly printed on white or coloured fabric for use in conjunction with transparent adhesive tape.

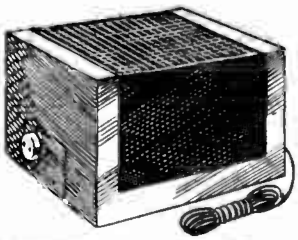
• *Guaranteed 2/3 day delivery service.*

P. P. PAYNE & SONS LTD.

HAYDN ROAD NOTTINGHAM *Phone:* 64335
BUSH HOUSE LONDON *Phone:* TEMple Bar 6356

● FOR RADIO **LONDON CENTRAL RADIO STORES** BARGAINS ●

CLARKE'S ATLAS A.C. to D.C. CONVERTERS



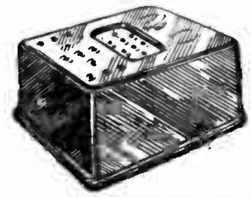
Type R.M. 80/150

Input: 230v. A.C. 50~
Output: 80, 100, 120, 150, m.a. at 230v. D.C. Incorporating Westinghouse Metal Rectifier. In strong steel case, well ventilated.
Price **5 Gns.**

Post. and packing 3/6 extra.

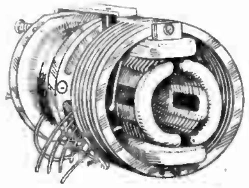
SUPREMUS H.T. BATTERY ELIMINATORS

Model E25A *for* **200-250v. A.C. 40-100~**



Tappings, 40, 60, 80, SGH, 100, SGL, 125v. These well-known H.T. Mains Supply Units are fitted in handsome bakelite cases. Here is an opportunity for battery set owners, who have A.C. mains current available, to be independent of the battery situation. Owing to post and rail conditions these are available TO CALLERS ONLY. Price **70/-**

PHILIPS SCANNING & DEFLECTOR COILS



Assembled complete in metal frame, as illustrated **7/6**
Post. & pkg. 1/1 extra.

ELECTRIC SOLDERING IRONS

200/250 v. 75 watts. Post., etc., 8d. extra **12/6**

OAK VIBRATOR UNITS

— Synchronous —

These well-known Units are fitted with 6-pin American bases. Input 6 volts. **15/6**
Post. & pkg. 8d. extra.

PIEZO-CRYSTAL *Hand — Table* MICROPHONES

See December issue for details. Post., etc., 2/- extra. **82/6**

EX.-GOVT. JACKS

These Jacks have powerful phosphor-bronze springs ensuring a perfect contact. Overall length, including ½in. threaded shank, 3½in. Supplied with nut for panel mounting. Post., etc., 3d. extra ... ... Each **3/6**

ON-OFF TOGGLE SWITCHES

Finest quality. Turn movement. 1¾in. spindle. Post., etc., 3d. extra. **2/6**

CONDENSERS with Bakelite Insulated Terminals

2.5 + 2.5 + 1 mfd. 250v., D.C. wkg. ... 6/6
2 mfd. 400v., D.C. wkg. 7/6
4 mfd. 250v., D.C. wkg. 9/6
Post. & pkg. 6d. extra.

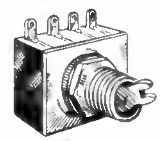
Side Contact Valve Holders

8 contacts. Post., etc., 3d. extra. Each **1/6**

T.C.C. Condensers

0.1 mfd. 5,000 v., D.C. wkg. Post., etc., 8d. extra. Each **9/6**

TWIN ON-OFF SWITCHES



As illustrated. Carries 1.5 amp. at 250v. Well and strongly made, with excellent snap action ... Price **4/6**
Post., etc., 3d. extra.

6 PUSH-BUTTON MECHANISM only UNIT

Complete with buttons. Post., etc., 9d. extra **4/6**

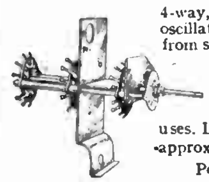
SPEAKERS

ROLA 5in. P.M., less transformer **22/6**
Post. and pkg. 1/6 extra.
CELESTION 8in. P.M. Pentode Output. New **25/6**
Post., etc., on above 2/- extra.
PHILCO 12in. Double Cone 4,000 ohms field, 5 ohms Speechcoil **5 Gns.**
Carr. 3/-, plus 5/- for packing case (returnable).

PHILCO BLEEDER RESISTANCES

In metal cans. 100, 150, 250 ohms. All 10 watts ... ... Each **2/6**
Post., etc., 3d. extra.

YAXLEY Type WAVE-CHANGE SWITCHES



4-way, 3-bank, with shielded oscillator section. Length from stop plate approx. 5in., spindle 2in. ... **5/6**
5-way, 6-bank, with 3 screened sections, adaptable to many uses. Length from stop plate approx 6½in., spindle 2in. **6/6**
Post., etc., 9d. each.

CHASSIS

Drilled for 9 valves, also rectangular hole 6¼ × 2¼in. Size 16¾ × 9½ × 2in. **3/6**
Also 11½ × 9½ × 2¼in. and 11½ × 7 × 2¼in. **3/6**
12 × 9 × 3in., drilled for 10v., transformer, etc. **5/6**
Post., etc., 10d. extra.

Screened Cable

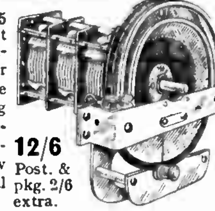
Fine quality, heavy duty, 15 strand, 30 gauge, 5mm. rubber covering, with two layers of Empire tape. ... **1/9** per yard

Rubber Covered Flexible Wire

Tinned copper, approx. 17 strands, 9ft. lengths **3d.** per yard

NO C.O.D.
NO PRICE LISTS
NO PRO-FORMA INVOICES

TUNING CONDENSERS

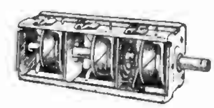


3-gang, 0.0005 mfd. without trimmers, designed for motor drive. With large diameter driving disc and reduction gear, adaptable for slow motion manual drive. **12/6** Post. & pkg. 2/6 extra.

PHILIPS POTENTIOMETERS

Carbon: 700,000 ohms, less switch **3/6**
100,000 ohms, with 2-pole M. & B. switch **4/6**
Wire-wound: 450 ohms and 10,000 ohms **6/6**
Post. & pkg. 6d. extra.

PHILIPS CONCENTRIC SPIRAL VANE VARIABLE CONDENSERS



3-Gang 0.0005 mfd. without trimmers. As used in Philips well-known Push-Button receivers.
Price **4/6** Post. & pkg. 9d. extra

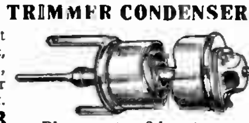
PHILIPS WET ELECTROLYTICS

50 mfd. 310v. working **9/6**
Post. & pkg. 9d. extra.

MULLARD EA50 DIODES

60 mm. × 12 mm. overall. 6.3v. heater at 15 amp. ... .. Each **10/6**
Post. & pkg. 3d. extra.

PHILIPS TRIMMER CONDENSERS

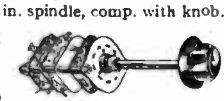


Non - drift air dielectric, 60 mmfds., suitable for S.W. work.
Price **1/3** Plus post., 3d. extra.

YAXLEY PATTERN SWITCHES

5-way, single-bank, with on-off mains switch, carrying 1 amp. at 250v., 2in. spindle with knob **5/6**
3-way single-bank, 1in. spindle with knob **2/9**
Post., etc., 6d. extra.

Oak Switches, 2¼in. spindle, comp. with knob.



4-way, 2-bank with connecting block ... **4/6**
4-way, 2-bank **3/9**
Post., etc., 6d. extra.

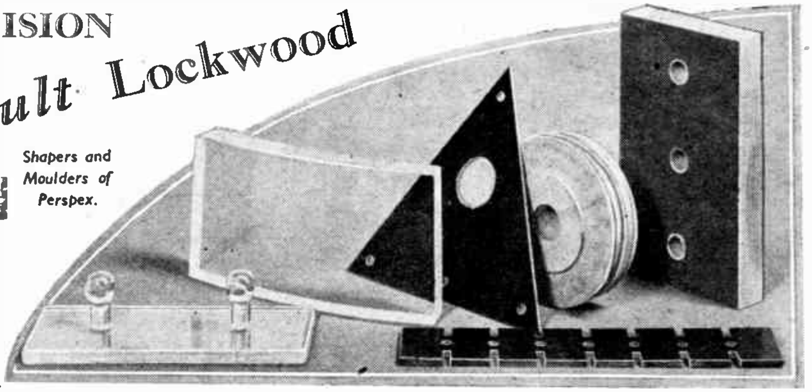
TUBULAR CONDENSERS

0.5 mfd. 500 v. wkg. Post., etc., 4d. **2/6**

LONDON CENTRAL RADIO STORES, 23, LISLE ST. *GERrard 2969* **LONDON, W.C.2**

B

If you want PRECISION *work in Wood or Plastics* *consult* Lockwood



Shapers and Moulders of Perspex.

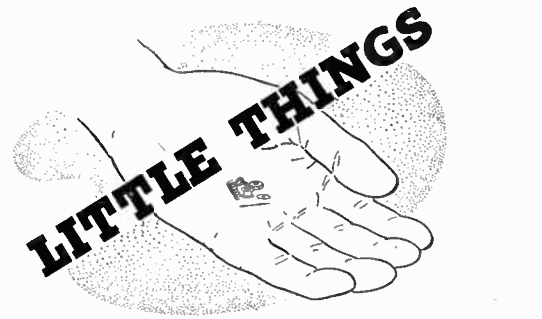
MANUFACTURERS OF FITTED INSTRUMENT CASES IN WOOD AND PLASTICS
PRECISION WORK IN BAKELITE SHEET, DELARON, PAXOLIN AND POLYSTYRENE etc.

LOCKWOOD & CO.
HARROW • MIDDLESEX

Bargains in radio COMPONENTS...

Battery Eliminators, in strong welded all-steel cases, 60v. and 120v. at 20 m/a. For A.C. mains, 200/250v....	2	5	0
Battery Chargers, in strong all-metal case. 2, 6 and 12v. at 1 amp. For A.C. mains, 200/250	2	5	0
Loud Speakers, 8in. P.M. (less transformer)	1	1	0
,, ,, In beautiful de-luxe polished walnut cabinet	3	5	0
,, ,, Industrial type in cabinet, 8in. P.M. in grey enamelled case with 2,500 ohm transformer	2	7	6
,, ,, 24in. Projection type, square horn, 6-watt unit	5	17	6
Moving-coil Microphones, high quality, with chrome case...	5	5	0
Table stand, black crystal-line base and chrome stem	0	19	6
,, ,, Heavy chromium - plated telescopic floor stand ...	2	15	0
Condensers, 8 mfd. Electrolytic 600v. Surge-proof ...	0	8	6
Sistoflex Sleeving, assorted colours, per 12 yd. length ...	0	2	6
Morse Keys, streamlined American type, light action ...	0	4	9
Resin Cored Solder, per lb.	0	4	6
Transformers, Replacement type, Primary 200/250, Sec : 350–0–350 at 80 m/a. 5v. 2a. 6.3v. 3a. C.T., or with 4v. 2a. and 4v. 4a Filament windings	1	1	0
,, Mains Pentode—Output transformers ...	0	6	6
,, Class "B" Intervalve	0	7	0
,, Q.P.P. Intervalve	0	7	6

POSTAL RADIO,
16, KING ST., WOLVERHAMPTON.
★ **Mail Order only.** *Cash with order or C.O.D. All enquiries must be accompanied by stamped addressed envelope.*



...and it's the "little things" that count!

In the final reckoning it's the little things that count. Not only the tangible "little things"—they can readily be seen and appreciated—but the intangible as well. That extra care in the selection of raw materials and components . . . that wider experience in design . . . that little more time spent in assembly . . . that added vigilance in inspection and test . . . these are the intangible "little things" that, plus the tangible, have made many dealers glad they bought and recommended R·S Sound Equipment.

R S *Amplifiers Limited*

3-4, Highfield Rd., Shepperton, Middlesex. *Tel. : Walton-on-Thames 1019*

W.W. 3/43

MAINS TRANSFORMERS.
210/230/250 volts, 50 cycles. 350-0-350 v., 70 m.a. 6.3 v., 1.5 amp. 4 v., 2.4 amp., 25/- each. 200/250 v., 350-0-350 75 m.a., 5 v., 2 amp., 6.3 v., 3 amp., 28/-. 200/250 v. 350-0-350 120 m.a., 5 v., 2 amp., 6.3 v., 3 amp., 37/6. 210/250 v., 6.3 v., 5 amp., 5 v. 2 amp., 350-0-350 75 m.a. Chassis mounting. Shrouded, 39/6 ea. 200/250 v., 4 v. 3 amp., 4 v. 6 amp., 350-0-350, 120 m.a., 39/6 each.

LOUDSPEAKER TRANSFORMERS.
SPECIAL OFFER.
Philco Pentode, 4/6 ; Heavy Duty Pentode, 7/- ; Multi Ratio, 8/- ; Heavy Duty Multi Ratio, 10/6.

ELECTRIC SOLDERING IRONS.
60-watt, with Flex, 200/250 volts, A.C./D.C., Chrome-Plated, best quality, 12/6, tax free.

H. H. LINTON & Co. LTD.
2, HIGHGATE HIGH STREET, N.6
Mountview 9431

CHROME-PLATED ELECTRIC BELLS
with Transformer, A.C. 200/250 volts, supplied with instructions for fitting, 15/6, tax free. WORTH DOUBLE. Do away with that old "Leclanche" cell or dry battery and fit a reliable door bell.

ELECTRIC APPLIANCE LEADS.
6 ft. long, with connector one end for kettle, iron, radio, toaster, etc. Light adaptor or 2-pin plug other end, 5/9 each.
Two-Way Line Cord replacement for Midget Receivers, 7/6.

● **POST ORDERS ONLY** ●
C.O.D. or Cash with Order. Carriage Paid

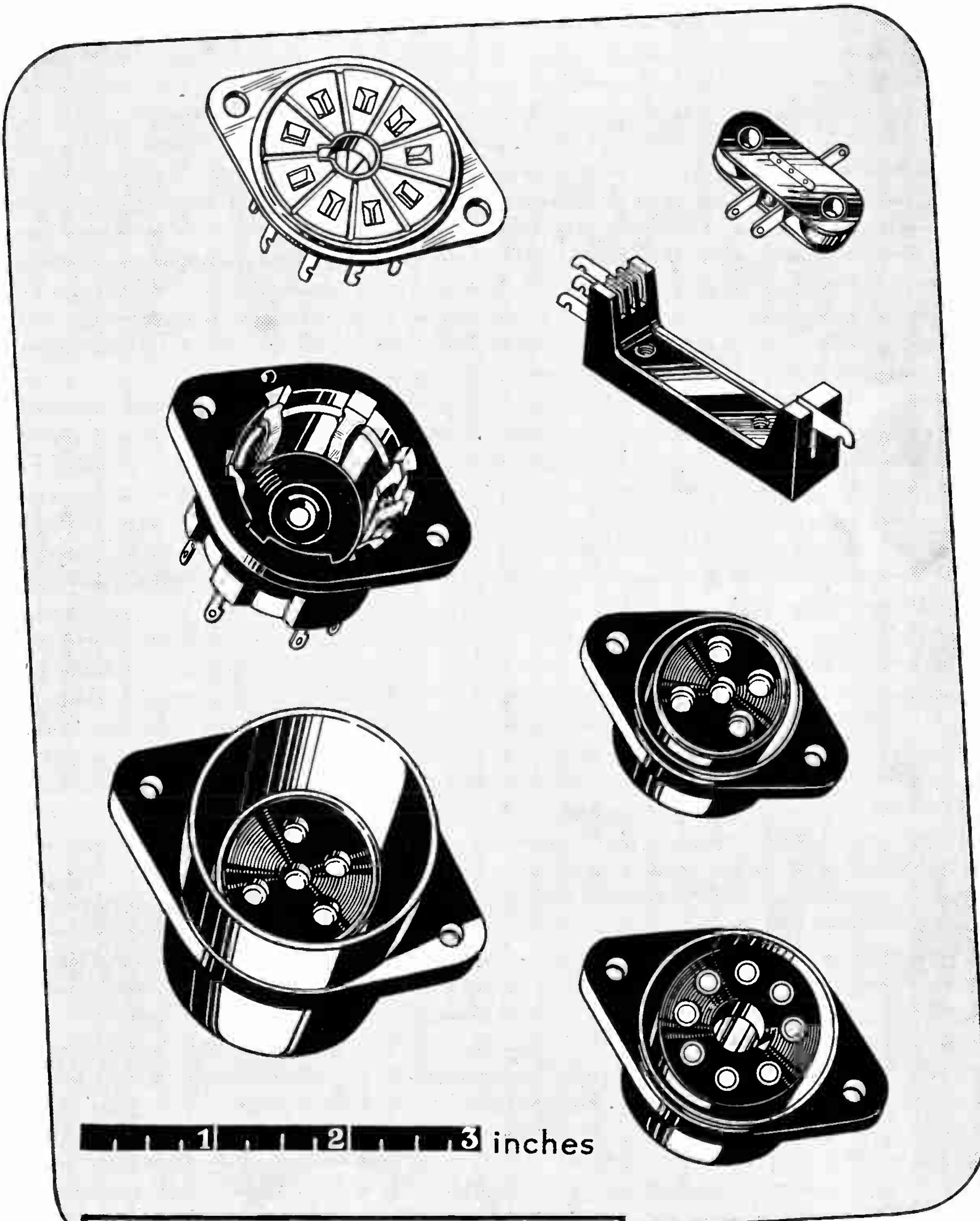
ROLA P.M. LOUDSPEAKERS.
With Transformer, 5in., 22/6 ; 6½in., 25/6 ; 8in., 29/6.
Without Transformer, 5in., 17/9 ; 6½in., 19/9 ; 8in., 24/-. Only a few left.
CELESTION, 8in., P.M., with Transformer, 25/6.
ROLA, 8in., ENERGISED, 2,000 ohm, without Transformer, 27/6.

FIRE BARS WITH ELEMENT.
Flat Type, 200/250 volt, 750 w., 3/9 each.

ROUND TYPE BAR.
With Spiral, 200/250 volt, 750 w., 3/9 each.

BOWL FIRE ELEMENTS.
Edison screw, 600 watt, 5/6 each.

SUNDRIES.
4-way Battery Leads, with wander plugs, best quality, 1/3 each.
Immersion Kettle Elements, 230/250 v., 1,000 watt, 22/6 each.
Iron Connectors, 1/6 each ; 2-pin 5 amp. plugs, 12/- doz. ; Insulating Tape (best quality American), 3/- per lb.



BELLING & LEE LTD
CAMBRIDGE ARTERIAL ROAD, ENFIELD, MIDDX

Wireless World

Radio • Electronics • Electro-Acoustics

32nd YEAR OF PUBLICATION

MARCH 1943

Proprietors :
ILIFFE & SONS LTD.

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

Editor :
H. F. SMITH.

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

Telephone :
Waterloo 3333 (35 lines).

Telegrams :
"Ethaworld, Sedist, London."

△

PUBLISHED MONTHLY

Price: 1/3

(Publication date 25th of preceding month)

Subscription Rate Home and Abroad 17/- per annum.

Branch Offices :

COVENTRY :
8-10, Corporation Street.
Telephone: Coventry 5210.
Telegrams: "Autocar, Coventry."

BIRMINGHAM :
Guildhall Buildings, Navigation Street, 2.
Telephone: Midland 2971 (5 lines).
Telegrams: "Autopress, Birmingham."

MANCHESTER :
260, Deansgate, 3.
Telephone: Blackfriars 4412 (4 lines).
Telegrams: "Iliffe, Manchester."

GLASGOW :
26B, Renfield Street, C.2.
Telephone: Central 4857.
Telegrams: "Iliffe, Glasgow."

△

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

Wireless World

Radio • Electronics • Electro-Acoustics

Vol. XLIX. No. 3 MARCH 1943 Price 1s. 3d.

Battery Shortages

Important Aspect of Broadcast Receiver Maintenance

MUCH publicity has recently been given to the shortage of dry-cell batteries of various kinds, and it has been disclosed that much of the scarcity from which we have suffered during the mid-winter period of "peak" demand has been due to the exceptional requirements of our Forces in North Africa. It would seem that wireless HT batteries have not been quite so scarce as other types; that is understandable, as there is little valid reason why the demand for them should have increased since the outbreak of war. It is easy to understand how the black-out and other wartime causes are responsible for a greatly increased consumption of, for example, torch and cycle-lamp batteries. But there is no doubt that HT batteries are scarce, particularly in some parts of the country, and many listeners without a mains electrical supply cannot keep their sets working.

We regard this matter as of even greater importance than the maintenance of mains-fed broadcast receivers, and consider that those dependent on batteries for news and general wartime information deserve special consideration. Speaking broadly, they are country dwellers, and represent the most isolated section of the community. They are often cut off from other sources of information, and the present restrictions on transport tend to accentuate their isolation.

Standardisation and the reduction of types as an aid to economical production is very much in the news in wireless circles at present; and, as reported elsewhere in this issue, it is proposed in the U.S.A. to use this principle to ensure the continuance of civilian broadcast reception in that country. We understand that some measure of standardisation of HT battery types is already in force here, and, without suggesting that it is likely to prove a panacea for all our troubles, would recommend that all the various possibilities be fully examined. By reducing the present multiplicity of types and sizes, it might be possible to increase production to a worth-while extent.

Of course, the elimination of many of the present types and sizes of batteries would introduce difficulties. For example, a standardised type of battery might not fit into the space available for it in certain types of receiver. But, after $3\frac{1}{2}$ years of war, it hardly seems unreasonable to subject a few set users to the inconvenience of installing a replacement HT battery externally when there is not room for it inside the cabinet. To simplify matters for those with no knowledge of these things, suitably insulated adaptor connections might be supplied for use in such cases. In addition to questions of physical dimensions, there are many others, including those of voltage, intermediate tappings and other matters which complicate the position and make the question of standardisation all the more difficult. The difficulties are enhanced by the lack of skilled service-men to make any minor adjustments that are needed when a replacement battery is fitted.

Foolish Extravagance

When the President of the Board of Trade spoke recently on the battery position, he complained of extravagance in the use of torch and cycle batteries; he might have added wireless HT batteries as well. It is doubtful if we can now afford the luxury of an all-day stream of broadcast entertainment from mains-fed receivers; it is certain that we cannot expect it from battery-fed sets. The general public fails to realise that a battery has a strictly determinate life, and that it is a foolish extravagance, under present conditions, to allow a battery-fed receiver to go on working unless the owner really wants to hear the programme. That, of course, is obvious to readers of this journal, but not, to judge by our own observation, to the ordinary listener. Useful work could be done in emphasising this point, and it is hoped that no opportunity for doing so will be lost. The B.B.C. might broadcast reminders on the subject, and at the same time might stress the evils of hoarding, explaining that to buy a battery not required at the moment is more than unfair; it is apt to be useless from the buyer's selfish point of view.

AMPLITUDE MODULATION UP TO DATE

Improving the Efficiency of Low-powered RT Transmitters

By
O. J. RUSSELL,
B.Sc. (Hons.)

BECAUSE frequency modulation is very much in the limelight these days it must not be thought that technical interest in amplitude modulation is exhausted. In fact, many interesting developments in amplitude modulation systems of high efficiency for small-power transmitters have taken place recently in America and some account of these will no doubt be of interest to readers of this journal.

The first system is termed the cathode modulation system, which shortly before the war was introduced into amateur circles in America, and appears to have been extremely popular. This popularity is no doubt due to the fact that it combines the advantages of both plate and grid modulation.

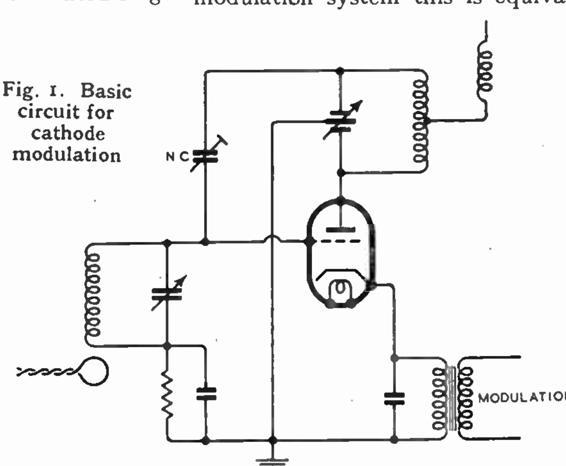
In the normal grid and suppressor grid types of modulation, which are often termed "efficiency modulation" systems, the effect is roughly that the modulated stage runs at a lower efficiency when unmodulated than a normal Class C stage, and operates at a greater efficiency on the modulation peaks, this being obtained in practice by reducing the radio-frequency excitation and increasing the grid bias. Compared with anode modulation, where the radio-frequency excitation may be adjusted for slight overdrive and the plate efficiency may be as high as 75 per cent. or so, the grid modulated stage is not likely to exceed an efficiency of 40 per cent. in converting DC power from the high tension supply into high-frequency power. In other words we may expect to obtain about half the carrier output for the same power input applied to a Class C anode-modulated stage.

However, what is far more serious, is that owing to the lowered plate efficiency, the actual power dissipated by the valve as heat is increased. When running at the limits of rated heat dissipation, the grid modulated stage is capable of much less actual carrier output than an anode modulated stage. Thus, taking the case of a valve rated to dissipate 10 watts as heat, under normal Class C conditions at 75 per cent. efficiency, the actual power input can be 40 watts, with a carrier output of 30 watts of RF energy. A grid-modulated stage dissipating 10 watts with an efficiency of about 40 per cent. would produce at the most about 7 watts of actual carrier output. It should be remembered that a grid-modulated stage dissipates most heat when unmodulated, for then the efficiency is lowest. An anode-modulated stage, on the other hand, only dissipates the maximum power upon the relatively transient modulation peaks. The result is that, although a Class C stage when anode modulated is usually run with slightly lower input than is permissible for telegraphy working, the reduction is not great, for overload only occurs for relatively transient periods. The net result is that the actual carrier power available from an anode modulated stage is of the order of four times the output to be obtained with a grid modulated stage for the same anode heat wastage.

Cathode modulation enables the difficulties inherent in orthodox grid modulation systems to be overcome. As the name implies, the low - frequency modulating impulses are injected into the cathode circuit of the Class C stage as shown diagrammatically in Fig. 1. The cathode circuit may be regarded as common to both the anode and grid circuits. Thus, if the cathode is made more positive with respect to the chassis potential, and hence with respect to the grid potential, the effect is an increase in the negative grid bias with the result that the anode current falls. However, as the cathode swings more positive with respect to the chassis, the effective anode-to-cathode potential is reduced, as the anode is held at a fixed positive potential above the chassis. This has the effect of lowering the effective value of the anode-to-cathode voltage, which is equivalent to a reduction in the total high-tension potential applied. This results also in a fall in anode current.

When the cathode is swung more negative by the modulating waveform the conditions are reversed, and both the resulting grid and anode voltage swings tend to increase the anode current. Thus the modulating signal when applied to the cathode circuit results in voltages appearing on both the anode and grid which are in phase. As there is a certain amount of anode modulation produced some power is actually supplied by the modulator to the anode circuit, although this is much smaller than the amount supplied by a normal anode modulator. In the cathode modulation system this is equivalent to only about 20 per cent. to 30 per cent. of actual anode modulation, the remaining 70 per cent. to 80 per cent. of the modulation

Fig. 1. Basic circuit for cathode modulation



depth is supplied by the grid modulation that is also produced by the cathode-applied modulation. Consequently if we swing up to full plate efficiency at a point that corresponds to 70 per cent. to 80 per cent. modulation, our plate efficiency when not modulating is higher than with straight grid modulation, and may approach 60 per cent. or so.

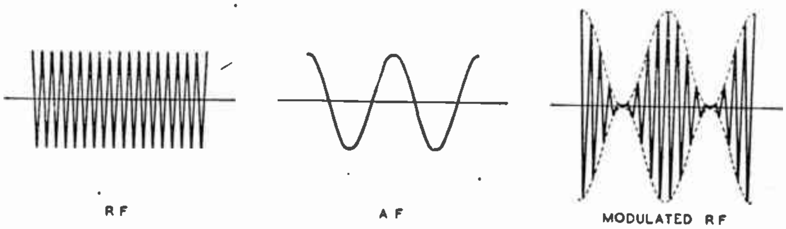


Fig. 2. An old friend—100 per cent. sine wave amplitude modulation

This means that employing our hypothetical valve with a rated dissipation of 10 watts we can for now obtain a carrier output of about 15 watts as compared with the permissible 7 watts when operating with grid modulation, and the 30 watts obtained with anode modulation. Owing to the greater efficiency we are not far short of anode modulation conditions in this respect. In other words, assuming we are limited to a 10-watt *actual power input* to our final amplifier stage, an anode modulated stage might give about 8 watts of actual RF power, a cathode-modulated stage 6 watts, while the grid-modulated stage would give about 3 to 4 watts.

Circuit Economies

The radio-frequency drive power required for the cathode system is about the same as that for a normal Class C telegraphy stage, or rather less than the requirements for a plate-modulated stage. Also, the cathode-modulated amplifier has a lower peak plate current than with anode modulation, which results in longer valve life. The peak plate voltages are also reduced, so that the tank tuning condenser need have only two-thirds of the spacing required for a comparable plate-modulated stage. The actual audio power requirements are about a quarter of the requirements for anode modulation. Thus, we may use a small output pentode giving 5 watts of audio to modulate an RF amplifier stage having an input of up to 50 watts, with a carrier output only a little less than with normal anode modulation.

Cathode modulation would therefore appear to be an ideal solution of the problem of obtaining grid modulation having an efficiency not greatly inferior to anode modulation. It must be remembered that the idea of simultaneously applying modulation to both the anode and grid circuits is not new. However, by applying the modulation into the cathode circuit an elegant solution of the problem is obtained. It is also claimed that by its use modulation depths of 200 per cent. to 300 per cent. may be obtained without overloading the transmitter.

To see how this is achieved let us briefly consider the process of modulation. Fig. 2 represents the high-frequency carrier, a sine wave modulation signal and a resulting carrier just modulated to a depth of 100 per cent. As has been explained in countless writings on the subject, for 100 per cent. modulation the carrier wave is reduced to zero on the negative peaks of the modulating wave, and swings up to twice its unmodulated value on the positive peaks. If we assume we are anode-modulating a perfect Class C amplifier stage, where the amplitude of the RF voltage output varies directly and linearly with the value of applied anode potential, then our modulating signal must swing the anode voltage to zero on the negative peaks, and to double the actual DC high-tension potential on the positive peaks.

In practice a Class C stage is not exactly linear, especially when the anode approaches zero volts, and to avoid distortion the modulation depth is usually not carried quite to the 100 per cent. limit. The actual modulation depth which can be attained without serious distortion is termed the modulation capability of the particular transmitter in question. To return to the perfect case of Fig. 2, it is easy to show that for a modulation depth of 100 per cent., the low-frequency power required is equal to half the actual DC power input to the modulated stage. The modulator stage, therefore, is designed to be capable of delivering an undistorted output of at least this amount to the high-frequency amplifier stage. Thus, a 50-watt Class C stage requires a modulation amplifier capable of supplying 25 watts of sine-wave modulating waveform.

The actual waveforms of speech are considerably peakier than pure sine waves. This means that for the same voltage swing a speech waveform represents rather less actual power than a sine wave. In other words, although a complex speech waveform and a sine wave may have the same voltage swing, their RMS value will be different. The sine wave in general has a higher RMS value than the narrow, peaky waveform. However, from our discussion on modulation it would appear that to fulfil the requirements of 100 per cent. modulation we shall require exactly the same voltage swing as when using a pure sine wave. Our speech amplifier must still be capable of handling this voltage swing; we are thus not able to use a smaller speech amplifier, although the actual energy in a speech waveform is less. Actually, the power in a speech waveform is only about half that in a sine waveform of the same peak power.

The above reasoning about speech waveforms assumes that even if they are peaky they are symmetrical. It appears that this is not really so, providing the extreme low frequencies are attenuated. The appearance of speech waveforms under these conditions is sketched in Fig. 3. The peaks are all in one direction, and those marked A may have an amplitude

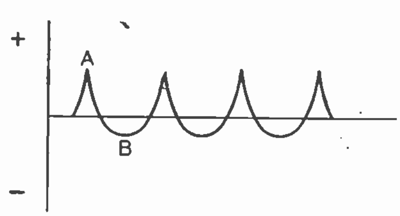


Fig. 3. Idealised asymmetrical speech waveform

which is from two to three times the amplitude of the peaks marked B.

If we apply such a waveform to

Amplitude modulation—
modulate a transmitter, we can obviously apply it in two ways. If we arrange the polarity so that it is the sharp peaks which just swing the carrier to zero, we obviously do not swing the carrier upwards on the positive peaks B to anything like the full height of twice the unmodulated carrier. However, we cannot increase the amplitude of the modulating signal any further, as otherwise we shall be cutting the carrier off completely for considerable periods on the negative peaks as we swing the anode voltage negative. This, of course, represents considerable overmodulation and distortion. Now if we reverse the polarity of the wave, the sharp peaks will swing the carrier just up to double its unmodulated value on the positive peaks, but the negative peaks B will not swing the carrier down to just zero. If we increase the amplitude of the modulating signals so that the blunt peaks B swing the carrier level down to zero, then in the positive direction we must be able to swing up on the sharp peaks to an amplitude which may be two or three times as great as the normal value of double the carrier level necessary for modulation with symmetrical waveforms. This would correspond to modulation depths of the order of 200 per cent. to 300 per cent., and corresponding apparent increase in the loudness of the signal on a receiver. The reverse case would correspond to a signal weaker than we should expect for the depth of modulation. Both of these conditions correspond to 100 per cent. modulation, however, assuming our Class C amplifier is capable of handling the excessive peaks linearly.

A cathode ray tube connected to show the trapezium modulation figure would give a triangle in both cases when we are just swinging the carrier to zero. In the case where we have peaks extending into the 200 per cent. to 300 per cent. positive region, however, our triangle would be much wider than if we were modulating 100 per cent. with a sine wave. In the case where the high peaks are arranged to swing the carrier down to zero, we should again get a triangular figure, only it would not open out in the positive direction to the same extent as with sine wave modulation.

These cases are illustrated in Fig. 4, together with the trapezium figures to be expected on a cathode ray tube. The advantage of using the condition where we expect to swing the carrier into the 200 per cent. positive modulation region is obvious, for we should be radiating a signal of something like four to nine times the power obtained by using the reverse polarity. Even if we do not expect to get as much improvement as this, there should evidently be considerable increase without introducing some distortion.

As the modulating voltage swings in a positive direction must be two or three times that required for normal modulation, the speech amplifier must be capable of handling this swing, which is equivalent to from four to nine times the power capability required for normal anode modulation. However,

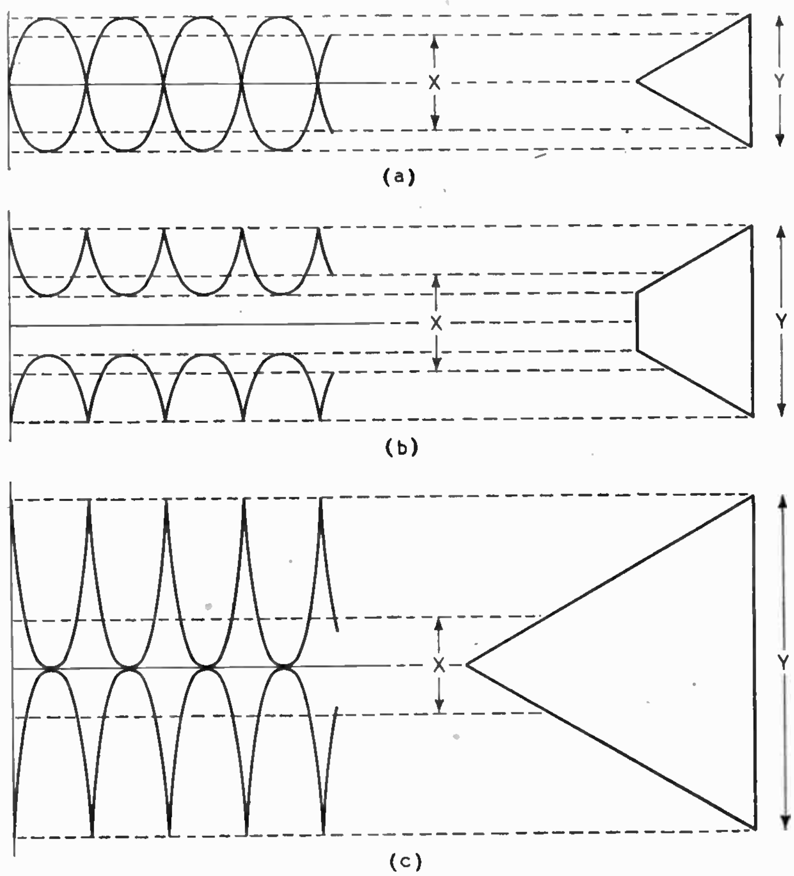


Fig. 4. Trapezium cathode ray figures corresponding to three possible methods of applying asymmetrical modulation (a) with higher peaks applied to swing carrier to zero. (b) with same amplitude but reversed polarity—carrier not reduced to zero (c) modulation applied in the same sense as (b) but with maximum permissible amplitude showing increase in power output. In all cases X is the unmodulated carrier swing and Y the maximum positive swing.

possible. . It is obvious that to use this system successfully considerable care must be taken. A cathode ray tube is essential for checking the operation, the Class C final amplifier requires some attention to ensure that it can handle the extended peaks, while there is the possibility that the detector circuits of a receiver may not be able to handle the increased modulation a Class B type modulator could probably handle these peaks without having to be quite so large as might be expected. As the valves in a Class B stage normally each handle only one-half of a modulation cycle, one valve would supply the very high peaks, and the other valve the lower rounded peaks. In the interests of valve life, it might be advantageous to change the two valves over occasionally, to equalise their loads. It must also be remembered that the valves in the Class C amplifier stage should be capable of handling the increased peaks, and also the tank tuning condenser should have increased spacing, if necessary, in order to avoid flashover on the modulation peaks. However, in the case of transmitters where the input to the final amplifier is limited arbitrarily to a low value, this system should enable very effective use to be made of limited inputs, as a 10-watt input should give roughly the same effect as a normal 40-watt transmitter with this system. It is likely, however, that with higher power transmitters such a large gain might not be achieved, owing to the increased risk of spurious radiation being produced by slight errors of adjustment. The increased cost of modulation equipment is also to be considered.

A further point of interest is that it is stated that only male voices show this asymmetric effect, while apparently if one inhales while speaking instead of exhaling the polarity of the waveform is reversed. Normally the polarity of the waveform is adjusted by reversing the microphone connections. It does not appear to be known whether an American accent is advised for the best operation of this system.

It is perhaps worth while to add a note upon the question of the frequency response for the greatest effectiveness in a communication transmitter, as opposed to high fidelity requirements. In an article published in the July, 1939, issue of *Radio*, J. W. Paddon (G2IS) discusses this point from the results obtained from an exhaustive series of tests. He evolved from these tests a curve showing the response characteristic for a speech amplifier to give maximum intelligibility for long-distance work. The curve consists roughly of a flat portion from about 200 cycles to 3,000 cycles, with a sharp attenuation of frequencies above 4,000 cycles and below 100 cycles. This is an interesting and understandable result. The frequencies above about 3,000 cycles add little if anything to the intelligibility of a speech signal, and consequently may very well be dispensed with, especially as the radiation of these higher frequencies, when working in a crowded band, results in considerable interference of the sideband splutter type. If only the top frequencies are removed, however, the resulting speech will sound boomy and low-pitched. The boomy effect can be largely removed, and the general balance is easier to follow, and more pleasant to listen to, if the low frequencies are also attenuated. Other workers on the question of the overall balance of reproduction of a receiver have found that the most pleasing response with a restricted frequency range may be obtained if the low-frequency cut-off multiplied by the top cut-off frequency gives a value of about 400,000.

It is hoped that the above may have been of interest to those interested in speech transmission, and that some of the points raised may have cleared up some of the legends surrounding the modulation question. The extended peak modulation, for example, may possibly explain why some amateur transmitters were able to obtain increases on their aerial ammeters far in excess of that to be expected on normal modulation. I have personally seen the feeder current doubled by an amateur using Class B modulation. On the other hand, the asymmetric nature of speech no doubt varies in different people, and might explain also why some people did not appear to get very good results with some modulation systems. Some of the old-timers, who adopt as their motto the principle that "theory isn't practical," have informed me that the secret of good results was to overmodulate, saying that this could be done "without the carrier breaking," that is, cutting off on the negative peaks, implying by this that the theoretical explanation of modulation was wrong. However, it would appear that while they may have been right in practice, the theory is still correct, but when speech waveforms are used it may be slightly modified.

In these cases Class B modulators were used, and I have long had a suspicion that it might be possible for the surges in the modulator circuit, which correspond to the modulation envelope, to be transferred via the modulation transformer to the Class C RF anode circuit giving the effect of a surge upward of the high-tension potential at low frequency, thus enabling slight overmodulation to occur without cutting the carrier. There appears to be grounds for this, as some reports seem to indicate that with a Class B modulator some signal appears to be radiated even when no high tension is applied to the RF amplifier.

However, the points raised in the foregoing should provide material for considerable experimenting some time in the future, and open up possibilities of increased efficiency with limited inputs. The restricted frequency response would appear by itself to offer some help, as by removing the power that would otherwise be radiated in the frequencies that are not required, the total power is concentrated in the limited band of frequencies for intelligibility, and these may be radiated at a higher intensity than with a full bandwidth.

"PAPER GOES TO WAR"

SOME very interesting developments in the use of paper in the construction of wireless accessories for the Forces were to be seen at the recent exhibition "Paper Goes to War" at the Royal Exchange, London. Sixty sheets of paper, impregnated with synthetic resin, are used for the laminated panels of aircraft receivers. Visitors to the exhibition saw that waste paper is indeed a "weapon of war."

TECHNICAL INFORMATION

Suspension of Individual Service

SHORTLY after the outbreak of war, it was decided to suspend the service formerly conducted by our Technical Information Bureau. This decision, arrived at with regret, was brought about by shortage of technical staff due to the demands of the Services. It was felt that the energies of those who remained could most usefully be employed in the production of the journal, and not in dealing with individual queries, either by letter or telephone.

Readers are reminded that this suspension is still in force, and must remain so as long as the present conditions exist.

AUTOMATIC CIRCUIT CHECKING

Design of Apparatus for Increasing Speed and Reliability

By
H. T. G. BISSMIRE, A.M.I.E.E., and
S. N. DAVIES, M.A., B.Sc.
(Murphy Radio, Ltd.)

AFTER wiring, the first electrical test applied to a radio chassis is generally a circuit check. This enables component values to be checked and wiring faults to be discovered, and so avoids the possibility of damage when power is applied to the receiver. This test is usually made with an ohmmeter, the operator making connection between appropriate points with a pair of prods, and comparing the reading obtained with a list of standard values. By paying careful attention to the sequence in which the circuit is checked, it can be ensured that a minimum of range changing is required on the ohmmeter, and the test is relatively simple. It is, however, a tedious operation in which the chance of error or omission due to the human element is fairly high; even with an operator who is familiar with a particular receiver the test takes a long time.

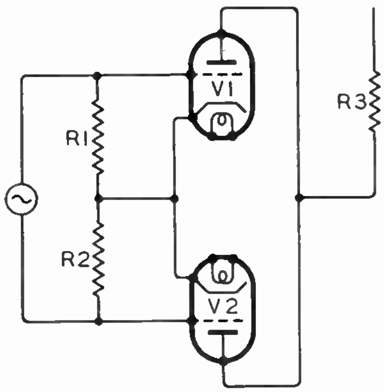


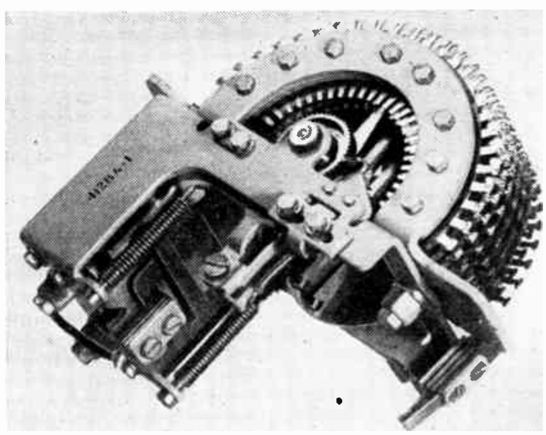
Fig. 1. Basic circuit of differential amplifier.

If a receiver is examined, it will be found that a large part of the circuit can be checked by measuring from each valve pin to earth. Hence a certain amount of simplification can be achieved by plugging a connector into each valve socket in turn and using an ordinary "wafer switch" to select the pins. This method reduces the chance of points being left out, but there is still the list of ohmmeter readings to be compared. The necessity of taking a long list of ohmmeter readings is undoubtedly one of the most tedious parts of the operation, and if it could be eliminated a considerable simplification would result.

It seems, therefore, that the ohmmeter check could be (a) made more reliable, (b) simplified (from the operator's point of view), and (c) speeded up. The apparatus to be described is the result of an attempt to achieve some improvement on these three points.

The circuit diagram of a particular receiver was studied; it was found by plugging into valveholders and other convenient sockets, to be possible to cover the whole circuit. The number of impedances to be measured was 46; this enabled a single uniselector switch of the type used in automatic telephone exchanges to be used for selecting the impedances. If the circuit had contained over 50 impedances, more than one uniselector would have been required, and the test arranged so that they followed on one after the other.

There are now the two alternatives. (a) To connect up to an ohmmeter and step the uniselector round by hand, this being a refined version of the wafer switch and connector test. (b) To arrange matters so that if the impedance under test was within tolerance the uniselector would step on, while if it was outside tolerance the uniselector would stop.



Uniselector switch of the type used in the automatic circuit tester.

Since the tolerance on a component can be either negative or positive, a method of test was required to give a result that depended only on the magnitude and not on the sign of the error. In addition, the effect of a given percentage error must be constant over a wide range of impedance values. The circuit arrangement which seemed to meet both these requirements was the differential valve amplifier.

Circuit Principle

Consider the circuit of Fig. 1. If R1 and R2 are equal, the AC voltages applied to the grids of V1 and V2 will be equal in magnitude but opposite in phase; therefore, if V1 and V2 are matched, the voltage appearing across R3 will be zero. If R1 and R2 are not equal, a voltage whose magnitude depends on the difference between $R1/(R1 + R2)$ and $R2/(R1 + R2)$ will appear across R3.

The magnitude of this voltage will be constant for a given percentage difference between R1 and R2, for all values of R1 and R2 that lie between the limits at which (a) $R1 + R2$ is no longer large compared with the impedance of the source, (b) R1 and R2 are no longer small compared with the input impedance of V1 and V2.

It is possible to ensure that no errors arise from (a) by making the impedance of the source low compared with the smallest value of R1 + R2, and, since the test will be operating at audio-frequency (b) can be neglected for all ordinary values of R1 and R2. Therefore, if it is arranged that the uniselector connects in place of R2 each impedance to be measured, and that if at the same time it connects in place of R1 a series of chosen standard impedances there will appear across R3 a series of voltages proportional to the errors in the impedances under test.

These voltages must now be made to control the driving coil of the uniselector. Consider the circuit of Fig. 2 and assume that the voltage V between grid and cathode of the gas-filled triode is zero.

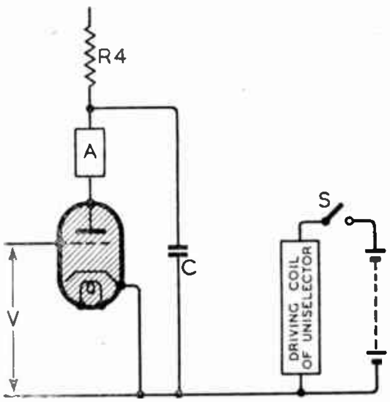


Fig. 2. Control circuit of uniselector switch.

The condenser C will be charged through the resistance R4 until the P.D. across its terminals becomes equal to the striking voltage of the gas-filled triode at zero grid volts. When this point is reached the condenser C will discharge through the gas-filled triode; this discharge will cause the relay A to operate, opening the switch S and interrupting the current through the driving coil of the uniselector. As a result the uniselector will be advanced one position. When the condenser voltage falls to the value at which the gas-filled triode stops conducting, the discharge ceases and the condenser once more charges up to the striking voltage, the above process then being repeated. Hence the uniselector will be stepped on at a rate depending on the time constant of the R4 C circuit.

If V is made sufficiently negative the striking voltage of the gas-filled triode will be raised until it exceeds the HT line voltage; the condenser C will be unable to discharge; the relay A will not operate and the uniselector will stop. Therefore, by amplifying the voltage appearing across R3 (Fig. 1), rectifying it and applying it between grid and cathode of the gas-filled triode, it can be arranged that when the uniselector is connected to a pair of circuits that are out of balance by more than a predetermined amount, it will not be stepped on.

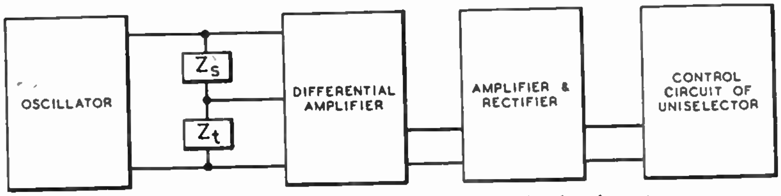


Fig. 3. Schematic arrangement of automatic circuit tester.

From the foregoing discussion it can be seen that an automatic apparatus for circuit checking can be made; a possible schematic diagram is shown in Fig. 3.

It now remains to discuss one or two practical points before passing on to the complete circuit diagram. Referring back to the circuit of the receiver the largest resistance to be measured is 2 megohms, while the smallest condenser is 150 μμF. In order that the reactance of 150 μμF shall be of the same order as 2 megohms the oscillator frequency must be 1000 c/s.

Passing on from the oscillator, consider Z_t and Z_s (Fig. 3). Z_t represents the impedance under test, while Z_s, which is built into the apparatus, represents the standard impedance with which Z_t is compared.

Let Z_n be the nominal value of Z_t and T be the tolerance expressed as a fraction. The extreme values of Z_t are then $Z_n(1 + T)$ and $Z_n(1 - T)$.

Now the output voltage of a differential amplifier is proportional to the difference between the grid voltages.

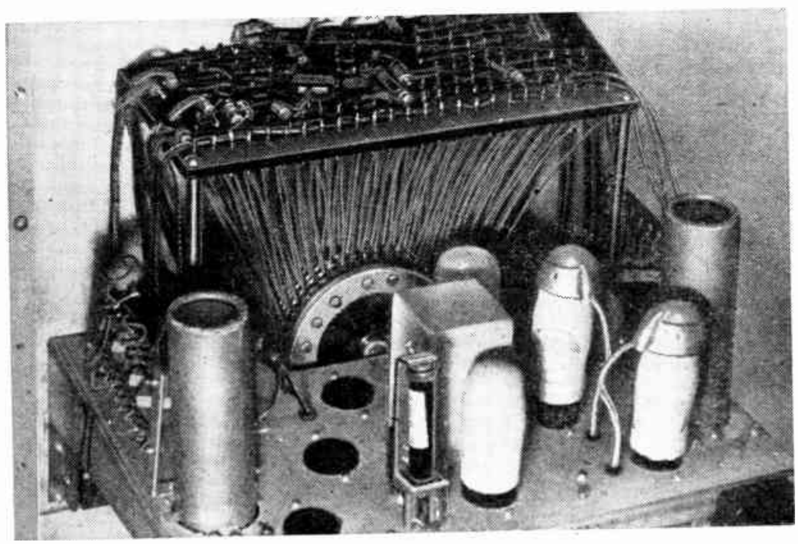
(a) When the test impedance is $Z_n(1 + T)$ the output voltage is proportional to

$$\frac{Z_n(1 + T)V}{Z_s + Z_n(1 + T)} - \frac{Z_s V}{Z_s + Z_n(1 + T)}$$

Where V is the constant voltage applied across the test and standard impedances.

(b) When the test impedance is $Z_n(1 - T)$, the output voltage is proportional to

$$\frac{Z_s V}{Z_s + Z_n(1 - T)} - \frac{Z_n(1 - T)V}{Z_s + Z_n(1 - T)}$$



Top view of chassis showing connections from uniselector switch to impedance standards.

Automatic Circuit Checking—

Since these voltages are to be equal

$$\frac{Z_n(1 + T) - Z_s}{Z_s + Z_n(1 + T)} = \frac{Z_s - Z_n(1 - T)}{Z_s + Z_n(1 - T}$$

Which reduces to

$$Z_s = Z_n(1 - T^2)^{\frac{1}{2}}$$

Thus, in order that the voltages due to equal positive and negative errors shall be the same it is necessary to use as standards impedances whose values differ slightly from the nominal values of the impedances under test.

Turning now to the complete circuit diagram (Fig. 4), V8 is the audio-frequency oscillator, which is of the negative transconductance type. The output of this valve is fed into a beam tetrode (V9), which enables the required output voltage to be developed across a load of 1 ohm; this load is connected across the secondary of a screened transformer. V1 and V2 form the differential amplifier, which is balanced by means of a preset control in the cathode lead of V1. The output from this stage is taken to an amplifier (V3 and V4) via a preset input control which is used to set the tolerance. The output of V4 is rectified by V5 and fed via the cathode follower V6 to the grid of the gas-filled triode V7.

It will be remembered that the receiver which it is desired to test has only 46 impedances while a 50-way uniselector is used. The four "spare" positions are therefore used as follows:—On position 1, Z_t and Z_s are resistors that differ by slightly less than the permitted tolerance, while on position 2 they differ by slightly more. Therefore, if the apparatus is working correctly the uniselector should pass 1 and stop on 2. On position 3, Z_t and Z_s are equal, this position being used for balancing V1 and V2. On position 50, Z_t and Z_s differ by a very large amount, so that the uniselector will always stop at this point.

Receivers are tested with the apparatus as follows:—The various plugs are connected. (The apparatus is so arranged that it is not possible to plug into the wrong

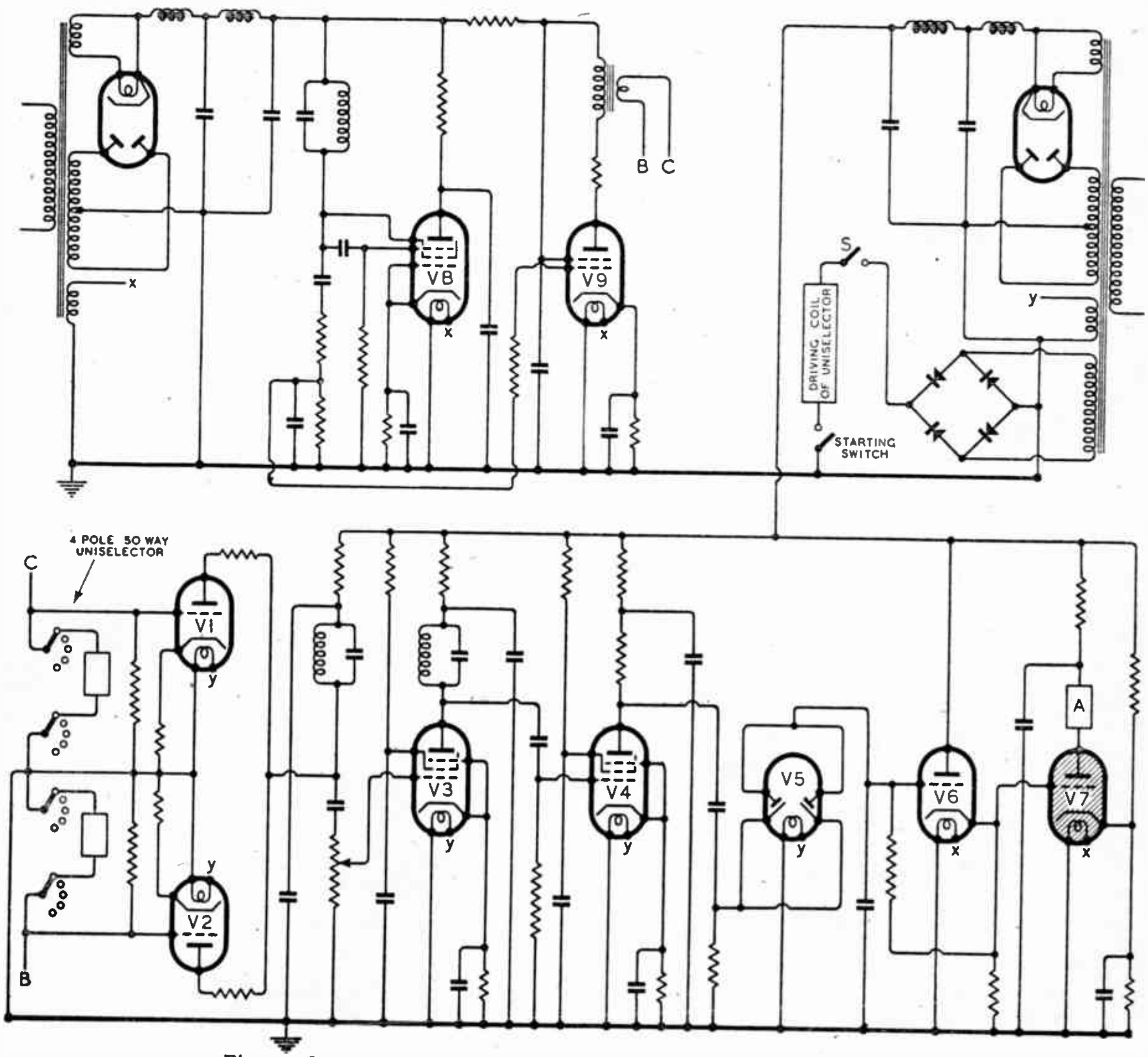


Fig. 4. Complete circuit diagram of automatic circuit testing apparatus.

sockets.) The starting switch is pressed; the apparatus should pass position 1 and reject position 2. (Fitted to the uniselector is a numbered plate indicating the switch positions.) The starting switch is released and pressed again, causing the uniselector to advance one position. The uniselector will now continue to step on unless a fault in the receiver is reached, when it will stop. If this happens a note of the position is made, and, as before, the uniselector stepped on to the next place by means of the starting switch.

At the conclusion of the test, if the set is a reject, the operator will have a list of numbers from which the faults may readily be located.

The apparatus which has been built operates at 15 tests per second so that a complete set can be checked in a little over 3 seconds.

This type of apparatus will, of course, find its chief application in dealing with long production runs. However, it can be used in development work to a certain extent. To do this it would be necessary to duplicate the system of plugs which is used for connecting up the receiver under test. It would then be possible to use a known good receiver as the "standard arm." This would necessitate the acceptance of a rather looser tolerance than that used with a specially selected "standard arm," since it is unlikely that all the components of a good receiver will lie on the mean of the tolerances.

In conclusion, thanks are due to Mr. D. J. Bridges for the photographs of the apparatus, and to Murphy Radio Ltd., for permission to publish this article.

BOOKS RECEIVED

Basic Electricity and Magnetism. By W. C. Frid, B.Sc. This booklet, one of Pitmans' Pocket Handbooks, is prepared for the Services and the Air Training Corps. No previous knowledge is assumed. Worked examples are given and a few simple experiments are described. Pp. 40; 30 diagrams. Published by Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price 1s. 6d.

Elementary Electricity for Radio Students. By W. E. Flood, M.A. This booklet contains an introduction to electrical theory, written primarily for those who intend to become wireless operators. DC and AC theory are treated, and there are chapters on inductance, capacity and magnetism. Pp. 64; 33 diagrams. Published by Longmans, Green and Company, Ltd., 43, Albert Drive, London, S.W.19. Price 1s.

STANDARDISATION OF FIXED RESISTORS

Agreement on Preferred Values and Tolerances

THE demand for composition-type resistances by the Services and Government Supply Departments is a heavy one, and to ensure prompt delivery it has been decided to limit the number of available values to those listed in the table.

It will be seen that the range from 10 ohms to 10 megohms can be covered by 255 values if three tolerance groups of ±20, ±10 and ±5 per cent. are accepted. For most positions in a circuit, resistances can be selected from the first two categories and will be near enough to function satisfactorily. Before resistances in the 5 per cent. group can be specified the sanction of the appropriate Government Department must be obtained.

The agreement is the result of consultation between the Inter-Service (Communications) Components Committee and representatives of the manufacturers and departments concerned. It does not affect existing designs and contracts, but will be brought into effect for all new developments. Wire-wound resistances are not affected by the present ruling.

±20%	±10%	±5%	±20%	±10%	±5%	±20%	±10%	±5%
10	10	10	1000	1000	1000	100000	100000	100000
		11			1100			110000
	12	12		1200	1200		120000	120000
		13			1300			130000
15	15	15	1500	1500	1500	150000	150000	150000
		16			1600			160000
	18	18		1800	1800		180000	180000
		20			2000			200000
22	22	22	2200	2200	2200	220000	220000	220000
		24			2400			240000
	27	27		2700	2700		270000	270000
		30			3000			300000
33	33	33	3300	3300	3300	330000	330000	330000
		36			3600			360000
	39	39		3900	3900		390000	390000
		43			4300			430000
47	47	47	4700	4700	4700	470000	470000	470000
		51			5100			510000
	56	56		5600	5600		560000	560000
		62			6200			620000
68	68	68	6800	6800	6800	680000	680000	680000
		75			7500			750000
	82	82		8200	8200		820000	820000
		91			9100			910000
100	100	100	10000	10000	10000	1.0 Meg.	1.0 Meg.	1.0 Meg.
		110			11000			1.1 Meg.
	120	120		12000	12000		1.2 Meg.	1.2 Meg.
		130			13000			1.3 Meg.
150	150	150	15000	15000	15000	1.5 Meg.	1.5 Meg.	1.5 Meg.
		160			16000			1.6 Meg.
	180	180		18000	18000		1.8 Meg.	1.8 Meg.
		200			20000			2.0 Meg.
220	220	220	22000	22000	22000	2.2 Meg.	2.2 Meg.	2.2 Meg.
		240			24000			2.4 Meg.
	270	270		27000	27000		2.7 Meg.	2.7 Meg.
		300			30000			3.0 Meg.
330	330	330	33000	33000	33000	3.3 Meg.	3.3 Meg.	3.3 Meg.
		360			36000			3.6 Meg.
	390	390		39000	39000		3.9 Meg.	3.9 Meg.
		430			43000			4.3 Meg.
470	470	470	47000	47000	47000	4.7 Meg.	4.7 Meg.	4.7 Meg.
		510			51000			5.1 Meg.
	560	560		56000	56000		5.6 Meg.	5.6 Meg.
		620			62000			6.2 Meg.
680	680	680	68000	68000	68000	6.8 Meg.	6.8 Meg.	6.8 Meg.
		750			75000			7.5 Meg.
	820	820		82000	82000		8.2 Meg.	8.2 Meg.
		910			91000			9.1 Meg.
						10.0 Meg.	10.0 Meg.	10.0 Meg.

RADIO DATA CHARTS—5

"Q" of Quarter-wavelength Resonant Line

By

J. McG. SOWERBY,

B.A., Grad. I.E.E.

(By Permission of the Ministry of Supply)

NOW that very high frequencies are coming into general use, the breakdown of ordinary circuit technique is becoming more and more apparent. Perhaps this breakdown is most apparent in the design of the ordinary tuned circuit, since at these very short wavelengths the required capacities and inductances become so small that their physical realisation becomes very difficult. For these reasons, the use of transmission line sections as tuned circuits is coming into wider use.

For those unfamiliar with this technique, it may be helpful to recapitulate the line of reasoning which led to its adoption. If, as is nearly true at high frequencies, ωL is large compared with R, and ωC is large compared with G (where L, R, C, and G are respectively inductance, resistance, capacitance, and conductance per unit length of line), then it can be shown[1] that the sending end impedance (Z) of a loaded line is

$$Z = Z_o \frac{Z_r \cos \beta l + jZ_o \sin \beta l}{Z_o \cos \beta l + jZ_r \sin \beta l}$$

[1] See, for instance, "Mathematics Applied to Electrical Engineering," by A. G. Warren, p. 280.

Where Z_o = characteristic impedance
Z_r = terminating impedance
l = length of line
$\beta = \omega\sqrt{LC}$.

β is the imaginary part of the propagation constant γ used in abac No. 4. If the line is one-quarter of a wavelength long, and the transmission velocity is that of light (or radio waves in free space), then $\beta l = \pi/2$, and the sending-end impedance becomes

$$Z = Z_o \frac{jZ_o}{jZ_r} = \frac{Z_o^2}{Z_r}$$

Short circuit the receiving end of the line ($Z_r = 0$) and the sending end impedance becomes infinity. Open circuit the receiving-end of the line ($Z_r = \infty$) and the sending-end impedance becomes zero. Thus the quarter-wavelength shorted line behaves almost exactly like the familiar parallel tuned circuit, and its tuned wavelength is, of course, four times its actual length.

Similarly the open-circuited section corresponds to the series tuned circuit.

It should be pointed out at once that the impedance of the shorted section will not be infinity—this being an ideal value due to the assumed absence of resistance—but merely large, and the line will yield a selectivity curve of the usual shape. Like the ordinary tuned circuit the line will have a finite "Q" which—in the case of the co-axial line—is given by[2] :—

$$Q = KD\sqrt{\frac{f}{\rho}} \frac{\log_e D/d}{1 + D/d + 2D/l \log_e D/d}$$

Where f = frequency
ρ = resistivity of line material (here assumed to be copper throughout)
l = length ($\frac{1}{4}\lambda$)
D = diameter of outer
d = diameter of inner
K = constant.

The D/l term at the right of the formula represents end effects (loss by radiation) tending to reduce the Q, and for normal lines and wavelengths of upwards of one metre is not of much importance. Since its incorporation would make the abac unwieldy this term has been neglected. However, if great accuracy is required the appropriate correction factor, F, may be calculated from the formula

$$F = \frac{1 + D/d}{1 + D/d + T},$$

where $T = \frac{0.338\, DZ_o}{\lambda}$,

(D in inches, λ in cms.).

λ is the wavelength and D/d can be found from the characteristic impedance abac (*Wireless World*, Jan., 1943). Calculation shows that the maximum "Q" for a quarter-wavelength co-axial line of given dimensions will be attained when Z_o = 76.8 ohms, and this is the line which is most commonly used. In Fig. 1 a family of curves has been drawn showing the correction factor F for different values of D as a function of wavelength for this optimum 76.8 ohm line. The reader should have no difficulty in interpolating where necessary. Thus the actual "Q" will be the value

(Concluded on page 74)

[2] "Wave Guides," by R. L. Lamont, p. 81.

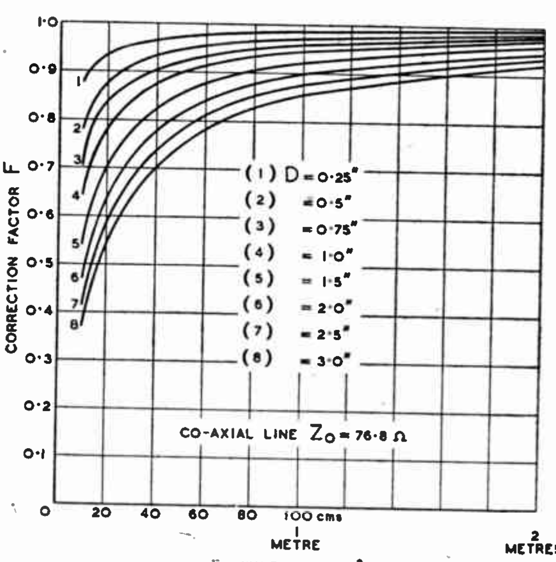


Fig. 1. Correction curves for "end effect" giving correction factor F for different wavelengths and values of D for a 76.8-ohm co-axial line.

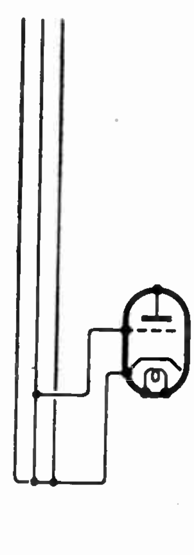
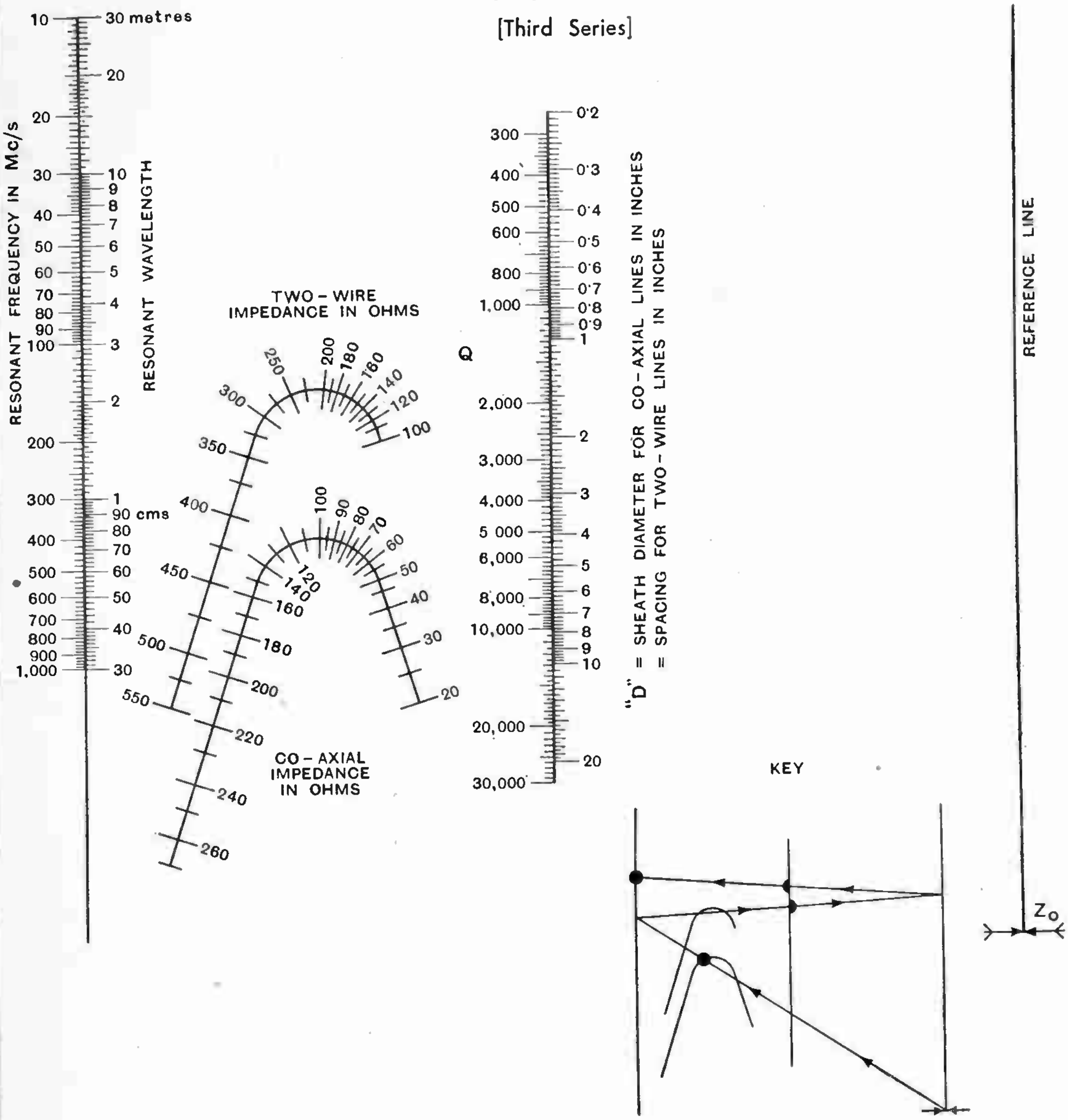


Fig. 2. "Tapping down" to reduce damping introduced by the valve input impedance.

ABAC No. 5

[Third Series]



"Q" OF A QUARTER-WAVELENGTH (λ/4) COPPER RESONANT LINE

Radio Data Charts—5—

given by the abac multiplied by the factor F (less than 1) determined either from the curves or from the formula. However, since the line is inevitably damped when put to any useful purpose, the abac value of "Q" will be sufficiently accurate for the vast majority of cases if the wavelength is one metre or more. There is little point in performing similar calculations to correct for the radiation loss of the two-wire quarter-wavelength line, since adjacent metal would probably have an equal effect.

What has been found by the abac (with or without the correction factor) is the "Q" of the line alone, and coupling this, say, to the grid of a valve will, of course, damp the circuit. This damping may be reduced by employing the old principle of "tapping down," and a shorted line in the grid of a triode might well be connected as shown in Fig. 2.

By suitable choice of dimensions, the "Q" of a line section can be made comparable to that of a crystal at frequencies above 10 Mc/s or so. In order to achieve the same stability as a crystal it is necessary to load the line very lightly (e.g. by tapping down) and to ensure the constancy of the line length. To this end it should be rigidly constructed and, in the best apparatus, thermostatically controlled.

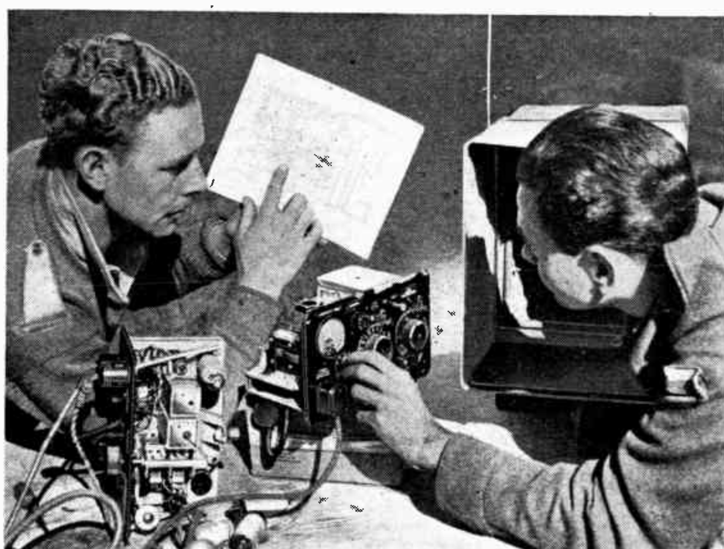
The mode of operation of the abac should be quite clear from the key, but an example may be helpful by way of illustration.

Example : It is desired to tune a receiver to 50 Mc/s using a co-axial quarter-wavelength shorted line of characteristic impedance 75 ohms and sheath diameter ¾in. ; what is the "Q" of the line? Set the ruler on the gauge point Z_0 and join this to 75 ohms on the co-axial Z_0 scale ; a point of intersection is found on the frequency scale. Join this point to 0.75in. on the D scale and a point is found on the reference line at the right ; join this point to 50 Mc/s on the frequency scale, and the "Q" of the line is read off on the appropriate scale at the centre. It is 566. In this case F = 0.994 so the corrected value of "Q" is 562.

The quarter-wavelength line used in this way can obviously only be tuned to one frequency. If it is desired to cover a band of frequencies it is necessary to load the line with a variable condenser ; this point will be discussed later.

"ENGINEER SCIENTISTS"

INTERESTING views in the higher training of telecommunication engineers were expressed in a paper read before the Wireless Section of the I.E.E. on February 3rd by Prof. Willis Jackson, of Manchester University. The author, whose paper dealt with university education and industrial training, pleaded for more effective co-ordination of engineering and physics training at the undergraduate stage; also that these studies, as well as the full-time postgraduate courses which were advocated, should both be preceded by practical experience in industrial or engineering work. The science of telecommunications requires a steady flow into its ranks of both pure and applied scientists, and those whose training Prof. Willis Jackson was discussing were described as "Engineer-Scientists"—men capable of interpreting scientific progress in relation to industrial possibilities. The author pleaded for closer co-operation between the universities and industry.



ROYAL SIGNALS IN PALESTINE

GREEK soldiers are among the men being trained at the Royal Corps of Signals School recently established in Palestine. The trainee signalmen acquire a first-hand knowledge of the equipment they will be using by locating faults and executing minor repairs in typical apparatus.

In the above picture an instructor is seen tracing the circuit of a dismantled No. 18 transmitter-receiver, which is one of the standard infantry pack sets.

The power supply unit of a No. 11 transmitter-receiver, which although obsolescent, is still widely used in army trucks, is seen being tested in the lower picture. The universal test set employed is of American manufacture and combines output meter, multi-range meter, valve test panel, etc.

Electromagnetic Fields in Radio—II.

PHYSICAL MEANING OF SOME MATHEMATICAL NOTATIONS

A thorough grasp of the physical basis of electromagnetism, without which the practical problems of wave generation and propagation cannot be tackled with assurance, calls for a certain amount of hard mental effort on the part of the reader. If he can assimilate the contents of this instalment, in which the essential mathematics are reduced to their simplest form, he will have made the most difficult stride towards the mastery of the subject and will be equipped to understand the practical aspects which will form the basis of later articles in the series.

By MARTIN JOHNSON D.Sc.

IN the previous article we derived properties of electromagnetic fields from the observed deflection of the beam in a cathode-ray tube as used in radio. The stream of electrons experiences a force perpendicular to its velocity and to any magnetic field through which it passes, the force being proportional to velocity, field, and charge. When we recognised the equivalence of moving either charge while magnet was stationary or magnet while charge was stationary, in turn, it was seen that an electric charge can "feel" a moving magnetic field as an electric field, and a magnetic pole can "feel" a moving electric field as a magnetic field. By rewriting our laws of force and velocity in electrostatic and again in electromagnetic units, it was found that under certain conditions the electric and magnetic fields can be considered as mutually generating one another. This special case occurs if both fields move forward together with a speed which is equal to the ratio between those two systems of units.

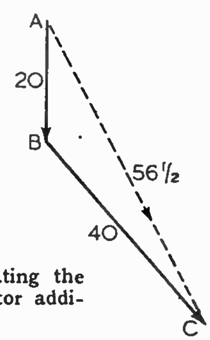


Fig. 1. Illustrating the principle of vector addition.

This forward motion of alternating electric and magnetic fields through space is, of course, what we mean by the transmission of a radio wave. But the reason for there being a wave motion could not be seen in the first equations when the electromagnetic laws emerged from the simple facts of the electron stream upon which our view has been based. We reached Faraday's law connecting line-integral of electric field with rate of change of magnetic flux, and Maxwell's law connecting line-integral of magnetic field with rate of change of electric flux, but to extract a radio wave these *integral* forms must be replaced by the equivalent *differential* forms known as Maxwell's equations.

Accordingly, the present article is given up to providing physical meaning for the several expressions in vector notation which lead to the Maxwell equations. The latter can then be seen as the translation of the electromagnetic laws into the new form required in discussing radio waves. In particular, the intimidating abbreviations "div," "grad," and "curl" which close the text-books against the uninitiated, must be shorn of their strangeness and made to act as useful shorthand for physical operations of practical importance.

Line and Area Vectors. Throughout any science capable of exact treatment, it is useful to distinguish *vector* from *scalar* quantities. Scalars are specified completely by their size, while vectors require for their specification not only their magnitude but also their direction and their "sense" or sign of plus or minus. In radio an electric charge is a scalar quantity, and so is a potential, but electric field-strength is a vector since it denotes a certain magnitude in a certain direction. In diagrams a vector may be represented by an arrow whose length measures the magnitude and whose orientation with respect to any fixed direction represents the vectorial property of being directional. Reversing the arrow-head denotes reversing the sense or sign from plus to minus.

The notion need be no more complex if we are only interested in lines or one-dimensional quantities. *Area vectors* extend the principle: we utilised surface areas in the previous article, for instance, when an electric flux was defined as product of field with an element of area, and it is often convenient to represent some function of an area by a line perpendicular to the area and to treat this line as a vector. Length of the line, and its direction and its arrowhead, may suitably denote the size of the area and the direction towards which it is to be considered facing.

Vectors are added, or "compounded" by the commonsense principle which is self-evident in the particular case of any vector which represents displacement: to move 20 yards southwards, then another 40 yards south-east, is equivalent to moving along the dotted line of Fig. 1, which is 56½ yards south-south-east, as may be verified on squared paper. This is expressed by saying that AC in the diagram is the *vector sum* of AB and BC, and that the latter are two possible *components* of AC.

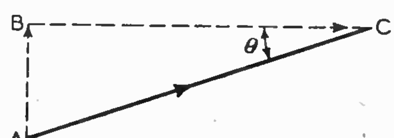


Fig. 2. Simple trigonometrical relations exist when the components of a vector are at right angles.

In the particular case where the components are mutually perpendicular (Fig. 2) they are simply

Electromagnetic Fields—

calculable since $AB = AC \sin \theta$ and $BC = AC \cos \theta$.

Products of Vectors and Scalars. The expressions for electromotive force used in the previous article, as field and path and work done, raise the question of what happens if vectors are multiplied, either by other vectors or by scalars. Such manipulation of the kinds of quantity described in the discussion of radio introduces the following distinctions.

(a) Scalar product of two vectors: this is the product of one vector's length by the other vector's length, multiplied by the *cosine* of the angle between their two directions. The net result becomes zero if the two vectors are mutually perpendicular, but becomes an ordinary multiplication of their magnitudes if they are both in the same direction. For the cosine is a minimum and a maximum for these two conditions respectively. This scalar product is often called the "dot product" and written with a dot between the components

$$A \cdot B = ab \cos \theta$$

if a and b are the magnitudes of the vectors A and B. The operation is equivalent to multiplying either vector by the projection upon it of the other. It may be noticed that a scalar product of two vectors is a scalar.

(b) Vector product of two vectors: this is the product of the two magnitudes but multiplied in this case by the *sine* of the angle between them. This kind of product is itself a vector, and may be regarded as the area of the parallelogram contained by the two components; according to our convention of area vectors it may therefore be seen as a line perpendicular to the plane of the original two. In contrast to the dot product, it is zero when the constituent vectors are parallel, and a maximum when they are perpendicular to each other. This is called, and written, the "cross product," $A \times B = ab \sin \theta$.

(c) In distinction to these products, to multiply a vector by a scalar gives another vector of n times the size but with direction unchanged.

It will be noticed that the line-integrals employed in our previous article are scalar products; this fits the fact that field (vector) multiplied by path (vector) gives work (scalar). Our definitions of flux in that article may also be regarded in the light of vector theory.

The distinction between dot and cross multiplication must next be extended to a wider range of "operations" to be performed on electrical quantities.

Derivatives and Operators. In the earlier article we had occasion to obtain the "derivative," or to "differentiate" some quantity of importance to radio, meaning that we needed to know the rate of change of that quantity as it varied in dependence upon some other quantity. In electricity, field is thus a derivative of potential with respect to distance, for instance in volts per centimetre. "Scalar differentiation" studies the rate of change of any vector, say V, as it varies in dependence upon a scalar, say t; if, for example, V is a displacement D and t is a time, dD/dt is a velocity or rate of change of displacement, and the "second derivative" d^2D/dt^2 is an acceleration or rate of change of velocity.

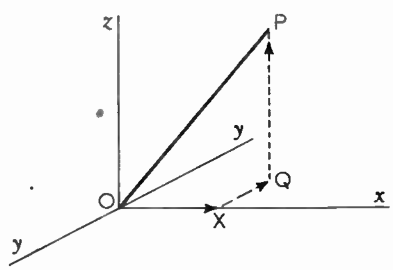


Fig. 3. Projection of a vector on three perpendicular axes.

If the vector V is a function of, that is to say depends on, three variables which can be represented as lengths in three mutually perpendicular directions x, y, z, the further notion of "partial derivative" becomes important. This contains three possibilities: if the conditions represented along y and z remain fixed while variations along x alone exert control over the situation, the partial derivative is $\partial V/\partial x$, while for each of the other possibilities $\partial V/\partial y$ and $\partial V/\partial z$ are the partials while the other pairs of variables in turn remain fixed. The total change of V if all vary together is

$$dV = \frac{\partial V}{\partial x}dx + \frac{\partial V}{\partial y}dy + \frac{\partial V}{\partial z}dz$$

$$= \left[\frac{\partial}{\partial x}dx + \frac{\partial}{\partial y}dy + \frac{\partial}{\partial z}dz\right]V$$

This illustrates how it is possible to account for the dependence of some electrical quantity upon more than one controlling factor. The conventional distinction in shape of symbol, ∂ instead of d, usually denotes partial differentiation when keeping in mind the constancy of the remaining controls.

It is often useful to employ "unit vectors"; if i, j, k, are line vectors of unit length in the x, y, z, directions, OP in Fig. 3 is the vector sum of its projections OX, XQ, QP, which are themselves scalar multiples of i, j, k, so that the total vector

$$V = V_x i + V_y j + V_z k$$

where V_x, V_y, V_z, are scalar components of the vector V. The notion can be further extended until i, j, k, represent areas instead of lines only.

We must now extend the methods of multiplication of a vector to other "operations," and we define an operator ∇ often called "del" as meaning in terms of our recent notations,

$$\nabla = i\frac{\partial}{\partial x} + j\frac{\partial}{\partial y} + k\frac{\partial}{\partial z}$$

Next consider how this operation can be performed upon scalars and vectors somewhat as multiplication can; for potentials and fields treated thus are a common shorthand in radio literature.

The Operator "Grad" or Gradient of a Scalar. We have already spoken in general of derivatives as representing the rate of change of a quantity when varying under some control: but there is one particular rate of change which is important in electromagnetism, known as the "gradient." Actually it is the maximum of all possible rates of change for a scalar. For instance, temperature and potential are scalars; the potential due to a distribution of static charges will show rates of change in different directions, but the electric force at any point is in the direction of steepest rate of decrease of potential, perpendicular to the equipotential surfaces, and has a magnitude which is called the "gradient" of potential. Of a scalar S, "grad S" is therefore a vector field quantity. This gradient can be shown to be equivalent to the operator "del" applied to such a scalar expressing the properties of space at a given point. So in terms of the unit vectors which we used before,

$$\nabla S = \frac{\partial S}{\partial x}i + \frac{\partial S}{\partial y}j + \frac{\partial S}{\partial z}k = \text{grad } S$$

This is the briefest shorthand for expressing that the acting force is in the direction of greatest rate of fall of potential; for example, the motion of electrons in valves. Corresponding application might be made to the flow of heat across temperature "isothermals" or to the fall of bodies across the equipotentials of gravitation.

The Operator "Div" or Divergence of a Vector. This in turn is the application of "del" to a vector instead of to a scalar, but it is of a kind analogous to the "dot product" discussed above.

$$\nabla . V = \text{div } V = \frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} + \frac{\partial V_z}{\partial z}$$

The dot notation is in accord with a view that "div" behaves somewhat as a scalar product of del and the vector, and the "divergence" itself has scalar properties. The name arises from the fact that it represents the extent to which lines of force in a field converge or diverge, becoming denser or less densely packed. For instance, in a fluid the amount of "div" expresses the rate at which material spreads from any point: if div is not zero, either the fluid is expanding or contracting or the region is a source at which material is entering or a sink into which it is disappearing. In the electric field non-zero div implies the presence of charges: in the study of heat it means there is a source of heat or a spot where temperature is falling. The important case div V = O means that flow lines are closed curves (as in the magnetic field of a current) or terminate at the bounding surface (the electric field of a condenser) or extend to infinity. A vector satisfying this condition is called "solenoidal" or "source-free" or "tubular" since the lines neither converge nor diverge.

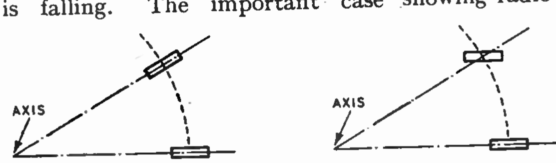


Fig. 4. Element of volume of a fluid during motion of the fluid about an axis. (a) Shows condition of "curl" and (b) of no "curl."

The Operator "Curl" or Rotation of a Vector. There remains the possibility of a "cross product" or $\nabla \times V = \text{curl } V$. It is equal, in our previous notations, to

$$\left(\frac{\partial V_z}{\partial y} - \frac{\partial V_y}{\partial z}\right)i + \left(\frac{\partial V_x}{\partial z} - \frac{\partial V_z}{\partial x}\right)j + \left(\frac{\partial V_y}{\partial x} - \frac{\partial V_x}{\partial y}\right)k$$

The term "rotation" or "curl" is due to the fact that it expresses "vortex" or whirlpool properties in a fluid, and if all spin in the fluid vanishes the curl becomes zero. For example, in the left-hand side of Fig. 4 a small element of fluid changes its orientation in such a way as to have an axis of rotation, while in the right-hand side the orientation stays constant and whatever motion the fluid is undergoing is irrotational. In a case of interest to radio, it will be found that the curl of a magnetic field is an essential way of denoting a current density. Another useful pictorial distinction (Fig. 5) between two of these operators occurs in Hague's book on vectors, to which the reader seeking a full and clear treatment may be referred.*

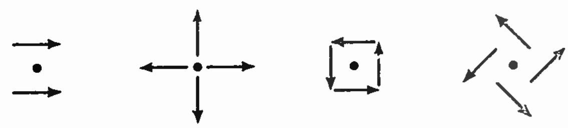


Fig. 5. Vectors illustrating the motion of fluid particles: (a) No "div" and no "curl"; (b) "div" but no "curl"; (c) "curl" but no "div"; (d) "div" and "curl."

Theorem of Gauss on Flux. The remaining items required from the mathematician's tool-box are the theorems of Gauss, Green, and Stokes. With these the laws of electromagnetism reach a form showing radio propagation. Draw any closed surface S in a field represented by a vector V. We discussed the flux through such a surface in our previous article, and in our recent dot notation it may be rewritten V·dS. The notation of the earlier article gave the total flux or integral over the whole area as $\iint V dS$, where we had used the double integral sign to denote the two dimensions of area. Now look at the same idea in the light of our recent discussion of "div": If there is an element of volume dv enclosed by this surface, the flux emerging can be measured by div V dv. So it is this quantity which can then be equated to $\iint V\, dS$. We shall use the triple integral sign to remind that three dimensions are included in a volume, and write $\iiint \text{div } V dv$ or in the del notation $\iiint \nabla . V dv$.

This throws upon the definitions of vectors and of flux the onus of the theorem of Gauss, only one of whose many forms is provided by this equivalence between certain volume and surface integrals.

For electric fields obeying the inverse square law, Gauss' theorem is convincingly demonstrated, since the vector V is here E, the intensity e/r^2. Hence the flux $\iint E dS = 4\pi e$, the r^2 cancelling by the definition of solid angle which we explained in the previous article. One or other form of the Gauss theorem is the basis of all electrostatics, for example, in treating the fields in condensers.

Poisson and Laplace Conditions in Space and in Material. We can now put together several results already reached to obtain the static portion of the radio field. The Gauss theorem is applied to a vector, here the electric intensity E perpendicular to a conducting surface of aerial, resonator, etc. If e is the total charge inside it is equivalent to $\iiint \rho dv$ which is the volume integral of charge per unit volume or charge density ρ. But the flux emerging from the element of volume was found to be $\iiint$ div. Edv so that the complete set of equivalents is

$$\iint E dS = 4\pi e = 4\pi \iiint \rho dv = \iiint \text{div } E dv$$

Since E was a "grad" of potential we have the effect of a double operation, "div grad" of potential, equal to $4\pi\rho$. Recalling what these operators meant, div E = ∇ . E

$$= \left(\frac{\partial}{\partial x} + \frac{\partial}{\partial y} + \frac{\partial}{\partial z}\right) \text{ intensity} = 4\pi\rho$$

* "Vector Analysis for Physicists and Engineers" by B. Hague. Methuen, 1939.

div. grad P $= \nabla^2 P$

$$= \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right) \text{potential} = 4\pi\rho$$

The operator div can thus act upon any vector denoting the sum of the results of the action of the operator grad on each of the components.

This is the famous Poisson's equation. For empty space $\rho = 0$ and the equation becomes zero and is then called Laplace's equation. The design of many types of apparatus depends ultimately upon deciding where certain conditions are fulfilled near electrodes, aerials, etc., and those expressed by the Poisson and Laplace equations are the first.

The Maxwell Equations of Electromagnetic Field in Free Space. We have already utilised relationships between volume and surface and line integrals. The mathematics has been much associated with the names of Green and of Stokes. Green's theorem is a purely geometrical way of expressing a volume integral throughout an enclosed space in terms of surface integrals over the boundaries of the space. It can therefore be used to derive the electrostatic work connected with Poisson's equation which we evolved from first principles. But the more important of the relations for the radio field is that of Stokes, connecting line and surface integrals. It may be expressed: "Line integral of vector taken round circuit is equivalent to surface integral of its curl taken over any surface bounded by this circuit."

$$\int V ds = \iint \text{curl } V dS$$

We recall that $\nabla \times V = \text{curl } V$ $= \left(\frac{\partial V_z}{\partial y} - \frac{\partial V_y}{\partial z}\right)$ . . . with accompanying terms for each of the other pairs of variables.

By this relation we now rewrite the fundamental laws of electromagnetism. In the earlier article they were derived from experiments with an electron beam, and in association with the names of Faraday, Maxwell and Ampere we wrote them:

$$\int_0 E ds = \frac{1}{c} \times \text{ rate of change of magnetic flux}$$

$$\int_0 H ds = \frac{1}{c} \times \text{ rate of change of electric flux}$$

$$\int_0 H ds = 4\pi i/c = 4\pi j$$

Replace the left-hand side by each "curl" according to Stokes' theorem:

$$\frac{\partial E_z}{\partial y} - \frac{\partial E_y}{\partial z} = \frac{1}{c}\frac{\partial H_x}{\partial t}$$

$$\frac{\partial E_x}{\partial z} - \frac{\partial E_z}{\partial x} = \frac{1}{c}\frac{\partial H_y}{\partial t}$$

$$\frac{\partial E_y}{\partial x} - \frac{\partial E_x}{\partial y} = \frac{1}{c}\frac{\partial H_z}{\partial t}$$

$$\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z} = \frac{1}{c}\frac{\partial E_x}{\partial t}$$

$$\frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x} = \frac{1}{c}\frac{\partial E_y}{\partial t}$$

$$\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} = \frac{1}{c}\frac{\partial E_z}{\partial t}$$

The first set, or curl $E = \frac{1}{c}\frac{\partial H}{\partial t}$ gives the distribution of electric field due to a change of magnetic field. The second set, or curl $H = \frac{1}{c}\frac{\partial E}{\partial t}$ gives the distribution of magnetic field due to electric phenomena. In the case of current-density written in the previous notation, the additional term is needed, curl $H = 4\pi j$. We have throughout omitted complications due to negative sign.

These are Maxwell's equations: with that of Poisson they sum up the whole of electrical theory. As we have seen in the two treatments of this and our previous article, Maxwell's equations do not express the way in which we arrive at field properties from experiment; from experiment we only reach the integral forms of the earlier article. But those forms provide no reason why the field should manifest itself as radio waves in space, and we propose next to see, as Maxwell first did, that combining the "curl" equations at once proves that radio waves are an inescapable character of the electromagnetic field, and also proves many of their properties.

BAN LIFTED

In response to many requests from oversea, the ban on the export of the *Bell System Technical Journal*, which was imposed nearly a year ago, has been lifted. The publishers, the American Telephone and Telegraph Company, state that the only issue published since the ban was imposed was dated June, 1942, and this has now been cleared by the U.S. Board of Economic Warfare and has been despatched to subscribers. The first issue to be published since the lifting of the ban is dated January, 1943.

APPEAL TO THE INDUSTRY

Wireless Contributions to the Red Cross

THERE are already indications that the wireless industry is replying generously to the appeal for the Electrical Industries Red Cross Fund, which was announced in our last issue. A preliminary list of covenanted subscriptions and donations, issued just before we went to press, contains the names of many wireless firms or of firms with wireless interests. Among those included in the long list, which covers the whole electrical industry, are:—

COVENANTED SUBSCRIPTIONS.

	£	s.
General Electric Co., Ltd., London ..	2,000	0
Murphy Radio, Ltd., Welwyn Garden City	210	0
Decca Radio & Television, Ltd., London	200	0
Wireless & Electrical Trader	100	0
Wireless World and *Wireless Engineer*	100	0
Everett Edgcumbe & Co., Ltd., London	21	0
British Tungsram Radio Works, Ltd., London	20	0
Mycalex Parent Co., Ltd., Cirencester	10	0
Young (Glasgow), Ltd., Glasgow	10	0
R. E. & C. Marshall, Ltd., Cheltenham	4	4
Bideford Radio Service, Bideford	2	2

DONATIONS.

	£	s.
Chloride Electrical Storage Co., Ltd., London	250	0
Falk, Stadelmann & Co., Ltd., London	100	0
Telegraph Construction & Maintenance Co., Ltd., London	50	0
Telegraph Condenser Co., Ltd., London	25	0
Wingrove & Rogers, Ltd., Liverpool	25	0
Radio & Elec. Equip. Renters, London	5	5
Scottish Radio Retailers Assn.	2	2
London Electric Firm, Croydon	2	2
Wholesale Fittings Co., Ltd., London	2	2
James Robertson, Glasgow	2	2
James & Co., Ltd. (Radio), London..	1	1

As stated last month, contributions should be sent to the Electrical Industries Red Cross Fund, St. James's Palace, London, S.W.1, and other correspondence to the Joint Secretaries of the Fund, c/o The E.D.A., 2, Savoy Hill, London, W.C.2.

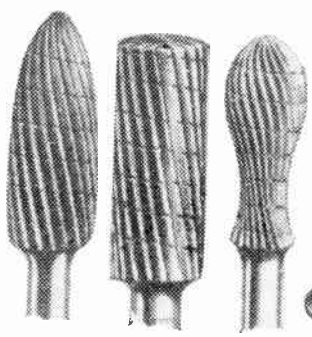
"WIRELESS ENGINEER"

THE problem of designing the inductively coupled input circuit of a receiver for optimum signal-to-noise ratio is discussed in an article in the February issue of *Wireless Engineer*. Another article deals with the calculation of the high-frequency resistance of plated conductors.

The issue also includes some 350 abstracts and references.

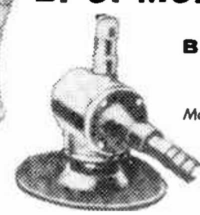
Published on the first of the month, *Wireless Engineer* is obtainable to order through newsagents or direct from our Publishers, price 2s. 8d. (including postage).

Rotary Cutting, Filing, Grinding and Polishing— *Economy and Accuracy*

Use **MORRISFLEX Flexible Shaft Equipment**, and **REX Rotary Files and Cutters** for cutting, filing, grinding and polishing components of aluminium, Elektron, non-ferrous alloys and ferrous metals. For metal buffing and cleaning we supply **MORREX Rotary Wire Brushes**, and **MORRISFLEX Rotary Polishing Mops and Felts**, also **Felt Cones**. **MORRISFLEX Rotary Rasps** are ideal for woodworking, and attachments for **MORRISFLEX** machines include **Sanders** and **Grinders**. **MORRISFLEX** machines are available in overhead suspension, bench and floor types. Their use ensures speed with accuracy, and a high degree of finish. Write for Lists.

B. O. MORRIS LTD.
SHIRLEY,
BIRMINGHAM.
Shirley 1237.
'Grams :
Morrisflex, Birmingham.




MORRISFLEX
FLEXIBLE SHAFT EQUIPMENT

WHEN THE FLOOD OF WAR HAS SUBSIDED . . . .

the bird of Peace will bring with it the demand for products to assist in the enjoyment of freedom and security. Goodmans Industries then, as in pre-war days, will be able to concentrate on "The Attainment of an Ideal"— the perfect reproduction of sound.

In the meantime the whole of our organisation is devoted to the design and production of the best possible acoustic apparatus.

The best of today will in turn lead to something better still in the future, in which Goodmans Industries will maintain their reputation for establishing standards of design for high fidelity sound reproducers.

Goodmans Industries LTD.

GOODMANS INDUSTRIES LIMITED ★ LANCELOT ROAD ★ WEMBLEY ★ MIDDX.

WORLD OF WIRELESS

STANDARDISED COMPONENTS

THE recent announcement by the U.S. War Production Board that replacement parts for receivers are to be standardised to such a degree as to ensure the maintenance of more than 90 per cent. of the civilian receivers in use, falsifies the rumour that due to a shortage of components sets in America would go out of commission at the rate of thousands a day.

It is stated that the plan will be sufficiently comprehensive to ensure the supply of replacements for all receivers manufactured during the past twelve years.

Production of valves has been suspended by the Board to exhaust the existing stocks before introducing the scheme, which reduces the number of types from 350 to 110. It will be recalled that an earlier Order reduced the 700 pre-war types to 350.

Valves are the first components to be dealt with under this plan. There is also to be a reduction in the number of transformers and chokes from 155 to fourteen—including six power transformers.

It is also learned from *Broadcasting* that there are to be nine varieties of dry electrolytic condensers and eleven types of paper tubular condensers.

The threatened shortage of transmitting apparatus has resulted in an issue of a questionnaire by the Federal Communications Commission to all transmitting stations—including broadcasting—asking for details of surplus apparatus; it is proposed to form a pool.

RECORD SALVAGE

THE major gramophone record manufacturers in this country have recently issued a statement that the further maintenance of adequate supplies of records is dependent upon the willingness of the public to return old and unwanted records for re-use. The Government has found it necessary to conserve for more urgent war needs the shellac and other raw materials essential for manufacture.

Provided they were not issued prior to the introduction of the solid stock system of manufacture in about 1932, and discs issued by the E.M.I. and Decca groups, irrespective of condition—if not actually broken—will be gladly received by record dealers, who will make an allowance for them. It has been noticed that in some cases dealers are paying as much as 4d. for 12in. and 2½d. for 10in. records.

"THERMAL" RADIO

IN his usual end-of-the-year review of radio in America, David Sarnoff, president of the Radio Corporation of America, laid considerable stress on the application of radio-frequency heating. This application of radio technique is pre-war, but in its war rôle it has assumed greater importance and made remarkable advances.

Among the applications of "thermal" radio enumerated by Mr. Sarnoff are glueing, annealing, welding, riveting, and even deactivating enzymes. It is also claimed that rubber may now be "radio-cemented" to wood or plastics.

Referring to television, Mr. Sarnoff stated that its laboratory status is a war secret, but those confident of the success that marks wartime developments expect television to emerge from this war to make a great post-war industry.

AMERICAN FM STATIONS

A RECENT survey of FM stations in the United States revealed that there are at present 37 commercial stations and eight experimental transmitters in use. Some of them are radiating a 24-hour service. In addition to these transmitters there are a further seventeen "under construction," the building of many of them, however, is delayed because of the shortage of equipment.

AN APPLICATION of radio technique has successfully been employed by our Middle East Forces for the location of mines in landing grounds, etc., captured from the enemy. The sapper hears a signal as soon as the detecting frame passes over a mine.

HIRE PURCHASE

UNDER a new Order, which comes into force on March 1st, the hire purchase of many price-controlled goods, including wireless receivers, is prohibited.

The Order will not affect hire-purchase agreements entered into before the above date, nor will it prevent the making of a new agreement in order to readjust the terms of an existing contract made at the hirer's request, provided that no additional goods are included therein. The Order also provides that a new hire-purchase agreement may be made, if the hirer so requests, in respect of goods which have sustained war damage, subject to certain conditions specified in the Order.

Copies of the Order, the title of which is the Hire Purchase (Control) Order, 1943 (S.R. & O., 1943, No. 157), will be obtainable in due course, price 1d., through any bookseller or newsagent or direct from H.M. Stationery Office, Kingsway, London, W.C.2.

LATE LORD HIRST

IT is with regret we record the death of Lord Hirst, chairman and managing director of the General Electric Co., on January 22nd, after a short illness. He was seventy-nine years of age, and until early this year had been in regular attendance at his office.

Lord Hirst, who was one of the founders of the G.E.C. over fifty years ago, became managing director in 1900 and chairman in 1910. He was quick to realise the potentialities of broadcasting, and played a prominent part in the formation of the British Broadcasting Co. It was in Magnet House, Kingsway, the head office of the G.E.C., that the B.B.C. had its original offices.

Lord Hirst, who was created a baronet in 1925, and raised to the peerage in 1934, has been president of the Radio Manufacturers' Association since 1938. He was one of the few honorary members of the Institution of Electrical Engineers.

PLANNING OF SCIENCE

WITH a view to contributing towards the full mobilisation of science and scientists for the speediest winning of the war and for the engendering of a rational approach to the problems of the peace, the Association of Scientific Workers recently organised an open conference at the Caxton Hall, London, S.W.1.

Sir Stafford Cripps, Minister of Aircraft Production; Sir Robert Watson-Watt, pioneer of radiolocation, who is chairman of the Association; Sir Lawrence Bragg, head of the Caven-

World of Wireless—
dish Laboratory, Cambridge; and Sir Philip Joubert, were among the many speakers. Sir Philip referred to the importance of the creation in 1939 of a team of scientists at an Operational Research Section to look after and analyse the new radio aids to air warfare. The activities of the O.R.S. have gradually increased, and they now cover a wide field in all three Services. He pointed out that the creation of these sections has resulted in scientist and soldier working side by side.

ELECTRO-ENCEPHALOGRAPHY

AT the next meeting of the Wireless Section of the Institution of Electrical Engineers at 5.30 on March 3rd, G. Parr, Editor of *Electronic Engineering*, and W. Grey Walter, M.A.(Camb.), a physiologist, will deliver a paper on "Amplifying and Recording Technique in Electro-Biology." The paper will make special reference to the electro-encephalograph which has been developed by Mr. Grey Walter for the detection of cerebral abnormalities and was briefly described in *Wireless World* in 1938. The lecture will include a demonstration on a human subject.

ELECTROLYTIC CONDENSERS

ASKED in the House of Commons whether he was aware of the shortage of electrolytic condensers, the President of the Board of Trade stated that the shortage was due to the ever-increasing demands of the Fighting Services for radio equipment. Recognising the importance of keeping civilian receivers in use, however, steps had already been taken to increase production of electrolytics.

He hoped that the increased output of electrolytic condensers would mean that by the end of March "the gaps in the 1942 maintenance programme will have been filled up."

It was stated by Mr. Dugdale, the questioner, that he understood that 25 per cent. of all repairs to receivers are due to breakdowns in electrolytic condensers.

BRIT.I.R.E.

A RECORD attendance of nearly 250 members and visitors was registered at the meeting of the Brit.I.R.E. on January 23rd, when J. H. Cozens, B.Sc., A.M.I.E.E., delivered a paper on "Modern Condenser Technique." Mr. Cozens dealt at length with methods adopted by manufacturers to reduce the inductive component in paper condensers. He stated that there was no such thing as a "non-inductive" condenser, and suggested that these should be styled "low-inductance."

The next meeting of the Institution

NEWS IN ENGLISH FROM ABROAD

REGULAR SHORT-WAVE TRANSMISSIONS

Country : Station	Mc/s	Metres	Daily Bulletins (BST)
America			
WRUW (Boston) ..	6.040	49.67	08.00.
WLWO (Mason) ..	6.080	49.34	06.00, 07.00, 08.00, 09.00, 10.00.
WBOS (Hull) ..	6.140	48.86	09.00, 10.00.
WCRC (Brentwood)	6.170	48.62	06.00.
WGEA (Schenectady)	6.190	48.47	06.00.
WBS	7.355	40.79	06.00, 07.00, 08.00, 09.00.
WDJ	7.565	39.66	01.00, 02.00, 03.00, 05.00, 07.00, 08.00, 09.00.
WJP	8.810	34.05	01.00, 02.00, 03.00.
WGEO (Schenectady)	9.530	31.48	21.00, 22.00.
WCBX (Brentwood)	9.650	31.09	05.00, 06.00.
WNBI (Bound Brook)	9.670	31.02	00.00.
WRUW (Boston) ..	9.700	30.93	21.00, 23.00.
WDL	9.750	30.77	10.00.
WHL5	9.897	30.32	10.00, 11.00, 23.00.
WRX	9.905	30.28	06.00, 08.00, 09.00.
WLWO (Mason) ..	11.710	25.62	19.00, 20.00, 21.00, 22.00.
WRUL (Boston) ..	11.790	25.45	21.00, 23.00.
WCDA (New York)	11.830	25.36	11.00, 12.00, 13.00, 15.30‡, 17.30, 21.00, 23.00.
WGEA (Schenectady)	11.847	25.33	13.00, 14.00, 15.00, 16.00, 17.00, 18.00, 19.00.
WBOS (Hull) ..	11.870	25.27	12.00, 19.00, 21.00, 22.00‡.
WHL6	13.442	22.32	12.00, 13.00, 14.00, 15.00, 16.00, 17.00, 18.00, 19.00, 20.00, 21.00.
WDO	14.470	20.73	14.00, 17.00, 18.00, 20.00.
WBOS (Hull) ..	15.210	19.72	14.00, 17.00.
WCBX (Brentwood)	15.270	19.65	15.30‡, 17.30, 21.00.
WGEO (Schenectady)	15.330	19.57	14.00, 17.00.
WRUL (Boston) ..	15.350	19.54	11.00, 12.00, 13.00, 14.00, 15.00.
WCW (New York) ..	15.850	18.92	19.00.
WLWO (Mason) ..	17.800	16.85	15.00, 16.00, 17.00.
WCRC (Brentwood)	17.830	16.83	11.00, 12.00, 13.00, 15.30‡, 17.30, 21.00.

Country : Station	Mc/s	Metres	Daily Bulletins (BST)
Australia			
VLQ6 (Sydney) ..	9.580	31.32	07.00.
VLQ5 (Sydney) ..	9.680	30.99	08.00.
VLG3 (Melbourne) ..	11.710	25.62	08.00.
Brazil			
PRL8 (Rio de Janeiro)	11.720	25.60	21.30.
China			
XGOY (Chungking)	11.900	25.21	14.00, 16.00, 17.15, 21.30.
French Equatorial Africa			
FZI (Brazzaville) ..	11.970	25.06	20.45.
India			
VUD3 (Delhi) ..	7.290	41.15	08.00, 13.00, 15.50.
VUD4	9.590	31.28	08.00, 13.00, 15.50.
VUD3	15.290	19.62	13.00.
Spain			
EAQ (Aranjuez) ..	9.860	30.43	18.15.
Sweden			
SBU (Motala) ..	9.535	31.46	22.20‡.
Turkey			
TAP (Ankara) ..	9.465	31.70	19.50.
U.S.S.R.			
Moscow	5.890	50.93	23.00.
	6.980	42.98	17.00, 23.00, 23.47.
	7.300	41.10	18.00, 20.00, 21.00, 22.00, 23.00.
	7.360	40.76	23.00.
	7.560	39.68	23.00.
	9.860	30.43	01.00, 12.40, 23.47.
	11.830	25.36	16.00.
	12.190	24.61	01.00, 23.47.
	15.230	19.70	12.40, 23.47.
Kuibyshev	8.050	37.27	20.30.
	11.700	25.64	06.00, 14.00, 14.45.
	13.010	23.06	06.00, 14.00, 14.45.
Vatican City			
HVJ	5.970	50.25	19.15.

MEDIUM-WAVE TRANSMISSIONS

	kc/s	Metres	
Ireland			
Radio Eireann ..	565	531	13.40‡, 18.45, 22.10.

It should be noted that the times are BST—**one hour** ahead of GMT. The times of the transmission of news in English in the B.B.C. Short-wave Service are given on the next page.

‡ Sundays excepted.

will be held on March 26th at the Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, when E. L. Gardiner, B.Sc., will deliver a paper on "Selective Methods in Radio Reception."

500 kW ON SHORT WAVES

SOME "night owls" will have heard the transmissions from the 500-kW medium-wave American station W8XO, the experimental adjunct of the Crossley Corporation's stations WLW and WLWO at Cincinnati, Ohio, which had an experimental licence for transmissions between midnight and 6 a.m. Eastern Standard Time. This licence has now been cancelled by the U.S. Federal Communications Commission, and it is rumoured that the station may be adapted for short-wave transmissions and employed by the Office of War Information for oversea broadcasts.

It is stated by our American contemporary *Broadcasting*, that in addition to the leasing of the fourteen international short-wave stations mentioned last month, a plan is under way for the construction of twenty-two more transmitters.

INDIAN AIR FORCE Signals School recruits are trained by European instructors as ground and air-crew operators. The course at the School, which is in the Bombay Presidency, lasts nearly six months. Wing Commander J. S. Smith, M.B.E., Commanding Officer, is seen with a group of recruits who come from all parts of India—there are no caste distinctions.

CHINESE AMATEURS' DAY

A WORLD-WIDE amateur convention is to be held in Chungking, the bomb-scarred war capital of China, on May 5th, which is now known as Chinese Amateurs' Day.

The China Amateur Radio League has asked for the co-operation of allied countries in providing items of interest in connection with amateur activities. It is understood the Radio Society of Great Britain is sending a collection of books.

In pre-war days many British amateurs have contacted XUOA, the headquarters' station of the League.

IN BRIEF

More Sets.—It was recently stated by the President of the Board of Trade, in reply to a question in the House of Commons, that arrangements had been made to supply components for the completion of over 100,000 civilian wireless sets now in process of manufacture.

Propaganda.—Recent statements from America regarding the co-ordinated use of wireless during the landing of the U.S. Forces in North Africa revealed that powerful portable transmitters were erected by the Army Signal Corps for the purpose of disseminating information to the inhabitants.

Oversea News Bulletins.—The following is the latest schedule of the times (BST) of short-wave transmissions of news in English in the B.B.C.'s various oversea services. Some transmissions are radiated on two or three frequencies in the waveband shown.

0200	49, 31
0345	49
0530	49, 41
0715	41, 31
0900	41, 31, 25
1000	49, 41, 31
1200	25, 19
1400	25, 19
1600	31, 25, 19, 16
1700	31, 25, 19, 16
1900	25, 19
2045	31, 25, 19
2245	49, 41, 31, 25*
2345	49, 31

* Sundays excepted.

There are also the morse transmissions of news in English, French and German at 0230, 0300 and 0330 (BST) respectively. These are radiated in the 49-metre band and on 261 metres.

Let the Blind Hear.—The Christmas Day broadcast appeal for the British "Wireless for the Blind" Fund has so far resulted in the receipt of over £15,000 from nearly 25,000 donors.

"Jairminy Calling."—According to details recently published in the German journal *Rundfunkarchiv*, a total of 56 European broadcasting stations are now being used by the Nazis. Of this number six operate in the long-wave band, thirty on medium waves and twenty on short waves. It is also stated that one hundred foreign-language news bulletins are broadcast each day by these stations.

Radio Relay Statistics.—An increase of 15,858 subscribers to radio relay exchanges in this country during the third quarter of last year is revealed by the figures now made available. There were 414,843 subscribers to 278 exchanges at the end of September, 1942. The increase during the previous three months was 11,751.

South African Television.—A recent report of the South African Broadcasting Corporation mentions the possibility of introducing television with an expansion programme costing £250,000. It is pointed out that owing to war conditions it is inadvisable to give details of the proposed expansion.

Women Radio Operators are to be employed by the Trans-Canada Air Lines for point-to-point communications. Twenty girls from all parts of the Dominion, some of whom already possess Government Radio Certificates, began training in Winnipeg early in the year.

Spanish Stations.—Two new broadcasting stations are being constructed at Arganda, about twelve miles south-east of Madrid. One will operate in the medium-wave band with a power of 120 kW, and the other, which will have a power of about 40 kW, on short waves. It is also learned that a new station is to be erected at Palma, Majorca.

"Handle with Care."—This notice appears on equipment in use in Canadian broadcasting stations as a reminder to the users that much of the apparatus cannot be replaced. One notice adds, "the cord on this mike is mostly copper and rubber. Can you think of any other two materials as precious as these are to-day? Please be careful to avoid kinking, twisting or crushing any microphone cord."

A. F. Bulgin, governing director of Bulgin and Co., who has been associated with the Air Training Corps since its inception, has been promoted to the rank of Squadron Leader, R.A.F.V.R.

Obituary.—Only two months ago we reported the death of Walter L. Fillmore, director of Jackson Brothers, the condenser manufacturers. It is with great regret that we now have to announce the death of his son, Louis E. Fillmore, managing director of the company.

Institution of Electronics.—At the Annual General Meeting of the Institution on January 16th it was decided to set up a North-Western Committee to deal with the increasing activities of the Institution in that area. Enquiries regarding membership of the North-Western Section, which will hold its meetings in the Manchester district at regular intervals, should be addressed to L. F. Berry, Honorary Secretary, The Institution of Electronics, 14, Heywood Avenue, Austerlands, Oldham. Following the annual meeting, Dr. F. J. G. van den Bosch delivered a paper on "Secondary Emission Tubes: Their Manufacture and Applications."

Frequency Modulation—III

INTERFERENCE SUPPRESSION, THE LIMITER, AND THE CAPTURE EFFECT

This article shows that F M results in a greatly improved signal-to-noise ratio, and deals with the mechanism by which this is effected

By
CHRISTOPHER TIBBS,
Grad.I.E.E.

THE fidelity of the pre-war Alexandra Palace television sound channel would not have been improved by the mere substitution of frequency modulation in place of amplitude modulation. As perfect reproduction is theoretically an inherent property of all methods of modulation, FM does not in itself result in any improvement in quality. Frequency modulation should not be credited with improvements which have been made possible by transmission on the ultra short waves.

On the broadcast band, where stations are 9 kc/s apart, the average radio manufacturer, regards second station break-through and interstation heterodynes as faults which must be eradicated at all costs. In the majority of cases this has resulted in an overall response curve which drops sharply somewhere between 2,000 and 5,000 cycles. On the ultra-high frequencies, where it is possible to separate stations by 100 kc/s or more, there is no great difficulty in producing a response which is level up to 15,000 cycles, the generally accepted upper limit of audibility of the human ear.

It should therefore be kept in mind when enumerating the system's advantages that its improved quality results, among other things, from the use of far greater channel widths than are possible on the broadcast band, and not simply from the use of frequency modulation.

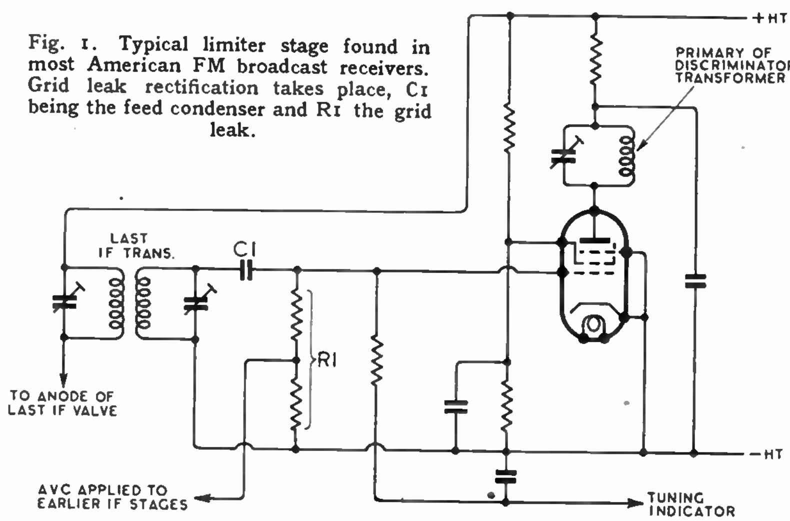
The Limiter

It was pointed out in a previous instalment that the FM receiver is similar to the receiver for amplitude modulation up to the limiter stage. Under normal working conditions the valve in this stage is supplied with a signal large enough to ensure that it is overdriven, therefore effectively limiting the signal amplitude. This results in the suppression of all amplitude modulation, and, regardless of variations in the carrier voltage, reduces the incoming signal to a constant level.

The circuit of a typical limiter stage is shown in Fig. 1. The output from the last IF stage is applied to its grid through the small condenser C1. The voltages on both anode and screen of the limiter valve are well below its normal operating values. This results in a very short grid base, the valve being frequently in the cut-off region, with only 2½ or 3 volts negative on its grid. As there is no bias, and the resistance R1 is high, grid leak rectification will take place as soon as a signal is applied. The grid unable to exceed the earth potential, and the larger the applied signal the further negative its mean is depressed.

If the time constant formed by C1 and R1 is too long, it is possible for the slow recovery, after grid rectification of a burst of interference, to momentarily allow the peaks of the signal to fall below earth potential. To take a practical example, the last IF valve may supply the limiter with a 16-volt peak-to-peak signal. The mean would normally lie at −8 volts, all but, say, 3 volts of the positive peaks being below the limiter's cut-off level. A burst of impulsive interference, after rectification, might depress the mean from −8 volts to, say, −10 volts. If the grid time constant is too long, then during the instant immediately following these conditions there will only be 1 volt of the carrier above the limiter valve's cut-off level, with the result that the output would be down to one-third. From cathode-ray oscillograph studies it is apparent that this time constant should be 2.5 microseconds or less if this fault is to be avoided. Fig. 3 shows the overall characteristic of the limiter stage; it will be noted

Fig. 1. Typical limiter stage found in most American FM broadcast receivers. Grid leak rectification takes place, C1 being the feed condenser and R1 the grid leak.



voltage to anode current characteristic is shown in Fig. 2. The mechanism by which a burst of impulsive interference is limited is also illustrated by this diagram. It will be noted that, due to grid rectification, the upper carrier peaks are that there is a slight drop in the output with increasing input, due to the larger harmonic content.

As shown in the circuit of Fig. 1

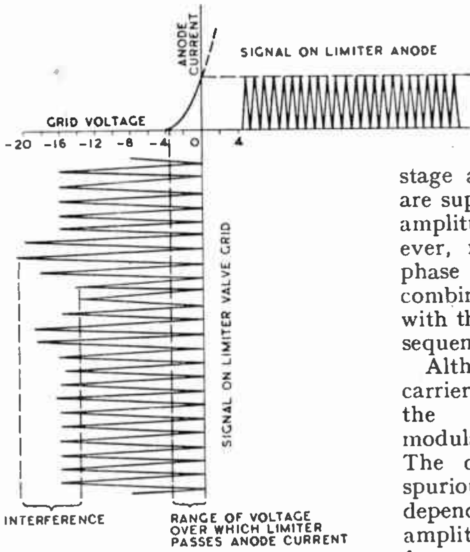


Fig. 2. Grid voltage/anode current characteristic of limiter valve showing the mechanism by which a burst of impulsive interference is limited.

a small amount of AVC is applied to stop overloading in the stages ahead of the limiter. The amount of AVC used is kept small in order that the signal applied to the limiter may be as large and as far up its characteristic as possible. This tapping down of the AVC feed is also desirable to eliminate any delay in the limiter operation resulting from the AVC circuit time constants.

If a tuning indicator is used it can either be operated from the limiter grid voltage as shown or from the voltage developed across the discriminator load. The latter gives more accurate control.

Interference Suppression

At first sight it would appear that the limiter, in suppressing all

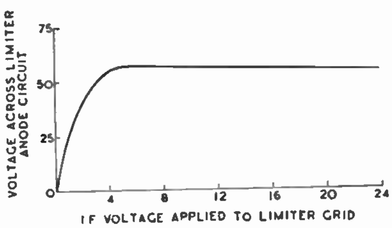


Fig. 3. Characteristic of a typical limiter stage.

amplitude and impulsive interference, had completely eliminated them. On closer investigation this is found to be far from the truth. Fig. 4 (a) shows how the carrier and interference combine to form a single complex wave. In this manner they are amplified and applied to the limiter. In passing through this stage all variations in amplitude are suppressed. The elimination of amplitude changes does not, however, remove the spurious carrier phase shifts which result from the combination of the interference with the carrier wave, and the subsequent amplitude limiting.

Although a phase shift of the carrier may not cause audio noise, the "by-product" frequency modulation accompanying it will. The deviation amplitude of the spurious frequency modulation will depend first on the interference amplitude, and secondly on the frequency at which it occurs in relation to the carrier. The actual deviation frequency resulting from any form of interference therefore depends on the following two factors:—

(1) The original interference amplitude. The larger it is the greater will be the spurious carrier phase shift which results.

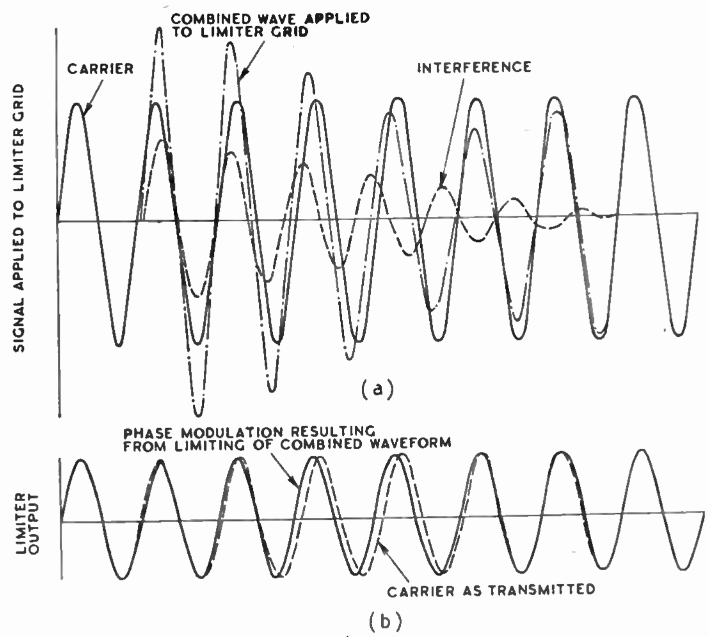


Fig. 4. Showing how the carrier and interference merge into a single waveform. The amplitude changes are absent in the limiter output, but the interference remains as a spurious frequency modulation of the carrier.

(2) The frequency spacing between the carrier and the interference. The interference will heterodyne the carrier, with the result that the larger the frequency difference between carrier and interference the higher the heterodyne frequency. After passing through the limiter this heterodyne appears as a phase modulation superimposed on the carrier. The deviation of the FM "by-product" of this phase modulation is determined by the following equation:—

$$F_d = P_m \times M_f.$$

Where F_d = deviation of the by-product frequency modulation.

P_m = the phase modulation expressed in cycles. (Determined by the interference amplitude.)

M_f = modulating frequency. (In this case the difference frequency between the interference and the carrier.)

From the above it will be seen that if the interference is close to the carrier, the resulting frequency modulation will be small, while if the difference frequency is large the spurious frequency modulation will also be large.

The position is illustrated graphically in Fig. 5, and in addition a comparison is made with an equiva-

Frequency Modulation—

lent amplitude modulation system. This diagram is commonly referred to as the FM "noise triangle," and assumes that the carrier and the interference are held at the same relative amplitudes, only their frequencies being varied. As an example assume that a burst of impulsive interference occurs 15 kc/s away from the carrier, then deviation of the resultant carrier frequency modulation will be ten times as great as that which would occur if the interference had been only 1,500 cycles from the carrier.

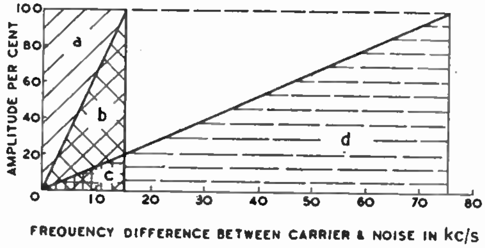


Fig. 5. Illustrating the FM "noise triangle." The noise spectra for two different FM deviations are compared with that of an equivalent AM system. The vertical scale represents the amplitude at which interference is reproduced expressed as a percentage of maximum output. (a) Maximum noise output from amplitude modulation receiver over whole band. (b) Noise output from FM receiver designed for 15 kc/s. deviation. (c) and (d) Output and demodulated noise respectively from FM receiver designed for 75 kc/s. deviation.

The FM noise spectrum shown in Fig. 5 indicates that an FM system (b) only reproduces half the noise which would be reproduced by a comparable amplitude modulation system (a). In other words, FM shows a 2 to 1 improvement in signal-to-noise with a deviation ratio of unity (i.e., when the maximum frequency deviation is the same as the highest audio frequency). In actual practice this improvement is only realised with certain types of interference, such as that due to motor car ignition, etc. Armstrong has given a figure of 1.7 to 1 as an improvement ratio covering all types of noise, including that produced in the early stages of a receiver.

Before considering the position with a deviation ratio other than unity, it is necessary to consider the effect of interference occurring at a frequency separation farther from the carrier than the highest audio frequency. It was shown in Fig. 4 that interference, after passing through the limiter, appears in the form of superimposed frequency modulation of the carrier, and that this modulation has a frequency equal to the difference between the carrier and the interference. If, however, this separation is greater than the highest audio frequency, then the resulting frequency modulation will be above the highest audio frequency. In an FM receiver, immediately following the discriminator, there is a filter which eliminates all frequencies above the required audio band. This has the effect of wiping out the demodulated resultant of all noise occurring at a frequency separated from the carrier by more than the highest audio frequency. The case of a system with a 75 kc/s deviation is shown in Fig. 5. The only interference which will be reproduced is that indicated by the small triangle.

The improvement over an amplitude modulation system can be summed up as follows (taking Armstrong's conservative improvement figure). Improvement in the signal to noise ratio =

$$\frac{1.7\times \text{deviation frequency}}{\text{Maximum audio frequency}}$$

or $1.7\times$ deviation ratio.

Taking the example of a 75 kc/s deviation as shown in Fig. 5, the improvement will be $\frac{1.7\times 75 \text{ kc/s}}{15 \text{ kc/s}} =$ 8.5 to 1 (in voltage) or 72 to 1 in power. (18.5 db.)

Armstrong claims that improvements calculated in this way are realised in practice, providing that the noise does not exceed some 10 per cent. of the signal immediately prior to the limiter stage. It should be noted that the figures obtained in this way do not take into account the further substantial improvements, which, as will be explained later, are affected by pre-emphasis.

The Capture Effect

In the second article in this series mention was made of the way in which a strong signal suppresses a weaker one. It is now possible to examine this phenomenon in greater detail. Fig. 6 shows a strong station A which is frequency modulated with a sinusoidal waveform.

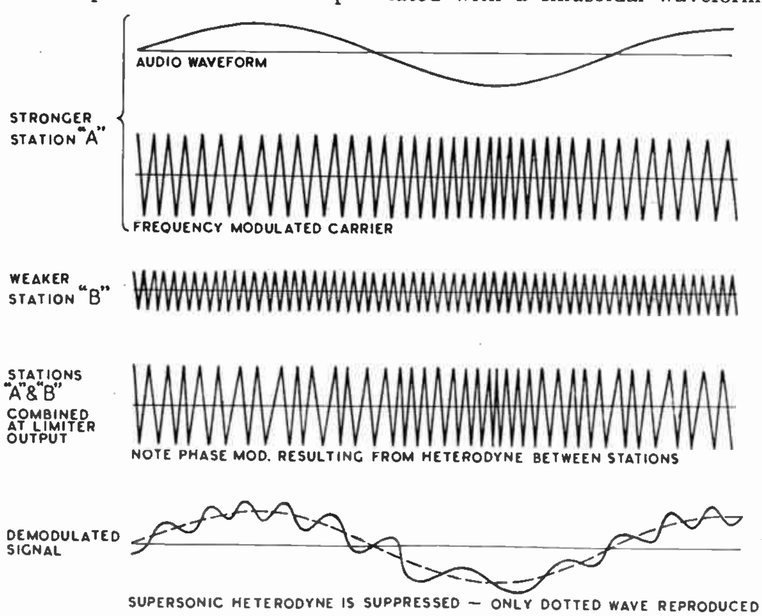


Fig. 6. The weaker station is demodulated as a heterodyne superimposed on the stronger station's modulation. The heterodyne frequency is the instantaneous difference between the two stations. With wide-band FM this difference is largely supersonic and the heterodyne is therefore inaudible.

The weaker station B is working on a nearby frequency and for simplicity is assumed to be unmodulated. The combined waveform, after the limiter has suppressed all amplitude variations, is shown in the third diagram. When this signal is demodulated the weaker station appears as a superimposed heterodyne on the stronger station's demodulated intelligence. This heterodyne has a frequency equal to the instantaneous frequency difference between the two stations. If station B is also frequency modulated, the superimposed heterodyne frequency will still be the difference between the two stations, although naturally its form will be complex.

As both stations are assumed to be wide-band frequency modulated, their instantaneous difference frequency will vary between zero and 150 kc/s or more, depending on the maximum deviation employed. If the two stations are, say, 25 kc/s apart the best note will, on the law of averages, be almost entirely supersonic, and therefore inaudible and for all practical purposes suppressed. Even with both stations on the same frequency the heterodyne will, for some 40 to 60 per cent. or more of the time, be above the audio band. For the remainder it will take the form of a background rustle conveying no intelligence whatsoever.

This suppression of a weaker station by a stronger one is an important characteristic of wide-band FM transmission, and is sometimes referred to as the "capture effect."

Within the zone in which two FM stations, operating on the same channel, are received at the same strength, neither station will have any programme value. This situation is normally overcome by the erection of a directive aerial system which favours either one or other station. A movement of only a few miles towards either station is normally sufficient to ensure that the weaker one is suppressed.

The capture effect is of very great importance when planning any network of FM stations. It would be possible to erect an FM network covering a whole continent, providing two alternative programmes and employing only three different carrier frequencies. The capture effect also makes any attempt at jamming extremely difficult. Unless the signal from the jamming station approaches the strength of the desired station it will be suppressed.

BIBLIOGRAPHY

"FM Receivers," by Marvin Hobbs. *Electronics*, August, 1940.

"A Method of Reducing Disturbances in Radio Signalling by a System of Frequency Modulation," by E. H. Armstrong. *Proc. I.R.E.*, May, 1936.

"Frequency Modulation" (Part V), by K. R. Sturley. *Electronic Engineering*, March, 1942.

"Frequency Modulation Noise Characteristics," by M. G. Crosby. *Proc. I.R.E.*, April, 1937.

"Impulse Noise in FM Reception," by V. D. Landon. *Electronics*, February, 1941.

"Noise in FM Transmissions." *Wireless World*, February, 1941.

UNITED STATES Army Signal Corps personnel setting up a transportable station in North Africa. The Corps maintains communications for the Army and Air Force.

TRANSITRON OSCILLATORS

Wide Range and High Frequency Stability with Untapped Coils

By

A. G. CHAMBERS (G5NO)

MOST readers of this journal are familiar with Hull's famous Dynatron oscillator. A similar circuit, not so well known, is the negative transconductance oscillator discovered by Herold[1] in 1935, and later developed and renamed the "Transitron," by Brunetti[2] in 1939.

This oscillator possesses essentially the same type of negative-resistance characteristic as the Dynatron, having all its advantages without its disadvantages. Its characteristic is independent of secondary emission, and remains practically constant for the life of the valve. Like the Dynatron, it is a low-powered oscillator, and will oscillate from 600 c/s to 60 Mc/s by changing the value of the associated LC circuit.

Brunetti reports that when properly designed, changes in frequency resulting from a 33 per cent. change in screen volts may be kept within 10 parts in 10^6, and that its stability may be compared with that of a crystal oscillator. Another great advantage is that no centre tap is required as in other types of oscillators. All that is necessary to switch from 160 to 5 metres is to change the coil!

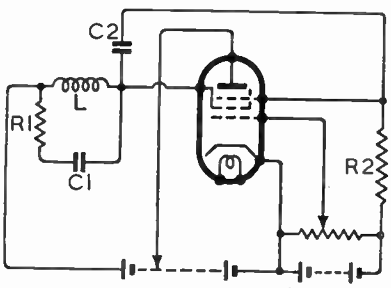


Fig. 1. Basic circuit of the Transitron oscillator.

The writer first built up a battery model on a bread board. The circuit, which is extremely simple, is shown in Fig. 1, the action being as follows: Negative voltage applied to the suppressor causes electrons that have passed through the screen to be returned. Over a certain range, a positive increment of suppressor voltage allows more electrons to go to the anode, and thus decreases the screen current, which means that the suppressor-screen transconductance is negative. When this negative resistance becomes equal to the equivalent resistance of the tuned circuit (R_1 in Fig. 1), oscillation results. Fig. 2 shows the screen current/screen voltage characteristic, O being the operating point.

The relative values of C_2 and R_2 are important; if they are so small that the reactance of C_2 is appreciable in comparison with R_2 at the desired frequency of oscillation, then the voltage-dividing action of C_2 and R_2 causes the change of suppressor volts to be less than that of the screen, and the system stops oscillating.

As with the Dynatron, it is desirable to keep the amplitude of oscillation small so as to keep the waveform and frequency stability good. If a small negative bias is applied to the control grid, the total current flowing to the screen may be controlled and the negative slope of the current/voltage characteristic may be varied. Hence a flexible means is available for varying the magnitude of the negative resistance, and thus the amplitude of oscillation. By arranging for the oscillation voltage to regulate the bias on the control grid, additional amplitude control may be obtained.

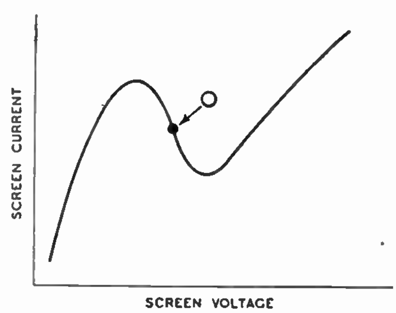


Fig. 2. Screen-current/screen-voltage characteristic of the Transitron. The operating point is at O.

Having obtained good oscillation down to 30 Mc/s, the layout was altered, a small metal chassis was obtained, a one-point earthing system adopted, and a Mullard EF50 valve placed in the circuit. After these alterations had been made, an inductance consisting of five ½in. diameter turns of silver-plated 16 SWG copper was placed in the circuit; the system was still found to oscillate. A half-wave Lecher wire system was coupled up, and the wavelength measured was 3¼ metres.

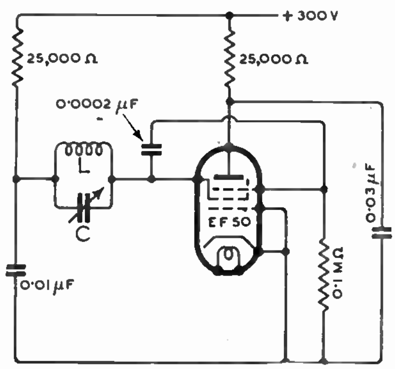


Fig. 3. Practical circuit for frequencies up to nearly 100 Mc/s.

The 3 Mc/s coil was then put back to make certain that it was still correct at this frequency, also the output was connected to an oscilloscope to observe the wave form. It was seen to be a pure sine wave.

Fig. 3 shows the circuit used. It will be noted that suppressor bias has been omitted, as it was found unnecessary with this type of valve. For those who are interested in this particular circuit, the following operating conditions are included. In an oscillating condition, at approximately 3 Mc/s, with the values shown, anode current is 4.5 mA and screen current

[1] "Negative Resistance" by E. W. Herold, *Proc. I.R.E.*, Oct. 1935.

[2] "The Transitron Oscillator" by C. Brunetti, *Proc. I.R.E.*, Feb. 1939.

7.6 mA; in a non-oscillating condition anode current is 10 mA, and that of the screen 3 mA.

Although it did not occur to the writer at the time, it is felt that if the metal screen covering the valve had been removed, it might have been possible to go higher still.

Other suitable pentodes Brunetti suggests are the American 57, 58, 59, 6C6, 6J7 and 6K7. The Osram ZA2 acorn pentode was tried, but could not be made to oscillate.

The enormous scope for this oscillator will be seen from the following list of advantages:—

(*a*) Stability.
(*b*) Simplicity.
(*c*) Ease with which output can be controlled.
(*d*) Purity of waveform.
(*e*) Ease in band changing (i.e., only one inductance required).
(*f*) Almost any pentode valve will suffice.

The only disadvantage seems to be that only low outputs can be expected if (*a*) and (*d*) are to be satisfied.

Putting the above advantages to practice, the writer has the following applications in mind:—

As a General Purpose RF and AF Oscillator.—An oscillator that will cover from 600 cycles to 60 Mc/s with a variable amplitude control, in place of the usual attenuator, is an attractive proposition for the amateur. Previously a Dynatron has been used with a specially selected valve which is dependent upon secondary emission, a property which is extremely variable with age, and which varies widely in valves of the same type.

As a Local Oscillator.—The local oscillator in a superhet receiver, with its inherent drift and large number of coil connections for band switching, has always been a source of trouble to the designer. It is felt that this oscillator could be utilised with advantage on account of its excellent stability and simplicity.

As a Frequency Meter.—In the past, the electron-coupled oscillator, with its inevitable cathode tap, has been used for this purpose. Here, now, is an oscillator which is more stable and only requires a coil with two connections.

As a Crystal Oscillator.—The output from a Transitron must be kept low if used in place of a crystal oscillator, in which case it would have to be followed by a stage of RF amplification, but, incidentally, this also applies to the electron-coupled oscillator, so widely used by amateurs in the past. The variable output control could be utilised with advantage as a control for varying the amount of drive required for the following stage. Again there is the advantage of two-pin coils for easy band changing. It is suggested that link coupling be used to avoid any undue loading which might spoil the stability of the oscillator.

(It is hoped later to describe a practical test oscillator using the Transitron principle.)

"FLIGHT" HANDBOOK

Issued by our associated journal *Flight*, this well-known guide to flying has just appeared in a third edition. There are chapters on the first principles of aviation, as well as on the more specialised aspects of the subject. The aim of the book is, without recourse to mathematics, to help the reader to understand the more important aerodynamic and structural principles.

Flight Handbook is issued by *Flight* Publishing Company, Ltd., Dorset House, Stamford Street, London, S.E.1, at 6s. net; by post, 6s. 5d.

UNBIASED

By

FREE GRID

Radio to the Rescue

JUST lately I have been studying an American work dealing with the speed of reactions between certain brain centres and the different groups of muscles they control. At first sight this doesn't seem to bear much relationship to radio technique, but this is far from being the case, as in a series of experiments carried out by three eminent research workers, and recorded in the book, there lies a whole heap of post-war troubles for the radio service man.

It appears that a big insurance combine across the herring pond had invited the three learned authors to investigate scientifically the cause of certain types of automobile accidents. I will just endeavour to summarise their work for you without the prolific medical jargon with which the book is filled. In brief, then, when a pedestrian steps off the kerb in front of an oncoming car, a large percentage of accidents could be avoided if the brakes were applied a split second sooner than is usually the case. The investigators have found that this all-important split second is thrown away by the relative slowness with which the vital message to jam on the brakes travels from the driver's brain to the muscles of his limbs.

For some reason which it is needless for me to discuss, this delay is very considerably less in the case of messages travelling from the brain centres to the muscles controlling the vocal chords, a fact which the investigators elicited by complicated measuring and recording apparatus involving many valves and much cathode-ray gear, thus confirming the evidence of most eye-witnesses of accidents who report that a car driver usually gives an almighty yell just before hitting his victim.

Eminent research workers.

It is just at this point that I find, to my amazement, that the learned investigators bring their book to what they imagine is a triumphant ending and seem unable to appreciate either the necessity or the opportunity of crowning their work by giving their mathematical and experimental data a practical and commercial application; evidently they expect me to play Marconi to their Clerk-Maxwell and Hertz. Needless to say, I intend to do so by taking the necessary action in the applications department of the Patent Office.

It must surely be as obvious to you as it is to me that as a result of these investigations all that is needed is a sort of "vogad" apparatus, such as is used in the transatlantic telephone for causing the human voice to actuate a relay. In this case, of course, by means of suitable banks of valve relays and other radio-associated apparatus, the controls of the car will be operated by the human voice instead of by the limbs, and the result will be the saving of the vital split second which will make all the difference in the world to the dividends of the insurance companies which so philanthropically and disinterestedly financed these investigations.

Anybody desiring to confirm the authors' neuro-muscular-reaction findings need only substitute his hand-operated motor horn by a simple PA system, and note how much more quickly he is able to make a pedestrian skip for safety, in addition to removing one job entirely from the all-too-many duties imposed on a driver's limbs.

Wooltonised Radio

JUST lately I have been glancing through several of the astrological almanacs which reached me round about the New Year and I am rather alarmed to notice that while the redoubtable "Old Moore" confidently prophesies victory and peace in 1943, another of his ilk who is entitled to equal credence seems to think that Japan will have no difficulty in keeping the ball rolling until 1949.

The reason for my alarm is the present state of the civilian valve cupboard to which the Editor so justly drew attention in January. A hasty calculation by means of the *Wireless World* Abac book tells me that by 1949, unless something is done about it, the size of the B.B.C.'s audience will have fallen to 1922 proportions, consisting only of what Adolf calls "the haves," or, in other words, those people who in war or in peace seem to possess the happy knack of wangling whatever they need in the way of goods and services.

No doubt, before that state of affairs is reached, something *will* have been done about it, as not only will many of the B.B.C.'s blatantly self-advertising artistes have woken up to the dwindling numbers of their audience, but the B.B.C. itself will be sharply reminded of the fact by the falling off in the revenue from its periodicals, for, after all, nobody is going to buy a professedly "programme paper" unless he can listen to the programmes therein dealt with, and no national advertiser is going to pay for valuable "goodwill" space in a journal which nobody would have any reason to buy.

The result of all this will be a sufficiently loud howl of indignation to penetrate the closed doors of Whitehall and compel the authorities to "wooltonise" the supply of valves and other necessities, not forgetting a few good service-men, and to supply both the service and civilian needs without approaching the danger line of semi-starvation in either case, just as has been done in the matter of food.

"Inundated with correspondence."

In the meantime I am being inundated with correspondence from owners of silent sets asking me if they have any right of action against the P.M.G. to recover that proportion of their licence fee corresponding to the period that their set has been forcibly out of action. Much as it goes against the grain for me to say it, the answer is "No." The licence fee is a tax and not payment for entertainment and is no more recoverable than would be your dog licence fee were Bonzo to be unlucky enough to be commandeered by the sausage controller on the day after you had bought his licence. To those who would argue that if you lay up your car before the expiry of its licence you can get part of the fee back, I would point out that this is not a parallel case, as such repayment is, I believe, an act of grace, and nobody who has had any dealings through the iron bars of the Postmaster-General's counter could possibly associate grace with his department.

Wireless World Brains Trust

Rationalised Broadcast Receivers

Question No. 10. — In the October Editorial you stressed the advantages of competition in the conduct of a broadcast service from the point of view of programmes. Arguing on parallel lines, surely free pre-war competition among broadcast receiver manufacturers should have produced a wide diversity of sets for all tastes, pockets and requirements. Actually the opposite was the case: what we had was, with few exceptions, a standardised superheterodyne circuit, with a few "frills" and expensive cabinet work for those who liked to pay for such things. Where, then, are the advantages of competition? Would not the public have been better served by the "rationalised" production of a standard set? And, after the war . . .?

"RADIOPHARE."

"RADIATOR" draws a comparison between the broadcast receiver industries of this country and of the U.S.A. He writes:—

I THINK "Radiophare" would agree that his requirements as to a wide diversity of set types (including car sets, "communications" sets, ultra-simple, ultra-cheap, and other "ultra" sets) were, in pre-war days, more completely met in the U.S.A. than in any other country in the world. Yet in the U.S.A. strong competition among the radio manufacturers did exist, probably to a greater degree than in any other country.

Judging, then, from conditions prevailing in the U.S.A., the only conclusion one can come to is that competition *does* tend to produce a wide diversity of types, such as will meet all possible requirements. If the same conditions did not produce the same result in this country—and it is true that they did not—then there must have been some other cause operating which was strong enough to override the tendency towards diversity of types provided by the competitive condition.

That cause was, I contend, the conservative outlook and complete lack of imagination of the British manufacturer, who was unwilling to venture into fields where he could not see an immediate and safe return. The situation as to "communication" receivers and amateur equipments generally should prove this point.

Can it be that the technical staffs of the manufacturers were also, in some degree, responsible for the paucity of types in this country? Personally, I do not think so. It was simply a case of technical brains and initiative being wasted by commercial conservatism and lack of foresight. The result was that the British manufacturer turned out, year by year, a few more or less standardised types, generally based on American designs of the previous year.

If anyone doubts that the British manufacturer was, in fact, so lacking in initiative and foresight, he should consider for a moment the way in which the industry catered for the vast market that was opening up in the British Colonies and Dominions. That market was his for the taking, yet he completely failed to deliver the goods, with the result that the American and Dutch manufacturers stepped in, studied the requirements, and very soon had the market in their own hands.

As to the situation after the war, one is inclined—like "Radiophare"—to trail off into an interrogative. At this stage too many "unknowns" exist to warrant a reasonable forecast. One can only hope that, whatever economic and commercial system then exists, it will be imbued, in some measure at least, with an ideal of service to the community, which should result in the consumer getting what he wants, or at least, what is *really* the best for him.

"T.J.R.," in his reply, questions whether true competition did in fact exist in the pre-war wireless industry:—

BOOKS have been written—and banned—that deal with smaller issues than those raised in this question. So some allowance must be made for any inadequacy in my reply.

As an engineer, I sympathise with the querist. The pre-war use of our technicians for duplicating someone else's results and saving farthings in production was often wasteful and insulting to the intel-

Wireless World Brains Trust—
ligence. But it is a mistake to blame "free competition." That expression conjures up a picture of rivals competing on both technical and economic planes, and with equal resources at their disposal. Such conditions never existed. With a few exceptions—mostly insignificant—we had about two groups of giant and medium-sized concerns. Even when there was no financial book-up, the basic uniformity of their products was assured by membership of various manufacturers' associations and common sources of component supplies, especially of valves.

Given some measure of planned co-ordination, our technicians could produce, after the war, all the receiver types wanted by the public, including "communications" sets and the like. But, in speaking of rationalisation, let us engineers remember that it has already been applied in a certain country, where it led to the production of a "People's Set," selling at the equivalent of 45s., which allowed the user to hear just as much as he was intended to hear. Rationalisation, if we are to have it here, must be in the hands of those who would use it to satisfy the consumers' real needs.

RANDOM RADIATIONS

By "DIALLIST"

Standard Resistors

'TIS curious to notice how the range of so many wireless components, however small it may be at first, tends to grow and grow, until at length it contains a preposterous number of types and values. Valves are, of course, the classic example. In 1919 and the very early twenties there was, believe me or not, only *one* type of valve in general use in receiving sets. This was the old "R." A few other valves existed, but they weren't often seen. Not so many years passed before valve types in this country reached four figures. And now I see in the *Wireless Trader* that the composition type of fixed resistor—a component you'd never have suspected of such conduct—has got out of hand. It was found recently that over 800 kinds and values were being demanded from manufacturers. Well, that's pretty surprising expansion. One would have thought off-hand that detector grid leaks running from one to ten megohms, ranges of ½ watt, 1 watt, 2 watt and 5 watt resistors from 1,000 and 250,000 ohms and of higher wattage from 50 to 1,000 ohms would have met the requirements of most receiver designers. But there are many things besides receivers involved and the position is complicated by the question of tolerances. Resistors of the highest grade have a tolerance of 5 per cent. of the stated value; next came those with a tolerance of 10 per cent.. and lastly those (most used of all) whose tolerance is 20 per cent. So you can see how the numbers begin to mount up. Recently, I'm glad to see, an agreement has been reached by which composition fixed resistors are standardised in 255 types. Even that is a largish number, but no further cutting down is possible. And that refers to the composition types only: there are still the wire-wound resistors.

Can't We Go Farther?

There's no doubt that lack of standardisation has been in the past a brake on the wheels of our radio industry. One reason why valves are so costly is that makers have to install the machinery for turning out a vast number of types in comparatively small quantities. And the same wastefulness is to be found in the making of other components. Take fixed condensers, for instance. How many different kinds are employed by receiving set designers? The number must run into many hundreds when you come to think of the big ranges of paper-dielectric, mica-dielectric, electrolytic and ceramic condensers. And there again the tolerance question comes in. HT batteries, too, are startling in the multiplicity of their shapes, sizes and tapping arrangements. A big saving in manufacturing costs could be effected were the types of HTB available reduced to a much smaller figure. And they could, I believe, be brought down to a total of three without in any way affecting the efficiency of battery sets. Only three? Yes; here's how it would work out. Most batteries are already made up from three sizes of cell: the standard-capacity cell (about ¾in. × 2in.—I haven't the figures by me. There is an intermediate type measuring about 1¼in. × 2½in., and the biggest measures about 1½in. × 3½in. My suggestion is a 40-cell battery for each cell size, the cells being arranged in eight rows of five, and there being only two terminals, or spring clips, marked 0 and 60 volts.

HTBs

The average battery set works on 120 or 180 volts: two or three of the suggested units in series. And there's no need for tappings if bleeder resistance networks are used, as they are to some extent in this country and in all battery sets in America. Besides eliminating tappings, the bleeder network has the great advantage of putting an equal load on all parts of the battery; tappings mean that the sections of the battery nearest the negative end do the most work, since they are common to all HT circuits. Set designers would not find that the lack of HTB's in anything but 60-volt block units cramped their style, once they got used to the idea. As things are, they can call on the unfortunate battery manufacturer to turn out batteries of odd shapes and sizes and with fantastic numbers of tappings to fit their cabinets and fit in with their circuits. Under the new order the bleeder network would be made to suit the circuits and layout and cabinet design would have to be suitable for batteries of fixed shapes and sizes. The reduction of HTBs to three standard types couldn't be done in a moment; but after the war we shall have a grand opportunity of cleaning up and of getting rid of obsolete types of valves, batteries and other components since the majority of the old sets, already on their last legs, will be scrapped at the earliest possible moment.

□ □ □

Wireless Isn't Standing Still

IN peacetime improvements in wireless receiving sets were continually being announced. All through the year we heard of new valves, new circuits, new methods of tuning, new ways of alleviating man-made interference, and so on. Then at the Radio Exhibition there were nearly always "surprises" which makers had kept up their sleeves until their new models were launched. Because in wartime we hear little about such things many people believe that wireless has more or less stood still since September, 1939. It certainly hasn't. I am sure that when peace returns we shall find more surprises waiting for us than any Radio Exhibition ever produced. Developments may have been made with warlike purposes in view, but no one can doubt that heaps of them will have direct applications to peacetime transmission and reception. Don't forget what happened in the last war; when it started, wireless telephony was in its infancy. Huge strides were made while hostilities lasted; the old general-purpose valve, for instance, was developed and many special types as well. When that war came to an end the stage was very nearly set for the entry of broadcasting into the life of nations. As soon as the restrictions on the use of wireless equipment which had been in force for some five years could be removed, the number of amateurs increased by leaps and bounds.

Post-war Paradise

Wireless components of many kinds were horribly expensive when the wireless 'twenties began, but the release of Government surplus stocks soon made a vast difference to that, and those of us who were in the game in those early days were able to buy for the proverbial old song apparatus that we couldn't possibly have afforded otherwise. I expect that it will be much the same this time—but probably more so; such vast use of wireless has been made by all the Services that there should be huge amounts of surplus stocks for disposal when the time comes. Experimenters, whether serious or of the dabbler type, can look forward to a glorious time.

Progress All Round

Then, we musn't lose sight of the fact that it isn't only our side that has been working hard to make improvements in wireless. Germans, Italians and Japs have all produced important developments in the past, and though their present doings were shrouded in mystery, we can feel sure that they're not letting the grass grow under their feet. You can't call to mind any Japs who have made a mark in radio? Well, what about Nagoyaka? And there's Yagi, the aerial man, as well, to mention just a couple. Until the United States came into the war wireless was going ahead untroubled on the other side of the Atlantic, and many new things were announced in *Wireless World*. No one can doubt that the American General Electric and others have made tremendous progress both in the application of frequency modulation to broadcasting and in television. In this country J. L. Baird has been far from idle in the television field; *Wireless World* has been able to publish accounts of some of his achievements in stereoscopic and colour reproduction.

FM

Personally, I've always been a staunch believer in frequency modulation as the coming thing in broadcasting. Luckily, its forward march in the United States at any rate has not been a wartime secret. *Wireless World* has kept its readers pretty well informed of what is being done. I have little doubt that the B.B.C. will go ahead with FM broadcasting as soon as they are free to start construction and development again. I don't mean that there is any likelihood that it will immediately begin to replace amplitude modulation. That would never do; amplitude modulation must continue for many years to be the method mainly in use. But I do foresee the erection of rapidly increasing numbers of FM transmitting stations, relaying the studio programmes and giving those who install FM receivers the chance of obtaining reproduction of high quality with almost entire freedom from interference. I doubt whether AM transmissions will ever be entirely superseded, for so far as our present knowledge goes FM is essentially a system adapted for short ranges and, therefore, small service areas only. There will always be large tracts of thinly populated country where (unless and until something on quite new lines is invented) AM is the only method which can deliver the goods.

□ □ □

Names for Frequency Bands

A DORSETSHIRE reader is kind enough to send me useful suggestions for names for the frequency bands used in wireless. You may remember that those put forward by the C.C.I.R. are:—

Below 30 kc/s.	Very low.
30—300 kc/s.	Low.
300—3,000 kc/s.	Intermediate.
3,000—30,000 kc/s.	High.
30,000—300,000 kc/s.	Very High.
300,000—3,000,000 kc/s.	Ultra High.
3,000,000—30,000,000 kc/s.	Super High.

I didn't like Intermediate or the Very, Ultra and Super Highs, suggesting in their stead Medium, Medium High, High, Very High and Ultra High. But I wasn't satisfied with these and asked for ideas on the subject. Here is one of them:—

Bottom; Low; Medium Low; Intermediate; Medium High; High; Top.

There are not the same objections to Intermediate here, for it comes right in the middle of the list. I don't like the name though, for we are sure to go on speaking of the IF stages of superhets, and it is undesirable that one and the same name should be used for frequencies of quite different orders. If we start the list with Bottom and work up to Top, why not speak of the 3,000-30,000 kc/s range as Middle. I'm not quite happy though about Top. True, it takes us to wavelengths of only one centimetre, but can we be sure that that is the radio top in frequencies or bottom in wavelengths? Not so very long ago it was held that wavelengths below 100 metres could never be of any use to wireless. Can anyone be sure that we shan't one day measure our wavelengths in millimeters and our frequencies in hundreds of thousands of megacycles?

GOODS FOR EXPORT

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export

Letters to the Editor

G.P.O. Control · Battery Socket Markings · Volume Expansion

G.P.O. Control of Wireless

I WOULD like to express my almost complete agreement with your "Brains Trustee," "Radiator" (February issue), as to the desirability of an independent body to control the nation's wireless services. The only point on which I am in disagreement with him is the representation of amateur transmitters on the proposed Commission. He states that as there is no representative organisation of listeners in this country, the listeners' representative should be an M.P., etc., but then, apparently as an afterthought, adds: "He might also represent the amateur transmitters." Now, with all due reverence to the average M.P., can you see him arguing about frequency bands, band occupancy, and the like, with any hope of success? Would the claims of five thousand or so amateur transmitters stand much chance against those of ten million "BCL's" if the same man had to represent both? By all means have a listeners' representative, but let the amateur transmitters have their own Commissioner. The amateurs *have* a representative organisation, the R.S.G.B., to which over 90 per cent. of amateurs with radiating licences belong. It might be as well to remind "Radiator" of the fact that amateur stations in peacetime exceeded in number stations of *all other classes combined*; also, that although the percentage of amateurs per thousand of the population in this country was only a small fraction of the percentage in the United States, if the relative areas of the two countries are considered, England and Wales had more than twice the amateurs per hundred square miles.

In the past, the G.P.O.'s attitude towards amateurs has been "don't allow amateurs to use high power, or the 56-Mc/s band, etc., without putting them to a lot of trouble and delay (and charging unjustified 'registration fees' in addition to the yearly fee), just in case they *may* cause interference to important (Post Office) services." However, whether the proposed National Radio Commission ever comes into being or not, and it is to be hoped sincerely that it does, we may hope for a more liberal treatment of amateur transmitters by the authorities *apres la guerre finie*.

"SIGNALMAN."

Battery Socket Markings

THERE has appeared recently a type of HT battery the markings upon which are very misleading to the average user. The battery is tapped at 1½-volt intervals for GB purposes, but the voltages are *positive* with respect to HT negative. It has been standard practice for years for these tappings to read negative, and as a result of the change I have found several receivers connected up with positive bias applied to the valves.

It should be clearly indicated on these batteries that, in the case of receivers using the combined type of battery, the HT negative lead should be inserted in the socket giving the amount of bias required; the GB leads being then tapped back towards the HT negative socket on the battery.

K. CHANDLER.
Mintlaw Station, Aberdeenshire.

Transmitter Volume Compression

I WOULD like to add some comments to the recent letters on the use of volume compression and expansion based upon my experience in the design, demonstration and operation of several hundred equipments of these types. There can be no doubt that volume compression and expansion will be a major post-war development, but I feel that the remarks of Mr. J. R. Hughes (your January issue) are based either upon experience with an unsatisfactory volume expander or solely upon theorising about the question. While there cannot be any doubt that volume expansion alone is theoretically incorrect, the advantages gained in practice far outweigh the small theoretical disadvantages. As Mr. Hughes points out, the volume expander used alone must either degrade the transient response and/or increase the non-linear distortion at low frequencies. The advantages of increased realism and decreased background noise, however, vastly outweigh the disadvantages. In confirmation of this, I can say that after demonstrating volume expander circuits to several hundred engineers and musicians, most of whom would be expected to adopt a critical attitude towards the subject, I found that favourable comment was almost unanimous. No one ever commented on an increase in the non-linear distortion, and on only one occasion did one engineer comment upon the degraded transient response, and on this occasion the particular record had to be replayed about half a dozen times before he was able to pick out any portion in which he thought that this degradation was in any way noticeable. No further support for his opinion was forthcoming from any of the remaining 200 people present at that particular demonstration. On the other hand, there have been many occasions on which it has been difficult to persuade members of the audience that the same record was being used during the "expanded" performance as was used during the ordinary run.

My experience so far is mainly confined to the reproduction of gramophone records, and I would like to stress that every gramophone record is not suitable for use with a volume expander. In general, dance records in which the volume level remains substantially constant throughout the whole performance are unsuitable, but there is a notable exception in "Exhibition Swing" (Par. 1235) in which the string bass is enormously enhanced by the use of a properly adjusted expander. Other records of a different nature which I have found favourable are "La Boutique Fantasque" (C2846) and "Three Men Suite" (C2723).

Like Mr. Hughes, my ideas on the subject of expansion were very unfavourable before I starter the actual development, because of the large number of theoretical objections; but after some practical experience I have become a most enthusiastic supporter of the system as an interim measure before fully automatic compression and expansion are adopted.

Rugby. J. MOIR.

Stereoscopic and Colour Television

THE article in your February issue on "Colour Television Development" refers to publication in February, 1942, of an account of the anaglyphic method of producing stereoscopic television, but a glance at the article in question shows that it did not describe a system in which the viewer wears spectacles with red and blue filters,* but a system in which the viewer must hold his head in the right place for each eye to receive alternately images projected in slightly different positions from the receiving apparatus—in fact, an adaptation of the hand stereoscope used for viewing pairs of photographs, but with the two images produced alternately instead of simultaneously.

The method using coloured spectacles was developed some years ago as a cinema novelty, and its application to television follows quite naturally from this. There is, however, a refinement which would now be possible. Instead of using coloured light, one colour for each eye, one could use polarised light, with the two images for the two eyes projected in light which is polarised horizontally and vertically respectively and viewed through Polaroid spectacles with the two eye-pieces set for these two planes. This would have two advantages: one could then apply colour to the television image, so as to have coloured stereoscopic television for a number of viewers, and the viewer's surroundings would look more normal through Polaroid than through coloured spectacles.

I think Baird's method of using separate images for colour, with stationary filters, is good if one can obtain accurate "register," though one might anticipate trouble from variations of tube deflecting voltages; but I would like to see a more detailed description of the way in which a "converging lens" brings the two images together.

D. A. BELL.

Winchmore Hill, N.21.

* [This method has, however, been demonstrated by Mr. Baird.—Ed.]

RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

PIEZO-ELECTRIC OSCILLATORS

If a piezo crystal, coupled to an amplifier, is used as a "motor" to drive, say, a recorder or loud-speaker, some distortion may be produced by piezo-electric hysteresis and other causes, including the varying impedance of the crystal at different frequencies.

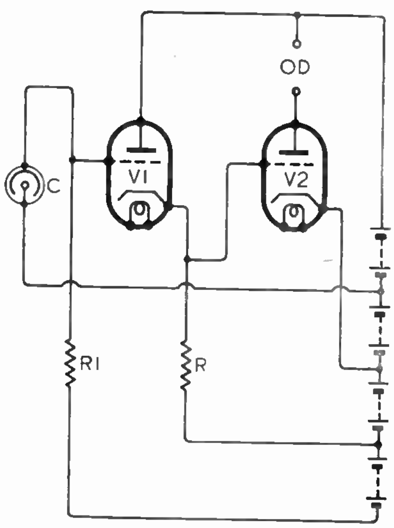
To offset this, the crystal is regarded as a "generator" as well as a "motor." Auxiliary electrodes are fitted to the crystal, from which an out-of-phase voltage is applied to the input of the amplifier, so as to give a negative feed-back which compensates for the initial distortion.

Electrical Research Products, Inc. Convention date (U.S.A.) March 30th, 1940. *No.* 546,182.

PHOTOELECTRIC RELAYS

The comparatively low grid insulation of a high-slope pentode renders this otherwise suitable type of valve unreliable when coupled to a photoelectric cell.

The circuit shows an arrangement in which a pair of valves, one operating as a "cathode-follower," offers a satisfactory substitute. It will be seen that the grid of V2 is coupled to the cathode load resistance R of the valve V1. The anode of the PE cell C is directly connected to the grid of V1, and is then taken



Photoelectric cell amplifier.

through a high resistance R1, of the order of 50 megohms, to the negative end of the supply. Both the valves V1, V2 are initially biased to cut-off so that there is no potential drop across the coupling resistance R.

When the cell is illuminated, the current taken by the resistance R1 raises the potential of the grid of V1 and causes that valve to conduct. This valve does not amplify, but the potential of its cathode automatically "follows" the grid potential. This, in turn, causes the valve V2 to conduct and amplify, and so operates an alarm OD or other relay. The initial bias on the valve V1 can be adjusted to regulate the intensity of the incident light required to operate the relay.

Vacuum-Science Products, Ltd., and H. S. Molyneux-Ffennell. Application date February 7th, 1941. *No.* 547,010.

TIME BASES

For a time-base circuit, the deflecting voltage applied to the electron stream should vary linearly with time. In practice, however, it is usual to charge a condenser through a high resistance, and to discharge it suddenly through a triggered valve. The result is a voltage which varies exponentially and not linearly with tme, though if only the lower part of the saw-toothed wave is used it gives a fair approximation to the desired straight-line law. On the other hand, it calls for an unnecessarily high charging voltage.

There are various other methods of securing the ideal response. One can, for instance, inject a supplementary voltage which is designed to correct or straighten the inherent curvature. According to the invention the charging condenser is connected to the grid of the first of two valves which are coupled through a common cathode resistance. The grid of the second valve is anchored to a fixed potential, and the charging resistance is tapped to the anode resistance of that valve This injects a voltage which is at all times equal to that across the condenser, and so keeps the charging current constant throughout the whole of the sweep.

Marconi's Wireless Telegraph Co., Ltd., and N. L. Yates-Fish. Application date March 13th, 1941. *No.* 547,949.

FREQUENCY MODULATION

A single multi-grid valve is arranged to generate oscillations at constant amplitude, but at a frequency that is controlled by the voltage applied to one of the grids. To secure this result the anode and screen-grid are both coupled to the control-grid through a branched path, the two separate arms of which are substantially free from reactance at the oscillation frequencies. In one application of the device the frequency control voltage is applied to the second grid, the resulting output being a frequency-modulated signal. If negative back-coupling is applied through a cathode load resistance the range of frequency modulation can be extended.

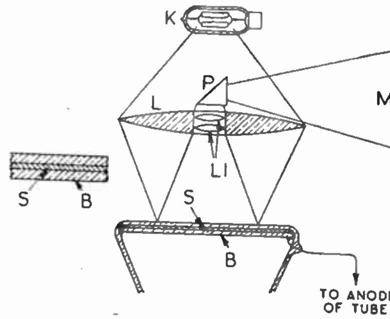
A. C. Cossor, Ltd., and O. H. Davie. Application date March 25th, 1941. *No.* 548,148.

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

TELEVISION RECEIVERS

The fluorescent screen of a cathode-ray tube is replaced by a thin film or layer of a substance, such as paraffin wax which tends to become liquid and more transparent under the action of heat. The effect is used to modulate the light from an external lamp, thereby reproducing the picture.

The figure shows the bulb end of a cathode-ray tube which is provided with the usual electrodes for scanning, and for modulating the electron streams in accordance with the received signals. The wax film or screen S is enclosed between two glass walls, the inner of which carries a thin backing B of silver.



Television picture projector.

Light from a lamp K is focused by a condensing lens L on to the bulb. The light reflected back from the silver coating B is controlled by the varying transparency of the intervening film of wax, as it is heated from point to point by the impact of the modulated electron stream. It is collected by the centre lenses L1 and is projected by a prism P on to an external viewing screen M. The inside film of silver B is preferably kept at the same potential as the anode.

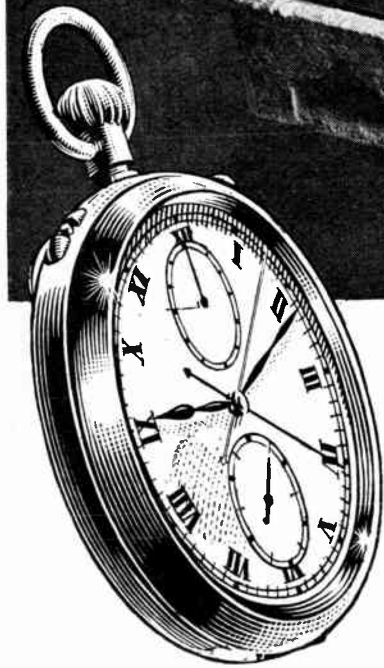
Farnsworth Television and Radio Corporation. Convention date (U.S.A.) September 7th, 1940. *No.* 547,075.

SUPERREGENERATIVE SETS

Although the characteristic "hiss" of a superregenerator is usually completely submerged by an incoming signal, its persistance during the intervals between and in the absence of the desired signal is irritating.

One way to get rid of it is to block the receiving channel whenever the desired signal is absent For this purpose the superregenerative stage is coupled (a) to a low-frequency amplifier which feeds a pair of headphones, and (b) to a high-pass filter arranged in parallel with the amplifier when there is no incoming signal, the filter passes the "hiss" frequencies, which are rectified and produce a paralysing bias which is applied to the grid of the LF amplifier so that no sound can be heard in the phones. When signals are being received, they cannot pass through the filter, any residue of hiss being insufficient to affect normal operation.

Philips Lamps, Ltd. (communicated by N. V. Philips' Gloeilampenfabrieken). Application date April 23rd, 1940. *No.* 547,698.



The accurate timing of watches and clocks is normally a lengthy procedure and involves keeping the instrument under observation for a considerable period.

The development of the Thermionic Valve and Cathode Ray Tube have made possible the design of special apparatus by means of which any timepiece can be regulated with great precision in a matter of minutes.

This is yet another example of the important part which the valve plays in solving specialised problems of control which arise in almost every industry.

COMMERCIAL
INDUSTRIAL
SCIENTIFIC
MEDICAL
EXPERIMENTAL
DOMESTIC

MULLARD

THE MASTER VALVE

A Valve for Every Purpose

THE MULLARD WIRELESS SERVICE CO. LTD., CENTURY HOUSE, SHAFTESBURY AVE., LONDON, W.C.2 (47)

Advertisers and buyers are reminded that under Defence Regulations 1939, Statutory Rules and Orders 1940, Number 1689, a permit (T 99 G) must be obtained before sale or purchase of certain electrical and wireless apparatus, particularly such valves and apparatus as are applicable to wireless transmission.

NEW RECEIVERS AND AMPLIFIERS

HIGH Fidelity A.C./D.C. Amplifiers, 18 watts, U.D.O. mixing input channels, bass and treble controls, input and output transformers, Octal base valves, complete chassis, 18gns.—Below.

DANCE and Stage Transportable Amplifying Equipment, comprising amplifier as above, M/C microphone, adj. stand, 2 auditorium speakers, cables; 36gns.—Broadcast and Acoustic Equipment Co., Ltd., Broadcast House, Tombland, Norwich. [1528

£22/10 Only. — New 7-valve "Wireless World" Quality Amplifier, with tone control stage, 8 watts push-pull triode output with tone control stage; price includes Super Quality triple cone 12in. permanent magnet speaker with large matched output transformer and all valves. Limited number available.—Bakers Selhurst Radio, 75, Sussex Rd., South Croydon. [1559

RECEIVERS, AMPLIFIERS—SECOND-HAND

NATIONAL NC44 Communications Receiver, seven valves, frequencies 540 to 30,000 kilocycles.—Box 2822, *Wireless World.*

McMICHAEL All-wave Model 137, with stand, list price; Gambrell 7-valve communication receiver, £30; few valves.—Box 2834, c/o *Wireless World.* [1581

COLUMBIA Radiogram, 200-250v D.C., good condition (owner now on A.C. mains), carriage paid; £14.—Feltham, 32 Cooperage Rd., Redfield, Bristol, 5. [1580

MARCONI Autoradiogram, 7-2,000 metres, 5 bands, Garrard changer, special burr walnut bureau cabinet, perfect; £90; collected.—Benson, Bush Barn, Robertsbridge. [1536

TWO Three-way Microphone Mixing Panels, having four volume controls, each three-gang, wire wound, £3/15 each; three mains transformers, input 200-250, output 40-50 volts, 125 watts, £2/10 each; 36 Mazda UU6 rectifiers, £19/16.—Box 2830, c/o *Wireless World.* [1569

Wanted

WANTED, A.C. communication receiver.—Box 2833, c/o *Wireless World.* [1579

EDDYSTONE "All-World 2."—J. K. R., "Windward," Kings Rd., Alton, Hants.

NATIONAL H.R.O. and Voigt Speaker.—Offers to Benson, Bush Barn, Robertsbridge. [1537

HIGH Fidelity "Straight" Set, W.W. Qual. amp., Qual. output transformer.—Box 2828, c/o *Wireless World.* [1547

"W.W." Quality Rec. and Ampl., gram. preferred; full details and price.—41, Eltisley Av., Cambridge. [1566

WE Offer Cash for Good Modern Communication and All-wave Receivers.—A.C.S. Radio, 44, Widmore Rd., Bromley. [1541

W.W. Quality Receiver, A.C., for radiogram cabinet; Universal amplifier and gramo. motor.—Box 2817, c/o *Wireless World.* [1515

WANTED, by "Comforts Organisation," a 5-20-watt amplifier.—Particulars to J. R. Walmsley, 46, Devonshire Rd., Burnley. [1546

U.H.F. National 1-10, Skyrider 5-10 or similar receiver wanted; state frequency range; top price for first class set.—BM/DAL, London, W.C.1. [1565

NATIONAL H.R.O. Communications Receiver Required, 230 volts A.C.; must be late model, in good condition; state lowest cash price.—Box 285a, 75-79, Farringdon St., London, E.C.4. [1557

LONDON CENTRAL RADIO STORES Will Pay Good Prices for Receivers, Radiograms, Amplifiers, Dynamos, Converters, Test Equipment, Electric Gramophone Motors, and all Radio and Electrical Accessories.—London Central Radio Stores, 23, Lisle St., London, W.C.2. Gerrard 2969. [9836

NEW MAINS EQUIPMENT

VORTEXION Mains Transformers, chokes, etc., are supplied to G.P.O., B.B.C., L.P.T.B.; why not you? Imitated but unequalled Orders can only be accepted against Government contracts.

VORTEXION, Ltd., 257, The Broadway, Wimbledon, London, S.W.19. 'Phone: Lib. 2814. [9942

NEW LOUDSPEAKERS

£3/15 Only.—Brand new Super Quality triple cone permanent magnet speaker, made by Bakers Selhurst Radio, the pioneer manufacturers of moving-coil speakers since 1925; wide frequency range, even response, ideal for quality reproduction. Limited number available under list price. Send 2½d. stamp for leaflet describing above and giving constructional details of infinite baffle cabinet. Every music lover interested in realistic reproduction should write for leaflet now.—Bakers Selhurst Radio, 75, Sussex Rd., S. Croydon.

SECOND-HAND LOUDSPEAKERS

VOIGT Speaker Unit, 100-200v, tapped field, £14; Wright De Costa auditorium speaker, A.C. field, £9; Webson speaker, 6v. field, £3; several others, smaller.—Harris, Strouds, Bradfield, Berks. [1556

F.H. WILSON

WAR-TIME 'ECONOMY' CONSTRUCTORS' KITS

Supplied with **B.V.A.** valves, blue prints, metal chassis, all necessary components, wire, etc., and provided with pick-up sockets.

A.C. STRAIGHT THREE. V.M. H.F. pen., triode, L.F. pen. (not a superhet), energised speaker. **£7 15s.**

BATTERY THREE. V.M. H.F. pen., triode detector and output tetrode. P.M. speaker. **£5 12s. 6d.**

● **CALL FOR DEMONSTRATION** ●

Delivery approx. one month

NOW IN STOCK

A. and H.F. COILS, with reaction, coloured wires for identification, brand new, unscreened. **7/6** per pair.

DUAL RANGE COILS, small, simple, with reaction, connections given. **5/-** each.

COIL, medium wave and primary windings on Paxolin former, no reaction, size 1⅛ × 2⅛. **2/-.**

TRIPLE RANGE COILS, screened, long, medium and short waves, iron cored except on S.W., trimmers permeability and ceramic on S.W., wiring diagram. **7/6** each.

SET OF 4 SHORT-WAVE COILS on low-loss formers, covering 5-91 metres. **6/6.**

SPECIAL LOW-LOSS COIL FORMERS, 1in. × 2in. **1/-** each.

SMALL 0.0005 2-GANG CONDENSERS, ceramic insulation, with trimmers, slow motion drive and dial. **7/6.**

"MIDGET" 2-GANG 0.0005 CONDENSERS, slow motion drive and dial, new. **10/-.**

STANDARD 2-GANG 0.0005 CONDENSERS, ceramic insulated, with trimmers. **5/6.**

STANDARD 3-GANG 0.0005 CONDENSERS, with trimmers. **7/6.**

SLOW MOTION DRIVE, 3-wave band, with coloured glass scale, station named. **7/6.**

MICA CONDENSERS, 30 mmfd., **8d.** 0.0001, 0.0005, **8d.** each. 0.0075, 0.01, **1/-** each.

TUBULAR CONDENSERS, 0.0002 mfd., 0.0003, 0.0005, 0.001, 0.005, 0.02. **6d.** each. 0.003, **8d.**

ALL-WAVE H.F. CHOKES, shielded. **4/6.**

PARALLEL FEED L.F. TRANSFORMERS, screened midget. **6/-.**

465 Kc. I.F. TRANSFORMERS, screened, with trimmers. **5/-.**

FILAMENT CHOKES, double wound, S.W., etc. **1/6.**

WAVE-CHANGE SWITCHES, 3-pole, 3-way. Can be altered to 4-way. **3/6.**

PRESS-BUTTON SWITCHES, 8-way, minus buttons. **2/6.**

FREQUENTITE VALVE HOLDERS, 7-pin only. **1/6.**

OCTAL CABLE PLUGS AND SOCKETS. **1/6** each.

DRILLED STEEL CHASSIS, 10½ × 8½ × 2¾in. **7/6.** 8 × 6 × 2¾in. **4/6.**

RESISTORS, different values, ½-watt, **4d.**; ½-watt, **6d.**; 1-watt, **1/-.**

VALVE HOLDERS, American U.X. type, 4-, 5-, and 7-pin, **6d.**

AERIAL SERIES CONDENSERS. 2/6.

Speakers and Mains Transformers will shortly be available in small quantities. Please send us your enquiries.

HOURS: 9-5 p.m., Saturdays, 1 p.m. C.O.D. orders accepted. Prices subject to alteration without notice. Special terms to members of H.M. Forces and Civil Defence workers. Licence to export to Northern Ireland and Irish Free State. Please add postage for enquiries and mail orders.

51-52 CHANCERY LANE. LONDON: W.C.2. *Telephone HOLBORN 4631.*

Wanted

HARTLEY TURNER or Similar Speaker.—Price, speech coil, field impedence; Little, 22, West Parade, Rhyl. [1523

MORSE EQUIPMENT

FULL Range of Transmitting Keys, practice sets and equipment for Morse training.—Webb's Radio, 14, Soho St., London, W.1. 'Phone: Gerrard 2089. [9553

Wanted

REQUIRED, Wheatstone Automatic Morse Transmitter (weight driven).—Please forward details to Wright and Weaire, 740, High Rd., Tottenham, N.17. [1517

TEST EQUIPMENT

UNIVERSAL Avominor, absolutely new; offers.—Box 2826 *Wireless World.* [1542

FERRANTI Multi-Range A.C./D.C. Test Set, as new; offers.—L. H., 70, Whitecross, Abingdon. [1554

TESTOSCOPE, used everywhere by radio service engineers, makes 20 important tests. Send for interesting leaflet "R1."—Runbaken, Manchester, 1. [1074

STOCKS of our Test Equipment in Kit Form are now very limited, and cannot be replaced (Oscillators, bridges, multimeters, V.V. meters, etc.); s.a.e. (fcp.) for 8-page lists.—MacLachlan and Co., Strathyre. [1551

AVOMINOR, 40/-; 80 T.C.C. 0.1 mf. 4,000v. D.C. working, 6/- each; 2,000 1¼in. cartridge fuses, 33/- gross; quantity Rota patt. 4 laminations in Armco quality, 4/- gross prs. E and I.; 0.1 mf. T.C.C. 350v. D.C. working tubulars, 6/- doz.; 60,000 tinned eyeletted tags, 8/- 1,000; 1,000 21in. and 20in.×2¼in.×½mm. bakelised paper insulating pieces, 4/- doz.; 12in.×1 11/32in.×½mm. pressphan strips, 2/6 doz.; offers in bulk entertained, no remittances, s.a.e. please.—Crawford Electric and Radio Manf. Co., "Hiniadi," Chartridge Lane, Chesham, Bucks.

Wanted

WANTED for Essential Work, Douglas No. 1, Macadie S.C.P.1 or Macadie automatic coil winding machines, any condition, Cossor 3343 oscillator.—Box 2831, c/o *Wireless World.* [1570

GRAMOPHONE EQUIPMENT

RECORDING Equipment.—For sale, M.S.S. recorder, complete with motor, tracker, mounting plate, and specially adjusted D.T.7 head and mounting bracket; £50; this equipment requires slight adjustment of driving gears, and until recently was in daily use in our own studio; can be seen by appointment only.—Star Sound Studios, 17, Cavendish Sq., London, W.1. Telephone: Langham 2201.

ELECTRIC Record Player for use with Wireless; Collaro mixed size record changer, in heavy cabinet, 24in. by 22in. by 41in. (height), containing cupboards for about 400 records. Also about 245 records, many only played once, and 75% little used; as guide, minimum values, without question; mechanism and cabinet, £24; records, £30; inspection at Welling, Kent; best offer(s) secure(s).—Wingfield, Hampton House, Minsterworth, Gloucester. [1549

IMPORTANT Notice re Southern Sound Studios.—We have recently taken over new premises and our works and office addresses will in future be: Office, 4, Bittacy Park Avenue, Mill Hill, N.W.7; works and service dept., 13a, Bittacy Hill, Mill Hill, N.W.7. All future enquiries should be sent to latter address. In addition to equipment previously advertised we now have available 2-stage push-pull gramophone amplifiers with 10-watt beam tetrode output stage, price including one 10-inch energised speaker, £15. Enquiries are invted for all types of sound equipment Please make a note of our after-the-war address, which will be "The Elms," Warham Road, South Croydon, Surrey, where large studios with every modern facility for high quality recording will be available. We would like to take this opportunity to apologise for any delay in the dispatch of equipment owing to our present shortage of staff and the large amount of priority work which we have in hand. [1576

Wanted

A.C. Turntable, Collaro preferred.—Stephen. 99, Greengate St., Oldham. [1550

GRAMOPHONE Turntable and Motor, 230v. A.C.—Hulley, 10, Anthony Drive, Alvaston. Derby. [1525

ELECTRIC Gramo. Motor Wanted (induction type); your price paid.—Details, Harrison, 34, Corrie Rd., Clifton, Manchester.

WANTED, A.C. gram. motor; also Goodman's inf. baffle speaker.—Write, stating price and condition, Box 2819, c/o *Wireless World.* [1520

WANTED, Saja recording motor with Grawor cutting head, also Simpson recording motor, in good condition.—Box 2824, c/o *Wireless World.* [1533

ELECTRADIX BARGAINS

DIMMERS or RHEOSTATS with "off" 0 to 1 ohm and will carry up to 3 amps., for regulation on 6 to 12 volts, dimming or bank circuit battery charge model control, etc. One hole fixing for panels with bracket for other fixing. Hollow knob has socket for min. bulb, glowing when circuit alive. New U.S.A. Atena make, in carton, **2/6.** Worth 5/-. Large 40 amp. ironclad grid Rheos with heavy 10 stud switch to drop 220 volts to 45 volts. Size 33in. × 16in. × 14in., **£5 10. 0d.** 110 volt ditto. 16in. × 14in. × 16in. **£2 10s. 0d.**

CIRCUIT BREAKERS, 25/-. **MOTOR STARTERS,** 220v. D.C., ¼ h.p. to ¾ h.p., with no-volt and overload release. Ironclad, 13in. × 12in. × 7in., **45/-.**

TRANSFORMERS, 220 volts, 50 cycles, to 4,000 volts, C.T. 150 m.a., with L.T. winding, approx. 7½ volts. 4 amps., **70/-.**

FOOT SWITCHES, 5 amp., enclosed "on-off" for motor control, etc., **5/6.** 8-way Lucas-Rotax walnut switch-boxes with brass top, 8 levers and fuses, 12/50 volts, **3/6,** 6-way ditto, **3/-.** 6-way Push Button R.A.F. Switches, **2/9.** **Knife Switches,** 100 amp., open type on slate panel, 24in. × 18in., with porcelain handle fuses, **42/6** pair. Three D.P. Knife Switches, 200 amps., and Fuses, and one 60 amps., all on one panel, **£6.** Automatic Trip Switches, 10 amps., **25/-.** 250 amp. on 13in. × 12in. panel, **£4.** 1,000 amp., **£6.** 8-stud 100 amp. Battery Switches on panel, **£4** 10-point Instrument Switches, **4/6.** R.I.7 Stud Switch Boxes, **10/6.**

MAGNETS. Massive horse-shoe permanent steel magnets. Various sizes, **3/6** and **4/6** each. Wonder midget 2 ozs. Disc Alni P.M. Magnets as last advert., **2/6** each.

A.C./D.C. MAINS MAGNETS, 2-pole, 110 volts or 220 volts. **5/6.** Small 12-volt solonoids with 2in. × ⅜in. plunger, **6/6.**

LIGHT RAY CELLS, Selenium Bridge, in bakelite case. Raycraft Model, **21/-.** Electro-cell, self generating, light meter type, **35/-.** Raycraft Ray Set, with relay, **42/-.** Gas-filled Photo Cells. W.E. type, for sound on film, **70/-.** Relay enclosed 10,000 ohm tele-type, **22/6.** For other Relays see special leaflet, 2d.

VEE PULLEYS for ½in. belt, turned steel, 4in. and 4½in. outside bore, **4/6** each.

COUPLINGS. For motor or dynamo to ½ h.p., **6/-.**

FANS. Exhaust wall type, 12in. to 24in.

ROTARIES. Latest American radio type, fitted filter and smoother, 75 watts, 6 volts, D.C. to 100 volts, 50/60 cycles **£12.** 110 watts, 110 volts D.C. to 110 volts, 50/60 cycles, **£4 10s.** 150 watts, 220 volts D.C. to 110 volts A.C., **£16 10s.** Other sizes in stock.

PETROL ENGINES. Almost new; twin cyl. Douglas. fan-cooled, governed, mag. ignition, light weight, 2½ h.p., **£15.**

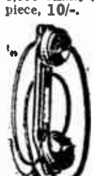
50-volt Petrol-Electric Lighting, secondhand, Pelapone. ½ kW. Sets, water cooled.

WATER TANKS for engines, storage, etc., ½ kW. galv. iron, 5ft. high, 14in. dia., with pipe unions, **35/-.**

TANKS. Small oil or suds tanks, 6½in. × 3in. × 1½in., **1/6,** post 6d.

Welded steel high press containers for liquid gas or refrig., pint size, 8½in. × 2½in., new. Make good model boiler, **3/6,** post 6d.

HEADPHONES. 120 ohms, **10/-.** H.R., 2,000 ohms and 4,000 ohms, **15/-,** Deskphone, G.P.O., pedestal and ear-piece, **10/-.** Wall Phone Sets from **30/-.**



HANDCOMS. Government all-metal Field Handcoms, Micro-telephones or Trans-ceivers, for portable or fixed telephones. The famous No. 16 Handcom used in so many field sets. Sturdily built with mike finger switch. Brand new, with 4-way cord, **15/-.** Limited number available. Similar Handcom, less switch and no cord, **7/6,** 4-way cord, **2/6.** A Home Guard can make a complete pocket telephone with these, a mike, transformer, buzzer and a torch battery.

TURNTABLES. Ball-bearing, for table sets etc., bakelite body, 4½in. dia., **2/-** each.

CABINETS. Suitable for test set apparatus, mike amplifier, oscillator, portables, etc. 9in. × 9in. × 6½in., with double doors. A very fine ex. W.D. job, in mahogany. canvas covered. Chassis, panel, 4 transformers, a 5-tap switch and rheostat is included. All-in price, **45/-.**

WAVEMETERS AND RADIOGONOMETERS. We have some ex. W.D. Wavemeters, Buzzer and Heterodyne, less calibration chart, **45/-** and **70/-.** Radio Direction-Finders in mahog. cases, **90/-.**

USEFUL PRECISION-MADE SPARE PARTS, NEW. Chart Drum and clips, **5/6.** Magnetic Clutch, 6 volt., complete, **25/-.** 9in. Traverse Shaft, 4in. Threaded 120 to inch, with bearings, **12/6.** Stylus, with carriage, rods and brackets, **7/6.** 5-pin plugs, with panel socket and cords, midget type, **4/6** pair. 14-way Plug and Socket, with cord, **7/6.** ⅛in. Aluminium Panel, drilled 13in. × 6½in., **3/-.** Bakelite ditto, 7½in. × 6½in., **2/3.**

LAB. GEAR. Mirror Galvos. Sullivan Marine Reflecting vertical M.C. suspen., **£9 10s.** Tinsley Ballistic ditto, **£4 10s.** Mahog. Stand Scales for Spot use,, **£2 10s.** Wheatstone Bridges and 142M Resistance boxes quoted for. A number of ex. W.D. Wheatstone Bridges, less coils, cheap. Circuit testing G.P.O. Vertical Galvos, **35/-.** Mag. Ringer and A.C. Bell, **25/-.**

Please add postage for all mail orders. Send Stamped envelopes for replies to all enquiries.

ELECTRADIX RADIOS,

19, Broughton Street, Battersea, London, S.W.8

Telephone: Macaulay 2159

GALPINS

ELECTRICAL STORES

21, WILLIAM ST., SLOUGH, BUCKS.
'Phone: SLOUGH 20855
TERMS: Cash with order

Regret Orders from Eire and Northern Ireland cannot be accepted.

SHEET EBONITE, size 12in. by 11in. by 1/32in., best quality. Price **4/-** per doz., post free.

ELECTRIC LIGHT CHECK METERS, well-known makers, first-class condition, electrically guaranteed, for A.C. mains, 200/250 volts 50 cy. 1 phase 5 amp. load, **10/-** each; 10 amp. load, **12/6,** carriage 1/-.

1 KW. FIRE ELEMENTS mounted on fireproof porcelain, for 220 volts, as new, easily mounted. Price **6/6,** post free.

POWER PACKS for smoothing, etc., consisting of two 300 ohm chokes and 2 M.F. condensers. Price **7/6,** post free.

LOUD RINGING BELLS, working on 110 volts D.C., 8in. dia. gong (bell metal), plated; waterproof, new. **32/6** each, post free.

1 KW TRANSFORMER, input 100 volts at 100 cycles, single phase, output 10,500 volts, centre tapped to earth. Price **£4 10s.,** carriage forward.

HEAVY DUTY CABLE, V.I.R., and braided, in first-class condition, size 37/13, lengths 30 to 40 yards. Price by the length, **5/-** per yard, carriage forward, or **7/-** per yard for short lengths, carriage paid.

200 AMP. SWITCH FUSE, three-way, Ironclad, unused. 400 volt, size overall 30in. × 12in. × 12in. maker E. N. Bray, Ltd. Price **£6,** carriage forward.

ROTARY CONVERTER, D.C. to D.C. Input 12 volts; output 1,100 volts at 30 M/A, ex R.A.F., can also be used as double output generator. Price **50/-,** carriage paid.

HEAVY DUTY knife switches, D.P., D.T., quick break, 100 amp., in first-class condition. Price **20/-,** carriage paid.

X-RAY TRANSFORMER, in oil-filled tank, medium size, input 120 volts, 50 cycles, 1 ph., output 45,000 volts at 2kW, intermittent rating, in perfect order. Price **£20,** carriage paid.

ROTARY CONVERTER, D.C. to D.C., input 48 volts, output 2,500 volts at 1 kW, condition as new and in perfect order. Price **£10,** carriage paid.

TWO 2¾ H.P. PORTABLE PETROL ENGINES by Douglas, flat twin, both incomplete, no carburettor, some oil pipes missing, mags., petrol tanks, etc., included. The two engines together would make one good one. Price for the pair **£7 10s.,** carriage paid.

½ WATT WIRE END RESISTANCES, new and unused, assorted sizes (our assortment), **6/6** per doz., post free.

EPOCH SUPER CINEMA SPEAKER, 20 watt, 15in. cone, 15 ohm speech coil, 6 volt field (no energising), in first-class condition. Weight 65 lbs. Price **£7 10s.,** carriage paid.

150,000 VOLT X-RAY transformer, large size, weight 12 cwt., input 120 volt, 50 cycle, single phase; output 150,000 volts at 10 KVA, intermittent rating, mounted in steel tank, oil filled, in good working order. Price **£45,** carriage paid.

DYNAMO, output 20 volt, 15 amp., shunt wound, interpole, slow speed, ball bearing, condition as new. Price **£3 10s.,** carriage paid.

STALLOY TRANSFORMER SHEET, sizes 16in. and 18in. long, with 1¾in., 2¼in. and 3in., mostly 3in., gauge 26 S.W.G., weight approx. 1 cwt., condition clean as new. Price the lot **£3,** carriage paid.

SOLID BRASS LAMPS (wing type). one hole mounting, fitted double contact S.B.C. holder, and 12 volt 16 watt bulb. Price **3/6** each, post free, or **30/-** per doz., carriage paid.

30 DUD MOVING COIL meters, 2in. and 2½in., all modern, mostly with cases intact. These meters are not guaranteed and beyond repair; they are offered for the magnets, bearing and springs only. Price the lot **£4,** carriage paid.

COMPONENTS—SECOND-HAND, SURPLUS

G. A. RYALL, "Arnehurst," Marsh Lane, Taplow, Bucks, offers radio components.

ERIE Resistors, ½-watt type, actual valves as used in many well-known sets, 680, 3,300, 27,000, 33,000 1½-meg., 3/- dozen, new goods; Erie resistors, 2-watt type, 150, 560, 820, 3,000, 3,900, 7,500, 140,000, 220,000, 560,000, 1-meg., three for 1/6, new goods; Erie resistors, 3-watt type, 70, 1,500, 3,300, 6,800, 8,200, two for 1/6; T.C.C. 0.1 tubular non-inductive condensers, 350v. working, in Paxolin tubes and waxed, 6/6 doz., 75/ gross.

SLOW Motion (Epicyclic) Drives, fit ¼in. shafts, long ¼in. spindles, well made in brass, with ball bearings ratio 8-1; 1/3 each.

PAXOLIN Strip, 2½in. wide, as used for group boards, etc., three 12in. lengths for 1/6; 4½d. ft. for 150 lengths.

GROUP Boards, undrilled; six for 1/3.

TURNTABLES, as used for rotating portables, ball bearing, 1/6 each, soiled; post 9d. extra on single items.

THIMBLE Top Caps; 36 for 1/3.

INSULATING Tape, 2oz. reels; eight for 1/3.

SWITCHES, Wearite, long type, silver plated contacts, ebonite barrel, will switch band pass, HF, and dial lights; 1/3 each.

CONE Units, heavy circular, less reeds, bobbins, mostly O.K., two 1/6, postage 9d.; Yaxley switch screens, 3¾×3⅝, with fixing flange, 4 for 1/3.

K.B. Wave Traps, iron core, 1/3 each, 12/6 doz.

SPEAKERS, damaged cones, otherwise O.K., resistance 750 ohms, 325 ohms, 8,600 ohms, carry 120 m.a., oval or round type, 6/9 each; pots only 5/9; 60 m.a. pots, 600, 7,500, 3/9, or complete 5/9.

DIAL Plates, 3-band, size approx. 6×5, scale 4×2½, white ground, 2 1/3; Burgoyne dial plate, 3-band, brown ground, 6×4, scale 3×2, station list printed on, 2 1/3; dial plate ex Berners 4-band, in green, red, blue, orange, transparent, brass stiffened edges, 1/6 each; dial and scale, 6¾×4; 9-pin v. holders, 4d. each.

OCTAL V. Holders, 5-pin, 6d. each.

1-MEG. Tone Controls (2 tags only); 1/6 each.

SPECIAL Note.—We now confine our business to Mail Order.—G. A. Ryall, "Arnehurst," Marsh Lane, Taplow, Bucks. [1558

COULPHONE Radio, New Longton, nr. Preston.—Brand new goods only; mains transfs., 350-350, 120ma., 6.3v. 3a., 5v. 3a., 28/6; P.M. speakers with transf., 8in. Celestion, 24/6; 5in. Rola, 21/-; Tungsram Valves; Cored Solder, 4/6 lb.; Barretter Resistors, 6/-; Line Cord Replacement Resistors, 800 ohm, 2 adjust. taps, 6/9; electrolytics, 50mfd, 50-volt, 3/3; Erie 1-watt resistors, all values, 9d. each; pushback wire, 100ft. coil, 6/-; switch cleaner, 2/3 bottle; power-pentode transformers, 6/9; S.A.E. for stock list. [1409

METAL Rectifiers.—LT. metal rectifiers for battery charging, with instructions, 12v. 3 amp., 34/6; 6v. 3 amp., 17/6, post 7d; 6v. 0.5 amp., 5/9, post 4d.; instrument type rectifiers for meters, bridge type, bakelite moulded, very good make, 15/6, post 3d.; transformer and rectifier for 2v. 0.5 amp. trickle charger, 13/6, postage 7d.; few only, complete chargers, 6v., 12v. 1 amp., very good make, 69/6; Rothermel "Bullet" crystal microphones for stand mounting, black crackle finish, tilting mount, £3; D104 type, with aluminium diaphragm, 95/-; Rothermel bakelite pick-ups, latest type, 67/6; milliammeter, 1 milliamp, full scale 2½-inch, flush mounting, second-hand but perfect, 72/6—Champion, 42, Howitt Rd., London, N.W.3. [1572

SOUTHERN RADIO'S Wireless Bargains.—9/-, gross assorted screws and nuts complete, 9/-; 6/-, gross soldering tags, including spade ends, 6/-; 7/6, Philco 3-point car aerials, make excellent short wave and home aerials, complete with fixing bolts, etc., 7/6; Ace P.O. microphones, complete with transformer, ready for use, 7/-; Goodman's 8in. P.M. speakers, with transformers, 21/- each, postage 1/-; tungsram H.R.210 general purpose battery valves, 4/9; wireless crystals (Dr. Cecil), 6d. each, 5/6 dozen; with catswhisker, 9d. each, 8/- dozen; complete crystal detectors, 2/6 each; 75 feet covered wire for aerials, etc., 2/6 per coil; push back connecting wire, 75 feet, 5/-; small powerful circular magnets, 1⅛in. diameter, ⅜in. thick, 1/6 each, 15/- per dozen; combined Morse practice equipment for buzzing and flashing complete with bulb and battery mounted on metal base, 22/6 each; single Morse keys (bakelite), 4/- each; buzzers, 4/- each; many other bargains for callers; postage extra; all goods guaranteed.—Southern Radio Supply Co., 46, Lisle St., London, W.C. Gerrard 6653. [1508

"ENGINEERING OPPORTUNITIES"

Book sent post free

This unique Handbook shows the easy way to secure A. M. I. C. E., A. M. I. Mech. E., A.M.I.E.E., A.M.I.A.E., A.M.Brit.I.R.E., and similar qualifications. WE GUARANTEE—"NO PASS—NO FEE." Details are given of over 150 Diploma Courses in all branches of Civil, Mech., Elec., Motor, Aero., Radio and Production Engineering, Draughtsmanship, Tracing, Inspection, Government Employment, BUILDING (great scope), MATRICULATION, R.A.F., MATHS., etc. Send for your copy at once—FREE. *Men with Radio knowledge can obtain attractive posts in the Services.*

BRITISH INSTITUTE OF ENGINEERING TECHNOLOGY, 387, Shakespeare House, 17, 18, 19, Stratford Place, London, W.1

HILL AND CHURCHILL

BOOKSELLERS

SWANAGE DORSET

•

ENGLISH & AMERICAN BOOKS IN STOCK ON RADIO AND TELECOMMUNICATION

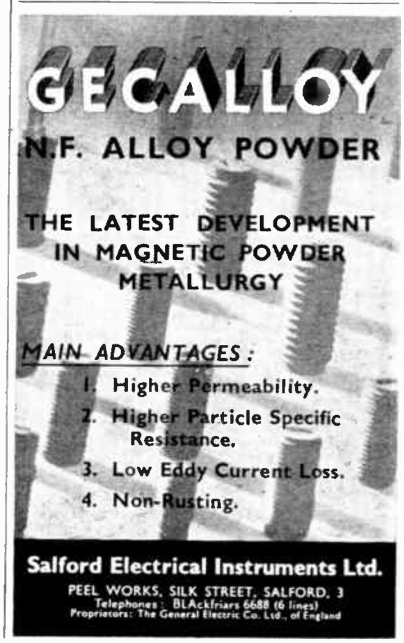
•

CATALOGUE ON APPLICATION

KESSLERS (London) LTD.

For TURNING and MACHINING of PLASTIC MATERIAL SIGNAL LAMP CAPS SCREW CUTTING IN BAK. FABRIC

Albion House, 201-3, Church St., London, N.16
Tel.: Clissold 6247



Look to your future . . .

Trained men get good jobs. Hundreds of our students write to thank us for their successes and increased earnings. Now, more than ever before, men with a good knowledge of radio or mathematics are urgently needed.

Even if you are already in the Forces, or engaged on work of National importance, you should think of your future. A sound technical training is the best insurance against the risks of unemployment.

Our simplified method of Home-Studying is a proved success. Even if you know nothing about radio or mathematics, you can master these subjects, and you will really enjoy studying.

Post coupon now for free details of our Home-Study Courses in Mathematics, Radio Calculations, Radio Reception, Servicing, Transmission and Television.

T. & C. RADIO COLLEGE
29, Market Place, READING

(Post in unsealed envelope, 1d. stamp.)

Please send me free details of your Home-Study Mathematics and Radio Courses.

NAME ....

ADDRESS ....

W.W.15 ....

"The Colonel's Lady — and Judy O'Grady"

These two charming persons may have been "sisters under the skin"; but whilst the more deadly are possibly all soul-mates it would not be wise to take it for granted that this generalisation applies equally to—transformers, for instance. Undoubtedly many of them superficially look equal to a Gardner, but beneath their metal 'skin' they are worlds apart. This 'class distinction' is noticeably marked in the case of Gardners' Small Power Transformers up to 4 kva. May we ask you then to consult with us when next you need this type of component and the specification stresses "The Colonel's Lady" aspect?

We regret that at present Small Power Transformers are available for highest priority orders only.

QUALITY MAINS GR TRANSFORMERS

GARDNERS RADIO LIMITED
SOMERFORD · CHRISTCHURCH · HANTS

INSULATED Telephone Wire on Drums, 1¼ mile, £7/7.—Duncan, Morwenstow. [1532

VARLEY 3-hry. Choke, Ferranti O.P.M.1(C), A.F.5; offers.—153, Ince Ave., Liverpool, 4. [1548

SKYROD Aerial, unused, 70/-; Baird incendiary bomb detector, unused, £5; Baker's 2RF tuning unit, £4/10; Radiolab valve tester, £10/10.—Particulars, Box 2835, c/o *Wireless World.* [1583

LASKY'S RADIO, 370, Harrow Rd., Paddington, W.9., offer for sale the following components: Rola 5in. speakers, with transformer, 21/-; Rola 5in. speakers, less transformer, 19/-; Rola 8in. speakers, with transformer, 26/6; speaker output transformers, 6/6 each. Condensers: .1 mfd., 350v, 5/6 doz.; 50 mfd., 12v, 16/- doz.; 25 mfd., 25v, 18/- doz.; 2 mfd., 400v, cans, 4/3 each; 8 mfd., 150v, tubular, 2/3 each; .23 mfd., 600v, tubular, 1/3 each; .02, mfd., 600v, tubular, 1/- each; .15 mfd., 2,000 v, 1/6 each; .05 mfd., 2,000v, 1/- each; .02 mfd., 2,000 v, 9d. each; 10 mfd., 25v, 1/6 each; assorted volume control less switch, 2/9 each. Mains transformers: 350/0/350, 4v, 18/6 each; 350/0/350, 6.3v, 26/- each. Cash with order or C.O.D. [1578

Wanted

INFINITE Baffle Speaker, A.C. record player, gramotor, cash waiting.—BM/DCA, W.C.1. [1568

COMPONENTS, valves, receivers, test gear, meters, etc., wanted.—R. J. W., 7, Elm Grove Rd., Ealing, London, W.5. [1563

WANTED, pair of Brown's "A" type Reed headphones, in good condition.—Box 370, Gordon House, 75-79, Farringdon St., E.C.4.

DYNAMOS, MOTORS, ETC.

ALL Types of Rotary Converters, electric motors, battery chargers, petrol-electric generator sets, etc., in stock, new and second-hand.

WARD, 37, White Post Lane, Hackney Wick, E.9. Tel.: Amherst 1393. [0518

ROTARY Convertor Bargains. — Electro Dynamic Co.'s motor-generator type, in various inputs from 50v. D.C. to 230 D.C., suit radio or talkie, cost £27/10 each; from £10 to £17/10 each.—Penrose (Cine), Ltd., 69, Streatham Hill, London, S.W.2. 'Phone: Tulse Hill 6756. [1564

FOR Sale, Rotary Converter, 50-volt D.C. to 230-v. A.C., 18 months old; also 50-v. D.C. Seafarer Radio, with extension speaker; both in excellent condition.—Apply W. Farley, 129, Longford Rd. West, Reddish, Stockport. [1524

ROTARY Converters by E.D.C., Crompton, Crypto, and others, all voltages to 3kw.—Below.

DYNAMOS and Battery Chargers, A.C. and D.C. to 5kw.; switchgear and meters for same.—Below.

LIGHTING Sets by Stuart Turner, Kohler, Delco, Lister, Petter, etc., all voltages to 10kw., with or without batteries.—Harris, Strouds, Bradfield, Berks. [1555

MOTOR-ALTERNATOR, 110 or 220v. D.C. input, 230v, 50 cycle 300 watts output, with starter, all on base, by Croydon Eng. Co.; £12/10.—Harris, Strouds, Bradfield, Berks.

L.T. Dynamos for Charging or Windmill, Lucas-Rotax, 6-12 volts 8 amps. D.C., 3rd brush, weight 11lb., size 8in.×4½in., unused ex W.D., cost £10, to clear 17/- each, carr. paid; H.T. and L.T. G.E.C. double-end 6 volts and 600 volts, 17lb. ditto, 27/6 carr. paid.—Electradix, 19, Broughton St., London, S.W.8. [9993

VALVES

VARIOUS Unused Valves and Electrolytic Condensers; list on application.—Duncan, Morwenstow. [1531

VALVES.—Thousands in stock; send requirements s.a.e.—Davies, 28, Mount Vernon Cres., Barnsley. [1073

AMERICAN Lease-Lend Valves, most popular types, speakers, line cords, etc.; see our other advertisement.—Sexton & Co., Ltd., 164, Grays Inn Rd., London, W.C.1. [1540

AMERICAN Universal Valves.—12K7GT, 25L6GT, 50L6GT, 25Z5, etc., etc., for replacement in radio receivers only; British and American types in large quantities always available; s.a.e. please.—The Dale Electric Co., 13, Tretawn Gardens, London, N.W.7.

1,000 Valves in Stock, S.A.E. for printed list at 1d. UU5 11/-, PEN.A4 12/10, 354V, 9/2, TH41 14/-, VP41 12/10, TP1340 18/3, CL4 12/10, ECH3 14/-, 6Q7G 11/7, 36 12/10, 45 11/7, 47 12/10 Post 6d.—Ransom, 34, Bond St., Brighton.

LASKY RADIO, 370, Harrow Rd., Paddington, W.9, have a large stock of B.V.A. mains and battery valves; we also have for immediate delivery a selection of American valves for midget receivers replacements as follows: 1A5GT, 1C5GT, 1H5GT, 573GT, 6A8GT, 6F6, 6J7, 6K7; 6Q7, 12SQ7GT, 12SJ7, 32L7GT, 35L6GT, 35Z4, 35Z5GT, 70L7GT, 117Z6GT. Send us your requirements. All at controlled Board of Trade prices, plus postage. [1577

PREMIER RADIO

Premier 1-Valve de Luxe Battery Model S.W. Receiver, complete with 2-volt valve, 4 coils covering 12-170 metres. Built on steel chassis and panel, **55/-,** including tax.

PREMIER MICROPHONES

Transverse Current Mike. High-grade large output unit. Response 45-7,500 cycles. Low hiss level, **23/-.**

Premier Super-Moving Coil Mike. Permanent Magnet model requiring no energising. Sensitivity 56db. Impedance 15 ohms. Excellent reproduction of speech and music, **£5/5/-.**

Microphone Transformers, 10/6 each.

Chromium Collapsible Type Microphone Stand, 52/6.

NEW PREMIER S.W. COILS

4- and 6-pin types now have octal pin spacing and will fit International Octal valve holders.

4-PIN TYPE			6-PIN TYPE		
Type	Range	Price	Type	Range	Price
04	9-15 m.	2/6	06	9-15 m.	2/6
04A	12-26 m.	2/6	06A	12-26 m.	2/6
04B	22-47 m.	2/6	06B	22-47 m.	2/6
04C	41-94 m.	2/6	06C	41-94 m.	2/6
04D	76-170 m.	2/6	06D	76-170 m.	2/6
04E	150-350 m.	3/-			
04F	255-550 m.	3/-			
04G	490-1,000 m.	4/-			
04H	1,000-2,000 m.	4/-			

CHASSIS MOUNTING OCTAL HOLDERS 10½d. each.

New Premier 3-Band S.W. Coil, 11-25, 25-38, 38-86 m., **4/9.**

Rotary Wave Change Switch, to suit above, **1/6.**

Premier 2-Gang S.W. Condenser, 2 × 00015 mfd., with integral slow motion, complete with pointer, knob and scale, **10/6.**

Bakelite Dielectric Reaction Condensers.
0003 mf. ...... 2/6 0005 mf. .... 2/9 each
0003 mf. Differential .... 2/11 each

H.F. CHOKES

S.W. H.F. Choke, 10-100 m. .... **10½d.**
Standard H.F. Choke **1/-**
Binocular H.F. Choke **1/6**

SHORT WAVE CONDENSERS

Trolitul Insulation. Certified superior to ceramic. All-brass construction. Easily ganged.
15 m.mfd. ...... 2/4 100 m.mfd. 3/-
25 m.mfd. ...... 2/2 160 m.mfd. 3/7
40 m.mfd. ...... 2/6 250 m.mfd. 4/-

Brass Shaft Couplers, ¼ in. bore .... **7½d.** each
Flexible Couplers. ¼ in. bore .... **11d.** each
7-pin Ceramic Chassis mtg. English fitting Valve Holders, 1/6 each.

"LEARNING MORSE?"

Then purchase one of the new practice Oscillators. Supplied complete with valve, on steel chassis, **27/6.** Practice key **3/3.** TX key, **5/9.** Super model on wooden base, **11/6.**
Brown's Headphones, 19/6 pair.
3-Henry Chokes, 10/-.
Good Quality **Buzzer, 3/-.**

ELECTROLYTIC CONDENSERS

Tubular wire end type, 25 mf. 25v., **1/6** each; 50 mf., 12v., **1/6** each; 50 mf., 50v., **3/-** each.

RESISTANCES

Mains Resistances, 660 ohms .3A Tapped. 360 × 180 × 60 × 60 ohms, **5/6** each.
1,000 ohms .2A Tapped. 900, 800, 700, 600, 500 ohms, **4/6** each.
Valve Screens for International and U.S.A. types, **1/2** each.
Push-Back Connecting Wire, 2d. per yard.
Resin-Cored Solder, 7½d. per coil.
Systoflex Sleeving, 2 mm., **2/6** per doz. yards.
Waterproof Covered Cable, 3-way, **1/3** per yard; 5-way, **1/6** per yard.
Screened Braided Cable, Single, **1/3** per yard; Twin, **1/6** per yard. Maximum lengths 6 yards approx.

MOVING COIL SPEAKERS

Celestion 8 in. P.M. Speaker, 25/-.
Plessey 8in. 2,000 ohms Field, 25/-.
Above speakers are complete with output transformer.
Rola 5in. P.M. Speaker, 3 ohms voice coil, **21/-.**
Rola 6½in. P.M. Speaker, 3 ohms voice coil, **25/-.**
Rola 8in. P.M. Speaker, 3 ohms voice coil, **25/-.**

Send for details of our Mains Transformers, Smoothing Chokes and Valves available.

ALL ENQUIRIES MUST BE ACCOMPANIED BY A 2½d. STAMP.

PREMIER RADIO CO.

ALL POST ORDERS TO:
JUBILEE WORKS, 167, LOWER CLAPTON ROAD, LONDON, E.5. (*Amherst* 4723.)

CALLERS to:
JUBILEE WORKS or 169, FLEET STREET, E.C.4. (*Central* 2833.)

MORSE CODE TRAINING

If you wish to become a proficient W/T Operator, or, if you are already an Operator and desire to increase your present sending and receiving speeds as well as to improve your technique, then apply for a copy of the Candler "Book of Facts."

Numerous students trained by the Candler system are now W/T Operators in the ARMY, NAVY, AIR FORCE and MERCHANT SERVICE, whilst many others are doing W/T work of national importance.

* *Read these extracts from letters sent in by Candler students*

The ARMY.—"I have derived immense benefit from the lessons . . . I am highly satisfied with the Course. Part 4 I find especially stimulating and helpful."
Ref. No. 8640. H. T. S.

The NAVY.—"Thanks to your Course I passed my Morse exam. in the Navy with 97 per cent., and at a speed varying from 18 to 20 w.p.m. I am certain I would not have done so had it not been for your Course."
Ref. No. 4214. R. L.

The AIR FORCE.—"I am pleased to state that I have already found a marked improvement in both sending and receiving, and all my former difficulties have become less and less . . . I can now send 5 w.p.m. faster and receive two or three letters behind." *Ref. No. 9248. T. C.*

The MERCHANT SERVICE.—"I am now spending my leave at the above address. . . . What has surprised me most is the remarkable difference your Course has made in my receiving of Visual Morse signals. . . . I can now receive long messages in 'my head' and write them down afterwards, so doing away with the necessity of a 'Writer' each time a message is received. I do not know what my 'Top Speed' is in V/S, but I imagine it is over the 25 w.p.m. mark, as I can read the fastest Naval signals without difficulty. My V/S speed before taking the Course was about 10/12 w.p.m., and very erratic at that. I am very pleased with the results I have achieved so far both in W/T and V/S." *Ref. No. 7209. I. F. R.*

A GRAND COURSE.—
"I am pleased to report further progress both in my sending and receiving speed.
"My sending speed has increased by a further 2 words per minute, thus making an increase of about 5 w.p.m., since I commenced your Course. More satisfactory than that is the fact, however, that my Morse is much crisper, better spaced and formed than before. Also, the old sending trouble which I reported to you now seems to have disappeared altogether, which is to me the most satisfactory thing of all.
"My receiving speed is also two or three words per minute better than when I last wrote you. I can now copy behind better, too, though if I get more than one word behind, I tend to 'lose out' periodically, particularly when unfamiliar names of persons or places come through. Still, I'm definitely improving and realise it is now mainly a matter of practice.
"Your's is a grand Course, and makes me realise the deficiencies of my telegraphic training in the old days, even though I was a student at one of the best wireless colleges in this country.
"I'm thoroughly enjoying the Course, and am so glad that I took it up." *Ref. No. 7849. A. L. S.*

The P.M.G. 'SPECIAL.'—"I thought you may be interested to know that I have now passed my P.M.G. 'Special' Radiotelegraphy examination . . . even though I have not yet completed the Candler course."
Ref. No. 7480. R. D. H.

The originals of these letters, and many similar ones, can be inspected at the London office.

Full details of the following Courses are given in the Candler "Book of Facts."

The JUNIOR Scientific Code Course for beginners, teaches all the necessary code fundamentals scientifically.

The ADVANCED and High-Speed Telegraphing Course for operators who want to increase their w.p.m. speed and improve their technique.

The TELEGRAPH Touch-Typewriting Course.

Courses supplied on Cash or Monthly Payment terms.

Fill in the Coupon and learn more about this highly efficient Candler method of Morse Code training in your own home.

COUPON

Please send me a Free Copy of Candler "Book of Facts."

NAME ....

ADDRESS ....

....

....

CANDLER SYSTEM CO.
(Room 55), 121, Kingsway, London, W.C.2
Candler System Co., Denver, Colorado, U.S.A.
(343)

Wanted

MULLARD P.M.13 Valve.—Day, 20, Mountfield Rd., N.3. [1539

VALVES Wanted, any quantity from one upwards; also test equipment, service sheets and spares.—J. Bull, 246, High St., Harlesden, N.W.10. [9732

REPAIRS AND SERVICE

L.T.P. Repair All Mains Transformers and Chokes. Prompt delivery.

LONDON TRANSFORMER PRODUCTS. Ltd., Wilesden, N.W.10. Wil. 6486 (3 lines). [9552

MIDWEST, etc., we are the American experts.—Bennett's, 4, Humberstone Drive, Leicester. [1552

TRANSFORMERS, motor rewinds, repairs of all descriptions to the wireless trade.—Marshall, 137, Windmill Lane, Nottingham.

VOLTMETERS, Ammeters and Multi-range Instruments repaired; prompt service.—Davies, 16, Greencroft Gardens, Hampstead, N.W.6. [1543

ACCURATE Radio Rewinds, mains transformers, Fields O.P. transformers, etc., and all loudspeaker repairs.—Southern Trade Services, 75a, George St., Croydon. [1039

MAINS Transformers Service, repairs, rewinds, or construction to specification of any type, competitive prices and prompt service.—Sturdy Electric Co., Ltd., Dipton, Newcastle-upon-Tyne. [9651

METROPOLITAN RADIO SERVICE Co. Guarantee Repairs to American and British Receivers.—1,021, Finchley Rd., N.W.11. Spe. 3000. [9641

"SERVICE with a Smile."—Repairers of all types of British and American receivers; coil rewinds; American valves, spares, line cords.—F.R.I., Ltd., 22, Howland St., W.1. Museum 5675. [1575

DEGALLIER'S, Ltd.—"Service with a Guarantee." If you have an English or American receiver that needs servicing, let American specialists do the job; any set handled from a T.R.F. Midget to a 30-valve Scott; first-class workmanship only; when forwarding, chassis and valves needed only. Send S.A.E. with all enquiries—Degallier's, Ltd., 9, Westbourne Court, London, W.2. [1468

MISCELLANEOUS

CAPACITY Will Be Available at Well-established Engineers for Production and Assembly, or part assemblies, of light electrical equipment and apparatus; Essential Work only.—Box 2823, Wireless World. [1529

MAKE (and Sell) Your Own Torch Battery Cigarette, pipe and gas lighters; no awkward wheels, wicks, etc., to fix; well tested; lasts 6-7 months; diagram and clear instructions for easy home construction; 3/-, element included free.—Wm. Barham, "Hilltop," Bradmore Green, Coulsdon, Surrey. [1522

CARDBOARD Containers, packing cases for sale, different sizes; regular quantities available.—Particulars, write Peter Goede, Bridge Arcade, Borough Market, London.

PATENT NOTICES

THE Proprietors of British Patents Nos. 516110, dated May 17, 1938 (Convention date May 28, 1937); No. 516111, dated May 17, 1938 (Convention date Feb. 8, 1938); No. 516167, dated May 17, 1938 (Convention date Feb. 8, 1938); No. 516168, dated May 17, 1938; all relating to Improvements in Electron Discharge Tubes; and No. 516169, dated May 17, 1938 (Convention date May 28, 1937), relating to Improvements in Bases or Caps for Electron Discharge Tubes; are desirous of entering into arrangements by way of a licence or otherwise on reasonable terms for the purpose of exploiting the above patents and ensuring their practical working in Great Britain.—Enquiries to Singer, Ehlert, Stern and Carlberg, Chrysler Bldg., New York City, N.Y., U.S.A. [1561

TUITION

RADIO Training.—P.M.G. exams. and I.E.E. Diploma. prospectus free. — Technical College. Hull. [0611

LEARN Morse Code the Candler Way. See advertisement on this page. [1292

A POSTAL Training in Electrical Engineering-power or radio; individual correspondence tuition by highly qualified engineers with wide teaching and technical experience. Elementary or advanced courses. Preparation for recognised examinations. Pre-service training specially arranged.—18, Springfield Mount, Kingsbury, N.W.9.

THE Tuitionary Board of the Institute of Practical Radio Engineers Have Available Home Study Courses Covering Elementary, theoretical, mathematical, practical, and laboratory tuition in radio and television engineering; the text is suitable coaching matter for I.P.R.E., Service-entry and progressive exams.; tuitionary fees—at pre-war rates—are moderate.—The Syllabus of Instructional Text may be obtained post free from the Secretary, Bush House, Walton Avenue, Henley-on-Thames, Oxon. [1462

VALVES FREE OF TAX

British Types equivalent to Mullard PMILF, PMIHF, PM2, SP4, VP20, TDD13C, 2D13C, SP2220, TDD13, CI and CIO barretters.

American Types 1A4, 1B4, 2101, 24, 35/51, 56, 58, 71A, 27, 50, 01A, 1F4, 6B6, 6H6G, 25L6GT, 26, 1F5G. Barretters 4- and 6-pin. All tax free.

Also **Tungsram** P215, SP220, HL4+, SP4B, SP4, VME4, DD6, DDT4, DDT13S, VP4, DDT13, FC13, VP13B, HP13, 6V6G, TX21, TH29, 6B7, 6U5, 6G5, 6B8G, 6K7G, 6U5G, 33, 35/51, 58. **National Union** 6Y5V, 6H6G, 1A6, 15, 6A8, 7Y4, 7C6, 6J8G, 6L7G, 6F6GT, at list, plus tax.

Fixed Resistances, ½ watt, 3/6 doz.; 1 watt, 5/6 doz.; 2 watt, 9/- doz. **Connecting Wire**, 3/- doz. yards.

Fixed Condensers, .00005 to .006, mica, 4/6 doz.; wire ended, 6/- doz.

Speaker Transformers, 5/- each. **Volume Controls**, 30/- doz., assorted. Philco IF, HF and Aerial transformers, fixed condensers and other replacement parts, at list price.

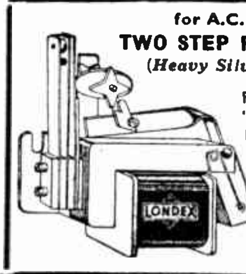
Parcels of assorted components, £1. *No lists, please send stamp with enquiries.* Terms: Cash with order, post extra.

E. H. ROBINS TRADING CO. LTD.
44, Kyle Crescent South, Whitchurch, Glam.

LONDEX for RELAYS

for A.C. and D.C.

TWO STEP RELAY LF/FS
(Heavy Silver Contacts)



First Impulse "ON." Second Impulse "OFF."

Also Aerial Change-over Relays.

Ask for leaflet 88A/WW

LONDEX · LTD
MANUFACTURERS OF RELAYS
207 ANERLEY ROAD LONDON S.E.20

W. BRYAN SAVAGE LTD.

Expert assistance in the solution of problems relating to

- TRANSFORMERS, CHOKES
- AMPLIFIERS
- POWER UNITS

and Specialised Equipment embodying

ELECTRONIC CONTROL

WESTMORELAND RD., N.W.9.
COLINDALE 7131

VOIGT

For high quality loud speakers when the "good times come again.

The Courts, Silverdale, London, S.E.26
'Phone: SYD 6666

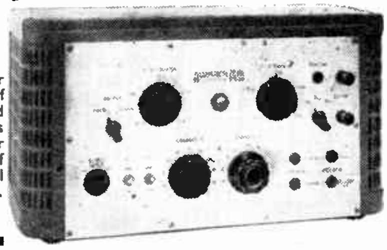
VOIGT PATENTS LTD

WARD ROTARY CONVERTERS

Petrol Electric Generating Plants, H.T. Generators, D.C. Motors, Frequency Changers, etc., up to 25 K.V.A.

CHAS. F. WARD
37, WHITE POST LANE, HACKNEY WICK, E.9
'Phone: Amherst 1393

AUDIO AMPLIFIERS and SUB-ASSEMBLIES



One of our range of Standard Amplifiers available for work of National Importance.

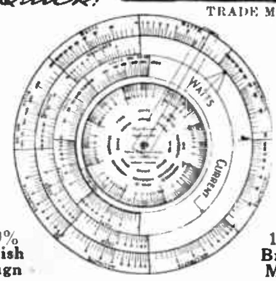
Standard Amplifiers ● Special Amplifiers for Industrial Applications ● Transformers and Coil Winding ● Sheet Metal Work and Stampings ● Switch Assemblies ● Microphones, etc.

ACOUSTICAL MANUFACTURING COMPANY LTD.
HUNTINGDON TEL: 361

FLIK-O-DISK

Answers! Quick!

TRADE MARK



100% British Design **100% British Made**

Answers all OHM'S LAW problems—for example:

What will be the voltage when current I flows through resistance R?
What will be the voltage with watts value W and I current flowing?
What is the current flowing where watts value is W and voltage is E?
What current will flow through R resistance where voltage is E?
What will be the resistance where current I flows at voltage E?
What will be the resistance where watts W is at voltage E?
What will be the resistance where watts W is at current I?
What is the wattage at voltage E through resistance R?
What is the wattage of current I through resistance R?
What will be the wattage of I current at E voltage?

The scales read from 1 millivolt to 1,000 volts. From 1 ohm to 1,000,000 ohms. From 1 milliamp to 10 amperes. From one-tenth of a milliwatt to 10,000 watts.

FULL INSTRUCTIONS WITH EACH INSTRUMENT

PRICE 4/6 Postage 3d.

Order at once whilst deliveries are good

IONIC LABORATORIES
6, Cranbourne Terrace, Salt Hill, SLOUGH, BUCKS, ENG.

KURZ-KASCH

RADIO KNOBS—DIALS INSTRUMENT KNOBS

NOT only are modern plastics materially helping to win the war, but they will also help in designing those better post-war days.

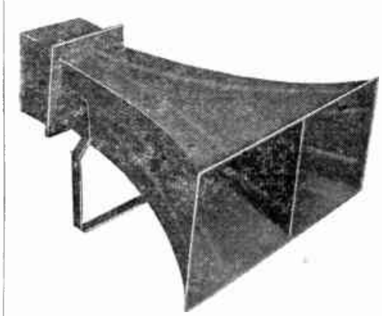
We patiently await the time when we shall once again be able to help equip your radio receivers and instruments with those well designed and good looking mouldings and, no doubt, with other items resulting from plant expansion and new developments.

Register your name with our Representative now. He will forward you information on our products as soon as they become available.

KURZ-KASCH INC.
Moulders of Plastics,
DAYTON, OHIO, U.S.A.

Exclusively Represented by
Frank Heaver Ltd. Kingsley Road, Bideford, N. Devon

DIRECTIONAL HORN LOUDSPEAKERS



Used extensively in general purpose P.A. Designed for maximum efficiency for Outdoor or Indoor use. Overall Length 39". Flare Opening 26" x 12". Handles 10 watts. Price **£8 - 18 - 6.**

INDUSTRIAL AMPLIFIER & TELEPHONE CO.
TOWER WORKS, OLD TOWN, CLAPHAM, S.W.4
Telephone No. - - - - - MACaulay 3200

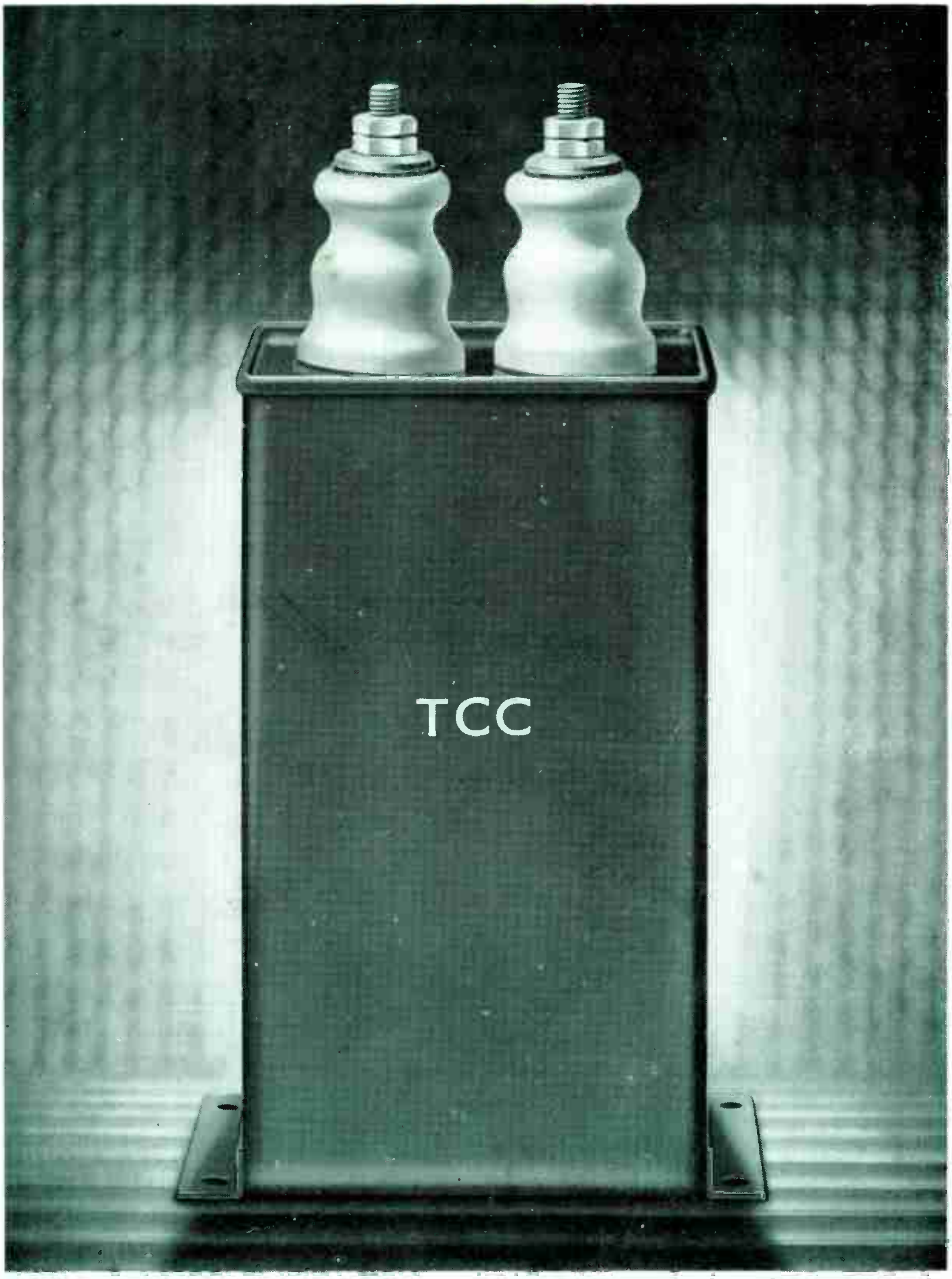
INVENTORS

We invite new inventions which, guided by the technical knowledge, manufacturing facilities and world-wide marketing organisation of the Simmonds Group, may be developed to play vital parts in modern industry.

The SIMMONDS GROUP
LONDON
MELBOURNE
PARIS
NEW YORK
LOS ANGELES

SIMMONDS DEVELOPMENT CORPORATION LTD · BUSH HOUSE · W.C.2

Printed in England for the Publishers, ILIFFE AND SONS LTD., Dorset House, Stamford Street, London, S.E.1, by THE CORNWALL PRESS LTD., Paris Garden, Stamford Street, London, S.E.1. "The Wireless World" can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch, Ltd. INDIA: A. H. Wheeler & Co. CANADA: Imperial News Co.; Gordon & Gotch, Ltd. SOUTH AFRICA: Central News Agency, Ltd.; Wm. Dawson & Sons (S.A.), Ltd. UNITED STATES: The International News Co.


TCC